

Real-time Location Systems (RTLS) in Healthcare:
Wi-Not Wi-Fi?

whitepaper

At-A-Glance

CIO's must ask some very important questions to really appraise the cost and value of Wi-Fi based RTLS:

1. Are you really using existing infrastructure?

The "just add water" story Wi-Fi marketers publicize loses steam in real-world applications.

2. What is the cost (in time and expertise) for on-going maintenance of Wi-Fi RTLS?

Once you've optimized your Wi-Fi infrastructure for RTLS, you will need extensive location planning of highly trained individuals to keep it calibrated.

3. How will Wi-Fi RTLS traffic affect your network?

Hospital administrators who select Wi-Fi based RTLS will be quickly disenchanted to find that with the increased "noise" Wi-Fi RTLS tags generate, Wi-Fi communications performance will degrade.

INTRODUCTION

The RTLS (Real Time Location System) market is one that has become pervasive in many vertical markets even before the days of Wi-Fi (802.11b ratification in 1999). For instance, supply yards and warehouse applications employed RTLS systems using TOA (time of arrival) for tracking logistical assets outside, and then used RSSI (Received Signal Strength Indicator) designs for inside building environments. Most other vertical markets are years ahead of the healthcare marketplace in terms of RTLS for supply chain visibility.

As far back as 2007, Gartner published an industry research paper, [Hype Cycle for Healthcare Provider Applications and Systems, 2007](#) describing the business value of wireless asset tracking in healthcare: "Using RFID and other means helps improve utilization of mobile equipment (Universal Hospital Services estimated a national average utilization of such equipment at just 45%), and reduces theft and write-offs due to inability to locate or service equipment. Location and management can also improve timely delivery of care and reduce staff time spent looking for misplaced hospital equipment. It also assists biomedical engineering staff in locating equipment for scheduling preventive maintenance, repair and replacement. Ensuring that equipment moving from patient to patient has gone through appropriate decontamination is also a significant issue for the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) in regard to infection control."

In fact, the business impact of wireless healthcare asset tracking (aka, real-time location systems or RTLS) has been well documented. So why hasn't RTLS become mainstream in the hospital vertical market? Likely because many hospital CIO's have embraced Wi-Fi-based RTLS, only to be disappointed with the business value it returns. Perhaps it is because they have been sold the value proposition, but the underlying technology to make this happen is not understood. In reality, RTLS encompasses myriad technology options. Although Wi-Fi-based RTLS is often considered (maybe because it's what CIOs are most comfortable with), it doesn't make it the best choice for long term clinical and financial ROI from an RTLS deployment.

GOALS AND TALKING POINTS

This white paper will discuss some of the past and current paradigm changes that are present within the healthcare vertical market regarding RTLS. It will additionally provide an overview of Wi-Fi RTLS solutions and why it seems these solutions have not moved out from a "science project" or a departmental system to one that is enterprise-wide and providing quantifiable business process improvement.

THE CURRENT RTLS MARKET

The RTLS market is becoming a very crowded space. There is a plethora of differing technology solutions to solve the unique healthcare market requirements for location tracking of assets (equipment and people). Even though it seems there have been hundreds of RTLS healthcare implementations over the past five years, the majority of these have been extremely limited in scope (small department applications).

It is also questioned if a true ROI can be obtained, since most deployed solutions are so limited.

TODAY'S NEED FOR ENTERPRISE RTLS IN HEALTHCARE

With the advances in technology options available for RTLS, healthcare institutions are finally looking out of the silo-based departmental business model and are realizing their business operations function as one huge supply chain of assets and people. This is, however, not unlike other wireless business models in different vertical markets. We can draw a direct connection to the largest retailer in the world. They have systems in place to provide real time visibility of every single asset moving throughout their distribution channel. This just-in-time inventory, and knowledge awareness of their assets by location, allows them to have the lowest costs in the retail industry. The same enterprise knowledge awareness must be applied to healthcare.

A typical healthcare example:

A Vice President of the Supply Chain/Capital Assets for an Integrated Healthcare Delivery Network (IHDN) pulls up his (non-RTLS enabled) asset management inventory software, an application listing the thousands of assets the IHDN owns across the hospital enterprise. With the click of a mouse, he or she has access to a wealth of information regarding those assets, except for a couple of really critical items.

1. The item's current location
2. The utilization of that item. (Has it been stored in a utility closet for the past year?)
3. The status of that item. (Is it in use in a patient room, sitting in the biomed department waiting for service, or sitting in a clean storage available for use?)

With the added visibility into location and movement RTLS provides, hospitals have much better information regarding actual asset utilization. Leveraging assets across the enterprise now becomes realistic. Moving assets from areas of low utilization to areas of higher utilization, when demand outstrips capacity, becomes a very real opportunity. Those hospitals can further avoid rental fees, reduce purchase of surplus equipment to meet demands and reduce inefficiencies in asset processing.

For operations to improve, assets have to be managed with the ultimate goal of improving supply chain throughput. To realize maximum clinical and financial ROI, an RTLS must provide realistic 100% coverage, with adequate location

accuracy, over every square foot. It is only then an RTLS achieves the business improvements. When you have a reliable and pervasive RTLS solution in place, then can you start looking at important business issues such as proactive asset management (workflow automation, and the ability to impact patient flow dynamically through the supply chain (continuum of care). And oh yes, locating equipment assets - however, this only one small part of the total RTLS value proposition.

WI-NOT WI-FI?

802.11a/b/g and now 802.11n have performed in an admirable fashion for both data and voice requirements. Wi-Fi based RTLS solutions have also been in the marketplace for a similar time. The attractiveness of a Wi-Fi RTLS solution, on the surface, appears to have merit, but CIO's must ask some very important questions to really appraise the cost and value:

1. Are you really using existing infrastructure?

The "just add water" story Wi-Fi marketers publicize loses steam in real-world applications. Although many Wi-Fi RTLS vendors tout the "plug and play" attributes of using their existing infrastructure; the leading manufacturer of WLANs has a deployment guideline document for Wi-Fi RTLS that is over 200 pages in length. Truly, this is not "plug and play" in any regard. Rest assured, Wi-Fi RTLS will require more infrastructure (and added cost) to be useful. According to the deployment guideline document, the density of Access Points (APs) has to be around 30 ft. So in essence, the actual value of using the "existing" infrastructure means you have to add a lot more infrastructure. The deployment guide further states:

- "selecting the location planning option results in the need for access points being placed along the perimeter and the corners of the floor, in addition to the interior of the floor as necessary."
- "in designs where location tracking is intended to co-reside with voice and high speed data, it is recommended best practice that the inter-access point spacing should be reduced below the general guideline of 40 feet."
- "the distance between deployed access points can impact location performance, as well as the performance of co-resident voice and data applications. An excessive

inter-access point distance can detract from good location accuracy by not providing sufficient signal strength differentiation at extended distances.”

- “even in the described WLAN based 2.4GHz RTLS systems, there still is a need to use 125kHz, chokepoint lower frequency transmitting devices.”

So in essence, to achieve some kind of potential room level accuracy, the WLAN 2.4GHz RTLS system has to have an overlay to accomplish its intended purpose. One only has to ask themselves how much does this add to the overall cost of what the customer thought was a “location ready” WLAN system?

2. What is the cost (in time and expertise) for on-going maintenance of Wi-Fi RTLS?

During the calibration phase, WLAN RTLS requires data accumulation by performing a walk-around of the target environment with a mobile device and allowing multiple access points to sample the signal strength.

Once you’ve optimized your Wi-Fi infrastructure for RTLS, you will need extensive location planning of highly trained individuals to keep it calibrated. If you don’t have this expertise on staff, or, like most hospitals, have an IT department that is strained in resources, a primary WLAN provider conveniently offers professional services that includes the tuning of location performance “and much more.” This service offering enlists the skills of trained WLAN engineers to deliver an integrated solution that includes services identified as essential for successful deployment of a secure location-based services solution.

Even if the WLAN was designed for -65dBm for voice over IP use, more than likely it was never designed early on for RTLS applications. Healthcare institutions are often sold the WLAN Location Appliance at the beginning phases of the WLAN deployment for data and voice, on the premise that no other additional infrastructure was needed. However, for RTLS to be deployed correctly, a complete “new site survey” will need to be completed. As everything related to RF or wireless, it comes down to physics, the budget and the intended use.

3. How will Wi-Fi RTLS traffic affect your network?

Just like combining WLAN with a DAS (Distributed Antenna Systems) on the surface makes sense, the costs to complete this are just way too much and there is

application performance degradation on WLAN. Hospital administrators who select Wi-Fi-based RTLS will be quickly disenchanted to find that with the increased “noise” Wi-Fi RTLS tags generate, Wi-Fi communications performance will degrade. Excessive radio interference not only diminishes location capabilities, but can cause congestion sufficient to disrupt or jam mission-critical application communications.

REQUIREMENTS OF A SUCCESSFUL RTLS SOLUTION

The issue is that for an RTLS to show real business value it has to be enterprise wide. Real time visibility is the key here, but it has to be complete. Every day that goes by that this enterprise supply chain RTLS model cannot be deployed decreases the opportunity to improve business value. This business value can be translated into improvements in operations, work flow studies, and asset management coupled to ERP (Enterprise Resources Planning). Consider a logistical distribution center for a large shipping company - they would not think of tracking only a ¼ of the warehouse. Thus in a hospital environment, every square inch of the floor plan needs to be tracked. So in the area of the WLAN, this means infrastructure has to be deployed for RTLS to cover the entire enterprise footprint.

What this really means is installing AP(s), every 40 feet (most hospitals will have both data and voice), and running Ethernet to each and every AP. In addition, you will need dedicated IT resources to design the site modeling and ensure everything works absolutely correctly. Designing and optimizing a Wi-Fi RTLS solution is no easy task. This is confirmed from review of the deployment guide document issued by the leading WLAN infrastructure provider on how to design and implement a Wi-Fi RTLS solution. For example, this is direct from this design document:

- “An excessive inter-access point distance can detract from good location accuracy by not providing sufficient signal strength differentiation at extended distances. Insufficient inter-access point distance can expose the system to short range antenna pattern anomalies, which may be non-conductive to good location accuracy”
- “From the perspective of co-resident voice and data applications, the inter-access point is one of the key factors determining whether required minimum signal level thresholds, signal to noise ratio (SNR), and required coverage overlap will be met”

The question the end user has to ask is what level of dedicated resources and expertise (outside consulting) needs to be allocated to this initial design and deployment process, yet alone ongoing support? This is large hidden cost, but a very expensive one both initially and potentially ongoing:

1. How will this WLAN design change to optimize RTLS affect or not affect other data, voice, and life critical medical device applications?
2. What about renovation projects in hospitals which are ongoing?
3. If someone adds or removes an access point, how will this affect the overall holistic RTLS model?
4. Is someone monitoring this?

There is a cost to this in time, resources, disruptions, and delay to actually obtaining benefit from a Wi-Fi based enterprise RTLS solution.

SO WHY HAVEN'T RTLS SOLUTIONS BEEN PERVASIVE?

One has to ask themselves with all the location based technologies out there, why are they not everywhere and being used on an enterprise basis in healthcare?

1. Many hospitals CIO's have been sold the "just add water" story Wi-Fi marketers publicize, only to be been disappointed with the performance.
2. Because many CIO's have opted to consider Wi-Fi RTLS without exploring the other technology alternatives available, they've concluded it costs a lot of capital in infrastructure and time to actually hope that a WLAN RTLS will work to return clinically significant information.
3. WLAN RTLS has proven to be tremendously costly to deploy (in time, disruption and cost), so they have been limited to specific high cost areas (surgery for example), and even then, performance has been somewhat poor.
4. Lack of confidence in the data received. When using WLAN RTLS in a multi-story structure, where there is considerable floor-to-floor cell overlap, the question remains: Is this IV pump actually on this floor, or where? If the technology or solution does not do what it was intended to do,

people will lose confidence in the data that is received.

LOCATION ACCURACY DOES MATTER.

While some say locating assets to a zone or floor has value, the greater need is to provide a more discrete level of accuracy. When you have some semblance of room level accuracy you can start to correlate the equipment to the patient to the care giver. This starts to give real valuable information to improve business process, augment charge capture, and help understand improvements in patient and equipment management.

Some of the stated WLAN RTLS guidelines are to ensure that access points are not solely clustered in the interior and toward the center of floors. The access points that form the perimeter and corners of the floor can be thought of as outlining the convex hull, or set of possible device locations where the best potential for high accuracy exists.

Although it may vary given the number of access points deployed and their inter-access point spacing, generally speaking, the rate of this accuracy degradation has been seen to be almost linear as the tracked devices move further outside the convex hull. For example, a device that experiences less than or equal to 10m/90% accuracy within the convex hull, may deteriorate by 18m/90% by the time the device moves to a point 20 feet outside of it.

RECOMMENDED BEST OF PRACTICES FOR RTLS SOLUTIONS

1. Ensure the RTLS solution provided covers the entire campus
2. Evaluate the capital expenditures needed to deploy an enterprise based RTLS solution that can provide you with adequate room level accuracy. With WLAN RTLS, this means understanding new access points (accounting for the inter-access point spacing required) and what additional overlay technologies are recommended. Ask the questions:
 - a. How long will this RTLS solution take to be installed and how soon can you start to achieve benefits?
 - b. How non-disruptive will this installation be to the healthcare environment?
 - c. How many more AP(s) do I need to install and how

many more runs of Ethernet need to be put in?

3. Calculate operational expenditures (man hours) that will need to be allocated to a site survey and implementation of the RTLS solution. Be sure to determine the man hours and opportunity cost for shut downs required to install new access points, initial calibration requirements and ongoing maintenance costs.

In contrast to a Wi-Fi based RTLS solution, technology such as a 802.15.4 Zigbee based network eliminates a lot of costs up front, is reliable, provides the intended accuracy, and is quick to install...and yes with this stated, it can be enterprise wide. A Zigbee-based solution uses the technology inherent in the Zigbee protocol to provide RTLS, without the reliance upon a separate infrastructure custom designed for RTLS. The 802.15.4 and ZigBee standards were developed to support networks of low power sensors. The low power utilization and built in networking capabilities make ZigBee well suited to RTLS applications. ZigBee based systems have low tag and receiver costs, long battery life, and are easy to deploy.



Awarepoint, a San Diego-based healthcare focused company, offers enterprise RTLS via an 802.15.4 ZigBee network. The company has developed sensors that are plugged into standard wall outlets to form the enterprise RTLS network. It does not need huge costs up front for added AP infrastructure and/or chokepoints, or dedicated IT design personnel that need to be savvy in networks and WLAN(s), to make this actually work. Finally, for the first time, "enterprise RTLS networks" can be deployed quickly and cheaply.

WHERE DO WE GO NEXT?

To derive the greatest return on investment for any RTLS solution, a business plan needs to be completed. This ensures the all departments are aligned to achieve the best ROI and that this is truly enterprise based. In today's healthcare environment, technology cannot be deployed without a thoughtful process on the "return on investment" and how this is impacting the business process. Without this analysis, the IT department may conclude that "zone level accuracy" with a few dead spots is "better than nothing".

Many previous RTLS solutions have been deployed in a limited fashion, but when looked at from a true enterprise perspective, just may not make sense. The truth is, with today's low cost and easily deployable technology options, you don't have to trade enterprise-wide coverage or location accuracy for cost savings.

Wi-Fi based RTLS solutions may appear to make some sense, but at the end of the day, will not be the right enterprise technical solution to accomplish the business requirements to drive true clinical and financial outcomes in the long term.

ABOUT INTEGRA SYSTEMS, INC.

Integra Systems, Inc., founded in 1997; is a full service global reach engineering healthcare and engineering centric consultancy with associates in a variety of engineering, design, and integration disciplines. Many in the medical device and wireless community have come to rely upon our now twelve years of experience and diverse technology know-how coupled to hands on field experience in the wireless and mobility space. This wireless domain experience spans all areas of personal area networks, wireless LANS, distributed antenna systems, cellular, PCS, Public Safety, and RFID/RFLS in multiple vertical markets.

David H. Hoglund, Principal and Founder
<http://www.integrasystems.org>
integratech@earthlink.net
davidhoggund@gmail.com
714.264.7101 (mobile) / 702.446.5813 (efax)