TEST REPORT

Tolly.

#214135

October 2014

Commissioned by
Samsung Electronics Co., Ltd.

Samsung WLAN vs. Cisco Systems & Aruba Networks

Performance Comparison

EXECUTIVE SUMMARY

Nowadays, it is more evident than ever that wireless communications have become one of the most popular means of personal and business communication. In the enterprise world, communication goes beyond basic email and web browsing into a whole new set of applications such as VoIP, video conferencing, video streaming, and much more.

Wireless LANs (WLANs), solutions based on the IEEE 802.11n/ac standards, have taken over as the prime role of communication service providers and provide unprecedented performance for business networks with WLAN solutions rivaling the gigabit speeds of wired LANs.

Samsung Electronics commissioned Tolly to evaluate the performance of its high-performance 802.11ac WEA403i access point (AP) and compare that to its direct competitors, Cisco Systems (AIR-CAP3702i) and Aruba Networks (AP 225).

The following three scenarios reflecting the characteristics of real, high-client-density office environments were tested:

THE BOTTOM LINE

Samsung WEA403i 802.11ac access point:

1. Delivered 40% greater throughput than Cisco Systems AIR-CAP3702i and 20% greater throughput than Aruba Networks AP 225 in heterogeneous environment
2. Guaranteed optimal voice performance up to 20 calls with simultaneous data traffic while Cisco and Aruba supported 10 and 14 respectively in the same test scenario
3. Neutralized the effect of environment obstacles and multipath providing robust services to all clients in the network

1. Client Throughput in a Heterogeneous Environment: Typical offices are heterogeneous environments, where the newest Wi-Fi devices (i.e. 802.11ac) share the network resources with old legacy ones (i.e., 802.11n). The test aim was to illustrate how Samsung APs provide fair resource distribution optimizing the use of network resources with its AirEqualizer technology. In tests of various client combinations, the Samsung solution delivered greater total AP throughput than either of the competing solutions. See Figure 1.

2. Real-Time Traffic (Voice) Quality in a Wireless Environment: A voice-centric scenario simulates an office where voice traffic is predominant and coexists with best effort data traffic. The goal was to demonstrate how Samsung APs guarantee optimal quality of service (QoS) for voice traffic supporting simultaneous data traffic as well. Samsung maintained excellent voice quality with 20 simultaneous calls, whereas Cisco and Aruba voice quality dropped below excellent from more than 10 and 14 calls respectively. See Figure 2.

3. Smart Antenna Performance: This test aimed to illustrate how Samsung APs guaranteed optimal performance regardless of the client position within the network by using its smart antenna technology. At certain test points, Cisco and Aruba clients' performance dropped significantly and even got disconnected while Samsung AP was able to automatically change the antenna pattern to recover the performance drop and always maintained good performance.

Test Results

Client Throughput in a Heterogeneous Environment

In enterprise networks, different devices from different vendors and models coexist sharing the same wireless resources. This test consisted of data traffic (TCP) being transmitted from one active AP to the clients associated to it, sharing the network resources. In the test, the throughput of each client was measured with respect to the client type as well as the total throughput achieved by the AP.

Samsung WEA403i outperformed the competing solutions in total throughput in all test cases with the AirEqualizer technology.

AirEqualizer technology from Samsung guarantees a fair distribution of the network air time resources and prevents slow clients from occupying the majority of the airtime with their transmissions. As a result, each client type obtains the same amount of airtime to transmit and achieves a throughput performance according to its abilities (maximum transmission rate and number of antennas).

The results from two test cases (different combination of clients) are shown in Figure 1 as an example. Samsung's AP served each client type to the best of its capabilities, giving higher throughput to the newer and faster devices. Aruba Networks' AP225 also supports air time fairness. But the overall performance was lower than Samsung and it was highly susceptible to the number of associated clients. Meanwhile, Cisco Systems' 3702i AP showed no fairness in the resource distribution and consequently the overall throughput obtained was considerably degraded. For example, the new 802.11ac 3x3 clients performed worse than the legacy 802.11n 2x2 and 802.11n 3x3 clients with the Cisco solution. To conclude, Samsung AP achieved 40% greater total throughput than Cisco and 20% greater total throughput than Aruba.

Also, by analyzing all other tested client combinations, Tolly engineers verified that Samsung AP could always support airtime

Samsung Electronics Co., Ltd.

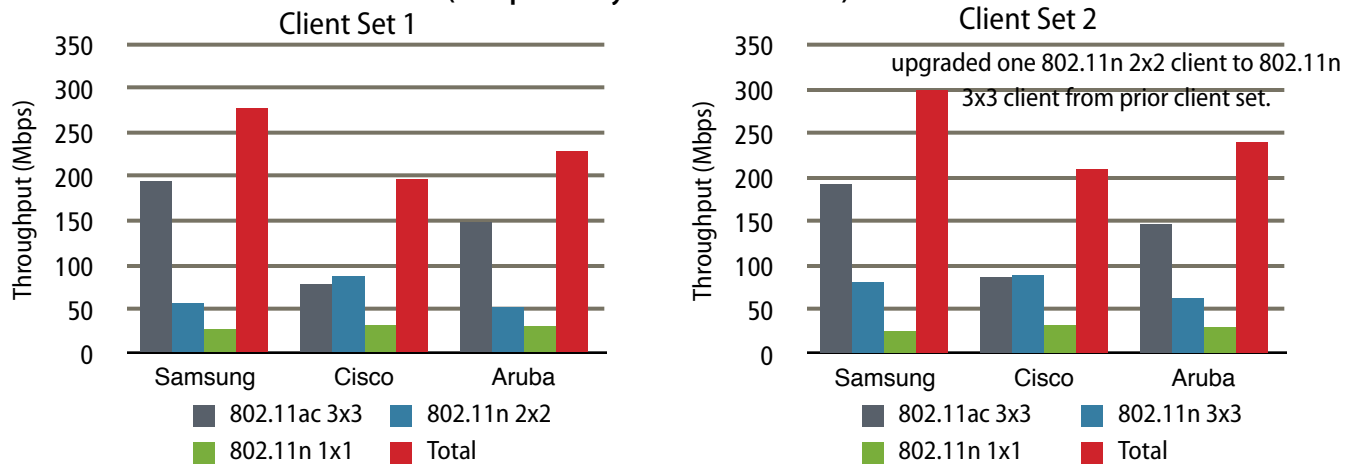
WEA403i 802.11ac Access Point Performance

Tested August 2014

Client Throughput in Heterogeneous Environment

802.11ac AP, channel 36, 80MHz channel width, downstream

(as reported by Ixia IxChariot 6.70)



Notes: Samsung supports airtime fairness. Each client type obtained the same amount of airtime to transmit and achieved a throughput performance according to its ability (maximum transmission rate). Aruba also supports airtime fairness. But the overall performance was not as good as Samsung. Engineers did not find the equivalent feature for Cisco. As a result, with Cisco, the new and more expensive 802.11ac 3x3 client performed worse than the legacy 802.11n 2x2 client in the left figure and worse than the legacy 802.11n 3x3 client in the right figure.

Source: Tolly, August 2014

Figure 1

fairness to each client. So while the number of active clients keeps the same, the airtime for each client is the same. As a result, when users upgrade their clients, they could get guaranteed improved performance while not degrading other users' client performance.

Real-Time Traffic (Voice) Quality in a Wireless Environment

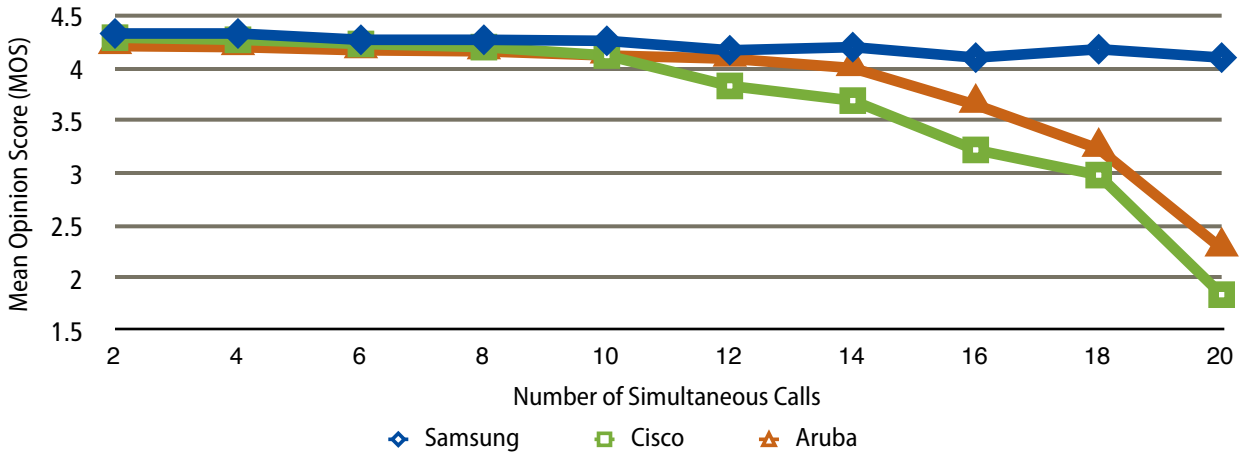
The combination of voice and WLAN represents a very promising approach for voice communication in the enterprise. Real-time traffic optimized WLANs allow businesses to enjoy wireless broadband phone services at a considerably reduced cost. One of the most important issues when designing an enterprise WLAN with voice traffic is the call capacity and the optimal user experience, in other words, the number of simultaneous voice connections that can be supported by the WLAN with satisfactory QoS.

In the test, with the Network Controlled Voice Optimization algorithm, Samsung WEA403i AP provided optimal service for the voice clients while still being able to support other data traffic in the network. The Mean Opinion Score (MOS), which represent the quality of the calls perceived by the users, were monitored as the number of call increased. To guarantee optimal voice experience for the user, a minimum of 4.0 MOS is set classify the calls as satisfactory.

Figure 2 summarizes the test results of an office scenario where the network resources of the active AP have to support simultaneous calls and downlink traffic to 6 data clients (802.11n:1x1, 2x2, 3x3; 802.11ac:1x1, 2x2, 3x3). Samsung WEA403i AP was capable of providing optimal voice performance with a MOS above 4 for up to 20 calls, whereas Cisco Systems and Aruba networks only managed to support up to 10 and 14 simultaneous calls respectively.

Also, the capability of the AP of supporting simultaneous lower priority TCP data of three vendors was almost same. As a result, the Samsung WEA403i was able to guarantee satisfactory quality for the voice clients as well as support the clients with lower priority data traffic and provide the same level of throughput than the

Voice Quality vs. Total Number of Calls
802.11ac AP, channel 36, 20MHz channel width, bidirectional RTP traffic, G.711µ codec
(as reported by Ixia IxChariot 6.70)



Notes: Real-time traffic (voice) optimization features were enabled for each AP under test. Six clients (802.11n 1x1, 2x2, 3x3, and 802.11ac 1x1, 2x2, 3x3) were used to run data traffic with TCP scripts in IxChariot to provide the background traffic. 20 Samsung Galaxy S3 were used as the Voice over IP (VoIP) clients. Average Mean Opinion Score (MOS) was reported by Ixia for each VoIP call (one call per client). The worst call's average MOS is reported here. For example, with 20 wireless clients making VoIP calls, all 20 calls' MOS were above 4 with the Samsung AP while the MOS of some calls dropped to below 2.5 with the Cisco and Aruba APs. MOS above 4 is considered to be excellent.

Source: Tolly, August 2014

Figure 2

competitors solutions, guaranteeing a fair distribution of the network resources.

Smart Antenna Performance

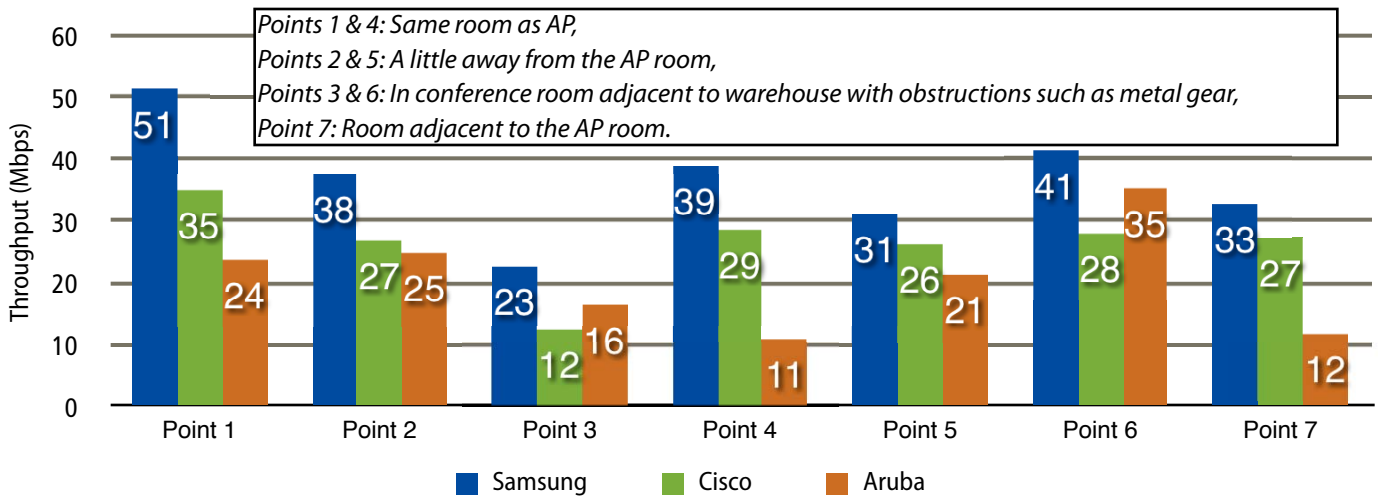
The Samsung WEA403i AP was able to provide satisfactory services to its clients regardless of their position using Samsung's smart antenna technology. Samsung WEA403i AP has six 2.4GHz antennas and six 5GHz antennas (the device selects three 2.4GHz antennas and three 5GHz antennas to use at a time). Samsung's smart antenna technology is able to optimize the antenna pattern according to the location of the client to:

- Deliver higher throughput to clients located in the network boundaries.
- Dynamically choose the optimal antenna pattern and overcome the negative effects of multipath in the office environment that causes signal reflection and refraction on walls, objects, other obstacles and even people inside the building. Multipath can have a destructive effect leading to erroneous reception of the wireless signals. However the Samsung AP is able to overcome this phenomenon by dynamically choosing the optimal antenna pattern.

Figure 3 shows the results of the tests carried out in a real office environment using a channel bandwidth of 20MHz. Samsung's efforts to provide satisfactory service to all clients in a high-client-density office environment were illustrated by selecting points within the office environment served by an active AP and measuring the downlink throughput to each client. When this phenomenon occurs, the throughput obtained by the client drops drastically making data transmission very slow or even impossible in some cases. Points 4 and 7 illustrate Aruba's AP 225 deficiencies in protecting the client against wireless signal degradation that hinders data communication. At some points, Cisco's and Aruba's deficiencies were so significant that clients got momentarily disconnected from the network. Unlike its competitors, Samsung's smart antenna solution was able to counteract the effect of environment obstacles and multipath providing robust services to all the clients in the network.

With the Aruba AP, engineers could easily find points where the client throughput dropped significantly and could not recover.

Performance for Various Locations - Samsung Smart Antenna Tests
802.11ac AP, channel 36, 20MHz channel bandwidth
(as reported by Ixia IxChariot 6.70)



Notes: 1. Apple iPhone 5s and Samsung Galaxy S3 (802.11n 1x1) were used as the clients.
2. Samsung WEA403i AP has six 2.4GHz antenna and six 5GHz antenna. The smart antenna technology automatically chooses the antennas to use and the transmission pattern in order provide better performance for the clients. During the tests, there were certain points that Cisco and Aruba clients' throughput dropped significantly and even got disconnected while Samsung clients were able to recover to good performance.

Source: Tolly, August 2014 Figure 3

With the Cisco AP, the client throughput was overall stable. But there were still certain points that the client throughput dropped significantly and could not recover.

With the Samsung AP, there were also certain points that the client throughput dropped. But the throughput was recovered to normal after a short time with Samsung's smart antenna technology.

Test Environment and Methodology

Each AP under test used the same configuration across all tests. Configuration with: frequency - 5GHz, channel - 36, Tx power - 17dBm, local bridge - on, country - Korea (KR) was used for all APs. For Samsung, the AirEqualizer, real-time traffic (voice) optimization, and Smart Antenna features were enabled. For Cisco, the real-time traffic (voice) optimization feature was enabled. For Aruba, the Fairness feature, high throughput (radio) and very high throughput (radio) were checked.

Engineers verified that there was no other wireless APs running on the same channel during the test.

Each client was running Ixia IxChariot 7.30 performance endpoint (SP1 build 32 with the exception of SP2 build 75 for iPhone 5s). One laptop was used to run Ixia IxChariot 6.70 server and connected to the network with one GbE port.

Each test was run with 3 iterations. Each iteration was with 3 minutes. The average results of the 3 iterations were reported here.

See Table 2 for the solutions under test. See Table 3 for the clients under test.

Client Throughput in a Heterogeneous Environment (Airtime Fairness)

The client tests were carried out in a 50 square meters empty room. All clients were put on desks and were about 5 meters away from the AP under test.

APs from each vendor (Samsung WEA403i, Aruba AP 225 and Cisco Air-CAP3702i) were placed at the exact same location. Only one of the solutions was mounted to the ceiling at a time and serving all the active clients. Channel bandwidth 80MHz was used for the test.

Two Apple Macbook Pros (802.11ac 3x3), two Samsung Galaxy S5 smartphones (802.11ac 2x2), two Dell laptops (802.11n 3x3), two Samsung laptops (802.11n 2x2), and two iPhone 5C smartphones (802.11n 1x1) were used as the clients under test. TCP traffic was generated to pass from the AP to the clients using 10 sessions of high performance TCP traffic from IxChariot.

The Aruba AP did not perform well when only the clients under test were associated with it. Engineers associated another 29 idle clients to each AP under test, but no test traffic was sent to any of the idle clients.

The results for two client combinations were reported here.

1. Two 802.11ac: 3x3, two 802.11n 3x3 and two 802.11n 1x1 clients;
2. Two 802.11ac: 3x3, two 802.11n 2x2 and two 802.11n 1x1 clients.

Other combinations in the test showed similar results.

Real-Time Traffic (Voice) Quality in a Wireless Environment

The real-time traffic (voice) optimization tests were carried out at the same location as the airtime fairness tests. One AP was mounted to the ceiling in a large empty room at a time. Channel bandwidth 20MHz was used for the test.

20 Galaxy S3 phones were used as the VoIP clients under test.

One Macbook Pro (802.11ac 3x3), one Samsung Galaxy S5 smartphone (802.11ac 2x2), one Samsung Galaxy S4 smartphone (802.11ac 1x1), one Dell laptop (802.11n 3x3), one Samsung laptop (802.11n 2x2) and one Samsung Galaxy S3 smartphone (802.11n 1x1) were used as the data clients under test to pass TCP data traffic. Another seven Galaxy S4 (802.11ac) clients were associated to the SSID but without passing any test traffic.

The performance of the enterprise WLAN is assessed with the Mean Opinion Score (MOS) of the calls. The MOS value ranges from 4.5 (optimal level) and below. We

Test Equipment Summary

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

Vendor	Product	Web
Ixia	**IxChariot Server 6.70** **IxChariot Client 7.30 SP1/SP2**	http://www.ixiacom.com

Detailed Test Results

Test 1 - Client Throughput in a Heterogeneous Environment

	Client Set 1				Client Set 2			
	Client Throughput (Mbps)			Total (Mbps)	Client Throughput (Mbps)			Total (Mbps)
	802.11ac 3x3	802.11n 2x2	802.11n 1x1		802.11ac 3x3	802.11n 3x3	802.11n 1x1	
Samsung	194.7	56.1	26.6	277.4	191.8	80.8	26.0	298.6
Cisco	78.4	86.9	31.9	197.2	86.9	89.2	32.6	208.7
Aruba	147.7	51.3	30.0	229	147.1	63.0	30.1	240.2

Test 2 - Real-Time Traffic (Voice) Quality in a Wireless Environment

	Worst Call's Average Mean Opinion Score (MOS) for Simultaneous 3 Minute VoIP calls (MOS > 4 is excellent)									
Number of Simultaneous Calls	2	4	6	8	10	12	14	16	18	20
Samsung	4.33	4.33	4.27	4.27	4.26	4.17	4.2	4.1	4.18	4.1
Cisco	4.29	4.27	4.23	4.2	4.12	3.83	3.69	3.22	2.98	1.84
Aruba	4.21	4.2	4.17	4.16	4.12	4.09	4.0	3.65	3.23	2.28

Test 3 - Smart Antenna Performance

	iPhone 5s Throughput (Mbps)			Samsung Galaxy S3 Throughput (Mbps)			
Points	1	2	3	4	5	6	7
Samsung	51.3	37.6	22.6	38.9	31.1	41.4	32.8
Cisco	35	26.8	12.4	28.6	26.2	28	27.3
Aruba	23.7	24.8	16.4	10.9	21.3	35.3	11.7

Source: Tolly, August 2014

Table 1

consider a value of 4.0 to be the minimum acceptable QoS for an enterprise WLANs.

Ten TCP sessions were made from a server in wired network to each data client using IxChariot traffic generator (downlink traffic).

A VoIP session was made from a server in wired network to each wireless VoIP client using IxChariot. G.711µ was used as the codec. Each VoIP session has bidirectional RTP traffic as the voice traffic.

Test cases for each AP under test: 10 cases (N= 2, 4, …, 20) adding 2 voice clients at a time.

When there were failures for the RTP sessions due to any reason, engineers rebooted all devices to repeat the test run. For Cisco with 20 wireless VoIP clients, there was always at least one RTP session failure after 10 tries.

WLAN Solutions Under Test

Vendor	Controller/Access Point	Firmware Version
Samsung Electronics Co., Ltd	WEC8500 WLAN Controller	2.2.11.R
	WEA403i Access Point	
Cisco Systems, Inc.	5500 Wireless Controller	7.6.110.0
	Air-CAP-3702i-K-K9	
Aruba Networks, Inc.	3600 Mobility Controller	6.3.1.5_43118
	AP-225	

Source: Tolly, August 2014 Table 2

Smart Antenna Performance Test

The smart antenna tests took place in a different location where the APs were mounted to the ceiling side by side. The performance of the clients located in specific points was measured within a real office environment. Figure 4 shows the layout of the office environment as well as the client locations in the test. The measuring points, where the clients were located are marked from 1-7.

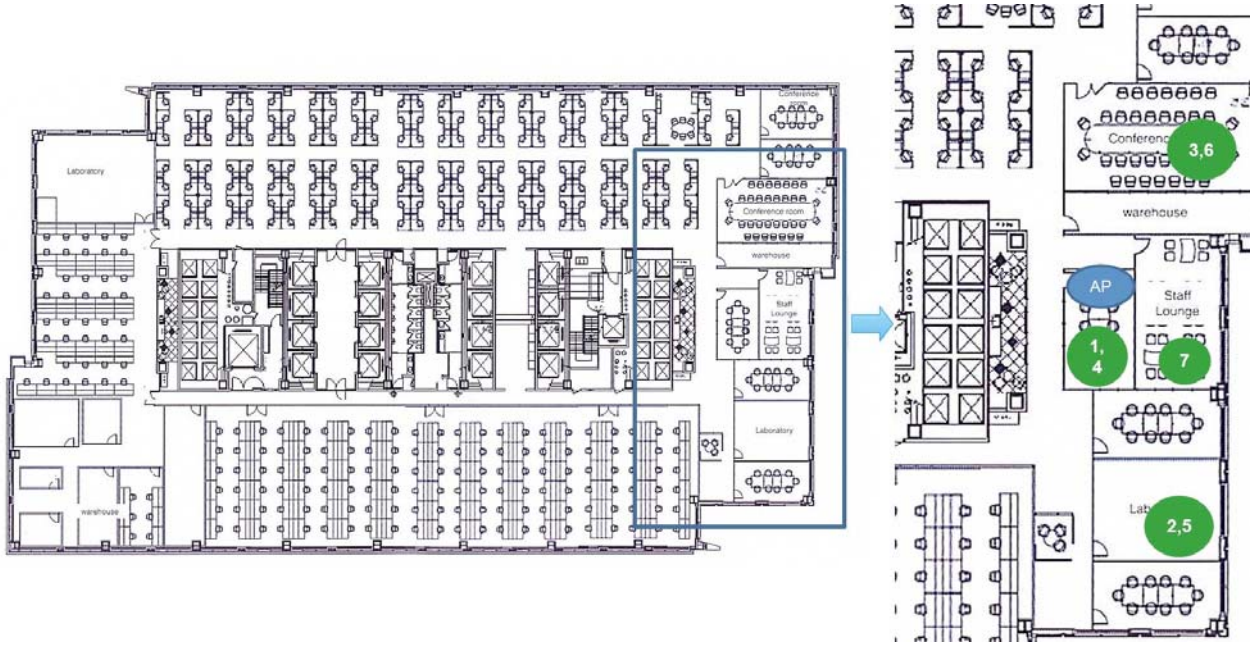
One iPhone 5s (802.11n 1x1) was used at points 1 to 3. One Samsung Galaxy S3 (802.11n 1x1) was used at points 4 to 7. Seven idle Galaxy S4 smartphones were connected to the AP under test first without passing test traffic. The clients under test were taped on the table for a fair comparison.

WLAN Clients Under Test

Type	Vendor	Model	Configuration	Wi-Fi module	Quantity
Laptop	Samsung Electronics	200B	Intel Core i5-2430 CPU @ 2.40GHz Windows 7 Enterprise K	Intel Centrino Advanced-N 6230 802.11n (2x2)	2
Laptop	Dell Inc.	E6530	Intel Core i5-3320M CPU @2.60GHz Windows 7 Enterprise K	Intel Centrino Ultimate-N 6300AGN 802.11n (3x3)	2
Laptop	Apple Inc.	MacBook Pro with Retina Display	Intel Core i7 2GHz OS X 10.9.2	Airport Extreme - Broadcom BCM 43xx 1.0 6.30.223.154.63 (802.11ac (3x3))	2
Smartphone	Samsung Electronics	Galaxy S3	Android 4.3	802.11n (1x1)	20
Smartphone	Samsung Electronics	Galaxy S4	Android 4.4.2	802.11ac (1x1)	12
Smartphone	Samsung Electronics	Galaxy S5	Android 4.4.2	802.11ac (2x2)	2
Smartphone	Apple Inc.	iPhone 5c	iOS 7.1.1	802.11n (1x1)	2
Smartphone	Apple Inc.	iPhone 5s	iOS 7.1.2	802.11n (1x1)	3

Source: Tolly, August 2014 Table 3

Smart Antenna Performance Test Environment

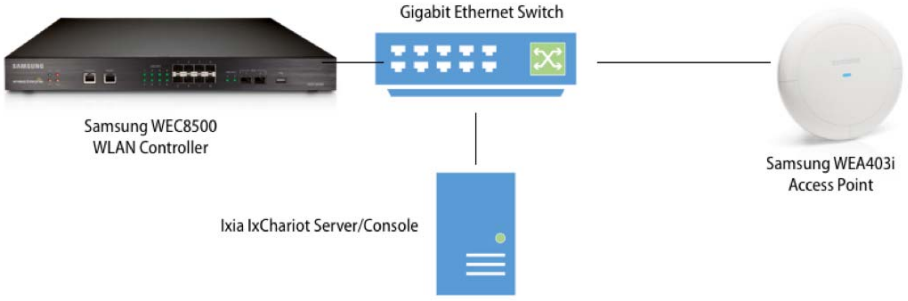


Notes: Layout on the left shows the whole floor of the office environment. Layout on the right shows the test area with multiple conference rooms. Samsung, Aruba and Cisco APs were mounted on the ceiling side by side. Only one AP was active during any test. No other APs were running on the same band during all tests. Test were run at off work hours without people walking by. One client was taped on the desk at each point for fair comparison. The points marked here shows the approximate locations of the clients. For example, points 1 and 4 are in the same room as the APs but they are not actually on the exact same point.

Source: Tolly, August 2014

Figure 4

Test Network Topology



Note: Shown with Samsung solution. Same test environment used for other solutions.

Source: Tolly, August 2014

Figure 5

About Tolly

The Tolly Group companies have been delivering world-class IT services for more than 25 years. Tolly is a leading global provider of third-party validation services for vendors of IT products, components and services.

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About Samsung Electronics

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