WHITEPAPER

Understanding the IEEE 802.11ac Wi-Fi Standard

Preparing for the next gen of WLAN

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Executive summary

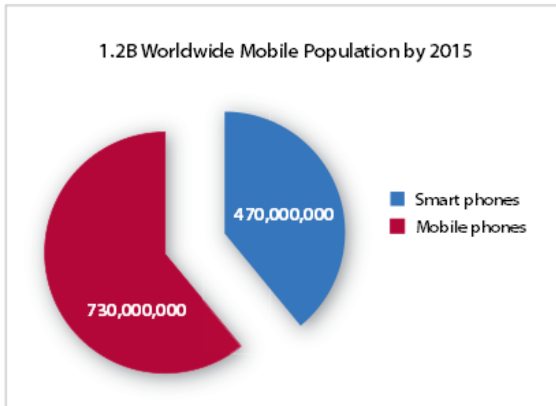
IEEE 802.11ac, also known as Gigabit Wi-Fi, is the latest Wi-Fi standard that builds upon 802.11n by improving data rates, network robustness, reliability, and RF bandwidth utilization efficiency. This evolutionary standard will be able to supply the wireless data rates and client capacity that are demanded by the increasingly mobile business community. Wireless network services are at the edge of today's network, and 802.11ac is designed to meet the throughput requirements of high-definition video and wireless voice applications. 802.11ac will provide wireless data rates in excess of 1 Gbps per radio, which rivals traditional hardwired speeds.

This white paper provides 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, and IDC has projected that by 2015 there will be 1.2 billion mobile workers using some 470 million smartphones.[1] It seems that in every area of our lives, the ability to communicate un-tethered is becoming more important, and people are using mobile devices to make calls, send email, and access the Internet and social networking applications on a daily basis. For most working adults, the phone or tablet has become an indispensable tool they carry everywhere—including to work.



The personal mobile device has become such a part of the landscape that we are now seeing BYOD (bring your own device) as an increasing trend in the enterprise. 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 often referred to as the "consumerization of IT." IT managers are being challenged with new network design requirements brought about by this phenomenon.

BYOD and Bandwidth Challenges

As the number of mobile applications has grown along with the increased use of smartphones and tablets, there has been 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 and other mobile devices. For cellular providers, this increased demand has taxed their network capacity, catching them off guard, and many have abandoned their "all you can eat" data plans, implementing metered data plans instead. This increased demand is mirrored in the corporate BYOD context, where users now expect that "if it works at home, why not at work?" This new workplace demand will also tax a Wi-Fi network in supplying sufficient bandwidth, especially with newer and more powerful mobile devices coming on the market every day. Streaming video, database searches, file transfers, and cloud-based storage are applications that place ever-increasing demands on a network's ability to provide consistent bandwidth. A recent report counsels:

[1] IDC, "2011-2015 Forecast"

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[2] and companies deploying tablets will need 300 percent more Wi-Fi capacity to be effective. The time to invest is now.

Some analysts[3] project that in the near future, the average enterprise worker will take two or three mobile devices to work, while others project as many as seven devices by 2016.[4] All these conditions 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 existing Wi-Fi standards. So, how can enterprise IT departments provide sufficient bandwidth on their wireless networks while maintaining the necessary control?

The New Standard

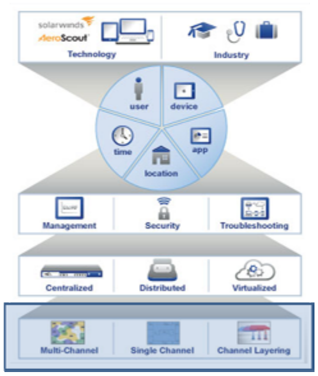
A new addition to the IEEE 802.11 family of standards, IEEE 802.11ac, has been defined with the promise of delivering significant increases in bandwidth while improving the overall reliability of a wireless connection. The ultimate goal of this standard is to produce a single-radio design with wireless 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.

Introduction to 802.11ac

Like many exciting new technologies, 802.11ac is being 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.). Smartphones based on the first-generation chipsets are already appearing in the market. Next, a new wave of tablets will leverage 802.11ac as part of their support for higher-definition video.

For the enterprise, 802.11ac represents a better way to deploy Wi-Fi in the 5 GHz band. It is a rich technology standard, and the improvements in radio performance it brings will enable more efficient deployment 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 client devices come into the enterprise, 802.11ac will enable IT departments 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.



Support for 802.11ac is implemented within the Meru Mobile***FLEX*** architecture at the FLEX Access layer.

Mobile***FLEX*** is a framework for constructing our solutions in support of RF services, network control & management, policy enforcement, and mobile applications. There are five service layers within the Mobile***FLEX*** architecture, each supporting capabilities focused on mobility with maximum deployment flexibility.

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

[3] 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.

[4] *"Bring-your-own-device requires new network strategies,"* ZK Research, September 2012

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 (mandatory) 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 per radio	150 Mbps	450 Mbps
Three Stream (3x3) Maximum Client Data Rate per radio	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 data can be encoded in the same packet size. More bits per packet 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 1.3 Gbps.

4. **Multi-user MIMO (MU-MIMO).** MU-MIMO will allow simultaneous downstream 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 silicon, and depending upon design constraints of successive generations, deploying a subsequent generation 802.11ac product will 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 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 vendors have developed chipsets based on the 802.11ac draft before it is formally ratified, and they have brought these draft 802.11ac chips to market.

The IEEE 802.11 process for formally ratifying the new standard will take some time, with final ratification expected the first half of 2014. To confirm interoperability and certification of adherence to the standard, the Wi-Fi Alliance (WFA) has committed to having a Wi-Fi certification program for draft 802.11ac products in the second half of 2013.

We expect enterprise-class Wi-Fi 802.11ac products to come to market in the second half of 2013. 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 solutions to support the following key features:

- Three spatial streams that will support raw data rates up to 1.3 Gbps per radio
- Support for 20, 40, and 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 30% increase in the data rate of 802.11n in the same size channel
- Beamforming for improved link reliability

Future generations of 802.11ac silicon will support wider channels (160 MHz), more spatial streams (up to 8), and Multi-user MIMO (MU-MIMO). Because 802.11n requires the client and the AP to have matching spatial stream support, a three-stream 802.11n AP 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. The 802.11ac system has the potential to operate at maximum capacity and spectrum use even when communicating with a group of single-stream clients.

Enterprise 802.11ac Deployment Considerations

In deciding whether or not to deploy 802.11ac, it will be important for IT administrators to understand the 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. With second-generation 802.11ac products, MU-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 incrementally improved battery life as a benefit.

A successful 802.11ac deployment will need to consider the following items:

1. **Cost**
    a. New access points must be purchased, along with making provisions for upgrading any existing controller firmware.
    b. To maximize the increase in data rate realized with 802.11ac, a second 1 Gbps Ethernet link may need to be run to an AP configured to operate two 5 GHz channels. This results in a 2+ Gpbs aggregate data rate to the backhaul.
    c. Ensure that the wired infrastructure can properly support the higher data rates—deployment of CAT-6 or CAT-6a cabling may be required.
2. **Network design**
    a. Plan for supporting 2.4 GHz devices for the next four to seven years.
    b. Channel plan for 80 MHz wide channels to reap the maximum data rate benefit possible.
    c. Deploy in Meru's Virtual Cell mode to simplify deployment and management, and to gain unique feature benefits.
    d. Leverage context-aware layers (CALs) where it makes sense to isolate applications to enhance their security, performance, and reliability.

Utilizing the anticipated 160 MHz channels, at best, requires the ability to deal with only a single available channel. In February of 2013, the FCC[5] announced proposing an additional 35% more spectrum for use in the 5 GHz band. This would expand the availability of wider channels for deployment consideration, but will not be commercially available for several years while the proposal is approved by the appropriate federal and state agencies.

[5] http://www.fcc.gov/document/increased-spectrum-available-unlicensed-devices-5-ghz-band

Delivering on the Promise of 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 Air Traffic Control® architecture, which has been built to mitigate co-channel interference on single-channel networks and can fully leverage 802.11ac's higher throughput and capacity. Leveraging the channel layering feature can multiply the capacity by 2x. Unique to Meru is its support of CALs, enabling application services to be associated with a specific RF layer to provide greater performance, reliability, and manageability. Whether an enterprise deploys a single-channel or layered-channel solution, Meru's architecture will allow the user community to utilize the most bandwidth in the most reliable way from an 802.11ac network.

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. 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 and multimedia-rich apps.

Meru Networks is excited about our AP832 solution, which is implemented as a FLEX Access component of our Mobile***FLEX*** architecture and part of Meru's Air Traffic Control. Because of our single-channel architecture approach, Meru will be able to leverage the new standard's features to deliver even higher capacity wireless LAN solutions to best serve the explosion of Wi-Fi clients making up the new enterprise.

Appendix

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 need to 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 increase, 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 most implementations, the network components—such as the network controllers and management applications—will operate in the same manner as they do in today's networks. APs are the only candidates for replacement and will depend solely upon a site's requirements; 802.11ac may be introduced as an overlay to an existing 802.11n network that is retained to support 2.4 GHz b/g/n devices.

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