KEY FINDINGS

- **In a high-density sixty client throughput test of 802.11ac APs, Aruba's AP-225 is two times faster than Cisco's 3702i AP.**
- **Aruba's 802.11ac AP delivered 27% more simultaneous HD video sessions from a single AP than Cisco.**
- **Aruba's ClientMatch addresses the "sticky client" problem and provides a better allocation of resources to roaming clients.**
- **In a multi-AP throughput test with 75 roaming clients, Aruba's system with ClientMatch increased performance by 39%.**

802.11ac Enterprise Wireless LAN Testing

IEEE 802.11ac is paving the way for enterprises to shift from a port-centric work environment to an all wireless workspace. 802.11ac technology boasts data rates up to 1.3 Gbps, but speeds and feeds are only one aspect for organizations to consider. The ability of an enterprise WLAN to support a high-density of mobile devices and a variety of application types such as streaming voice and video is also crucial.

Novarum conducted performance tests with current enterprise 802.11ac wireless LAN systems from Aruba and Cisco. This testing goes beyond simple drag race throughput tests by looking at real world scenarios involving high-density throughput and client roaming as well as real applications including VLC media streaming.

The Aruba AP-225 and Cisco 3702i 802.11ac APs were tested for the following scenarios:

- High-density performance for sixty 802.11ac clients supported by a single AP in the 5 GHz band.
- Maximum number of simultaneous video sessions supported on a single 802.11ac AP.
- Overall system throughput when 75 clients roam in a multi-AP environment.

For the high-density client-roaming test with multiple APs, vendor specific radio management capabilities were enabled for APs to automatically select their channel and transmit power level. However, for single AP tests, static channel and power was assigned to maintain consistent test conditions for both vendors.

System configurations for Cisco and Aruba were optimized based on recommended best practices for both vendors. All the test results presented in this report are averages of three test runs to eliminate any anomalies.

High-Density Throughput Test

The purpose of this test was to quantify the throughput performance of Aruba's AP-225 and Cisco's 3702i in a high-density environment. The test measured the single AP throughput with sixty 802.11ac clients including 48 MacBook Airs (2x2:2) and 12 MacBook Pros (3x3:3).

All the clients were within line of sight from the AP and associated in the 5 GHz band. Ixia Chariot was used to generate traffic and measure aggregate throughput.

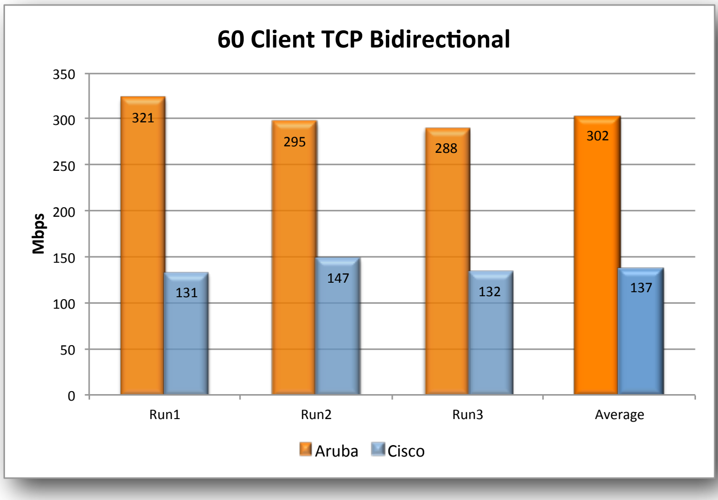


Figure 1.

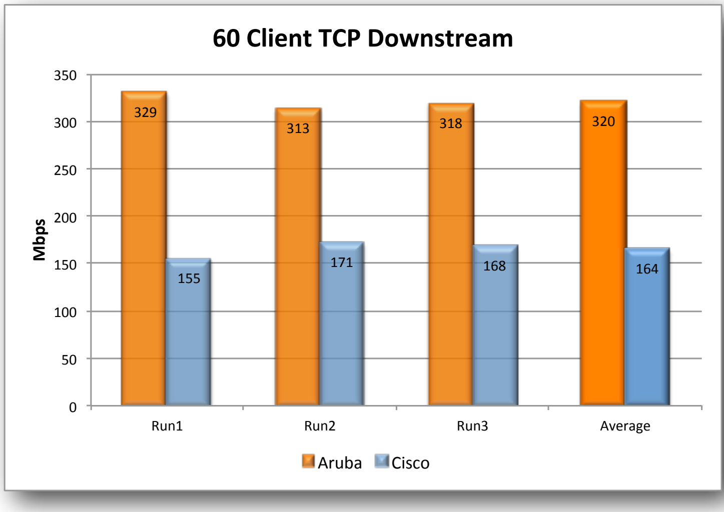


Figure 2.

The Aruba AP-225 delivered an average of 302 Mbps in bi-directional throughput across 60 clients – twice the aggregate throughput of Cisco's 3702i which was 137 Mbps as shown in Figure 1. The results were consistent for each test run, and inline with the test results shown for the sixty client throughput test with downstream only traffic shown in Figure 2.

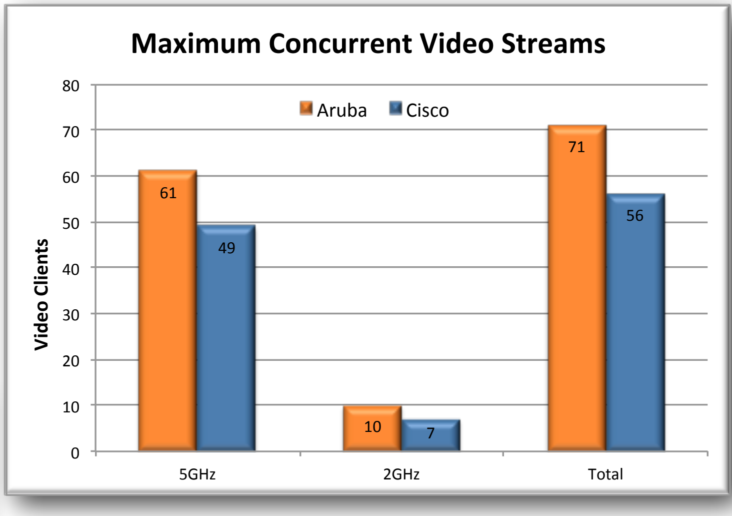
High-Definition Video Streaming Test

The purpose of this test was to illustrate how these enterprise 802.11ac systems hold up to the demands of high bandwidth, latency sensitive video traffic. The test pushed the AP's to their limits by streaming high-definition, 8 Mbps video using as many 802.11ac clients as possible in both the 2.4 GHz and 5 GHz bands.

The VLC Media server was used to stream video to 802.11ac clients running VLC media player. Both Aruba and Cisco controllers were configured to enable video prioritization and to enable multicast to unicast traffic conversion.

Clients were added one by one to both the 2.4 GHz and 5 GHz bands until there was visible degradation in video quality. At the limit, the Aruba AP-225 supported 10 clients in the 2.4 GHz band and 61 clients in the 5 GHz band. Cisco's AP 3702i supported 7 clients at 2.4 GHz and 49 clients at 5 GHz as seen in Figure 3, before pixelation occurred.

Figure 3.



The Aruba AP-225 delivers 27% more concurrent high-definition video streams than the Cisco 3702i with 802.11ac.

The CPU utilization of APs was constantly monitored during the test. Aruba AP-225 was 56% busy when the client count reached 71 and there were no visible artifacts. When the Cisco AP 3702i was delivering 56 simultaneous video streams its CPU utilization was 94%, and when the video quality degraded with more simultaneous streams CPU utilization was at 100%. The hardware design of the Cisco AP appeared to constrain performance in this test.

High-Density Client Roaming Test

The purpose of this test was to evaluate the impact of the "sticky client" problem on wireless LAN performance in dense environments.

The 'sticky client' problem is a common issue seen in complex multi - AP environments. When clients enter a network, they frequently stay attached to the first AP to which they connect; even a when there are better APs available as the client moves around the network. These sticky clients tend to operate at lower data rates when communicating at the limits of AP coverage, and this can drag down performance of the entire wireless LAN.

Aruba recently introduced ClientMatch™ software which optimizes the clients' wireless connection based on a system-wide view of available resources and the needs of each client. This roaming test allowed us to measure the impact of ClientMatch on system performance.

For this test we simulated a scenario where a group of people congregate outside of a classroom or auditorium, and then spread out when they enter the larger room.

We tested with 75 clients and they were all 802.11ac dual band capable devices.

- 25 MacBook Air laptops with two spatial streams.
- 30 MacBook Pro laptops with three spatial streams.
- 10 single-stream Samsung Galaxy S4 smartphones.
- 10 single-stream Samsung Galaxy Note 10.1 tablets.

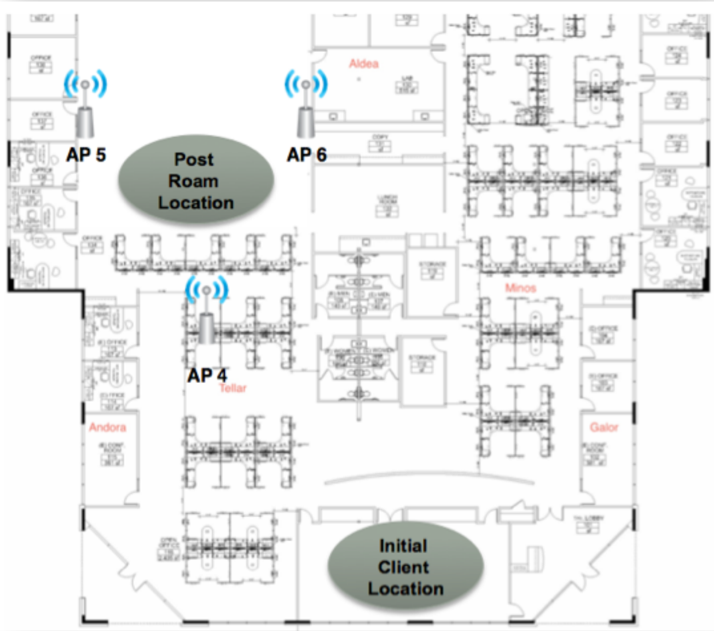


Figure 4.

Figure 4 shows the layout of the roaming test area. Three APs were were mounted on the ceiling in an open office environment and placed about 65 feet apart from each other in a triangular formation. The APs were configured to automatically select the channel and power using Adaptive Radio Management (ARM) for Aruba APs and Radio Resource Management (RRM) for Cisco APs.

To start the roaming test, we placed all 75 clients in a conference room, which is located closest to AP4 and far away from AP5 and AP6. We enabled Wi-Fi on the clients and waited for them to associate to an AP. We recorded the starting client distribution and then moved the clients to an area in the center of the three APs, identified as the Post Roam Location in Figure 4.

We ran a continuous ping to the clients while they were roaming to simulate traffic between the AP and client. A few minutes after all 75 clients were moved to the Post Roam Location, we documented the client distribution across the three APs. We then ran Ixia Chariot downstream TCP throughput tests to measure the aggregate throughput of all of the clients. The entire roaming and throughput test procedure was repeated three times for both vendors to ensure consistent results.

Client Distribution

Before the roam, all the clients were in the Initial Client Location which is closest to AP4 and farther away from AP5 and AP6. As expected, the majority of the clients associated to AP4 for both vendors when the test started. With Aruba, all the clients were associated to AP4 and for Cisco 68 out of 75 clients were associated to AP4.

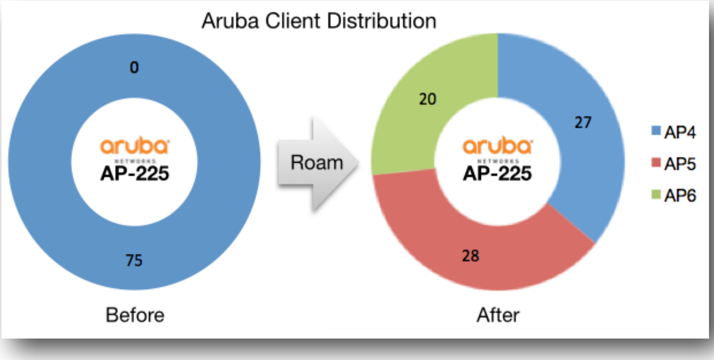


Figure 5.

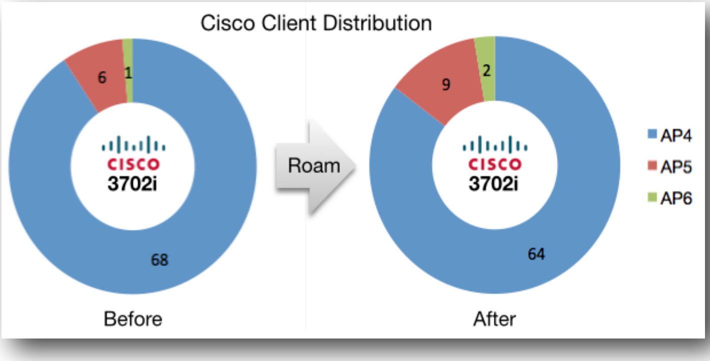


Figure 6.

The results are very different after roaming, as shown in Figures 5 and 6. For Aruba, 48 of the clients roam to different APs after moving to the center of the three APs. With Cisco, only 4 clients changed their AP association most of the clients are "sticky". The Aruba ClientMatch system does cause the clients to move to better APs and results in a more even distribution of the clients across the available APs.

Overall System Performance After Roaming

We ran Ixia Chariot Download TCP throughput tests after moving all the clients to examine how the client distribution across APs affects system performance. After the roam, Aruba delivered an aggregate throughput of 752 Mbps total for all of the clients. The Cisco infrastructure delivered 540 Mbps of aggregate throughput in total, as seen in Figure 7. Aruba overall system throughput was 39% higher than Cisco.

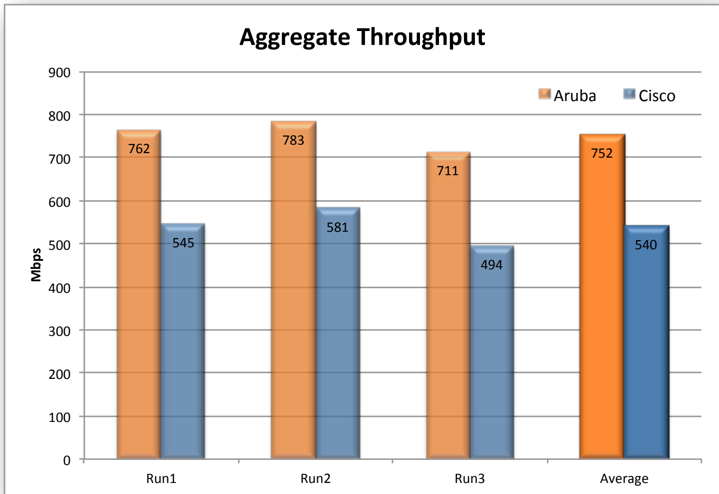


Figure 7.

Per Client Throughput

The overall system throughput reveals only part of the story. We took a closer look at per client throughput to understand if there were any differences in fairness – were some clients hogging the airwaves, while others were starving for access.

In Figure 8 each vertical bar shows the number of clients that achieved a given throughput. Number of clients is the vertical axis and throughput in Mbps is the horizontal axis. For Cisco, 14 clients had throughput between 0 and 1 Mbps, 17 clients had throughput between 1 and 2 Mbps, and so forth.

With Cisco there was a much greater variance between the worst and best performing clients – most clients got less than 3 Mbps throughput while one client got almost 120 Mbps.

In comparison, the better distribution of clients across APs for Aruba led to more consistent performance for the clients. Only one client in the Aruba test had throughput below 2 Mbps, while 59 clients achieved throughput greater than 5 Mbps.

Figures 9 and 10 show the per client throughput results for every client on a per AP basis. The clients associated with an AP are grouped together and highlighted within a shaded box matching that AP. AP4 results are in the green shaded box, AP5 is yellow and AP6 is pink.

Figure 9 shows the Cisco throughput for each of the 75 clients. The naming shows the type of client as well. For example:

- MBP-16 is a MacBook Pro;
- MBA-06 is a MacBook Air;
- SGNT-08 is a Samsung Galaxy Note;
- SGS4-09 is a Samsung Galaxy S4 smartphone.

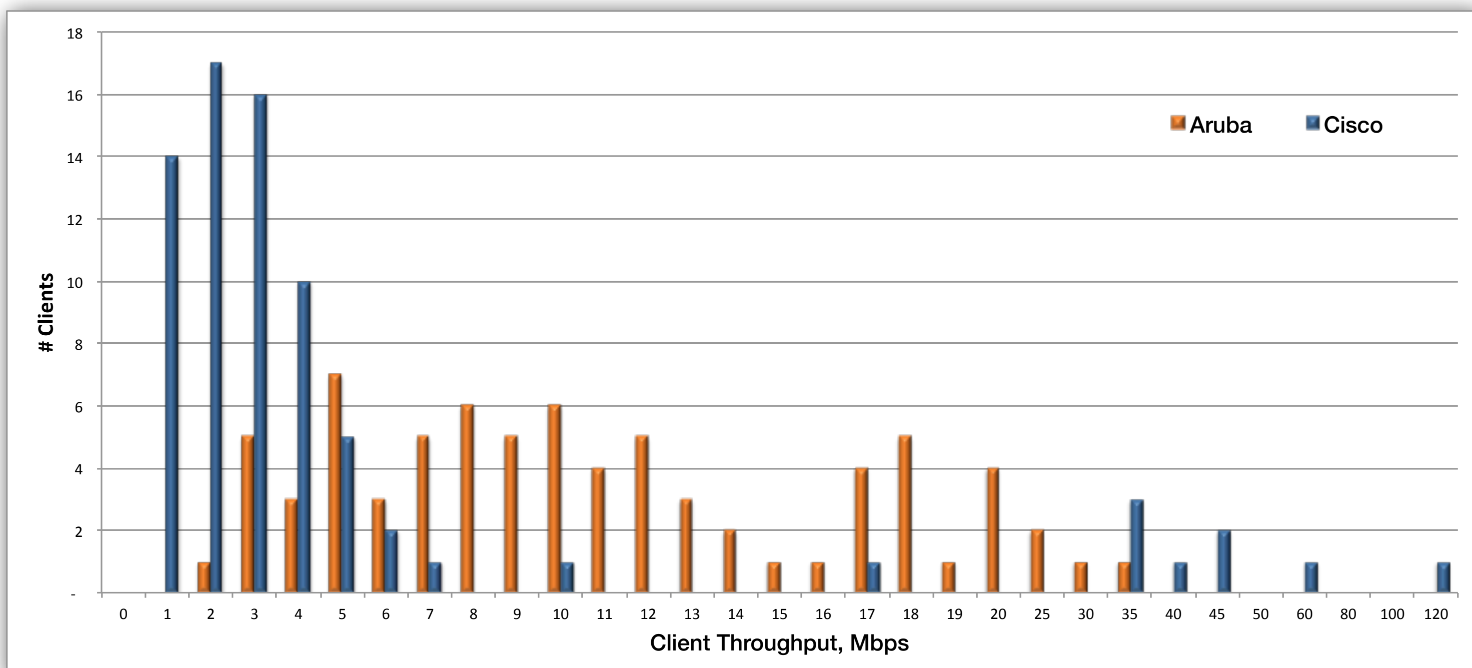


Figure 8.

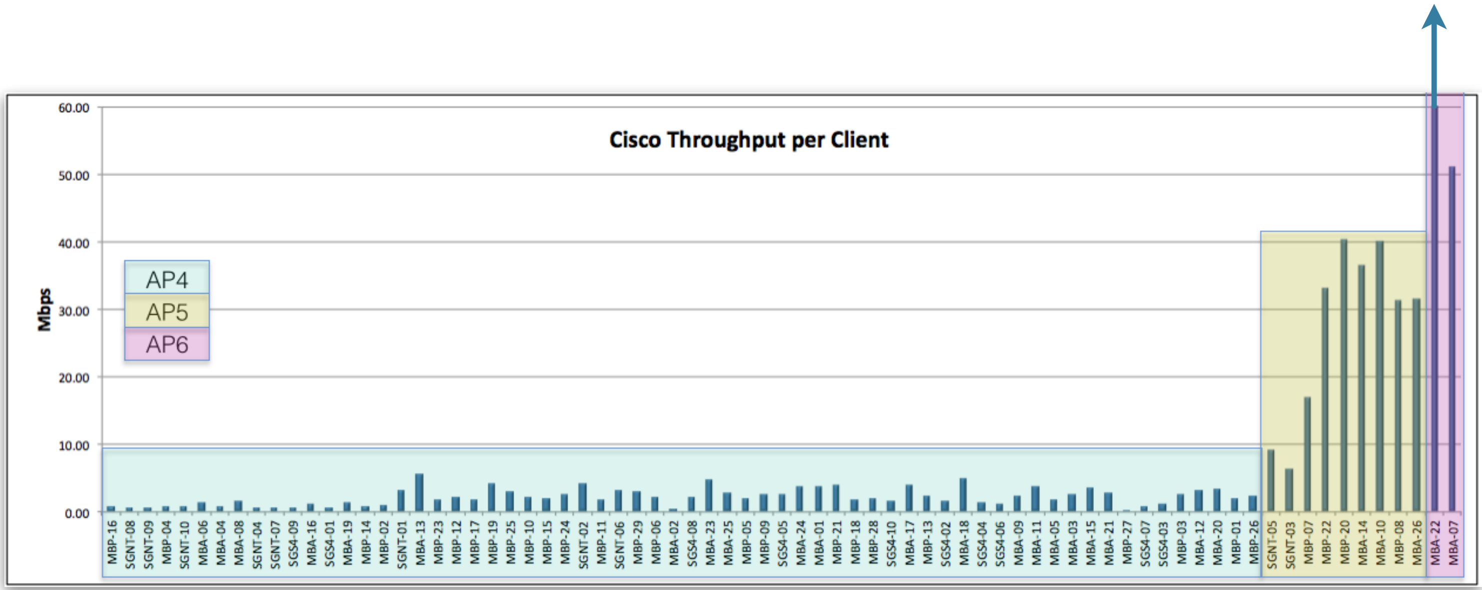


Figure 9.

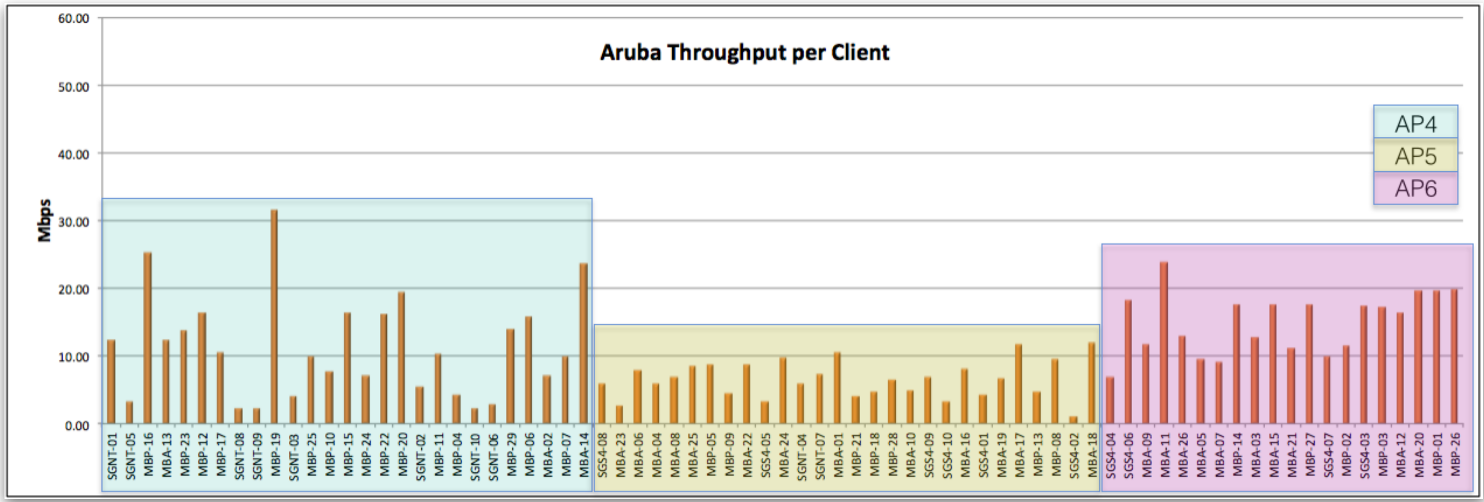


Figure 10.

The cost of the sticky clients is clearly shown in Figure 9. 64 out of 75 clients in the Cisco test were sharing the same AP and a single 5 GHz channel. Most of these clients associated to AP4 were starved for airtime and were getting very low throughput.

At the other extreme, AP6 served only two clients during the Cisco test, with one client that achieved about 50 Mbps and another client achieved close to 120 Mbps (this result goes "off the chart" in Figure 9). This is because the entire 80 MHz channel was shared between just two clients. The great throughput for those two clients comes at the expense of the majority of the clients who are stuck with AP4 and getting low throughput.

As seen in Figure 10, the clients were spread across the APs much more evenly during the Aruba test. As a result, a majority of the clients performed well, and they were able to perform to a level that matched their capabilities – number of antennae, spatial streams etc.

Conclusion

Aruba's 802.11ac AP-225 outperformed Cisco's AP3702i in the high-density performance throughput test, high-definition video test, and high-density roaming test. The video test showed the value of AP hardware that is custom designed for 802.11ac. The roaming tests showed how Aruba's ClientMatch moved the clients to available APs to spread the load and improve performance for most clients.

The controller configurations, the tools that we used, and the test scripts are documented in a more detailed report. We are confident that the behavior we saw can be reproduced in similar testing environments and the test results are repeatable.

Novarum made every attempt to ensure that the tests were done fairly and we tried optimize the results for both vendors. We followed best practices for configuration and deployment guides as published by the vendors.