Re-engineering the Wireless Network in Healthcare to Support Mission Critical Patient Applications Today and Tomorrow

White Paper

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Enterprise Mobility – We make it happen!

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Executive Summary

The Healthcare industry has been heavy users and early adopters of mobility applications due to the productivity gains and improved patient care. These productivity gains and improvements in patient care have been phenomenal and well documented. Consequently, most healthcare facilities built their wireless infrastructure years ago and updated it as needed. Whether your wireless network is based on autonomous Access Point architecture or the newer controller based architectures, the real question is: **Is your network prepared to support the mission critical application demands of the end users?** Improved patient care systems using passive and active RFID, new clinical applications, IP based voice systems, tracking the location and condition of expensive and critical equipment are just of few of the demands being placed on IT professionals in healthcare. Today's IT Healthcare Professionals are challenged with providing the wireless infrastructure to enable mobility applications for end users while budgets are tight or perhaps frozen. Compounding the challenge, many Healthcare IT professionals often find out about the new mobility application that must be supported on the wireless network after the end user group has purchased the technology.

Our experience in working with hospitals and other healthcare facilities over the last 15 years is that most Healthcare facilities rightfully designed their wireless network to support their initial mobility applications such as guest access and patient care data applications. While these networks designs did a fine job of supporting the initial applications, the applications demands of the end users have changed which have adversely impacted the wireless network resulting in poor end user satisfaction. Dropped calls and the inability to seamlessly roam are just a few of the symptoms of an outdated and obsolete design. In years past a 3D design that supports multiple floor RF coverage was adequate, however in today's healthcare environment, a 2D (same floor) coverage model with lower RF output throughout the WLAN is optimum. In some WLAN deployments, and depending on the wireless manufacturer chosen, a 3D RF coverage model may work well, however as the network continues to expand and grow, the vertical penetration of the RF signal will deteriorate as the transmit power on the radios are 'dialed down' or reduced.

The purpose of this white-paper is to outline a methodology for re-engineering your wireless network to support the mission critical applications of today while creating a consistent design that will serve your needs for the next five to seven years. In essence, this paper will provide ideas on how to restore end user satisfaction today and tomorrow while staying within the constraints of your budget.

In this white-paper you first find a review of the new mobile applications that are impacting the wireless infrastructure. These applications can be broadly put into 3 categories; Voice, Data, and, Location Based Services. Each of these application categories will be reviewed highlighting the mobility application details, client connectivity issues, and the wireless architectural design ramifications. This will be followed by a methodology to migrate your architecture to meet the application requirements.

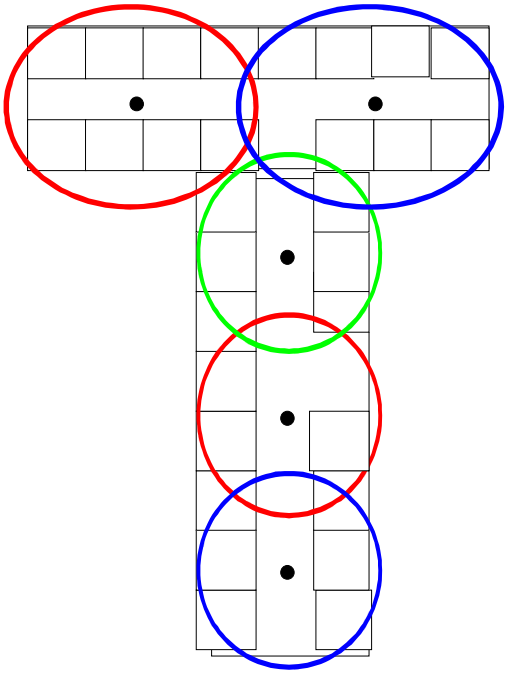
Applications Impact on the Wireless Network

Data Applications - Conventional

Legacy data 802.11b/g: Traditionally, data only 802.11 WLANs' have been relatively easy to deploy from an application and client connectivity standpoint. The applications and the wireless networks were deployed without any significant throughput or acceptance testing and expected to work, and for the most part, they did. These legacy designs were very forgiving when it came to overall wireless network performance and did not show any vulnerability until later in the WLAN life cycle until additional applications and mobile devices began to populate the WLAN environment. The 1st generation applications were typically bar-code warehousing data application using some type of VT100 or IBM mainframe terminal emulation where only screen positioning commands combined with raw data were transmitted at 1, 2, & 5.5 mbps at best. These legacy 802.11 networks were very tolerant of weak RF signaling and data retransmits but typically would provide an average of second or two in application response time, which was acceptable in the early days of Wi-Fi networking. The WLAN infrastructure and client side were always transmitting at maximum RF output power and cell sizes of 20,000 sq. ft. and higher were not uncommon and intelligent RF management between the network and the client did not exist. In reference, today's enterprise data grade cell coverage normally does not exceed 10,000 sq. ft. in order to support the applications demand for more bandwidth and ensuring prompt response time for a user. The data grade applications in use today are many but the take away here is that the wireless network and requires more bandwidth to perform adequately. With the industry acceptance of thin-client technology and hosted applications, the data application becomes much more 'latency sensitive' in terms of application response time and the ability to roam seamlessly throughout the enterprise. Additionally, thin-client computing is somewhat analogous to asynchronous data transmissions, whereas the data signaling from every key stroke or mouse movement makes a complete round trip across the network to the host and back to the client. The difference today is the more intelligent interface that requires more bandwidth.

Data Applications – Conventional

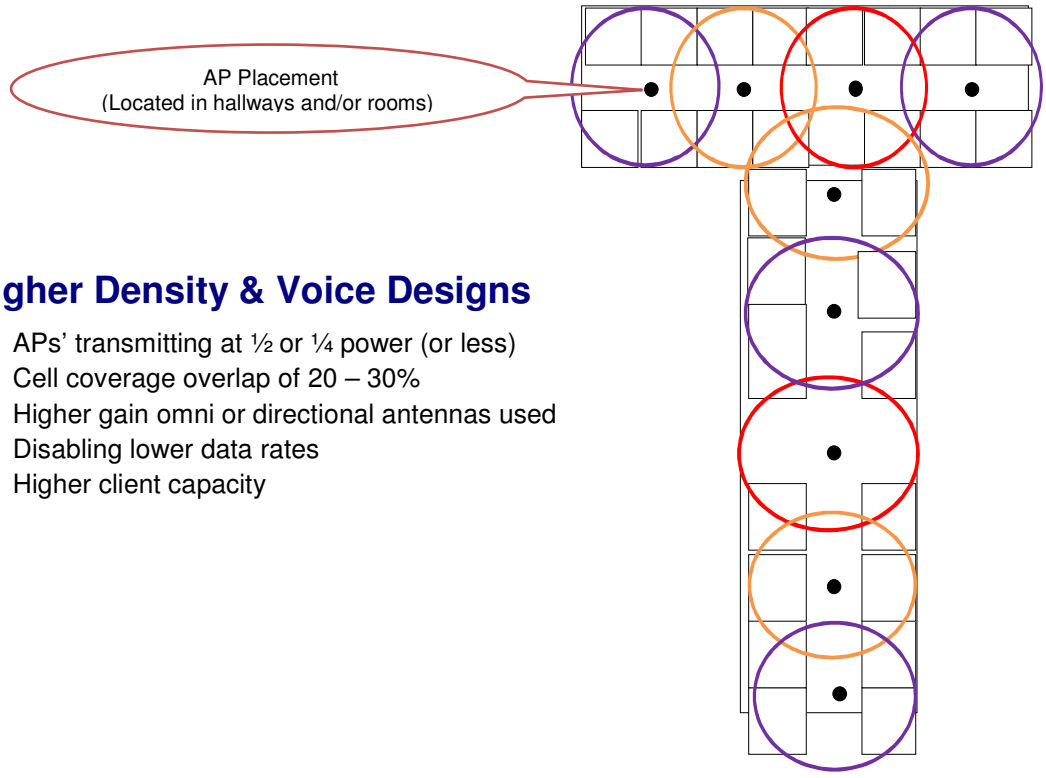
- APs' and clients transmitting at or near full power
- Antenna diversity not enabled
- Minimal cell coverage overlap
- Cell edges utilized at 1-2mbps
- APs' not staggered between floors
- Low gain omni directional antennas providing through floor coverage
- All data rates enabled
- All applications reside on the 2.4Ghz network



Higher Density Design & Voice applications

In the Healthcare environment, ubiquitous communications (even in the stairwells and elevators), mobile voice communication to the doctors, nurses and other caregivers has become a mission critical application for healthcare providers. IP telephony and wirelessly enabled handsets from vendors like Cisco®, SpectraLink®, (Polycom©), and Vocera® have gained acceptance across the healthcare enterprise and continue to grow. The business case and ROI for uninterrupted mobile communications to IP enabled phones and nurse call integration systems has been proven over time, yet many healthcare organizations still struggle in deployment of the voice grade WLAN in healthcare. Regardless of handset vendor, a properly designed wireless network should be able to support any WiFi handset in the marketplace. Obviously, a very robust and high density enabled wireless infrastructure is necessary to provide the coverage needed to maintain voice communications throughout the enterprise. The latest trend in wireless voice communications that is gaining popularity is the cellular and WiFi enabled, or 'dual mode' phone which utilizes the cellular providers network and seamlessly roams to the internal wireless Wi-Fi network when the cellular signal deteriorates enough to warrant a roam to the internal wireless network or in reverse to the cellular network. Although this paper focuses on the indoor aspect of wireless voice communications', it just further validates a good voice quality design is essential when the hand-off of the call from cellular to Wi-Fi and where in the facility that will occur. Key end user groups typically include Nursing, Facilities Administration, Security, Director of Emergency Services, Director of Engineering, and Biomed Engineering.

Below is one example of a typical voice or higher density design.



Higher Density & Voice Designs

- APs' transmitting at ½ or ¼ power (or less)
- Cell coverage overlap of 20 – 30%
- Higher gain omni or directional antennas used
- Disabling lower data rates
- Higher client capacity

Location Based Services (LBS) – Indoor

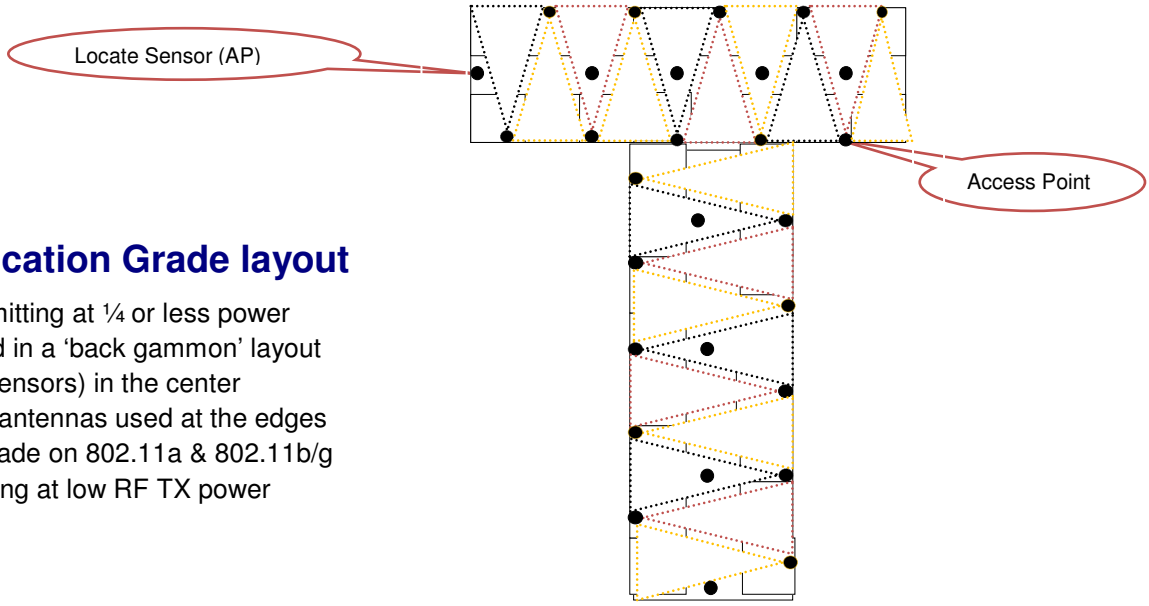
Location Based Services (LBS), Real-Time Location Services (RTLS), Active RFID, Context-Aware Networking (Cisco®), Asset Tracking, Remote Presence, are all references to tracking assets or devices on 802.11 networks. Sometimes it is confused with passive RFID and is used in healthcare for pharmacy and inventory applications but we will not discuss passive RFID in this paper. In years past, RTLS was a very expensive and proprietary solution that did not provide the ROI as it does today deployed on 802.11 networks. The 802.11 locate environment is in most cases a 'predictive' or signal sensing (RSSI) environment versus a TDOA (Time Difference of Arrival) type of deployment. The predictive type of locate is typically not as accurate as TDOA; however with the proper site survey and tuning, a WLAN can provide accurate locates within 10 feet or less 80-90 percent of the time. With the adaptation of RTLS technology in Wi-Fi, the ROI becomes much more attractive given that an 802.11 network may already exist in the enterprise and is considered the 'killer app' in Wi-Fi networking. Although most indoor systems utilize the predictive RSSI (Received Signal Strength Indicator) versus a TDOA (Time Difference of Arrival), the ability to track everything from vacuum cleaners to IV pumps is compelling when the proper design is put in place. Wireless networking equipment vendors and independent manufacturers of locate solutions are offering solutions that provide an ROI of months instead of years and the tag prices continue to drop while the functionality of the tags improve. Additionally, motion activated, temperature sensing, and push button tags with exchangeable batteries are substantially extending the life of the tag.

The ideal Wi-Fi RTLS or locate design is a network that can track a wireless device regardless of whether it resides on the 2.4 or 5 GHz network. This type of design will inherently support a very high dense client base for data and voice applications. The next section of our whitepaper addresses the current trend in moving applications or devices to the 5 GHz spectrum or 802.11a networks in which in most cases, the 802.11a radios are present on existing wireless networks but are not being utilized.

One of the primary challenges for healthcare IT organizations is identifying what type of 'granularity' or accuracy is required in relation to the cost of deploying location grade Wi-Fi network. Locate granularity directs effects the number of access points or sensors that will be required and in most cases, location accuracy of 10 feet or less 90 percent of the time is not required. In the needs and analysis phase, a well conducted interview process with the healthcare organization will pay-off on the backend costs. The majority of Bio-Med engineers and Clinical professionals' agree that if you can get them within 20-30 feet of the asset, you have already saved them 80-90% of time of what it normally takes to find it. To further illustrate; If a clinical professional could walk the wing of the hospital on a given floor, they are not concerned if they have to look left or right to find the asset, just have it somewhere in the area and on the floor where the system says it is?, i.e., a 2D locate design. Whether 'room' or 'zone' level locates are desired, each can play an effective role in a cost effective design and deployment of the locate grade wireless network.

This example is just one of many used in the re-enforcement of the ROI for Asset tracking healthcare. The systems are becoming easier to deploy and the locate algorithms from the manufacturers continue to improve.

Location Based Services Design (LBS) – Indoor



Typical Location Grade layout

- APs' transmitting at ¼ or less power
- APs' placed in a 'back gammon' layout
  - APs' (sensors) in the center
- Directional antennas used at the edges
- Location grade on 802.11a & 802.11b/g
- Client running at low RF TX power

Healthcare Data Applications utilizing 802.11a

Deploying to 802.11a: In larger healthcare organizations where multiple applications are wirelessly enabled, we are seeing a definite trend in the desire to move existing applications to the 802.11a spectrum and deploying new apps and devices to the 5 GHz bands. This airspace has an attractive appeal given the saturation that sometimes occurs in the 2.4 GHz (802.11b/g) networks. In high density 802.11b/g deployments, the protocol overhead can be a substantial performance issue with the legacy 802.11b and 802.11g devices operating on the same network. The existence of legacy 'b' devices may prevent network tuning in terms of disabling lower data rates and are required by many manufacturers' devices operating in the 2.4 GHz space. This consideration applies more times than not and furthers the consideration to utilize the 802.11a spectrum. Given the limited number of 802.11a voice handsets in the market and the abundance of data devices that do contain the 802.11a chipsets; also combined with the fact that most sites have not been surveyed for 802.11a voice, the decision to move data applications to the 'a' network becomes easier. This decision can present many challenges starting with the question of whether or not an 802.11a site survey has even been performed. In most instances the answer is no, although site surveys today are typically performed in a tri-mode (a/b/g) fashion, or they should be.

802.11a Deployment Considerations: There are a few fundamental differences and operating characteristics that exist between the 2.4 and 5 GHz spectrums that must be observed and understood. Primarily, the radio behavior between the 802.11b/g and the 802.11a chip sets are not equal when relative transmit power settings on the access point are utilized. The indoor attenuation and propagation characteristics of a 802.11a deployments is a learning experience itself and should not be viewed in the same manner as 802.11b/g. The wavelength of a 5 GHz signal is about one-half the size of a 2.4 signal, which behaves very differently in an RF 'rich' environment such as healthcare.

802.11a benefits: Some of the obvious benefits of utilizing the 5 GHz spectrum or 802.11a channels include:

- **23 non-overlapping channels (If UNII-1, UNII-2, and UNII-3 are utilized)**
  - These channels provide flexibility in developing a channel plan in that channel re-use is greatly minimized.
- **Clean Air**
  - No saturation of the 5 GHz space and absence of potential 2.4 GHz interference from Bluetooth devices or microwaves.
- **Pure OFMD**
  - No protocol requirement for legacy lower data rates using older modulation techniques.
- **Manageable Attenuation**
  - There can be 'too much' coverage with non-overlapping channels in 5Ghz operation

802.11a Deployment Challenges: As we continue to assist our customer base in converting existing or deploying new applications to the 802.11a spectrum, we are finding that tuning and configuration of the access points and more so, the clients is required for successfully deploying clients to the 802.11a network. This is especially true today as it relates to laptops and tablets; the of-the-shelf configurations of the 802.11a client adapters are not configured optimally from the factory for a high dense mobility environment. Proper pre-deployment testing and client-side tuning can address this problem. In today's high dense WLAN designs, there should be a lower and more consistent RF transmit power between the client and the access points to facilitate a more clean and consistent RF connection between the client and access point. The common misconception with 802.11a is that with potentially twenty three non-overlapping channels, one would have the freedom to deploy 802.11a networks without much regard to channeling and overall coverage characteristics, i.e. too much RF coverage. We have found is that this is simply not the case at all. Although there are a number of non-overlapping channels, the client still must make a roaming decision. Whether or not your environment contains a 2D or 3D coverage model, the potential for too much coverage still does exist.

In many cases, these devices are the contributors of network performance issues once a voice application or thin client deployment entered the picture.

802.11a considerations: Some things to consider in deploying 802.11a networks

- **RF Coverage**
  - There is a potential for too much coverage in the 5Ghz spectrum
  - A proper Site Survey should be done
  - Consistent cell sizes between the 802.11b/g and 802.11a radios
  - The focus should be around 'channel utilization' and spectrum efficiency
  - Understand receiver sensitivity thresholds between the clients and infrastructure
- **Client behavior**
  - Configurations of clients is almost always required of the tablets and laptops
  - 802.11a chipsets are not all equal – research and test all options available
- **Data rates**
  - Disabling lower data rates can aid in improving client throughput and roaming effectiveness
- **UNII-1, UNII-2, and UNII-3 Support**
  - The RF power output between the three bands are different

Methodology for Identifying and Migrating to the Optimal Architecture

A wireless network that has been in place for 5 years or more without any type of major upgrades is typically a good indicator for a network refresh to build in bandwidth and throughput capacity and also to support latency sensitive applications such as WiFi voice and thin client computing. Another indicator is the amount of complaints coming from the user community.
Listed below are some key in determining how you network is currently performing and some questions that will help determine what future demands the user community will need for healthcare mission critical application support.

Identifying current WLAN characteristics & client behavior

A few key questions in determining the overall health of the WLAN

- ✓ Are users complaining?
  - Your best information will come from the user community – it just needs translation.
- ✓ Do I have 'dead spots' or 'holes' in our RF coverage?
  - Lost connections?
  - Roaming problems?
- ✓ Are my clients and access points transmitting at or near full power?
- ✓ Do I have too much coverage?
  - Roaming problems?
  - Co-channel interference?
  - Can a client maintain and association to an access point on another floor?
- ✓ Do I have a 2D or 3D coverage model?
  - Can a client maintain and association to an access point on another floor?
  - Are the antennas utilized providing omni (360 degrees) or directional RF coverage?

Network Performance Assessment

- ✓ Are we utilizing the 802.11b/g and 802.11a spectrums to double network capacity?
  - Do we have applications deployed on 802.11a of just 802.11b/g?
- ✓ Will I have coverage issues if I reduce the RF output to ½ or ¼ of the transmitters' capability?
- ✓ Determine current RF footprint and determine coverage areas in sq. ft.
- ✓ What wireless enable applications are being deployed or under consideration?

Steps for improving the overall health of the WLAN

- ✓ Plan for a 5 year growth cycle
  - Determine budget allocation projections
- ✓ Identify and maintain design goals; i.e., voice, data, video, or locate
- ✓ Include 802.11ag & 802.11n if applicable
- ✓ Choose an area where the WLAN is not performing to expectations (test bed)
  - Typically a patient wing on an upper floor of facility with RF coverage above and below
  - Talk to the user community - very valuable
    - Listen for references to certain areas
    - Identify Quality of Service complaints, i.e. 'choppy' audio
- ✓ Perform a professional RF Audit
  - Determine AP coverage model and RF TX power settings
  - Determine client side preferences
    - Voice @ -67dbm with SNR of 20 or better (check manufacturers req.)
    - Locate @ -73 with 3 access points listening
- ✓ Perform passive RF Audits (map network)
- ✓ Implement changes as a result of the RF Audit
  - Adjust RF TX power
  - Perform passive surveys
  - Identify and insert access points where necessary
  - Develop/adjust channeling
  - Tune radio to consistent values with adjacent access points
  - Tune client side RF settings consistent with access points
  - Test RF coverage characteristics
    - Test voice quality
    - Test data bandwidth speeds
    - Test roaming effectiveness and predictability
- ✓ Perform active RF Audits against new design
- ✓ Analyze results
- ✓ Create a plan for network upgrade

Summary

Our goal of this whitepaper is to provide the healthcare professional with the ability to identify categorically, what type of Wi-Fi deployment exits in your environment and some high-level concepts for making your wireless network "Medical Grade". The scenarios outlined in the above examples have been successfully deployed all across the United States with great success and we continue to refine our deployment techniques as more applications and devices are brought to the forefront of wireless computing. In today's tough economic climate, the option for a 'forklift' or 'rip – and-replace' Wi-Fi upgrade is not an option for many healthcare organizations. In a number of examples, we have been successful in assisting healthcare IT organizations in reverse engineering or re-tuning the existing WLAN to support high density deployments for their mission critical applications on both 802.11b/g & 802.11a networks. In other scenarios, bringing in a qualified wireless integrator to assist can be very cost effective and is a cheaper route than the forklift upgrade as well. For IT organizations who wish to seek outside help; find a seasoned wireless partner who can effectively address your needs and who is willing to provide the support and knowledge transfer for your staff . In the world of complex Wi-Fi networking, there is no substitute for experience. A trusted partner will assist address the immediate needs and that will not only upgrade your WLAN but will also part with the knowledge that will enable you to provide Day 2 support. Depending on the size of the WLAN, the re-work can be very time consuming but the rewards can be significant, and it is cheaper than a complete rip and replace of the WLAN.

It is important to remember that a well designed and properly implemented wireless network needs very little day-to-day maintenance.

About The Author

Dan Cooper is a seasoned wireless veteran with over 30 years in the IT and Wireless industries and holds a variety of industry certifications including his CWNP. Dan is the founder and President of Radiant Networks; headquartered in Louisville, Kentucky. Radiant Networks is one of the country's leading wireless engineering companies and has a vertical focus on Healthcare. Dan got his start in wireless over 20 years ago as an Engineer for Telxon, which developed the Aironet RF product set, which was ultimately acquired by Cisco, and with Telxon being ultimately acquired by Symbol Technologies who was eventually acquired by Motorola. Subsequent to Cisco, Dan went moved on to develop RFID and Asset Tracking solutions with a start-up named WhereNet in developing RFID solutions. Radiant Networks core competency is in the design & integration of high-dense and specialized wireless networks serving the healthcare, mining, education and the government sectors. With many of the healthcare applications that demand "bulletproof" wireless infrastructure such as asset tracking and voice enabled applications.

Radiant Networks is one of just a handful of companies that actually guarantee their solutions in an unpredictable environment as RF inherently brings to the forefront. You can contact Dan at dcooper@radiant-networks.com .

CWNE Whitepaper Series

The CWNP Program has been certifying WLAN professionals since 2001, and the CWNE certification is the most prominent Wi-Fi industry certification. As a continuing education requirement, all CWNEs are required to publish one whitepaper annually to contribute to the overall health and growth of the Wi-Fi market. Additional whitepapers and more information on CWNP certifications can be found at www.cwnp.com. This whitepaper in the series dealt directly with various deployment scenarios in healthcare. Be on the lookout for our forthcoming whitepapers that will cover 802.11n migration and indoor wireless mesh networking.