Performance Testing of 802.11n Enterprise Access Points

April, 2012

Executive Summary

Juniper Networks recently released the WLA532 Access Point (AP) (http://www.juniper.net/us/en/products-services/wireless/wla-series/wla532/) a dual band, three spatial-stream, 802.11n enterprise AP with integrated antennas in a surprisingly small package. The WLA532 is part of Juniper's Simply Connected portfolio of products.

Juniper Networks claims three primary design goals for this access point:

- The highest performing three spatial stream access point
- The lowest power consumption for a dual band three spatial stream enterprise access point
- The smallest form factor three spatial stream access point

Simple data sheet validation shows that Juniper achieved the latter two design goals. Novarum has focused this paper on the performance objective. A key feature of the WLA532 is extended coverage with high performance in an office setting. The WLA532 includes a patented antenna system that employs an array of six integrated antennas with polarization diversity. Juniper asserts that this design delivers better range and more robust coverage. To validate this marketing assertion, we tested the WLA532 and other three spatial stream enterprise APs in a typical office environment in a simple way that illustrates the effective performance at different ranges.

Is the coverage and range of the WLA532 better than competing APs? How well does the 3x3 MIMO work with typical enterprise clients? Is there a difference in range that is meaningful to the user?

This paper describes the testing and the results.

Key Findings

- The range of the Juniper access point at 5 GHz is impressive. Juniper delivered an average of 111 Mbps sustained single client throughput120 feet from the AP.
- The Juniper WLA532 does have better useful range at 5 GHz than the other access points we tested. The WLA532 delivered better performance in the 5 GHz band to the three stream laptops we tested at any range.
- The farther from the AP, the bigger the Juniper performance improvement compared to the other APs.
- At 2.4 GHz, the performance difference between the APs was not that significant. None of the vendors tested was a clear leader.
- Juniper's WLA532 access point makes it practical to deploy 5 GHz wireless in the enterprise. The superior 5 GHz throughput at extended range means it is possible to design dual band enterprise networks with the same cell size for 2.4 GHz and 5 GHz coverage.

Test Environment

The Facility

We conducted the testing in an office building with an open floor plan - cubicles in the middle and a few walled offices around the perimeter. Testing was done during the day when there were employees working in the building. There is an active wireless LAN deployed throughout the building. Our testing used Channel 6 in the 2.4 GHz band and Channel 161 in the 5 GHz band. The production wireless LAN was configured to avoid using those channels, but we did not actively police the use of those channels to guarantee that they were not being used. (It would be possible for a smartphone user to turn on tethering and select channel 6 while we were testing.) While we did not conduct the testing in an isolated RF chamber, it is fair to say that there was low noise and low utilization of those channels during the testing.

The access points under test were mounted on the suspended ceiling at one end of a hallway near the wall.

We selected three different locations down the hallway for client testing. We tested at 30 feet from the APs, 60 feet from the APs and 120 feet from the APs. We marked the test locations and the laptops were placed on a cart that we could roll to the exact location so that we could consistently repeat the tests. The 30 and 60 feet locations are direct line of sight to the APs. The 120 feet location is not line of sight. At that location, the hallway is offset from the main hallway. The effect is similar to the 120 feet test location being inside a cubicle.

Infrastructure Equipment

Juniper

- Juniper Networks WLC2 Wireless LAN Controller
- Juniper Networks WLA532 Three Spatial Stream Wireless LAN Access Point
    - Software Version 7.6.2.2

Aruba

- Aruba Networks 3600 Mobility Controller
- Aruba Networks AP-135 Three Spatial Stream Access Point
    - Software Version 6.1.2.2

Cisco

- Cisco 5508 Wireless LAN Controller
- Cisco Aironet CAP3602I Three Spatial Stream Access Point
    - Software Version 7.2.103.0

Client Equipment

We tested with three enterprise class laptops with Wi-Fi clients based on different chipsets. All three clients are modern dual band 802.11n supporting three spatial streams.

Apple MacBook Pro

MacBook Pro (Card Type: Airport Extreme - Firmware Broadcom BCM43XX 1.0.5.100.198.10.2) - Mac OS x 10.6.7 10j3250 (kernel version:10.7.3)

Dell ES420 with Atheros

Dell ES420 with Atheros XP114 Wireless Card. Atheros Osprey Wireless Adaptor - Windows 7 32 bit - Driver Atheros 9.2.0.412 (4/21/2011)

Dell ES420 with Intel

Dell ES420 with Intel 6300 wireless card (default configuration). Intel Centrino Ultimate N-6300 AGN - Windows 7 32 bit - Driver Intel 14.0.1.2 (12/21/2010).

Test Network

The test network configuration is shown in figure 1. One EX2200 Ethernet switch is used to connect a wireless LAN controller, the AP under test and a laptop that is running Ixia Chariot.

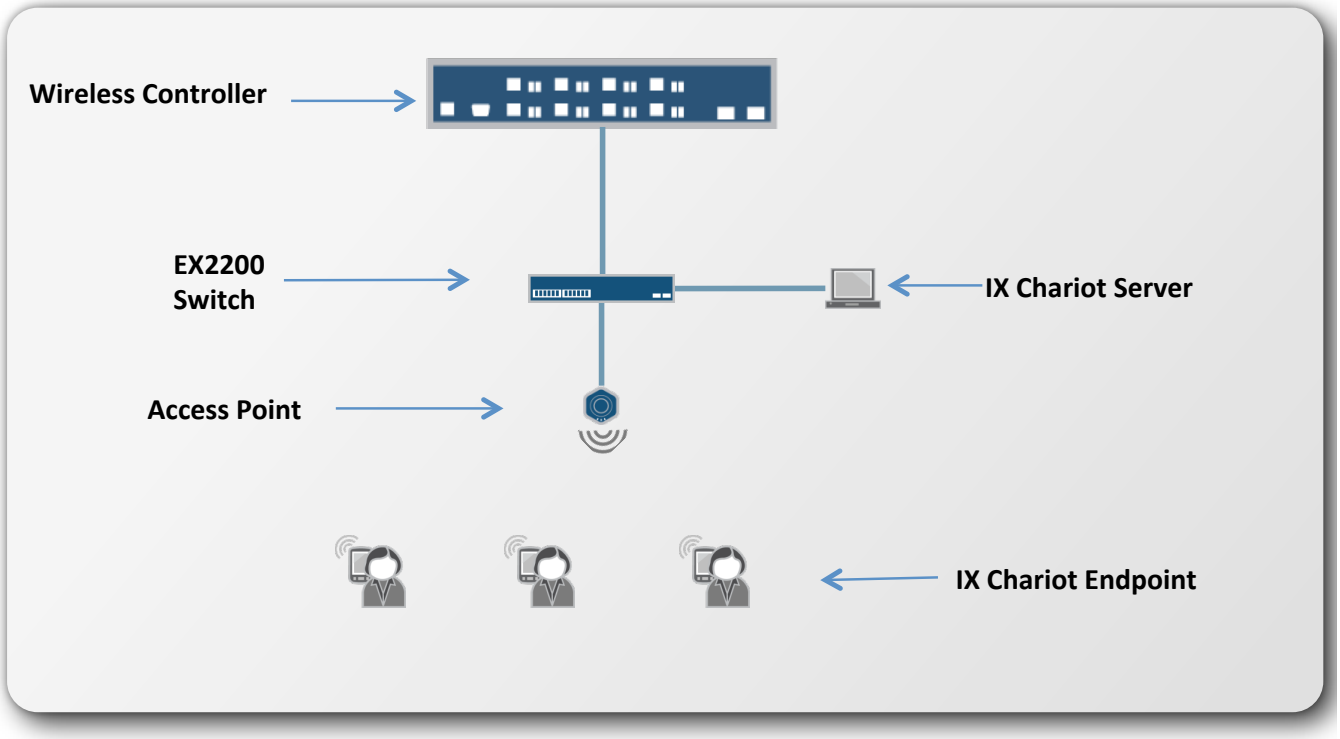


Figure 1 - Test Network Configuration

Testing Methodology

The testing is essentially a series of throughput tests. We wrote an IX Chariot script that we can run repeatedly with different clients, at different locations and with different APs. The script is a TCP throughput test. Chariot generates TCP traffic and sends it from one endpoint to another. In this case, we configured an endpoint on the Chariot console laptop and another endpoint on the laptop to be tested. All of our tests were traffic flows from the Chariot laptop on Ethernet to the wirelessly connected laptop. These are downstream tests that are similar to the wireless laptop reading from a local file server.

We configured Chariot to send four simultaneous TCP streams (not to be confused with spatial streams from 802.11n MIMO, these are simultaneous TCP packet flows) during each test. Each test is run for two minutes with Chariot reporting the average TCP throughput over the entire duration of the test. We experimented with single TCP stream testing and found that the 2.4 GHz results were not that different, but the 5 GHz results were much better with four TCP streams. We believe that the simultaneous TCP streams kept the transmit queues full at the AP and allowed the 802.11n frame aggregation to work more often and deliver the packets more efficiently resulting in higher throughput for all of the APs.

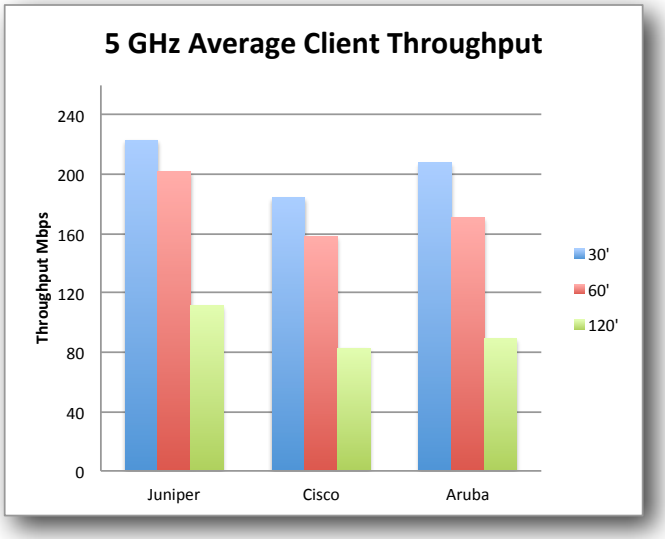
All APs and WLAN controllers are configured with the same standard settings. The APs are set to their maximum power level. The SSIDs are the same. We used standard enterprise WLAN security - WPA2 with AES. We used Channel 6 in the 2.4 GHz band and Channel 161 in the 5 GHz band. The 5 GHz channel is 40 MHz wide. The laptops are all three stream capable, so the maximum raw data rate for 2.4 GHz is 195 Mbps and 450 Mbps at 5 GHz.

Test Results

We tested all of the systems at both 2.4 GHz and 5 GHz. The 5 GHz results are more dramatic.

5 GHz Overview

The chart at right shows the 5 GHz performance of the three clients averaged for each AP vendor. The average throughput for Juniper is better than Cisco or Aruba at any range. For example, at 60 feet from the access point, Juniper delivers an average of 200 Mbps of throughput to a single client compared to 158 Mbps and 171 Mbps for Cisco and Aruba respectively.

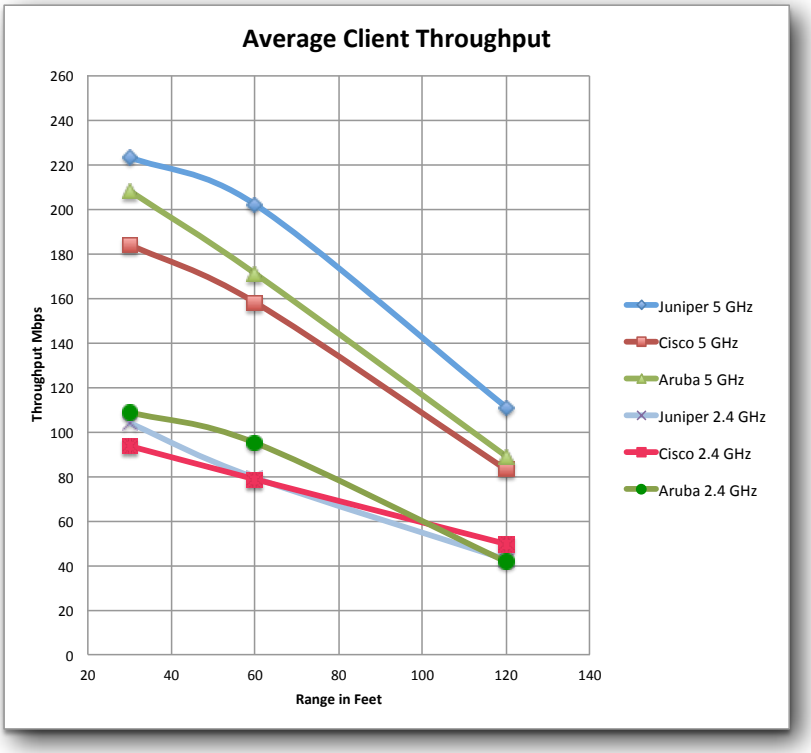


The Juniper AP seems to be optimized for performance in the 5 GHz band. The farther from the AP, the greater the performance benefit of the Juniper AP. Compared to Cisco, Juniper delivers 21% higher throughput at 30 feet, 28% better throughput at 60 feet and 35% better at 120 feet. Aruba performance is closer to Juniper than Cisco. Juniper 5 GHz throughput is 7% better than Aruba at 30 feet, 18% better at 60 feet and 25% better at 120 feet.

We are comparing the average of the three clients for each vendor here, but the results are conclusive - Juniper throughput at 5 GHz was higher than the other APs with any client at any distance.

2.4 GHz Overview

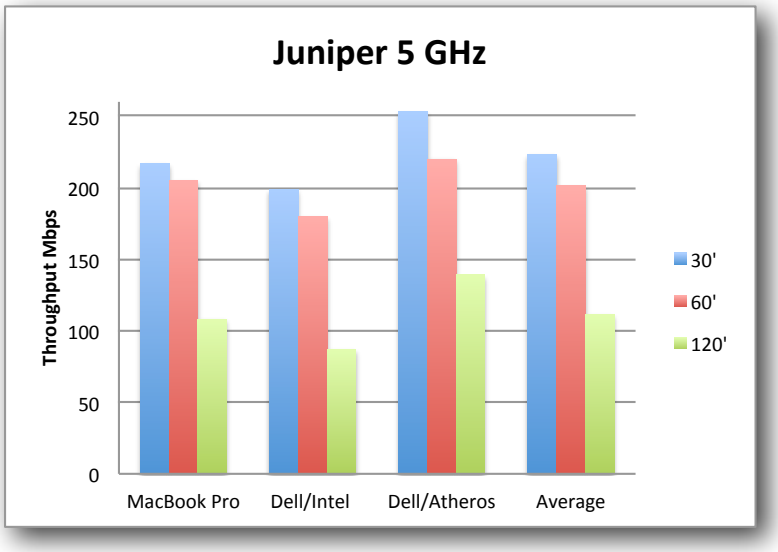
The 2.4 GHz performance results are different. No vendor was the clear leader. The performance results were all within 5 to 16% of each other.



Client Differences

With so many different parameters and options, 802.11n technology introduces the potential for variability in performance from client to client based on a number of factors including: multiple spatial streams, MIMO and multi-path. We attempted to reduce some of these effects during the testing by placing the client laptops on a rotating turntable. The laptop under test rotates through at least 360 degrees during the two minute Chariot test and the throughput is averaged across the entire two minutes. This should smooth out the throughput measured by avoiding the situation where one client antenna configuration is perfectly oriented to get the best signal from the AP and another client is not so well aligned.

The results show a significant variability between the performance of different clients. The Juniper AP works particularly well with the Dell laptop and the Atheros client. Surprisingly, the same Dell laptop with an Intel Wi-Fi module was the lowest performer in the same tests. The Dell with the Atheros client was 27% faster at 30 feet and almost 60% faster at 120 feet than the Dell with the Intel client. The Apple MacBook Pro laptop showed solid performance with the Juniper AP at 5 GHz, delivering 205 Mbps at 60 feet from the AP and maintaining 108 Mbps at 120 feet from the AP.



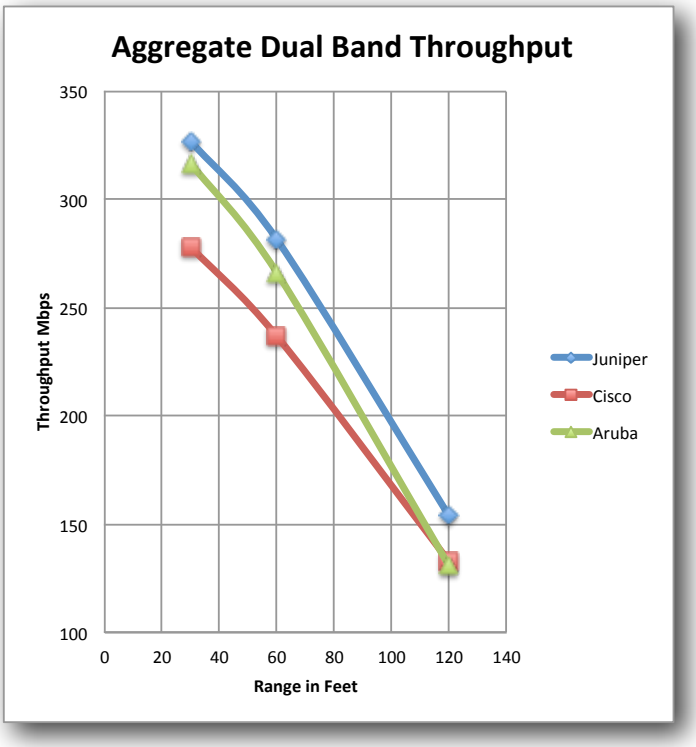
Coverage and Capacity

We conducted single access point throughput tests in a typical open office environment. What we can tell from these tests are two important properties of the access points when deployed - coverage and capacity.

For today's enterprise networks 5 GHz coverage and capacity is arguably the most important. The 2.4 GHz band, in most enterprise deployments, is dedicated to the support of legacy Wi-Fi devices and guest devices temporarily accessing the network. The 2.4 GHz band is running out of capacity - due to slower performing legacy 802.11 protocols, the explosion of Wi-Fi enabled mobile devices and the growing noise floor in this band. The 5 GHz band has much more available spectrum, can support more and wider Wi-Fi channels and generally has lower noise than the 2.4 GHz band. 5 GHz is recommended for enterprise deployments as the band with the most potential to serve modern laptops and tablets at very high speed. Enterprises were slow to deploy 5 GHz wireless LANs initially because of the range limitations of 5 GHz. The rule of thumb was: 5 GHz does not propagate as far as 2.4 GHz indoors, so you must deploy more APs in a given area to get solid coverage at 5 GHz. Advances in technology have changed this rule; and Juniper's excellent 5 GHz performance now makes it practical to deploy 5 GHz Wi-Fi in the enterprise with the same AP spacing as typical 2.4 GHz enterprise coverage.

The Juniper AP delivered superior performance in the 5 GHz band at any range. It appears that Juniper has optimized 5 GHz performance at range. We think this is the right balance for dual band enterprise APs - 5 GHz coverage and performance is most important while maintaining expected enterprise service levels at 2.4 GHz. The 2.4 GHz performance was mixed, with Juniper's performance similar to the other vendors but no clear 2.4 GHz performance leader.

If we combine the 2.4 GHz and 5 GHz results, we can compute the aggregate throughput of these dual band APs. Once again the Juniper access point out performs both the Cisco and Aruba access points at all distances.



Using this metric we can compare the delivered capacity of these access points at different ranges. For example, a dense deployment of these APs in an open office environment might use 60 foot radius cells. In this case the Juniper AP has at least 281 Mbps of total throughput anywhere within the cell. This is 6% better than Aruba and 19% better than Cisco.

Alternatively a network may be designed to optimize coverage and use cells with a 120 foot radius. Juniper will deliver aggregate throughput of 154 Mbps anywhere within these larger cells. For this larger coverage example, this is 16% better than Cisco and 18% better than Aruba.

When deployed in an open office enterprise, we would expect that a Juniper 802.11n infrastructure based on the WLA532 will deliver higher overall capacity than Aruba or Cisco.

Conclusions

We conducted a series of single AP and single client throughput tests designed to measure the performance of different 80211n three stream enterprise access points. The testing was done in a live office within a large open office environment that is typical for many enterprises. All of the APs were tested in exactly the same fashion and we took great care to make sure that the tests would be repeatable as we tested different clients and different APs.

We were particularly impressed with the performance of the Juniper Networks WLA532 AP at 5 GHz. We would like to see how these APs perform in more complex tests with multiple clients and multiple APs, but the performance advantage of the Juniper AP was clearly demonstrated in these single client, single AP tests.

Key Findings

- The range of the Juniper access point at 5 GHz is impressive. Juniper delivered an average of 111 Mbps sustained single client throughput 120 feet from the AP.
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Novarum

Novarum is an independent consulting firm specializing in wireless broadband technology and business. Novarum provides consulting, strategic advice, analysis and network design for cities, service providers, enterprises and vendors in the wireless broadband industry. Our technology focus spans Wi-Fi, WiMAX and 4G cellular data systems. Novarum offers a unique insider perspective from pioneers in the wireless and networking industry who have practical experience bringing wireless products to market.

Phil Belanger

Phil has over 25 years of broad leadership in the technology, marketing and standards of data networks. Phil pioneered local area networking technology with Zilog and Corvus and extended that leadership by co-leading the multi-company technical and marketing efforts that produced the original IEEE 802.11 wireless LAN standard.

Phil defined the original market position of wireless LANs for mobile computing with Xircom. While at Aironet, he broadened the market for wireless LANs and laid the foundation for Wi-Fi's success with the acquisition of Aironet by Cisco. Phil was one of the founders of the the Wi-Fi Alliance and served as the group's initial Chairman, creating the Wi-Fi brand and promoting Wi-Fi for the entire industry. He helped create the business model for Wi-Fi service providers with Wayport and expanded the market for Wi-Fi infrastructure with extended range technology of Vivato and municipal mesh networks at BelAir Networks.

Ken Biba

Ken has over 30 years experience in the network information systems industry bringing a unique background of general management with a strong product and marketing focus in network systems and information security. Ken was an early engineer of the Internet in 1975. He has co-founded and managed four notable networking companies- Sytek, which was focused on cable TV-based local and metropolitan data networks, Agilis which was focused on wireless handheld computers, Xircom, which developed local area network client products for mobile computing, and Vivato, which was focused on scaling Wi-Fi infrastructure to cover campuses and metropolitan areas.
Ken's perspective as CEO, board member of public and private companies, and as a technologist brings unique insight to the business, market and technology of bringing useful wireless solutions to users. Ken has a Bachelor of Science in Physics (Magna Cum Laude, Tau Beta Pi) and a Master of Science in Computer Science from Case Western Reserve University.

Wayne Gartin

Wayne is a senior executive with world-wide experience at start-ups and Fortune 500 companies. He has built high level relationships and delivered business partnerships at all levels for companies in the communication, software, and semiconductor markets. Wayne has worked with industry leading suppliers in all aspects of network technology, including long haul transport, metropolitan networks, wired and wireless LANs. He has successfully run multi-million dollar sales teams for companies in the access (last mile) consumer oriented markets, Passive Optical Networks, VoIP, and IMS. Wayne has held executive and senior level positions at Centillium, Agility (now JDSU), Bandwidth 9 (now NeoPhotonics), Infineon, Lucent, Adaptec, and Intel. He is also the co-founder of a semi-conductor IP company. Wayne's experience with multiple channels and leading successful sales teams to multi-million dollar revenue levels brings a unique insight to the strategies necessary to successfully launch new products and technologies into the market. Wayne has a BS in Math and an MBA from the University of Utah. He has been a certified instructor for sales and marketing courses in strategic planning, negotiations, and sales management.