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ESSAY #1
WI-FI TROUBLESHOOTING IN A COOLER WAREHOUSE

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I remember getting contacted because “*the Wi-Fi was not working in the cooler warehouse*”. When I got there the first time, I understood why they were calling it the “cooler warehouse”: 3º Celsius in a 42,000 square foot warehouse, stocking milk on top of milk. They used to have an old IEEE 802.11b wireless infrastructure and have upgraded to IEEE 802.11n installing new controllers and new access points. According to the users: “the situation was now worse than before”. In this context, my job was to troubleshoot and fix the current issue(s).

The issue did not get solved on the first day, I worked with the customer on different trial and error scenarios and it took quite a lot of testing to fix the problem.

Eleven (11) Cisco Aironet 2702i/e were deployed and managed by a remote Cisco 5508 wireless LAN controller. The main client devices used were IEEE 802.11b/g RF guns and embedded computers (Omnii XT 15 and PSION 8525/8530 G2). They were used by the staff on the ground in order to work on orders and update inventory. Therefore, my studies were focused on the 2.4GHz band. I guess, 2.4GHz is not dead yet.

The first part of the work was to assess the current situation in order to know exactly what was wrong. In order to perform this general assessment, I have used an arsenal of different Wi-Fi tools:

- I have used MetaGeek Chanalyzer to perform a spectrum analysis in order to find out if major sources of interference could be an issue.
- I have used TamoGraph Site Survey in order to perform the validation site surveys. These surveys provided information about the signal strength and the Signal-to-Noise Ratio (SNR) received.
- I have use Air Magnet Wi-Fi Analyzer in order to get a general idea of the Wi-Fi infrastructure health.
- Finally, I have used a combination of AirTool and MetaGeek Eye P.A. in order to capture packets and analyze the health of the RF environment.

The assessment revealed the following list of Wi-Fi related issues:

- A high level of retry rate was measured (an average of 15% on channel 1, 18% on channel 6 and 13% on channel 11).
- A high level of Co-Channel Interference (CCI) was measured on the 2.4GHz frequency band.
- Some workers were working in galleries located underneath the racks surrounded by milk. The initial site survey, performed before the new installation, has not taken these galleries into consideration. Therefore, Wi-Fi coverage was really bad.
- Access points were using omnidirectional external antennas installed under the ceiling and could hear each other. The Radio Resource Management algorithm (RRM) from the controller was, therefore, reducing the transmit power of these access points to values ranging from 4dBm to 7dBm. This was resulting in a weak signal measured on the ground.
- The antennas were, sometimes, installed right under the ceiling steel structure resulting in an direct obstruction of the signal as soon as it was leaving the antenna.

The retry rate is calculated by looking at the “*Retry Bit*” field in the MAC header. This bit is part of the frame control flags. If this field is equal to 1, it means that the packet has been sent before but no ACK were received. This is called a retransmission. The retry rate refers to the percentage of retransmitted packets and is calculated as follow:

$$RetryRate\ (\%) = \frac{\#packets\ with\ Retry\ Bit == 1}{\#packets\ with\ Retry\ Bit == 0} * 100$$

In our case, the retry rate were high because of several factors:

- The environment composed of metal racks was introducing a lot of signal reflection (and even scattering in some cases). Therefore, the IEEE 802.11b/g clients (not supporting MIMO) had a hard time decoding the receive signals.
- The racks filled with milk bags were introducing absorption. Therefore, the signal received by the client was sometime weak (< -80dBm). It is then harder for the client to decode the signal received.

When the client is not able to decode the signal received, it won't be able to send the ACK and this will generate a retransmission. Retransmission affect a Wi-Fi network in a negative way because it is using airtime to transmit data that has already been transmitted. In other words, the less retransmission you have, the more efficient your Wi-Fi network is.

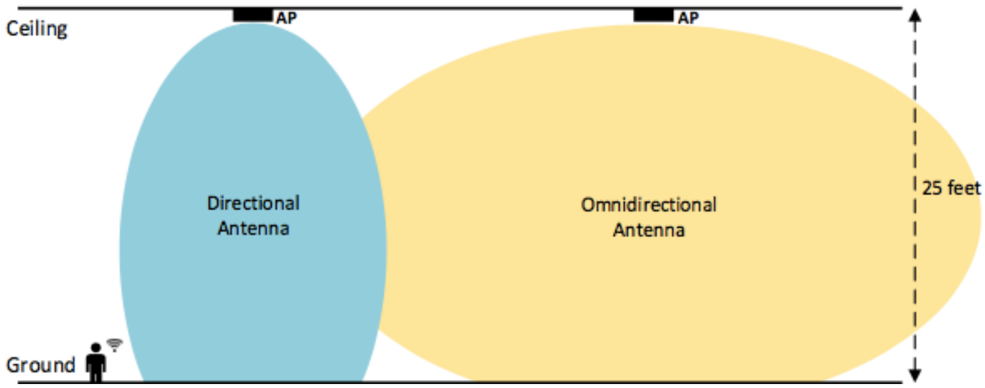
In order to fix the issue related to the RRM setting low transmit powers, I defined a static channel plan and static transmit power to use on the APs located in the warehouse. I even disabled two (2) of the 2.4GHz radios in order to minimize the risk of excessive co-channel interference. Therefore, RRM got disabled on the Cisco controller. Channel one (1), six (6) and eleven (11) were used for the channel planning. Transmit powers got configured according to the different measurements I have been doing on the ground and according to the maximum capabilities of the clients. These transmit powers were ranging from 7dBm to 13dBm.

Following these changes, the situation got a little bit better but users were still having some issues and the Wi-Fi was not performing well enough. The fact of dealing with IEEE 802.11b/g clients in a warehouse full of liquid and having workers working underneath these racks forced us to have a perfect RF setup. However, it was not the case using the omnidirectional antennas.

So I decided to perform some testing using a directional antenna in order to try to focus the RF signal only where needed. To do so, a directional antenna with a gain of +6dBi from Cisco was used. The transmit power was set to 13dBm. This was the maximum I could use if I wanted the power to be symmetrical between the APs and the clients. However, this was higher that what I had configured for most of the APs previously. Since the RF was going to be more focus, I could go a little higher without having to worry about creating too much CCI.

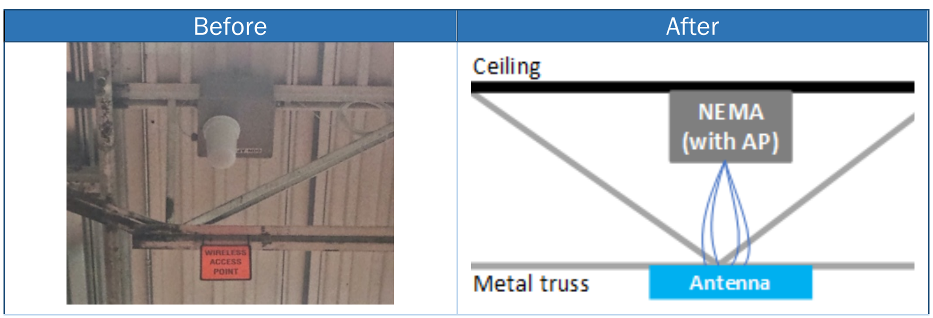
I performed the testing, just like if I was performing an AP-on-a-stick site survey (I only had one (1) antenna to work with). So I would swap one (1) of the omnidirectional antenna for the directional one and perform a site survey around the covered area. I would repeat the process for every APs I wanted to work on. The warehouse was full at the time of these studies, which worked in my advantage since you always want to find yourself in the worst environment possible while surveying.

As expected, the use of directional antenna did not necessarily improve the coverage on the ground, however, it contained the signal by directing it downside. This way, the signal was not affecting other APs as much. Here is an illustration explaining the phenomena:



The results of these testing were good and the customer decided to purchase a few of these directional antennas to use in the warehouse. Seven (7) of the eleven (11) access points ended up using these new type of antennas. Moreover, one (1) access point was relocated and moved about 15 feet from its original location to better take advantage of these new antennas.

On top of these new changes, I have advised the customer to change the installation of their antennas in order to fix the previous situation where ceiling metal truss were obstructing the signal as soon as it was leaving the antenna. I recommended to install the antenna below the metal truss as shown in the diagram bellow:



Once the new antennas got installed, we re-enabled RRM and re-enabled the couple of 2.4GHz radios that we had previously disabled. RRM did a good job at selecting the right channels, but I decided to configure static transmit powers in order to better accommodate our needs.

A final exit survey was performed in order to validate the level of signal strength and SNR everywhere in the warehouse (including the galleries). On top of that, I have performed a couple of packet captures in order to validate the performance of the Wi-Fi environment. Overall, the results were better than what we had before the installation of the new antennas. This table illustrates the results and compared them to what we had before:

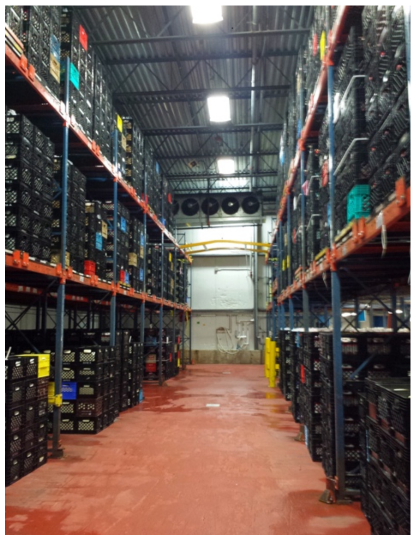
Channel	Retry Rate Before	Retry Rate After	Improvements (%)
1	15%	6.5%	-56%
6	18%	9.5%	-47%
11	13%	6.5%	-50%

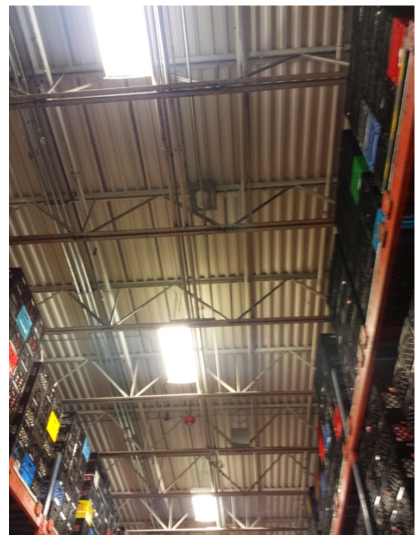
Concerning the data rate, the client stations were transmitting at 54mbps, which is the best they could do using IEEE 802.11g. The management frames were being transmitted at a rate of 5.5mbps, which correspond to the lowest data rate configured on the controller. The utilization of the airtime did not go over 7% during the site survey.

Bottom line, the density and location of the access points were decent. The access points were just not using the right type of antenna to suit this type of environment resulting in creating a bad RF environment. The fact of changing the type of antenna to focus the RF signal and making sure that the channel and transmit power setting were configured properly, allowed me to create a stable RF environment. Since then, the Wi-Fi has been working properly.

This was one of my first project working as an independent consultant. As you could imagine, this was quite challenging and a very good way to put in practice some of the knowledge I have acquired going through the CWNP certifications.


Gallery under racks


Typical aisle


Example of bad antena installation