ALLION USA

INTERNET SERVICE PROVIDER WIRELESS GATEWAY COMPETITIVE ANALYSIS

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Introduction

Internet Service Providers (ISP) have a number of factors to consider when deploying wireless gateways with their service, and those decisions on gateway selection can have a major impact on the end user experience – especially as homes become more wirelessly connected (i.e. TVs, gaming consoles, media servers, computing devices, etc.). Both performance and coverage delivered throughout the home should be key considerations when ISPs evaluate the capabilities of the gateways they offer. As the widely deployed 2.4GHz band becomes increasingly congested, the ability to leverage the 5GHz band becomes an important consideration. The newly developed 5GHz 802.11ac mode which can theoretically deliver up to 1.3Gbps (3x3), is also an important factor when planning for the future when more client devices develop this capability.

Allion's competitive analysis evaluated both the performance and coverage of the gateways currently available from Comcast, Verizon, and AT&T. It highlights how ISPs decisions on including the following Wi-Fi technologies impact performance:

- MIMO vs. SISO antenna configuration(s)
- Dual-band capability (2.4GHz vs. 5GHz)
- 802.11ac vs. 802.11n vs. Legacy (802.11bg) protocols

The performance analysis was accomplished by conducting lab measurements of each gateway's throughput rate over the connection range of the test station / gateway connection. This was done by performing a Rate vs. Range test.

The second area of interest (coverage) was analyzed by measuring the gateway signal coverage throughout the area. An Over-The-Air (OTA) RSSI Heat Map test was performed at the Allion test house to observe real-world signal coverage of each gateway.

Wireless Gateway's Tested

The *"Allion Internet Service Provider Wireless Gateway Competitive Analysis*" summarizes a study conducted by Allion USA, LLC of the potential strengths and weaknesses of the following residential gateways available from three major Internet service providers:

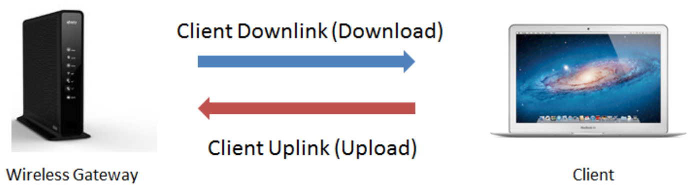
- Comcast / Cisco DPC3941T 3x3 802.11a/b/g/n/ac XB3 with SW dpc3941-P20-18-v303r2042162-140822a-CMCST
- Comcast / Cisco DPC3939 3x3 802.11a/b/g/n XB3 with SW dpc3939-P20-18-v303r204113-140822a-CMCST
- Verizon / Actiontec 2x2 802.11b/g/n MI424WR Rev. I with SW 40.20.4.2
- AT&T / 2-Wire 1x1 802.11b/g 2701HG-B with SW 6.1.5.74-enh.tm
- Verizon / Actiontec 2x2 802.11b/g/n MI424WR Rev. G with SW 30.0.16.15

The following reference station was used to collect measurements:

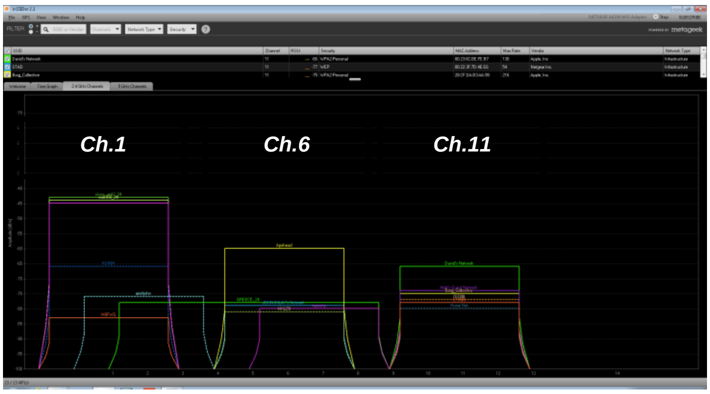
- Late 2013 MacBook Pro 802.11a/b/g/n/ac (Mac OS 10.9) with Broadcom BCM4360 chipset

Tools used:

- Iperf (traffic generator): This tool was used for collecting throughput measurements during the test. Commands used during the test are shown below:
    - Sender: iperf –c <IP> -w 256K –l 1472 –P4 –fm –i1 –t <DURATION>
    - Receiver: iperf –s –w 256K

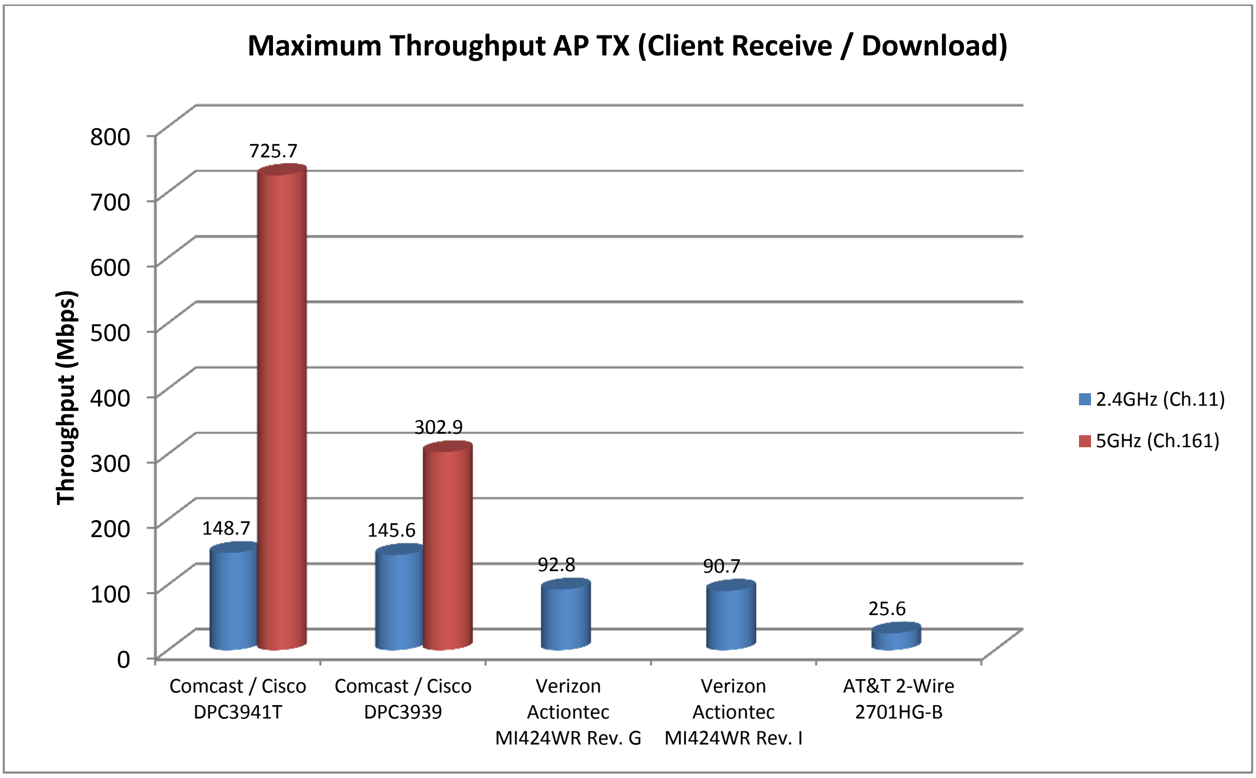


- InSSIDer by Metageek: This SW tool detects the operating channel and the signal strength of all Wi-Fi signals (both bands) in nearby areas



Conclusion

Based on the tests performed, the Comcast / Cisco DPC3941T gateway significantly outperformed the competitor devices. The Comcast gateway achieved over 700Mbps in downlink throughput while the Verizon and AT&T gateways only achieved max throughputs of 92.8Mbps, 90.7Mbps, and 25.6Mbps respectively. The DPC3941T also outperformed the previous generation gateway DPC3939 by more than 2.3 times the throughput, which is more than 400Mbps in improvement.



Several key features were present only on the Comcast / Cisco gateways which led to the advantage.

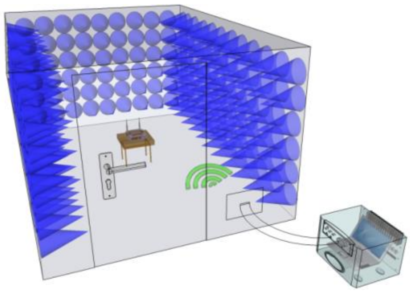
1. 3x3 antennas
    a. Both the Verizon and AT&T gateways had fewer antennas than the Comcast / Cisco gateway. The Verizon was equipped with a 2x2 solution while the AT&T only had a 1x1 system. Each antenna can theoretically add up to 150Mbps in 802.11n mode.
2. Dual band capability
    a. The ability to leverage both the 2.4GHz and 5GHz was a big advantage for the Comcast / Cisco gateway for several reasons. 5GHz 802.11n has the option to double the channel width to 40MHz in order to theoretically double the throughput.

   b. The 2.4GHz spectrum is also limited in the number of available channels while the 5GHz band offers many more. Due to this, the 2.4GHz experiences noticeable interference from neighboring Wi-Fi signals.

3. 802.11ac vs. 802.11n vs. 802.11b/g
   a. This particular mode is what allowed the Comcast / Cisco DPC3941T gateway to achieve over 700Mbps. 802.11ac mode supports channel widths of 80MHz and 160MHz; theoretically doubling or quadrupling the throughput compared to 802.11n 40MHz mode. With a 3x3 antenna system, the theoretical max throughput can reach up to 1.3Gbps.

This study evidenced that the Comcast / Cisco DPC3941T gateway was superior in performance with both throughput and range compared to the gateways deployed by Verizon and AT&T, as well as the previous generation model DPC3939. The end result of higher throughput will most likely lead to a more pleasant network experience for the Wi-Fi users at home.

Rate vs. Range



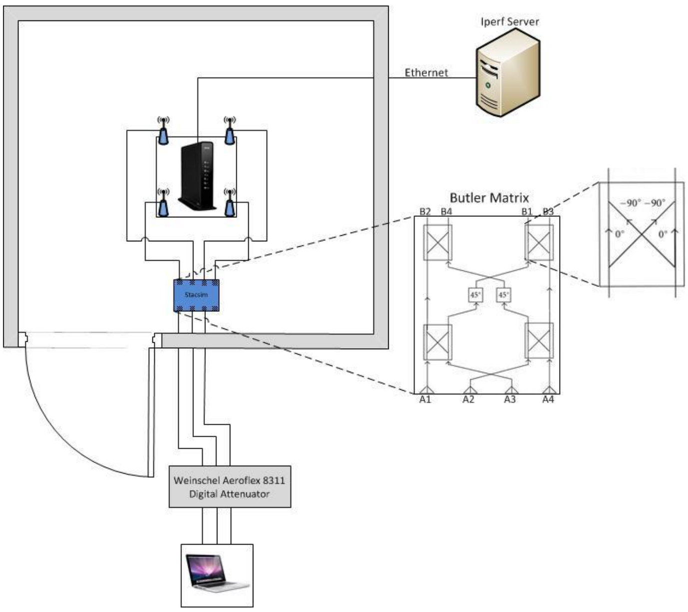
This test simulated the effect of moving a wireless gateway from within very close proximity of the connected station to outside of the connectivity range of the gateway / station – effectively measuring the ability of the gateway to negotiate an optimal modulation with a client under a given signal condition.

Throughput performance is base-lined by collecting throughput measurements based on the changing RF conditions (channel fading) by performing a throughput speed test at each attenuation level – incrementally increasing the attenuation between the station and wireless gateway.

The goal of this test was twofold:

1. To determine the baseline ***peak throughput performance*** of a connected station as the signal is gradually faded out.
2. To understand the ***connection range*** of the tested wireless gateway device.

Typically, rate vs. range tests are run in a completely conductive (cabled-only) environment where the gateway's antenna sub-system is by-passed via a cabled solution. This methodology is inadequate when system integrators (ISPs) want to make these same types of measurements in an end-to-end environment with an integrated product that has a specific antenna sub-system.

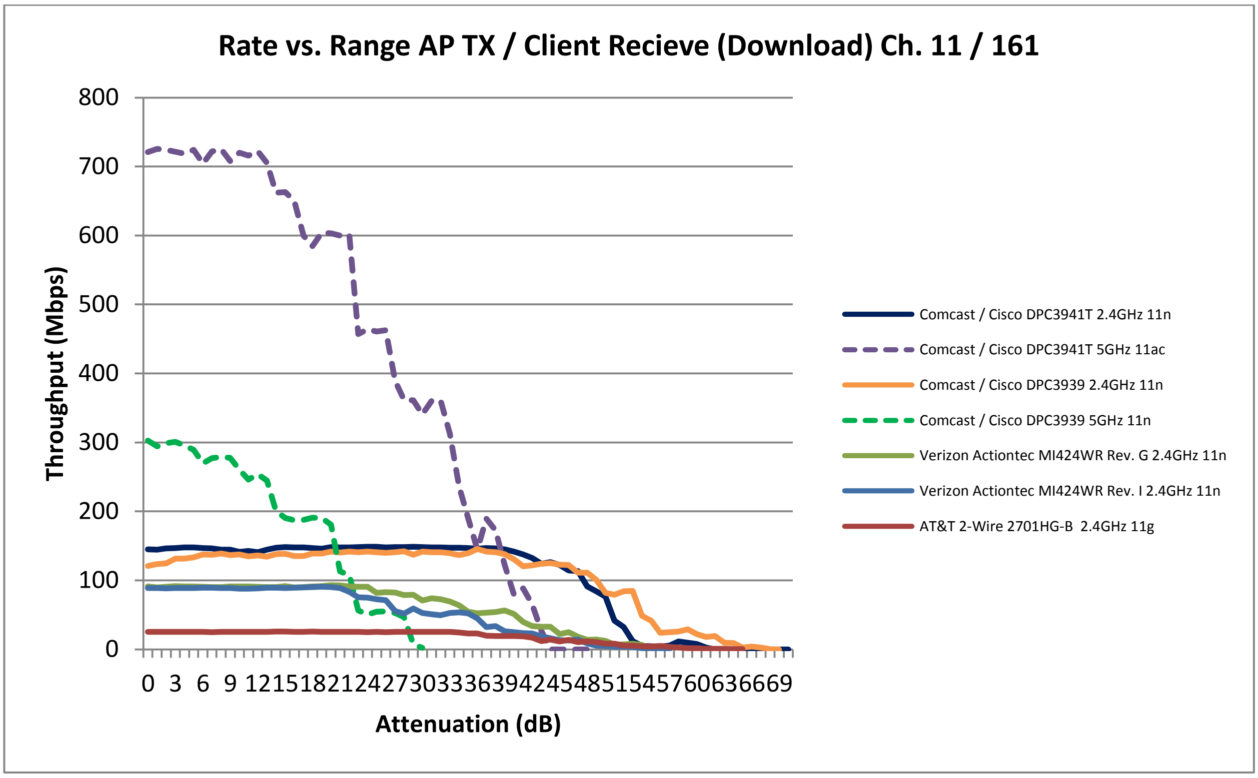


Allion leverages a unique solution that combines a large anechoic chamber (3m x 3m x 3.5m) coupled with inline programmable attenuation and butler matrix used to simulate the multi-path that is usually seen in an over-the-air environment.

This environment provides the ability to test the performance of a wireless device in an ideal environment with consistent repeatable results, while at the same time keeping the Wireless Gateway intact as a final integrated solution.

The throughput measurements taken at each attenuation step are based on TCP (Transmission Control Protocol) results using a 30 second throughput test using Iperf. Traffic direction is based on “client receive” throughput values at each attenuation point.

Below are results from the testing against gateways used in Comcast, Verizon, & AT&T deployments.



Range does NOT include the system path-loss of the test-bed

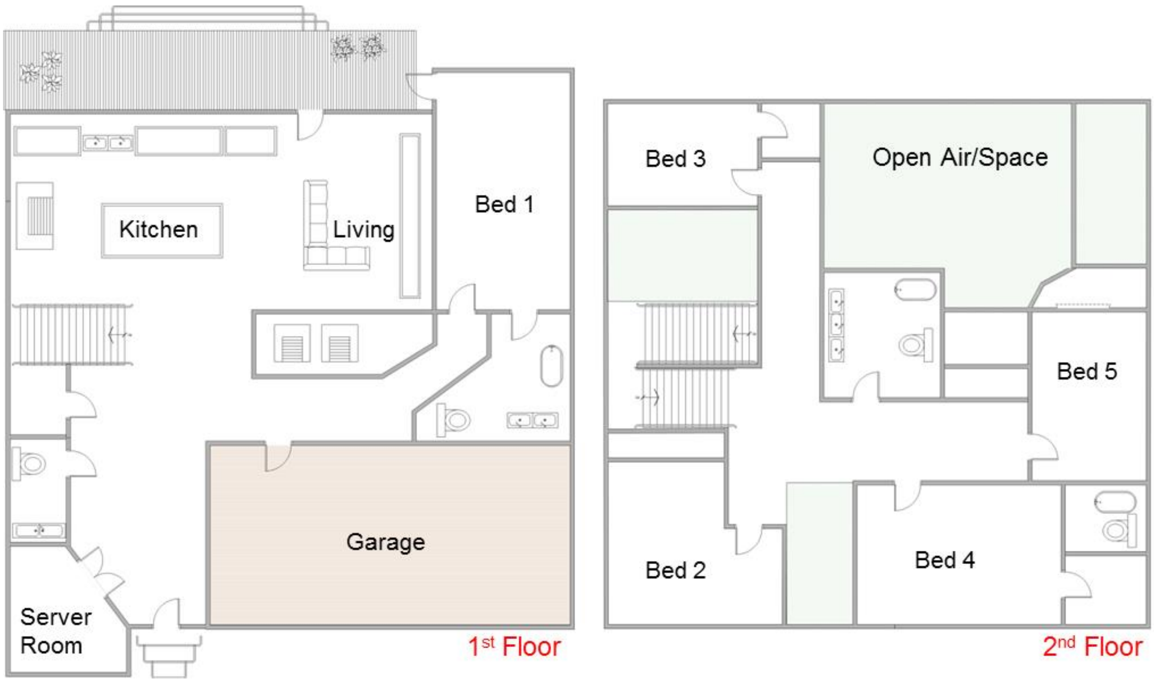
As shown above, the Comcast gateways outperformed the competitors in both 2.4GHz and 5GHz (5GHz was not supported by Verzion and AT&T gateways). The Comcast gateways exhibited ~150Mbps of throughput while the Verizon gateways showed ~90Mbps and the AT&T was limited at 25Mbps on the 2.4GHz band. With the 5GHz band and 802.11ac mode, the Comcast / Cisco DPC3941T gateway significantly increased the throughput surpassing 700Mbps. The longest connection range was also observed with the Comcast gateways while the Verizon and AT&T gateways dropped to ~0Mbps early in the attenuation.

RSSI HEAT MAPS

This test measured the gateway's ability to penetrate a coverage area, from a Received Signal Strength Indication (RSSI) measured from a station. The test provides a strong indication of the signal coverage of a residential gateway from a reference client connected to the gateway.

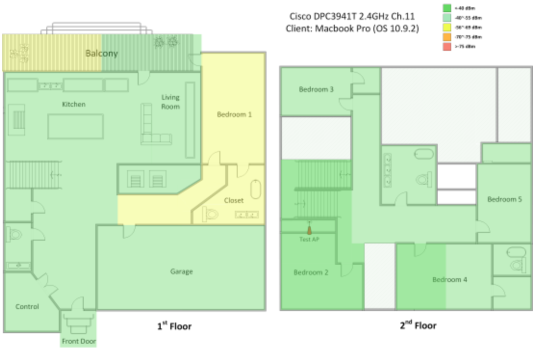
While RSSI measurements alone do not guarantee good performance, they are useful as an indicator of the potential coverage footprint of a specific gateway.

Allion uses a dedicated residential home in the Pacific Northwest as an OTA range to conduct the study. The site is comprised of a ~3,000 sq. ft., two-story residence with a combination of drywall, wood, glass, and brick as its main building material. While no OTA environment is an absolute indicator of another OTA environment because of the complexities of building structure & material, RF multi-path, etc., Allion's Wireless Test House helps provide a differentiation of gateway coverage. Below is the floor-plan of Allion's test environment:

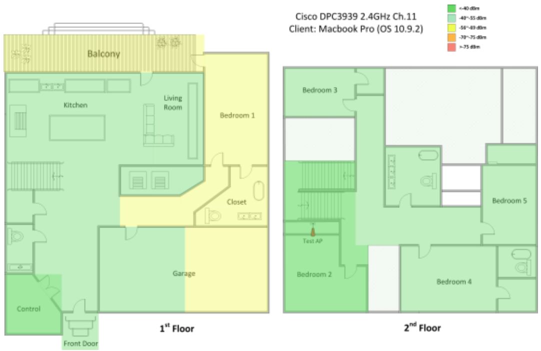


Below are the measured client “Received Signal Strength Indication (RSSI)” values at each attenuation point – measured in “dBm”.

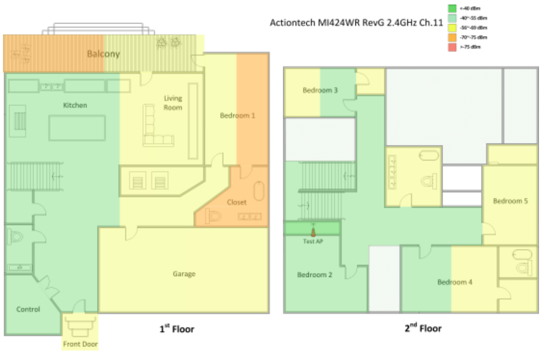
Comcast / Cisco DPC3941T Ch. 11



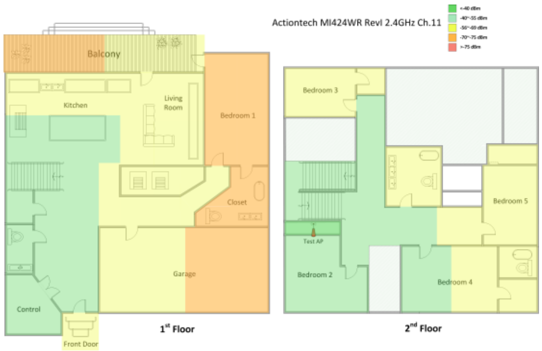
Comcast / Cisco DPC3939 Ch. 11



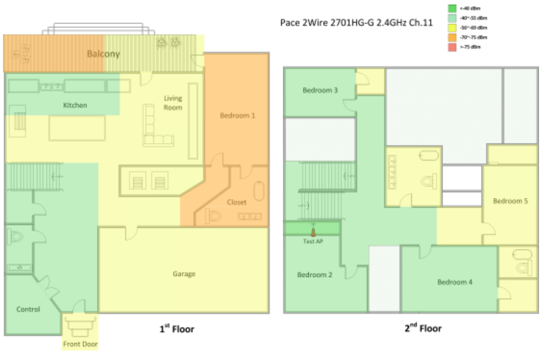
Verizon Actiontec MI424WR Rev. G Ch. 11



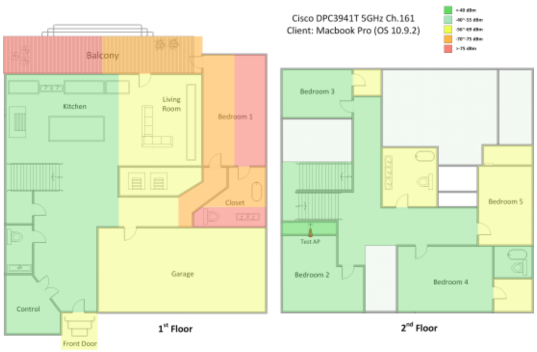
Verizon Actiontec MI424WR Rev. I Ch. 11



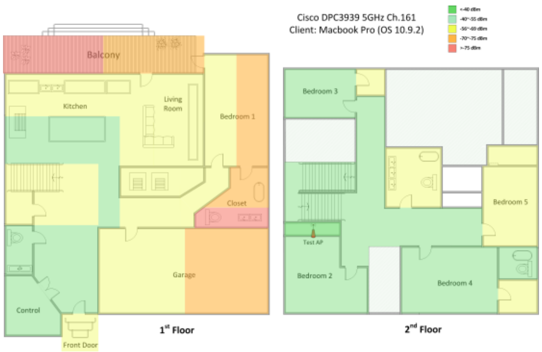
AT&T 2-Wire 2701HG-B Ch. 11



Comcast / Cisco DPC3941T Ch. 161



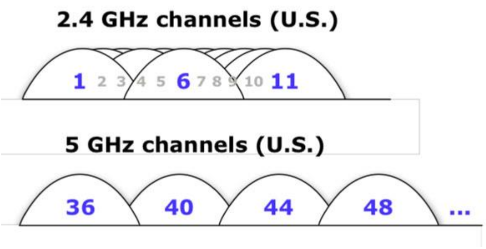
Comcast / Cisco DPC3939 Ch. 161



The results above support the results reported from the Rate vs. Range testing that using a gateway that leverages both the benefits of 802.11n and more advanced hardware (3x3 antenna configuration) also results in overall better coverage as compared to either legacy 802.11a/b/g or lesser 802.11n technologies.

The Comcast wireless gateways tested showed greater coverage in terms of client RSSI versus both Verizon and AT&T gateways tested.

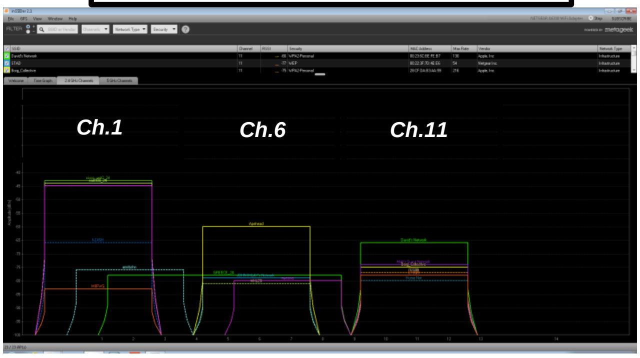
Dual-band Capability & 802.11ac



Wi-Fi can be deployed in 2 separate RF bands consisting of spectrum located in 2.4GHz and 5GHz spectrums. Many gateways operate solely on 2.4GHz because of the legacy Wi-Fi support of 802.11b and 802.11g, as well as the additional cost and complexity to design involved. Vendors have long avoided adding support for 5GHz. This line of reasoning is fast becoming an out of date strategy for ISP's providing gateways as a part of their deployment. In addition, the industry has recently expanded the 5GHz band with a new mode 802.11ac. This mode can support up to 160MHz of channel width - theoretically quadrupling the throughput compared to 40MHz 802.11n mode. Below is the outline of the major benefits of 5GHz operation:

1. Availability of 5GHz bands – more recent clients available in the market (i.e. iPhone 5/5S, iPad Air, Kindle Fire HDX, various ultra-books, etc…) support 5GHz, and if a gateway could leverage this capability – it would allow the ability to off-load clients to an operating band that experiences significantly less interference with neighboring Wi-Fi networks. Below are Wi-Fi network examples of a typical home environment on both bands:

2.4GHz Home Environment



5GHz Home Environment

The image above shows that the 2.4GHz band not only has several APs across the entire spectrum, but a noticeable amount of RF noise generated due to the limited channels. On the other hand, the 5GHz band shows plenty of non-overlapping channels. The extra channels helps prevent RF interference, which results in a better end-user experience.

2. 20MHz vs. 40MHz channel width – with the introduction of 802.11n, the potential to widen the bandwidth of a certain connection was created by doubling the amount of channel width used for a single connection on a given Wi-Fi channel. Typical Wi-Fi channels operate on a

20MHz channel width, 802.11n allows the ability to double this channel width to 40MHz. However, this obvious advantage in bandwidth must also take into account overall available spectrum (2.4 GHz only has ~60 MHz of channel spectrum while 5GHz has over 400 MHz to available to utilize depending on the connection).

3. 802.11ac – the recently developed 802.11ac mode operates on the 5GHz spectrum which supports channel widths of 80MHz and 160MHz; theoretically doubling or quadrupling the throughput compared to 802.11n 40MHz mode. Only a handful of client devices support this mode as this technology was just ratified in January 2014, but this number is expected to grow rapidly as newer devices enter the market.

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