WHITE PAPER:

Lessons learned: Making WiFi work in outdoor industrial environments

Summary:

As computer technology and applications have extended into industrial operations, the need for robust wireless local area networks (WLAN) covering outdoor environments has emerged. Industrial WLANs to be effective must offer security, performance and the scalability necessary to support mission critical business operations, rigorous security requirements and government mandated safety applications.

Commercially available WiFi (802.11x) technologies offer potential capabilities to deliver secure mobile wireless networking to address these requirements. While the potential to use WiFi technology is attractive, outdoor industrial environments pose numerous network design challenges, making successful WLAN implementations difficult and thus, many in place WiFi networks fail to deliver expected performance.

In this paper, we discuss the challenges that a major intermodal transportation firm faced as they deployed WiFi networks in 74 of their rail classification yards. We identify why early WiFi implementations in their rail yards failed to deliver expected performance. We will also discuss the lessons learned and the practical solutions that were developed and utilized to successfully complete the project.

The challenges:

New and changing Federal requirements:

- Homeland Security requirements to monitor the movement of hazardous cargo and freight.
- Department of Transportation requirements to improve the safety of operations.

Changing business requirements:

- Requirements to improve management, control and efficiency.
- Uploading and downloading data from equipment, locomotives and other machinery
- New real time applications

On the surface, engineering an outdoor WiFi network would appear to be a straightforward networking project. Conduct a comprehensive site survey, engineer appropriate
spacing of Access Points (AP) and select AP’s that are environmentally protected and ruggedized for outdoor environments.

What you find in the real world is that 802.11 (WiFi) technologies were conceived for indoor LAN applications with access to extensive wired infrastructure. Outdoor industrial environments are large, harsh and RF noisy environments that present a variety of unique problems.

Chief among these challenges is diagnosing why existing WiFi infrastructures are not performing as expected in terms of availability, range, coverage and security.

Successfully diagnosing WLAN performance issues requires applying classic RF engineering techniques and adapting existing WiFi engineering tools to fit the environment challenges presented.

It can also mean creating new tools, processes and training for the staff responsible for maintaining the WLAN.

The picture above is an aerial photo of a typical rail classification yard, one of the 74 sites involved in this project.
**The typical rail classification yard characteristics:**

300+ acres of area covered
2+ linear miles end to end length
Metropolitan and rural area environments
Limited road access within the yard
Very high levels of Radio Frequency Interference

**Site survey and engineering discoveries:**

Based on our project we find that Rail yard WiFi implementations often fail due to:

- Co-channel interference
- Excessive Attenuation
- Contention loss (too many clients converging on a single AP).
- Inaccurate Signal strength mapping.

**Lessons learned:**

1. Successful WLAN design must incorporate RF engineering considerations such as attenuation loss in long antenna cable runs.
2. Co-channel interference will often occur due to the presence of multiple and rogue Access Points competing for bandwidth.
3. Existing tools for signal strength mapping are difficult to apply to large outdoor environments.
4. Security and encryption are essential requirements for most applications.

**Applying these lessons:**

Addressing these challenges required that a variety of new approaches be developed, these included:

1. Creating an automated broad area WiFi RF signal strength survey process. A PC based tool was created that permits the collecting of GPS and Signal strength plotting data while driving around a large site.

2. Using KML language and global mapping technologies to create an application that produces detailed interactive signal strength heat maps of the facility surveyed.
3. Creating a RF “engineering considerations” training to insure that as WLAN’s are engineered and implemented they incorporate best RF design and WiFi engineering practices.

4. RF issues to be addressed in an outdoor industrial environment include:
   a. Influence of terrain and obstructions
   b. Sources of RFI
   c. Antenna placement
   d. Transmitter power
   e. Cable attenuation losses

5. Establishing minimum security and encryption standards for all locations. We recommend that security include:
   a. Authentication & Encryption
   b. 802.1i MAC security enhancement
   c. 802.1x authentication
   d. EAPOL
   e. TKIP encryption.

The above screenshot was created by our proprietary GPS based heat-mapping tool. The tool utilizes KML to create interactive heat maps of signal strength throughout the site.
The color coded individual points are signal strength measurement sites that were mapped while driving through the yard. The color coding indicates the Signal Quality at and each icon may be toggled to see the actual signal strength measurement in dBm at that site. This permits the engineer to evaluate the placement of AP’s and to identify specific trouble areas. This tool is also server based to allow remote access to the specific site data by engineers located away from the yard.

*The outcome:*

This Class one railroad has successfully established WiFi based WLAN infrastructure at 74 of their rail classification yards. The implementation utilized their existing yard maintenance and support personnel. With this new infrastructure in place a variety of new train operations and yard management applications are being deployed. Including:

- Locomotive Event Recording
- Train Control Optimization
- Car Repair Data Collection
- Wireless Onboard Event and Data Recording System.

These and other new applications will support the continued expansion and improvement of operations at the railroad.

Beyond the outdoor WiFi requirements of a Class One railroad, we believe that other industrial environments are experiencing similar under performance of their WLANs. By applying the lessons learned in this project we believe that

- Port Authorities
- Warehouse and Distribution Facilities
- Large Manufacturing facilities
- Railroads & Transit Authorities

will be able to turn underperforming WiFi networks into important assets for the operation and expansion of their business.