



mojo

Competitive Test Report

Executive Summary - Spring 2016

Mojo Networks C-120 vs. Aerohive AP250, Aruba IAP-325,
Meraki MR42, and Ruckus R710

Introduction

In the Spring of 2016, Mojo Networks conducted access point performance tests on the generally available 802.11ac Wave 2, enterprise class access points to evaluate the state of the competitive access point market in typical customer use cases. If a vendor had multiple offerings, the most current, highest performing access point was selected (See Table 1 for details on the specific access points tested). Mojo Networks is constantly adding new access points to its testing curriculum and will reports its findings as they develop.

The Results

The C-120 outperformed the competition in almost every scenario tested. This report provides a high-level summary of each test performed with the following access point models: Mojo Networks C-120, Aerohive AP250, Aruba IAP-325, Meraki MR42, and Ruckus R710.

Table 1

AP Make	Mojo	Aerohive	Meraki	Ruckus	Aruba
Model Tested	C-120	AP250	MR42	R710	IAP-325
WiFi Chipset	QCA9994	BCM43525	BCM43525	QCA9990	QCA9990
802.11 Version	11ac W2	11ac W2	11ac W2	11ac W2	11ac W2
MIMO Streams	4x4:4	3x3:3	3x3:3	4x4:4	4x4:4
2.4GHz (Mbps) Max Throughput	800	600	600	800	800
5GHz (Mbps) Max Throughput	1700	1300	1300	1733	1733
SW Version Tested	8.0.168	7.0r1_2381	Latest	9.12.1.0 Build 148	6.4.4.4- 4.2.3.2_54910

Test Configuration

Wireless testing is challenging because there are many variables that are difficult to control, account for, or work around. If something changes during a test or between test runs, it can change the result and the reproducibility of the test.

Mojo strives to produce fair and reproducible results. We know our products are as good or better than the best of the competition and are not afraid of a fair comparison. For each test, we configure each AP system in accordance with the manufacturer's published, recommended best practices, and at the beginning of the test, we upgrade the AP to the most current version of AP code available.

This summary provides an overview of the test results. The details of each individual test including AP system configurations, and test methodology will be shared in detailed test reports.

All tests were conducted in Mojo Network's performance test lab by Senior Technical Marketing Engineer Robert Ferruolo.



Mojo Networks Performance Test Lab

All access points tested were configured for optimized performance and at max capacity. Table 2 shows what settings were used on all access points for all tests unless otherwise noted:

Table 2

Test Parameters	Configuration
Band(s) Used	5 GHz Band
Channel Width	80 MHz
Guard Interval	Short Guard Interval
MCS Rates	0 - 9
Cabled or Over-the-Air	Over-the-Air
AP to Client Distance	3 to 15 feet
AP to Client Distance – Distributed Client	1 to 60 feet

Test Cases

Each competitive test case is designed around a real-life use case, and then taken up a notch. For example, we turn a typical use case of a person downloading one large file into 50 clients downloading 50 large files. A competitive test of a single client streaming quality HD video becomes 30 clients simultaneously streaming the same quality HD video; this demonstrates a use case of 30 students in a classroom streaming video.

This round of testing focused on five competitive test cases:

- **Distributed Client Throughput:** a test collecting downstream data throughput of 10 simultaneous clients, each at different distance from the access point
- **Concurrent Client Download:** a test collecting data download throughput among groups of simultaneous clients (4, 30, 40, and 50, respectively)
- **50 Client Mixed Application:** a test observing concurrent performance of:
 - 30 clients passing data (20 downstream, 10 upstream)
 - 10 voice clients (bi-directional)
 - 10 clients streaming video (downstream)
- **Real-Time Application Client Scale:** a test determining the maximum number of clients an access point can support streaming good-quality voice and video
- **30 Client Mixed Application with Application Visibility and Control:** a test collecting data download throughput among simultaneous clients operating a variety of applications
 - 12 data client throughput – 6 upstream, 6 downstream
 - 6 voice clients (bi-directional)
 - 6 video streaming (720p) clients
 - 6 HD video conferencing clients

Test Devices

Each competitive test leverages devices of varying make and model. Table 3 shows an overview of these devices. Note that the detailed test reports will provide more information about which specific clients were used in each specific test.

Table 3

Client Make	Model	802.11 Version	Streams	Chipset Vendor	Chipset	Driver Version	OS Version
Google	Nexus 5x	11ac Wave 2	2x2	Qualcomm	QCA6174	-	Android 6.0.1
Acer	Aspire F15	11ac Wave 2	1x1	Qualcomm	QCA9377	12.0.0.203	Windows 10
OnePlus	OnePlus Two	11ac Wave 2	1x1	Qualcomm	QCA9377	-	Android 6.0.1
Apple	Macbook Pro	11ac Wave 1	3x3	Broadcom	BCM4360	7.21.94.136.1a1	MacOS 10.11.2
Dell	Inspiron 7000	11ac Wave 1	2x2	Intel	7265	18.40.0.9	Windows 10
HP	Elitebook	11ac Wave 1	2x2	Intel	7265	18.33.0.1	Windows 7
Apple	Macbook Air	11ac Wave 1	2x2	Broadcom	BCM4360	7.21.94.136.1a1	MacOS 10.11.2
Apple	iMac	11ac Wave 1	3x3	Broadcom	BCM4360	7.21.94.136.1a1	MacOS 10.11.3
Apple	iPad Pro	11ac Wave 1	2x2	Broadcom	-	-	iOS 9.2.1
Samsung	Tab S2	11ac Wave 1	2x2	-	-	-	Android 6.0.1
HP	ProBook	11n	2x2	Broadcom	BCM943228Z	6.30.223.255	Windows 10
Apple	iPad Mini	11n	1x1	Broadcom	-	-	iOS 9.3.1

Test Case #1: Distributed Client Throughput

A typical enterprise deployment has clients which are dispersed and, as a result, at varying distances from the access point. This test evaluates the downstream performance of the access point when it serves 10 dispersed clients simultaneously.

There are two important things to consider in this test:

1. What is the user experience of the clients furthest from the access point? (These users will often generate WLAN IT tickets.)
2. What is the aggregate performance of the access point?

Results

Figure 1 shows the results from each access point. Each vertical bar denotes a single client at a single location relative to the access point. The first bar represents a client at -35 dBm, the next at -40 dBm, and so on until the last client positioned at -80 dBm relative to the access point. Table 4 provides the specific numbers.

Furthest Client Performance

The C-120 outperformed all other access points when looking at the furthest two clients. Only one client (Aerohive at location 9) performed better than the C-120 at these distances.

Aggregate Performance

The best aggregate performance was achieved by Ruckus. Their score was helped by high numbers from the five closest clients (-55 dBm and closer) despite a significant decrease in performance of the five clients furthest away (there was a 61% drop in throughput between clients 5 and 6).

The C-120 came in second to Ruckus in aggregate throughput.

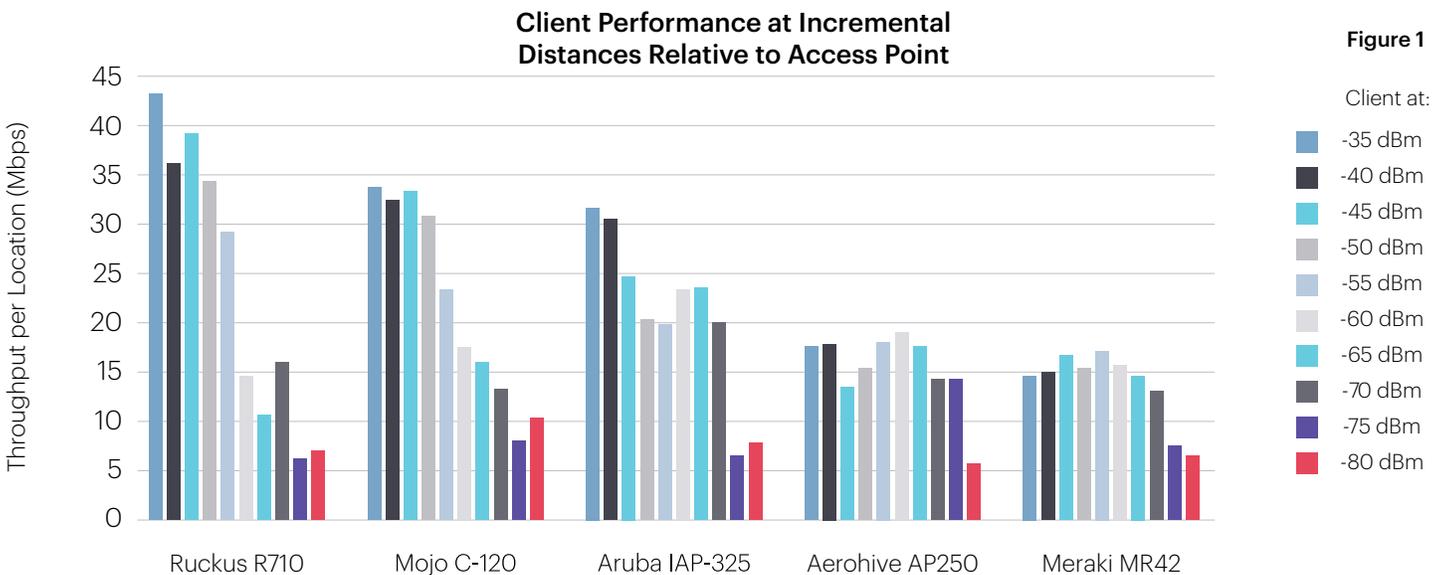


Table 4

	Ruckus R710	Mojo C-120	Aruba IAP-325	Aerohive AP250	Meraki MR42
L1	42.7	33.9	31.4	17.8	14.5
L2	36.0	32.3	30.2	17.9	15.0
L3	39.5	33.5	24.8	13.5	16.5
L4	34.3	30.8	20.2	15.2	15.1
L5	29.5	28.0	19.9	18.3	17.0
L6	14.7	18.0	23.8	19.0	15.3
L7	10.6	16.3	24.1	18.0	14.8
L8	15.8	13.2	20.0	14.4	12.9
L9	6.2	8.1	7.3	14.4	7.3
L10	6.9	10.0	8.0	5.7	6.4
Aggregate	236	224	209	154	135

Test Case #2: Concurrent Client Download

This test determines the aggregate the download throughput of multiple clients all in close proximity to the access point. The use case for this test represents a number of people in a room concurrently downloading a large file.

Four versions of the test were run to evaluate different client densities and protocols. The variations are:

- 4 Clients using TCP
- 30 Clients using TCP
- 40 Clients using UDP
- 50 Clients using TCP

Results

In all cases the C-120 outperformed the competition. The C-120 was on average 35% better than its closest competitor, the Ruckus R710.

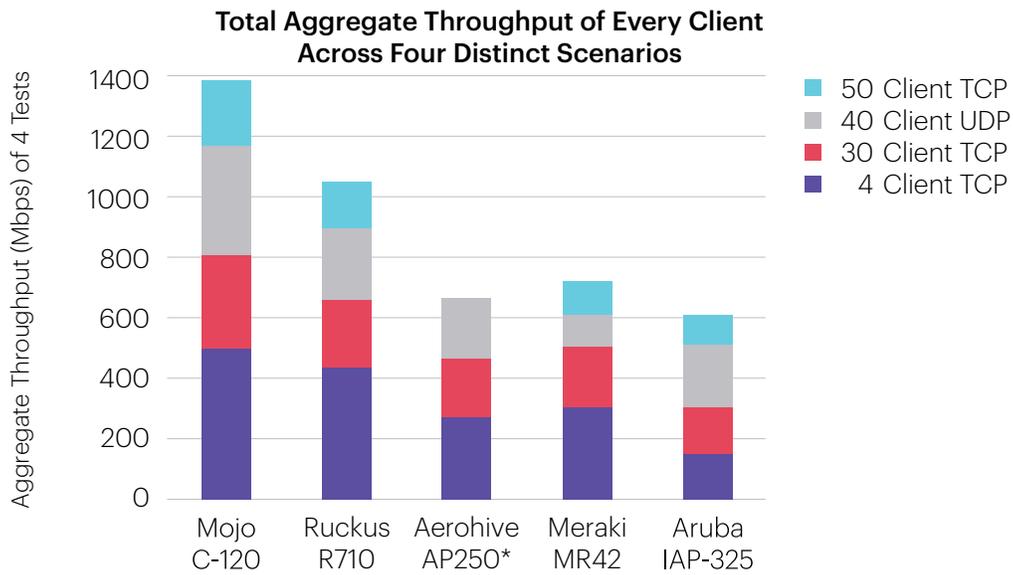


Figure 2

*50 Client TCP Down data unavailable for Aerohive AP250

Table 5

802.11ac Downstream Performance	Mojo C-120	Ruckus R710	Aerohive AP250*	Meraki MR42	Aruba IAP-325
4 Client TCP	500	438	272	304	151
30 Client TCP	309	227	199	204	155
40 Client UDP	367	236	197	103	210
50 Client TCP	216	151	*	108	88

*50 Client TCP Down data unavailable for Aerohive AP250

Test Case #3: 50 Client Mixed Application

The 50 Client Mixed Application case tests 50 clients simultaneously using a mixture of data, voice, and video streaming. This is the most taxing performance test as each application type (data, voice, and video) has different standards for acceptable use. Since the results of the three different applications are not directly comparable (Mbps for data, MOS score for voice, and performance index for video), a Service Level Assurance (SLA) is assigned to each application.

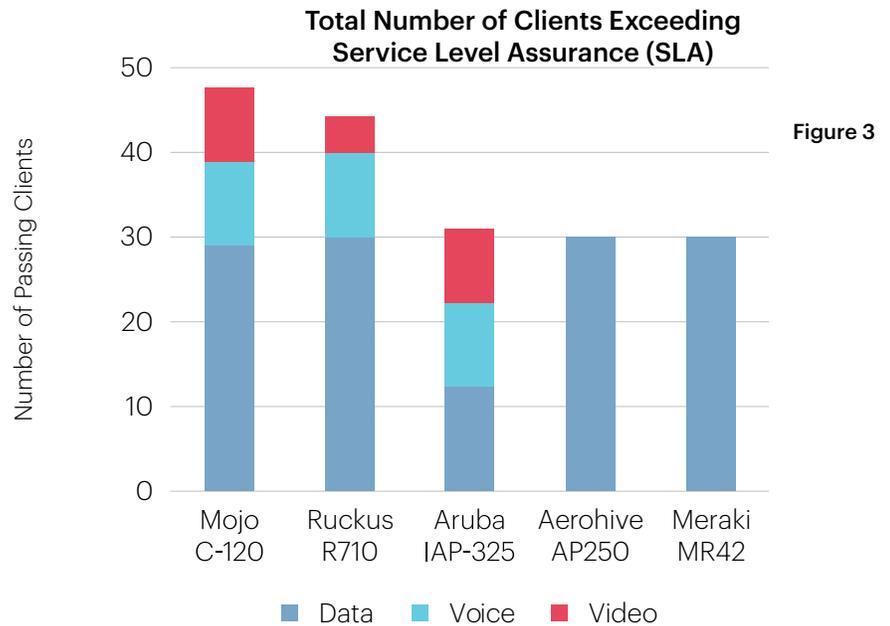
The SLA metrics that each access point must pass can be found in Table 6. The metrics for voice and video are representative of industry best standards, while the metric for data represents a minimum threshold for proper data transmission. If a particular client failed to meet the designated SLA it was not marked in the results below (see Table 7).

Results

The C-120 met the SLA criteria with 48 out of 50 clients. The Aruba IAP-325 met the SLA for all of the voice and video clients at the expense of the data clients. Neither Aerohive nor Meraki met voice or video client SLA criteria.

Table 6

Pass Metrics	
Data	1 Mbps SLA
Voice	MOS => 3.8 Up and Down
Video	Media Loss Rate < .004
	Delay Factor < 50ms



Number of Clients Meeting Respective SLA's

Table 7

Passing Clients	Mojo C-120	Ruckus R710	Aruba IAP-325	Aerohive AP250	Meraki MR42
Data	29	30	12	30	30
Voice	10	10	10	0	0
Video	9	4	9	0	0
Total	48	44	31	30	30

Test Case #4: Real-Time Application Scale Tests

Real-time applications such as voice calls or streaming video can be challenging to both wired and wireless networks. When planning a wireless network for the best user experience, it is important to know the types of applications that may be used and the number of clients the access point can support.

This test is designed to add clients that are running voice or video applications incrementally until the user experience is impacted.

Results

All access points supported good quality voice (a MOS score of 3.8 or greater) with 30 clients, the maximum number of clients tested. Mojo outperformed all competitors by streaming good quality 1080p video up to 20 clients.

Number of Clients Meeting Respective SLA's

Table 8

Real-Time Scale Tests	Video Tests		Voice
	720P	1080P	MOS > 3.8
Mojo C-120	30	20	30
Aerohive AP250	30	17	30
Aruba IAP-325	25	10	30
Meraki MR42	30	17	30
Ruckus R710	30	17	30

Test Case #5: 30 Client Mixed Application (with Application Visibility and Control)

This test evaluates the performance of the access point in a mixed application use case with Application Visibility and Control (AVC) enabled. AVC can cause access point performance to decrease due to the increased CPU overhead incurred as the access point determines the types of traffic flowing through it and takes action when necessary.

This test observed 30 clients simultaneously using a mixture of data, voice, video streaming and video conferencing. The test results were evaluated to determine the number of clients that had a quality experience. The pass metrics used to determine a “quality experience” are found in the tables below.

Table 9

Pass Metrics	
Data	3 Mbps SLA
Voice	MOS => 3.8 Up and Down
Video	Video Score = 5
	Video Score = 5

Table 10

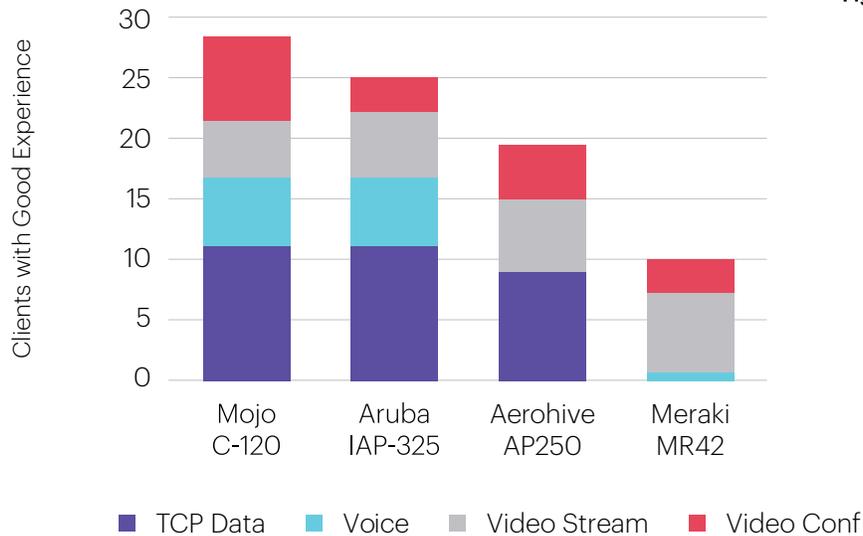
Video Score	Criteria
5	Perfect video – no pixelation or freezing
4	Occasional pixelation or momentary freezing
3	Regular pixelation or momentary freezing
2	Regular pixelation and momentary freezing
1	Video stops playing for two seconds or more

Video streaming and video conferencing are live tests and did not use simulated data. Therefore, additional metrics were developed to properly evaluate the video experience. Clients transmitting streaming video or video conferencing passed the test if they experienced no pixelation or freezing.

Results

Under this strenuous test the C-120 met the criteria of a good user experience for 28 out of 30 users. Ruckus was not included in the test as they do not perform AVC.

30 Client Mixed Application Performance (with AVC Enabled)



Conclusion

The Mojo C-120 consistently outperformed the best of the competition in almost every performance test.

Most access point manufacturers do not publicly post competitive performance numbers. If they do, they are published by an independent or third-party test facility, paid for by the vendor. By publishing these results we are bringing open communication and transparency to the industry.

Why should you believe us? Because we have nothing to hide. We know our solution is as good or better than our competitors and feel confident in the reproducibility of our results.

As a result, we encourage you to validate our results. For each test mentioned in this report we will provide a comprehensive report that will include the test results, the test methodology, and the tested access point system configurations: all the information needed to reproduce our results.

We will also meet any AP manufacturer in a head-to-head performance test, with the following rules:

- Testing is apples-to-apples
- Hardware, firmware, and software under test is at the latest version and generally available
- Testing will be overseen by a mutually-agreed-upon, independent WiFi industry leader, who will:
 - Act as an arbiter
 - Confirm the test bed, environment, and methodology
 - Validate WLAN configurations, optimizations, hardware, and versions of code
 - Publish the results

If you have questions about these tests, or anything else related to Mojo Networks, please feel free to reach us at info@mojonetworks.com or call us at +1 (877) 930-6394.