The 2.4 vs. 5 GHz. Debate Continues:
Evaluating Key Architectural and Operational WLAN Strategies in the Era of 802.11n

A Farpoint Group Technical Note

Document FPG 2009-384.1
September 2009

Farpoint Group

With the approval this month of the final 802.11n standard, many have assumed that any remaining questions with respect to wireless LAN performance have been consequently settled. After all, 802.11n, in the form of products approved under the 2007 Draft Specification from the Wi-Fi Alliance, has been available for some time. Many of these products offer raw performance of 300 Mbps, and products with 450 and 600 Mbps capabilities are also available. It is no longer unusual to see realized (Layer 7) single-client performance well in excess of 150 Mbps, and, thanks to a corresponding improvement in overall system *capacity* enabled by 802.11n and, importantly, architectural innovations implemented by WLAN system vendors, .11n is expected to be broadly influential across essentially all application areas over the next few years. Of course, .11n cannot reach the magic 1 Gbps level, but, while we do not expect these activities to result in a replacement for 802.11n, the IEEE 802.11 organization now has two additional task groups (.11ac and .11ad) looking into this level of performance and beyond. One might regardless therefore be tempted to make the statement that brute force has once again obviated the need for more sophisticated approaches to improving the throughput and, even more importantly, again, the capacity of wireless-LAN networks, but one should give a bit of pause before proceeding down that path – a path that Farpoint Group believes is, in fact, dead wrong.

And the reasons for this are less than subtle. To begin, the demands on networks only grow over time. This demand materializes in the form of an ever-increasing number of clients, with corresponding ever-growing application requirements, and not just for throughput, but also with respect to time-boundedness, responsiveness, and network-wide capacity. While the throughput embodied in 802.11n is most welcome, to be sure, we would argue that such alone is insufficient for enterprise-class performance – proper deployment, aided by architectural innovations from WLAN system vendors, is of at least equal importance. And, finally, keep in mind that access to any given 802.11 channel is serialized and that contention is almost always a factor in realized performance. It therefore behooves us to make the best use of the scare resource that the airwaves always are, with significant burden falling here to system-level architectural approaches and innovations. Brute force alone is thus no solution at all.

This challenge thus introduces another dimension to explore, the subject of this Farpoint Group Tech Note. Specifically, we set out to examine the importance of wireless-LAN system architecture in provisioning optimal solutions based on 802.11n. It is, however, very difficult to examine the benefits of a given architectural strategy directly, because such is complicated by the specifics of a given implementation. We therefore decided to run a few tests on a particular (and very popular) implementation to evaluate a specific architectural feature – in this case, Cisco's BandSelect capability.

About Bandselect

Cisco's BandSelect feature can be enabled with a single command on the company's wireless controllers. The objective is to make sure that clients that can use the 5 GHz.

bands do so. A number of configuration parameters are provided to fine-tune this capability if desired, but the benefits are obvious – 5 GHz. has about eight times the spectrum of 2.4 GHz., and is usually uncongested in most venues. Some network managers, however, have historically shied away from the use of 802.11a (and now 802.11n in the 5 GHz. bands) due to mistaken assumptions about range. Farpoint Group's testing over the years has shown that there is little practical difference in rate-vs.-range performance between 2.4 GHz. and 5 GHz., and that throughput at 5 GHz. is usually better than that at 2.4 at any given distance likely to be encountered in office an similar applications, this difference primarily attributable to the lack of congestion (which is effectively interference) noted above. We thus regularly use and recommend 5 GHz. as the default, and BandSelect thus fits very nicely into our strategy, automatically moving dual-band clients to 5 GHz. with no client configuration (or re-configuration) or other action required on the part of either users or network operations staff.

The question is, of course, given the level of performance now available in 802.11n, whether operation at 5 GHz. still has the benefits outlined above. So we set out to test whether the 5 GHz. bands should in fact remain the default today. And we also examined exactly what level of performance could be obtained when .11n competes with .11g, compared, of course, to a set of baselines deried in this testing exercise.

Test Configuration

For this test (see Figure 1), we used a Cisco 5508 Wireless Controller, a Cisco Aironet 1252 access point (AP), a Cisco Catalyst 3560-E switch, VeriWave hardware and software, and three notebook computers with Intel's ABG and AGN adapters.

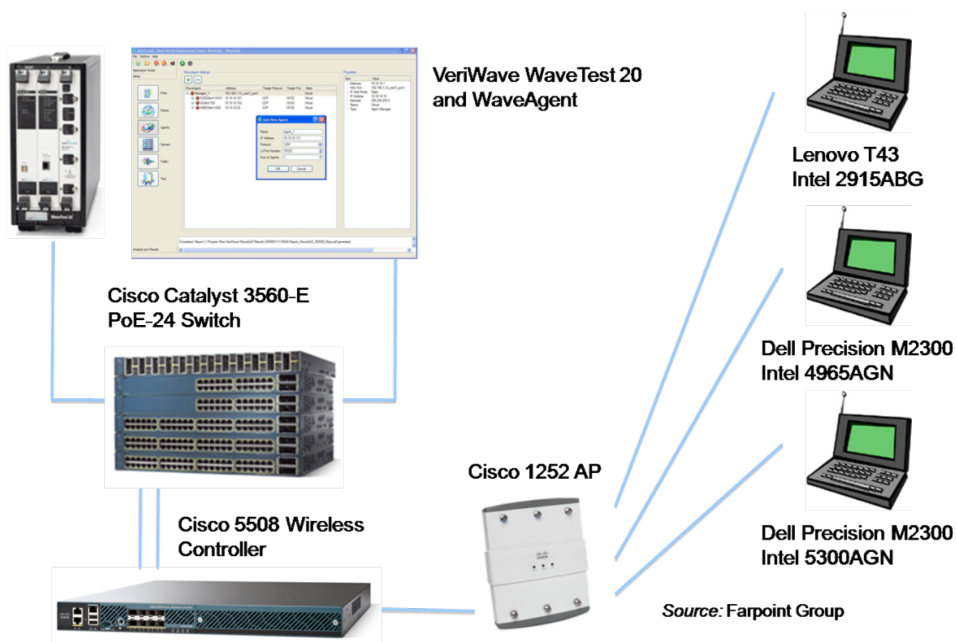

Figure 1 – Test configuration schematic diagram. *Source:* Farpoint Group

The Cisco Aironet 1252 access point was configured for both .11g and .11n at 2.4 GHz., using Channel 1 (20 MHz.), and for a 40 MHz. .11n channel at 5 GHz., using Channel 36. All settings in the controller were left at their defaults, except for enabling BandSelect, which is discussed under Test 1a and 1b below. The Cisco Wireless 5508 controller was connected (via link aggregation, so as to assure that there would be no bottlenecks) to a Cisco Catalyst 3560-E PoE-24 switch, which also provided power over Ethernet for the AP and connectivity to the other infrastructure-side equipment required.

Clients, all contemporary notebook computers, included the following:

- Lenovo T43, with an Intel 2915ABG adapter and driver version 9.0.3.39.
- Dell Precision M2300, with an Intel 4965AGN adapter and driver version 12.4.3.9.
- Dell Precision M2300, with an Intel 5300AGN adapter and driver version 12.4.0.21.

All of these PCs ran Windows XP Pro, and all used Intel's PROSet/Wireless WiFi Connection Utility 12.4.0.0.

Traffic for this series of tests was generated by a combination of a VeriWave WaveTest 20 traffic generator/analyzer and VeriWave's new WaveAgent OTA software. WaveAgent involves the use of a small utility loaded on each client PC (which has no user interface and regardless requires no configuration of any form) with the actual traffic defined by the WaveAgent console, which runs on a PC and is very easy to use. We set up a simple TCP downlink traffic flow designed to swamp the capabilities of any given 802.11 PHY-layer technology, and used exactly the same test for all clients and test cases. The WaveTest 20 is capable of provisioning enormous loads using a large number of clients, and can even simulate clients over the air as well (although we didn't use this capability in this series of tests).

All clients were stationary during testing and placed roughly 3-4 meters from the AP. Each test run was 90 seconds in length. We carefully monitored for energy in the 2.5 and 5 GHz. channels using Cisco's Spectrum Expert, and noted no meaningful traffic or interference during any of the test runs.

Test Operations and Results

The first objective (Test 1a – see Figure 2) was to obtain a baseline .11g result using the Lenovo with the Intel 2915ABG.

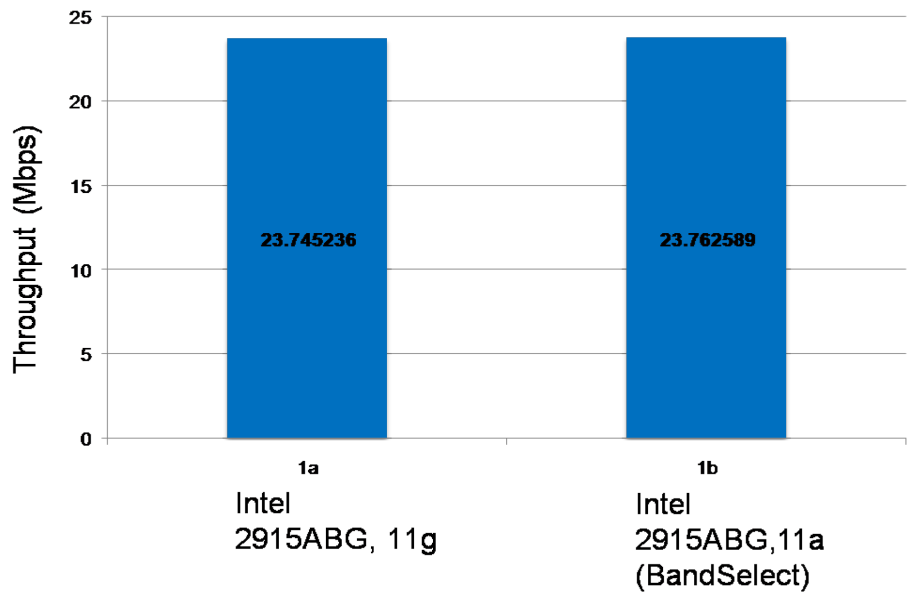

Figure 2 – Test results for the 2915ABG in .11g and .11a mode. The switch to .11a was performed automatically by Cisco's BandSelect. *Source:* Farpoint Group

This test resulted in performance of about 24 Mbps, as expected for 802.11g. We then enabled BandSelect (Test 1b) and noted that the client shifted to 5 GHz. automatically. Running the same test again for .11a resulted in roughly the same performance, again as expected. Of course, had the 2.4 GHz. channel used been crowded, as is often the case in enterprise settings, we would expect that the 5 GHz. result would have been noticeably better than that obtained at 2.4 GHz. No matter, we really just wanted to see if BandSelect worked and to establish a baseline for the comparison of results using 802.11n.

Test 2 (see Figure 3) used the 4965AGN in .11n mode but at 2.4 GHz. and thus in a 20 MHz. channel. Test 3, the result of which is also shown in Figure 3, used the 5300AGN in a 40 MHz. channel at 5 GHz. Again, these tests established baselines for comparison with subsequent results. The numbers here, regardless, were impressive.

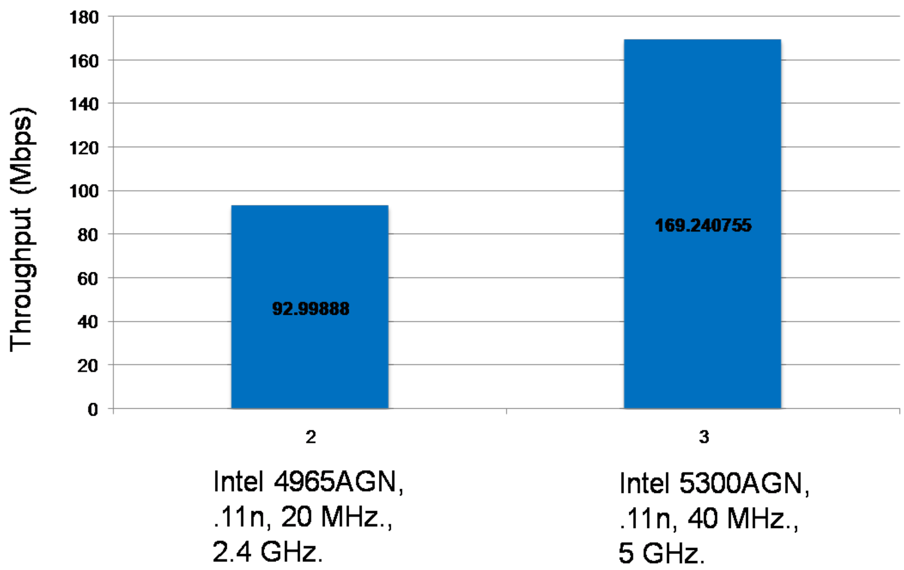

Figure 3 – Test results for single-client .11n for both 20 and 40 MHz. channels. *Source:* Farpoint Group.

As expected, the performance in both cases was outstanding – about 93 Mbps for 2.4 GHz., and a whopping 169 Mbps at 5 GHz. Note that 40 MHz. channels make a big difference in performance – a key advantage of using 802.11n in the first place. And, again using the single 40-MHz. channel possible in the 2.4 GHz. band would be completely impractical given the broad deployment of .11g today.

Tests 4a and 4b (see Figure 4) involved the same clients used in Test 2 and Test 3, but with the benchmark for each run simultaneously. This yielded aggregate throughput of almost 226 Mbps, again outstanding.

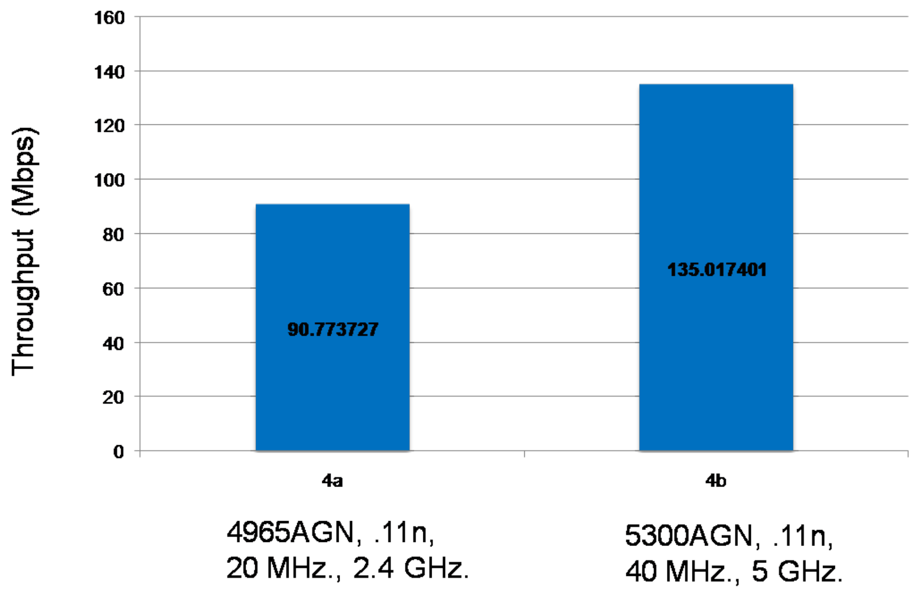

Figure 4 – Test results for single-client .11n for both 20 and 40 MHz. channels. *Source:* Farpoint Group.

Finally, we wanted to see if simultaneous operation of .11g and .11n in the same 20-MHz. channel at 2.4 GHz. was in fact as detrimental as we had assumed it would be. The results here (Tests 5a and 5b, see Figure 5) confirmed a pattern that we've seen many times.

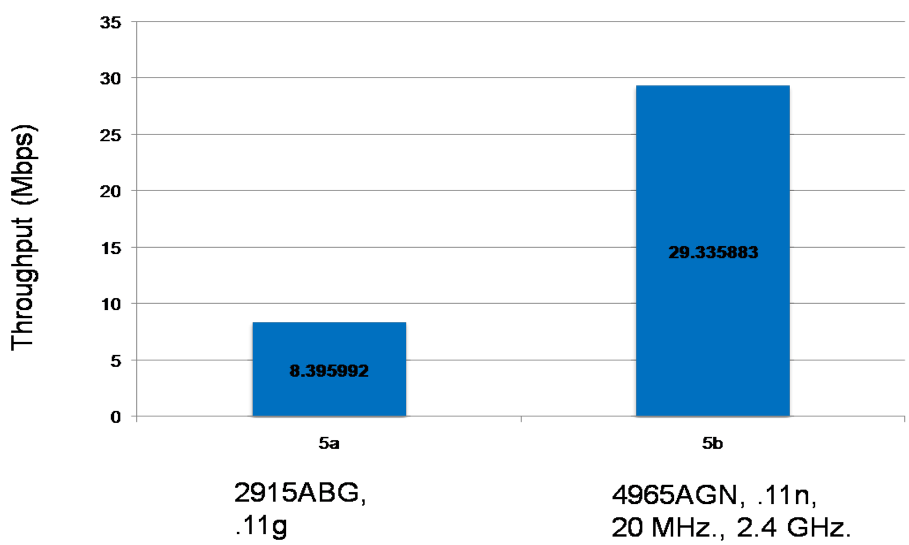

Figure 5 – Test results for *simultaneous* single-client .11g and .11n. *Source:* Farpoint Group.

Note here that the .11g result was only about 35% of the baseline in Test 1a, and the .11n performance was only a little better than 31% of the result in Test 4a. While, of course, the 802.11n standard does indeed allow coexistence of these two different PHYs in the same channel simultaneously, the results were not pretty, with severe throughput degradation vs. the baseline noted for both clients. We thus continue to recommend against this mode of operation, further motivation indeed for the use of the 5 GHz. bands.

Conclusions

Apart from the excellent performance of our Cisco test configuration, the simplicity and effectiveness of BandSelect in moving dual-band devices from the 2.4GHz to the 5GHz frequency, allowing for an optimal use of available spectrum, and the remarkable ease-of-use of the WaveTest gear, we found our usual conclusions and recommendations with respect to 802.11n remain appropriate:

- 802.11n results in *much* higher throughput than 802.11g or .11a. There is, with the approval of the standard and full backwards compatibility to the draft interoperability specification assured by the Wi-Fi Alliance, no longer *any* reason to avoid or postpone the adoption of 802.11n as the primary vehicle in enterprise-class deployments.

- But as .11n deployments proceed, any assumptions about taking advantage of the coexistence mechanisms in the standard allowing simultaneous operation of .11n and .11g in a single channel should be discarded without further thought. Performance here is far from optimal and will not produce a meaningful return on investment for any 802.11n deployment.

- It’s very clear that 40 MHz. channels are the way to go with 802.11n, but such simply is not going to work at 2.4 GHz. We therefore recommend that current 3-channel (or, in some cases, 4-channel) bandplans already in use in many enterprises be left in place, with some number of 40-MHz. channels exclusively for 802.11n allocated, per country-specific regulations, of course, at 5 GHz. This, as our testing shows, will result in the non-disruptive deployment of 802.11n with the highest possible performance as a key – and clearly very desirable – result.

Acknowledgements

Special thanks to Cisco System and VeriWave, Inc. for the loan of the required equipment and technical assistance in configuration.

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