VeEX Inc.

Wi-Fi Expectations vs. Reality

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Should you believe the specs? The case for educating subscribers about true Wi-Fi performance.

More often than not, service providers are faced with the difficult task of educating their customers about true Wi-Fi performance. Wi-Fi routers targeting residential consumers, especially gamers, have been engaged in a speed race. With aggressive designs and a slew of external antennas, routers sometimes look like spaceships and advertise incredible speeds. But can 7.4 Gbps really be achieved or is it just deceptive advertising?

From theoretical speed to reality, this article discusses in detail the reasons why there is a gap between advertised speeds on the datasheets versus real applications data throughput as experienced by the client device, so that customer education can become a little bit easier.

IEEE 802.11 a, b, g, n, ac

Over the years, IEEE 802.11 standards have evolved to bring faster and faster speed, from the early days of 802.11 in 1999, with a meager speed of 54 Mbps to the latest standards, 802.11ac that can achieve a maximum theoretical speed over 2 Gbps.

Speed increases have been achieved by several means. Modulation technique improvements and the use of multiple parallel data streams have been instrumental to these improvements.

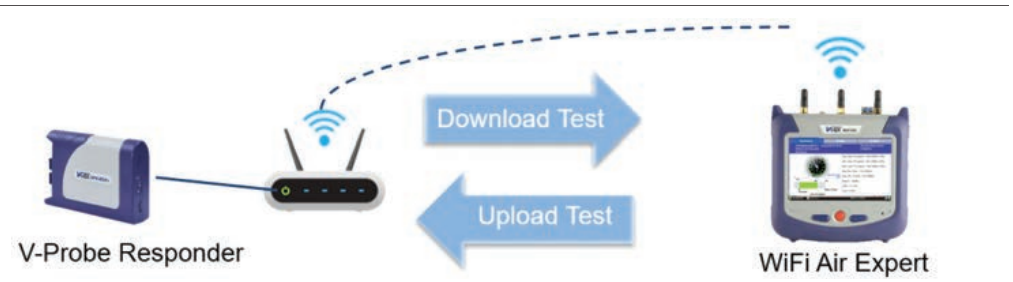
QAM

802.11 standards use quadrature amplitude modulation (QAM) to encode data bits before transmission. Although the details of modulation are beyond the scope of this article, it is useful to understand that the data bits are encoded into a QAM constellation symbol that is transmitted over the air and decoded by the receiver. The higher the order of the modulation scheme, the more bits can be encoded into a symbol. The highest order modulation supported in 802.11ac is 256-QAM, encoding eight bits per symbol, whereas with 64-QAM, the highest modulation supported in 802.11n encodes six bits per symbol. It gives ac a significant improvement of efficiency and therefore data speed. On the decoder side, 256-QAM is also more challenging, because the receiver needs higher sensitivity to detect each one of the 256 states that the symbol can take. This means that it is required to have very clean RF channel conditions (high signal level and low noise level), between the transmitter and the receiver in order to decode 256-QAM symbols. In Wi-Fi standards, transmitters use dynamic modulation selection to adapt to the RF channel's conditions. A transmitter will revert to a lower order modulation, therefore lower data speed, if the channel conditions are not optimal.

For 802.11ac, in practice, it means that the top data speed can only be achieved if the receiver is 10 to 20 feet away from the transmitter and with a clear line of sight. If the signal level is low or the noise level is high the transmitter will revert to 64-QAM 802.11n speed. The standard allows the transmitter to revert to even lower transmission speeds if the signal level is low or noise level high. This makes the Wi-Fi standard very resilient to any condition, but also deceptive if customer expectations are to always link-up at the top speed advertised on the datasheets.

Generational Gap

Regardless of the signal's and RF channel's quality, the higher order modulation is only achievable if both transmitter and receiver devices are 802.11ac capable. An older device, with only 802.11n or 802.11b/g capabilities will never be able to transmit or receive 256-QAM; it would be similar to speaking a different language. Therefore, if subscribers upgrade their Wi-Fi router to a model supporting 802.11ac, but their client device (PC, tablet, phone ...) is not



upgraded, the 802.11ac capabilities will not be used. Conversely, if subscribers upgrade their client device to a newer generation, but not their Wi-Fi router, they won't be able to take full benefits of the upgrade. Very often customers will overlook this fact and simply get frustrated by the lack of speed improvements after purchasing a new device.

MIMO

Another method used in Wi-Fi to achieve higher data speed is to use multiple parallel streams. This method is called MIMO (multiple input multiple output), and requires multiple antennas. In a device with four MIMO antennas (4x4), the user data is broken down into four streams that are transmitted in parallel, one stream per antenna. On the receiving end, the four data streams are received by four antennas and the user data is reassembled. This method can effectively transmit four times "faster" than devices with a single antenna. However, it requires both the transmitter and the receiver to have the same number of MIMO streams capability to take full advantage of the feature. The reality is that even though Wi-Fi routers often support four MIMO streams, there are no clients at this time that can match it. Mobile devices like phones or tablets often have one or two antennas, while only high-end laptops will have three antennas. Therefore regardless of the speed advertised on the Wi-Fi access point's spec, the fastest Wi-Fi client on the market will only be able to connect at 1.3 Gbps, and that's only in the best RF conditions a few feet away from the AP as explained earlier. Unfortunately the number of antennas in a client device is often difficult to figure out, as they are not externally visible in a phone, tablet or laptop, and manufacturers don't make this information easily accessible.

Dual-Band or Tri-Band Access Point

Another deceptive trick up the router vendor's sleeve is to add up the maximum theoretical speed of each Wi-Fi band, and advertise it as a single aggregated speed. Modern Wi-Fi routers are capable of supporting the 2.4 GHz and 5 GHz frequency bands simultaneously, more advanced routers will even support tri-bands with the lower and upper 5 GHz bands supported in addition to the 2.4 GHz band. These routers integrate multiple RF radio chains and therefore are capable of transmitting or receiving data on each band simultaneously. However, having a tri-band AP doesn't increase the speed at which an individual client device connects, because client devices can only connect to a router on a single frequency band at a time.

PHY Speed vs. User Data Throughput

This article, so far, has been focused on the maximum speed that can be achieved by the AP and client devices at the physical layer (PHY). This speed indicates how fast each "bit" can be transmitted over the air. Unfortunately, the PHY speed does not directly translate into user data upload or download throughput; there are a few things to take into account:

- Not every bit transmitted carries data. Overhead is required by the 802.11 protocol (preambles, data headers, management frames, acknowledgement frames ….) and the TCP/IP header protocols.
- In addition, a device cannot takeover all the available air-time when it needs to transmit data. Just as a fast car gets stuck in a traffic jam, the same phenomenon is true for wireless traffic. With the Wi-Fi RF channel being a shared medium, each device only transmits data when there is no other device transmitting, so this effectively divides the available air-time between the number of devices attempting to transmit simultaneously. This sharing mechanism applies to devices connected to the local AP and to all devices connected to neighboring APs, if configured on the same or overlapping RF channel.

True Performance Verification

All these considerations combined make it difficult to predict the actual data throughput on a Wi-Fi network. To educate customers about true Wi-Fi performance, service providers need to be able to test the actual data throughput as experienced by the subscribers, in the locations where they will be using the service. For this purpose, test equipment like VeEX's Air Expert V-Perf dual-ended Upload and Download traffic test tool is used to evaluate the network's performance under load and measures QoE parameters from an end user's point of view. Technicians can quickly establish whether the achieved upload and download rates meet SLA requirements and readiness for high bandwidth traffic like audio and video streaming, with pre-configured profiles for common applications (Netflix, YouTube, Skype, VoIP….).

V-Perf dual-ended test is compatible with iPerf3 servers, Air Expert or companion V-Probe responders, connected directly on the back of the AP 10/100/1000BASE-T interface to perform actual Wi-Fi to Ethernet data throughput tests. The test can also be performed to a cloud-based server, qualifying Wi-Fi and broadband access bandwidth in one step.

Air Expert

VeEX's Wi-Fi Air Expert is the perfect test tool to ensure a successful home Wi-Fi installation. With an intuitive guided interface and ease of use, the Air Expert will make any field technician a Wi-Fi expert.

To learn more about Wi-Fi technology and how the VeEX Wi-Fi Air Expert can help you survey, optimize, troubleshoot and enhance user experience on your networks visit us at www.wifi-testing.com.

