White Paper

Understanding the IEEE 802.11ac Wi-Fi Standard

How to prepare the enterprise WLAN

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Table of Contents

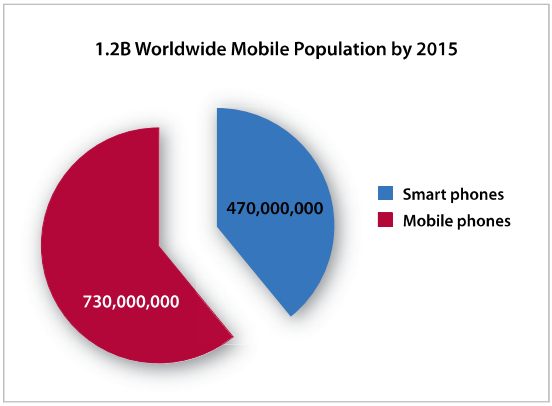
Executive Summary

IEEE 802.11ac is the next generation of Wi-Fi standard, building on IEEE 802.11n and improving data rates, network robustness, reliability, and RF bandwidth utilization efficiency. This white paper gives an overview of this emerging standard, debunks some myths, provides a view on how the technology will be introduced, and describes its importance in the enterprise network.

Introduction

Mobility Everywhere

Our society is becoming more mobile every day: approximately 85% of Americans have a cellular phone,[1] and some 38% of those have smartphones.[2] For the workplace, IDC projected that by 2013 there will be 1.2 billion mobile workers, making up nearly 35% of the workforce and using some 470 million smartphones.[3] It seems that in every area of our lives, the ability to communicate untethered is becoming more important, and people are using these devices to make calls, send email, and access the Internet and social networking applications on a daily basis. For most working adults, their phone or tablet has become an indispensible tool they carry everywhere—even to work.



The utility of these mobile devices is ideal for both personal and business use. The explosive adoption of mobile devices has been driven by several factors: (1) the availability of higher data rate wireless services for Internet access, (2) the proliferation of mobile applications (personal and business), and (3) an increase in societal mobility.

The personal mobile device has become such a part of the landscape that we are now seeing a BYOD (bring your own device) trend in the enterprise. Many of the new smartphones and tablets are dual-mode—supporting both cellular and Wi-Fi services—and have the ability to attach to an 802.11 wireless corporate network and fulfill many of the computing needs of an individual's workday responsibilities. As a result, in addition to carrying a corporate device, such as a laptop, many employees are choosing to bring to work one or more personal mobile devices to conduct their daily business tasks while also managing their personal lives. This growing demand for corporations to allow employees to use their personal mobile devices for work-related tasks is being referred to as the "consumerization of IT." IT managers are being challenged with new network design requirements brought about by this phenomenon.

1 http://247wallst.com/2010/04/23/the-cellular-market-in-the-us-is-saturated/

2 100 million smartphones out of 260 million cellular phones in North America. http://www.mobileburn.com/18862/news/america-is-now-home-to-100-million-smartphone-users-says-new-report

3 IDC, "2011-2015 Forecast"

BYOD and Bandwidth Challenges

As the number of mobile applications has grown, the increased use of smartphones/tablets has resulted in a meteoric rise in bandwidth demand. This demand is driven, to a great extent, by the popularity of streaming video on Apple iPhones and iPads. For cellular providers, this increased demand has taxed their network capacity, catching them off guard, and most are now abandoning their "all you can eat" data plans and implementing metered data plans instead. This increased demand is mirrored in the corporate BYOD context because users expect that "if it works at home, why not at work?" This new demand will also tax a Wi-Fi network to supply sufficient bandwidth, especially with newer and more powerful mobile devices coming on the market every day. Streaming video, database searches, file transfers, and voice over Wi-Fi are applications that place ever-increasing demands on a network's ability to provide consistent bandwidth. A recent report counsels:

> *For companies deploying tablets—whether provisioned to employees or part of a "bring your own" policy—evaluate your Wi-Fi implementation. As mentioned earlier, Gartner predicts that 80 percent of corporate Wi-Fi networks will be obsolete by 2015[4] and companies deploying tablets will need 300 percent more Wi-Fi capacity to be effective. The time to invest is now.*

Other analysts[5] project that, in the near future, the average enterprise worker will bring two or three mobile devices to work, which will further compound the challenge of providing adequate Wi-Fi bandwidth.

Prohibiting workers from bringing their personal mobile devices to work is not a real option, and providing ample wireless bandwidth for enterprise users is a challenge with the current Wi-Fi standards capabilities. So, how can enterprise IT departments provide sufficient bandwidth on their wireless networks while maintaining the necessary control?

The New Standard

A new addition to the IEEE 802.11 family of standards, **IEEE 802.11ac**, has been defined with the promise of delivering significant increases in bandwidth while improving the overall reliability of a wireless connection. The ultimate goal of this standard is to produce a single-radio design with wireless data rates in excess of 1 Gbps. As with previous extensions to the 802.11 standard, 802.11ac augments the standard with new enhancements while continuing to support all legacy 5 GHz 802.11 devices.

Products based on 802.11ac—able to provide reliable high data rates—will meet the challenge of supporting the new wireless bandwidth demands coming into the enterprise. This white paper introduces 802.11ac, a very high throughput wireless LAN standard, providing an overview of the new standard and its importance in the enterprise network.

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4 "IT1 – Top Wireless Issues That May Derail Your Mobile Strategy," Paul DeBeasi, 11/10/2011

5 Forrester Q2-2011, "US Workforce Technology & Engagement Online Survey," estimated up to 3.2 devices per user, and the iPass March 2011 report, "The iPass Mobile Workforce Report," estimated 2.7 devices per user would become the norm in the enterprise.

Technology Introduction

802.11ac specifies changes for both the physical and the media access control (MAC) layers of the 802.11 standard, enabling significant improvements in the wireless range and coverage in the 5 GHz band, and delivering very high throughput to 802.11ac-capable clients. As with earlier IEEE 802.11 amendments, 802.11ac specifies improvements over the previous standards and implements new enhancements, yet maintains backwards compatibility with previous generations of 802.11 in the 5 GHz band. OFDM modulation is improved, wider channels are defined, more antennas are used, the number of spatial streams is increased, MIMO is enhanced, and there is a single, standard way to do beam forming (see Table 1). When all of these improvements are implemented, 802.11ac will be able to deliver on its "very high throughput" (VHT) promise, with single-radio throughput exceeding 1 Gbps.

Like many exciting new technologies, 802.11ac will be adopted first in the consumer space. Wireless multimedia streaming is the initial use case envisioned for 802.11ac, and the speed and quality improvements of 802.11ac will enable multiple streams of high-definition video on home Wi-Fi networks (HDTV, Blu-ray, set-top, etc.). Next, a new wave of tablets will leverage 802.11ac as part of their support for higher-definition video. Smartphones will then be redesigned to support Wi-Fi in the 5 GHz band, based on the new 802.11ac chipsets.

For the enterprise, 802.11ac represents a better way to deploy Wi-Fi in the 5 GHz band. While there will certainly be a need to support 802.11ac clients in enterprise networks, that is not the only reason to upgrade enterprise Wi-Fi to 802.11ac technology. It is a rich technology standard, and the improvements in radio performance it brings will enable more efficient deployment of Wi-Fi in the 5 GHz band, with access point (AP) spacing closely matching that of a 2.4 GHz infrastructure, and better coverage for all clients operating in 5 GHz.

As 802.11ac clients come into the enterprise, 802.11ac will enable vendors to build Wi-Fi infrastructures that make more efficient use of the 5 GHz band, creating high-capacity voice systems and pools of multimedia streaming. Enterprise Wi-Fi networks can also use 802.11ac technology to create VHT wireless backhaul links or wireless bridges.

There will be a gradual transition to 802.11ac in the enterprise, and because the 802.11ac technology is implemented at the chip level, hardware replacement will be required. *However, 802.11n will not be displaced by 802.11ac. The two standards will coexist in enterprise wireless networks to continue to support legacy devices in the 2.4 GHz band.* One way to view 802.11ac is as a superset of 802.11n, operating in the 5 GHz band. Wi-Fi clients with 802.11ac technology will operate seamlessly in 802.11n infrastructures and will perform as well as the best 802.11n clients at 5 GHz. Conversely, 802.11ac infrastructures will support 5 GHz 802.11n clients at full performance and with the best possible coverage.

Inside IEEE 802.11ac

802.11ac is an amendment to the 802.11 standard that defines "enhancements for very high throughput for operation in bands below 6 GHz." Because of the channel bonding limitations (40 MHz wide and greater) in the 2.4 GHz band, this 802.11 amendment explicitly excludes the 2.4 GHz band.

A primary goal for the 802.11ac standard is to support a single-radio design with throughput greater than 1 Gbps and multi-radio designs with throughput approaching 3.5 Gbps. A system that implements the draft 802.11ac specification and enables some of the optional features will be able to achieve single-station throughput of almost 3.47 Gbps and system throughput of up to 6.9 Gbps.

Like 802.11n, 802.11ac is a series of incremental improvements to many aspects of the existing standard. While many of the new 802.11ac features are aimed at increasing the speed, there are many other benefits of the 802.11ac technology. Range is improved, coverage is more robust, there is more resistance to interference, system capacity is improved, and streaming has been further optimized.

Table 1. Feature Enhancement Comparison: 802.11n / 802.11ac

	IEEE 802.11n	IEEE 802.11ac
Frequency Band	2.4 GHz and 5 GHz	5 GHz only
Channel Widths	20, 40 MHz	20, 40, 80 MHz 160 MHz optional
Spatial Streams	1 to 4	1 to 8 total up to 4 per client
Multi-user MIMO	No	Yes
Single Stream (1x1) Maximum Client Data Rate	150 Mbps	450 Mbps
Three Stream (3x3) Maximum Client Data Rate	450 Mbps	1.3 Gbps

The major enhancements of 802.11ac are at the physical layer (PHY). They include:

1. **Wider channels.** 802.11n supported 20 MHz and 40 MHz channels. 802.11ac has mandatory support for 20, 40, and 80 MHz channels and optional support for 160 MHz channels. Doubling the channel width doubles the data rate.

2. **Improved modulation.** 802.11ac supports the same OFDM modulation scheme as 802.11n and adds 256 QAM, which will enable more bits to be encoded in the same channel size. More bits in the same channel means higher data rates.

3. **Increased number of spatial streams.** 802.11n defined one, two, three, or four spatial streams. 802.11ac defines up to eight spatial streams, with a maximum of four streams per client. Each additional spatial stream increases the aggregate data rate. A single-stream 802.11ac client operating in an 80 MHz channel may achieve a 450 Mbps raw data rate. A three-stream 802.11ac client will be able to operate at 1.35 Gbps.

4. **Multi-user MIMO (MU-MIMO).** MU-MIMO will allow simultaneous transmission of different user streams in the same channel at the same time. An 802.11ac AP will be able to simultaneously transmit packets to two different four-stream clients on the same channel. Even better, an 802.11ac AP will be able to transmit to multiple single-stream clients, such as smartphones, simultaneously. To take advantage of the new 802.11ac feature set, deployment of 802.11ac clients will be required. Legacy 802.11a and 802.11n 5 GHz clients will be supported with no upgrade required.

   Note that this feature will not be supported in the first generation 802.11ac chips, and depending upon design constraints of successive generations, deploying a subsequent-generation 802.11ac product may require replacing the previous-generation 802.11ac product.

5. **Beamforming now standard.** Beamforming is optional in the 802.11n standard. There were multiple implementation schemes, but the feature was never widely adopted due to vendor incompatibilities. 802.11ac specifies a standard beamforming implementation that will facilitate interoperability and increase the effective range of 802.11ac-based systems.

All of these improvements have been defined to ensure backwards compatibility and coexistence with previous generations of the 802.11 standard. The MAC protocol improvements include upgrades to the RTS/CTS protocol to support the mix of wide and narrow channels possible with 802.11ac. Frame aggregation has been enhanced to allow larger aggregate frames, which increases effective throughput and better supports streaming.

Status of IEEE 802.11ac

802.11ac is not yet an approved international standard. Unlike previous generations of 802.11, however, there is no controversy concerning the technical details of the current draft version. As a result, Wi-Fi silicon providers are comfortable developing chipsets based on the 802.11ac draft before it is formally ratified, and they are already bringing draft 802.11ac chips to market.

The IEEE 802.11 process for formally ratifying and publishing the new standard will take some time, with final ratification expected in December 2013.

Recognizing that chip vendors are aggressively promoting the 802.11ac technology and that consumer electronics products based on 802.11ac are projected to be for sale in mid-2012, the Wi-Fi Alliance (WFA) has committed to having a Wi-Fi certification program for draft 802.11ac products sometime in 2012.

First to market will be consumer products, driven by the need for speed and the improved wireless reliability required for streaming high-definition multimedia. Blu-ray players, network-connected TVs, and streaming media players will add 802.11ac very quickly. Following this, rich media devices like the iPad 3 and Kindle Fire will upgrade to 802.11ac technology. Smartphones will move to 802.11ac next, as they add support for 5 GHz Wi-Fi. These new devices will be the first 802.11ac clients brought into the enterprise and will create more demand for high bandwidth and a higher quality of service on enterprise Wi-Fi networks. Enterprise-class 802.11ac networks will then be adopted by enterprises to address the increased demand for more capacity and better support of Wi-Fi for bandwidth-hungry applications. It is a case of the clients driving the feature requirements of the networks, a kind of "cart-before-the-horse" scenario.

We expect non-consumer, system-level Wi-Fi 802.11ac products to come to market in the second half of 2012. The 802.11ac standard will not replace 802.11n, because 802.11n is required to support operations in the 2.4 GHz band. Enterprise wireless LAN infrastructures will therefore be dual band, including both 802.11ac and 802.11n technologies. The first wave of 802.11ac chips will be three times faster than equivalent 802.11n solutions. We expect first-generation 802.11ac enterprise systems to support the following key features:

- Three spatial streams that will support raw data rates up to 1.3 Gbps
- Support for 20, 40, or 80 MHz channels—channels up to two times wider than current 802.11n solutions
- Improved OFDM—256 QAM, a higher modulation scheme that increases data transfer efficiency, enabling up to four times the data rate of 802.11n in the same size channel
- Beamforming for improved link reliability

Future generations of 802.11ac chips will support wider channels, more antennas, more spatial streams, and MU-MIMO. With 802.11n, support for a three-stream connection required three antenna groups on both the AP and the client. Because 802.11n requires both the client and the AP to have matching spatial stream support, a three-stream 802.11n system operates only at single-stream speeds when communicating with single-stream clients—the lowest common denominator. MU-MIMO relaxes this requirement and defines a more effective spectrum management technique to support simultaneous communications with multiple devices with a mix of stream-connect types. An 802.11ac AP may support eight streams, while 802.11ac clients may be single stream. The 802.11ac system has the potential to operate at maximum capacity, even when communicating with a group of single-stream clients.

Enterprise IEEE 802.11ac Considerations

In deciding whether or not to deploy 802.11ac, it will be important for the site IT team to understand their wireless application requirements. Initially, there may be only a few devices capable of fully supporting first-generation 802.11ac products, and an understanding of how and where these devices may be used within a network is critical. First-generation 802.11ac AP products will have to be matched with peer 802.11ac clients. This means that a three-stream, 80 MHz channel connection can only be supported between matching AP/client pairs. The maximum benefit from the 802.11ac standard can be ensured wherever peer-to-peer VHT applications can be identified. Multimedia applications are obvious choices, but there may be other applications that can benefit from 11ac's increased bandwidth. Use of machine-to-user, machine-to-machine, or real-time security applications are potential candidates for 802.11ac deployments.

With second-generation 802.11ac products, multi-user MIMO will be supported, expanding the deployment options available to network planners. No longer will it be a requirement that the AP and the client have to be matched at the physical link layer—multiple clients can be serviced simultaneously, whether they are single stream or multi-stream. MU-MIMO will help maximize the bandwidth utilization of an 802.11ac deployment. Mobile clients that support 802.11ac will also see improved battery life as a benefit.

IEEE 802.11ac Myths Debunked

"IEEE 802.11ac is for consumers, not enterprise networks."
While it is true that 802.11ac is initially targeted at consumer applications such as high-definition video streaming, 802.11ac is important for the enterprise as well. High-performance multimedia tablets will be the first Wi-Fi clients to adopt 802.11ac. Employees are bringing these personal multimedia devices into the enterprise, and companies need to add secure guest access for them or integrate them into the corporate network in a secure fashion. The new enterprise wireless LAN infrastructure needs to provide the capacity and quality of service demanded by these devices, and 802.11ac will enable better coverage in the 5 GHz band, increased capacity, support for more devices of all types, and improved reliability in harsh environments.

"IEEE 802.11ac will replace 802.11n."
No, the two standards complement each other. 802.11n will not go away, because it is needed to support the 2.4 GHz band. 802.11ac will be an upgrade to the 5 GHz portion of the enterprise wireless LAN, but most enterprise Wi-Fi systems will support both standards for many years to come. 802.11ac can be inserted by replacing existing APs with dual-radio (802.11n and 802.11ac) APs, or 802.11ac products can be installed as a network overlay. Regardless of the option chosen, there remains a need to support both 802.11n and 802.11ac services within the network.

"IEEE 802.11ac is for high-powered, gigabit-per-second clients only."
A lot of the excitement about the new 802.11ac standard is about breaking the gigabit barrier—Wi-Fi supporting single-station throughput greater than a gigabit per second. But 802.11ac is much more than a speed bump, and the improvements are targeted at many different classes of Wi-Fi devices. 802.11ac will bring significant benefits for next-generation single-stream, low-power Wi-Fi clients such as smartphones—a single stream 802.11ac smartphone will be able to transmit three times more data using the same power or less than an 802.11n smartphone. And wireless LAN infrastructures based on 802.11ac will be able to support multiple 802.11ac devices at the same time in the same channel, making more effective use of the precious spectrum.

"IEEE 802.11ac will require a 'rip and replace.'"
Not necessarily. In many implementations, the network software—such as the network operating system and network management application—will operate on the same computing systems used in today's networks. Only the APs will be candidates for replacement, and that will depend solely upon a site's requirements: 802.11ac may be introduced as an overlay to an existing 802.11n network, retained to support 2.4 GHz b/g/n devices.

Meru Embraces IEEE 802.11ac

IEEE 802.11ac opens up many new market opportunities, supporting an ever-growing array of bandwidth-hungry mobile applications launched from a new generation of mobile devices. The wider 802.11ac channels (80 and 160 MHz) support higher data rates, but, when implemented, reduce the number of available non-overlapping channels. This doesn't pose a problem for Meru's Virtualized Wireless Network architecture,

which has been built to mitigate co-channel interference and fully leverage 802.11ac's higher throughput and capacity. Whether an enterprise deploys a single-channel or layered-channel solution, Meru's architecture will allow the user community to access the most bandwidth in the most reliable way from an 802.11ac network.

Meru is committed to the emerging 802.11ac standard and plans to introduce solutions based on the draft standard by the end of 2012, when interoperability events validate the robustness of this new technology.

Summary

IEEE 802.11ac will deliver very high throughput for streaming multimedia devices, improvements in range, expanded overall system capacity, and network resilience to interference—boosting application performance for any enterprise with a high density of mobile devices. Consumer products supporting high-definition video streaming based on 802.11ac will be coming to market in the first half of 2012. Following the introduction of these first consumer products, 802.11ac-based laptops and tablets will become commercially available, and the BYOD trend will compel enterprise networks to support 802.11ac. Fortunately, 802.11ac technology can be easily integrated into an enterprise's existing Wi-Fi network and will add the bandwidth to support the influx of new Wi-Fi devices.

Meru Networks is excited about the enterprise applications for the new IEEE 802.11ac standard. Because the 802.11ac design is complementary to Meru's Virtualized Wireless LAN architecture, Meru will be able to leverage the new standard's capabilities to deliver even higher capacity wireless LAN solutions to best serve the explosion of Wi-Fi clients making up the new enterprise.

Powering the Wireless Enterprise

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