Wireless Controller Comparative Performance:

Cisco 5520 and 8540

Aruba 7210 and 7240

CISCO

Contents

1 - Executive Summary

Miercom was engaged to perform independent, hands-on, comparative testing of performance and features of mid-range and high-end Wireless Controllers from Cisco Systems and Aruba Networks.

This report summarizes the results of the Wireless Controller testing in these areas:

- Data plane: The Wireless Controller's comparative throughput for varying packet sizes
- Control plane: The Wireless Controller's capacity and rate for client authentication
- RF (radio frequency) spectrum management: The effect on throughput of channel-bandwidth selection, and the extent that Cisco's Dynamic Bandwidth Selection (DBS) makes a difference.

Key Findings:

Significantly higher throughput than Aruba	The Cisco 8540 delivers more than twice as much throughput than the high-end Aruba 7240 Wireless Controller with small and medium packet sizes, and with an IMIX real-world mixture of traffic packet sizes.
Cisco uses most of 40 Gbps bandwidth at all packet sizes	Both the Cisco 8540 and the Aruba 7240 Wireless Controllers support 40 Gbps of network-connectivity bandwidth. However, with small-packet and IMIX test traffic Aruba effectively uses only about 30 percent, while the Cisco 8540 can fill most of this bandwidth at all packet sizes.
Cisco uses most of 20 Gbps bandwidth, compared to Aruba	The Cisco 5520 and the Aruba 7210 both support 20 Gbps of network bandwidth. Cisco can fill 85 to 95 percent of the 20-Gbps bandwidth, while Aruba achieves less than 25 percent at most packet sizes.
Latest Cisco 5520 delivers much faster client authentication rate	Testing found that the latest Cisco 5520 controller can handle 764 WiFi client authentications (IEEE 802.1X) per second – more than three times the rate supported by the predecessor Cisco 5508 controller.
Better TCP throughput over all channel bandwidths	TCP throughput performance is notably better with Cisco than Aruba for all channel bandwidths – 50 percent better for 20-MHz channels and 116 percent better for 40-MHz channels. The highest throughput was achieved with Cisco's Dynamic Bandwidth Selection, which Aruba doesn't support.

Miercom independently verified key performance and feature differences between the Cisco 5520 and 8540 Wireless Controllers, and comparable Wireless Controller models from Aruba Networks. With better throughput, faster authentication and improved Radio Resource Management (RRM), we present the ***Miercom Performance Verified*** certification to the Cisco 5520 and 8540 Wireless Controllers.

Robert Smithers
CEO
Miercom

2 - About the Products Tested

The Wireless Controllers that were tested represent the current mid-range and high-end offerings from Cisco Systems, Inc. and Aruba Networks, Inc. The specific models tested are described in more detail below.

Cisco

The Cisco 8540 Wireless Controller is the current top-of-the-line model, designed to handle the wireless infrastructure of medium to large enterprises, campus and Service Provider deployments. This controller is designed to manage Cisco Aironet access points (APs). The Cisco 8540 supports 40-Gbps of bidirectional throughput via four 10GE interfaces.

The Cisco 8540, supports up to 6,000 APs and up to 64,000 clients, which can be subdivided into 4,096 VLANs. The unit ships with solid state drive and redundant power supplies.

Cisco 8540

The Cisco 5520 wireless controller addresses wireless-network control and management for medium-sized enterprises, branches and campuses. This controller handles up to 20,000 clients and up to 1,500 APs. The 5520 supports 20 Gbps of network-connectivity bandwidth via two 10GE interfaces. The unit ships with solid state drive and optional redundant power supplies.

Cisco 5520

Both Cisco Wireless Controllers ran latest software release version 8.1.102.0 and were tested with Cisco Aironet 2702i APs.

Aruba

The Aruba Wireless Controllers tested represent the equivalent models to the Cisco units, including their network-connectivity bandwidth. The 7210 and 7240 are shown below: Both models look the same from the front but support substantially different capacities. They also support dual redundant hot-swappable power supplies.

Front view of the Aruba 7210 and 7240 (both models look the same)

The mid-range 7210, tested against the Cisco 5520, supports up to 512 APs and up to 16,384 clients. And while the controller comes with four 10GE interfaces (SFP+), it supports up to 20 Gbps of network-connectivity bandwidth.

The Aruba 7240 is the vendor's current high-end model, which was tested against the Cisco 8540. Like the Cisco 8540, up to 40 Gbps of network-connectivity bandwidth is supported via the unit's four 10GE interfaces. The 7240 supports up to 2,048 APs and up to 32,768 clients. Both controllers were tested with Aruba AP 225 access points.

The below table summarizes the Wireless Controller models tested:

	High-end, 40-Gbps Wireless Controllers		Mid-range, 20-Gbps Wireless Controllers	
	Cisco 8540	**Aruba 7240**	**Cisco 5520**	**Aruba 7210**
Number of clients/ users concurrently supported	64,000	32,768	20,000	16,384
Number of APs supported	6,000	2,048	1,500	512
Net-connectivity bandwidth	40 Gbps	40 Gbps	20 Gbps	20 Gbps

3 - Test Setup

A diverse set of tests were applied to the Wireless Controllers.   Subsequently, the test beds were equally diverse and fairly complicated. Three discrete test beds were assembled for the three areas of testing:

1. Data Plane Scale. This test bed was designed to ascertain and compare the aggregate **throughput** supported by the vendors' Wireless Controller. As noted earlier, the 20-Gbps-supporting Cisco 5520 was matched against the comparable 20-Gbps Aruba 7210, and the 40-Gbps-supporting Cisco 8540 was pitted against the 40-Gbps Aruba 7240.

2. Control Plane Scale. This test bed was designed to ascertain the **maximum user-authentication rate** of the Wireless Controller. Because custom test equipment was employed, in the absence of any off-the-shelf test tools, and due to authentication-protocol differences, this test could not be performed with Aruba. Instead, the user-authentication rate of Cisco's latest 5520 was measured, and compared with the user-authentication rate measured for the predecessor Cisco 5508 Wireless Controller, which was tested in exactly the same manner.

3. Radio Resource Management (RRM): This test bed compared the **throughputs achieved using the different channel widths** – 20-MHz, 40-MHz and 80-MHz. In addition, throughput was measured for Cisco's Dynamic Bandwidth Selection (DBS), which applies additional criteria provided by the APs in selecting the optimum channel width for each AP. The Aruba equipment tested did not offer such a best or auto channel-bandwidth selection.

All APs and controllers were configured using similar configurations (same channels, SSID, Cat-6A cable length) with the individual vendors' best practices applied. The latest publicly available controller codes at the time of testing were deployed: Cisco 8.1.102.0, Aruba 6.4.3.1.

Miercom recognizes IxChariot by Ixia (www.ixiacom.com) and Spirent Test Center (www.spirent.com) as a leading test tools for simulating real-world applications for predicting device and system performance under practical load conditions. IxChariot and Spirent were used to accurately access the performance characteristics of any application running on wired and wireless networks. For all the RRM Test cases, IxChariot v7.30 server was used with TCP High-Throughput Script for each pair. The most recent available client IxChariot endpoints were installed on respective client devices.

Each test bed is discussed in more detail in the following sections.

4 - Throughput

Test Objective

To compare the throughputs supported by the Cisco and Aruba Wireless Controllers, with each other and with their network-connectivity bandwidths.

How We Did It

We compared the throughput of two Wireless Controllers with 20 Gbps of network-connectivity bandwidth – the Cisco 5520 and the Aruba 7210 – and then two Wireless Controllers with 40 Gbps of network-connectivity bandwidth – the Cisco 8540 and the Aruba 7240.

A Spirent test system was used to deliver traffic simulating the flows of multiple simultaneous wireless clients. The Spirent sent the test data through a Nexus 7000 switch to the Cisco controller being tested over multiple interfaces. The controller then sent the data back through the switch to eight simulated APs and out to their simulated clients, which returned it through the Cisco controller back to the Spirent test system where throughput was carefully measured.

We lacked the facility to simulate APs and clients on the Aruba controllers, as this protocol is proprietary. Subsequently, raw throughput traffic for the given number of clients was generated by the Spirent system and sent through the switch to the Aruba controller being tested, which returned the data back to the Spirent system.

The Spirent system adjusted traffic levels to determine maximum throughput for a specific packet size, before loss occurred. A more real-world mixture of packets, called IMIX, which comprised 60 percent of 64-byte packets, 25 percent of 594-byte packets and 15 percent of 1,518-byte packets. The test bed for the throughput tests is shown below.
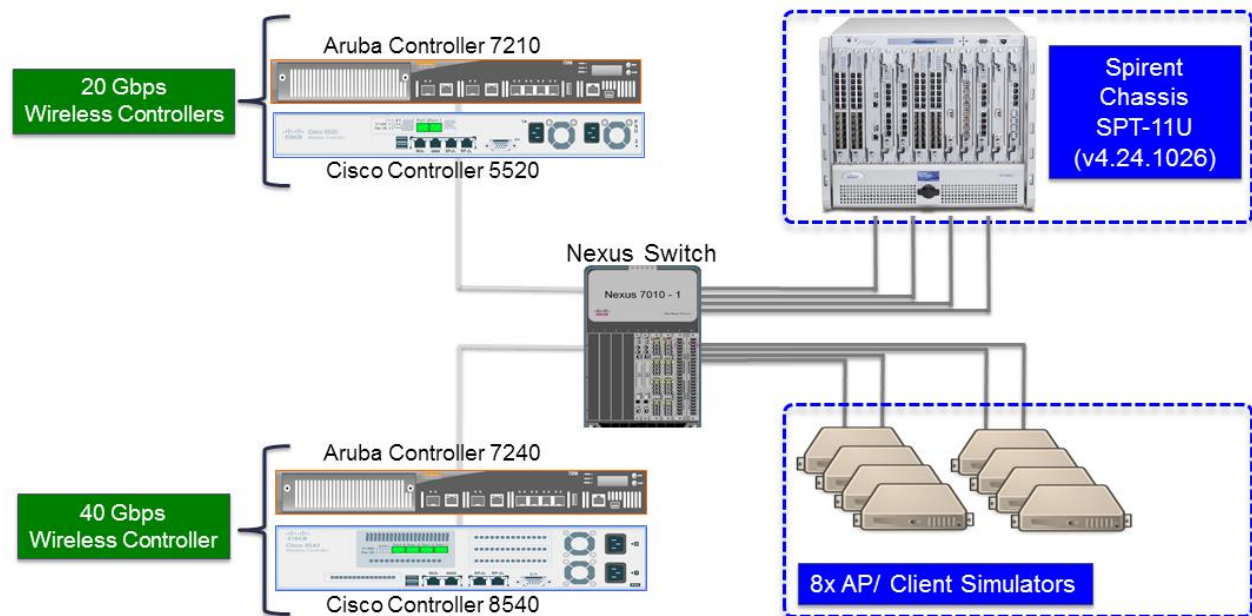

Source: Miercom June 2015

The following charts show the results of the throughput tests.

Cisco 5520 vs Aruba 7210, 20-Gbps Wireless Conrtollers Throughput

Source: Miercom June 2015
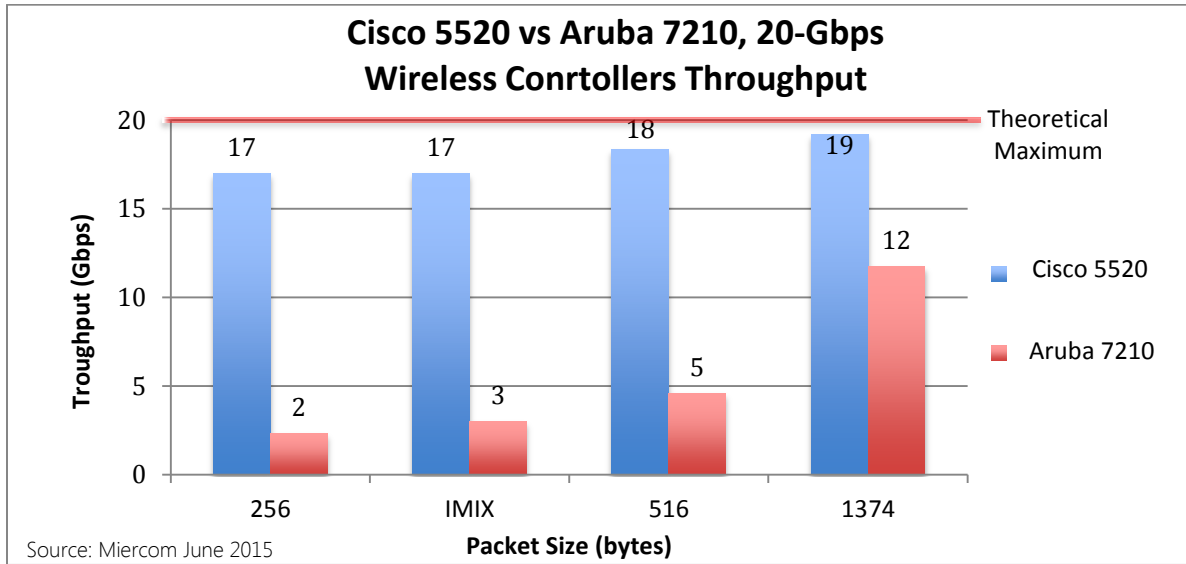
Cisco fills available bandwidth*. The Cisco 5520 can effectively utilize available 20-Gbps network bandwidth at packet sizes from 256 to 1,374 bytes. The Aruba 7210 fills 10 to 25 percent of available bandwidth at packet sizes up to 516 bytes.*

Unaffected by number of clients. *The Cisco 5520 controller proved better overall throughput with client tests for a wide range of packet sizes.*

Cisco 8540 vs Aruba 7240, 40-Gbps Wireless Controllers Throughput

Source: Miercom June 2015
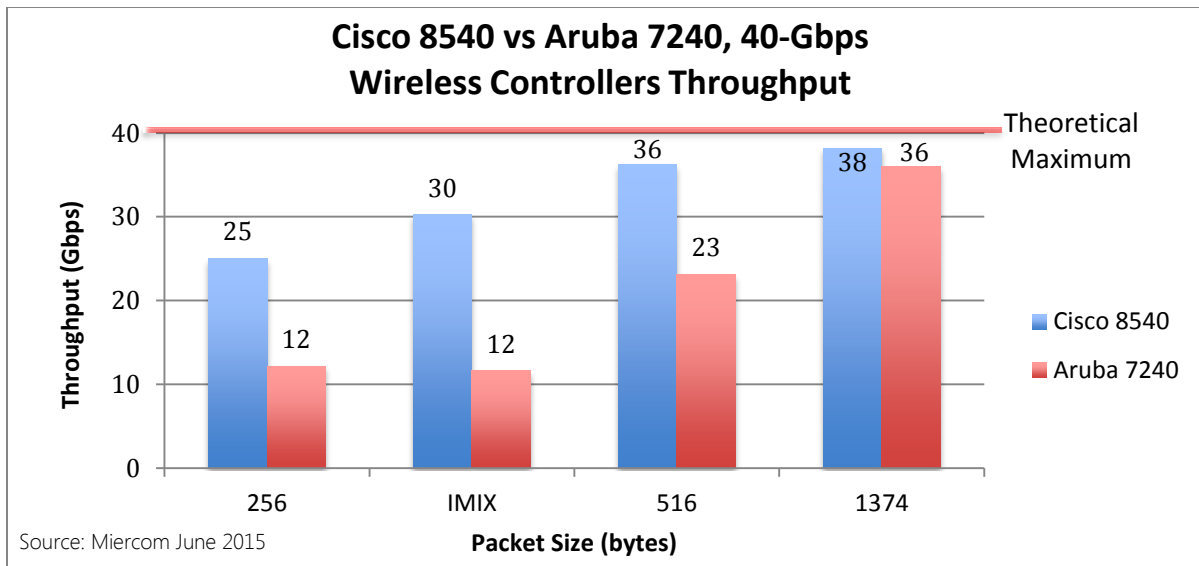
Cisco outperforms Aruba. *At small packets sizes up to 1,374 bytes as well as with the IMIX packet-size mixture, Cisco's latest 8540 controller roundly outperforms the Aruba 7240.*

Aruba throughput depends on big packets*. The Aruba 7240 can make good use of its 40 Gbps of network bandwidth only with large packet sizes. The Controller datapath CPU hits 90-95% limiting its ability to pass more traffic.*

5 - User Authentication Rate

Test Objective

To determine the maximum rate that new WiFi client authentications can be processed.

How We Did It

Our research was unable to find any known test tools on the market for conducting high-volume WiFi client-authentication testing. So to quantify client-authentication performance, we acquired a custom test platform originally developed for this purpose by Cisco.

The client-authentication test package would work with Cisco wireless controllers, but not with Aruba. Subsequently, we decided to conduct this comparative performance testing on two Cisco models the latest Cisco 5520 controller, supporting 20 Gbps of network bandwidth, and the older Cisco 5508 Wireless Controller, which supports 8 Gbps of network connectivity.

We decided to test most commonly used and one of the most secured authentication methods based on IEEE 802.1X WPA2 Protected Access 2 specification. IEEE802.1X authentications like PEAP, EAP-FAST , EAP-SIM, EAP-TLC are commonly used in the deployments like enterprises, campuses, hotspot deployments.

This test simulates a campus spanning wireless environment, where classes change on a college campus, or a stadium game starts or restarts, or a corporation starts up in the morning. In these cases large numbers of users with wireless devices all want to connect, or disconnect and re-connect to, the wireless network or connection at approximately the same time. It is important in such environments for the WiFi system to be able to handle these requests quickly the first time.

As shown in the test bed configuration diagram on the next page, the Cisco 5520 and the older 5508 were connected through a wire speed switch to five AAA/RADIUS (Remote Authentication Dial In User Service, a networking protocol that provides centralized Authentication, Authorization and Accounting (AAA)).

The controllers were connected through the switch to five simulators, which were set up to simulate 1,500 APs (300 APs/simulator), each AP with 13 simulated clients – a total of 19,500 simulated clients. The simulated clients are spread across all five of the simulators.

The authentication was done by roaming each simulated client from one AP to the next, at a rate of 800 roams per second. This is designed to roll all the clients through all 1,500 APs. The test was run for 5 minutes, using the 802.1X authentication.

WiFi client-authentication test bed. The configuration that was used to test the controller's ability to handle high volumes of WiFi client authentications, is shown below.
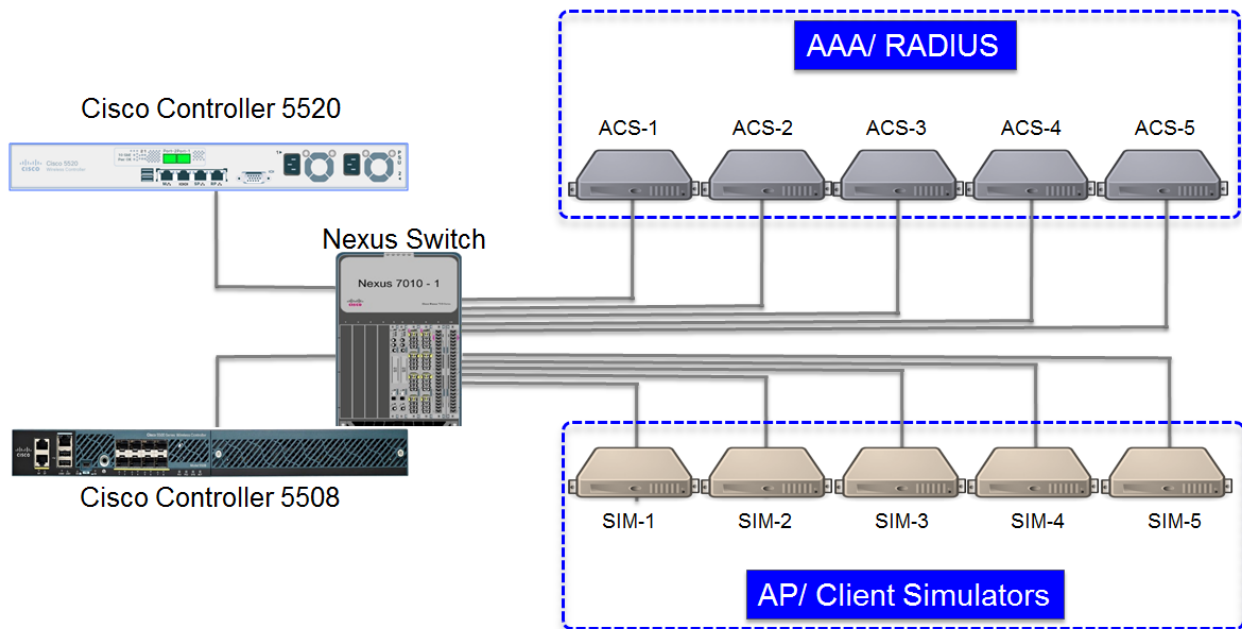
Source: Miercom June 2015
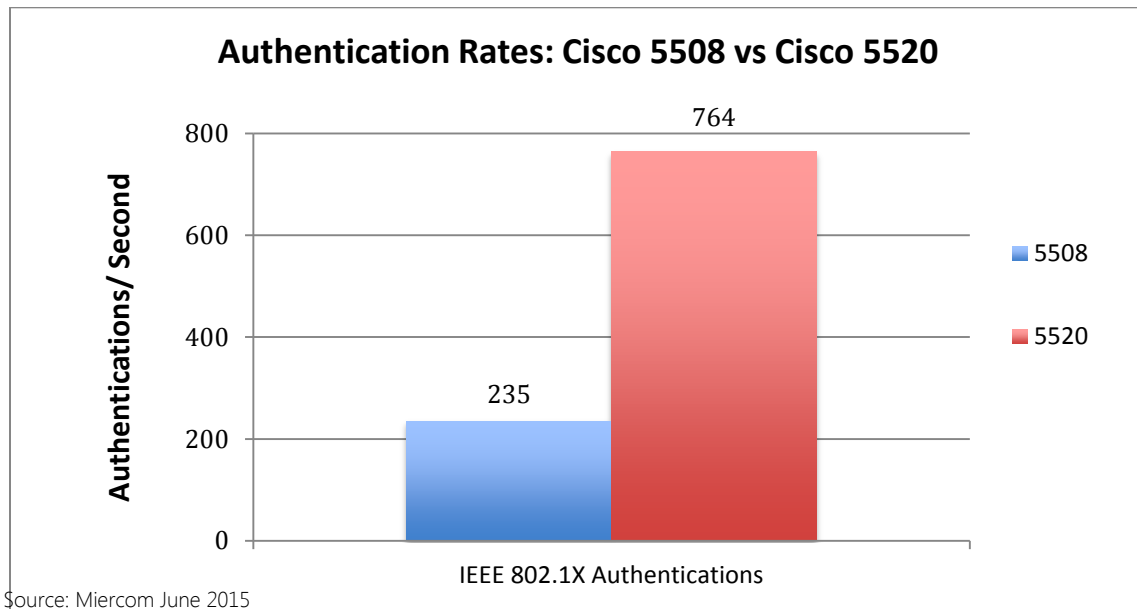
Source: Miercom June 2015

***Three times faster authentication**. The results below show that the Cisco 5520 can authenticate new WiFi clients using the 802.1X authentication 3.25 times faster than the predecessor Cisco 5508.*
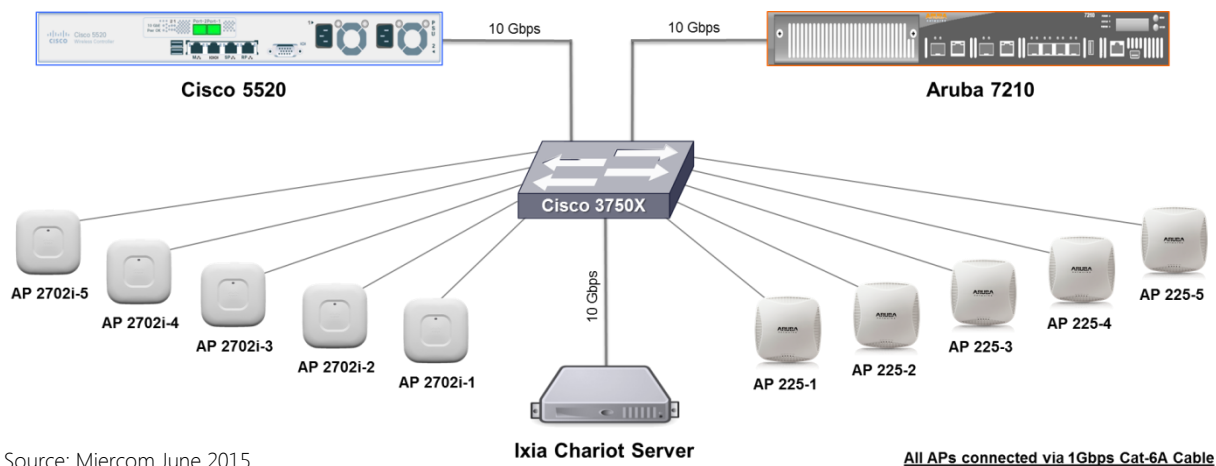
6 – Radio Resource Management

Test Objective

To determine how aggregate throughput varies for a set of 5 APs with Cisco 5520 and Aruba 7210 environments with a diverse mix of clients, for the various channel widths and channel-selection options offered by Cisco (RRM) and Aruba (ARM).

How We Did It

An elaborate test bed was set up with the Cisco 5520 and the Aruba 7210 side by side along with five sets of co-located Access Points – Cisco AP 2702i and Aruba AP 225.

Source: Miercom June 2015

APs mounted in the office area for the Radio Resource Management Tests
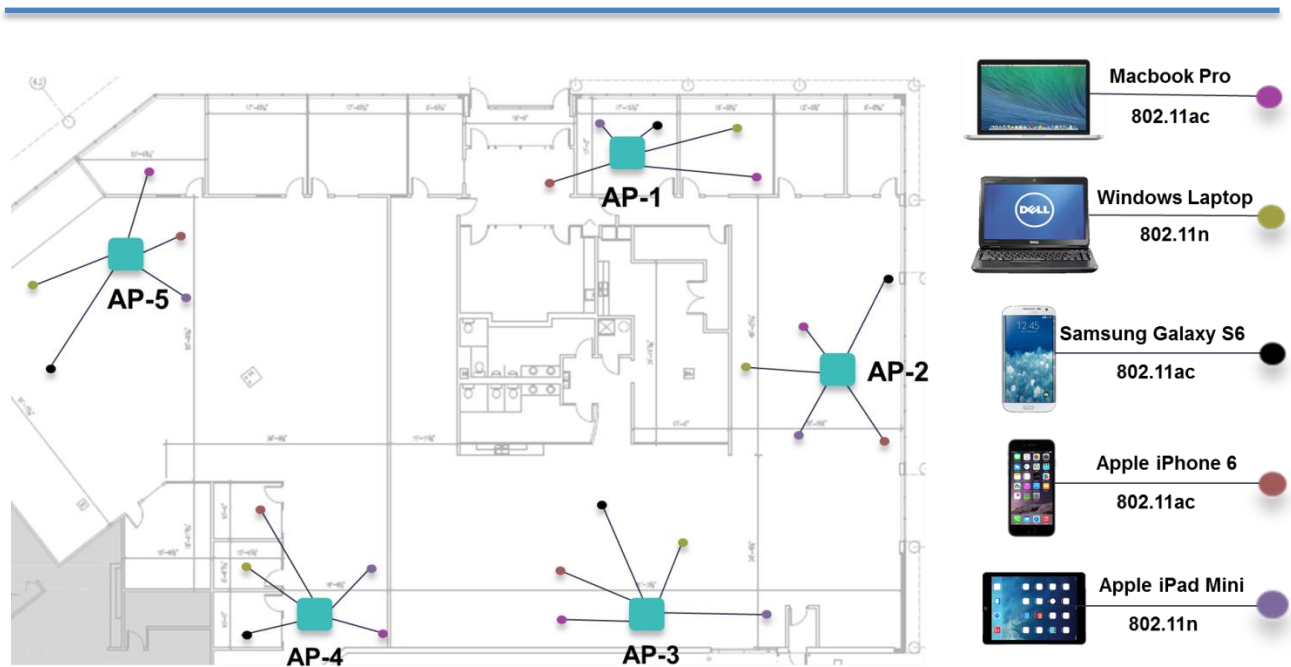

Source: Miercom June 2015
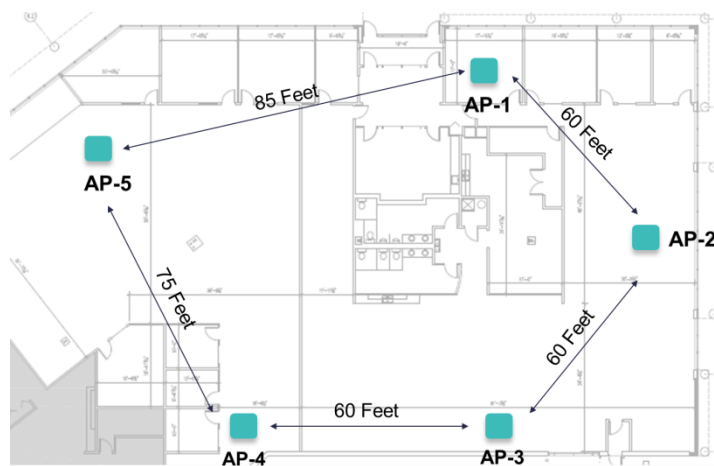
All RRM tests were performed in an office building dedicated for interference-free wireless testing where the tests can be easily reproduced and aggregated over multiple test runs. Five AP locations are located around the building on the same floor, as indicated on the floor plan on the left. The office space had a typical style of cubicle areas, and open areas with each AP neighbor about 60 to 80 feet apart.

The Ixia Chariot Performance tool was used to assess the overall network performance under realistic load conditions. The tool supported high-speed TCP connections with the chariot endpoints installed on every client associated to the network – a total of 100 paired TCP connections, four per wireless client during the active tests. The Ixia Chariot meticulously measured the TCP throughput for each paired connection and provided an average throughput number for each test run.

Clients connected to the network

| Total 25 Clients | 5 x **Macbook Pro** OS X, v10.10.10.3 802.11ac 3x3 ss | 5 x **Dell** Latitude E6430 Windows 7, SP2 802.11n 3x3 3ss | 5 x **Samsung** Galaxy S6 Android v5.0.2 802.11ac 2x2 2ss | 5 x **Apple** iPhone 6 iOS v8.3 802.11ac 1x1 1ss | 5 x **Apple** iPad Mini iOS v8.3 802.11n 1x1 1ss |

Source: Miercom June 2015

The floor plan above is to scale. Each AP was connected to the five diverse clients as shown in the chart above. Clients connected to each AP were located at distance of about 15 to 35 feet in both line of sight and non-line of sight locations.

Channels Available for APs

The RRM tests were evaluated for the 5GHz Channels. Available channels for both the vendors were limited to UNII-1 (36, 40, 44, and 48) and UNII-3 (149, 153, 157, 161, and 165) channels, allowing a total of nine 20MHz non-overlapping channels to select and bond with. The DFS Channels (UNII-2 and UNII-2 extended) were excluded from the AP Channel list to create an environment with an increased chance of channel overlapping especially when the five APs are bonding on 40-MHz and 80-MHz channel widths. In addition, since Aruba ships with all DFS channels disabled, the same configuration was mirrored on the Cisco controller to ensure an apples-to-apples comparison. Restricting the number of channels for this test also helps to determine at a system level how the radio manages the channels and widths when there is limited spectrum for Wi-Fi, which again is a common occurrence in many wireless deployments across different regulatory domains.

Selection for Available Channel Widths on the Cisco and Aruba Controllers at Time of Testing

Source: Miercom June 2015
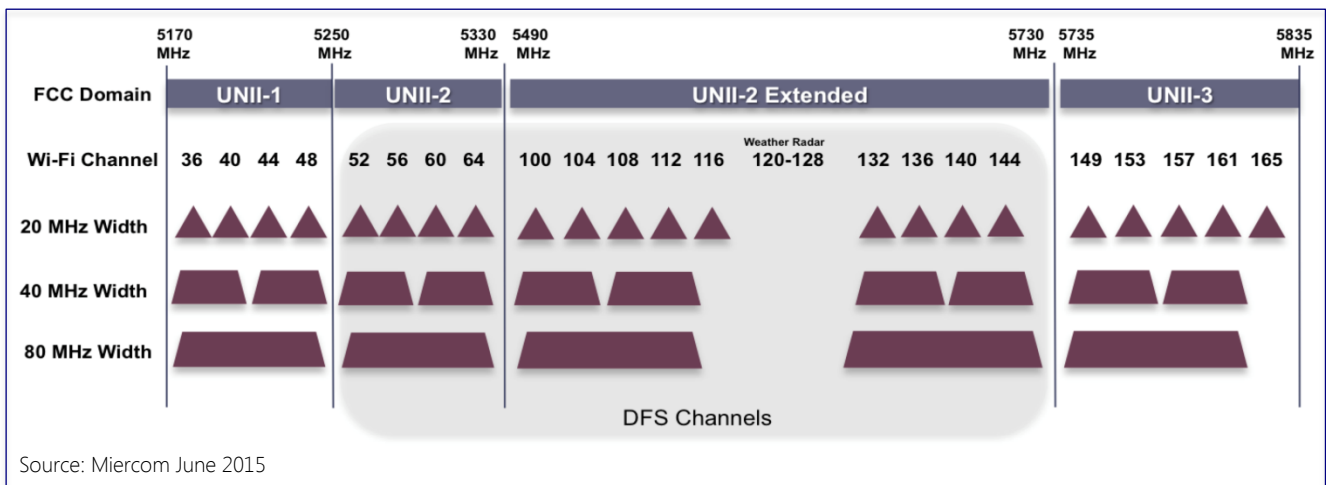
Bonded channel widths are achieved by using multiple 20-MHz channels. By bonding two 20MHz channels together you get a 40-MHz wide channel, and bonding four 20-MHz channels together forms a single 80-MHz wide channel.

With the DFS Channels disabled, both Cisco and Aruba had a choice of:

- Nine 20 MHz non-overlapping channels
- Four 40 MHz non-overlapping channels
- Two 80 MHz non- overlapping channels

Conduct of RRM Tests

The RF spectrum in each case was managed by the respective Cisco and Aruba wireless controllers, interacting with their respective access points. The tests exercised the choice of channels, the channel-width choices, and the overlap of channels affect the overall throughput in a typical office configuration.

Cisco and Aruba tests were run separately for each channel-width choice, with sufficient time allowed for the configurations to settle down following each configuration change. All 25 clients

were associated to the APs during these settling periods. Different volumes of test traffic were run during the settling periods to simulate a typical office's busy daytime environment, and then single ping streams for inactive periods.

Sequence of Bandwidth Management Testing

1. 20-MHz channel width: First the Cisco controller was set for 20-MHz channels and the network allowed to settle for six hours while clients connected to the APs. Then the IxChariot traffic was run to get an aggregate throughput performance for all 25 clients from a total of three runs. Then the Aruba controller was set for 20-MHz channels and likewise settled for six hours while clients connected to the APs. Then the IxChariot traffic was run to get an aggregate throughput performance for all 25 Clients from a total of three runs.

2. 40-MHz channel width: Similar to the same sequence as above but channel width selected as 40-MHz.

3. 80-MHz channel width: Similar to the same sequence as above but channel width selected as 80-MHz.

4. Best (Auto channel width) selection: The Cisco controller was set for best channel-selection mode to dynamically select the optimum channel widths for each individual AP and the wireless network allowed to settle for six hours while clients connected. Then the IxChariot traffic was run to get an aggregate throughput performance for all 25 Clients from a total of three runs. Aruba did not offer a comparable auto channel-selection setting for their ARM configuration.

RRM Channel Selection Results

The channel selection assignments for these tests are summarized in the below table:

	AP Channel Selection Plan									
Channel Width	Cisco					Aruba				
	AP-1	AP-2	AP-3	AP-4	AP-5	AP-1	AP-2	AP-3	AP-4	AP-5
20 MHz	40	149	48	165	36	149	161	48	165	161
40 MHz	36-40	149-153	48-44	161-157	36-40	36-40	36-40	149-153	149-153	40-36
80 MHz	161-157-149-153	48-44-36-40	48-44-36-40	161-157-149-153	48-44-36-40	36-40-44-48	48-44-40-36	157-161-149-153	153-149-157-161	161-157-153-149
Auto	165	149-153	48-44	161-157	36-40	n/a	n/a	n/a	n/a	n/a

In our testing we would change the AP configurations and then let them settle on the channels to be used for their 5 clients for ~6+ hours. It was observed that the Aruba's ARM would tend to settle with more overlapping channels than Cisco's RRM in almost all test cases. Aruba's situation would improve if the controller and APs were rebooted before starting each test. This behavior was not present on the Cisco Infrastructure, where Cisco's RRM would quickly configure to the selected channel widths with least overlapping channels within the first hour itself. In the test cases, where Aruba ARM's channel selection had heavy overlapping, the controller was rebooted and allowed to settle for another 6 hour period before the performance tests were run.
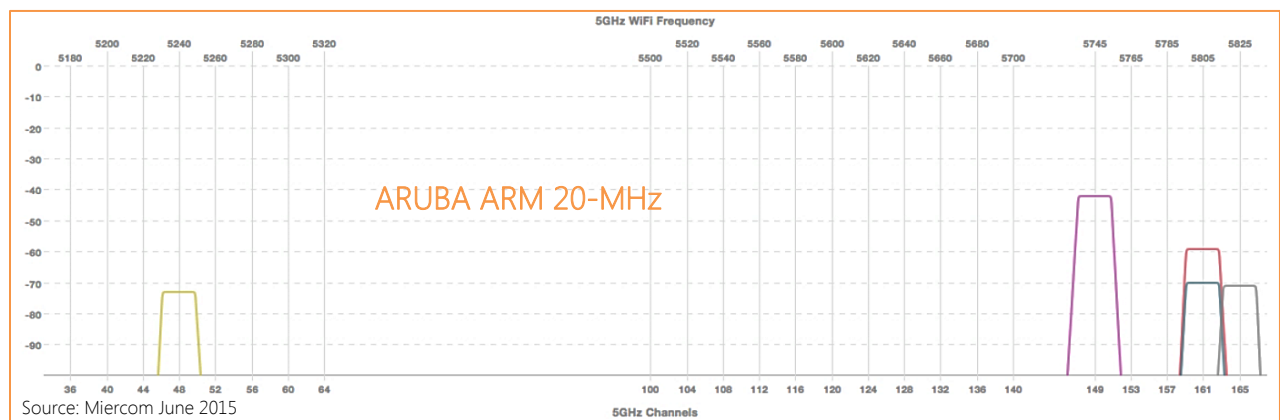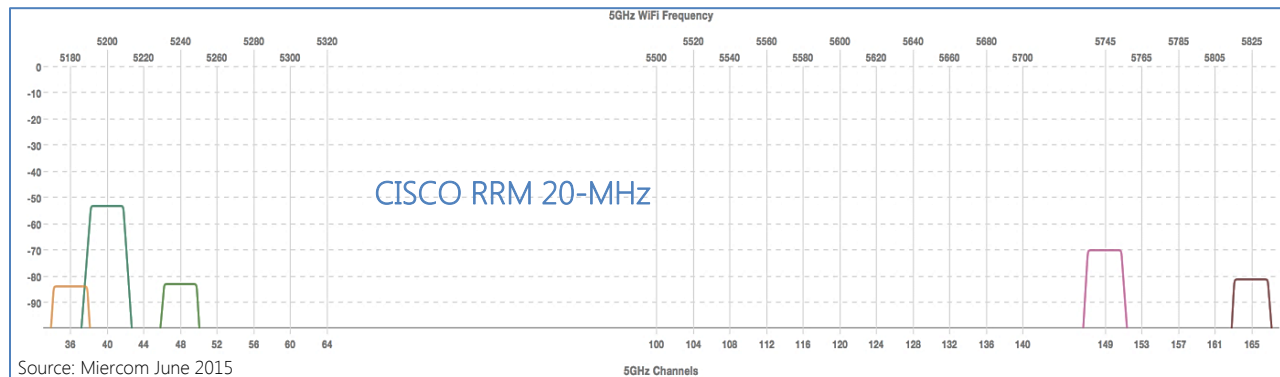
Channel Overlapping

Comparing the final channel selections for both the vendors, it was observed that Cisco 5520 did a better job of assessing the environment and providing a better RRM configuration by selecting least overlapping channels in all test cases, thus minimizing the problem of co-channel interference. With less co-channel interference, the APs would have a better shot in delivering the traffic to the wireless clients and directly improving the overall system performance. The Aruba 7210 tended to select channels for the five APs that overlapped more than Cisco. Also, as noted, the Aruba controller did better, in terms of avoiding overlapping channels, if the controller was rebooted before starting a new test.

Shown below are the visual channel selections by each controller for 20 and 40 MHz (The 80-MHz option is left out for brevity).

The x-axis shows the channel numbers, and the y-axis shows the signal strength in decibels: from 0 dB (the strongest) to -90 dBm. Each mountain slope represents an AP.

20-MHz Channel Selection Visual Representation

Source: Miercom June 2015

Source: Miercom June 2015

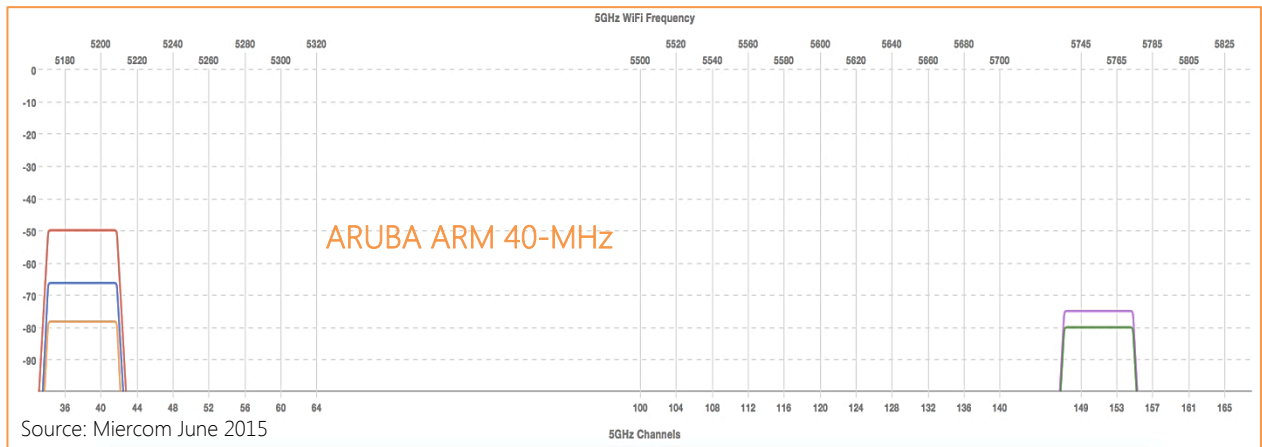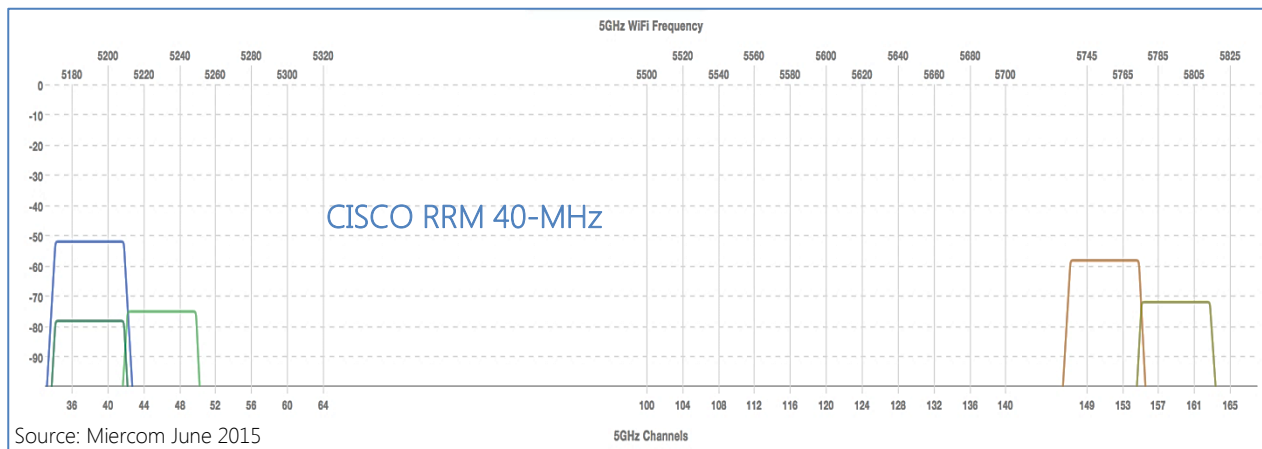| 20-MHZ CHANNEL WIDTH SELECTION TEST		
VENDOR	NUMBER OF OVERLAPPING APS	CHANNELS OVERLAP PERCENTAGE
CISCO	0	0%
ARUBA	2	40%

Wi-Fi is a shared medium. When APs select an overlapping channel, the APs and clients have to share the airtime on that overlapping channel. This means that when one AP is transmitting data to the client, the other APs on the same channel will have to pause their traffic communication and wait till the first AP has finished the transmission. This goes in a round-robin fashion with each AP getting an airtime to send data to the respective clients. More the overlapping, more the waiting period for the APs. As the overlapping channel gets more crowded, the APs tend to have higher retries for a successful data transmission.

With heavy overlapping of channels as seen in Aruba's 40-MHz channel selection below, the overall performance of the network tends to reduce as the co-channel interference and the number of retransmissions goes up.

40-MHz Channel Selection Visual Representation

Source: Miercom June 2015

Source: Miercom June 2015

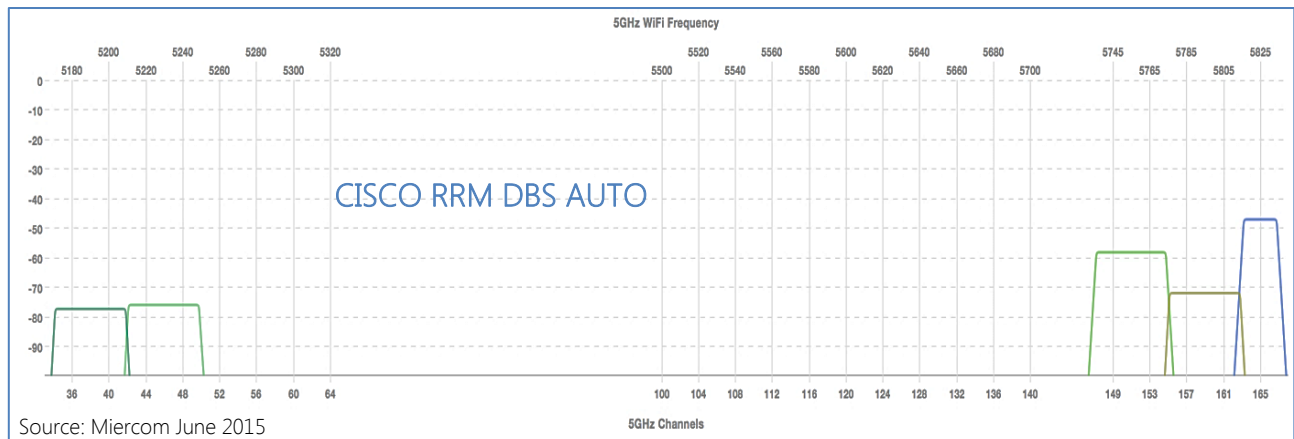| 40-MHZ CHANNEL WIDTH SELECTION TEST		
VENDOR	NUMBER OF OVERLAPPING APS	CHANNELS OVERLAP PERCENTAGE
CISCO	2	40%
ARUBA	5	100%

For the 40-MHz tests, channel overlapping was observed on both the vendors but varied in comparison. Cisco chose to overlap 2 of the 5 APs, while in Aruba's case all the 5 APs ended up sharing channels amongst each other.

For the 80-MHz channel width tests, as there were only two channels to select from, both Cisco and Aruba had no choice but overlap the APs on shared channels. The AP distribution was similar for both vendors (3 on one channel, 2 on other channel) but the difference was in the overall power levels. Cisco APs had lowered the power levels more than Aruba APs to create smaller cell sizes in order to compensate for the heavy overlapping. This was determined as one of the reasons why even with the heavy overlapping for the 80-MHz channels, Cisco APs performed slightly better in terms of overall system throughput as seen in the performance comparison chart below.

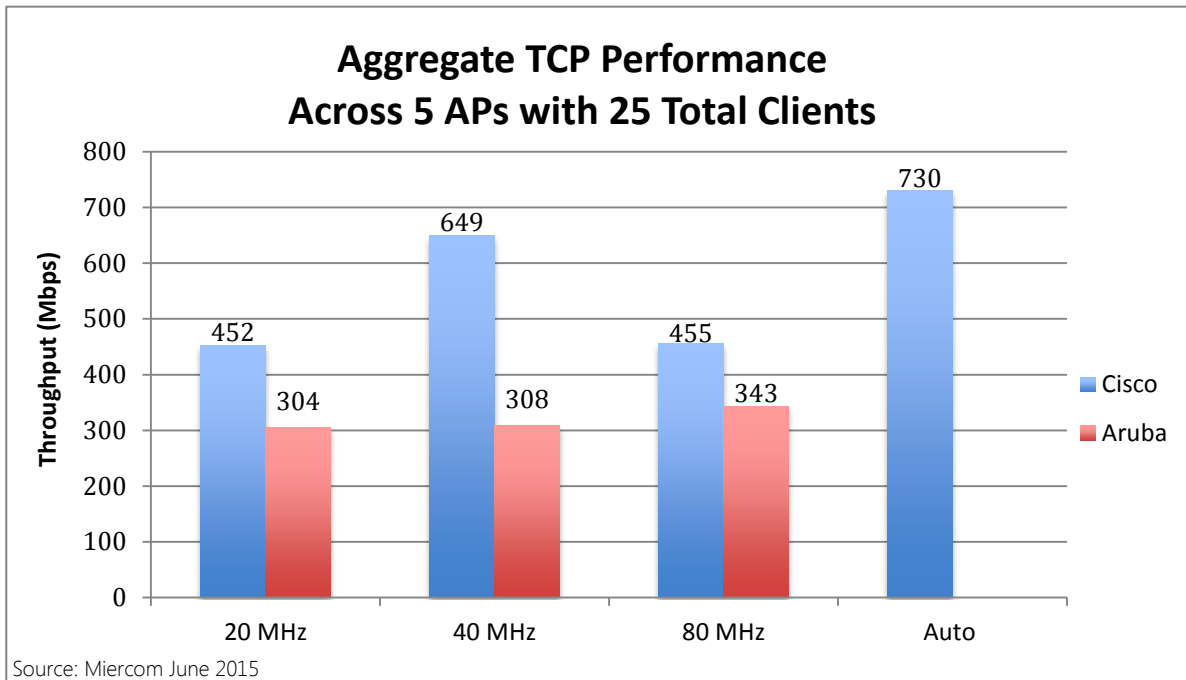| 80 MHZ CHANNEL WIDTH SELECTION TEST		
VENDOR	NUMBER OF OVERLAPPING APS	CHANNELS OVERLAP PERCENTAGE
CISCO	5	100%
ARUBA	5	100%

Cisco's Dynamic Bandwidth Channel Selection is based on the Auto channel-width select feature. As shown, four 40-MHz channels and one 20-MHz channel were used by the five APs, with minimal overlap. The result: less interference and better throughput.

Cisco's Auto Channel-Width Selection Visual Representation

Source: Miercom June 2015

AUTO CHANNEL WIDTH SELECTION TEST		
VENDOR	NUMBER OF OVERLAPPING APS	CHANNELS OVERLAP PERCENTAGE
CISCO	0	0%
ARUBA	N/A	N/A

We observed that the Aruba controller would tend to settle with more overlapping channels than the Cisco controller. All performance tests were run three times. The below graph shows the average performance of the three test runs for each channel width test case.

**Aggregate TCP Performance
Across 5 APs with 25 Total Clients**

Source: Miercom June 2015

Aruba offered no similar option for "auto" or "best" channel-bandwidth selection.

As noted, Cisco offers a best channel-width selection option, where the controller selects the best channel width for each AP, based on the AP's neighbor information, which each AP sends to the controller. We found that this option, called Dynamic Bandwidth Selection (DBS) yielded the best throughput in our test environment. With DBS, the controller selects the channel bandwidth for each AP – based on more reported frequency and interference data – rather than the operator, who selects the channel width on a more-or-less "one-channel-size-fits-all" basis.

7 - Summary

Cisco 5520 and 8540 Wireless Controllers have successfully proved superior performance through testing to offer higher data plane throughput of 20 Gbps and 40 Gbps respectively and improved control plane performance for higher scale deployments.

 Cisco's RRM and Dynamic Bandwidth Selection together exhibited the most ideal channel & channel-width selection, resulting in the highest performing RF configuration among all the RF performance tests. Real-world testing proved that Cisco's RRM with DBS enhances the spectrum management for any typical wireless environment, thus earning the Miercom Performance Verified Certification.

8 - Independent Evaluation

This report was sponsored by Cisco Systems, Inc. The data was obtained completely and independently as part of Miercom's competitive analysis.

9 - About Miercom

Miercom has published hundreds of network-product-comparison analyses – many made public, appearing in leading trade periodicals and other publications, and many confidential, for internal use only. Miercom's reputation as the leading, independent product test center is undisputed.

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10 - Use of This Report

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