WHITE PAPER

Centralized WLAN Troubleshooting

Maximizing Wireless Network Availability

Wireless Local Area Networks (WLAN) have proliferated within the enterprise. The business efficiencies realized though wireless mobility are fairly well established. WLAN infrastructure solutions have matured, and provide reasonable interoperability under the Wi-Fi certification program. While the cost of deploying a WLAN solution has dropped over the last several years, the operational expense of maintaining and managing a WLAN continues to rise. As more and more enterprise applications and workforce migrate to wireless, the cost of troubleshooting and fixing wireless network connectivity and performance issues is increasing. Unlike wired networks, wireless networks pose unique challenges given the transient and shared nature of the communication medium. The ability to effectively analyze and respond to wireless problems is indispensable for maximizing the Return-on-Investment (ROI) from a WLAN solution. This paper provides a summary of some of the key wireless performance issues that affect enterprise WLAN deployments. The Motorola AirDefense distributed WLAN monitoring system provides a vendor agnostic, cost effective, centrally managed, WLAN troubleshooting solution that can significantly improve the wireless network availability for enterprises.

WLAN Performance Challenges

WLAN networks use a shared, license-free, Radio Frequency (RF) medium for communications. The operational challenges of running a wireless network are unique and different from wired networks. Some common issues often affecting WLAN performance are illustrated in Figure 1.

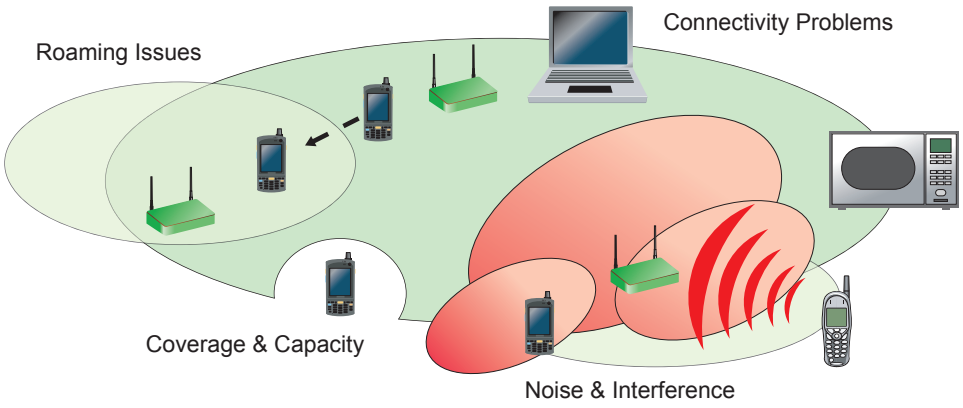


Figure 1: Common problems affecting WLAN performance

Coverage and Capacity

WLANs typically consist of Access Points (APs) distributed across the enterprise. RF signal strength wanes as the distance from the transmitting source increases. Indoor RF propagation is strongly affected by scattering and multipath in the environment, which in turn depends on the obstacles and building characteristics. Careful site survey and planning is needed to optimize the placement of APs to assure robust coverage where needed.

Despite best efforts, most enterprise deployments still suffer from coverage holes. Apart from zones where consistent signal fading occurs, there may still be areas where the practical wireless throughput is lower than expected. Being unable to connect to the wireless network or having a poor connection can be frustrating and result in reduced productivity.

Sometimes, despite good signal strength, users experience reduced throughput from the WLAN. This often happens when other users are consuming excessive shared bandwidth or when the AP is overloaded. One slow connection can bring down the whole network. This often happens when a user on the periphery of an AP's coverage (operating at lower data rates) is utilizing the network excessively. Since WLANs use a fair channel sharing algorithm, the slow user gets to access the channel as frequently as the fast user. The situation is similar to a fast car being stuck behind a slow truck on a single lane highway. Another common performance bottleneck is excessive clients connected to a single AP.

Noise and Interference

The RF medium used by WLANs has ambient thermal noise as well as interference introduced by other devices radiating energy in the same frequencies used by the WLAN. WLANs operate in the Industrial, Medical and Scientific (ISM) license free band (2.4 GHz and 5 GHz), shared by other wireless protocols and devices such as Bluetooth, cordless phones, microwave ovens, wireless cameras, etc. Excessive noise and interference will increase the packet error rate in the WLAN leading to reduced wireless throughput and potential loss of connectivity.

Since RF interference is hard to "see" and quantify without sophisticated spectrum analyzers and other costly RF equipment, IT is often left guessing at what the potential source of wireless performance degradation might be. Many interference sources are transient and only detected intermittently, exacerbating the complexity of wireless troubleshooting. For example, a microwave oven in the office might be on during lunch break, seriously degrading the WLAN in its vicinity during mid-day.

Co-channel interference is another common problem for WLANs. Since APs often limit coverage to provide wireless access over a large area, a frequency reuse pattern can be used to allow two adjacent APs to operate without collisions. The number of non-overlapping channels in the 2.4 GHz band is limited to three. This forces enterprises to re-use the same frequencies across the deployment. This creates co-channel interference where two APs and their associated devices are operating on one channel causing increased collisions resulting in higher packet error rates.

Connectivity Problems

Even with proper coverage and reduced interference levels, enterprise IT often receives support calls associated with wireless connectivity issues. For example, the WLAN could be healthy but a user may have a wrong security key, a bad wireless driver, wireless supplicant issues or other tools preventing wireless connections. Alternatively, the user's client might be fine, but the AP could be misconfigured, an antenna might have fallen off or the AP may have a hardware problem. Sometimes a wireless connectivity problem may not even be a wireless access issue – the problem may be on the wired side of the network (a bad gateway for example). Having to rule out coverage, capacity, noise and interference problems is daunting enough, not to mention user error, device/software misconfigurations and wired network issues.

Roaming Issues

Another common problem affecting mobile wireless clients is roaming. This particularly impacts Voice over WLAN (VoWLAN) clients with stringent jitter and latency requirements. When a mobile client roams, it may have to switch its AP connection. Roaming between APs efficiently and securely is a challenging requirement. Troubleshooting roaming problems is even more challenging. A static connection between a client and a fixed AP can be analyzed with a laptop analyzer. However, a mobile client associating with several APs makes laptop based analysis cumbersome. A distributed monitoring system can automatically lock onto a mobile client and provide a centralized, consolidated view of its behavior as the client roams, significantly simplifying troubleshooting.

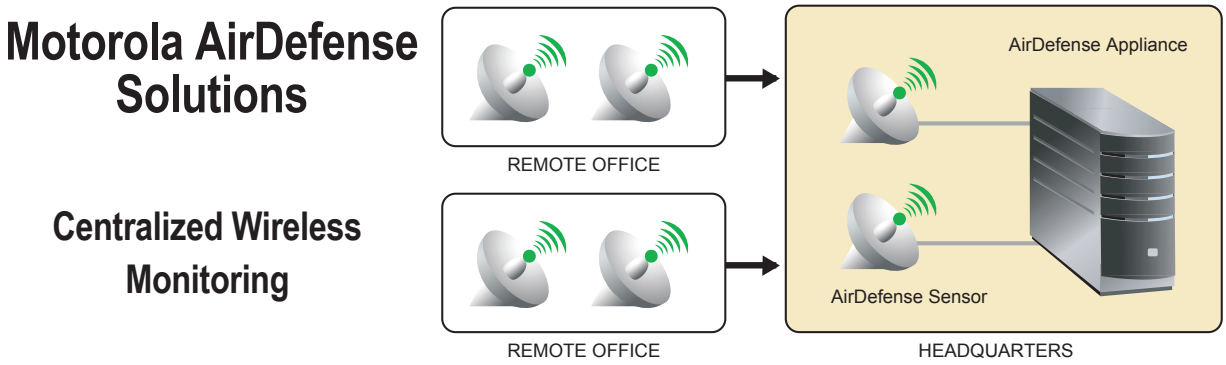
Centralized WLAN Troubleshooting

The operational cost of a WLAN increases significantly as performance problems increase. Unlike wired networks, where reliability of the communication medium is not as significant a problem and the availability of centralized tools results in quick turnaround of networking trouble tickets, enterprise IT often struggles with effective resolution of wireless network problems. When a user calls a help desk complaining about the lack of wireless connectivity, the inability of the support staff to immediate look at the RF medium and analyze wireless traffic around the user often results in inadequate problem resolution or necessitates the presence of a field technician with a laptop wireless analyzer to further investigate the problem. This method leads to increased cost and longer resolution times for wireless trouble tickets, not to mention decreased productivity in the interim. Often, when a field technician shows up on site, the problem might not even manifest itself, especially if the root cause is a transient noise source. The ability to remotely troubleshoot and resolve WLAN performance problems, in real-time, with access to historical data for perspective, is crucial for maximizing the availability and ROI from a WLAN.

Figure 2 illustrates the Motorola AirDefense solution architecture and summarizes available WLAN troubleshooting features. The Motorola AirDefense wireless monitoring solution is based on the industry leading AirDefense Wireless Intrusion Prevention System (WIPS). The system uses a dedicated network of RF sensors that continuously monitor the airwaves – intelligently scanning different frequencies over time and space to detect WLAN performance problems and policy violations. The remote sensors serve as the "eyes and ears" of the WLAN, observing network behavior 24x7 and allowing an administrator to "look into" a wireless issue from any location with network access.

APs with special firmware allowing "promiscuous mode" packet visibility are used as dedicated sensors. Promiscuous mode allows sensors to listen to all the packets received by an antenna. In addition, sensors use an intelligent channel scanning algorithm to detect WLAN traffic and interference sources across the RF spectrum. The sensors locally analyze the received packets, collect several statistics and events of interest and use an efficient Application Programming Interface (API) to communicate over a secure link to the centralized appliance. Sensor software can be enabled on dedicated radios available in the Motorola WLAN infrastructure – a dual-radio Motorola AP can have AP functions enabled on one radio and 24x7 sensing enabled on the second radio. Alternatively, sensor only functions can be enabled on a dedicated device and the system can be overlayed on any WLAN infrastructure to provide vendor agnostic WLAN performance monitoring and troubleshooting.

The appliance correlates events and statistics from the sensors and provides a centralized data repository. The appliance also allows the system to be administered and managed from one point. Performance policies can be specified on the appliance and various WLAN performance reports can be automatically generated and archived by the appliance.



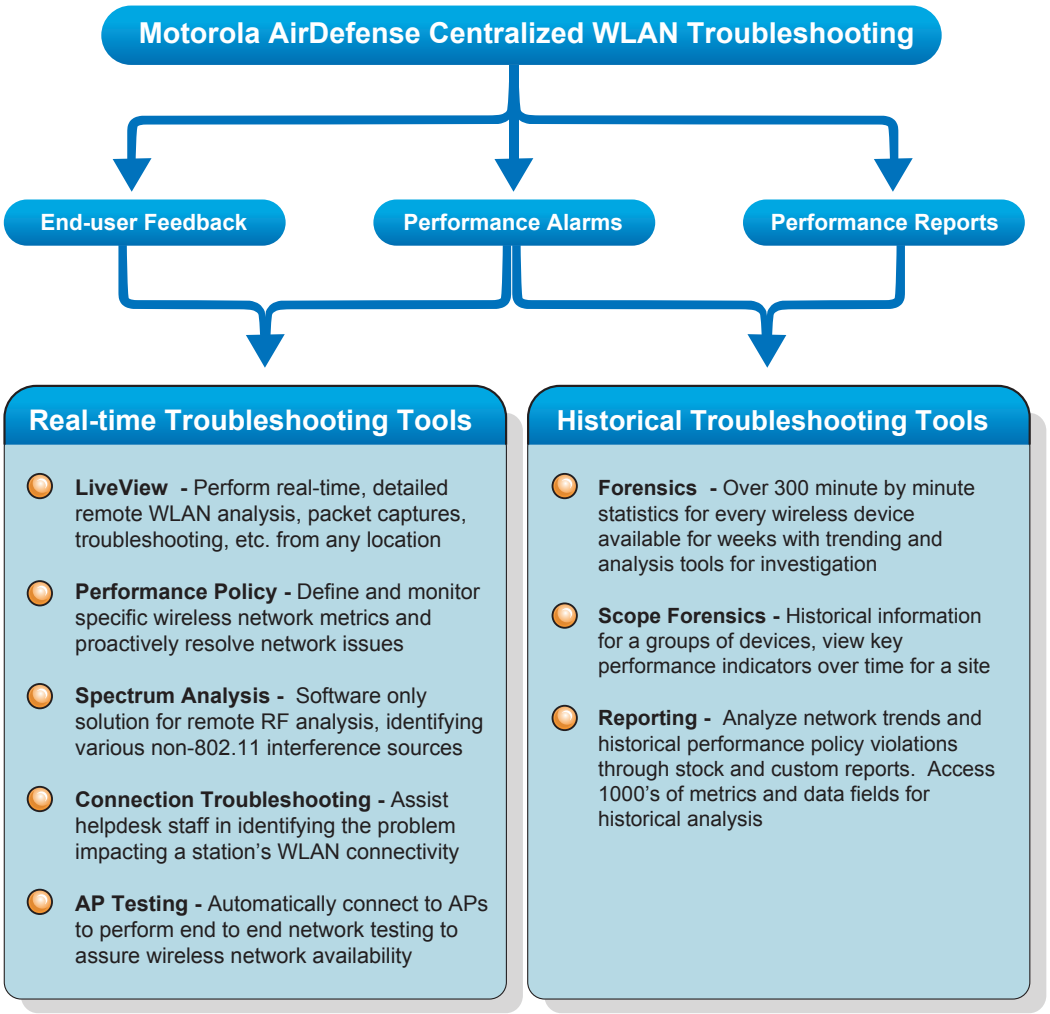


Figure 2: Centralized WLAN troubleshooting using the Motorola AirDefense solution

Performance problems are flagged in three ways.

1. **End-user feedback:**
   A WLAN user can call an IT helpdesk reporting a wireless problem. A ticketing system can issue a trouble ticket and forward the problem to the wireless IT support staff.

2. **System performance alarms:**
   The system has various performance monitoring alarms built in. If enabled, the system can detect congestion, noise, interference sources, coverage and capacity issues and generate an alarm. The alarm can be viewed on the system console, sent as an email to an administrator or forwarded to a Network Operations Center (NOC) using standard protocols (such as SNMP traps or SYSLOG).

3. **System performance reports:**
   Various performance thresholds and criteria can be specified in the system. The system audits the WLAN 24x7 based on the specified criteria and generates reports automatically. The report can point to systematic problems detected on the WLAN over time.

Once a problem is flagged, the system provides sophisticated real-time and historical troubleshooting tools.

Real-time Troubleshooting Tools

Real-time tools allows an administrator to look into what is happening on the WLAN at the given instant. Many RF issues are hard to replicate or transient in nature, and the ability to remotely and instantly visualize and analyze the user's WLAN from a central location is valuable.

LiveView

LiveView allows an administrator to capture and analyze 802.11 packets from any location. Traditionally this feature was limited to laptop based analysis tools equipped with a WLAN card and special software to capture and analyze 802.11 frames. The limitation of this approach is that the laptop along with the technician has to be physically present at the site where the problem has occurred. LiveView allows the administrator to leverage the remote sensors to capture 802.11 packets and analyze them from any location. LiveView automatically uses distributed sensors to effectively capture frames from a device, removing duplicates and switching sensors as the device roams. A complete 802.11 packet analyzer is included within LiveView as depicted in Figure 3.

LiveView also allows the administrator to analyze connection diagrams that establish the network link from a wireless device to an AP and all the way through to a wired device. Connection diagrams facilitate the visual analysis of device roaming behavior and traffic flow. LiveView supports 28 different analysis charts and allows the user to create customized views for individual devices as well as groups of devices based on different locations or scope. Capacity and channel utilization graphs can be generated in real-time providing valuable insights into performance bottlenecks as depicted in Figure 3.

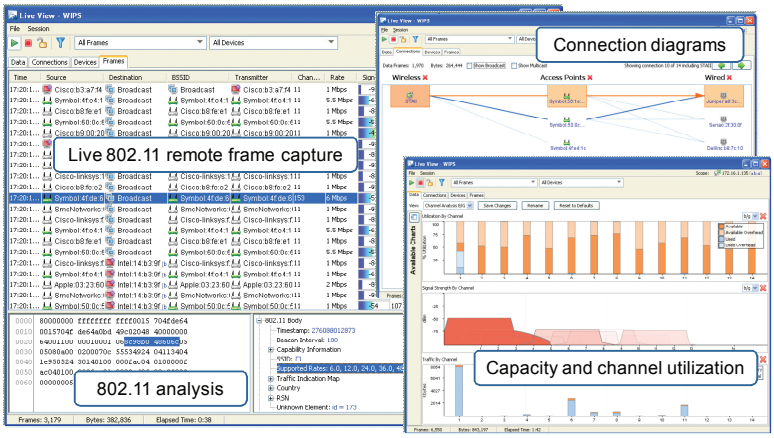


Figure 3: LiveView features

Performance Policy

The Motorola AirDefense system proactively monitors the WLAN using a specified performance policy based on various metrics and thresholds. The system can be tuned to monitor for 50 device specific parameters, 7 environmental parameters and 50 performance specific events. The system can proactively identify and flag common wireless issues such as excessive utilization, interference sources, congestion and coverage issues, even before users experience a significant disruption.

Some of the performance alarms the system is capable of generating are as follows:

1. **Utilization Alarms:**
   The system has 33 utilization specific alarms that trigger when management, control and data frames of different types exceed a specified threshold. For example, the system can detect when the total number of associations in a Basic Service Set (BSS) has exceeded threshold, indicating an overloaded WLAN. Similarly, the system can detect when there are an excessive number of WLAN disassociations, indicating an overload or a potential denial of service attack.

2. **Congestion Alarms:**
   The system has 6 congestion alarms that can detect issues such as high channel noise levels and excessive station roaming.

3. **Coverage Alarms:**
   The system has 4 coverage specific alarms that can detect issues such as an AP communicating excessively using low data rates and hidden stations.

4. **Interference Alarms:**
   The system has 7 interference alarms capable of detecting common sources of interference such as microwave ovens, Bluetooth devices, continuous wave transmitters and frequency hopping phones. It can also detect non-standards based WLAN equipment (Atheros 'Turbo' mode devices, pre-standard 802.11n devices, etc.)

5. **Configuration/Compatibility Alarms:**
   The system has 8 configuration related alarms that can detect legacy mode transmissions that could be degrading network throughput and creating data rate mismatches between an AP and a station.

Spectrum Analysis

The Motorola AirDefense solution features a spectrum analysis module providing the industry's first software only solution that can remotely view the physical layer of an enterprise WLAN using distributed sensors (without requiring specialized hardware). With the spectrum analysis tool, network administrators can identify and classify possible sources of interference in the 2.4 and 5 GHz WLAN frequency bands. Sources of interference could include microwave ovens, Bluetooth devices, frequency hopping phones and wireless cameras. Using the spectrum analysis tool, you can view the impact of WLAN interference sources without sending a technician with expensive hardware to a remote location.

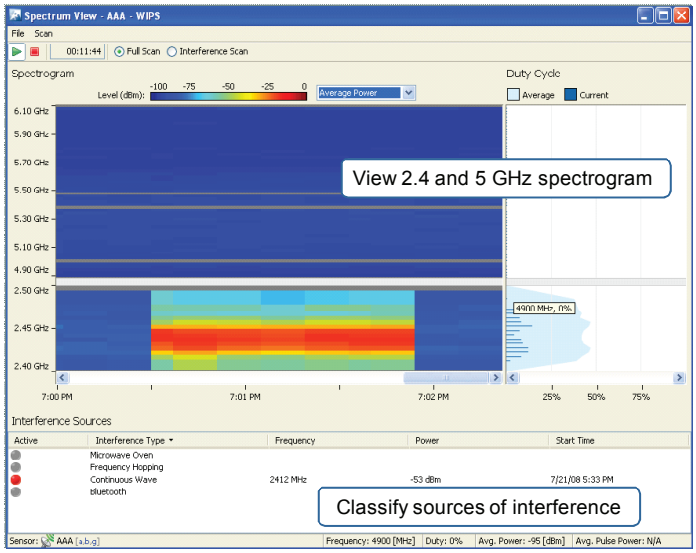


Figure 4: Spectrum analysis module showing spectrograms and interference classification

The spectrum analysis module can work silently in the background, periodically scanning WLAN bands for sources of interference. If interference is detected, performance alarms are generated. In addition to background scanning, the spectrum analysis tool can be used in real-time to remotely analyze the WLAN spectrum at any deployed location. The tool plots a spectrogram in the 2.4 and 5 GHz bands and reports the observed power level in a given time-frequency bin (as depicted in Figure 4). Spectrograms are routinely used to analyze the wireless spectrum and determine how much energy is present on a given radio frequency at any instant. Wireless devices using different physical layer protocols often have unique spectral signatures that can be used to identify them.

Connection Troubleshooting

Client connectivity problems can be caused by a variety of issues, many of which are not related to the wireless network. Unfortunately, the wireless network often gets faulted for connectivity problems experienced by mobile users. The wireless network support staff is then required to devote time trouble-shooting issues which may not be a wireless problem. The client connectivity troubleshooting tool is designed to assist Tier-1 helpdesk personnel, with limited wireless networking expertise, to easily identify a connectivity problem. This allows them to either resolve it or escalate it to the appropriate IT support staff. The connectivity troubleshooting module's sophisticated analysis engine quickly identifies device level problems, wireless network health, wireless network availability, wireless network or client configuration and wired network connectivity issues.

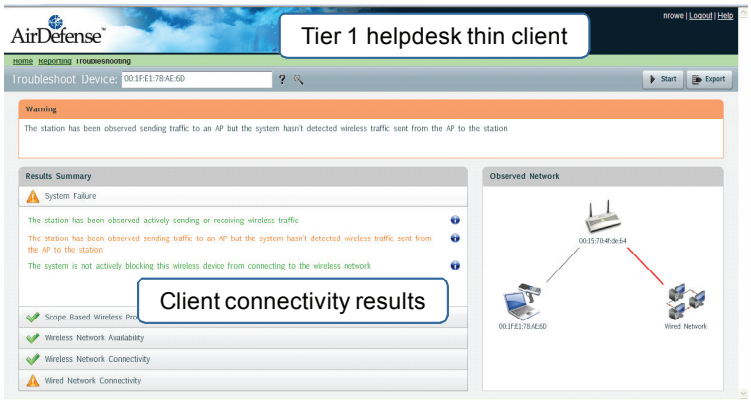


Figure 5: Wireless connection troubleshooting tool

The tool allows helpdesk staff to log onto a thin user interface with limited access to the Motorola AirDefense appliance. Using a device selection wizard, the helpdesk staff can remotely identify the wireless device via its hardware MAC address. The system then runs a series of connection tests enumerating success, failure or warning results for each step (as depicted in Figure 5). The system can present the analysis in simple terms, for example "the wireless network around the station is healthy" or "the station has been observed actively sending or receiving wireless traffic". This enables diagnosis and resolution of common wireless problems. Apart from troubleshooting a specific device, the tool also allows helpdesk personnel to employ a scope based analysis to analyze problems that might be affecting a group of devices.

AP Testing

Wireless applications rely on the configuration of both wireless and wired network elements to function correctly. A simple change to the wired network could render wireless applications inoperable. Troubleshooting can be cumbersome and time-consuming since network administrators cannot connect to the wireless network to perform the tests required to identify where the problem occurred. The AP connectivity testing module addresses these issues by allowing the remote testing of network connectivity from the perspective of a wireless station. By utilizing the radio of the wireless sensor to simulate a wireless client station, true end-to-end network testing can verify all aspects of the wireless application's datapath. Connectivity tests can be customized to verify the specific wireless configuration, wired network configuration and application server availability. These tests can be configured to run automatically on a pre-configured schedule (or on demand as needed) to proactively identify and notify configuration changes which impact wireless applications.

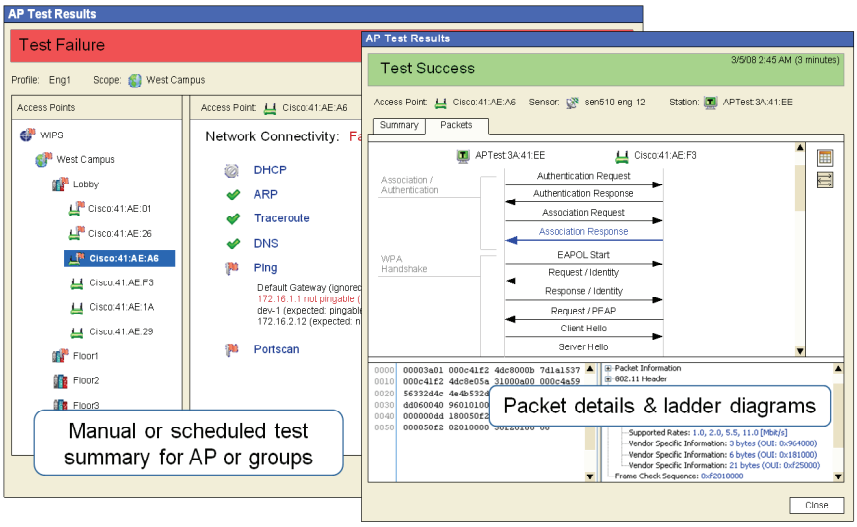


Figure 6: Access Point test results

Once an AP is chosen for testing, configuration data such as security keys, SSID, IP address settings is obtained via a user input or a pre-configured profile from the appliance. A sensor is chosen for the test. This is typically the sensor closest to the AP with the best received signal strength. Other sensors in range can also be used. The sensor is then locked on the AP's operating channel and several Layer 2 wireless tests and Layer 3 wired network tests are performed, as shown in Figure 6. If the AP uses 802.11i based security, a 4-way handshake is performed and temporal as well as group keys are installed. Based on the success of the Layer 2 connection, an appropriate report is generated. Once a successful Layer 2 connection is established, the sensor client tries to establish a Layer 3 session. If the sensor is configured for DHCP, it tries to automatically obtain an IP address, otherwise it uses pre-specified IP address settings. Once an IP address is obtained, the sensor performs a ping and traceroute test to determine if a client can successfully ping a known machine on the wired network.

Historical Troubleshooting Tools

Historical troubleshooting tools allow an administrator to analyze device specific trends over time to better understand the root cause of a problem or detect intermittent problems.

Advanced Forensics

Wireless events are by their nature transient. This presents an enormous problem for administrators researching complex and intermittent performance issues. Without granular historical activity records, research is virtually impossible. The Motorola AirDefense solution provides administrators the ability to rewind and review detailed records of wireless activity. This provides valuable historical insights into complex wireless performance issues.

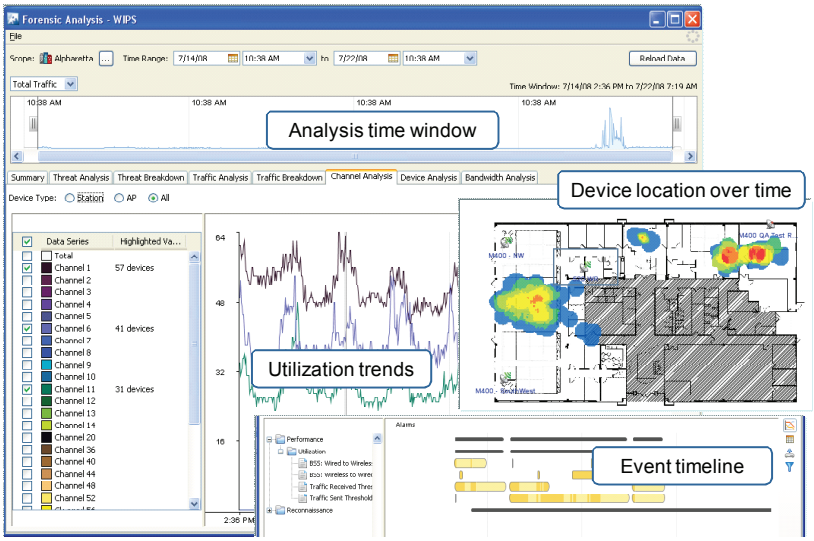


Figure 7: Historical performance analysis using the advanced forensics module

Administrators can view the activity of a poorly performing device over a period of months and drill down to minute-by-minute wireless activity. The system maintains 325 data points per minute for every wireless device. Statistics stored by the system include critical device communication and traffic information, channel utilization, signal and noise characteristics, device activity and traffic flow. This historical data can be trended and analyzed over configurable time windows. The system can re-create a timeline and sequence of events identifying specific instances when performance problems occurred (as depicted in Figure 7). Historical association analysis can show how clients have been connecting to APs in the past and identify imbalances, such as over or under utilized APs. Historical traffic analysis can quickly isolate anomalous behaviors, such as a device suddenly sending excessive traffic or periodic problems such as connectivity loss when a microwave oven is operating in the vicinity of an AP (at lunch time). Historical channel analysis can determine spare channel capacity and help optimize WLAN frequency planning. Historical location tracking can determine the physical location of a device over time, identifying hot zones where the device typically operates, and roaming trajectories for mobile clients.

Performance Reports

Advanced forensics provides an interactive tool for historical performance analysis. While an interactive tool is needed for troubleshooting complex and intermittent problems, often the ability to automatically generate performance summary reports based on historical data and have it automatically sent to wireless network administrators is desirable. The Motorola AirDefense system can schedule and automatically generate granular performance reports. Fully customizable reports can be generated in a variety of formats such as HTML, CSV and PDF. Key performance indicator reports can be automatically sent to IT executives to validate the benefits of WLAN mobility and quantify ROI. Detailed reports delivered to the network administrators can help them track performance and identify potential problems ahead of time.

Conclusions

Managing large distributed WLANs poses unique challenges. Unlike wired networks, WLANs have to operate in a shared wireless medium that is constantly changing. WLAN performance and coverage can be significantly impacted by noise and transient interference in the local air space. Wireless devices are mobile and frequently roam between different WLANs. Mobile devices often have incorrect settings preventing a device from successfully communicating. The cost of troubleshooting wireless problems is significant. Typically, when a user reports connectivity problems, an on-site technician armed with a wireless laptop based network analyzer is sent on site to capture wireless traffic and analyze the root cause of the issue. This method is costly and time consuming. The ability to "look into" a wireless network remotely from a central facility is indispensable for efficient WLAN troubleshooting.

The Motorola AirDefense centralized WLAN monitoring and troubleshooting solution offers a unique set of tools for vendor agnostic, remote WLAN performance management. The system features powerful real-time tools to capture and analyze 802.11 frames, detect and classify non-802.11 sources of interference, monitor performance policy violations and remotely debug client and AP connectivity issues. The system also maintains minute-by-minute granular information for all monitored devices and facilitates reporting and historical troubleshooting of complex and intermittent problems. The net result is that enterprises can maximize the availability of their WLAN while simultaneously reducing operational expenses.

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