Applying RF CAD Modeling to Wireless System Design

This paper from Connect802 Corporation, explains how Computer Aided Design (CAD) is applied to the task of creating an accurate, cost-effective Wi-Fi wireless system design. It will be shown why a typical “site survey” produces results that are either inaccurate, over-priced, or both. It will then be shown how RF engineers apply CAD modeling and simulation software to the design process to enhance the accuracy and cost-effectiveness of a Wi-Fi design.

Proper Design for a Wireless Network

If you’re going to implement an indoor Wi-Fi network, the walls, doors, shelving, and other parts of your building will affect the way radio signals travel. Outdoors, trees, buildings, and other obstructions can get in the way. You don’t want “dead spots” and areas of weak or intermittent coverage to cause problems and, unless you have an unlimited budget, you don’t want to install an excessive number of access points in hopes of curing potential problems. A properly operating Wi-Fi system begins with a proper design.

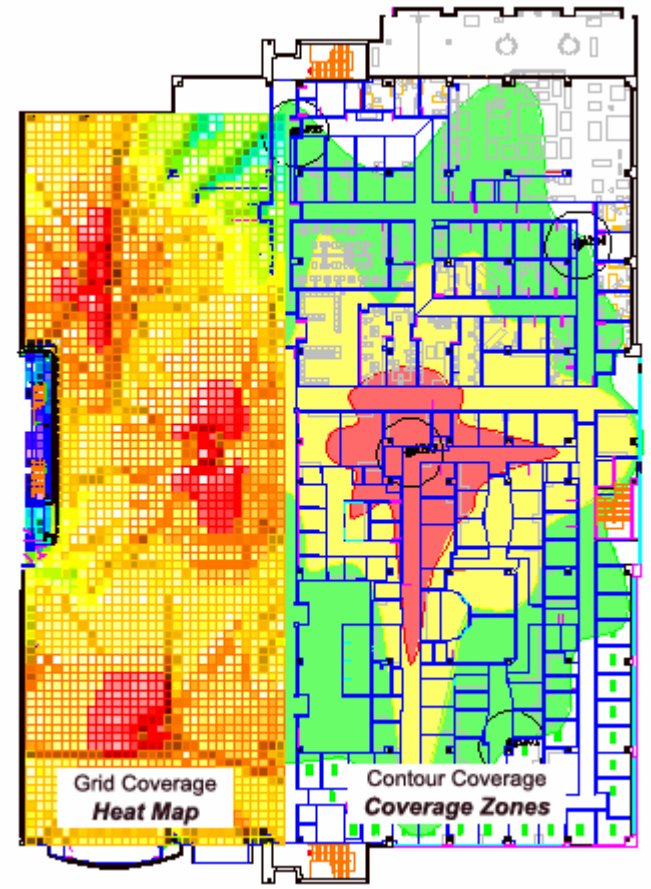
Problems with an On-Site Survey

In the past, creating a design for a Wi-Fi network involved having an engineer come out to your site and walk around, placing test access points in various locations and measuring the resulting signal coverage. At best, this method is incomplete because the person on-site will not measure the results in every corner of every room, and at every point down every hallway. The outcome is that problems arise after the network is installed an in use. At worst, the limitations of an on-site survey result in a design with far more access points that are necessary as the designer compensates for the inability to make complete measurements by over-provisioning the network. An excessive number of access points increases the equipment and installation costs. The unnecessary radio signal levels produced by having access points too close together results in co-channel interference and reduced data throughput.

Computer Aided Design Methods

Engineers in many industries have long used computer modeling to aid in the creation of accurate designs. As early as 1963, commercial Computer Aided Design (CAD) systems were available in the automotive and aerospace industries. Electronics engineers have, for many years, used CAD simulation to develop chip and circuit designs. RF equipment developers have been using electromagnetic modeling systems to create new types of antenna systems, tuning and adjusting them before producing an actual prototype. Before a cellular telephone company spends up to a quarter-million dollars building a cell tower on a hillside, they have validated the location using CAD modeling. Today, the proliferation in the growth of wireless network technologies has moved RF CAD modeling and simulation into the realm of Wi-Fi system design.

The Application of RF CAD Modeling and Simulation



On the right is a building floorplan into which seven virtual access points have been placed. On the left is a Grid Coverage overlay showing the signal levels on the building floor. Red is “hot” and blue is “cool” (ranging from -40 dBm to -95 dBm.) This is commonly referred to as a “heat map.” On the right is a Contour Coverage model, depicting signal strength coverage zones. Red is very strong (> -50 dBm), Yellow is excellent (maximum bit-rate connectivity), and Green is the minimum usable level (1 Mbps 802.11b).

When creating an RF CAD design the RF engineer formats the building walls and structures, assigning RF attenuation and reflection characteristics to each. Then the engineer chooses from a pre-existing library of manufacturer’s equipment which includes radios, antennas, and other pieces of equipment. New equipment can be created and added to the library as it becomes available.

The model can be studied in 2-dimensions (as shown above) or it can be rotated into a 3-dimensional view to study the way RF signals behave in space. For example, in a retail store with merchandise racks, an employee using a hand-held inventory scanner may experience a very different RF environment when they’re scanning merchandise close to the floor, as opposed to merchandise that’s 5 feet (or more) above the floor. A user of a wireless VoIP telephone may be sitting in a chair, standing, or riding an escalator up to the second floor of a store. In these and other cases, the requirement to evaluate a design in 3-dimensions becomes critical to accuracy and suitability.

The actual modeling and design process takes place in real-time. The RF design engineer moves access points and antennas in the virtual building and, as they are moved, the engineer observes the signal coverage results changing. In this way, the optimal installation location (and antenna orientation for directional antennas) can be determined.

Using CAD Modeling in Conjunction with an On-Site Survey
The inefficient, potentially inaccurate and costly way to implement a Wi-Fi system is to start with an on-site survey. This is not to suggest that on-site analysis is completely excluded from every design process. Rather, starting with on-site work is like starting the design of a new airplane by strapping some wings on your back and jumping out of the barn to see if the wings work. The right way to start designing a Wi-Fi system is to create a CAD model of the intended installation location and simulate the performance of the proposed radio equipment. Then, if the installation is sufficiently complicated, an on-site validation of the CAD model can be performed. In this case, the on-site survey is not based on an engineers “best guess” as to where equipment should be placed. Instead, the engineer confirms that the model is correct.

In the CAD design, 100% of a buildings floor space can be evaluated. 100% of dead spots or weak coverage areas can be identified. The fact that an on-site survey can’t measure 100% of the building is compensated for by the complete assessment performed in the CAD model, with on-site verification and validation confirming the accuracy of the design. In fact, roughly 85% of commercial buildings have characteristics that are well known. Architectural design and construction methods create categories of buildings that have very consistent effects on RF signal propagation. This, coupled with the testing that’s been performed in the industry to ascertain the RF characteristics of building materials makes it possible to complete many in-building designs without a final requirement for a pre-installation on-site validation. Confidence in the CAD modeling process is sufficiently high that typical Wi-Fi system projects can move into the installation phase based solely on the CAD model. On-site validation during the installation phase is a simple, quick, and straightforward process.

Conclusions
As the Wi-Fi wireless network market grows, the need for small- to medium-size business to implement commercial-grade wireless networks grows with it. Requirements for handheld device connectivity, wireless Voice-over-IP, and radio tagging of merchandise (RFID) push the requirements for a business-class Wi-Fi system well beyond simply checking email and surfing the Web.

Performing an on-site survey as a primary or sole method of developing a wireless network design may have been suitable in the past for simple networks supporting simple applications. Today, the integration of RF CAD modeling and simulation in the Wi-Fi design process provides the accuracy and cost-effectiveness that is required to meet expanding wireless system requirements.

RF CAD design considers 100% of a buildings floor space, unlike the on-site survey which can only provide “spot” measurements in a subset of the overall coverage area. Because of this, the use of an excessive number of access points is avoided thereby reducing equipment and installation costs and reducing co-channel interference.

Any Wi-Fi wireless network that's going to impact a company's revenue stream, either directly or indirectly, must have a commercial-grade design and must use commercial-grade equipment. Business-class wireless networks are properly designed through the integration of RF CAD modeling and simulation.

Wireless Data Solutions

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