TCO ANALYSIS

EXTRICOM WLAN
TCO CONSIDERATIONS

LOGISTICS ENVIRONMENT

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About This Document

This document details the Total Cost of Ownership (TCO) of an Extricom WLAN deployment and a competitor WLAN deployment, in a logistics environment such as a warehouse.

1. Executive Summary

In today's highly competitive business environment, logistics center operators need to run their operations more efficiently than ever before. The key efficiency tools used in the logistics sector today, such as handheld scanners, RFID tags, Wi-Fi phones, and automatic pick-and-place robots, are entirely dependent on the presence of a reliable WLAN infrastructure.

Implementing a reliable, effective WLAN in a logistics environment, however, is a very difficult task for traditional WLAN technologies. The presence of large metal surfaces in the ceiling and walls of the warehouse, high shelves filled with changing inventory, moving vehicles, and large distances, create a very challenging RF environment. Furthermore, the inherent mobility of clients makes additional performance demands on the WLAN.

The purpose of this document is to examine the cost factors in deploying traditional WLAN technology in a harsh logistics environment versus deploying Extricom's Channel Blanket™-based system.

Our analysis shows that there are significant differences in the CAPEX (Capital Expenditures) and OPEX (Operational Expenditures) of the two solutions, which decision makers should be aware of. In the TCO use case outlined in the following chapters, deployment of a cell-based solution proved to be 44% more expensive than deployment of a similar Extricom solution.

2. Logistics Use Case

The use case that was chosen represents a modern, medium-sized warehouse measuring 150 m x 150 m, with a small office near the center. The characteristics of the warehouse are:

- Building size: 150 meters x 150 meters (22,500 m2)
- Shelf aisle width: most aisles are 1.8 meters, to conform with industry-standard VNA (Very Narrow Aisle) dimensions, and several wider main aisles
- Shelf depth: 1.2 meters, for accepting standard pallet sizes.
- Ceiling clear height: 15 meters
- Shelf height: 12 meters
- Varying types and volumes of stock on the shelves, causing frequent changes in the RF environment.
- Large amounts of metal in the structure, leading to severe multipath interference.

A similar structure is shown in the picture below.

2-1 Logistics warehouse

Below is a list of the WLAN clients that will be deployed in this warehouse.

WLAN Clients

- Handheld mobile computers and barcode scanners. These clients are in constant motion. They can run.NET applications and are 802.11b/g compliant.

- Desktop PCs and laptops used by employees in the central office and also occasionally on the warehouse floor. The computers are 802.11a/b/g compliant.
- VoIP clients that are 802.11 b/g compliant
- Future: RFID tags, that are 802.11b/g compliant

To support these clients in the warehouse, the following WLAN equipment would be required from Extricom:

Extricom Equipment List

- 21 x EXRP-40E APs, and 3 x EXRP-40 APs, each with 4 internal radios, supporting up to 4 Channel Blankets across the warehouse: in Phase 1, one blanket on the 802.11a band for PCs, one running 802.11b/g for scanners and Wi-Fi phones, and a third Channel Blanket for rogue detection. The fourth radio is available for future use.
- 168 x external “rubber duck” antennas
- 1 x EXSW-2400 switch

The following equipment would be required from the cell-based WLAN vendor:

Cell-based Equipment List

- 35 x 2-radio APs (one radio for 2.4 GHz, one radio for 5 GHz)
- 62 YAGI antennas (2.4 GHz)
- 1 x WLAN controller

Chapter 4 contains a detailed explanation of how the equipment was provisioned, and why the above equipment types and quantities are required.

3. Calculating TCO

The table below compares the TCO of the Extricom-based deployment to the TCO of a cell-based WLAN deployment, for the use case described in chapter 2. The assumptions underlying this table are outlined in chapters 4 and 5.

	Extricom	Cell-Based*
Capital Expenditures		
APs	$18,780	$13,965
External Antennas	$2,436	$11,656
Switches	$10,995	$10,194
Cable Drops	$3,600	$5,250
Management software	$1,500	$3,995
Subtotal CAPEX	**$37,311**	**$45,060**
Operational Expenditures		
Site Survey and Cell Planning	$800	$4,000
Installation and Testing	$2,400	$10,000
System Admin Training	$1,000	$1,000
Annual Maintenance Contract	$2,239	$2,704
Subtotal OPEX	**$6,439**	**$17,704**
Total CAPEX and OPEX	**$43,750**	**$62,764**

*Assumed values

Table 3-1 Total Cost of Ownership for Logistics Installation

The overall results of the comparison are captured in the bar chart below.

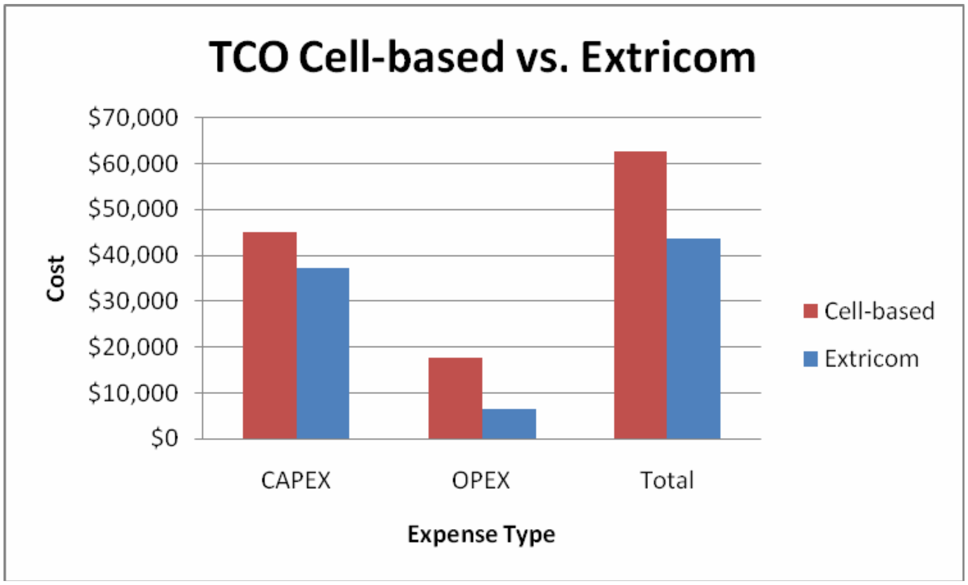

Figure 3-1 TCO Comparison Results

The Extricom solution is less expensive for both CAPEX and OPEX. Taking into account both CAPEX and OPEX, the cell-based solution is 44% more expensive than the Extricom solution.

4. CAPEX Explained

In order to understand the CAPEX comparison in Table 3-1, it is necessary to understand the fundamental differences between the Extricom and cell-based solutions.

The Extricom Solution

The Extricom solution uses “Channel Blanket” architecture. In Channel Blanket architecture, each available radio channel is activated on every access point, to create blankets of coverage that are controlled by a central switch.

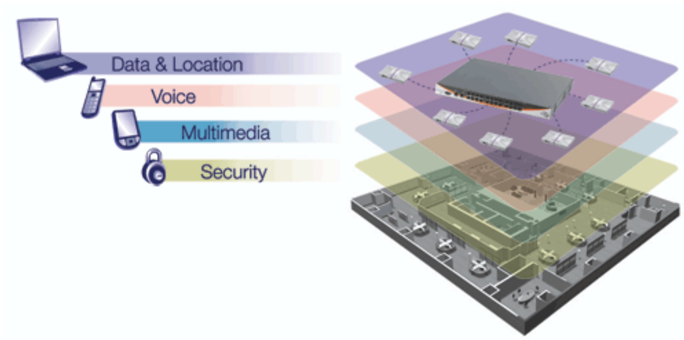

Figure 4-1 Extricom Channel Blanket Architecture

The Channel Blanket makes it possible to deploy APs on the ceiling of the warehouse, at a sufficient density to ensure RF penetration between the shelves and thus, high bandwidth for the clients. The Extricom solution is immune to co-channel interference, so locating the APs relatively close together in the noisy RF environment of a warehouse is not a problem.

The Extricom solution is also largely immune to multipath problems, so the wide radiation pattern of standard omnidirectional antennas, even in a building with metal walls and a metal roof, will not cause problems. In fact the opposite is true: *the Extricom solution takes advantage of multipath RF reflections to achieve even better coverage*.

For the 150 x 150 x 15 meter building in our use case, the Extricom APs are set up in a standard way, on the ceiling, with an approximately 30-meter gap between APs, as shown in the floor plan on the following page (Figure 4-2 Extricom Warehouse Deployment). A slightly higher density of APs has been used in the office area, to provide service to the expected larger number of clients there.

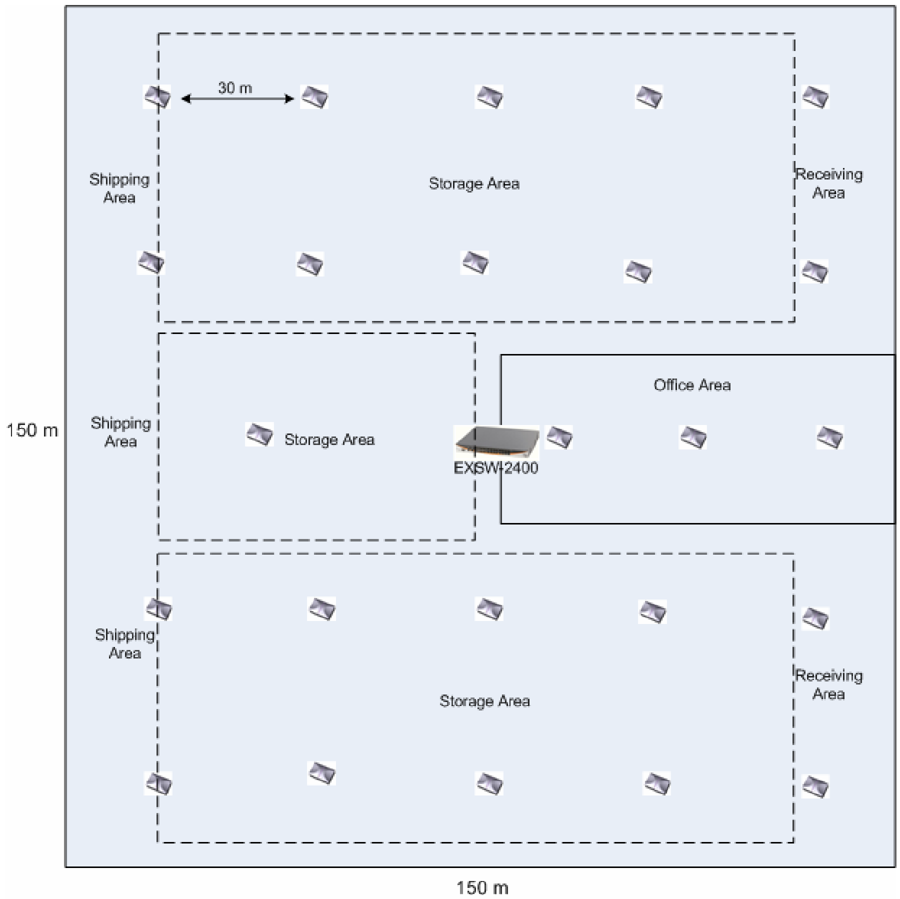

Figure 4-2 Extricom Warehouse Deployment

The Cell-Based Solution

Cell-based WLANs, unlike the Extricom solution, are highly susceptible to co-channel interference. The inherent need in a logistics environment for a relatively dense deployment of APs to reach into the aisles, together with the expected multipath problems, means that locating the APs on the ceiling of the building is not a viable option for cell-based WLANs. If attempted, it would lead to very poor performance.

Why APs with Standard Antennas Would Not Work Well

There are three main reasons that standard omnidirectional antennas would not work well for a cell-based WLAN in a warehouse:

1. Too many handoffs for roaming users, especially while roaming in the receiving or shipping areas
2. Clients receive too many beacons
3. Severe co-channel interference due to AP density and multipath RF interference

In a standard cell-based WLAN, a client always communicates with a specific AP. It's important, therefore, that the other APs not hear the transmission. Cell-planning is used to achieve this. A classic cell-planning scheme would look like this.

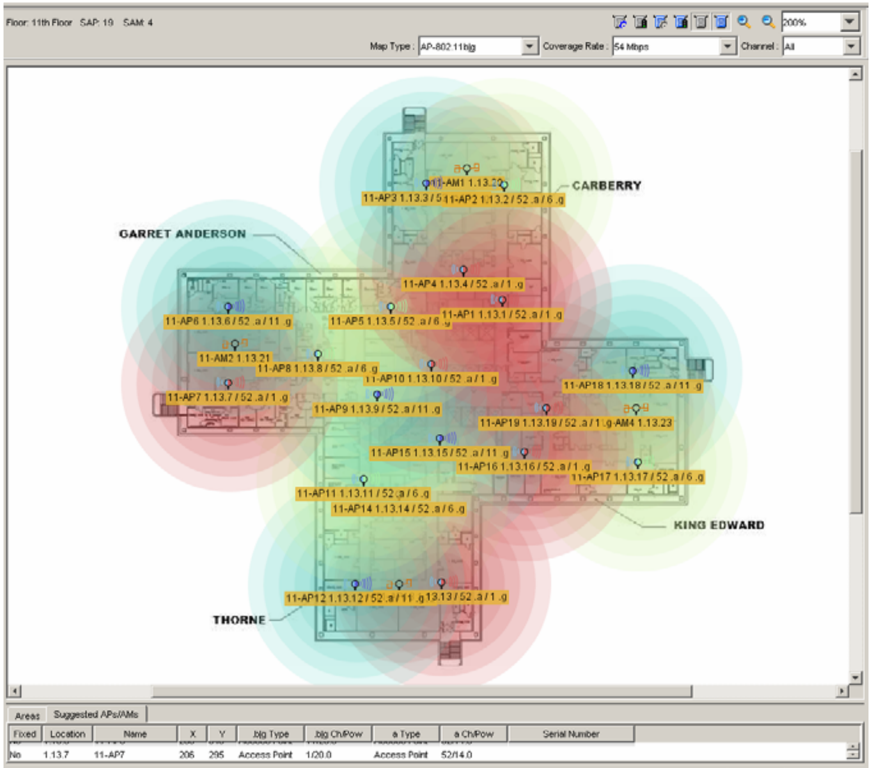

Figure 4-3 Cell-Planning View for High Bandwidths

This layout looks good for high bandwidth transmissions. However, all the clients beacon at low bandwidth (1 mbps) and many mobile data and VoIP clients will also communicate data at low bandwidths. So the real picture the clients would see is a combination of the much longer range of 1 Mbps (approximately 150 meters) and the multipath noise inherent in the warehouse, as shown below in Figure 4-4 Client RF Environment for Low Bandwidths.

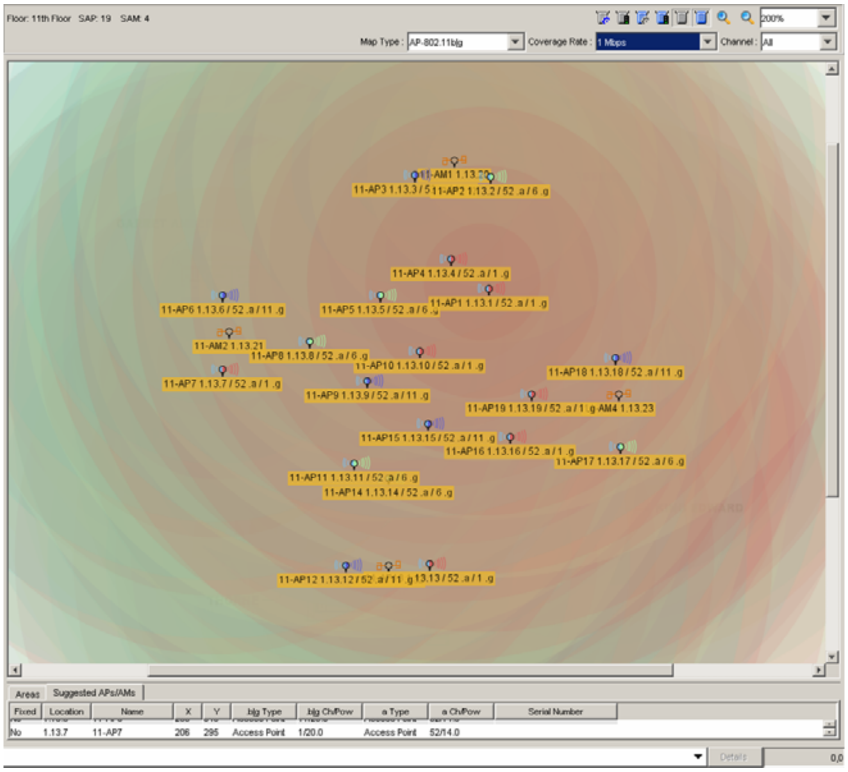

Figure 4-4 Client RF Environment for Low Bandwidths

So in our use case, clients in a cell-based WLAN would see almost all of the 24 ceiling mounted APs in the warehouse since the beacon range is approximately 150 m, and the warehouse is 150 m x 150 m. Consequently, the client's BSSID table would be long and roaming decisions would take longer, creating high-latency handoffs.

To make matters even worse, roaming decisions would need to be made often, because in a warehouse most clients are always moving up and down the aisles. While moving through the main corridor at the end of aisles, a client could pass through as many as 16 cells in the cell-based WLAN.

Finally, co-channel interference would be high and would degrade the bandwidth of the WLAN service offered. Faster clients would suffer the largest performance degradation, and slower clients would also experience lower throughput.

It is important to reiterate that with the Extricom Channel Blanket architecture, the situation is the opposite. The client does not associate with individual APs but rather with a Channel Blanket. The client does not roam at all as it moves through the aisles because it stays associated with the same Channel Blanket. Its BSSID table would only contain one entry per channel.

Using YAGI Antennas to Provide Coverage in Cell-based WLANs

To counteract the problems noted above, cell-based WLANs use YAGI antennas, which focus the radio transmission into the aisles. This is illustrated in the following diagram, which is an expanded view of a sub-section of the warehouse.

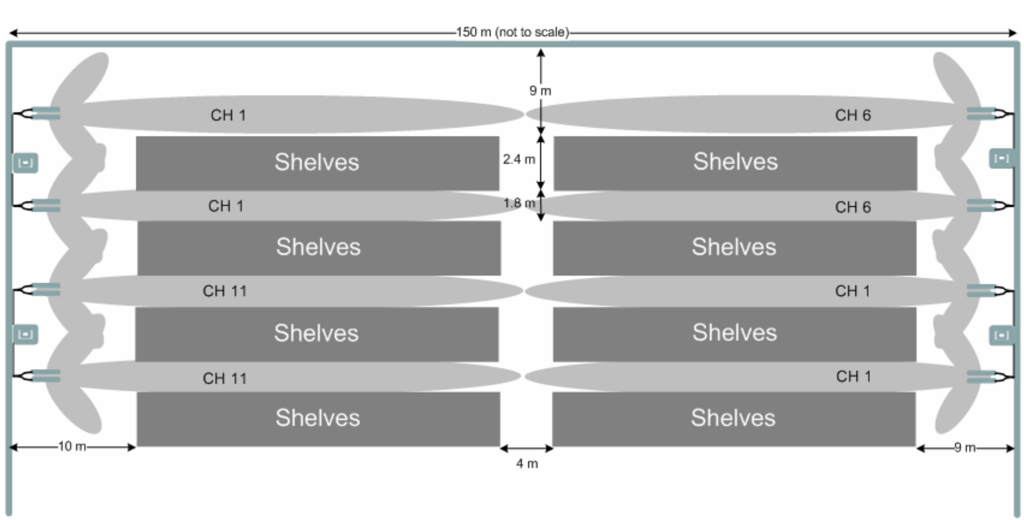

Figure 4-5 YAGI Antenna Deployment

Although YAGI antennas theoretically have a longer reach, two are still needed for each aisle. This is because even though a YAGI antenna can reach a client at the opposite end of the 150 meter aisle in our example, the client's internal patch antenna is not capable of transmitting back across such a great distance.

Each aisle and its two corresponding shelves are a total of 4.2 meters wide (aisle = 1.8 m + 1.2 m x 2 shelves). Assuming some wider aisles between storage areas (Figure 4-2 Extricom Warehouse Deployment), there would be a total of 29 internal aisles in the use case, with 9-meter corridors next to two of the outside walls of the building for a total of 31 aisles that must be covered by the WLAN solution.

This scenario will necessitate 30 APs, each with two external YAGI antenna's, to cover 30 aisles from both directions as shown above, and 2 more APs each with 1 external YAGI antenna to cover the remaining aisle. Three APs with internal antennas are needed to cover the office area, bringing the total number of APs for the cell-based solution to 35, and the total number of YAGI antennas to 62. It should be noted that even for the shorter storage aisles near the office area, a YAGI antenna will deployed at each end of the aisle to ensure good line of site between a client and an antenna no matter what direction the user is walking down the aisle.

Due to the need for 35 APs, at minimum a 36-port switch is required for this solution.

Relative to cell-based WLANs with omnidirectional antennas, a cell-based WLAN with YAGI-antennas reduces the number of handoffs within internal aisles (from 4 or more to 2 per aisle), and lowers the co-channel interference somewhat. It still does not approach the Channel Blanket's interference immunity and lack of handoffs, but YAGI antennas are at least an improvement over traditional omnidirectional antennas for cell-based deployments.

5. OPEX Explained

This chapter details the calculations used to arrive at the OPEX numbers of Chapter 3. Additional OPEX that were not included in table 3-1 are also discussed. In table 3-1, the labor rate used is $100 per hour.

Site Survey and Cell Planning

For the Extricom solution, the site survey and cell-planning phase is relatively simple. Because the Extricom WLAN is not susceptible to co-channel interference, a simple deployment tool is used to place the APs at a fixed distance from each other, to ensure the minimum desired bandwidth for clients is provided everywhere in the warehouse. RF cell-planning, which can be highly labor-intensive is not required in an Extricom deployment, so eight man-hours were assumed for this phase.

For a cell-based WLAN installation, the site survey and cell-planning phase is more complicated. Detailed RF planning and analysis is required, as well as channel allocation, to ensure that neighboring APs do not interfere with each other. One week (40 man-hours) was assumed for this phase.

Installation and Testing

For the Extricom solution, the installation and testing phase is also relatively simple. The APs are installed on the ceiling at the fixed distance between APs determined at the planning stage. An Extricom engineer then uses the Extricom Verification Tool to check that the received power is as specified in the system design. If not, APs can be moved closer together or farther apart. A maximum of 24 man-hours was allocated for this activity, although this can be adjusted downwards under most conditions.

For a cell-based WLAN, the installation and testing phase is more complex. Installation of the YAGI antennas is required, including attaching each YAGI articulating mount, then determining the beam direction for each of the antennas. After the antennas have been installed, the deployment team must perform tests to determine the actual RF patterns and the extent of multipath and co-channel interference. The antennas are then adjusted again, and the test process is repeated. 100 man-hours were allocated for this activity.

RF Retuning

A warehouse is a dynamic environment. A row of shelves may be stocked with bottles one day, and boxes of cereal the next. This changes the RF patterns, and de-optimizes the RF cell planning that was done initially for the cell-based solution. It is assumed, however, that the directional beams of the YAGI antenna will minimize this common cell-based problem.

The Extricom solution is inherently far less susceptible to changes in the RF environment due to changing shelf content because the APs are overhead and the warehouse’s inherent multipath RF helps boost the signal in each aisle even if the nearest AP is a few degrees to either side of the aisle.

Consequently, no retuning cost was applied to either solution.

Impact of Wi-Fi Client Handoff on VoIP calls

WLAN clients in a warehouse are in motion most of the time, especially Wi-Fi phones. Companies that have deployed VoWLAN solutions report a 20 to 35% savings per year in their voice call costs. This is because the "connectivity anywhere" nature of VoWLAN greatly reduces the number of call-backs (i.e. an employee misses a call, and then calls back the caller) from the logistics floor, which in turn reduces telecom charges.

Cell-based WLAN requires many client handoffs as the client roams from one aisle to the other. If YAGI antennas are used, the number of handoffs is reduced for workers walking down the aisles, but increases for workers walking down the corridors. This renders the VoIP phones far less usable for mobile workers.

Consequently, if a classic cell-based WLAN is deployed in a logistics environment, the company is unlikely to benefit from much VoIP use on the logistics floor and workers are more likely to use their cellular phones instead. This unrealized cost-savings over an assumed 5-year service life is a real issue for cell-based WLAN's. A warehouse similar to the one described in this use case, could experience extra expenditures of $10,000 to $15,000 over 5 years, due to increased volume of call-backs by mobile workers.

In the Extricom Channel Blanket architecture, mobile clients do not hand off between APs, which translates to a greatly reduced likelihood of a call dropping and call-back being required. In addition, a Channel Blanket can be dedicated to VoIP calls, enhancing system QoS.

If the VoIP issue is taken into account, the TCO of the competitor solution is likely to increase to $73,000, while the Extricom TCO would remain at $44,000.

Future RTLS Deployment

Once a warehouse has adopted RTLS, the amount of RFID tags in use can easily reach 10,000 or more. The Extricom solution has distinct advantages for RTLS use, as it enables higher-accuracy positioning. The reason for this is that each tag is heard by more APs in the Extricom Channel Blanket than in the cell-based scenario, allowing for more accurate triangulation by the RTLS server.

In the cell-based scenario, the YAGI antenna's directionality will limit the number of APs that pick up the RTLS transmission of a particular tag. This will lower the RTLS horizontal and vertical accuracy. The OPEX impact of lower accuracy is more personnel time when searching for an item.

The precise OPEX delta for RTLS depends on a number of factors such as the exact accuracy degradation, number of searches performed per unit time, and other factors which will not be quantified here. *However, it is important to be aware of this potential OPEX factor.*

Ready for the Future?

What other client deployments could be looming in the future of this warehouse? Given the constant need to improve efficiency, this is a very relevant question during the initial deployment of the WLAN, because it can be very expensive to make significant WLAN infrastructure changes later, especially with cell-based deployments. At minimum, the cell-planning phase would have to be repeated with a cell-based WLAN, if any significant changes were made. This would not be required with the Extricom solution.

Furthermore, Extricom APs include up to four radios. In the scenario described here, only three radios were needed in Phase 1, so the fourth radio is available for use in a Phase 2 client deployment, such as RTLS.

Each radio in an Extricom AP can operate on 2.4 GHz or 5GHz and Extricom's Same Band technology allows up to three of those radios to operate in the same band. This provides a high level of flexibility to the WLAN administrator, who can decide at anytime in the future what client type each radio will serve, in order to maximize QoS where it's needed.

In contrast, the cell-based APs in this use case have only one radio remaining after the phase 1 deployment, and that radio operates only on 5GHz. Consequently, in the cell-based deployment, any future clients need to be 802.11a compatible or they will need to share the existing 2.4GHz radio with all of the phase 1 clients.

6. Summary

The Extricom WLAN provides both better performance and compelling financial advantages in a logistics environment. Both the CAPEX and OPEX in the use case were significantly lower for the Extricom solution than for the cell-based WLAN. This is despite that fact that the cell-based vendor chosen for this study has one of the most aggressive pricing strategies in the WLAN logistics market and despite the fact that we used a four-radio Extricom AP for this TCO scenario in order to provide dedicated service per client type while the cell-based AP contained only two radios.

To sum up, the relative immunity of the Extricom solution to both co-channel and multipath interference make it the ideal solution for logistics environments. The Extricom solution provides both lower TCO *and* better performance.