Take the W-LAN Test Challenge

A WLAN system's RF environment challenges designers, installers and administrators with planning re-use patterns, interference detection and system coverage in both installation and maintenance. These challenges are also found in seemingly more complicated cellular phone systems. Frequency re-use patterns, coverage mapping, interference from neighbors, locating unauthorized users and locating stolen equipment must be considered in addition to the standard PER and throughput metrics. Installing and maintaining a large WLAN system can rival the complexity of a cellular phone system. The author presents a comparison of equipment that is available to designers, installers and administrators to measure and overcome these challenges. Spectrum analyzers, standard WLAN cards and RF equipment specifically designed to measure 802.11 on the air are examined. Examples are drawn from the author's experience in designing WLAN test equipment; parallels are also drawn to methods and equipment that are found in the relatively mature cellular phone industry.

Introduction

The installation of an 802.11b Wireless LAN system to cover a large office setting can be very challenging and techniques found in cellular system engineering are often required. WLAN systems have the added complexity of operating in an unlicensed band where interference may not be under control of the WLAN manager, and the WLAN often operates in a harsher indoor RF environment.

Large WLAN installations will in many ways resemble a cellular phone system. Access Points (APs) are analogous to Base Stations. APs connect to the clients within their coverage area. APs have a "backhaul", Ethernet, which ties them together and into the network. Adjacent APs must be channelized so that they do not interfere with each other.

The most basic and readily available test tool is a laptop with an 802.11b card. The measurements vary with manufacturer, but the ability to measure signal strength and signal quality is common. These measurements are often relative, scaled 1–10. Specialized test tools are available that measure to traceable quantities, dBm, and have more types of measurements available. The tool or set of measurement tools should detect and measure interference, measure AP signal strength and Packet Error Rate (PER) from an AP.

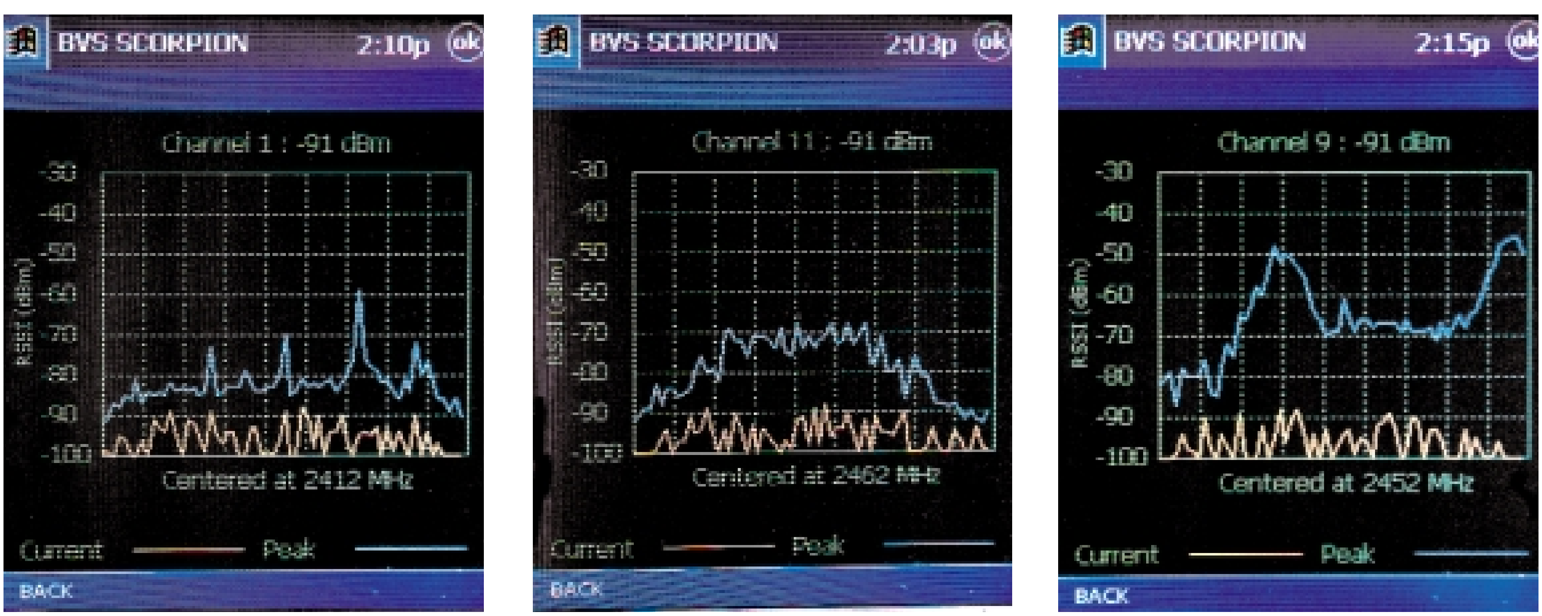
Measuring the Existing RF Environment for Interference

The place to start an 802.11 installation is to measure the existing interference. Microwave ovens, 2.4 GHz cordless telephones, other 802.11b WLANs, 802.11 frequency hoppers and bluetooth devices can all interfere with and degrade the performance of an 802.11b system.

Figure 1 illustrates a frequency sweep of an 802.11b channel with several types of common interference. A specialized WLAN test tool or spectrum analyzer is used to measure the interference and is moved throughout the coverage area of the WLAN system. A peak hold or logging of the data is essential to establish the "noise floor" that will be interfering with the WLAN in different areas. A more rigorous check would leave the instrument measuring for perhaps a day or more with data logging and then moved to different locations in the coverage area. The tool or spectrum analyzer should have a sensitivity of at least –90dBm.

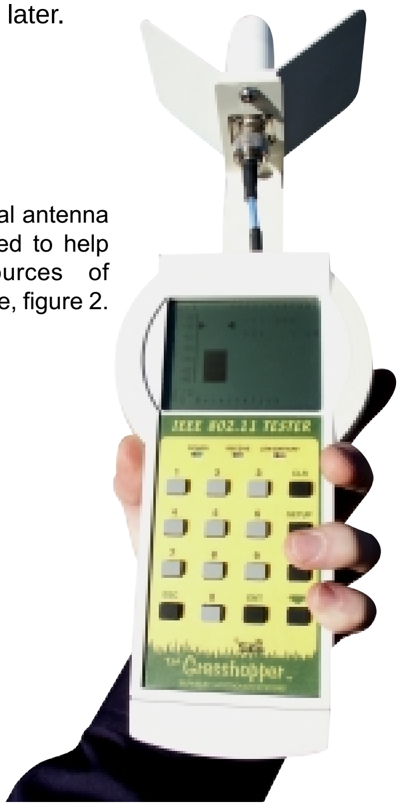
The spectrum scan detects energy present in the band from all sources and is best to scan for all types of interference. A test tool or 802.11b card should also be used to demodulate any existing 802.11b interference on the air. Testing for 802.11b interference via demodulation yields more information about these interferers and is more sensi-

Figure 1 illustrates a frequency sweep of an 802.11b channel with several types of common interference. We see a frequency hopper (left), an 802.11b access point (center) and a microwave oven (right).



tive.

A directional antenna can be used to help locate sources of interference, shown in figure 2. As many interferers should be eliminated as possible. Microwave ovens may be moved, and bluetooth devices and cordless phones can be banned from the office. Some interference may be impractical to eliminate. A neighboring business may also have an 802.11 system or some other interfere. In these areas, plan to have a higher density of APs, spend more time planning channelization and use some special techniques that are discussed later.



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Measuring the Coverage of an Access Point

The coverage area of an Access Point is experimentally found by simply locating the AP at a candidate site and measuring the signal strength and PER with a test tool. A spectrum analyzer could be used, but it can only measure signal power in the channel; and this measurement may also include interference, other Access Points other than the one being measured or even energy from a different AP on an overlapping adjacent channel. A test tool with demodulation is desirable because it can measure the signal strength of the AP coverage under test and the signal to noise is indirectly measured by the PER.

A typical signal level required for adequate coverage is around -80 dBm or stronger. This level includes some margin for typical interference and signal fading. The signal strength required will be greater in areas with interference levels greater than -90 dBm. Figure 3 tabulates typical signal strengths required with varying amounts of interference.

BER	Min Eb/No Required	Eb (Min) required for thermal noise = -100 dBm	Eb (Min) required for interference = -90 dBm
10^{-4}	10	-90 dBm	-80 dBm
10^{-5}	12	-88 dBm	-78 dBm

Note:Figures estimated from Harris HFA3861B data sheet.

Figure 3: Required Received Power (Eb) for various Bit Error Rates (BER) and Noise/Interference Levels (NO).

Measuring Coverage and Co-Channel System Interference

After testing AP coverage in several locations, the APs required for adequate coverage and overlap can be located. This may require an educated estimate or specialized propagation software. Neither method is perfect, so additional APs may need to be added or locations adjusted with testing.

Channelization is required so that neighboring APs do not interfere with each other. Figure 4 depicts a typical hexagonal frequency reuse pattern for three frequencies. For continuos coverage, APs must overlap, and the frequencies in these overlap areas should be different for each AP to avoid interference in these overlap areas.

The installation site must be surveyed to insure that all areas have sufficient signal strength, good PER from at least one AP and is without significant co-channel interference. Co-channel interference is when energy on the same channel is received from different APs. Co-channel interference should be at least 15dB weaker than the stronger AP. This survey requires that 3 frequencies be measured for a reuse pattern of 3, figure 5.

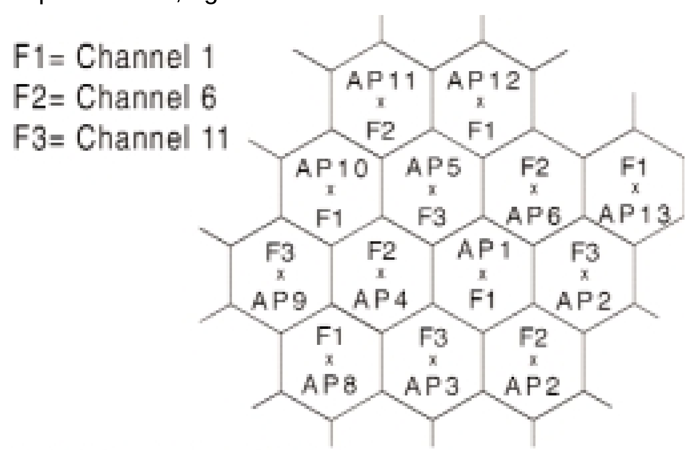

Figure 4: Coverage layout for 3 frequencies.
Three frequencies were chosen because there are only 3 non-overlapping channels available for 802.11b in the U.S.. Co-channel interference near AP1 can be received from other APs transmitting on the same frequency (AP8, AP10, AP12...).

Fixing Problem Areas

A site survey or the operation of the WLAN itself will probably reveal areas where coverage is not adequate. Adding or moving an AP closer to an area with high interference will boost the signal level. Directional antennas such as corner reflectors can direct more energy to your coverage area and reduce the amount of received interference. This is a useful technique for existing with a neighboring WLAN system; use directional antennas on the AP to direct coverage into the coverage area and to reduce interference received from outside the coverage area. A directional antenna may also be used at the client.

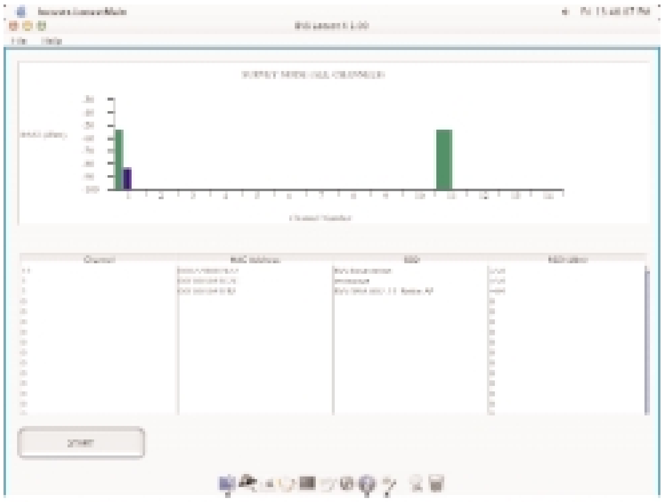

Figure 6: Site survey showing multiple frequencies and multiple APs. Note the co-channel interference on channel 1.

Keep the tools ready for Problems

Periodic checks and monitoring can avoid problems, but be prepared for a client with little or no throughput. Tools can quickly verify the RF link for signal level, PER and interference. The tools can help debug a new interfering AP a neighbor has set-up or to find the antenna that has been knocked over.

A directional antenna and receiver are very useful for locating interference or even an unauthorized user or stolen equipment. The directional set-up shown in figure 2 can be used to direction find a node with a specific MAC address.

Summary of tools and techniques

A microwave oven, a client with slightly weak signal strength or another interferer with short transmissions should not bring down the network or significantly degrade performance. The guidelines presented here are conservative, aim for them when planning and setting up a network. An outage or a drop in performance will justify the cost of WLAN RF test tools.

A laptop with an 802.11b card is a good test tool and may be adequate for small installations and maintenance of small systems where interference is not significant. For larger installations and maintenance or in areas with significant interference, a tool or set of tools with the following characteristics is recommended:

Spectrum Analysis: sensitivity at least -90dBm, with peak hold, and data logging is a plus. Best used to check for and measure interference of any type.

Demodulation Analysis: Signal strength (measured in dBm is a plus), PER, and scanning of multiple channels is a plus. Best used to measure 802.11b interference, coverage of APs, channelization and co-channel interference.

Directional antenna: Can be used to locate interference or an unauthorized user.