CARNet Wi-Fi Independent Test Results

Access Points Comparison

May 2015

CARNet
CROATIAN ACADEMIC AND RESEARCH NETWORK

TEST HIGHLIGHTS

- 19 enterprise class 802.11ac and 802.11n access points stressed in progressive test environment
- Mix of .11ac and .11n single, dual and three-stream clients within the classroom
- Each AP tested on the other side of a 5dB drywall
- Increasing number of clients (12, 23, 36 and 60) used with each test run three times
- Highest aggregate TCP throughput recorded using latest IxChariot test suite
- Only publicly available code allowed

EXECUTIVE SUMMARY

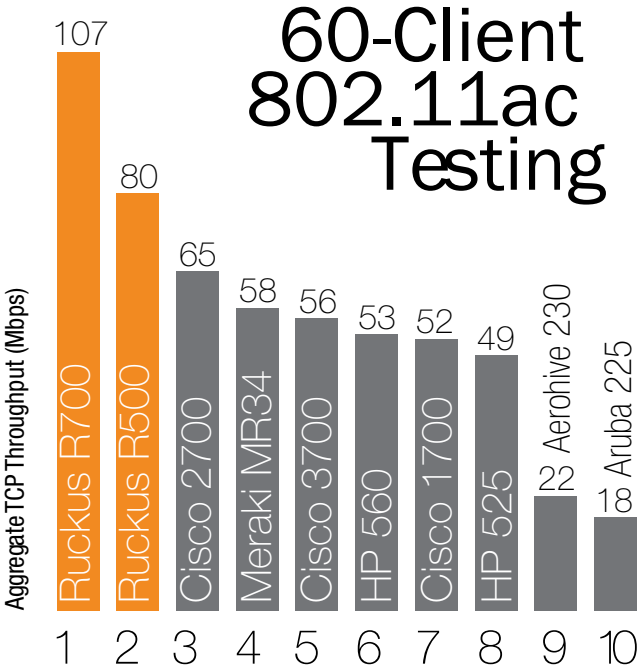
Croatian Academic and Research Network (CARNet) recently conducted independent Wi-Fi performance testing, showcasing the world's top 802.11ac and 802.11n access points (APs) within a real world high-capacity, high interference classroom environment.

Using industry standard test tools, 19 APs were stressed within several progressive testing scenarios that included 12, 23, 36, and 60 clients, increasing number of clients for each throughput test.

Maximum aggregate TCP throughput to a mix of 802.11ac and 802.11n clients that included one- two- three-stream mobile and laptop devices. Each test was run three times with the highest result recorded.

Vendors were invited to actively participate in the testing with the latest publicly available code for the device under test (DUT) and the option to choose their own channels and channel width for testing, with no encryption required.

The results of the exhaustive testing found that Ruckus Smart Wi-Fi APs consistently outperformed all DUTs, taking top marks in almost every test scenario.



Ruckus®
Simply Better Wireless.

CARNet Wi-Fi Independent Test Results

Access Points Comparison

Dual-Band Devices Under Test

VENDOR	MODEL	PHY	Tx/Rx:SS	RESULT	RANK*
Aerohive	121	802.11n	2x2:2	38.16 Mbps	15
Aerohive	230	802.11ac	3x3:3	42.68 Mbps	14
Aerohive	330	802.11n	3x3:3	54.45 Mbps	13
Aruba	225	802.11ac	3x3:3	67.84 Mbps	8
Cisco	1700	802.11ac	3x3:2	54.50 Mbps	12
Cisco	2700	802.11ac	3x4:3	83.56 Mbps	6
Clsco	3700	802.11ac	4x4:3	76.21 Mbps	7
HP	430	802.11n	3x3:2	61.43 Mbps	10
HP	525	802.11ac	2x2:2	37.67 Mbps	16
HP	560	802.11ac	3x3:3	65.09 Mbps	9
Meraki	MR34	802.11ac	3x3:3	56.00 Mbps	11
Ruckus	7372	802.11n	2x2:2	91.27 Mbps	4
Ruckus	7982	802.11n	3x3:3	85.23 Mbps	5
Ruckus	R300	802.11n	2x2:2	95.24 Mbps	3
Ruckus	R500	802.11ac	2x2:2	122.16 Mbps	2
Ruckus	R700	802.11ac	3x3:3	137.00 Mbps	1
Ubiquiti	Uni-Fi Pro	802.11n	2x2:2		n/a
Xirrus	XR520	802.11n	2x2:2		n/a
Xirrus	XR430	802.11n	3x3:3		na

* Results from 36 (distributed) client testing.
(n/a= access points that were unable to complete tests)

All enterprise Wi-Fi manufacturers were invited to bring in their choice of APs, without limitation as to what type or how many APs could be tested in a single day. Each of the following vendors chose to send an engineer to the tests with equipment in hand: Aerohive, Cisco, HP, and Ruckus. Each vendor was also given a test cycle to prove that their AP is working as desired and had the opportunity to optimize their configuration for performance.

Downlink throughput tests, using a 1MB file transferred and the latest version of IxChariot, were conducted, in order, from a single AP to 13, 23, 36, 60, and 36 (distributed) clients. For the 36 (distributed) test, the client devices were spread into a 270° arc pattern. All 60 clients were associated to the AP being tested prior to each test starting. Band balancing of clients could be performed automatically by the AP or manually by the on-site technical staff. Five different test were run with the best result from the three tests recorded:

Test 1: 13 clients (a mix of 802.11ac and 802.11n)

Test 2: add 10 802.11n clients

Test 3: add 13 802.11n clients

Test 4: add 24 802.11n clients

Test 5: spread 36 clients into a 270° arc pattern

CARNET

CARNet is a public institution that facilitates the progress of individuals and society through the use of new information technologies. Primary and secondary educational institutions are able to take advantage of CARNet services, which include information and communication technologies and their application in education network and infrastructure. CARNet includes:

- Over 240 academic community members
- Over 1,380 primary and secondary education schools
- Over 2,320 connected locations through the CARNet network

For more information please visit: http://www.carnet.hr/en

CARNet Wi-Fi Independent Test Results

Access Points Comparison

APPENDIX

CARNet
CROATIAN ACADEMIC AND RESEARCH NETWORK

Participation

Manufacturer	Model	PHY	Dual-Band	TxR:SS
Aerohive	121	802.11n	Y	2x2:2
Aerohive	230	802.11ac	Y	3x3:3
Aerohive	330	802.11n	Y	3x3:3
Aruba	225	802.11ac	Y	3x3:3
Cisco	1700	802.11ac	Y	3x3:2
Cisco	2700	802.11ac	Y	3x4:3
Cisco	3700	802.11ac	Y	4x4:3
HP	430	802.11n	Y	3x3:2
HP	525	802.11ac	Y	2x2:2
HP	560	802.11ac	Y	3x3:3
Meraki	MR34	802.11ac	Y	3x3:3
Ruckus	7372	802.11n	Y	2x2:2
Ruckus	7982	802.11n	Y	3x3:3
Ruckus	R300	802.11n	Y	2x2:2
Ruckus	R500	802.11ac	Y	2x2:2
Ruckus	R700	802.11ac	Y	3x3:3
Ubiquiti	Uni-Fi Pro	802.11n	Y	2x2:2
Xirrus	XR520	802.11n	Y	2x2:2
Xirrus	XR4430	802.11n	Y	3x3:3

Client Devices

A real-world mix (60 total) of mobile devices, tablets, and laptops, each with varying Wi-Fi specifications and operating systems, were used.

Qty	Manufacturer & Model	802.11n	802.11ac	20MHz	40MHz	80MHz	1SS	2SS	3SS	802.11h
1	Samsung S-SM-T230	Y		Y			Y			Y
1	Samsung S-SM-T235	Y		Y	Y		Y	Y		Y
2	Samsung S-SM-T700	Y	Y	Y	Y	Y	Y	Y		Y
1	Samsung S-SM-T705	Y	Y	Y	Y	Y	Y	Y		Y
1	Samsung S-SM-T800	Y	Y	Y	Y	Y	Y			Y
1	Samsung S-SM-T805	Y	Y	Y	Y	Y	Y			Y
1	Samsung S-SM-N910C	Y	Y	Y	Y	Y	Y	Y		Y
1	Samsung S-SM-P600	Y	Y	Y	Y		Y	Y		Y
6	Samsung N8000	Y		Y	Y		Y			Y
4	iPad 3	Y		Y	Y		Y			Y
1	iPad 4	Y		Y	Y		Y			Y
1	MacBook Pro 15" (2011)	Y		Y	Y		Y	Y	Y	Y
10	Lenovo X200 laptops	Y		Y	Y		Y	Y	Y	
14	Lenovo T400 laptops	Y		Y	Y		Y	Y	Y	
15	HP Pro Tablet 610 G1	Y		Y	Y		Y	Y		Y

Ruckus®
Simply Better Wireless.

CARNet Wi-Fi Independent Test Results

Access Points Comparison

APPENDIX

CARNet
CROATIAN ACADEMIC AND RESEARCH NETWORK

Testing Environment

APs were placed outside of a classroom, separated from the client devices within the classroom by a single drywall with a measured loss of 5dB. The classroom measured 12 meters (~39 feet) by 10 meters (~33 feet). Each vendor was given a test cycle to prove that their AP is working as desired and had the opportunity to optimize their configuration for performance.

Evaluation Criteria

Criteria to be evaluated included throughput maximized to all test clients. Downlink throughput tests, using a 1MB file transferred using the latest version of IxChariot, were conducted, in order, from a single AP, to 13, 23, 36, 60, and 36 (distributed). For the 36 (distributed) test, the client devices were spread into a 270° arc pattern. All 60 clients were associated to the AP being tested prior to each test starting. Band balancing of clients could be performed automatically by the AP or manually by the on-site technical staff.

The Rules

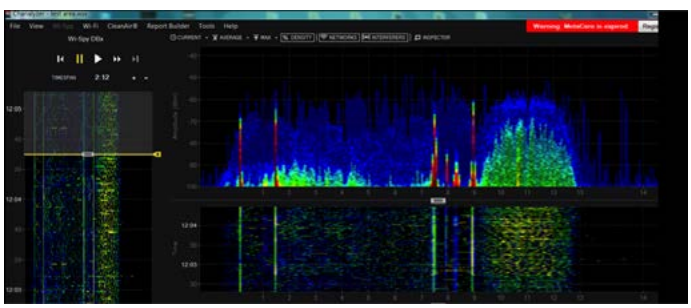
- Tests must be run in order: 13, 23, 36, 60, 36 (distributed).
- Each vendor was given a trial run, if requested.
- If a TCP session to a client fails in any test, that test is considered to have failed and the AP under test does not progress to the next round of testing (with a higher number of clients).
- Each test was run three times, and the highest number (in Mbps) was recorded.
- Each vendor can choose its own channel(s) and channel width for testing.

The RF Environment

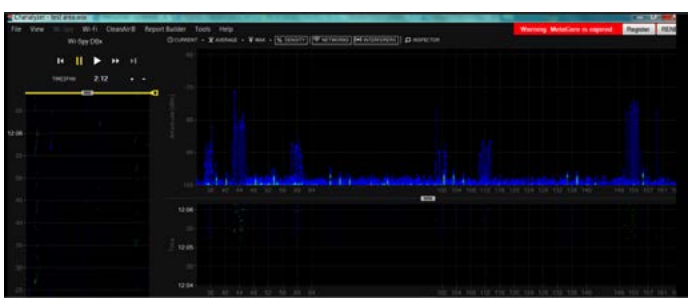
No effort was made to “clean up” the RF environment, as real-world deployments have to deal with random, and often un-controllable, levels of modulated and unmodulated interference. CARNet’s dual-band Wi-Fi network and 2.4GHz motion sensors remained operational during the test.

Before the test began, MetaGeek’s Wi-Spy DBx spectrum analysis USB dongle and Chanalyzer software showed was used to view the 2.4GHz ISM band and 5GHz UNII bands. Illustrations are below.

2.4GHz before the test began.



5GHz before the test began.



Ruckus®
Simply Better Wireless.

CARNet
CROATIAN ACADEMIC AND RESEARCH NETWORK

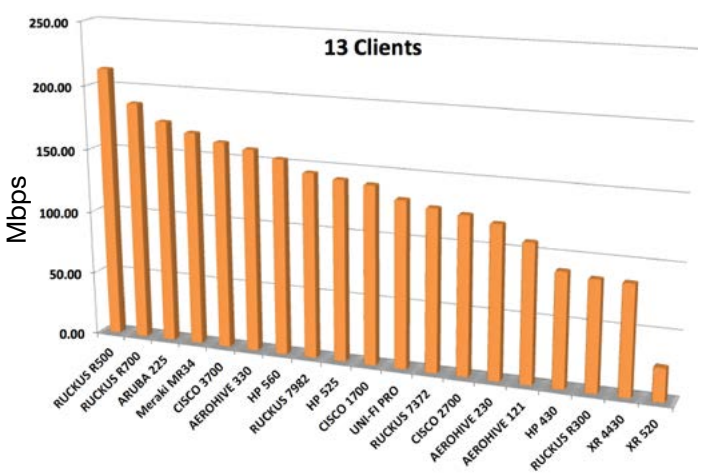
TEST RESULTS

Test #1 – 13 Clients Test

The clients used in the test are shown in the chart below.

Client #	Type	PHY	Dual-Band?
Client 1	Samsung S-SM-T230	802.11n 1x1:1	Yes
Client 2	Samsung S-SM-T235	802.11n 2x2:2	Yes
Clients 3-4	Samsung S-SM-T700	802.11ac 2x2:2	Yes
Client 5	Samsung S-SM-T705	802.11ac 2x2:2	Yes
Client 6	Samsung S-SM-T800	802.11ac 1x1:1	Yes
Client 7	Samsung S-SM-T805	802.11ac 1x1:1	Yes
Client 8	Samsung S-SM-N910C	802.11ac 2x2:2	Yes
Client 9	Samsung S-SM-P600	802.11ac 2x2:2	Yes
Clients 10-13	Samsung N8000	802.11n 1x1:1	Yes

Test #1 – 13 Clients Results



The full list of numeric ranking and throughput is shown below.

Ranking	Manufacturer	AP Model	Result (Mbps)
1	Ruckus	R500	213.26
2	Ruckus	R700	187.69
3	Aruba	225	175.00
4	Meraki	MR34	168.19
5	Cisco	3700	162.66
6	Aerohive	330	158.92
7	HP	560	153.48
8	Ruckus	7982	144.87
9	HP	525	141.74
10	Cisco	1700	139.89
11	Ubiquiti	Uni-Fi Pro	130.78
12	Ruckus	7372	126.80
13	Cisco	2700	123.82
14	Aerohive	230	119.52
15	Aerohive	121	108.10
16	HP	430	89.06
17	Ruckus	R300	86.00
18	Xirrus	XR4300	85.58
19	Xirrus	XR520	25.90

Ruckus®
Simply Better Wireless.

CARNet Wi-Fi Independent Test Results

Access Points Comparison

APPENDIX

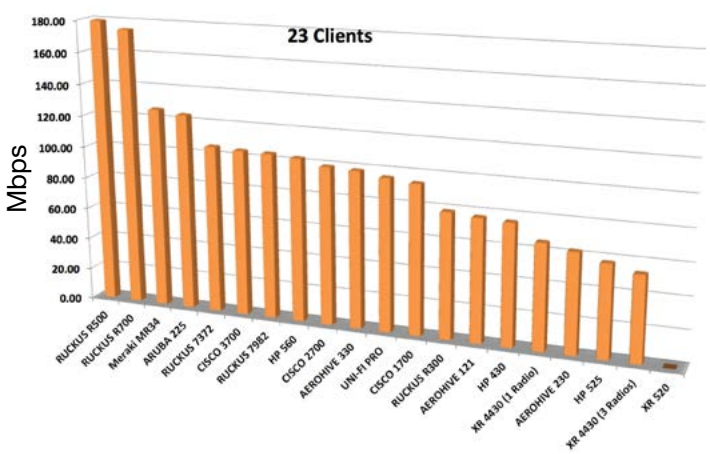
CARNet
CROATIAN ACADEMIC AND RESEARCH NETWORK

Test #2 – 23 Clients Test

The additional clients added for this test are shown in the chart below.

Client #	Type	PHY	Dual-Band?
Client 14	Samsung N8000	802.11n 1x1:1	Yes
Client 15-16	iPad 3	802.11n 1x1:1	Yes
Clients 17-23	HP Pro Tablet 610	802.11n 2x2:2	Yes

Test #2 – 23 Clients Results



The full list of numeric ranking and throughput is shown below.

Ranking	Manufacturer	AP Model	Result (Mbps)
1	Ruckus	R500	179.59
2	Ruckus	R700	174.92
3	Meraki	MR34	126.30
4	Aruba	225	124.09
5	Ruckus	7372	105.73
6	Cisco	3700	104.67
7	Ruckus	7982	104.36
8	HP	560	103.03
9	Cisco	2700	99.41
10	Aerohive	330	98.66
11	Ubiquiti	Uni-Fi Pro	95.94
12	Cisco	1700	94.17
13	Ruckus	R300	78.90
14	Aerohive	121	77.29
15	HP	430	76.27
16	Xirrus	XR4430 (1 radio)	66.15
17	Aerohive	230	62.74
18	HP	525	58.00

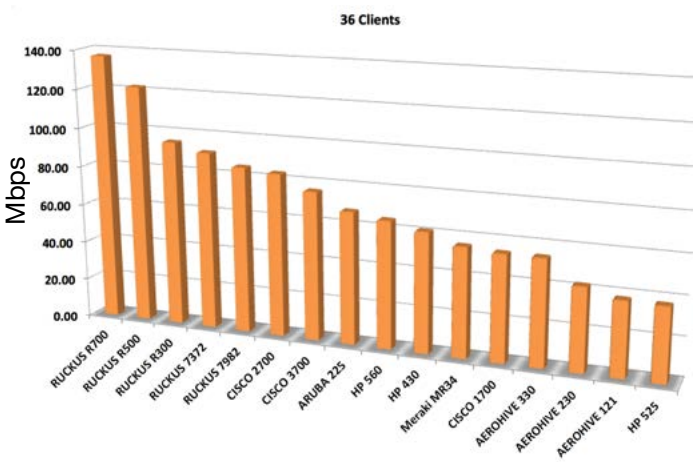
Ruckus®
Simply Better Wireless.

Test #3 – 36 Clients Test

The additional clients added for this test are shown in the chart below.

Client #	Type	PHY	Dual-Band?
Client 24-25	iPad 3	802.11n 1x1:1	Yes
Client 26	iPad 4	802.11n 1x1:1	Yes
Client 27	Samsung N8000	802.11n 1x1:1	Yes
Client 28	MacBook Pro 15" (2011)	802.11n 3x3:3	Yes
Client 29-36	HP Pro Tablet 610	802.11n 2x2:2	Yes

Test #3 – 36 Clients Results



The full list of numeric ranking and throughput is shown below.

Ranking	Manufacturer	AP Model	Result (Mbps)
1	Ruckus	R700	137.00
2	Ruckus	R500	122.16
3	Ruckus	R300	95.24
4	Ruckus	7372	91.27
5	Ruckus	7982	85.23
6	Cisco	2700	83.56
7	Cisco	3700	76.21
8	Aruba	225	67.84
9	HP	560	65.09
10	HP	430	61.43
11	Meraki	MR34	56.00
12	Cisco	1700	54.50
13	Aerohive	330	54.45
14	Aerohive	230	42.68
15	Aerohive	121	38.16
16	HP	525	37.67

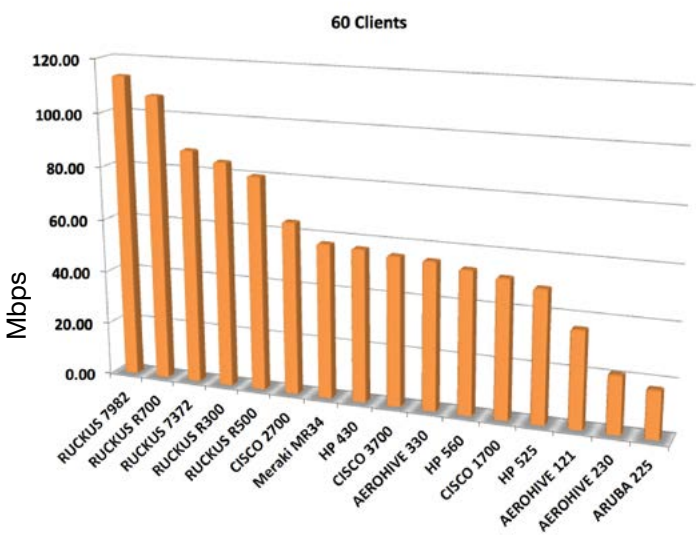
Test #4 – 60 Clients Test

The additional clients added for this test are shown in the chart below

The full list of numeric ranking and throughput is shown below.

Test #4 – 60 Clients Results

Client #	Type	PHY	Dual-Band?
Client 37-46	Lenovo X200 laptop	802.11n 3x3:3	Yes
Client 47-60	Lenovo T400 laptop	802.11n 3x3:3	Yes

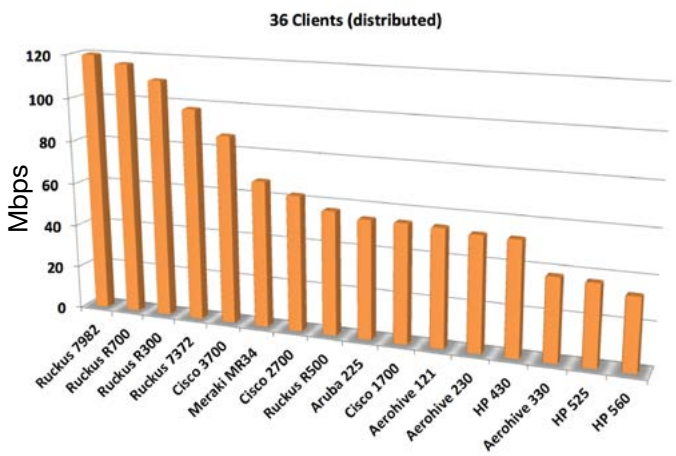


Ranking	Manufacturer	AP Model	Result (Mbps)
1	Ruckus	7982	113.65
2	Ruckus	R700	107.06
3	Ruckus	7372	87.85
4	Ruckus	R300	84.50
5	Ruckus	R500	80.25
6	Cisco	2700	64.48
7	Meraki	MR34	57.70
8	HP	430	57.06
9	Cisco	3700	55.68
10	Aerohive	330	55.17
11	HP	560	53.35
12	Cisco	1700	51.66
13	HP	525	49.28
14	Aerohive	121	36.14
15	Aerohive	230	21.52
16	Aruba	225	17.78

Test #5 – 36 Clients (distributed) Test

The same clients were used for this test as were used with the standard 36 client test. The difference is that the client devices were spread around in a 270 degree arc shape so that APs would have to alternate speaking to clients in various directions.

Test #5 – 36 Clients (distributed) Results



The full list of numeric ranking and throughput is shown below.

Ranking	Manufacturer	AP Model	Result (Mbps)
1	Ruckus	R7982	120.00
2	Ruckus	R700	116.42
3	Ruckus	R300	110.00
4	Ruckus	7372	98.00
5	Cisco	3700	86.95
6	Meraki	MR34	67.76
7	Cisco	2700	62.67
8	Ruckus	R500	57.19
9	Aruba	225	54.91
10	Cisco	1700	54.84
11	Aerohive	121	54.36
12	Aerohive	230	52.85
13	HP	430	52.53
14	Aerohive	330	38.00
15	HP	525	37.30
16	HP	560	33.36

Ruckus Wireless, Inc.
350 West Java Drive
Sunnyvale, CA 94089 USA
(650) 265-4200 Ph \ (408) 738-2065 Fx
www.ruckuswireless.com