RF Engineering: Why Is It So Important To The ED Director?

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Why is it so important that a hospital or large physicians practice implement and maintain a well engineered wireless local area network (WLAN)? Here's a fictional scenario that illustrates factually sound reasons why Radio Frequency Engineering (RF Engineering) plays such an important role in the constantly evolving technical landscape of a hospital or large physicians practice…

> *Just last month, Dr. Abrams had arrived at the prestigious Naples Palmetto Dunes Country Club to meet the rest of his foursome of fellow Neurosurgeons when he received an urgent call on his smart phone. With his car's engine still running, he apologized for his abrupt departure but his golf buddies knew the drill. The doctor pulled into Naples Bay Hospital, southwest Florida's prestigious Level 1 Trauma Center, literally minutes after he received the call on his afternoon off. As he quickly parked his car in the physician's lot, he was still on hold waiting on an important consult from a respected colleague, Dr. Scott from across the state who shares in his dedication to Neurosurgery. Dr. Abrams ran from his parked car through the ED to Surgical Suite 4 to find the Chief of Neurosurgery. This time however, it was the Chief that was about to be on the operating room table having collapsed from a brain aneurysm while in his office at the hospital that fateful afternoon.*
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> *As Dr. Abrams started his preparations for surgery, he asked his surgical resident to hold his smart phone for a moment and to listen for Dr. Scott to join the call from his Miami office. After Dr. Abrams reviewed the Chief's current status report revealing unusual complications, he knew he urgently needed input from his colleague. Dr. Abrams grabbed his smart phone and descended deeper into the hospital where the Radiology Department is located to read the CT scan stat. The lead-lined walls of the Radiology serve to contain all the various and somewhat harmful electronic signals and radiation sources that are generated by the heavy concentration of high-powered diagnostic imaging equipment, Electronic signals such as Electromagnetic Communications (EMC), Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI) must be controlled for safety's sake. Misfortunately, cellular signals are also completely attenuated as a result. Dr. Abrams finally heard his colleague's voice from his smart phone's speaker as the CT scan was first being viewed.*
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> *The call on his smart phone was never dropped! The collaboration provided vital input as Drs. Scott and Abrams agreed on the proper surgical intervention for the complications the Chief had presented. When the Chief woke up in recovery, his first question was whether or not there were any technology interruptions while he was being treated. The thought of network issues from the past still lingered with much of the staff. He knew how unreliable the WLAN had been in the ER and also that cellular calls dropped all the time throughout the facility. Thanks to the initiative of the ED Director in promoting the hospital-wide RF Engineering Project that was recently completed, communications were maintained and had a positive impact on the Chief's emergency surgery making it in large part a complete success. One month later, the Chief is now happy to be back in action and equally happy that he had lobbied hard with Accounting and Finance to approve the RF Engineering Project.*

What the ED Director lobbied for eight months earlier was a hospital-wide solution to address the issues her staff had complained about within the hospital facility. Complaints ranged from COWs to VoIP and RTLS. The Computer on Wheels carts (COWs) were experiencing intermittent wireless connectivity delaying the timely entry of orders in their new Electronic Medical Record (EMR) system. Poor performance of the Voice over Internet Protocol (VoIP) application driving all the nurse call badges were the result of WiFi access point coverage issues occurring in certain areas on all floors. The Biomedical Engineering and Telemedicine departments had also complained about the difficulty they have had with Real Time Location Services (RTLS) in locating high-value telemetry equipment equipped with RFID

(Radio Frequency IDentification) tracking sensors. The Director wanted the hospital to "sure up" the Wireless Local Area Network (WLAN) infrastructure for several good reasons and her proposed budget was quickly approved when supported by multiple department heads. First and foremost, the hospital wanted the WLAN to be able to keep pace with the new EMR application the hospital had just made a substantial investment in. They also wanted to reduce or eliminate all the other device and application connectivity issues her staff and the visiting doctors had been complaining about. As well, it was time to take steps towards a well planned and purposed BYOD (Bring Your Own Device) strategy to improve productivity and quality of work life for those that bring their own smart phone and tablet devices to work. She had come to realize that these issues had tremendous impact on everyone's morale. The staff members had been working very hard over the last few months to reverse the recent dip in their Press Ganey scores and it seemed to them that all their hard work was not paying off – something had to be done with the network. Diminished patient care, falling patient satisfaction and reduced profitability for the hospital certainly would not be acceptable.

What did the ED Director actually get done with the WLAN?

After conducting a preliminary technology consulting engagement, a Request for Information, Request for Proposal (RFI/RFP) and selection process was completed to identify a way to address and resolve all the connectivity and performance issues the consulting audit had identified and the staff had been complaining about. With the consultant's help, a project plan and budget was defined and recommended by the ED Director and Chief of Neurosurgery. It was quickly approved by the Hospital Board of Directors and Finance. A highly qualified RF Engineering firm, experienced in complex venues and Level 1 Trauma Centers was identified and retained for the project. A more detailed project plan was generated after an initial site survey by the Engineering firm and the process that was methodically followed revealed many serious issues with the existing WLAN and its maintenance. Recommendations were made and enhanced options defined to convert the existing WLAN to a fully functional asset.

Table 1 below provides a broad outline of the transformation process and is followed by further discussion of some of the concepts involved.

Table 1: Basic WLAN Project Activities

Item	Process Step	Discussion
1	Stakeholder Interviews	Conducted to understand all the impacting issues. An advisory panel designated by hospital management is identified. Skills assessment is made of hospital staff IT personal responsible for the network. Identify and meet with technical representatives from all EMR/EHR application vendors.
2	Requirements Planning	Review of issues with hospital panel to set plans. First recommendations are made and discussed.
3	Pre-Conditions Survey	Perform comprehensive walk-through covering every square foot of the facility using specific WLAN Mapping Tools.
4	Pre-Conditions Survey Report	Includes findings of WLAN equipment inventory, equipment settings review, "Heat Maps" from preconditions site survey and additional recommendations based on findings are made. Heat maps are overlaid onto existing CAD or PDF floor layout drawings.
5	Implementation Planning Meeting with Advisory Panel	Plans are created for consolidation of existing investment for best performance, BOMs are presented for procurement of new equipment, staging, facilities wiring and Access Point implementation, staffing and risk mitigation, system testing, acceptance and sign-off. Project Milestone Plan is issued and accepted.
6	Implementation/Remediation Efforts	Work begins, work is monitored and plans are executed, on time and on budget minimizing risks.
7	Post-Conditions Site Survey	A complete walk-through survey is repeated to capture the improvement in WLAN coverage. Access Point placement is verified, channel and power settings documented. Any conflicts are resolved and adjustments are made.

8	Acceptance Tests Performed	Site performance is verified with the hospital panel, the Approved Acceptance Test Plan is completed and the WLAN network is turned over to hospital designated IT support.
9	Project Report	The Final Project Report is generated and delivered.
10	Annual Site Survey	RF Engineering firm returns to perform Annual Site Survey and share results. This is the WLAN "Annual Physical."

Technology is Synonymous with Change – Get Used to It!

Much can be discussed regarding the methods and tools used to properly engineer a ubiquitous, robust wireless infrastructure for the hospital environment. It starts, and is best served by a comprehensive review of the requirements. Who are the stakeholders being served by the environment? Who has access and how are they authenticated? What devices are to be authorized for use in the environment? What are the security requirements for the collection and transport of data and how does the whole hospital infrastructure support it? When will the system be upgraded to keep pace with emerging technology? Many more questions can arise in that process and it should never be cut short. The WLAN has to be able to serve its community well and strategies must be in place to address the challenges and contingencies that can and will arise with emerging technology.

If one has studied technology for a period of time, constant change and advancement is the norm. Hospitals have to be prepared to take advantage of this fact. A unique proposition is guaranteed to occur and is explained best by Moore's Law. Countless papers and books have been published on this subject but for brevity, here is an informative Wikipedia entry on Moore's Law, which holds that:

> ***"Moore's law** is the observation that, over the history of computing hardware, the number of transistors on integrated circuits doubles approximately every two years. The period often quoted as "18 months" is due to Intel executive David House, who predicted that period for a doubling in chip performance (being a combination of the effect of more transistors and their being faster)…"*

This "Law" has held true ever since Intel co-founder Gordon E. Moore first published his observations in 1965. What has happened to our computing environment and all technology fields dependent upon integrated circuit design, along with the software systems and applications it takes to harness the technology, is an interesting "Leap Frog" effect. As an example, anyone that has owned a personal computer for several years is well familiar with this. Once you make the purchase for a computer equipped with all the latest hardware, soon thereafter, advancements in the software will start to obviate your hardware purchase. As time rolls on, your aging hardware becomes too slow to operate the newest software. Likewise, anyone that has upgraded their PC's Operating System software knows this because they find they need more memory or storage space simply because the software has leaped ahead of the hardware. A few months later, about 18 months according to David House, new hardware with faster processing speeds and advanced features will make its debut and jumps ahead of the existing software capability that once held the lead. Soon, new software will be released and the cycle starts again – another case of *"the exception becomes the rule"* but in this case, it is a good thing. Knowing that this relationship has existed for many years will prepare hospitals for the budgeting of periodic capability reviews to ensure that their networks are maintained for peak performance.

RF Engineering for the Hospital WLAN "Community"

When we say community, it can mean the individuals as well as the devices in use and dependent upon the WLAN. Doctors, Nurses, Administrators, Technicians and even Patients and their Guests are all part of the community. Proper WLAN design begets proper wireless coverage but who should have access?

This is a great question, especially from a security point of view. Without going into several directions with this discussion, let's focus on the device community and the importance of proper RF Engineering as it is the device that we all rely on in the hospital WLAN environment.

Multiple communication protocols are in use in any one hospital network but none of them will work well without proper RF Engineering. Sparing a detailed discussion of the actual protocols in use, we will define a fundamental framework for understanding these communication concepts. There are essentially three network communication environments to be engineered: the Data Environment, the Voice over Internet Protocol (VoIP)/Voice over WiFi (VoWiFi) Environment and the Real Time Location Service (RTLS) Environment.

In Figure 1 below, a single hospital floor is represented in two ways: a "Survey Route Map" is illustrated on the left and the resultant "Coverage Map" or "Heat Map" is seen on the right. With close examination, one can see that there is no uniformity of coverage on the Heat Map ranging from pockets of strong coverage to poor coverage and even voids, hopefully not in critical areas. This may be the result of improper placement or configuration of the Access Points (AP) or even the construction materials used in the walls. Conversely, if the implementation of the hospital WLAN had little engineering foresight into the device community it will serve, it might look similar to the Heat Map. Again, type and quantity of equipment, placement, power, channelization, proximity of wiring closets, etc., are all attributes that make up the WLAN "fabric" and must be properly engineered.

Single Floor Survey Route

Pre-Existing Conditions Coverage "Heat Map"
Wireless Signal Strength

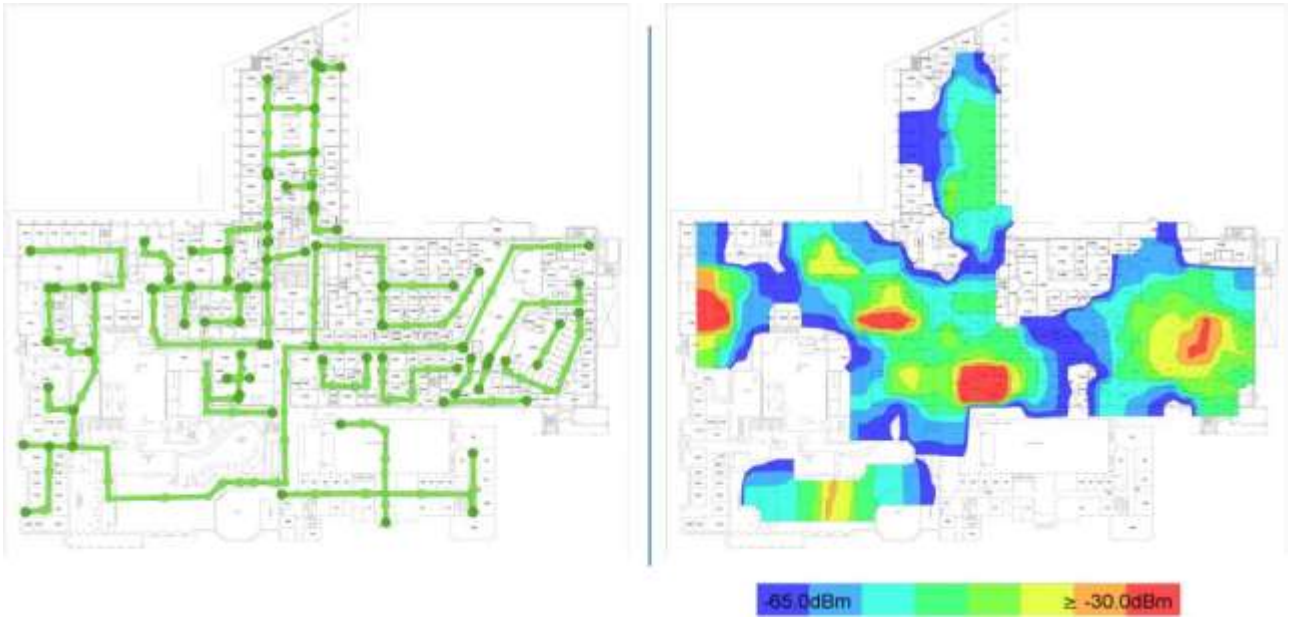

Figure 1

RF Engineering for the "Communication Environment" and for Device Requirements
To further define our fundamental framework for the device community seen in most hospitals, we will add to the definition of the "Communication Environment" in our discussion. Example devices of the three types of communication environments typically found in a hospital setting are represented in Table 2 below. Each class of device and their specific communication protocols must be considered when

properly engineering and implementing the WLAN. Failure to do so, more than likely was the reason our ED Director was receiving so many complaints. It could have been untrained, but "smart hands" that installed the original equipment for a wiring contractor that said they also install wireless networks along with installing cable. Emphasis here is placed on "install" rather than "engineer and implement." There could be additional training-related reasons for poor WLAN performance as well as compatibility issues with the all the hardware involved.

Table 2: Device Classification

Communication Environment	Examples Devices
Data	Desktop Computers, Computers on Wheels (COWs), Workstations on Wheels (WOWs), Laptops, Tablets, Smart Phones (data mode)
Voice over Internet Protocol (VoIP) or (VoWiFi)	Nurse Communication Badge, WiFi Phones, Smart Phones (WiFi mode)
Real Time Location Service (RTLS)	Radio Frequency Identification Tags (RFID) for tracking of telemetry equipment, employee access badges, patient security badges, etc. used for instant "real time" location of equipment and people within the hospital

RF Engineering and WLAN Access Points

So, what are the issues with Access Points (APs)? First, they are not all created equal. Proper vendor selection has a lot to do with the level of functionality and capability that is achieved. The community of wireless devices employed or introduced in the hospital setting today have to rely upon the engineering (quantity, configuration and placement) of all the Access Points. Each class of device mandates a differing approach. To have the total wireless environment operate at peak performance requires the skills of highly trained and experienced RF Engineers and the implementation and management of a comprehensive plan based on survey analysis. APs are appliances that are spaced and installed throughout the hospital serving as points at which the device, in close proximity, connects to the WLAN. Figure 2, below is a simple illustration to aid in examining this concept.

Consider the three circles of coins as representative of the differing communication environments for Data, VoIP and RTLS. Each circle represents the same size environment for which a WLAN might be engineered. Each coin represents a wireless Access Point. Knowing the requirements that are defined by the applications and the devices in use as well as other variables such as the wall construction and how it may vary from the radiology department to the patient room is key to proper RF Engineering design.

QUESTION:

Which circle represents the AP configuration necessary to support which class of device?

ANSWER: **Engineered for RTLS** **Engineered for Data** **Engineered for VoIP**

Figure 2

Data only environments (center image) can tolerate fewer APs as they can be located in work areas and the power and channelization settings are not so critical. Add VoIP applications (right image) and then the wireless coverage has to be more specifically engineered to provide ubiquitous coverage. Now add the need to have real time location services running (left image) in the environment to locate equipment, track staff having access badges or even follow patients in critical areas such as Pediatrics and Psych Wards. Given a mixture of these requirements with variations of need and environment from floor to floor, one can easily understand that RF Engineering for peak performance becomes a more demanding science requiring expertise even the telecommunication carries and product manufacturers seldom have on their bench and in their employ.

Where Do We Stand on RF Engineering for the Hospital?

Admittedly, this article was written for hospital and physicians practice stakeholders and not for the technologist. There would have to be more ones and zeros and obscure concepts in electronics and terminology to satiate the technologist. This article attempted to share commonly overlooked concepts that can make a big difference in how technology is intended to perform in the hospital environment where, arguably, there exists a heavy concentration of wireless and mobile devices utilized in delivering the best in patient care. It also examined what has become an immutable fact or "law" of technology which guarantees constant change. If all this was informative, then that is great but do you want to know why Dr. Abrams' call was never dropped which lead to the happy ending in our story up front?

> **Here's why:**
> When Dr. Abrams placed his call, he was told Dr. Scott was available and would be able to take his call in a few minutes. The few minutes actually ended up being a bit longer but Dr. Abrams agreed to hold because his call was that urgent to do so. The receptionist understood. Dr. Abrams' call was placed over his cellular carrier's network when he was at the golf course and good signal coverage from the carrier's towers supported the call all the time he drove down the Interstate highway to the hospital close by the exit.
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> Once Dr. Abrams entered the hospital, the cellular call was seamlessly handed off to operate in WiFi mode on the hospital's WLAN network when the cellular signal strength weakened. This capability was one of the options the RF Engineering firm offered with their response to the original RFI/RFP. It involved the integration of a mobility router into the hospital network and it interfaced with the existing digital IP PBX the hospital had in place. Dr. Abrams' smart phone is programmed in the new system to act as his hospital office extension as well as his personal cell phone. When he was deep inside the hospital having his consult with Dr. Scott while reviewing the CT scan, the call was in WiFi mode connected by the Access points engineered to properly manage VoIP calls. When he collected the information from Dr. Scott, he thanked him, ended the call and the rest of his day went well, except that he missed another round of golf!

What Does the Future Hold?

Simple answer: more change! Over the past few years, Information Technology in the healthcare arena has placed more focus on the advancement of best practices and the integration of mobile technologies in healthcare environments. With patient care being the primary goal, healthcare organizations remain embroiled in the regulatory battle waged by healthcare reform. Adaptation of the latest trends in mobile technologies and healthcare best practices will help to lead organizations to greater efficiencies and their fair share of incentives. The parade of mobile devices and their integration into healthcare environments remains an urgent need and requires specific engineering skills. Until there comes a time when we see a complete shift in the way network communications manage our healthcare technology environment, RF Engineering will remain a specialized and necessary resource for well-engineered healthcare networks.