802.11n Wireless Technology Overview

Deploying the Next Generation of High Performance Wireless

Introduction

In less than a decade, wireless LANs have evolved from an interesting idea to an indispensable technology for millions of businesses and consumers. This technology continues to evolve. The latest generation of high-speed wireless LAN solutions, based on the Institute of Electrical and Electronics Engineers (IEEE) Draft 802.11n standard, are now available.

The 802.11n standard will offer several advantages over previous wireless LAN technologies. The most notable advantages are substantially improved reliability and greater application data throughput. However, before deciding whether to deploy 802.11n wireless solutions, organizations need answers to several questions: What do 802.11n technologies do differently from previous wireless solutions? What is the state of the standardization effort for 802.11n? Will 802.11n be backward-compatible with currently deployed wireless clients and access points? What factors should be considered to determine when it makes sense to deploy 802.11n?

To help you make more informed decisions about 802.11n, this overview provides answers to these and other questions. The overview also provides details on the state of 802.11n technology today, and discusses the reasons why Cisco Systems® is taking an incremental approach to the new standard. Finally, the overview introduces the Cisco® Aironet® 1250 Series Access Point—a modular enterprise-class access point that is Wi-Fi certified to the 802.11n draft 2.0 standard and provides investment protection to support future high-speed WLAN technologies.

The Emergence of 802.11n

Today's 802.11a/b/g wireless networks have provided a powerful tool for increasing the mobility and productivity of users, and have unlocked a new generation of wireless-enabled applications. However, as wireless applications become more pervasive, the demand for greater network reliability with additional bandwidth is increasing.

The IEEE 802.11 Task Group n (TGn) has been working for several years to create a new wireless standard that will support much greater application data throughput than existing 802.11a/b/g wireless standards. The 802.11n standard is expected to deliver data rates of up to 300 Mbps per radio. (Today's 802.11a and 802.11g solutions can achieve a maximum data rate of 54 Mbps, while older 802.11b platforms deliver a maximum data rate of 11 Mbps.)

The TGn effort has progressed steadily since its inception in September 2003, but as with most complex technologies, the process of ratifying a standard takes several years. With so much interest in boosting wireless network performance and capacity, 32 different proposals were submitted initially, and the task group has struggled to agree upon a single proposal to develop into the standard.

In October 2005, Cisco and several other companies formed the Enhanced Wireless Consortium (EWC) to help break the deadlock and accelerate the 802.11n standard development process. The EWC created a new proposal, and in January 2006, the IEEE voted to accept it as the basis for

the 802.11n standard. Technology providers across the industry have raced to put 802.11n solutions into production, and devices based on the second draft of the proposed standard have now begun to enter the market.

The State of 802.11n Today

The next-generation of wireless LAN technology is now moving forward, but organizations should recognize that 802.11n is still a draft standard. The final details of 802.11n are still under discussion, and TGn is not expected to ratify the final standard until 2H 2008. The Wi-Fi Alliance is using the interim IEEE 802.11n draft 2.0 as the baseline for the initial round of Wi-Fi certification and compatibility testing that began in June, 2007. Businesses considering 802.11n should weigh the option of whether to deploy today or wait for the standard to be ratified. The 802.11n solutions entering the market now are based on the draft proposal, not on a ratified standard. The industry is working aggressively to try to ensure that existing 802.11n draft 2.0 products will be able to be software upgraded to the final 802.11n standard. However, there is no guarantee that this will be the case. While the hope is for existing products to be able to be software upgraded to the final standard, Cisco is using platform modularity to ensure that in the event a hardware change is required that this only affect the radio modules as opposed to requiring a complete access point change.

How 802.11n Technology Works

Current wireless solutions operate in the 2.4-GHz radio frequency band (802.11g and 802.11b) or the 5-GHz radio band (802.11a.). Solutions based on the 802.11n standard will operate in the 2.4-GHz, the 5-GHz radio band, or both bands, offering backward compatibility with preexisting 802.11a/b/g deployments. The majority of Wi-Fi devices and access points hitting the market are dual-band – operating in both the 2.4-GHz and 5-GHz frequencies. The net result for business will be a shift to greater utilization of the 5-GHz band with 802.11n given the greater available capacity and cleaner frequency.

Wireless solutions based on the 802.11n standard employ several techniques to improve the throughput, reliability, and predictability of wireless LANs. The three primary innovations are:

- Multiple Input Multiple Output (MIMO) technology
- Packet aggregation
- Channel bonding (40MHz Channels)

Together, these techniques allow 802.11n solutions to achieve an approximate fivefold performance increase over current 802.11a/b/g networks.

MIMO Technology

802.11a/b/g wireless access points and clients communicate through a single spatial stream over a single antenna. 802.11n access points and clients transmit two or more spatial streams, and employ multiple receive antennas and advanced signal processing to recover the multiple transmitted data streams. MIMO-enabled access points use spatial multiplexing to transmit different bits of a message over separate antennas, providing much greater data throughput and allowing for more robust, resilient wireless LANs. Whereas previous wireless technologies had problems dealing with signal reflections, MIMO actually uses these reflections to increase the range and reduce “dead spots” in the wireless coverage area.

Ultimately, 802.11n networks that incorporate both MIMO-enabled access points and MIMO-enabled wireless clients will deliver dramatic gains in reliability and data throughput. However, even when MIMO is deployed only in wireless access points, the technology still delivers significant performance enhancements (up to 30 percent over conventional 802.11a/b/g networks)—even when communicating only with non-MIMO 802.11a/b/g clients.

This performance gain is a result of MIMO smart antenna technology, which allows wireless access points to receive signals more reliably over greater distances (and allows clients to operate at higher data rates) than with standard diversity antennas. For example, at the distance from the access point at which an 802.11a/g client communicating with a conventional access point might drop from 54 Mbps to 48 Mbps or 36 Mbps, the same client communicating with a MIMO access point may be able to continue operating at 54 Mbps.

Channel Bonding

The most straightforward way to increase the capacity of a network is to increase the operating bandwidth. However, conventional wireless technologies are limited to transmitting over one of several 20-MHz channels. 802.11n networks employ a technique called channel bonding to combine two adjacent 20-MHz channels into a single 40-MHz channel. The technique more than doubles the channel bandwidth. Channel bonding is most effective in the 5-GHz frequency given the far greater number of available channels. The 2.4-GHz frequency has only 3 non-overlapping 20-MHz channels. Therefore, bonding two 20-MHz channels uses two thirds of the total frequency capacity. Therefore, the IEEE has defined rules on when a device can operate in 40MHz channels in the 2.4GHz space to ensure optimal performance. Cisco expects that the greatest benefits of channel bonding will be realized in the 5-GHz frequency.

Packet Aggregation

In conventional wireless transmission methods, the amount of channel access overhead required to transmit each packet is fixed, regardless of the size of the packet itself. As data rates increase, the time required to transmit each packet shrinks, but the overhead cost remains the same, potentially becoming much greater than the packet itself at the high speeds delivered with 802.11n.

802.11n technologies increase efficiency by aggregating multiple packets of application data into a single transmission frame. In this way, 802.11n networks can send multiple data packets with the fixed overhead cost of just a single frame. Packet aggregation is more beneficial for certain types of applications such as file transfers due to the ability to aggregate packet content. However, real-time applications (e.g. voice) do not benefit specifically from packet aggregation because its packets would be interspersed at regular intervals and combining packets into a larger payload would introduce unnecessary latency. Voice and other multimedia applications still benefit from other effects of MIMO.

Advantages of 802.11n

The innovative techniques and technologies employed in 802.11n result in a wireless LAN that offers several important advantages over previous wireless solutions. These advantages include:

- Greater reliability: MIMO allows 802.11n networks to provide a more robust wireless service that supports more concurrent connections. With the ability to communicate over multiple antennas and eliminate dead spots, 802.11n networks can maintain optimal performance at greater distances (even with conventional 802.11a/b/g clients) and provide an improved

user experience for high-bandwidth voice and video applications. MIMO improves the signal transmit and receive characteristics of the wireless transmission to reduce the number of packet retries resulting in a more reliable and consistent level of throughput.

- Greater throughput: The combination of MIMO, channel bonding, and packet aggregation allow 802.11n networks (employing both 802.11n clients and access points) to achieve data rates as high as 300 Mbps per radio, fully five times greater than the maximum available with 802.11a/g. However, 802.11n access points also enhance the performance of wireless clients built under previous standards. An 802.11a/b/g client communicating with an 802.11n access point will usually deliver better throughput than if it were communicating with an 802.11a/b/g wireless access point at the same range, simply as a result of MIMO technology.
- Greater coverage predictability: Enterprises are designing wireless networks for performance and MIMO provides greater throughput resulting in more predictable coverage throughout the facility. The coverage improvements extend to 802.11a/b/g clients as well as 802.11n clients. At any given location, a client connecting to an 802.11n access point with MIMO will receive greater throughput than it would otherwise receive from a traditional 802.11a/b/g access point. As a result, 802.11n networks can support more clients using high-bandwidth applications than previous wireless solutions.

Applications that will benefit most from the additional throughput, reliability, and predictable coverage of 802.11n wireless LANs include:

- Environments and applications that require sharing of large files, including anything from advanced design and engineering applications to users in a conference room collaborating on a large Microsoft PowerPoint presentation
- Voice and video applications that demand high-quality transmissions, such as video conferencing and IPTV services that use multiple streams of high-definition video
- Facilities with challenging RF characteristics including warehouses, manufacturing floors and retail locations
- Disaster recovery, backup, and storage applications

Backward Compatibility with Existing Platforms

Like today's 802.11g platforms, 802.11n networks will be backward compatible with clients built under previous 802.11a/b/g wireless standards. 802.11n wireless access points will interoperate easily in mixed environments. They can be configured to concurrently support both conventional 802.11a/b/g transmissions over 20-MHz channels and higher-bandwidth 802.11n transmission over 40-MHz channels. However, the introduction of 802.11a/b/g clients into an 802.11n network will impact overall throughput rates for the network, and decrease aggregate throughput of the access points. This impact differs depending on which type of wireless client is introduced.

An 802.11n network can incorporate 802.11a/g clients with minimal performance loss. However, as with today's 802.11g networks, operating in a mixed environment that includes 802.11b clients can substantially affect throughput. (The throughput of today's 802.11g networks may drop from 25 Mbps to as low as 7 Mbps when 802.11b clients enter the environment, and 802.11n networks will suffer a comparable performance decrease.) However, organizations deploying 802.11n have the option of configuring the network to exclude 802.11b clients on some channels or on all channels to ensure that throughput remains high.

Organizations that can benefit from 802.11n but still rely on 802.11b/g devices (and plan to continue using those devices for the foreseeable future) can plan to deploy 802.11n in mixed mode in both the 2.4-GHz frequency and 5-GHz frequency. Organizations will experience the greatest performance improvements in the 5-GHz frequency given the relatively fewer number of existing 802.11a clients, the greater availability of spectrum, and the fact that the 5-GHz frequency has less interference than the 2.4GHz frequency.

An Incremental Approach to 802.11n

With questions still to be resolved around the final 802.11n standard, organizations are understandably hesitant to leap into an 802.11n deployment. After all, there is no guarantee that networks built under today's 802.11n draft 2.0 standard will be software upgradeable to the final ratified standard. However, several factors increase the confidence that an investment made in 802.11n draft 2.0 technology today will last for the foreseeable future. The Wi-Fi Alliance certification of draft 2.0 products effectively sets the industry standard – a standard implies interoperability and the Wi-Fi Alliance, not the IEEE, has always been the body to certify interoperability. Furthermore, work that Cisco and leading client manufacturers like Intel are doing to test and validate interoperability help to ensure a seamless experience for the breadth of 802.11n draft 2.0 devices currently available on the market. As a validation of the momentum the market has gained around the 802.11n draft 2.0 standard, Gartner has modified its recommendation to enterprises. Previously, a Gartner report issued on January 26, 2006 ("Draft 802.11n Could Cause Confusion Among Wi-Fi Users"), recommended that enterprises should not rush into 802.11n deployments based on prestandard implementations of the technology, and should instead continue to use Wi-Fi certified 802.11a/b/g products for the next few years at least. However, in a report issued on July 25, 2007 ("Hype Cycle for Wireless Networking Infrastructure, 2007"), Gartner advises that enterprises requiring more bandwidth may consider Wi-Fi certified products based on the 802.11n draft 2.0 standard.

Organizations that are planning to adopt higher-bandwidth wireless applications in the future and are currently contemplating a wireless LAN implementation will want to deploy a solution that is Wi-Fi certified to the current 802.11n draft 2.0 standard, yet will provide a path to upgradeability to the final standard once ratified. To meet this requirement, Cisco is introducing the Cisco Aironet 1250 Series access point.

The Cisco Aironet® 1250 Series Access Point

The Cisco Aironet 1250 Series is an enterprise-class access point that supports the 802.11n draft 2.0 standard and has a modular design to incorporate emerging higher-speed WLAN technologies in the future (including the final ratified 802.11n standard). The platform was specifically engineered to support the power, thermal dissipation, and throughput requirements of higher-speed WLAN technologies such as MIMO and 802.11n, and its modular design makes it easy to field-upgrade radios, helping to protect wireless investments. The Cisco Aironet 1250 Series supports the 802.11n draft 2.0 standard now, and as the technology evolves, the existing radios can be replaced with more sophisticated radios offering end users more consistent throughput and improved reliability.

The Cisco Aironet 1250 Series provides:

- A modular platform: The Cisco Aironet 1250 Series supports dual radios, allowing simultaneous operation of 2.4-GHz and 5 GHz wireless networks. This provides a greater number of available channels, and therefore greater capacity and scalability.

- Full Dynamic Frequency Selection (DFS) Support: The Cisco Aironet 1250 Series is one of the only access points to provide robust compliance to the complete DFS requirements. This provides access to the entire 5-GHz frequency allowing for greater channel utilization (including the 5-GHz UNII 1 and UNII 2 bands) and greater aggregate available bandwidth.
- Field upgradability: The Cisco Aironet 1250 Series is field-upgradable, allowing organizations to swap out radios as standards, applications, and bandwidth requirements evolve. Customers can deploy high-performance 802.11n draft 2.0 MIMO radio modules now, with the confidence that their existing platform has a migration path (software or hardware) to the final 802.11n standard once ratified. The solution includes 64 MB of Flash memory to accommodate future firmware upgrades, allowing customers to deploy new wireless standards and advanced features as they emerge.
- Robust security: The Cisco Aironet 1250 Series supports 802.11i, Wi-Fi Protected Access (WPA), WPA2, and numerous Extensible Authentication Protocol (EAP) types, helping to ensure interoperability with all Wi-Fi-certified devices. These certifications support IEEE 802.1X for user-based authentication, Temporal Key Integrity Protocol (TKIP) for WPA encryption, and Advanced Encryption Standard (AES) for WPA2 encryption. When operating with the Lightweight Access Point Protocol (LWAPP), the solution also supports Cisco Unified Intrusion Detection System/Intrusion Prevention System (IDS/IPS), and integration with Network Admission Control services and the Cisco Self-Defending Network.
- Ruggedness: The Cisco Aironet 1250 Series is a rugged indoor access point designed for above-ceiling deployments or challenging RF environments such as factories, warehouses, and large retail establishments. The solution provides antenna versatility, a strong metal enclosure, a broad operating temperature range, and plenum rating.
- Power flexibility: The Cisco Aironet 1250 Series supports local as well as inline power options, including support for IEEE 802.3af Power over Ethernet (PoE) (note: 802.3af is adequate to power a single radio ONLY. To power both radios, the access point requires local power or the use of a power injector). Cisco provides a power injector and local power supply that are available for the Cisco Aironet 1250 Series and meet the higher power requirements of the 802.11n radio modules.
- Enterprise-class manageability: The Cisco Aironet 1250 operates as part of the Cisco Unified Wireless Network, an integrated, end-to-end wired and wireless environment. Unified access points can operate with Cisco wireless LAN controllers and the Cisco Wireless Control System (WCS), allowing for centralized management, rapid deployment, and self-healing capabilities. Alternatively, the solution can be configured in autonomous mode, and upgraded to a centrally managed solution if requirements change.

Investment Protection

Cisco Systems has developed a strong reputation in the industry for delivering scalable, long-term solutions that protect customers' investments. With the Cisco Aironet 1250 Series, Cisco offers investment protection in a time of evolving WLAN standards. The Cisco Aironet 1250 Series Access Point helps safeguard wireless infrastructure investments through field-upgradable radios. The current market momentum behind the 802.11n draft 2.0 standard is such that a significant change to the final standard requiring more than a software upgrade is unlikely. However, Cisco is delivering a modular access point platform to help protect the customer investment in the event that such a change be required. Customers who need to enhance the performance of their WLAN networks can confidently deploy existing 802.11n draft 2.0 solutions with a determined path to the final 802.11n standard once ratified.

As a fully 802.11n-upgradable wireless access point, the Cisco Aironet 1250 Series provides a clear, low-risk migration path to 802.11n. Organizations can deploy the Cisco Aironet 1250 Series based on the 802.11n draft 2.0 standard for higher-performance, knowing that their investments are protected. With the Cisco Aironet 1250 Series Access Point, your organization can confidently implement wireless today, without worrying about incompatibility with future wireless technologies, protocols, and standards.

Cisco Services

When integrating a wireless LAN with your wired infrastructure or migrating from an autonomous solution to a centralized one, the challenge is to design, build, and operate a secure wireless network in alignment with your business requirements that can scale with the evolving business environment.

Cisco and our Wireless LAN Specialized Partners offer a broad portfolio of end-to-end services based on proven methodologies for planning, designing, implementing, operating, and optimizing the performance of a variety of secure voice and data wireless network solutions, technologies, and strategies. Cisco Wireless LAN Specialized Partners bring application expertise to help deliver a secure enterprise mobility solution with a low total cost of ownership.

Conclusion

The high-speed wireless applications of the future may change the way people work and communicate as profoundly as the advent of wireless networking itself. However, the enormous potential of these innovations may be mitigated if the next-generation wireless technologies that an organization deploys today cannot support the standards of tomorrow.

Organizations that stand to realize the most benefit from emerging high-speed wireless technologies should seriously consider the advantages and deployment options of MIMO and 802.11n solutions. For most organizations, an incremental approach to the new standard will offer the most flexible, cost-effective, and long-lasting solution.

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Printed in USA C02-427790-00 8/07

