802.11ac Speed Versus RF Channel Width
Does deploying 802.11ac in a 40 MHz channel make sense?

When planning an 802.11ac deployment, you will hear recommendations that you should use 40 MHz channels. But increasing the channel bandwidth is one of the primary ways of increasing data rates, so does it really make financial or technical sense to deploy 802.11ac if you are restricted to the same channel size as legacy 802.11n equipment?

Why deploy 40 MHz channels

There are several reasons that people recommend 802.11ac deployment using a 40 MHz channel. The primary ones are spectrum availability, the need for Dynamic Frequency Selection (DFS), and destructive interference.

Wider channels mean that you need more spectrum. Traditionally, in an enterprise setting where you wish to deploy multiple access points, you would deploy them on different channels. If you use a 1 in 3 frequency reuse plan, you would need at least 240 MHz of spectrum (3 x 80 MHz).

In the United States, there are six 80 MHz channels in the 5 GHz frequency band. Channels 120 to 132 are restricted near airports, due to potential interference with the Terminal Doppler Weather Radar (TDWR). Even with this restriction for specific locations, there is still sufficient spectrum to deploy three 80 MHz channels.

DFS is a feature that enables the Wi-Fi network to detect the presence of interference and dynamically move to a clearer channel. In the United States, Channels 52 to 144 require implementation of DFS. There are only two 80 MHz channels that do not require DFS. Because of this, deployment of a 1 in 3 frequency reuse plan with 80 MHz channels requires access points and clients to support DFS. From a client perspective, this means the client must be capable of responding to an 802.11 management action frame request to move to another channel.

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1 The allocation and usage rules can vary by country. Some countries allocate less spectrum than shown here for the United States. Some countries also prohibit transmissions greater than 40 MHz.

2 FCC KDB 443999 5.6–5.65 GHz.
When deploying a traditional 1 in 3 frequency reuse scheme, you also have to worry about co-channel and adjacent channel interference. Interference deteriorates the performance of the network. To maximize throughput, it is important to avoid contention on the same channel and interference with adjacent channels. The spectral mask for 802.11ac 20 MHz and 40 MHz channels is the same as for 802.11n (see Table 1). The mask for the 80 MHz channel is an extension of the 40 MHz mask. A 40 MHz channel causes more adjacent channel interference (ACI) than a 20 MHz channel, and an 80 MHz channel is expected to cause more interference than a 40 MHz channel.

<table>
<thead>
<tr>
<th>Signal Bandwidth</th>
<th>Offset Frequency</th>
<th>802.11n Maximum</th>
<th>802.11ac Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 MHz</td>
<td>≥ 30 MHz</td>
<td>-53 dBm/MHz</td>
<td>-45 dBr</td>
</tr>
<tr>
<td>40 MHz</td>
<td>≥ 60 MHz</td>
<td>-56 dBm/MHz</td>
<td>-45 dBr</td>
</tr>
<tr>
<td>80 MHz</td>
<td>≥ 120 MHz</td>
<td>-59 dBm/MHz</td>
<td>-40 dBr</td>
</tr>
</tbody>
</table>

Table 1 – 802.11n and 802.11ac Spectral Mask

In 802.11n deployments, it is common to configure adjacent access points on non-adjacent channels: in other words, adjacent APs operate on channels that are at least 40 MHz apart. The reason for this is that power from transmissions in adjacent channels can spill into neighboring channels and cause ACI. However, when you are deploying 80 MHz channels, it isn’t possible to deploy adjacent access points on non-adjacent channels, because there aren’t enough 80 MHz channels available today.

It is therefore reasonable to conclude that if you are deploying in an enterprise environment using a 1 in 3 frequency reuse scheme with 80 MHz channels, they are going to suffer ACI and performance will be impacted. This impact depends on the duty cycle of the adjacent channels. The more traffic on adjacent channels, the greater the ACI and the greater the impact on performance. This has led some to suggest that deploying 802.11ac on 80 MHz channels could result in worse performance than deploying 802.11ac on 40 MHz channels.

Comparing 802.11n and 802.11ac performance in a 40MHz channel

It is common to compare technologies by looking at the maximum theoretical data rates. There are two technologies in 802.11ac Wave-1 products that are not in 802.11n: explicit beamforming and 256-QAM.

Although technically explicit beamforming was defined in 802.11n, it was not implemented. This was because the specification provided the flexibility to implement beamforming in multiple ways, and vendors did not wish to support multiple mechanisms, due to the implications for product costs. The 802.11ac specifications fix this problem by defining a single explicit beamforming mechanism. Explicit beamforming requires the beamformee (i.e., the client) to provide explicit feedback regarding the channel conditions to the beamformer (i.e., the access point). The beamformer then uses this information to generate beams toward the beamformee.

The advantage of beamforming is that it increases the range at which the higher data rates can be attained. The advantage of the explicit beamforming defined in 802.11ac over the implicit transmit beamforming implemented in many of today’s 802.11n products is twofold. First, because it is based on channel conditions, the beamforming should be more accurate and result in a strong received signal. Second, because vendors are aligned on a common mechanism, it can be used for both transmitted and received signals.

The introduction of 256-QAM means that, in extremely good RF conditions, a signal can be modulated to carry 8 rather than 6 bits per modulation symbol. This results in an increase in the data rate of 1.33x (8/6). This higher data rate can only be achieved in the best RF conditions. However, coupling 256-QAM with beamforming extends the range at which this higher data rate can be attained.
The business case

If you deploy 802.11ac in a 40 MHz channel, explicit beamforming has a very high probability of increasing the range at which you can get higher data rates. In some limited regions, you will also be able to use 256-QAM and get slightly higher date rates. In addition to the transmit beamforming capabilities of 802.11n, you should also have the benefit of beamforming on the uplink. Explicit beamforming does introduce higher overhead, due to the need to report channel conditions to the beamformer, but overall, you can expect to see a performance improvement.

It is impossible to say exactly what the throughput benefit will be, as it varies with RF conditions and traffic loading. Is it enough for you to replace your existing 802.11n deployment? The answer is clearly no. If you are currently an 802.11g network, is it enough to make you upgrade to 802.11ac over 802.11n? The answer to that depends on the equipment cost. The cost of 802.11n equipment is starting to drop significantly, while 802.11ac equipment carries the “new technology” price tag.

The bottom line is: Today, if your vendor is telling you to deploy 802.11ac in 40 MHz channels, you will have trouble justifying it. To get the true gain out of 802.11ac, you need to deploy it in 80 MHz channels.