WHITE PAPER

DEPLOYING HIGH CAPACITY WIRELESS LANS

Since the ratification of the first 802.11 standard in 1997, the landscape for wireless LANs has undergone dramatic changes. Initially a technology for non-bandwidth-intensive applications in vertical markets, today, wireless LANs provide far greater performance, are found in a wide range of applications, and are used virtually everywhere---from homes to public areas to offices.

This increase in performance and applicability is only the beginning. Developing commercial and technical trends promise to provide far greater wireless LAN performance, which will in turn allow for a broader array of applications and services. Increasing economies of scale, robust competition, and more refined process technology will significantly lower the cost of wireless LANs, which will in turn lead to a dramatic increase in the number of wireless LAN users, particularly in the enterprise.

The challenge for IT professionals is to deploy an infrastructure that takes full advantage of increasingly capable wireless LAN clients and provides the capacity required to meet the performance needs of an ever-increasing user base. This document provides IT professionals with a high-level understanding of:

- The evolving capabilities of wireless LAN clients, and how these capabilities are instrumental in meeting both per-user and aggregate bandwidth requirements
- How only a dual-band wireless LAN infrastructure can deliver the capacity necessary to address the growing popularity of wireless connectivity
- The issues inherent in deploying a dual-band infrastructure, and how operation in 2.4- and 5-GHz both simplifies and complicates these deployments
- How IT professionals can successfully deploy and maintain a wireless LAN infrastructure that will meet the needs of an evolving user base

THE EVOLVING WIRELESS LAN CLIENT---BACKGROUND

The first wireless LAN standard, the 802.11 standard that was ratified in 1997, allowed operation in the unlicensed 2.4-GHz portion of the radio frequency spectrum and provided for up to 2 Mbps of aggregate data rate operating on a channel measuring 22 MHz wide. While this level of performance was insufficient for office applications even then, it did represent a significant performance increase relative to earlier proprietary implementations. Two years later, the 802.11b standard delivered a five-time increase in performance to an “Ethernet-like” data rate of 11 Mbps, and set off the dramatic increase in wireless LANs in homes, in public areas, and in an increasing number of markets like education and healthcare. Another five-time increase was provided by the 802.11g standard ratified in 2003. Using the same 22-MHz-wide channels and operating in the same 2.4-GHz band as 802.11 and 802.11b, 802.11g delivered up to a 54-Mbps data rate and backward compatibility to the preceding 2.4-GHz standards.

It should be noted that in order to provide this backward compatibility to 802.11b, 802.11g invokes “protection mechanisms,” which have the negative impact of decreasing throughput from about half that of data rate (as is typical for 802.11 technologies) to around 14 Mbps when operating at a 54-Mbps data rate.

This 2.4-GHz band is in some respects a victim of its own popularity. Increasingly, ubiquitous technologies like Bluetooth and devices like cordless phones all share this narrow band with wireless LANs, leading to crowding, interference, and performance degradation. Depending upon local regulations, the 2.4 GHz band measures between 83 and 96 MHz wide, limiting the band to no more than three nonoverlapping channels.

A limited number of available channels results in limited network capacity. When access points set to the same channel are within range of each other, they become mutual interferers, degrading the performance of each device. This relatively small number of channels and resulting cochannel interference limits wireless LAN capacity when operating in the narrow 2.4-GHz band.

Absent from this discussion thus far is the 802.11a standard. While ratified at the same time as 802.11b, 802.11a has achieved a small fraction of the unit sales of 802.11b or even the much more recent 802.11g standard---despite the fact that 802.11a provides the same 54-Mbps data rate of 802.11g. This relative lack of acceptance is due in large part to the standard's lack of backward compatibility, a critical capability provided by both 802.11b and 802.11g.

802.11a's lack of backward compatibility is due to its operation in the 5-GHz, not 2.4-GHz, portion of the radio frequency spectrum. The 5-GHz band brings with it both regulatory advantages and physical disadvantages relative to the 2.4-GHz band. While regulatory bodies like the FCC and ETSI have provided a small amount of license-free spectrum in the 2.4-GHz band, they have provided a great deal of license-free spectrum at 5 GHz. Today, the FCC provides 300 MHz of license-free spectrum at 5 GHz, with an additional 250 MHz planned in 2005. In Europe, a similar amount of license-free spectrum is *already* provided in the 5-GHz band. With the same 22-MHz channel width as other 802.11 technologies, 802.11a operating on 5 GHz provides for as many as 19 nonoverlapping channels compared to the three channels available in 2.4 GHz.

On the other hand, devices operating in the 5-GHz band have a fundamental disadvantage relative to 2.4 GHz in terms of range and resulting coverage area. There is an inverse relationship between frequency and signal propagation---as frequency increases, range decreases. Early 802.11a devices suffered from both the laws of physics and the shortcomings inherent in any first-generation product, resulting in range significantly less than 802.11g devices that provide the same nominal data rates (see Table 1).

Table 1. Comparison Between Different Wireless LAN Standards

Standard	Maximum Data Rate (Mbps)	Typical Throughput (Mbps)	Operating Band	Maximum Available Channels	Capacity (Mbps)	Compatibility
802.11b	11	5	2.4-GHz	3	33	802.11b
802.11g	54	14	2.4-GHz	3	162	802.11b/g
802.11a	54	25	5-GHz	19	1,242	802.11a
802.11a/g	54	25 and 14	2.4- and 5-GHz	22	1,404	802.11a/b/g

Note: Only devices that support both 802.11a and 802.11g provide backward compatibility and a substantial increase in network capacity.

THE EVOLVING WIRELESS LAN CLIENT---THE FUTURE

The limitations of 802.11b and 802.11g are already being encountered, as IT professionals deploy infrastructure in multitenant and multifloor buildings. Channel reuse patterns are complicated, and interference from adjacent access points is inevitable given the small number of available 2.4-GHz channels. As the number of wireless users increases, the available bandwidth is taxed, which limits performance and the sorts of applications that can be supported.

Few organizations are willing to abandon the investment they've already made in these technologies, making 802.11a nonviable *on its own*. To address this seeming conundrum, the wireless LAN community has learned from both radio and television. In much the same way as radio added the FM band to the legacy AM band and television added the UHF band to the legacy VHF band, the wireless LAN industry is set to make a 2.4- and 5-GHz architecture the norm. This dual-band architecture provides both backward compatibility with associated investment protection and a large number of available channels with associated high capacity.

Already, this migration to a dual-band architecture is underway. Client adapters that support 802.11a, 802.11b, and 802.11g are becoming the norm. Typically, these client devices prioritize their 802.11a radio, meaning that the device will first scan the 5-GHz band for an available 802.11a access point to which it may associate. Only when an 802.11a access point is unavailable will the client then scan the 2.4-GHz band for an 802.11g or, failing that, an 802.11b access point.

Equipped with greatly improved 5-GHz radios, these devices address the shortcomings of earlier offerings, providing 802.11a range that is quite similar to that of 802.11g. Similarly, process engineering has integrated many functions into a decreasing number of components---dual-band client adapters consume only a marginally greater amount of power and are available with only a modest price premium relative to single-band predecessors. While the installed base of wireless LAN clients promises to be largely single-band 802.11b for some time, the trend for new client adapters indicates that a majority of installed clients will have dual-band capabilities as early as 2007.

DEPLOYING AN INFRASTRUCTURE FOR TODAY---AND TOMORROW

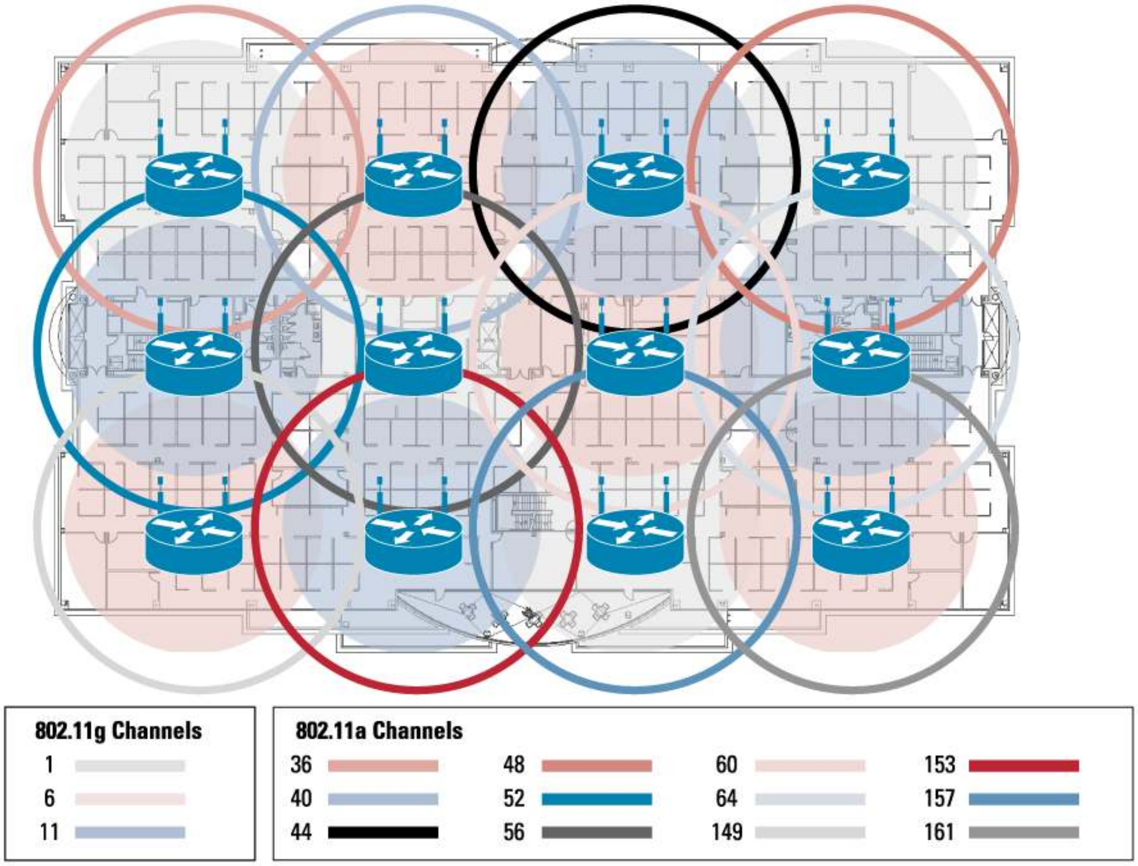
Investment protection is a crucial consideration for most technology purchases today. The key is to deploy an infrastructure designed to meet the needs of not only the current user base, but also the far larger one expected in the near term. This “future proofing” requirement is acute for wireless LAN infrastructure devices, which are often installed in remote locations that are difficult and expensive to access and reaccess. The cost of installing an access point can easily rival the cost of the access point itself.

To address this requirement, Cisco Systems® has delivered two new access points, both of which provide the backward compatibility of 802.11g with the high capacity that’s unique to 802.11a. The Cisco Aironet® 1230AG Series is well-suited for more challenging environments such as warehouses and retail spaces, with support for a selection of antenna gains and beam widths, a cast-aluminum housing, and support for extended environmental conditions. The Cisco Aironet 1130AG Series is ideal for office environments, offering an unobtrusive design and integrated antennas designed for typical office installations.

A high-capacity deployment involves minimizing channel interference between access points. For dual-band access points, this goal is no different. A site survey should be conducted to determine optimal placement of access points and to characterize coverage. However, with dual-band access points, for most installations, this effort need only be done once under the channel constraints of the 802.11b/g network. The 802.11a radios in the access points can then be enabled, with up to 19 access points being set to unique channels before channel interference becomes an issue.

A dual-band deployment may look like the deployment shown in Figure 1.

Figure 1. A Sample Dual-Band Deployment



In this example, a site survey is conducted to optimize the 2.4 GHz (802.11b/g) network, depending on the required coverage and throughput requirements. The number of 802.11b-only and 802.11g-only clients should be factored in, as these clients will be using the 2.4-GHz network. For some networks, this number can be expected to decline over time, since client devices like laptops and handhelds will be replenished with dual-band capable devices (which will use an available 5-GHz channel a priori, as discussed previously). Because only three nonoverlapping channels are available in the 2.4-GHz band, interference from adjacent cells must be considered. This interference is generally compensated for by reducing the transmit power of the radios.

With the 802.11b/g network designed, deploying the 802.11a network can simply consist of configuring each 802.11a radio to a unique 5-GHz channel. In most cases, no second site survey is needed. Since there can be up to 19 channels in the 5-GHz band, up to 19 802.11a radios can be enabled before interference is encountered. For networks with more than 19 access points, interference must be considered, but its impact should be negligible---signals will fade before cochannel interference is encountered. In most cases, the 802.11a radios can be deployed at maximum transmit power without causing cochannel interference. If the deployment density is such that cochannel interference becomes relevant, then the transmit power of the access points should be reduced to minimize interference.

CONCLUSION

Today's dual-band access points provide both the incentive and the mechanism to transition to high-capacity wireless LANs. Available for a negligible premium over 802.11g-only access points while providing critical backwards compatibility, dual-band access points also deliver 802.11a capability, offering twice the capacity of single-band access points. In a multiple access point deployment, even greater relative capacity is attained, as the abundance of available channels in the 5-GHz band results in less interference and less throughput degradation. Further, deploying dual-band access points can be no more involved than deploying an 802.11g-only network as the availability of up to 19 channels in the 5-GHz band greatly simplifies channel reuse planning. The demand for wireless access will only increase over time, as devices continue to become wireless-enabled. Dual-band access points deliver, today, the capacity required to meet this demand.

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