



**WI-FI PERFORMANCE  
BENCHMARK TESTING:**  
Aruba Networks AP-135 and  
Cisco AP3602i

Conducted at Aruba Proof of Concept (PoC) Lab  
June 2012



## Statement of test result confidence

- Aruba makes every attempt to optimize all vendors for performance and follow best practices for configuration as published by the vendor.
- Aruba makes every attempt to make a fair and apples-to-apples comparison, including AP mounting position, client location, transmit power, channel and the latest shipping firmware.
- Aruba ensures the test bed environment to be free of any interference sources. Also, the 802.11 Wi-Fi channels configured are ensured to be consistent when testing 2.4 GHz and 5 GHz bands for all vendors.
- Aruba believes the test results are both repeatable and reproducible in similar testing environments.

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## Executive Summary

The Aruba Networks proof-of-concept lab is a clean RF environment dedicated to showcasing complex networking solutions in a real world setup. Aruba customers, partners and prospects rely on the lab to validate interoperability with other vendors' products as well as test uncommon deployment scenarios. The lab is also fully equipped to conduct feature and performance benchmark testing for customer evaluations.

This report focuses on performance and functionality testing to compare and benchmark Wi-Fi solutions using Aruba AP-135 access point and the Cisco AP3602i access point. The results from the tests are summarized in Table 1 below and explained in detail in the report.

**Table 1**                      **Test Results Summary**

	Test Case	Aruba	Cisco	Aruba Advantage
TCP throughput	Download	219	194	13%
	Upload	224	202	11%
	Vertical orientation of tablet	16	8	50%
	Beamforming - Cisco ClientLink On / ClientLink Off)	N/A	66 / 71	N/A
Video density	Max number of laptops – 2 Mbps Video	51	44	16%
	Max number of laptops – 5 Mbps video	39	31	25%
	Max number of iPads - 1 Mbps video	21	16	31%
Wi-Fi client density	Video performance with mixed clients types	Pass	Fail	N/A
Battery Drain	Percentage batter drain	6 %	6 %	N/A

The test results indicate a significant variation in performance between Aruba and Cisco Wi-Fi products. Customers are advised to exercise their own judgment before making a vendor decision for their Wi-Fi network. The rest of the document provides comprehensive details of the test cases, test bed setup, observations and results collected. Detailed configuration for both vendors is also included in the appendix for easy reference.

## Test Environment

**Table 2**      **Devices under test**

Vendor	Device	Firmware version
Aruba	AP-135	AOS 6.1.3.2
	Mobility Controller 3600	AOS 6.1.3.2
Cisco	3602i	7.2.103.0
	5508 controller	7.2.103.0

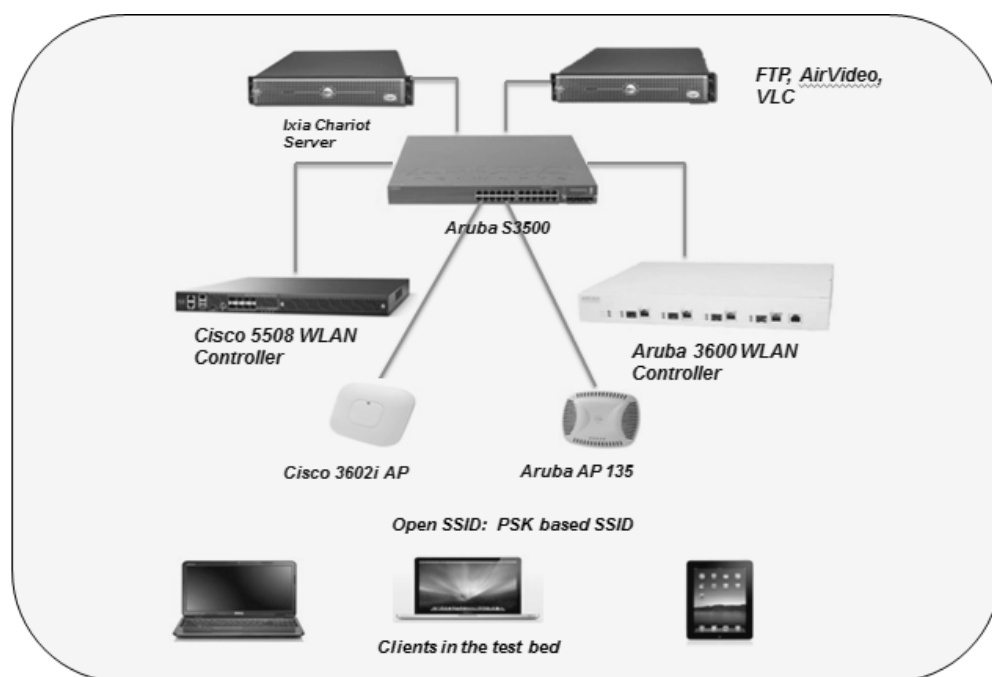
The following table shows the detailed information on various network components that were part of the infrastructure used for performance tests.

**Table 3**      **Test equipment used**

Item	Component	Specifications	Details
1	Wi-Fi devices	Laptops	<ul style="list-style-type: none"> <li>MacBook Pro (13)</li> <li>Dell with Intel 6300 chipset (47)</li> <li>Dell with Intel 4905 chipset (10)</li> </ul>
		Tablets	iPad 2
		Bonjour services	Apple TV
2	Test tools	Performance Evaluation Software	<ul style="list-style-type: none"> <li>IxChariot</li> <li>VLC media server</li> <li>Air Video server</li> </ul>
3	Switch	Type	Aruba Mobility Access Switch S3500-48P
4	AP mounting type	Type	Ceiling

### Test Bed Setup

Figure 1 below shows the logical network topology of the test bed. All networking components were connected at Layer 2 using the Aruba S3500 Mobility Access Switch. The switch performed DHCP services providing IP addresses to devices connected to either the Cisco or Aruba setup.



*Figure 1: Test Bed Setup*

The controller configuration is included in the appendix for reference.

## Real World Test Scenarios

Based on customer demand, the following real-world scenarios were tested in the proof-of-concept lab for benchmarking.

1. TCP throughput – Determine the maximum throughput for the device at varying distances from the Access Point (AP)
2. Video density – Determine maximum number of laptops and iPads without compromising HD video quality for varying video rates
  - 2 Mbps multicast live HD video stream
  - 5 Mbps multicast live HD video stream
  - 1 Mbps unicast live HD video stream over iPad
3. Wi-Fi client density – Determine video performance with a wide mix of clients supporting speeds from 11 Mbps to 450 Mbps
  - Mixed traffic, mixed client density test
4. Battery drain test – Determine impact on battery life while downloading large files
  - Test both a Laptop and an iPad

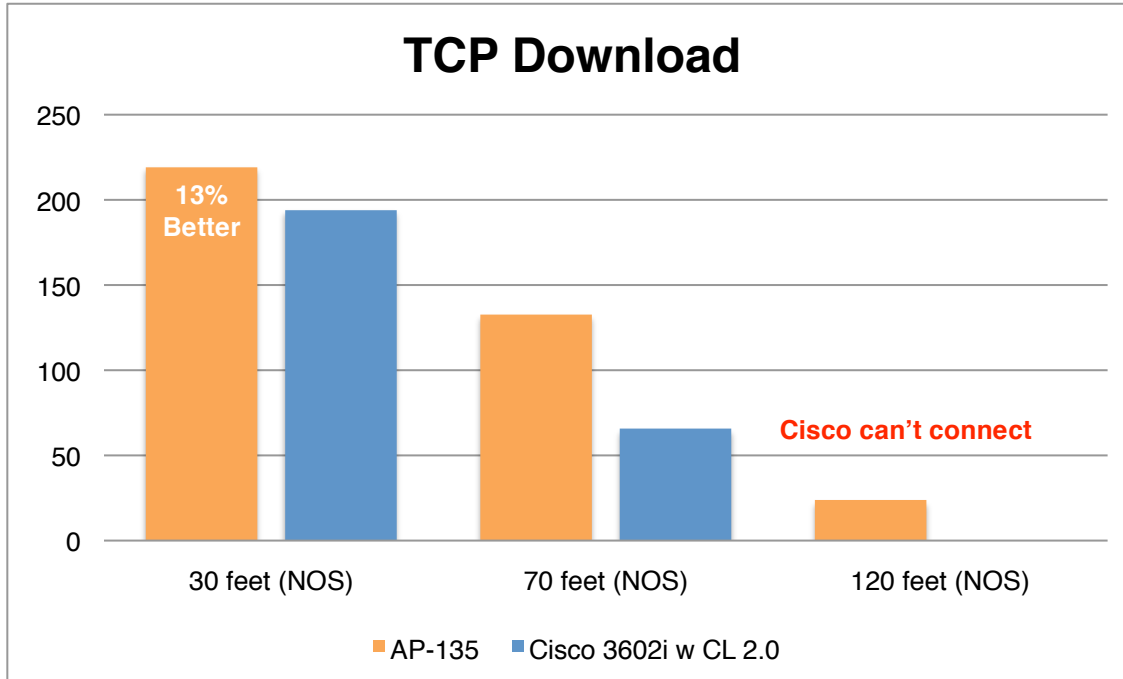
### 1. TCP throughput

The throughput tests were performed to understand how the distance of a client from the AP affects the client's performance. It is expected that the performance of the client will degrade as it moves away from the access point. MIMO effects also impact the throughput along with the channel model for the specific environment used for the test. In the actual test, a single client was tested for maximum throughput at three different non-line of site (NOS) locations: 30 feet, 70 feet and 120 feet from the AP. This was done to measure the benefits of ClientLink 2.0, if any, and compare the benefits of 4x4 MIMO vs. 3x3 MIMO at difficult-to-reach locations. TCP download traffic was used to highlight ability of the AP to transmit effectively to the client, and upload traffic was used to highlight the receive sensitivity of the AP. Additionally, client orientation was tested with a tablet (iPad), and the benefit of ClientLink 2.0 was isolated when enabled and disabled for Cisco.

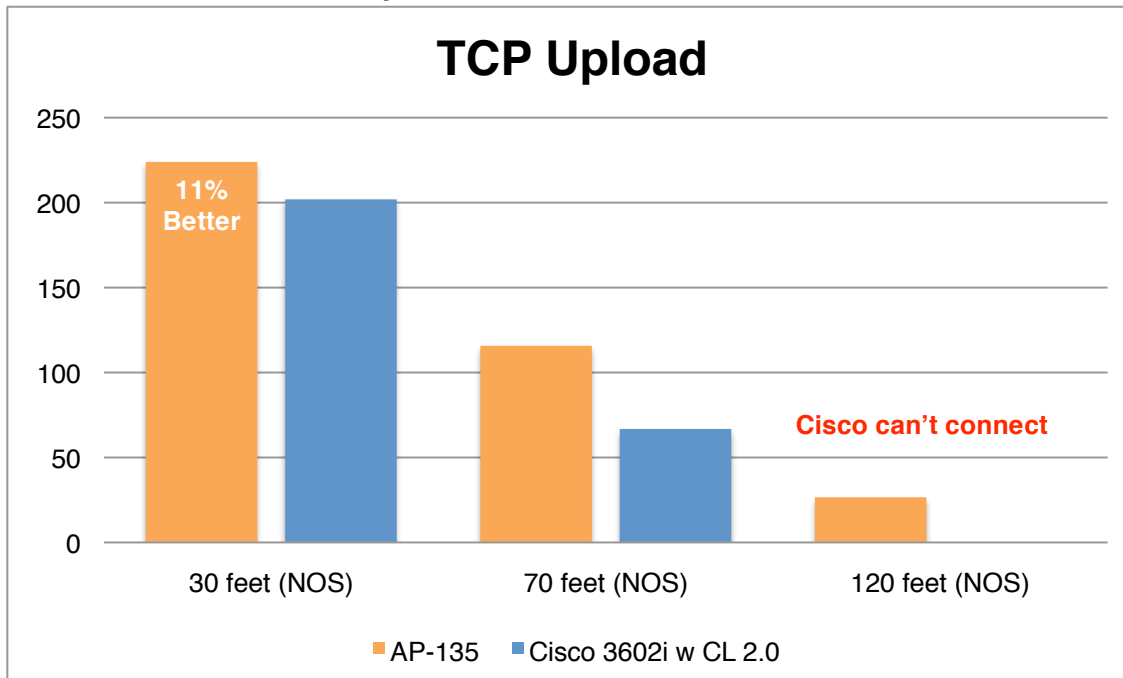
**Table 4 TCP throughput test setup**

Clients used for testing	Apple MacBook Pro (1) (3x3:3, 450 Mbps)
Tools used for testing	Ixia Chariot, throughput script
AP operation mode	5-GHz radio, same 40-MHz wide channel used for Aruba and Cisco

**Chart 1** TCP download

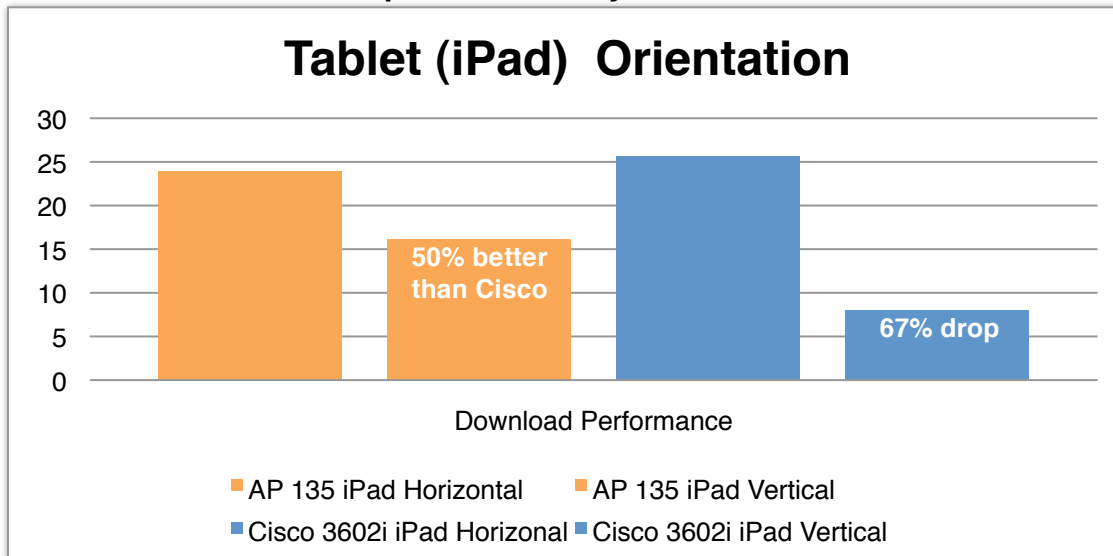


**Chart 2** TCP upload

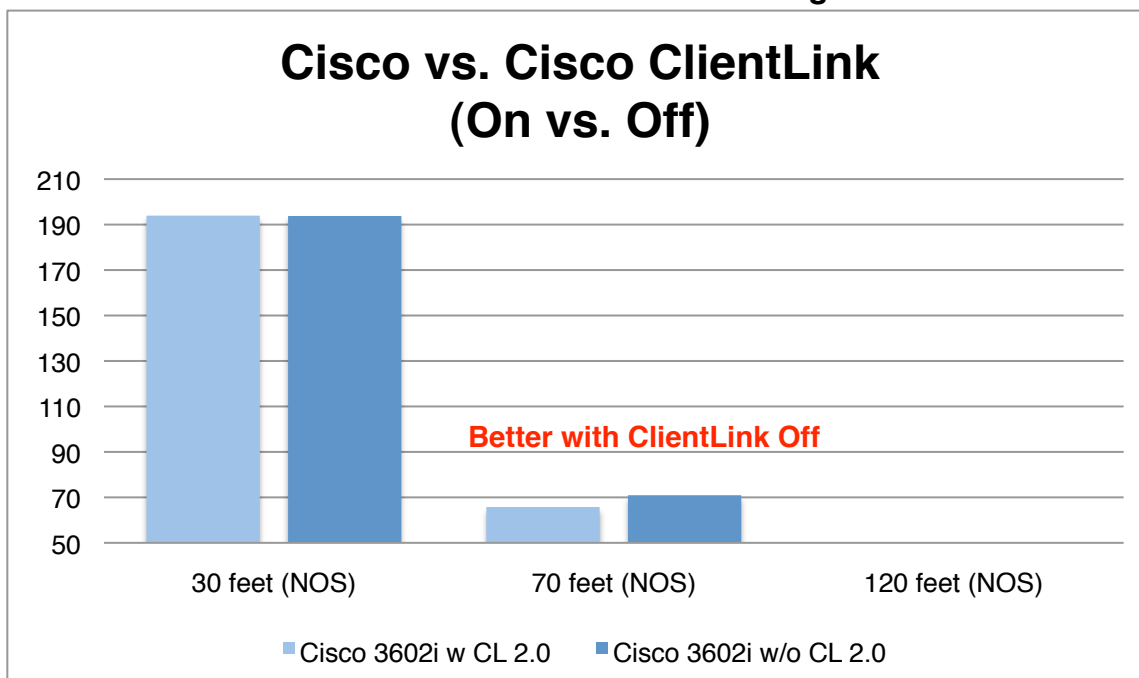




**Chart 3 Tablet performance by orientation**



**Chart 4 Cisco ClientLink 2.0 / Beamforming on and off**



### TCP throughput results summary

The tests demonstrate that the Aruba AP-135 performs better than the Cisco AP3602i. The AP-135 with 3x3 MIMO has a superior design and outperforms the pricier Cisco AP3600. Also Cisco's proprietary ClientLink 2.0 beamforming technology and 4x4 MIMO add little to no value for mobile clients, and in fact the Mac Book Pro laptop is *unable to connect* to the AP3602i at distances greater than 100 feet. The testing also showed that ClientLink 2.0 causes the throughput for the iPad to drop by 67% when orientation is changed from horizontal to vertical, and the throughput at 70' for a Macbook Pro was *better when ClientLink 2.0 was disabled*.

## 2. Video density tests for 2 Mbps and 5 Mbps multicast HD video stream

For the laptop density test, 2 Mbps and 5Mbps HD video streams were multicast from the VLC server (one at a time). Devices were added to the network one at a time till the picture quality started to degrade due to the load on the network.

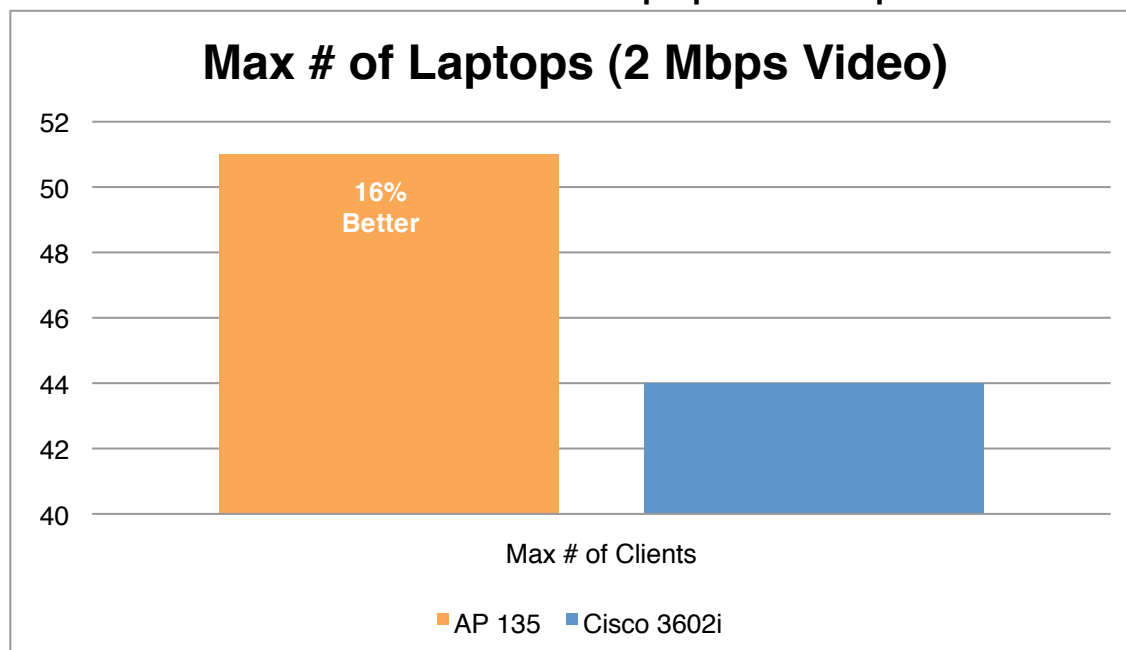
For the iPad density test, a 1 Mbps TCP HD video was streamed from the Air Video server to Air Video clients installed on iPads. Initially, only one iPad was added onto the network, which was streaming 1 Mbps video while mirroring its screen to an Apple TV using AirPlay. Then more iPads were added to the network one at a time, until either video freezes were observed or the connection to Apple TV was lost.

**Table 5 Maximum number of video streams test setup**

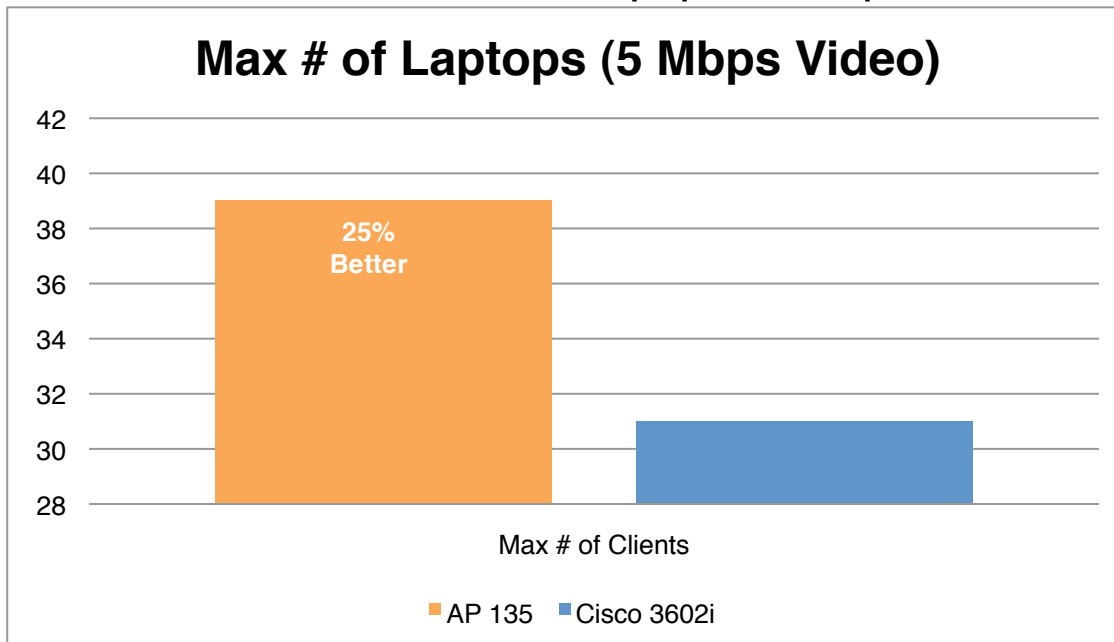
Clients used for testing	<ul style="list-style-type: none"><li>MacBook Pro + Dell with Intel 6300 chipsets (60)</li><li>20 iPads</li></ul>
Tools used for testing	<ul style="list-style-type: none"><li>VLC server streaming 5 Mbps and 2 Mbps HD video using active transcoding; VLC software on all client devices</li><li>Air Video Server, Apple TV</li></ul>
AP operation mode	5-GHz radio, same 40 MHz wide channel used for both Aruba and Cisco AP

### Test cases

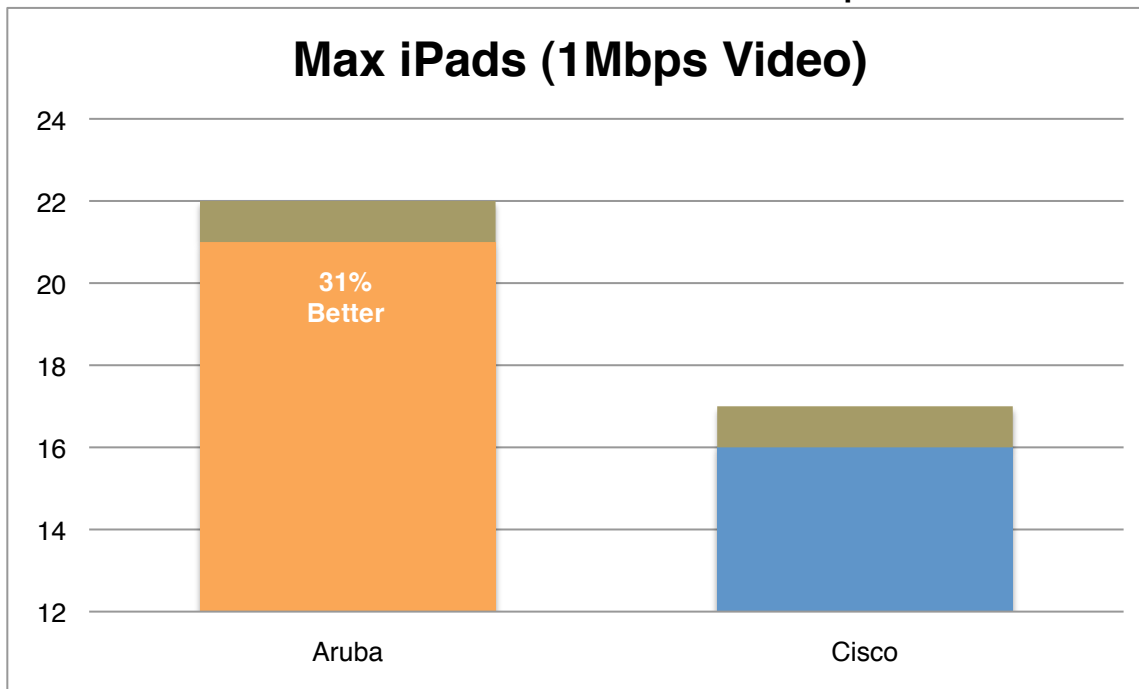
**Chart 5 Maximum number of laptops with 2Mbps video**



**Chart 6** Maximum number of laptops with 5Mbps video



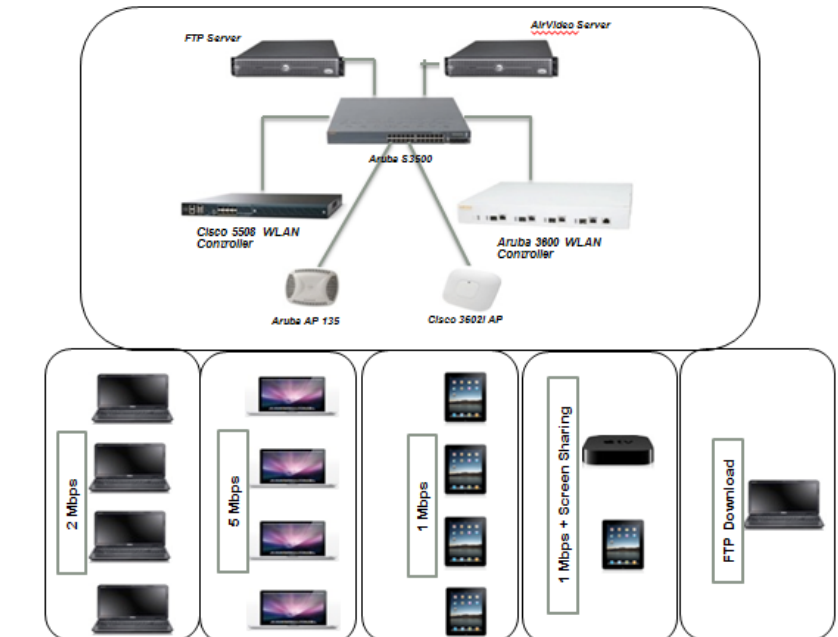
**Chart 7** Maximum number of iPads with 1Mbps video



### Video Density test results summary

The client density tests for laptops as well as iPads both reveal that the Aruba AP-135 scales better than the Cisco AP3602i. The Aruba system by design is better optimized to handle live HD quality video streams.

### 3. Wi-Fi client density and video performance with mixed clients and background traffic



This test showcases a mix of applications (video, data), client types (laptops, tablets, Apple TVs), and client capabilities (3x3, 2x2, and 1x1) in a high-density enterprise environment. In this test, a variety of laptops (3x3 as well as 2x2 capable) were used to stream 5 Mbps and 2 Mbps live HD video from the VLC server. Multicast HD video was used to highlight downstream video performance. There were several iPads (1x1) streaming 1 Mbps video from the Air Video server with one iPad mirroring its screen to an AppleTV using AirPlay. The iPad mirror generated upstream TCP video traffic. In the background there was a client transferring an 11 GB file, adding background data traffic to further saturate the channel. The quantity of various devices was adjusted such there was no degradation in video quality to reach an optimal mix of clients.

The objective of this test was to observe the impact of increasing load on a network that has a variety of different clients with different types of traffic.

**Table 6 Video performance with mixed devices test setup**

Clients used for testing	<ul style="list-style-type: none"> <li>Mac Book Pro + Dell with Intel 6300 chipsets (60)</li> <li>Dell with Intel 4905 chipsets (10)</li> <li>iPad2 (48)</li> <li>Apple TV</li> </ul>
Tools used for testing	VLC server streaming 5 Mbps and 2 Mbps HD video using active transcoding; Air Video server streaming 1 Mbps HD video
AP operation mode	5-GHz radio, same 40-MHz wide channel used for Aruba and Cisco AP

## Results

**Table 7 Maximum number of video streams test setup**

Model/Make	Clients Specs	Count	Application	Traffic Direction
Dell Latitude	Intel 4965 (2x2:2)	4	2 Mbps Video (Downstream UDP)	AP -> Client
Lenovo ThinkPad	Intel 6300 (3x3:3)	9	2 Mbps Video (Downstream UDP)	AP -> Client
MacBook Pro	Broadcom (3x3:3)	10	5 Mbps Video (Downstream UDP)	AP -> Client
iPad	Broadcom (1x1:1)	12	1 Mbps Video (Downstream TCP)	AP -> Client
iPad, Apple TV streaming	Broadcom (1x1:1)	1	1 Mbps Video (Upstream TCP)	Client -> AP
Lenovo ThinkPad	Intel 6205 (2x3:2)	1	FTP (Downstream TCP)	AP -> Client
	Total Clients	37		

The mixed traffic, mixed client-density test case reveals the architectural deficiencies of Cisco WLAN controller. Since Aruba's solution has a stateful firewall built in, the controller is able to detect and prioritize not only multicast video but also TCP video (Air Video) over best effort FTP traffic.

In the Aruba case, high quality video (both 2 and 5 Mbps video) was observed without any artifacts, including pixilation or video freezes. The iPad videos did not exhibit any buffering or video quality issues. The Apple TV stream was low-latency, reflecting what was seen on both the iPad and the projected screen simultaneously. The 11 GB FTP file download never timed out.

For Cisco, the HD video (both 2 and 5 Mbps) experienced a significant amount of pixilation artifacts and video freezes across all laptops. There was noticeable buffering on the iPads playing TCP video. The Apple TV had difficulty mirroring, and there was significant latency between the iPad and the projected monitor. Finally, the 11 GB FTP file download timed out in the middle of the test.

Cisco's solution can prioritize multicast video traffic, but has no mechanism to identify TCP video used for streaming to iPads in a mixed traffic environment and hence the video performance takes a hit. Cisco is clearly not the better solution for a highly dense mix of laptops and tablets, and is not optimized for high-performance BYOD.

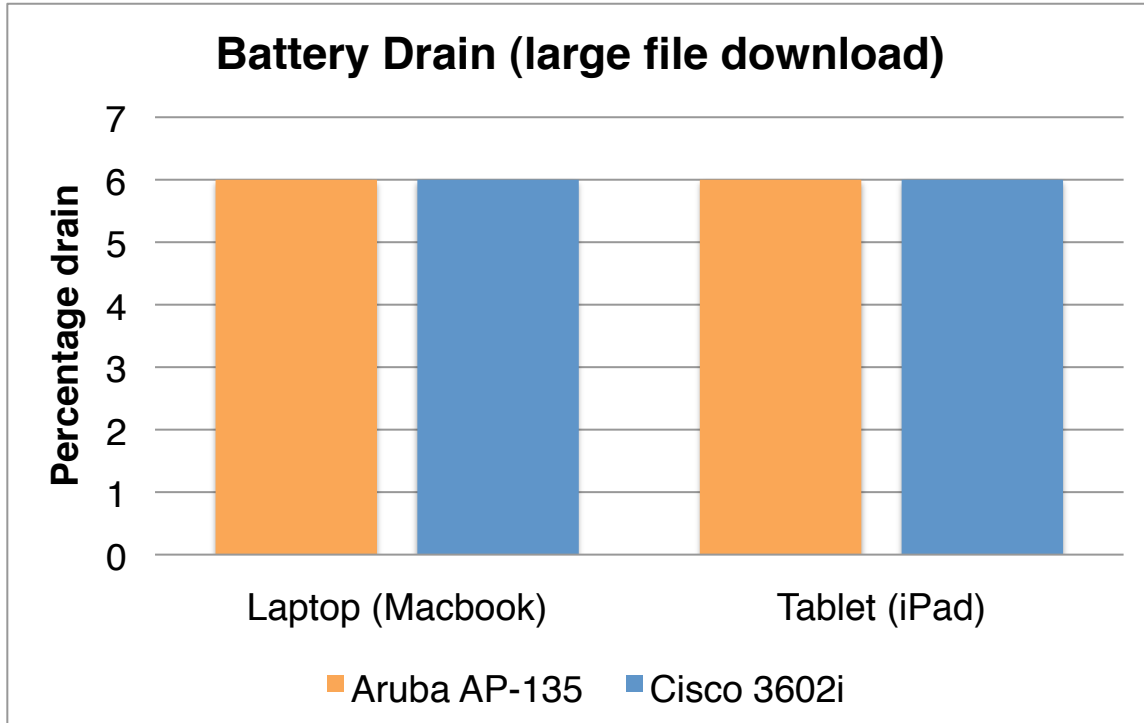
#### 4. Battery drain – Impact on battery life of mobile devices while downloading large files

The objective of this test was to identify the amount of battery drain when using a tablet for network intensive tasks. This test was performed using both a laptop and a tablet while downloading an 11 GB file while the device was located 100 feet away from the AP.

**Table 8 Maximum number of video streams test setup**

<b>Clients used for testing</b>	Mac Book Pro, Android Tablet
<b>Tools used for testing</b>	IxChariot, FTPget script to simulate 11GB file transfer for MacBook Pro and Filesnds script to simulate 3 GB file transfer for iPad.
<b>AP operation mode</b>	5-GHz radio, same 40-MHz wide channel used for Aruba and Cisco AP

## Results



The battery test reveals that there is almost no difference in the performance of mobile device battery life when running on either the Aruba AP-135 or Cisco AP3602i.

## What Do the Tests Reveal?

The tests conclusively show that the Aruba AP-135 is superior in performance to Cisco's AP3602i in almost all test scenarios. The rate vs. range test proves that the Aruba AP-135, which supports up to 450 Mbps, outperforms the Cisco AP3602i.

Common devices like the Apple MacBook are unable to get a connection to the AP3602i at distances greater than 100 feet. We also observed that the Cisco AP3602i is very sensitive to the orientation of the device as evidenced by iPad throughput dropping by 67% at 100 feet when its orientation is changed.

The client density tests for laptops as well as iPads both reveal that the Aruba AP-135 scales far better than the Cisco AP3602i. The mixed traffic, mixed client-density tests reveal the inherent architectural deficiencies of Cisco WLAN controller.

With an integrated stateful firewall built into the Aruba controller, it is able to detect and prioritize not only multicast video but also TCP video (Air Video) over best effort FTP traffic. Cisco's solution does prioritize multicast video traffic, but has no mechanism to identify TCP video used for streaming to iPads in a mixed traffic environment and hence the video performance takes a hit.

The battery drain test reveals that there is almost no difference in the performance of mobile device battery life when running on either AP-135 or AP3602i.



## Appendix – Vendor configurations

The configurations for both Aruba and Cisco WLAN controllers used for test cases are shown below.

### Aruba Configuration:

```
!
ip access-list session video-priority
  any network 239.0.0.0 255.0.0.0 any permit tos 40
  any network 224.0.0.0 255.0.0.0 any permit tos 40
  any any any permit
!
user-role video-test
access-list session video-priority
!
interface gigabitethernet 0/0
  description "GE0/0"
  trusted
  trusted vlan 1-4094
  ip access-group "video-priority" session vlan 1
!
interface vlan 1
  ip address 10.18.66.6 255.255.255.0
  ip igmp snooping
!
aaa profile "video-test-PSK-AAA-Profile"
  initial-role "video-test"
  authentication-dot1x "default-psk"
!
control-plane-security
  auto-cert-prov
!
ap system-profile "default"
  telnet
!
!
rf arm-profile "default"
  min-tx-power 127
  voip-aware-scan
  noise-wait-time 30
!
rf dot11a-radio-profile "default"
  disable-arm-wids-functions
!
rf dot11a-radio-profile "default"
  no spectrum-monitoring
!
rf dot11g-radio-profile "default"
  no spectrum-monitoring
!
wlan ht-ssid-profile "default"
  temporal-diversity
!
wlan ssid-profile "video-test-wpa2"
  essid "video-test-wpa2"
```

```
opmode wpa2-aes
wmm
mcast-rate-opt
!
wlan virtual-ap "default"
  allowed-band a
  ssid-profile "video-test-wpa2"
  vlan 1
  forward-mode decrypt-tunnel
  dynamic-mcast-optimization
  dynamic-mcast-optimization-thresh 48
!
wlan traffic-management-profile "default"
  shaping-policy fair-access
!
ap-group "default"
  virtual-ap "default"
  dot11a-traffic-mgmt-profile "default"
!
```

### Cisco Config:

(Cisco Controller) >show running-config  
 Notice: "show running-config" has been changed to be an alias to "show run-config".  
 Use "show run-config commands" to display the configuration commands.  
 Press Enter to continue or <Ctrl-Z> to abort...

#### System Inventory

NAME: "Chassis" , DESCR: "Cisco 5500 Series Wireless LAN Controller"

PID: AIR-CT5508-K9, VID: V01,

Burned-in MAC Address..... 0  
 Power Supply 1..... Absent  
 Power Supply 2..... Present, OK  
 Maximum number of APs supported..... 12  
 Press Enter to continue or <ctrl-z> to abort

#### System Information

Manufacturer's Name..... Cisco Systems Inc.  
 Product Name..... Cisco Controller  
 Product Version..... 7.2.103.0  
 Bootloader Version..... 1.0.1  
 Field Recovery Image Version..... 6.0.182.0

Firmwe Version..... FPGA 1.3, Env  
1.6, USB console 1.27  
Build Type..... DATA + WPS  
System Name..... Cisco5508  
System Location.....  
System Contact.....  
System ObjectID.....  
1.3.6.1.4.1.9.1.1069  
IP Address..... 10.68.3.52  
Last Reset..... Power on reset  
System Up Time..... 16 days 2 hrs  
21 mins 28 secs  
System Timezone Location.....

Configured Country..... Multiple  
Countries:US  
Operating Environment.....  
Commercial (0 to 40 C)  
Internal Temp Alm Limits..... 0 to 65 C  
Internal Temperature..... +39 C  
External Temperature..... +23 C

--More or (q)uit current module or <ctrl-z> to abort  
Fan Status..... OK

State of 802.11b Network..... Disabled  
State of 802.11a Network..... Enabled  
Number of WLANs..... 1  
Number of Active Clients..... 2  
Burned-in MAC Address..... 0  
Power Supply 1..... Absent  
Power Supply 2..... Present, OK  
Maximum number of APs supported..... 12  
Press Enter to continue or <ctrl-z> to abort

WLAN ID	Interface	Network Admission
Control	Radio Policy	
1	clients	Disabled
2	ciscoclients	Disabled
3	multicast-vlan	Disabled
4	management	Disabled

AP Name	Slots	AP Model	Ethernet
MAC	Location	Port	Country
AP3600	2	AIR-CAP3602I-A-K9	
default location	1	US	1

CleanAir Management Information  
CleanAir Capable..... Yes

CleanAir Management Admin State.....  
Enabled  
CleanAir Management Operation State..... Up  
Rapid Update Mode..... Off  
Spectrum Expert connection..... Enabled  
CleanAir NSI Key..... 0  
Spectrum Expert Connections counter.... 0  
CleanAir Sensor State.....

Radio Extended Configurations  
Beacon period..... 100  
milliseconds  
Beacon range..... AUTO  
Multicast buffer..... AUTO  
Multicast data-rate..... AUTO  
RX SOP threshold..... AUTO  
CCA threshold..... AUTO

CleanAir Management Information  
CleanAir Capable..... Yes  
CleanAir Management Admin State.....  
Enabled  
CleanAir Management Operation State..... Up  
Rapid Update Mode..... Off

--More or (q)uit current module or <ctrl-z> to abort  
Spectrum Expert connection..... Enabled  
CleanAir NSI Key..... 0  
Spectrum Expert Connections counter.... 0  
CleanAir Sensor State..... Configured

Radio Extended Configurations  
Beacon period..... 100  
milliseconds  
Beacon range..... AUTO  
Multicast buffer..... AUTO  
Multicast data-rate..... AUTO  
RX SOP threshold..... AUTO  
CCA threshold..... AUTO

802.11a Configuration  
802.11a Network..... Enabled

Default Tx Power Level..... 1  
DTPC Status..... Enabled  
Fragmentation Threshold..... 2346  
TI Threshold..... -50  
Legacy Tx Beamforming setting.....  
Enabled  
Traffic Stream Metrics Status..... Disabled  
Expedited BW Request Status.....  
Disabled  
World Mode..... Enabled  
EDCA profile type..... default-wmm  
Voice MAC optimization status..... Disabled  
Call Admission Control (CAC) configuration

Voice AC:  
 Voice AC - Admission control (ACM).....  
 Disabled  
 Voice Stream-Size..... 84000  
 Voice Max-Streams..... 2  
 Voice max RF bandwidth..... 75  
 Voice reserved roaming bandwidth..... 6  
 Voice CAC Method ..... Load-Based  
 Voice tspec inactivity timeout..... Disabled  
 CAC SIP-Voice configuration  
 SIP based CAC ..... Disabled  
 SIP Codec Type .....  
 CODEC\_TYPE\_G711  
 SIP call bandwidth ..... 64

--More or (q)uit current module or <ctrl-z> to abort  
 SIP call bandwidth sample-size ..... 20

Video AC:  
 Video AC - Admission control (ACM).....  
 Disabled  
 Video max RF bandwidth..... Infinite  
 Video reserved roaming bandwidth..... 0  
 Best-effort AC - Admission control (ACM).....  
 Disabled  
 Background AC - Admission control (ACM).....  
 Disabled  
 Maximum Number of Clients per AP Radio.....  
 200

#### 802.11a Advanced Configuration

##### Member RRM Information

AP Name	MAC Address	Admin
State	Operation State	Channel
TxPower		

AP3600		0
ENABLED	UP	(149,153) Level 1

##### WLAN Configuration

WLAN Identifier..... 4  
 Profile Name.....  
 ArubaShowcase  
 Network Name (SSID).....  
 ArubaShowcase  
 Status..... Enabled  
 MAC Filtering..... Disabled

Broadcast SSID..... Enabled  
 AAA Policy Override..... Disabled  
 Network Admission Control

Qos Queue Length Info  
 Platinum queue length..... 100  
 Gold queue length..... 75  
 Silver queue length..... 50  
 Bronze queue length..... 25  
 Press Enter to continue or <ctrl-z> to abort

##### Media-Stream Configuration

Multicast-direct State..... enable  
 Allowed WLANs..... 2,4,5

Stream Name	Stt IP	End IP
Operation Status		

2Mbps stream	239.11.11.11	
239.11.11.11		Multicast-direct
5Mbps stream	239.10.10.10	
239.10.10.10		Multicast-direct

URL.....  
 E-mail.....  
 Phone.....  
 Note.....  
 State..... disable

##### 5G Band Media-Stream Configuration

Multicast-direct..... Enabled  
 Best Effort..... Disabled  
 Video Re-Direct..... Enabled  
 Max Allowed Streams Per Radio..... Auto  
 Max Allowed Streams Per Client..... Auto  
 Max Video Bandwidth..... 0  
 Max Voice Bandwidth..... 75  
 Max Media Bandwidth..... 85  
 Min PHY Rate..... 6000  
 Max Retry Percentage..... 80

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## About Aruba Networks

Aruba Networks is a leading provider of next-generation network access solutions for the mobile enterprise. The company's Mobile Virtual Enterprise (MOVE) architecture unifies wired and wireless network infrastructures into one seamless access solution for corporate headquarters, mobile business professionals, remote workers and guests. This unified approach to access networks dramatically improves productivity and lowers capital and operational costs.

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