IEEE 802.11ac—Wi-Fi for the Mobile and Video Generation

Contents

IEEE 802.11ac AT A GLANCE

IEEE 802.11ac is the **fifth generation in Wi-Fi networking** standards and will bring fast, **high-quality video** streaming and nearly instantaneous **data syncing and backup** to the notebooks, tablets, and mobile phones that have become our everyday companions.

Improvements in transmission speeds will be dramatic. Entry-level IEEE 802.11ac products will provide a data rate of 433 Mbps (megabits per second), which is **at least three times faster** than that of the most common devices using the current wireless standard, which is IEEE 802.11n. Because the new standard gives manufacturers the flexibility to offer a range of products with different levels of performance, some high-speed IEEE 802.11ac devices will offer wireless transmission in excess of a Gigabit per second—remarkable speeds that put IEEE 802.11ac wireless networks ahead of most wired networks.

In addition, there will be **dramatic improvements in wireless reliability, range, and coverage**. Homes and apartments now plagued with "dead spots" will enjoy vastly improved reception. Faster file transfer also leads to longer battery life in mobile phones.

Products based on IEEE 802.11ac will be **fully backward compatible** with current Wi-Fi devices. Older devices, however, won't be able to take advantage of the improved speeds offered by IEEE 802.11ac. Home networking products containing IEEE 802.11ac adapters are expected **in Q3 2012**. They will begin appearing in laptops and notebooks for the Christmas 2012 selling season. Mobile phones and tablets—both crucial Wi-Fi markets—are likely to ship with IEEE 802.11ac chips in 2013.

IEEE 802.11ac is the fifth generation of Wi-Fi to come along since Wi-Fi was introduced in 1997. The roll-out of new IEEE 802.11ac devices, like those of previous generations, is expected to take between one and three years, beginning first with home networking products and then working its way to other products as manufacturing costs decline. By 2015, virtually all new Wi-Fi products are expected to be based on IEEE 802.11ac technology, in the same way that nearly all Wi-Fi products on sale today are based on IEEE 802.11n, which is the current standard.

Wi-Fi ISN'T JUST FOR COMPUTERS ANYMORE

The modern world has become dependent on Wi-Fi technology. It is available just about everywhere we go—in homes, offices, hotels, restaurants, and sometimes even in the great outdoors.

We seek out wireless connectivity more and more because we're using it more and more—and not just for work and e-mail. We've come to depend on Wi-Fi to stream movies and TV shows to our laptops, to play online games and use social media on our mobile phones, and to read books and watch video on our tablets. Between office work, school assignments, and simple entertainment, the average household often has several Wi-Fi devices running at the same time, downloading rich content at all hours of the day and night.

But the Wi-Fi technology we use today is three years old, and it simply can't keep up with the new demands we are placing on it, just as booming cities with narrow roads and streets cannot handle the increased traffic. And so, a

January 2012

IEEE 802.11ac—Wi-Fi for the Mobile and Video Generation

new generation of Wi-Fi technology, known as IEEE 802.11ac, is being introduced to guarantee that our wireless networks keep pace with our constantly expanding use of computers, phones, and tablets, for both work and fun.

Unlike most consumer devices, which have new models once or twice a year, Wi-Fi standards take years to develop, as they require many companies working together on scores of intricate technical issues. Thus, new Wi-Fi systems don't appear that frequently, and when they do, they are important events for the computer and consumer electronics industries. The IEEE 802.11ac standard is only the fifth generation of wireless to come along since Wi-Fi first started to revolutionize our use of computers back in 1997.

The new IEEE 802.11ac is a worldwide standard that will offer at least triple the transmission speeds of current Wi-Fi products using IEEE 802.11n. (It accomplishes this mainly by taking advantage of a new swath of the radio spectrum, which will be explained later.) Even the slowest IEEE 802.11ac connection will be about as fast as today's USB 2.0 wired links, which are widely used in external storage. That means that streaming video won't freeze or sputter, or that Web downloading won't slow to a crawl when more than one family member is using a tablet or mobile phone. What's more, wireless reception will be available in many portions of a house that are now "dead spots" for coverage.

Of course, devices with the new IEEE 802.11ac standard will be backward compatible, allowing older Wi-Fi products to interoperate seamlessly. (Older products, however, won't be able to take advantage of the increased speeds of the new system.) Products with the new standard are expected to become available in the third quarter of 2012, initially in home networking devices such as wireless routers/access points. In the fourth quarter, notebooks and laptops containing IEEE 802.11ac adapters are expected.

Mobile phones equipped with IEEE 802.11ac chips will probably be on the shelves in 2013. That's important because, although Wi-Fi was initially created in the 1990s with computers in mind, today there are many more mobile phones than computers using Wi-Fi. What's more, growth rates in mobile equipment far outstrip those for traditional computing equipment.

Mobile phone users appreciate Wi-Fi because in addition to being free, it's usually faster than their carrier's 3G or 4G network. In fact, due to the popularity of mobile applications such as Skype and FaceTime, some mobile phone owners use Wi-Fi for all of their communications needs, including simple phone calls. But even carriers understand the importance of wireless because it allows them to offload certain kinds of data—video, for example—from their already saturated networks.

Because IEEE 802.11ac transfers files so much more quickly, wireless chips will be much more power-efficient than those found in phones today. Mobile phone users will thus be able to go longer between battery rechargings than they would if they were transferring equivalent amounts of data on today's Wi-Fi networks.

Being mainly spurred by the explosion of media content, the transition to IEEE 802.11ac is expected to be faster than the transitions from earlier generations of Wi-Fi standards.

As in the past, the new network standard will at first be found in higher-end products. But before long, virtually all new Wi-Fi products will likely be based on the IEEE 802.11ac standard, just as nearly all Wi-Fi products on sale today are based on IEEE 802.11n.

WHY IEEE 802.11ac?

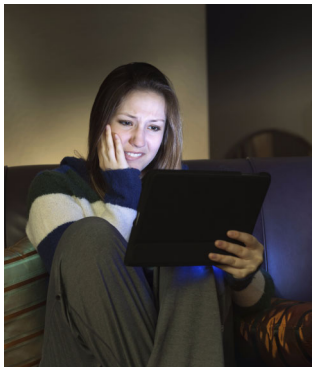
Although there are many benefits of IEEE 802.11ac technology, it was developed with three main features in mind—video streaming, data syncing, and backup.

Video Streaming

PCs may have started out as "computers," but increasingly, we are using our PCs—not to mention our mobile phones and tablets—as convenient substitutes for TVs. Video entertainment has become one of the most popular use of electronic devices, so much so that video content from Netflix, Hulu, YouTube, and similar services now constitutes most of the Wi-Fi traffic.

> ***What's in a Name? Sometimes, Nothing At All***
>
> The "ac" in "IEEE 802.11ac" doesn't really stand for anything. In fact, the standard got its name just by standing in line.
>
> Wi-Fi standards are developed by scores of electronics companies working together under the auspices of the Institute of Electrical and Electronics Engineers (IEEE) in an ongoing project called IEEE 802.11. (Insiders pronounce that "eight-oh-two-dot-eleven.") Each technical paper released by the group is given a letter suffix; the one setting forth the specifications for IEEE 802.11g came out in 2003, followed by IEEE 802.11n in 2007. After reaching "z," the papers started over with "aa." Most of the papers between IEEE 802.11n and IEEE 802.11ac involved intricate technical matters, rather than a new networking standard meant for widespread use.

But video streaming requires a great deal of bandwidth, many times more than does music. And so, watching video over current Wi-Fi networks can be a frustrating experience.



For example, it's common for the picture to freeze because the wireless network simply can't keep up. The problem becomes much worse the further you are from your Wi-Fi access point.

January 2012

IEEE 802.11ac—Wi-Fi for the Mobile and Video Generation

And, when different members of the household are watching different programs, each on their own computer, mobile phone, or tablet, video streaming can come to a near standstill.

But because it is so much faster than current networks, an IEEE 802.11ac network can easily handle the video needs of an entire household, even when dad, mom, and the kids are watching different programs in different rooms. The quality of the video can be better, too. The simplest IEEE 802.11ac network can transmit data over short distances—across a room, for example—at 433 Mbps (using a single antenna and 80 MHz bandwidth). That's enough to transmit high-definition Blu-ray Disc movies, which have a much higher video quality than most streaming Web videos.Because IEEE 802.11ac will handily keep up with video traffic, consumer electronics companies are expected to use it as the basis of a new generation of well-designed, easy-to-use living room video products. Watching streaming Web video on a big-screen living room TV is currently something of an "experts only" affair, because these products are often designed for advanced users. But IEEE 802.11ac is expected to herald the arrival of living room video products that will make enjoying streaming Web video as easy as watching cable TV is today.

Data Syncing and Backing Up

Nearly everyone today makes daily use of multiple devices. The home computer remains the hub for most people, a central repository containing files for work, music, video, games, and more. But we take our mobiles phones with us as we go about our daily lives and need to keep our phones and computers in sync. Unfortunately, that has become a time-consuming chore. Ask anyone who tries to download a playlist of music, a new batch of photos, or some recently changed calendar appointments onto a mobile phone while dashing out the door in the morning.

With movies, it is even worse. Frequent travelers enjoy spending part of a plane ride catching up on the latest Hollywood release. But they often discover too late that they don't have time for a 20-minute movie transfer from PC to tablet before catching a cab for the airport.

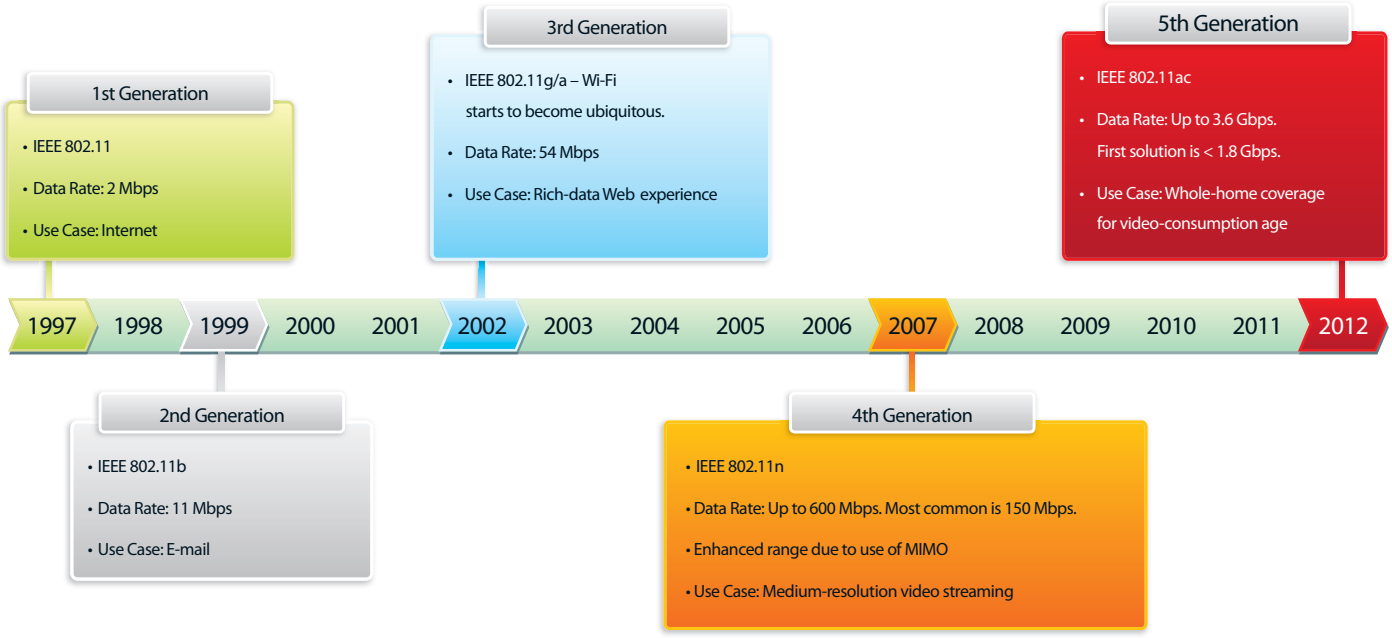
The high throughput rates of IEEE 802.11ac will slash all these sync times. You'll be able to put a phone or tablet next to your PC and sync your playlists and calendars in a few seconds. Entire movies can be transferred in minutes. With IEEE 802.11ac, quick, effortless background syncing will soon be as much a part of the mobile phone experience as texting or taking pictures is today.

The same is true for backing up our mobile devices, which is becoming an increasingly important task considering how much of our lives we carry around on them. Between calendar entries, text messages, photos, videos, and downloaded applications, losing the data contained on a mobile phone for most people would be as calamitous as losing everything on their computer hard drive.

The speed of IEEE 802.11ac will take the hassle out of backing up mobile phones and tablets. Consumers can have peace of mind knowing that they will always have access to their phone data, even if the phone itself is no longer available.

IEEE 802.11ac—THE TECHNICAL DETAILS

Computers, mobile phones, tablets, networking equipment, and other devices equipped with the new IEEE 802.11ac networking technology will experience connections between three and 10 times faster than is possible today. Wi-Fi coverage will experience less interference, extend to greater distances, and be spread out across a larger coverage area.



January 2012

IEEE 802.11ac—Wi-Fi for the Mobile and Video Generation

Here are some of the ways that IEEE 802.11ac achieves these benefits.

- **Spectrum Changes**

You may not realize it, but every Wi-Fi device is, in fact, a small radio station, sending and receiving signals over a portion of the radio spectrum just like AM and FM broadcasters. The amount of available spectrum is limited by the laws of physics, and use that spectrum is strictly regulated by international agreements.

Most of today's IEEE 802.11n Wi-Fi devices operate in the 2.4 GHz frequency band. (A frequency band is a slice of the radio spectrum, and the number associated with it tells you where on the spectrum it is located, the same way that the frequencies of radio stations identify their place on the dial.) One problem with current Wi-Fi networks is that the 2.4 GHz band is crowded with many other devices, from baby monitors to Bluetooth headsets to microwave ovens. Because all of these devices are competing for the same limited bandwidth, everyone's Internet connection slows down, just as the traffic on a highway slows down when too many cars are on the road.

By contrast, IEEE 802.11ac works exclusively in the much less crowded, or "cleaner," 5 GHz spectrum. With less competition for the airwaves from other devices, transmission rates shoot up.

But IEEE 802.11ac has one other extremely important bandwidth advantage over its predecessor standard: There is simply more room available for
Wi-Fi in the 5 GHz band than there is in the 2.4 GHz band. Each IEEE 802.11ac communications channel is as much as four times wider than the channels available in IEEE 802.11n. Just like a six-lane freeway can handle more cars than one with two lanes, the wider the available swath of bandwidth, the faster the Wi-Fi connections can operate.

- **Beamforming**

Beamforming is the ability of a Wi-Fi transmitter to "learn" to avoid inefficient pathways between it and the device it is transmitting to. Beamforming is analogous to a car being able to automatically avoid a highway lane that is full of pot holes.

Beamforming is possible in the current generation of IEEE 802.11n products, but many of them did not take advantage of it. With IEEE 802.11ac, beamforming is a standard feature, and all products that implement it will be interoperable and thereby able to operate at maximum range and coverage for the IEEE 802.11ac network.

- **Range and Coverage Area**

Wi-Fi transmission rates slow down the further away you are from a transmitter. Absolute top speeds are usually available only within a few dozen yards, with performance gradually tapering off as you move further away. This relationship, which is determined by the laws of physics, is true no matter what network standard is being used, IEEE 802.11ac being no exception. But because IEEE 802.11ac transmissions start out so much faster than those from earlier networks, you can be, say, 30 feet away from an IEEE 802.11ac access point and get the same data throughput that you would if you were 10 away feet from an IEEE 802.11n transmitter.

Many factors affect the coverage area of a network—most notably, the way a structure is built. Concrete walls, ceramic bathroom tile, and metal appliances are more difficult for Wi-Fi signals to penetrate, in contrast to wooden walls with gypsum board, which are easier to penetrate. But signals from IEEE 802.11ac networks, with beamforming and other innovations, do a much better job in penetrating all forms of building materials than do the signals from its predecessor networks. In fact, the ability of IEEE 802.11ac signals to transmit through some concrete walls is expected to help homes in India and China, where concrete is used extensively as a construction material.

- **Multiple Antennas**

An IEEE 802.11ac Wi-Fi device can contain between one and eight antennas. Transmission speeds increase in direct proportion to the number of antennas. Companies selling computers, mobile phones, networking gear, and other Wi-Fi equipment can choose how many antennas to include, depending on considerations such as their price and performance targets for each product. (This is a lot like car companies offering a model with a choice of four-, six-, or eight-cylinder engines.) Entry-level, price-sensitive networking products can be built with a single antenna, whereas high-performance devices, especially for the enterprise, can be equipped with more antennas.

Do I Need to Upgrade to IEEE 802.11ac?

The first IEEE 802.11ac products expected to hit the market will be home networking routers/access points, which should be available in the third quarter of 2012. If you are shopping for a new piece of home networking equipment then, you'd be smart to "future-proof" your purchase by choosing one that is compatible with IEEE 802.11ac.

Its usefulness will become apparent toward the end of 2012, and especially in 2013. That's when IEEE 802.11ac laptops, tablets, and mobile phones will become available. You'll need to upgrade your home networking equipment to enjoy their greater speeds and improved coverage areas. (These new notebooks, laptops, and phones will work fine on older networking equipment, although not at the speeds of the new system.) The networking industry is working hard behind-the-scenes to guarantee that all IEEE 802.11ac networking products will work with all brands of IEEE 802.11ac-based computers, phones, and tablets, regardless of their manufacturer.

In two or three years, all home networking products are expected to come equipped with IEEE 802.11ac, just as nearly all of them have, by now, migrated to IEEE 802.11n, which was introduced in 2007.

January 2012

IEEE 802.11ac—Wi-Fi for the Mobile and Video Generation

Form factors are another consideration. A device that must, of necessity, be extremely compact, such as a mobile phone, will simply have less room for extra antennas than a home networking device. Regardless of the number of internal antennas they have, all IEEE 802.11ac devices will work with all other IEEE 802.11ac devices, though speeds will be capped at those of the slower device. (And again, all IEEE 802.11ac products will work with all earlier generations of Wi-Fi products, but with the same speed limitation.)

OTHER USES FOR IEEE 802.11ac

More reliable video delivery and faster syncing between phones and computers will be two of the most important applications of IEEE 802.11ac networks. But, they are expected to find a home in many other applications as well.

The Enterprise

Wi-Fi is becoming as important at work as it is in the home. Some offices already have nearly as many Wi-Fi access points as printers or copiers. With IEEE 802.11ac, coverage can be accomplished with fewer devices, even while transmission rates increase. Among those benefiting from this more efficient Wi-Fi networking technology will be the many office workers using mobile devices, either their own or ones that have been supplied by the IT department. These devices have caused a spike in enterprise demand for Wi-Fi, an increase that IEEE 802.11ac can easily accommodate.

The new IEEE 802.11ac standard will also be useful for companies experimenting with new seating arrangements, such as "virtual teams," in which workers don't use the same desk every day but assemble themselves into ad hoc groups that are determined by the job that needs doing. Traditional wired Ethernet networks don't always give enterprises the flexibility they need to support these constantly-evolving workplace layouts.

Set-top Boxes

Right now, cable and telco video providers have to run a cable not only from the street to the house for each subscriber, they also have to run an interior cable or phone line to each room with a TV set. The process of drilling holes and pulling wires is expensive and time-consuming for the companies involved and also extremely inconvenient for customers. But the high data throughput and wide coverage range of IEEE 802.11ac networks makes possible the installation of "satellite" set-top boxes that receive their signals over Wi-Fi from a central wired device. Customers wanting to add a second or third TV in another room wouldn't need to make an appointment with an installer. Instead, they'll simply plug in a Wi-Fi device and hook it up to the new TV set.

Wi-Fi Direct

This exciting new capability for wireless devices is not technically part of the IEEE 802.11ac standard, but it is expected to grow in popularity along with it.

Wi-Fi Direct allows two Wi-Fi devices to communicate with each other directly, without the need for a Wi-Fi access point in between. For example, suppose you and a seatmate on an airplane want to swap files from your notebooks or mobile phones. Right now, you need Wi-Fi access points to do so. But with Wi-Fi Direct, the two devices could communicate back and forth directly, even without wireless coverage being provided.

Wi-Fi Direct is supported in the current IEEE 802.11n standard, but has not been widely used. That is changing rapidly, however. Microsoft is building native support for Wi-Fi Direct into Windows 8, which is scheduled for release in 2012. In addition, the latest version of Google's Android mobile operating system supports Wi-Fi Direct connections.

3G and 4G Offloading

While most mobile carriers are building out their 3G and 4G networks as fast as they can, they are facing challenges as they attempt to satisfy the ever-growing download and streaming demands of their users, especially for mobile video. As a result, both mobile carriers and mobile users are becoming excited about using IEEE 802.11ac Wi-Fi networks to offload 3G and 4G traffic.

There are many ways these hybrid systems might work. One of the most commonly discussed methods involves using a Near Field Communications (NFC) link to identify nearby Wi-Fi networks, and then automatically setting up a connection with a network within range. After that, Wi-Fi would take over and do the actual transmission.

NFC is an entirely separate wireless system being built into a growing number of mobile devices. It works only over very short ranges—a few feet—because it was designed with commerce applications in mind, such as paying for a purchase by tapping an NFC-equipped mobile phone at the cash register, rather than swiping a credit card.

Although NFC networks are not by themselves fast enough to transmit high-data applications such as video, they can easily handle the intradevice negotiations and communications necessary to set up an IEEE 802.11ac connection, which would then step in and do the heavy lifting.

WHAT'S NEXT IN WI-FI?

With the introduction of IEEE 802.11ac, the wireless industry is accommodating the increased importance of streaming video to mobile devices. Similarly, the industry is already planning for the wireless transmission needs of tomorrow. Two projects deserve mentioning.

January 2012

IEEE 802.11ac—Wi-Fi for the Mobile and Video Generation

Ultralow Power

There has been much recent discussion of the "Internet of things," a network that connects not only people and computers, but also household appliances, security systems, door locks, light switches, garage door openers, and the scores of other devices we depend on every day. With these devices online, we would be able to control them from our computers or mobile phones. We might, for example, use a mobile phone app to turn on the home heating system should we find ourselves coming home earlier on a winter day than the time programmed into the home thermostat.

These types of devices transmit much less data than do traditional PCs. And, because many of these devices are powered by AA and AAA batteries, their Wi-Fi chips must use an absolute minimum amount of power. A group of leading companies is working together on a standard for this form of low-power, low-throughput networking, called IEEE 802.11ah. The standard is expected to be finalized in the near future.

Super High-Speed Networking

The other ongoing development effort in Wi-Fi is at the opposite end of the performance spectrum. Called 60 GHz Communications, it is designed for super high-speed connectivity—several gigabits per second, which is much faster than even the broadband Internet connections most people have coming in to their homes. At these speeds, a high-definition movie could be transferred in just a few seconds. Most of these speed gains come from moving to an entirely different part of the spectrum from either IEEE 802.11n or IEEE 802.11ac.

The downside: Because of the laws of physics, transmissions in this part of the spectrum can

travel only relatively short distances and can't easily penetrate walls or furniture. Thus, 60 GHz communications will be on a "line of sight" basis within a single room. Even with those limitations, however, this form of high-speed wireless networking will find its way into many applications. One example is as a cable replacement between computers and high-resolution monitors.

The new technology is also expected to be put to use in enterprises, an example of which might be to implement wireless device docking solutions.

CONCLUSIONS

Wireless networking is widely, and rightly, regarded as a fundamental technology nearly as important as computing itself. One reason for that being true is that the Wi-Fi industry, collectively, has continually pushed the performance envelope of wireless to guarantee that it was keeping up with how people were using first their PCs and, later, their mobile phones and tablets. Watching a high-resolution movie over Wi-Fi was once considered a wild, even unrealistic, fantasy. Soon, with IEEE 802.11ac, millions of people will be doing so every day.

Although the future is uncertain, two things are a safe bet. The first is that digital devices will continue to demand ever-greater amounts of data. The second is that the Wi-Fi industry will be keeping pace. Its track record in innovation over the years has been first-rate, and it shows no signs of slowing down now.

January 2012