Strategies for Increasing Cell Reception Inside Properties: Why Wireless Phones/Devices Don't Work Inside Buildings

By Jim McCoy ■ *InnerWireless*

Wireless is becoming the preferred mode of connecting with people and information. It delivers both professional and personal productivity, connectivity, and security, even in traditionally wired indoor environments like business offices. But buildings present unique barriers to wireless signals—particularly those coming from outside. Materials, construction, design and height all combine to compromise reception and signal quality in buildings, and make users unable to realize the "anytime, anywhere" promise of wireless services.

The heart of the problem lies in the fact that radio frequency (RF) signals are either weakened or blocked by any object they encounter. RF signals can't effectively penetrate buildings because construction materials act as a barrier, resulting in inconsistent or even nonexistent wireless coverage and service indoors.

Metals completely reflect RF signals. Dense materials such as concrete, rock, and packed earth have high attenuation – or reduction – values. As little as three inches of concrete can attenuate a signal to less than 10 percent of its original value, and the attenuation increases dramatically with thickness. The metallic thermal energy coating on glass exteriors of modern office buildings can block up to 99 percent of the RF signal. Even soft objects like interior walls can attenuate signals up to 50 percent.

Compounding the RF signal loss caused by building materials is the sheer number of cellular and PCS sites. Wireless devices often receive too many competing, weakened signals in buildings, resulting in interference. This phenomenon particularly applies above the tenth floor of office buildings that are looking down onto tens or hundreds of cell sites. It explains why one often sees "five bars of coverage" on a wireless device, but the call is garbled or is quickly dropped.

What Wireless Services Are Used In Commercial Office Space

For many years property managers have relied on hand-held two-way radios for maintenance, operations, and security. These seemingly simple functions become much more sophisticated as higher levels of service are expected, greater productivity and communication is needed, and the available two-way radio spectrum becomes crowded.

Enterprises have become increasingly dependent on wireless technologies over the last 20 years. Prior to the early 1980's the primary enterprise use of wireless was for dispatch – taxicabs and construction materials delivery trucks. Today, virtually every enterprise, regardless of business type, relies on a communications fabric with some combination of paging, two-way paging, wireless email, cellular, PCS, data, and or location tracking services to run their business. While some businesses integrate their enterprise applications to run over the wireless service, most businesses rely on wireless services to quickly communicate among key business functions.

Individuals have embraced the efficiency of wireless communicating into their lives on all fronts – work, family, and leisure. Fifty percent of us keep at least one wireless device with them throughout the day and greater than 40% report using the devices for both business and personal reasons while located at their workstation or office area.

Wireless has recently become a driving factor in the perception of safety. Individuals now want their mobile phones to be dependable in emergencies – both in-building and on the road. Tenants have expectations that the property manager's two-way radio services work everywhere throughout the building. After September 11, 2001 enterprise tenants, as well as individuals, clearly understand that emergency services personnel can not do their jobs if their two-way wireless communications don't work everywhere throughout the building.

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What are 2G, 2.5 G And 3G?

The history of the domestic wireless networks actually begins prior to cellular. The early days of mobile wireless communications were defined by "radio telephones". These "generation zero" networks were little more than a high-power vehicular mounted two-way radio with an operator standing-bye on the other end to literally connect you to a "land-line" via an old fashion "patch panel". The cellular networks of the early/mid 1980's are now looked upon as the "first generation" (1G). They were based on analog technologies (AMPS) and the networks were designed for "car phones". More importantly they introduced the technique of deploying the tower site antennas such that coverage was deliberately limited to a prescribed "cell". By limiting coverage to a cell, an alternating pattern of cells could be established whereby the available frequencies were re-used thus increasing the overall call handling capacity.

As competition increased and pricing decreased, adoption rates shot up. In the late 1980's / early 1990's wireless carriers faced a capacity problem. Capacity was created when the FCC auctioned PCS spectrum at the 1900 MHz frequencies and technology improved with the availability of digital protocols – TDMA, CDMA and GSM, with more voice channels per radio channel than analog technology. The digital networks that are widely deployed and used by most of us today are considered "second generation" (2G). The digital technology allowed the user devices to shrink and become "personal phones" instead of "car phones".

The terms 2.5G and 3G are widely used and often misused. Some countries have created standard definitions for these terms as a matter of public policy in conjunction with the auction of new spectrum for the wireless Operators. In those countries the definition includes both the frequency for the service and the minimum acceptable set of functional features that the Operator must offer. For example they would not be allowed to use the new frequency to only offer voice service. In the USA the FCC has been unable to allocate any additional spectrum for advanced services but continues to allow the domestic Operators to upgrade and re-provision their networks to offer next generation services.

In the USA 2.5G networks refers to the upgrades to existing digital 2G networks to allow greater call capacity, and higher speed "connectionless / always on" access to the Internet, enhanced messaging, and enterprise intranet resources. Depending on the specific network technology the speed will increase from approximately 10 Kbps to somewhere between 40 Kbps to 140 Kbps. With this increase in speed the wireless carriers can offer new voice and data applications.

The objective of "third generation" (3G) networks is to deliver services at speeds equivalent to T1/E1 landlines (1.5 to 2 Mbps) and some wired LAN Internet/intranet. It is believed that this will spawn a whole new variety of applications unique to the mobile user.

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Are 2.5 and 3G Going to Work Better In-Building Than 2G?

2.5G and 3G network roll outs are currently focused on the wireless carriers' outdoor "macro-networks". New generation services will not work better in-building than 2G or analog. In fact, they will require better signal quality than voice. The previously mentioned RF signal penetration and competing cell site issues will continue to exist with next-generation wireless services, but the impact on service effectiveness and quality is aggravated. New higher-speed data or converged services will not be as tolerant of high bit error rates (BER) in the wireless link as current low-speed voice centric services. When high bit error rates in a voice link result in a minor loss of fidelity, users often encounter "garbling". Unless BER is reduced by a significant factor, data centric applications will either "hang" spending all of their time in endless re-transmission cycles or the link's transmission speed will be reduced such that the BER becomes acceptable.

How Is WLAN Different From Other Wireless Services

Wireless local area networks (WLANs) are different than cellular/PCS because they operate at a much higher speed (11 Mbps vs. 9.6 Kbps) and at a higher frequency (2400 MHz vs. 1900 MHz), and are required to operate at lower power levels (less than 0.1 watt vs. "tens" of watts). Most significantly, WLANs operate in unlicensed spectrum. Unlicensed means that deployments are not explicitly "coordinated". Wireless network deployment in licensed spectrum is always explicitly coordinated to minimize interference caused by multiple parties reusing the same frequencies. The presumption regarding unlicensed spectrum made by the FCC is that no one type of device or service becomes widespread enough to require explicit coordination.

The number of corporate WLANs and public "hot spots" are growing rapidly. Design and deployment techniques often don't consider the many tradeoffs of coverage, throughput, available channels, access point handoffs, and security. Many WLAN (IEEE 802.11 b) deployments use a large number of access points to ensure good RF coverage within the enterprise office space, but they don't evaluate the effects of RF interference or spillover of the RF signal to undesired areas.

How Is Wireless Coverage Provided In-Buildings

Consider the difference between the statements "how is wireless coverage provided in buildings?" and "how can wireless coverage be provided in buildings?" The first questions the current state of network deployments. The second questions the viable options that may or may-not actually be in place today.

The generalized answer to the first question is that coverage is presumed to exist inside buildings from the external antenna sites. In many cases with small buildings this presumption is accurate. In most cases with larger buildings it is only partially true because the building blocks the signal to varying levels depending on the user's location in the building. Most two-way radio systems used by building owners include dedicated in-building repeaters/antennas. A very limited number of enterprises with sufficient purchasing leverage have convinced their preferred service provider (cellular/PCS or paging) to dedicate a system to their building or campus.

In-building wireless coverage can be achieved with; existing external antenna sites given sufficient power levels, dedicated external micro-cell sites with antenna coverage optimized to the building, donor antenna / repeater combination to bring the external signals inside, dedicated micro-cell internal to the building with in-building distribution antennas, or dedicated pico-cells to fill in each coverage "dead spot". For reasons stated earlier, if the building still has coverage problems, the first two strategies have already proven themselves ineffective. The remaining alternatives are discussed below.

The donor antenna / repeater combination strategy to bring the external signals inside can provide coverage in small to mid-size spaces provided the external donor cell site has sufficient capacity. If it doesn't, then the in-building users will continue to experience dropped and blocked calls even though the coverage has been improved. This strategy is also viable for bringing public emergency services signals into areas of a building that need coverage enhancement (e.g. an underground parking garage or the floors above the 21st level).

A dedicated micro-cell inside the building with properly optimized in-building distribution antennas is the most robust strategy. The micro-cell equipment allows the service provider to scale the available capacity to match the needs of the users and matches the signal levels to the distribution challenges of the specific building.

Dedicated pico-cells also provide capacity but are not scalable in capacity or signal levels, and are often limited to use a pre-configured antenna. Therefore, the service provider must normally choose between very poor average utilization of resources (if an entire building is covered by an array of pico-cells) or to fill in individual coverage "dead spots".

Why Single-Service Point Solutions Are Not Optimal

Today, individual consumers and businesses have a wide selection of choices for wireless services. In all major US cities there are at least 6 cellular/PCS providers, 2 wireless email providers, 3 paging providers, and the full array of two-way radio and WLAN services to choose from. Protocol choices abound as well. TDMA, GSM, CDMA, iDEN, GRPS, CDPD, and 802.11 are available today with more scheduled for introduction during the next three years. With choice readily available nearly one-third of all wireless users change services every year. Any in-building coverage solution that is protocol-specific is positioned for obsolescence the day it is installed. Attempts to provide multiple in-building coverage systems independently are fraught with problems. Single service solutions are always optimized assuming stand-alone operation. Once installed in close proximity to each other interference issues arise. Also the simple logistics issue of finding space, power, and cabling for multiple providers' equipment and multiple sets of antennas make this approach impractical.

A New Breed Of Broadband, Multi-Purpose In-Building Solutions

A new generation of "future-proof" in-building wireless technologies and products are available that simultaneously support a wide range of wireless voice and data services and protocols – including 2G, 2.5G, and 3G cellular/PCS, WLAN, paging, and two-way radio – over a single, broadband wireless in-building infrastructure. This new breed of solution does not rely on ever increasing electronics complexity. Instead it relies on the inherent broadband nature of passive RF technology. Active electronics are used only where they are essential and only in manners whereby they remain completely unobtrusive to the signals. It is not based on finding the best way to deploy a fixed configuration of electronics boxes. Instead it is based on uniquely designing the optimum distribution of antennas to fully meet the coverage and capacity delivery objectives for multiple wireless services.

These new products deliver higher performance with lower life cycle and

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total cost of ownership than legacy or stand-alone systems. Upon installation they support current frequencies and technologies and allow for migration to new ones while continuing to support legacy services and protocols. These products are tailored for application in commercial offices, campus (corporate and academic), large shopping malls, airports, and convention centers.

802.11b WLAN deployments can be more effective when IT designers collaborate with RF designers and utilize an in-building wireless distribution solution. Today, IT designers deploy WLAN access points throughout each floor of a building to ensure coverage and capacity objectives. With today's new breed of wireless distribution solution access points for a floor can be centrally clustered and interconnected to the distribution system. This simplifies WLAN access point management and gives all users within the coverage area benefit of the total throughput of the combined access points.

Benefits to Property Managers / Building Owners

Tenant satisfaction and property differentiation are key factors in tenant retention and the ability to attract new tenants. With growth in wireless use inside buildings and today's inconsistent user experience comes the opportunity for the manager / owner to take a leading role in facilitating solutions. Managers / owners that bring this new breed of wireless service infrastructure to their properties will enjoy a real differentiation from all other competing properties. While tenants may not understand the technology they readily understand the benefits.

The ability to use the solution for their own wireless needs is a direct benefit to the manager / owner. Maintenance, operations, and security groups can take advantage of newer more efficient technology since they won't be tied to a single purpose radio repeater. Also, the manager/ owner can be prepared to provide access to fire/police agencies as new city ordnances take effect.

The CLECs and BLECs debacle will not be repeated. Each of the xLECs installed their own infrastructure throughout buildings which has now been abandoned due to changed business conditions. The new broadband in-building wireless products are not prone to obsolescence or lack of use because they provide equal access to all wireless services due to their inherent frequency and protocol independent nature. Clearly, these broadband passive RF distribution solutions are the only choice for a usable, future-proof infrastructure.

Other benefits include: installations with no visual signature – completely above ceiling; all service provider electronics equipment installed inside the main telecom room; no space or power requirements in telecom closets on each floor; no need for ongoing access to tenant space for maintenance or for upgrades; no inbuilt wear-out or failure mechanisms; no interference with other infrastructure – signal levels are kept low; and, all upgrades and changes in service by the service providers occur in the main telecom room.

Another benefit is that a broadband solution which includes WLAN minimizes the need for tenants to pull their own WLAN wiring. This can significantly reduce wiring clutter in the tenant plenum spaces.

The ultimate benefit is the ability to equitably share the cost of the broadband infrastructure among all the beneficiaries – wireless service provider, enterprise tenant, building owner, and more.

Conclusion

Equal in importance to the availability of these new products is awareness. Property managers and owners, enterprise communications professionals, and even the wireless service providers must be aware that these new solutions for wireless in-building issues exist. With this knowledge they can change the wireless status quo.

The answer to strategically solving wireless issues for in-building users lies in bringing the RF signal sources into the building and then distributing them via a single broadband in-building wireless infrastructure. Collectively, we can bring wireless services into our offices and work environments. ■

About the Author

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