TEST REPORT

Tolly.

#216133

July 2016

Commissioned by Linksys, Inc.

Linksys EA9500 Max-Stream AC5400 MU-MIMO Gigabit Router

Comparative Wireless LAN Performance

EXECUTIVE SUMMARY

Busy home networks are now the rule rather than the exception with multiple clients demanding multiple high-bandwidth services - like video streaming - simultaneously. Multi-user MIMO (MU-MIMO) technology can deliver significantly more throughput to multiple users than the prior generation single-user MIMO (SU-MIMO). The Linksys EA9500 Max-Stream AC5400 MU-MIMO Gigabit Router is a dual-purpose home office and entertainment Wi-Fi router.

Linksys, Inc. commissioned Tolly to benchmark the multi-client throughput of the Linksys EA9500 and compare that to the aggregate throughput of several competing tri-band wireless LAN (WLAN) solutions. The Linksys solution can deliver up to 40% greater aggregate throughput than competing solutions. See Figure 1.

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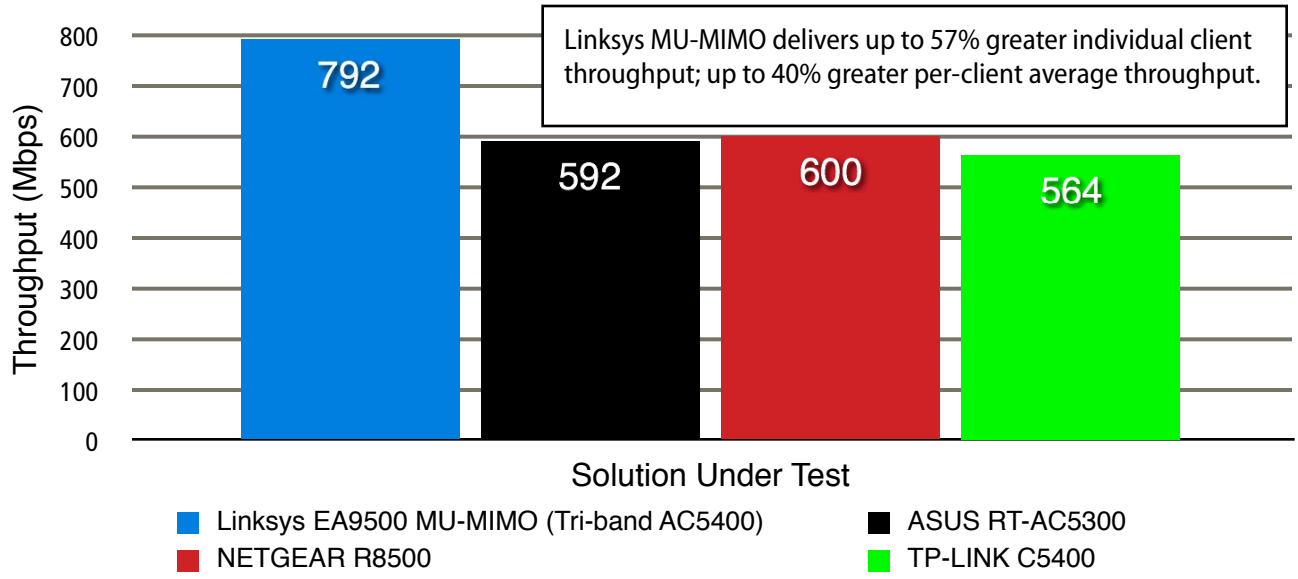
THE BOTTOM LINE

Linksys EA9500 Max-Stream AC5400 MU-MIMO Gigabit Router provides:

1. Up to 40% greater aggregate throughput in line-of-sight tests
2. Up to 57% greater individual client throughput in line-of-sight tests
3. Up to 36% faster per client average client throughput in mixed distance/floors tests

Wireless LAN MU-MIMO Multi-Client Downstream Performance

Four Clients, Line-of-Site Aggregate Performance,
(as reported by Ixia IxChariot v7.10 SP3)



Notes: Tri-band devices provide a single 2.4GHz radio and two 5GHz radios. All testing used 5GHz band. Average of three runs.

Source: Tolly, July 2016

Figure 1

Tests were conducted in a residential environment and benchmarked two different client configurations. All tests were run against three other WLAN 802.11ac solutions running 4x4 MU-MIMO.

In the first test, four clients were situated equidistant (eight feet) from the access point (AP) under test. This scenario illustrates the benefits that MU-MIMO can offer across a group of clients situated at similar distances.

In the second test, four clients were used and only two were near each other with the other two placed at greater distances on another floor of the house. This scenario illustrates performance with more diverse client locations.

Test Results

Multi-Client, Line-of-Sight

The per-client average for the Linksys EA9500 was 198Mbps with the aggregate throughput at 792Mbps. The competing solutions per-client averages were 150Mbps or below. See Figure and Table 1.

Multi-Client, Mixed Distance

This test of four clients in a different set of locations in the residence again showed the benefit of the Linksys solution.

Across the tests, the Linksys solution delivered the highest results for a single client at 192Mbps. This was significantly greater than the 156Mbps of the nearest competitor. See Figure 2.

Linksys, Inc.

EA9500 Max-Stream AC5400 MU-MIMO Gigabit Router

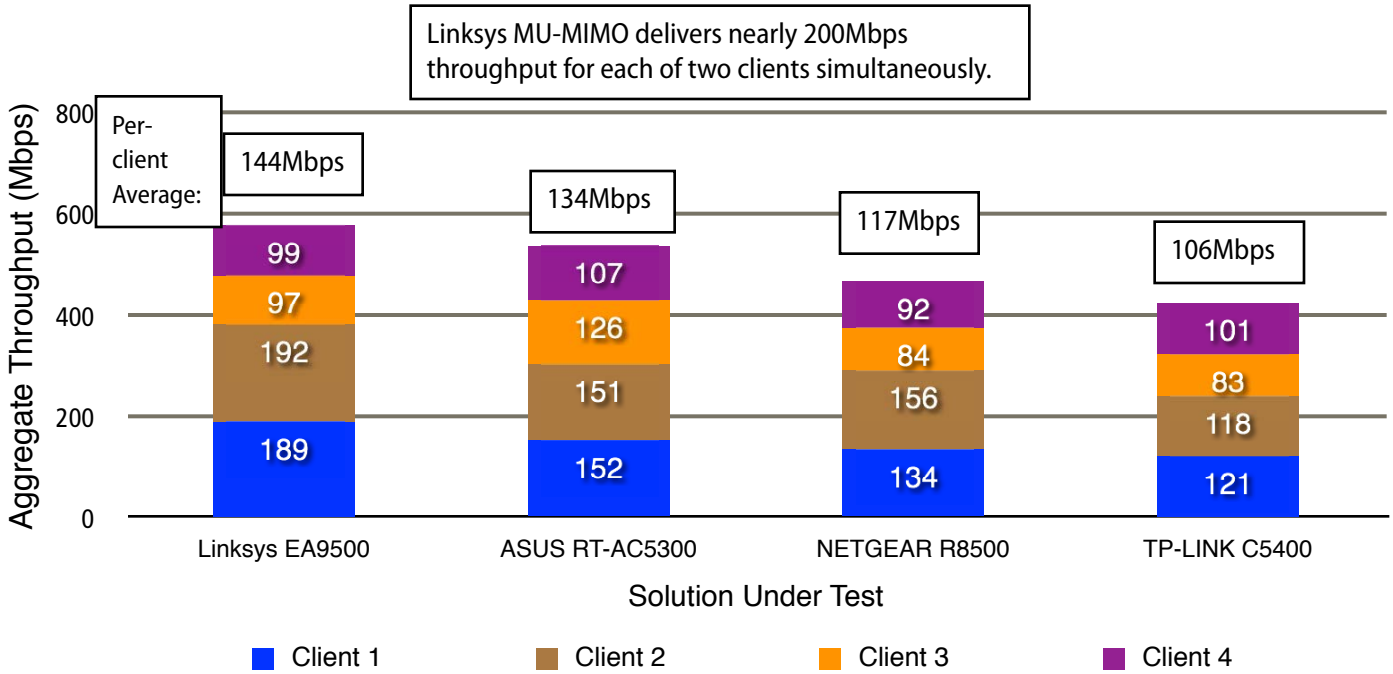
MU-MIMO Wireless LAN Performance

Tested July 2016

Wireless LAN MU-MIMO Multi-Client Downstream Performance

Four Devices, Mixed Distance - Individual Client Performance

(as reported by Ixia IxChariot v7.10 SP3)



Notes: Tri-band devices provide a single 2.4GHz radio and two 5GHz radios. All testing used 5GHz band. Average of three runs. See Test Methodology for AP-to-client distance information.

Source: Tolly, July 2016

Figure 2

Test Setup & Methodology

Objective

The objective of the test was to benchmark the wireless LAN (WLAN) access points (APs) to determine their downstream throughput using MU-MIMO only clients.

Systems Under Test

All systems provided access point functionality and were marketed as commercial grade devices. All devices were upgraded to the most current firmware available at time of test. Wherever possible, SUTs were configured with identical settings with respect to bandwidth, channels, transmit power and security. The SUT was connected to a router via a wired Ethernet connection and Gigabit Ethernet switch. The router provided DHCP addressing services for the test clients and was not used during the test runs. WPA2-PSK security was enabled on each of the systems under test.

All systems were running current firmware. The Linksys EA9500 was running firmware 1.1.5.172212. For additional details about the systems under test and the test clients, see Tables 2 and 3.

Environment & Setup

All testing was conducted using 5GHz.

Four Client - Line of Sight Test

This test used 4 Acer Aspire V3-371-51UJ systems. Two Acer clients were enabled on one 5GHz band and the other two Acer clients were enabled on a second, different 5GHz band. For all test client information see Table 3.

Testing was conducted in a residence with no other WLAN access points enabled in 5GHz band. All testing was line of sight (LOS). SUTs were positioned 8 feet from the clients. All systems used Channel 40 and Channel 153 with a bandwidth on 80.

Clients were situated at the same distance from the AP under test and were situated at table level. The AP under test was placed at approximately two feet above the floor.

Test traffic was generated using the Ixia IxChariot benchmarking system. All testing used the IxChariot High Throughput script. Four WLAN clients running the IxChariot Endpoint software communicated with a single IxChariot Endpoint that was connected via wired Ethernet connection to the test network via the aforementioned Gigabit Ethernet switch. Run time for each test was one minute at each test location. Tests were run at least three times and the average result for each SUT was used. Tolly engineers monitored the AP under test to be certain that all clients were

WLAN MU-MIMO Downstream Throughput Test Result Details

(Data Summarized in Figure 1)

Wireless LAN MU-MIMO Multi-Client Downstream Performance Four Devices, Line-of-Site Aggregate Throughput (as reported by Ixia IxChariot v7.10 SP3)				
	Linksys EA9500 (Tri-band AC5400)	Asus RT-AC5300 (Tri-band AC5300)	NETGEAR R8500 (Tri-band AC5300)	TP-LINK C5400 (Tri-band AC5400)
Client 1	212.80	157.14	161.48	146.60
Client 2	175.86	148.24	145.87	159.53
Client 3	217.70	148.68	152.11	138.59
Client 4	185.64	137.55	140.52	119.43
Per-Client Average	198.00	147.90	150.00	141.03
Total	**792**	**592**	**600**	**564**

Notes: Linksys running MU-MIMO. Tri-band devices provide a single 2.4GHz radio and two 5GHz radios. All testing used 5GHz band. Average of 3 runs.

Source: Tolly, July 2016

Table 1

communicating with the appropriate SSID/ radio being tested.

Four Client - Mixed Distance

For the four client test, which used four Acer Aspire V3-371-51UJ systems, engineers placed two clients in bedroom #1 on the first floor of the home which was 20 feet from the access point. The AP was located on the second floor of the home. The third and fourth clients were located on the same floor (2nd) as the AP through one wall, which was 30 feet from the access point.

Test traffic was generated using the Ixia IxChariot benchmarking system. All testing used the IxChariot High Throughput script. Four WLAN clients running the IxChariot Endpoint software communicated with a single IxChariot Endpoint that was connected via wired Ethernet connection to the test network via the aforementioned Gigabit Ethernet switch. Run time for each test was one minute at each test location. Tests were run at least three times and the average result for each SUT was used. Tolly engineers monitored the AP under test to be certain that four clients were communicating with the appropriate SSID/ radio being tested.

Relative Performance Calculation

To calculate how much better one solution is than another, the formula used is 1- (T1/ T2) where T1 is the better result and T2 is the slower (worse) result. This is multiplied by 100 to give the percentage benefit.

802.11ac Systems Under Test

Vendor	Model	Firmware Version	MIMO Streams	Antenna Location
Linksys, Inc.	EA9500	1.1.5.172212	4x4	8 External
ASUS	RT-AC5300	3.0.0.4.380_3341	4x4	8 External
NETGEAR, Inc.	R8500	1.0.264_1.0.62	4x4	4 External & 4 Internal
TP-LINK Technologies Co. Ltd	C5400	1.0.0	4x4	8 External

Source: Tolly, July 2016 Table 2

Test Equipment Summary

The Tolly Group gratefully acknowledges the providers of test equipment/software used in this project.

Vendor	Product	Web
Ixia	**IxChariot v7.10 SP3 Console & Endpoint & IxChariot Endpoint 9.1**	http://www.ixiacom.com

WLAN Client System Details

Function	Wired Chariot Endpoint & Console	Wireless Chariot Endpoint
Quantity	1	4
Computer Brand	HP	Acer
Model	Envy 17	Aspire V3-371-51UJ
CPU	Intel i7 2630QM	Intel i5 5200U
Operating System	Windows 7	Windows 8.1
LAN/WiFi Card	Ethernet Realtek PCIe GBE Family Controller	WUSB6100M
Driver	7.23.623.2010	11.1.0.49 (4/27/2016)
Chariot Version	Console & Endpoint 7.10 SP3	Endpoint 9.1

Source: Tolly, July 2016 Table 3

About Tolly

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You can reach the company by E-mail at sales@tolly.com, or by telephone at +1 561.391.5610.

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Linksys, Inc.

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Linksys, Inc.
121 Theory
Suite 150
Irvine, CA 92617
USA

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