D-Link®
Building Networks for People

Wireless AC

white paper

Wireless AC – all you need to know

An explanation of the advances and benefits of next generation Gigabit Wi-Fi

Executive summary

The technology currently used to support wireless networks is struggling to cope with the ever-growing numbers of bandwidth hungry Wi-Fi devices we want to connect, both in the home and business. We want more from our wireless networks and something better is urgently required, prompting the development of a new IEEE wireless networking standard called 802.11ac, the main aim being to boost wireless bandwidth from the 300-450Mbps available using current 802.11n technology to 1.3Gbps and beyond.

Variously referred to as Gigabit Wi-Fi or Wireless AC, the new standard sees a move away from the 2.4GHz radio spectrum favoured for most current wireless technologies, to 5GHz where there is less interference plus a lot more space for the extra channels need to deliver the promised bandwidth hike. In addition the new Wi-Fi also includes enhancements to support more devices, help eliminate deadspots and generally equip wireless networks to cope with the demands set to be placed on them over the coming decade.

Development is at an advanced stage with ratification of the 802.11ac standard expected in late 2013. Meanwhile, pre-standard products based on the latest feature-complete draft are available already from D-Link and other leading vendors and by 2015 all new Wi-Fi devices are expected to be Wireless AC enabled.

The need for this new technology is clear. We're doing more with Wi-Fi from an ever expanding number of devices and need wireless networks able to cope. That's what the fifth generation of Wi-Fi is all about and in this D-Link white paper we look at exactly what the technological advances are, how they work and what's how it will benefit us moving forward.

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From humble beginnings wireless networking has become an indispensable part of everyday life with Wi-Fi to be found on just about every electronic device we buy, everything from notebook computers and home broadband routers to Smartphones, tablets, Smart TVs and more. In fact, you name it and, chances are, you can connect it to a wireless network.

In fact, the more we're offered Wi-Fi the more we use it, whether in the home, office or, thanks to growing numbers of public hotspots, on the move. We're also using more devices at the same time and, as a result, increasingly hitting performance, capacity and availability limits imposed by current wireless technologies, even Wireless N, barely four years since final ratification.

Something better is needed and that can only happen by leaving the 2.4GHz spectrum used by most wireless networks at present, in favour of the comparatively empty 5GHz waveband. Wireless N started that move and now Wireless AC (802.11ac) completes it. Moreover, the new wireless standard uses the extra headroom available to significantly enhance many of the technologies introduced, but not fully exploited, in Wireless N to deliver a significantly faster, scalable and reliable Wi-Fi.

The development of this fifth generation of Wi-Fi is being driven by a number of technical, industry and social trends, including:

Critical mass – the convenience and availability of Wi-Fi is leading to it replacing cabled Ethernet both for home networks and, at the access level, on business networks too. Wi-Fi is fast becoming the preferred networking technology just about everywhere, leading to huge increases in traffic and growing coverage and reliability issues directly related to shortcomings inherent in the current Wireless N infrastructure.

Multi-device usage – Wi-Fi networks are having to deliver high bandwidth connectivity to multiple devices simultaneously. In the home, for example, users want to stream HD video to different rooms while at the same time play online games and browse the Web using their smartphones and tablets. Likewise, in business it is now commonplace for users to carry two or more mobile devices about and have them all onnected via Wi-Fi. BYOD is no longer a possibility – it's happening.

Video streaming – High definition (HD) video is increasingly being streamed around Wi-Fi networks, and not just to PCs, set-top boxes and Smart TVs but to handheld devices such as tablets and smartphones as users watch TV and video, make video calls and take part in video conferences on the move. All of this requires sustainable high bandwidth connectivity and reliable coverage which current Wireless N networks struggle to deliver.

Wi-Fi savvy apps – Application developers are taking network connectivity for granted and releasing applications that consume huge amounts of bandwidth collecting information, streaming and synchronising data, downloading updates and so on. The growth of the Cloud also assumes always-on connectivity, with mobile access an integral part of the equation, putting yet more strain on Wi-Fi networks.

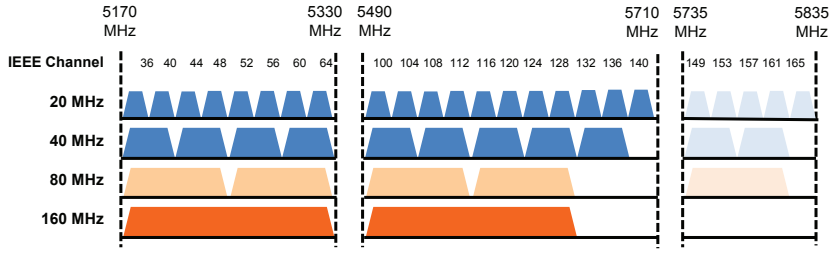
Wireless AC – the answer to real problems

There's nothing revolutionary in the 802.11ac standard. Rather it builds on technologies introduced in Wireless N, enhancing and evolving those technologies to deliver gigabit-class levels of bandwidth while, at the same time, boosting signal strength and device capacity as outlined below:

Channel changes

The radio spectrum used by wireless networking is divided into separate channels, the size and number of which are key factors when it comes to determining bandwidth. At 2.4GHz, for example, there is enough space for just three[1] non-overlapping 20MHz channels falling to one when channel bonding technology (introduced in Wireless N) is applied to enable pairs of channels to be aggregated to 40MHz.

In Europe the number of 20MHz channels at 5GHz rises to 19. Channel bonding is also extended with new 80MHz channels available in the first wave of Wireless AC products. Nine 40MHz or four 80MHz channels are available in Europe, and a further doubling to 160MHz planned for a second phase of the new standard.



Wireless AC channels at 5GHz

Wireless AC also introduces more efficient modulation, moving from 64-bit to 256-bit QAM (Quadrature Amplitude Modulation) to further enhance throughput.

Multiple antennas, MIMO and spatial streams

Another Wireless N development was support for multiple antennas and MIMO (Multiple Input, Multiple Output) technology. That's where data to be transmitted is divided up into multiple spatial streams capable of being sent and received in parallel between devices with multiple antennas.

Wireless N products tend to have no more than three pairs of antennas (3 sending and 3 receiving – written 3x3) supporting three associated spatial streams (3x3:3). The first Wireless AC products will also stick to that limit which, with 80MHz channels, gives a maximum bandwidth of 1.3Gbps, three times the throughput of equivalent Wireless N products (see table below).

Spatial Streams	20 MHz channels	40 MHz channels	80 MHz channels	1600 MHz channels
1	86 Mbps	200 Mbps	433 Mbps	867 Mbps
2	173 Mbps	400 Mbps	866 Mbps	1.73 Gbps
3	288.9 Mbps	600 Mbps	1.3 Gbps	2.6 Gbps
4	346.7 Mbps	800 Mbps	1.73 Gbps	3.47 Gbps

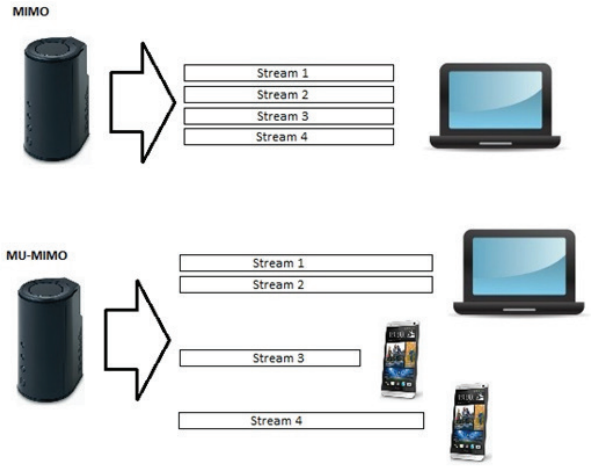
Note that Wireless AC bandwidth is set to double when 160MHz channels are introduced. Added to which the 802.11ac standard will eventually allow up to eight sets of antennas/streams to further enhance throughput on later products.

[1] Up to 14 channels may be available if frequency ranges are allowed to overlap and there may be differences in the number of channels licensed for use in different countries.

Multi-User MIMO

Another development in Wireless AC is a further extension of MIMO technology to allow spatial streams to be allocated to several client devices at once instead of just one, as in Wireless N.

Known as Multi-User MIMO (MU-MIMO)[2] this development will be of particular importance when it comes to supporting things like smartphones, low-end tablets and TVs equipped with just one or two antennas. These devices are unable to take advantage of the extra spatial streams available when connecting to a wireless Access Point (AP)/Router with multiple antennas, whereas with MU-MIMO a Wireless AC router or access point with four sets of antennas will be able to handle up to four single stream or two dual-stream devices simultaneously.



MU-MIMO will enable streams to be directed to multiple clients

[2] MU-MIMO won't be available on first-generation Wireless AC products

Beamforming for stronger signals

Complimenting MIMO and spatial multiplexing is the addition of beamforming technology in Wireless AC, to enable a wireless AP/router to work out where a receiver is located and boost the signal in that direction.

Beamforming is available already in some existing Wireless N products, such as the D-Link Cloud Gigabit Router N600 (DIR-845L) which employs D-Link SmartBeam™ technology to deliver a strong and stable Internet connection to every corner of the home. However, as beamforming is not part of the Wireless N standard there is no guarantee of interoperability, something addressed in Wireless AC which also includes optional support for "sounding" to enable a receiving station to guide signals from the transmitter towards its antennas.

Beamforming is optional and some vendors have left it out of their initial Wireless AC products, with some planning to add it later by a software upgrade. Thanks to its experience with beamforming on Wireless N products, however, D-Link has been able to include standards-based beamforming on its new AC SmartBeam™ products, including the D-Link Wireless AC1750 Dual-Band Gigabit Cloud Router (DIR-868L), enabling it to intelligently track and adjust the signals sent to notebooks, smartphones, tablets and other mobile devices.

AC SmartBeam™ helps the DIR-868L maintain stable Wi-Fi connections even when users are moving around, resulting in a finely tuned network able to automatically adjust signal strengths to optimise performance. Plus if you add to that the extra bandwidth of Wireless AC and it is easy to see how an AC SmartBeam™ router like the DIR-868L will enable mobile users to do more without additional battery drain.

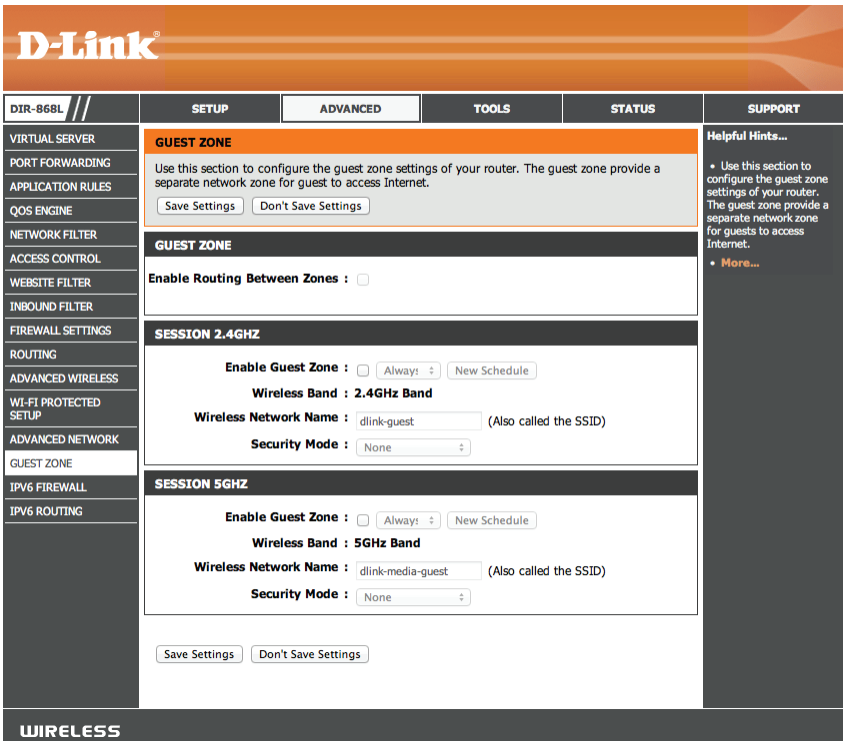
Interoperability and compatibility

One of the changes in Wireless AC is a move away from the crowded 2.4GHz radio spectrum to 5Ghz where there is less interference from other wireless devices and, more importantly, space for the extra wireless channels needed to deliver gigabit-class bandwidth.

Wireless N can be deployed here already with some, mostly business, networks using it to avoid the congestion and interference issues of 2.4Ghz. Likewise, legacy 802.11a networks use the 5GHz spectrum.

These slower networks can co-exist with Wireless AC and devices on them connect newer Wireless AC routers and access points albeit not at the higher AC speeds. In addition Wireless N devices operating at 2.4GHz and earlier implementations operating in the lower frequency band can also be handled through the use of dual-band technology, as in the D-Link Wireless AC1750 Dual-Band Gigabit Cloud Router (DIR-868L), where a second, 2.4GHz Wireless N interface is integrated alongside the 5GHz radio.

Configured independently, the 2.4GHz interface on the DIR-868L can be assigned its own unique SSID (effectively the network name) together with custom security encryption to enable older devices to connect without the need to change their setup.



The DIR-868L is a dual-band router supporting both 2.4GHz and 5GHz networks

The two networks can also be routed independently, separate guest networks configured in each frequency band and different levels of service assigned to suit the users and applications involved.

So, for example, you could reserve the 5GHz network to deliver maximum bandwidth when streaming video and other data to your own devices yet still allow your children and their friends to connect using the slower 2.4GHz spectrum.

There is no impact on performance from having a second 2.4GHz network. Quite the reverse as the two networks operate independently of each other with the 450Mbps of bandwidth provided by the 2.4GHz network on the DIR-868L available in addition to the 1.3Gbps of Wireless AC.

The roadmap to Wireless AC

Unlike 802.11n, development of the new 802.11ac standard has been a relatively quick and straightforward process. Final ratification is expected towards the end of 2013 and pre-standard products based on a feature complete draft of the new standard are available already, offering demonstrable gains in Wi-Fi performance plus the interoperability and backwards compatibility needed to give buyers the confidence to catch the Wireless AC wave now rather than wait for final ratification.

One reason for this relatively easy ride has been the evolutionary approach taken to development. Channel bonding, for example, is merely updated to double the maximum channel width supported by Wireless N and MIMO extended to support more antennas and multi-user streaming (MU-MIMO). Even the switching to 5GHz has been done before, both as an option in Wireless N and, earlier still, in 802.11a.

This has shortened the development timescales and made it easier to gain consensus between the parties ratifying the standard. Promotion of rival implementations simply hasn't happened this time around and objections from other users of the spectrum (such as Bluetooth at 2.4GHz) have not been an issue.

Dual-band for compatibility

Another lesson learnt has been the release of fewer draft standards, leading to barely a trickle of pre-standard products, mostly from respected vendors like D-Link closely involved in the ratification process. Moreover, pre-standard products have been dual-band implementations employing mature and proven Wireless N technology to provide for interoperability and backwards compatibility with existing Wi-Fi networks.
The dual-band approach removes the risk of buying Wireless AC products and finding that they won't work with current wireless notebooks, tablets or smartphones. The specification might change prior to final ratification, but the draft specification to which D-Link and other vendors are working is more or less complete and any changes required can be handled by firmware updates.

Deciding when to update

The only remaining concern is whether the benefits of the new Wireless AC technology can be realised now when there are so few products available. Most of the initial Wireless AC products have been routers only capable of delivering the full benefit of Wireless AC when bridged to a similar device. That, however, is changing fast with D-Link leading the way with the launch of the Wireless AC Dual-Band USB Adapter (DWA-182) enabling Windows desktops and notebooks to also get in on the Wireless AC act.

The recently launched HTC One Smartphone and Samsung Galaxy S4, for example, both support Wireless AC. Tablet vendors are, similarly, lining up new products, the majority of which are expected to offer support for the new Wi-Fi, plus it won't be long before Windows notebooks, too, come with Wireless AC built in. Indeed, Apple has confirmed that Wireless AC will be available in the next MacBook Air.

Adoption of the 802.11ac standard and technology will take time, but by 2015 analysts believe that all Wi-Fi devices will be Wireless AC enabled. In the meantime, it is still worth considering if, for example, you need to replace a broken Wi-Fi router and want to avoid another upgrade a year or so down the line in order to get Wireless AC. The same applies if you're looking to get more functionality than provided by the free router supplied by a broadband provider, or need help with coverage problems.

Lastly, gamers and others looking for the ultimate in Wi-Fi performance will also want to take advantage of the upcoming new Wi-Fi now, as will anyone looking to future-proof their home or business network. After all, with Wireless AC widely seen as the future of Wi-Fi, there are very few reasons for waiting.

Appendix 1. Wi-Fi classification explained

The numbers used to classify Wireless N and Wireless AC products can be confusing, here's what the figures found in datasheets and other marketing materials are all about:

Wireless N

Before Wireless N there was only one sending and one receiving antenna (written 1x1) supporting just one communication stream (1x1:1), resulting in just the one figure when it came to maximum throughput. Then came Wireless N with support for multiple antennas, MIMO and spatial streams to make things a little bit more complicated.

With just one pair of antennas it's easy, Wireless N delivering up to 150Mbps – often referred to as N150. That then doubles to 300Mbps where two antennas and two streams (2x2:2) are available, increasing again to 450Mbps with three (3x3:3) – N300 and N450 respectively.

However, Wireless N can also be implemented using 2.4GHz or 5GHz radios or both and for dual-band products able to communicate simultaneously on both wavebands the numbers quoted tend to be the sum of the two.

Wireless N class designation	2.4GHz bandwidth	5GHz bandwidth
N600	300 Mbps (2x2)	300 Mbps (2x2)
N750	450 Mbps (3x3)	300 Mbps (2x2)
N750	300 Mbps (2x2)	450 Mbps (3x3)
N900	450 Mbps (3x3)	450 Mbps (3x3)

Dual-band Wireless N speeds and feeds

Wireless AC

With Wireless AC the maximum throughput rate per antenna is tripled such that the 450Mbps currently available using Wireless N with 3 pairs of antennas can be achieved using just one with Wireless AC. But then the new Wi-Fi works solely in the 5GHz waveband so, for backwards compatibility a second 2.4GHz radio supporting Wireless N is required and the bandwidth of that is also incorporated into the classification numbers.

Wireless AC class designation	2.4GHz Wireless N bandwidth	5GHz Wireless AC bandwidth
AC580	150 Mbps (1x1)	433 Mbps (1x1)
AC750	300 Mbps (2x2)	433 Mbps (1x1)
AC1000	150 Mbps (1x1)	867 Mbps (2x2)
AC1200	300 Mbps (2x2)	867 Mbps (2x2)
AC1310	450 Mbps (3x3)	867 Mbps (2x2)
AC1600	300 Mbps (2x2)	1300 Mbps (3x3)
AC1750	450 Mbps (3x3)	1300 Mbps (3x3)

Dual-band Wireless AC speeds and feeds

As with all technologies, Wireless AC will be improving all the time, and in the future you can expect to look forward to an even better performance than the already high standard that is being achieved today.

For more information: www.dlink.com

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