Healthcare market segment: Site survey best practices

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Executive Summary

Healthcare facilities[1] are known to be some of the most challenging radio frequency (RF) environments when operating a Wi-Fi® network. Many hospitals include construction materials that can significantly reduce Wi-Fi signals from propagating throughout the coverage areas, including lead-lined walls where X-rays are conducted. Furthermore, healthcare facilities are built and expanded over the years which can lead to walls within 'new' outer walls. Additionally, expected clinical workflows within hospitals can include mobile metal carts and other RF-interfering devices, such as workstations on wheels, that roam throughout the hospital. Finally, the number and variety of both medical and guest devices expected within a healthcare facility are growing significantly and can lead to network congestion if the Wi-Fi network is not designed properly. From laptops and smartphones using guest access, to video streaming cameras, infusion pumps, and other medical devices, a given hospital can connect thousands of these devices to the Wi-Fi network in a single day.

To help ensure the successful installation of a Wi-Fi enabled medical device, it is important to determine if the coverage and capacity of the hospital's wireless network infrastructure is performant enough to support medical device connectivity and function in the intended coverage area. This assessment is commonly referred to as a site survey and typically involves a two-stage process. In the first stage, a professional services organization assesses the quality of the wireless network infrastructure itself. In the second stage, the stations that will connect wirelessly in the intended coverage area are assessed individually for their respective performance. Given the variation in radio and antenna performance across stations connecting to a wireless network infrastructure, it is important that both site survey stages are executed to give an accurate representation of performance for a given medical device. This paper is intended to equip those within, and of direct influence on, healthcare IT departments with the necessary information required to successfully prepare for, execute, and assess the results of wireless site survey in a healthcare facility.

Introduction

A wireless site survey is a comprehensive assessment conducted to analyze the wireless network coverage, capacity and performance within a specific area. It involves meticulously mapping out the signal strength, available bandwidth, interference sources, and potential obstacles that could affect the quality of wireless communication. These surveys are particularly crucial in environments where reliable wireless connectivity is vital, such as hospitals and healthcare facilities.

Data collected from a wireless site survey serves multiple purposes. Firstly, it provides valuable insights into the optimal placement of wireless access points (APs) to ensure uniform coverage throughout the facility. By identifying dead zones or areas with weak signal strength, network administrators can strategically position APs to maximize coverage and minimize potential connectivity issues.

Moreover, the survey data aids in determining the most suitable wireless technology and configurations for the healthcare environment. Factors such as the type of medical equipment in use, the density of wireless devices, and the need for seamless roaming for staff and patients all influence the network design. Through thorough analysis of survey data, IT professionals can tailor the wireless infrastructure to meet the specific demands of healthcare operations, prioritizing reliability, security, and performance.

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[1] A healthcare facility is an office or institution providing care or treatment of diseases, whether physical, mental, or emotional, or other medical, physiological, or psychological conditions, including but not limited to, hospitals, rehabilitation hospitals or other clinics, including weight control clinics, nursing homes, homes for the aging or chronically ill, laboratories, and offices of surgeons, chiropractors, physical therapists, physicians, dentists, and all specialists within these professions. This definition shall include all waiting rooms, hallways, private rooms, semiprivate rooms, and wards within health care facilities. (https://www.lawinsider.com/dictionary/health-care-facility).

In a healthcare setting, where immediate access to patient records, patient monitoring data, medical imaging, and communication tools is critical for delivering efficient and effective care, the importance of a reliable wireless network cannot be overstated. Wireless connectivity enables healthcare professionals to access patient information at the point of care, collaborate with colleagues in real-time, and utilize mobile medical devices for tasks such as bedside monitoring and telemedicine consultations. Any disruption or downtime in wireless communication can impede clinical workflows, delay patient care, and compromise patient safety.

Therefore, conducting regular wireless site surveys and optimizing the wireless infrastructure based on survey findings are essential practices in healthcare IT management. By ensuring robust wireless connectivity, healthcare organizations can enhance operational efficiency, improve staff productivity, and ultimately, deliver better patient outcomes. Additionally, maintaining a well-designed wireless network contributes to compliance with regulatory requirements regarding data security and patient privacy, further underscoring the significance of wireless site surveys in healthcare settings.

Requirements and Preparation

A wireless site survey is a critical step in designing and deploying a reliable and efficient wireless network in a healthcare facility. The primary objective of a site survey is to gather comprehensive data that will inform the design, implementation, and optimization of the wireless network. Preparation for a wireless site survey involves several key activities, including obtaining a detailed floor plan, understanding station KPIs, and selecting appropriate survey tools.

Floor plan

A detailed floor plan is essential for a successful wireless site survey. The floor plan should ideally be a Computer-Aided Design (CAD) drawing, which offers a precise and scalable representation of the physical environment. The floor plan should outline the boundaries of the coverage area, ensuring that all areas intended to be serviced by the wireless network are included. Identifying potential problematic areas on the floor plan, such as locations with heavy machinery, dense structural materials (e.g., lead-lined walls in an imaging procedure room), or other sources of interference, is crucial. These areas can significantly affect signal propagation and must be accounted for in the survey to ensure comprehensive coverage and performance.

Station KPIs

Key Performance Indicators (KPIs) for stations, particularly medical devices, are fundamental to the site survey. These KPIs include throughput, latency, packet loss, signal strength, and security to name a few. For medical devices, these items are often found in the device's networking disclosure statement and consistent with guidance found in IEC 80001-1 Application of risk management for IT-networks incorporating medical devices. Understanding the specific networking needs and usage patterns of the users is crucial. For instance, clinical applications in a healthcare setting may require low-latency, high-reliability connections to support critical applications such as patient monitoring systems. Knowing these requirements helps in designing a network that meets the performance standards necessary for the intended applications in a healthcare facility.

Identification of the site survey tool

Choosing the right site survey tool is critical to collecting accurate data and performing a thorough analysis. Tools range from simple software applications to sophisticated hardware solutions. These tools often come with features like heat mapping, which visually represents the signal coverage across the surveyed area, and spectrum analysis to identify sources of interference. The choice of tool will depend on the specific needs of the survey, such as the complexity of the environment and the precision required in the data.

A well-prepared wireless site survey involves meticulous planning and consideration of various factors. A detailed floor plan, understanding of station KPIs, and the selection of appropriate survey tools are all crucial elements that contribute to the successful deployment of a wireless network in a healthcare setting. This preparation ensures that

the network will meet the performance requirements and provide reliable connectivity for all users within the coverage area.

Available methods and tools

Performing a wireless site survey is a crucial step in designing and optimizing a wireless network within a healthcare facility to ensure optimal coverage, performance, and reliability. Several methods and tools are available to conduct a comprehensive wireless site survey.

Wireless site survey methods

- **Predictive site survey**: Utilizing specialized software, a predictive site survey simulates wireless coverage based on the floor plan, building materials, and other parameters. This method predicts potential coverage, signal strength, and interference patterns without physically being at the site. It helps in planning access point (AP) placement and antenna selection
- **Passive site survey:** Passive surveys use tools to capture existing wireless signals without actively sending any signals. This method analyzes the existing wireless environment, including neighboring networks and interference sources, helping in channel selection and interference mitigation
- **Active site survey:** This involves deploying temporary access points at specific locations to measure actual wireless coverage and performance. Test devices are used to collect data on signal strength, throughput, and latency in real-time. This method provides accurate insights into the actual network performance

Site Survey Method	Description	Level of Accruacy
Active	A qualified site survey radio is associated with the Access Point. Both the coverage and capacity of the wireless network infrastructure are measured.	High
Passive	A qualified site survey radio records the Access Point Received Signal Level only.	Medium
Predictive	Wireless propagation modeling based on floor plan and construction materials used; no measurements made onsite.	Low

When considering the available site survey methods, it is important to note the overall impact of performing the site survey and the corrective actions that come up due to the wireless site survey results. In a healthcare facility, clinical use of the Wi-Fi network is already occurring so the cost to return to redo a survey is higher. A predictive site survey is more prone to error given the “best guess” inputs in generating the floor plan, building material and other parameters that impact wireless propagation. Additionally, the cost of pulling a cable to the wrong location can exceed the total cost of doing a predictive survey. Given all of this, an active site survey is preferred in a healthcare setting.

Wireless site survey tools

Tools commonly used for conducting wireless site surveys include:

- **Wi-Fi scanners**: Applications and devices that scan for available wireless networks, displaying signal strength, channel usage, and other network details. Examples include NetSpot, inSSIDer, and Ekahau HeatMapper
- **Spectrum analyzers:** These tools detect and analyze wireless signals across different frequencies, identifying interference sources such as microwaves or Bluetooth devices. Devices like MetaGeek's Chanalyzer and Wi-Spy are commonly used for this purpose
- **Site survey software:** Applications like Ekahau Site Survey, AirMagnet Survey, and iBwave Wi-Fi allow for predictive modeling, creating heatmaps, and analyzing survey data to plan and optimize wireless networks
- **Portable devices:** Tools such as wireless access points, laptops, or smartphones equipped with Wi-Fi scanners and survey software are used for active surveys, collecting real-time data at various locations within the surveyed area

Each method and tool have their respective advantages and limitations. A combination of these methods, tailored to the specific needs of the environment, ensures a comprehensive understanding of the wireless landscape, aiding in the effective design and deployment of a robust wireless network.

Ekahau Site Survey:

Key Characteristics:

- Predictive modeling capabilities based on building floor plans and materials
- Real-time heatmaps for visualizing signal strength, coverage areas, and interference
- Capacity to plan AP placements and antenna configurations for optimal coverage
- Integration with Ekahau Sidekick hardware for more accurate measurements
- Reporting features for documenting survey results and network designs

AirMagnet Survey:

Key Characteristics:

- Active, passive, and predictive survey modes for comprehensive analysis
- Detects and mitigates interference sources, ensuring reliable network performance
- Multi-floor planning and predictive modeling for complex environments
- Real-time spectrum analysis to identify non-Wi-Fi interference sources
- Automated reporting tools for generating detailed survey reports

iBwave Wi-Fi:

Key Characteristics:

- Predictive modeling using 3D building models and CAD drawings
- Capacity to simulate various scenarios for AP placement and antenna configurations
- Integration with iBwave Mobile Planner for on-site data collection and validation
- Collaboration features enabling team members to work on projects simultaneously
- Customizable reporting options for creating detailed survey documentation

NetSpot:

Key Characteristics:

- Active and passive survey modes for both Windows and macOS platforms
- Heatmapping capabilities to visualize signal strength and coverage areas
- Discover and analyze neighboring Wi-Fi networks for channel optimization
- Offers both free and paid versions with varying features and capabilities
- User-friendly interface suitable for small to mid-sized deployments

MetaGeek Chanalyzer with Wi-Spy:

Key Characteristics:

- Spectrum analysis to identify and troubleshoot non-Wi-Fi interference sources
- Real-time visualization of RF activity across different frequency bands
- Captures and analyzes data from various Wi-Spy hardware devices
- Helps in optimizing channel selection and minimizing interference issues
- Provides detailed reports and graphs for visualizing interference patterns

When choosing a wireless site survey tool, considerations should include the size and complexity of the environment, the level of accuracy needed, budget constraints, and the specific features required for the survey. Each tool has its strengths, whether in predictive modeling, real-time data collection, interference analysis, or reporting capabilities. Combining multiple tools or using complementary features from different software can provide a more comprehensive understanding of the wireless landscape in a healthcare setting and facilitate effective network planning and optimization.

Procedure

Performing a comprehensive wireless site survey is critical for ensuring optimal performance and coverage of a wireless network in a healthcare setting. The procedure typically involves several key steps, including setup, calibration, and the actual measurement process at various points within the surveyed area.

Setup

To begin, assemble the necessary equipment, including the measurement device with any specialized site survey software. Ensure that the survey equipment is fully charged and functioning properly. Additionally, verify that any necessary cables or adapters are available for connectivity. Next, gather required site documentation including floor plans and construction materials used in the environment. Plan the site survey route, taking into account the layout of the area to be surveyed and any potential obstacles or sources of interference.

Calibration

Before starting the actual survey, calibrate the equipment to establish a baseline for measurement accuracy. This may involve adjusting the settings on the survey software or ensuring that the equipment is properly configured for the specific wireless environment. When performing a calibration, be mindful of the site survey tool manufacturer's recommendations and ensure that their guidelines are followed properly.

Conduct a brief test survey in a controlled environment to verify that the equipment is functioning correctly and that the survey software is accurately capturing relevant data.

Measurement process

Begin the survey at the designated starting point, typically near the center of the area to be surveyed. Record the physical location of each measurement point to accurately map the coverage area. For each measurement point, capture relevant data such as signal strength (RSSI), signal-to-noise ratio (SNR), and data transfer rates. Take multiple measurements at each point to account for variability in signal strength and potential interference from nearby devices or environmental factors. As you move through the surveyed area, pay attention to any areas of weak or inconsistent coverage, as these may indicate the need for additional AP placement or configuration adjustments. Document any notable observations or issues encountered during the survey, such as dead zones, areas of interference, or signal attenuation due to building materials.

By following a systematic site survey procedure, organizations can ensure that their wireless networks are properly configured to meet the needs of users and provide reliable connectivity across the surveyed area. Regular site surveys may be necessary to accommodate changes in the wireless environment or address evolving network requirements.

Results summary

Summarizing results obtained from a wireless site survey is an important task that ensures stakeholders understand the performance and coverage of the wireless network. The summary should be clear, concise, and comprehensive, encapsulating the key findings and data that illustrate the state of the wireless infrastructure. Key elements include signal strength measurements, coverage maps, interference sources, and recommendations for improvements. These elements help to assess the current network capabilities and identifying areas that need enhancement.

A test report must contain several essential elements to be effective. First, it should begin with an executive summary that provides a high-level overview of the findings and recommendations. This is followed by detailed sections that include the methodology used during the survey, such as the types of equipment and software employed, the specific locations surveyed, and the times at which data were collected. The report should present detailed signal strength readings, coverage heatmaps, and data on interference sources. Furthermore, it should include an analysis of the network's performance metrics, such as throughput, latency, and packet loss. Lastly, the report should offer actionable recommendations based on the findings, providing a roadmap for optimizing the wireless network.

Comparing the survey results to the station's key performance indicators (KPIs) is crucial for determining the success of the wireless network. KPIs may include metrics like minimum acceptable signal strength, coverage area percentage, maximum allowable latency, and desired throughput levels. By mapping the survey results to these KPIs, one can objectively assess whether the network meets the station's performance expectations. This comparison helps in identifying any gaps between the current network performance and the desired benchmarks, guiding the necessary steps for improvement.

The quality of the wireless coverage area is determined through several factors, primarily focusing on signal strength, interference levels, and network performance metrics. Signal strength is often measured in decibels relative to a milliwatt (dBm), with values typically needing to be above a certain threshold (e.g., -65 dBm) for reliable connectivity for critical clinical applications. Coverage maps, generated from survey data, visually represent areas of strong and weak signals, helping to pinpoint dead zones and areas of potential improvement. Additionally, the presence of interference, from both co-channel and adjacent-channel sources, can significantly impact the quality of the wireless coverage. Identifying and mitigating these sources is vital. Lastly, performance metrics such as throughput, latency, and packet loss are crucial in determining the end-user experience. Comprehensive analysis of these factors ensures a detailed understanding of the wireless network's quality and guides targeted enhancements to meet user needs. It is important to share the results of key stakeholders in the healthcare organization such as network administrators or facility managers, to facilitate informed decision-making and implementation of recommended changes.

Corrective actions

When wireless site survey results indicate poor performance or coverage issues, it's crucial to take corrective actions to improve the overall quality and reliability of the wireless network. Here are several potential corrective actions that can be taken based on the findings of the survey:

Optimize access point placement

Adjust the placement of access points to ensure better coverage and signal strength throughout the surveyed area. This may involve relocating APs to areas with weaker coverage or increasing the number of APs in densely populated areas to alleviate congestion and improve performance.

Optimize channel allocation

Optimize channel allocation and frequency band usage to reduce co-channel interference and improve network performance. This may involve utilizing network infrastructure algorithms that dynamically adjust channel selection switch to less congested channels or manually configuring channels to minimize interference from neighboring networks.

Optimize data rates

This involves disabling lower data rates on the wireless network infrastructure. The effect is a reduction in the AP coverage area as it eliminates the possibility of a STA connecting to an AP at a low data rate such at 1Mbps or 2Mbps. This also improves network throughput by eliminating the possibility to communicate at low data rates.

Adjust antenna orientation and configuration

Fine-tune the orientation and configuration of AP antennas to maximize signal coverage and minimize interference. For APs with internal antennas, this would include adjusting mainly output power to increase (not enough signal in weak spots) or decrease the size of the area coverage (too much co-channel interference) in a given healthcare setting. If APs with external antenna connections are used, this may include adjusting antenna tilt, rotation, or polarization to optimize signal propagation and reduce signal attenuation.

Mitigate interference sources

Identify and mitigate sources of interference, such as other wireless networks, electronic devices, or environmental factors like microwave ovens or building materials. This could involve changing operating frequencies, adjusting transmit power levels, or implementing shielding or isolation measures to minimize interference.

Implement Quality of Service (QoS) policies

Implementing QoS policies to prioritize critical applications and ensure adequate bandwidth for voice, video, clinical data and other high-priority traffic can help improve overall network performance and user experience, particularly in environments with limited bandwidth or high levels of congestion.

By administering these corrective actions based on the results of a wireless site survey, healthcare delivery organizations can improve the overall performance, reliability, and coverage of their wireless networks, resulting in better connectivity and user satisfaction. Regular monitoring and maintenance are essential to ensuring that the network continues to meet the evolving needs of users and remains resilient to changing environmental conditions.

Maintenance

Performing a site survey in a healthcare facility, is a snapshot of the wireless network performance at that specific moment. After a period of time, utilization of the wireless network will likely increase as more wireless devices are brought into the healthcare facility. In addition, the physical environment will change as care areas flex up or down in size based on patient population variations at the healthcare facility. This means that the wireless site survey results will no longer match the future performance of the wireless network. Maintenance of the wireless network infrastructure will be required.

Routine wireless site survey

Consider performing a wireless site survey if the test results are more than 1 year old and/or if the environment or network utilization has changed significantly.

Upgrade equipment or firmware

Consider upgrading outdated or underperforming equipment, such as APs, wireless controllers, or stations, to newer models with improved features and capabilities. Additionally, ensure that all equipment firmware is up to date to take advantage of performance enhancements and bug fixes.

Conduct regular maintenance and monitoring

Establish a schedule for regular maintenance and monitoring of the wireless network to proactively identify and address potential issues before they impact performance. This may include periodic site surveys, performance testing, and firmware updates to ensure optimal operation of the network over time.

Conclusion

Wi-Fi networks are ubiquitous in a healthcare setting and provide connectivity to a wide range of medical and non-medical stations. As Wi-Fi Alliance® technologies evolve, it's important to deploy the latest available technology to enable key performance and reliability improvements, especially for critical medical applications. Given the variation in radio and antenna performance across stations connecting to a wireless network infrastructure, it is paramount that all site survey stages are executed to give an accurate representation of performance, especially for medical devices providing critical clinical functions. Healthcare IT departments will be best prepared for a wireless site survey when they have a solid understanding of the coverage area, station requirements and available methods and tools. During the wireless site survey process, gathering the right data at enough locations within the healthcare facility will allow one to gain an accurate understanding of the coverage and capacity provided by the wireless network infrastructure. Once the wireless site survey is completed and results are summarized, developing corrective action and maintenance plans will be key to ensuring the wireless performance is achievable and sustainable throughout the intended coverage area. By following the steps documented in the whitepaper, healthcare IT personnel will be able to precisely determine the performance of the coverage and capacity of the hospital's wireless network infrastructure and ensure support for medical device connectivity and its corresponding clinical function in the intended coverage area.

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Wi-Fi Alliance® is the worldwide network of companies that brings you Wi-Fi®. Members of our collaboration forum come together from across the Wi-Fi ecosystem with the shared vision to connect everyone and everything, everywhere, while providing the best possible user experience. Since 2000, Wi-Fi Alliance has completed more than 80,000 Wi-Fi certifications. The Wi-Fi CERTIFIED™ seal of approval designates products with proven interoperability, backward compatibility, and the highest industry-standard security protections in place. Today, Wi-Fi carries more than half of the Internet's traffic in an ever-expanding variety of applications. Wi-Fi Alliance continues to drive the adoption and evolution of Wi-Fi, which billions of people rely on every day.

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