Lab Testing Summary Report

January 2010

Report 100101

Product Category:
Wireless LAN Controller

Vendors Tested:

Cisco Systems
Aruba
Hewlett-Packard
Motorola

Products Tested:

Cisco 5508 Controller; 1140 and 1250 APs

Aruba 6000 Controller; 125 and 124 APs

HP MSM750 Controller; HP Procurve MSM422 AP

Motorola RFS7000 Controller

Motorola AP1731 AP

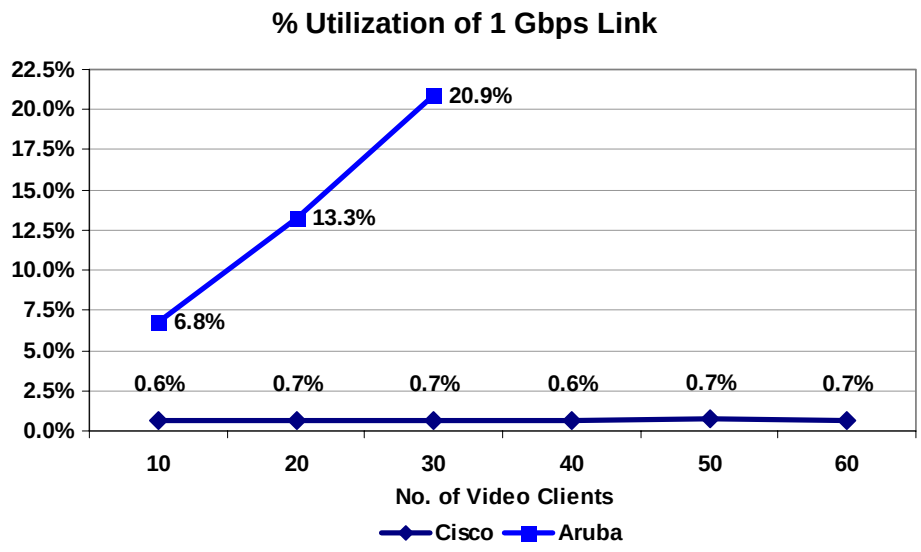
Key findings and conclusions:

- **Cisco 5508 Wireless Controller with VideoStream offered 3 times the scalability of competing products by maintaining video quality at a perfect 5.0 MOS**
- **Cisco VideoStream technology optimizes network performance by utilizing 30 times less bandwidth than Aruba Optimized Dynamic Multicast feature**
- **Lowest latency and zero Media Loss Rate were observed when Cisco VideoStream was enabled**
- **Cisco VideoStream had the most efficient delivery of standard and high definition media streams**

Cisco Systems engaged Miercom to validate the reliability and quality of multicast delivery for enterprise grade video streams over wired and wireless LANs using the Cisco 5508 Wireless Controller (6.0.185) enabled with VideoStream technology. The objective of the testing was to measure and compare the end-user Quality of Experience (QoE), overall scalability of the system, and end-to-end network utilization efficiency of these solutions. Miercom also competitively compared the quality of video experience offered by the Aruba 6000 (3.4.1), Hewlett-Packard MSM750 (5.3.1) and Motorola RFS7000 (4.1) wireless controllers, and the corresponding 802.11n access points that are designed for the enterprise market from each vendor. Cisco VideoStream technology is a new feature that delivers a reliable and scalable platform for all types of video delivery on the WLAN.

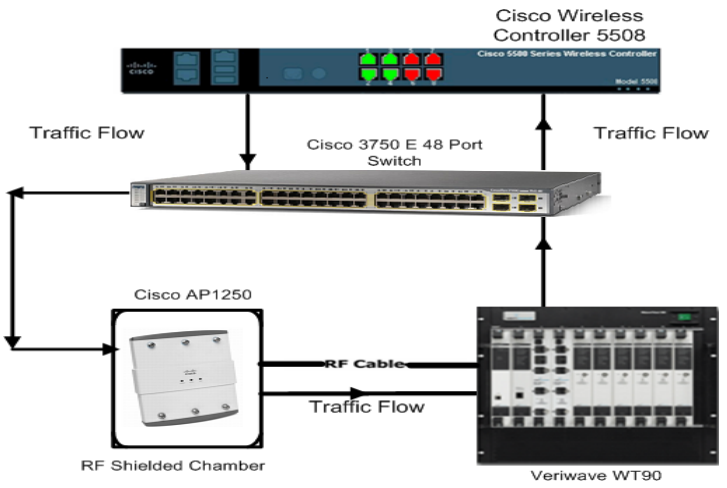
To check video user Quality of Experience (QoE) first we recorded the "Media Delivery Index" (MDI) score *(continued on page 3)*

Figure 1: Port Utilization
Ethernet bandwidth utilization of 1 Gbps uplink on Cisco and Aruba controllers.



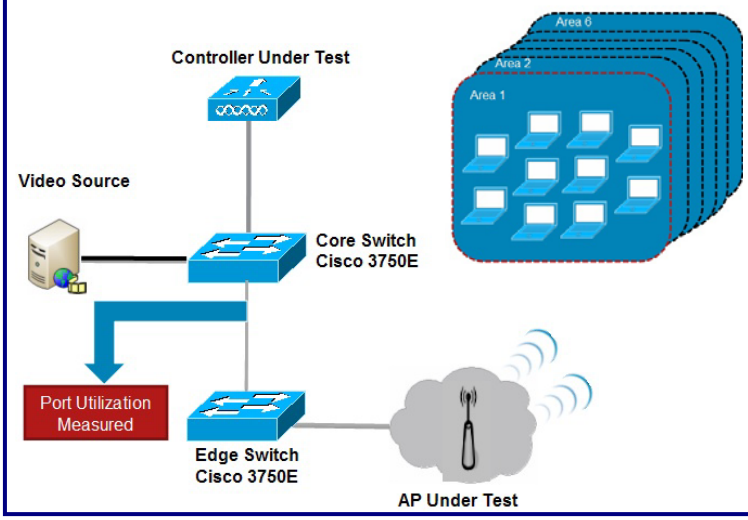
Cisco 5508 Wireless Controller with VideoStream enabled allows more than double the video client scalability compared to Aruba due to more efficient bandwidth utilization for the wireless controller uplink.

Test Bed 1



The objectives for Test Bed 1 were to obtain quantifiable metrics for video quality for the Cisco 5508 Wireless Controller with VideoStream technology. Media Delivery Index (MDI) metrics were observed by measuring Delay Factor (DF) and Media Loss Rate (MLR). DF provides a metric for measuring jitter or latency and MLR provides a metric for measuring packets dropped or out-of-order packets both of which impact the system's ability to deliver quality video to end-users. These tests were not conducted on the competitive products. The Cisco AP under test was connected using an RF cable to the VeriWave (www.veriwave.com) 802.11n MIMO test card. The application utilized in testing was the VeriWave WaveQoE test suite running the Multicast Video Performance script. The VeriWave software generates reports that include DF and MLR metrics by simulating video traffic. Service Level Agreement (SLA) was defined in VeriWave's suite as a DF of 50 ms and a MLR of 10 frames/sec resulting in a MDI (Media Definition Index) Score of 50:10. Any flow that does not meet the SLA criteria (meaning scores lower than 50 DF and/or 10 MLR) is considered to be less than "enterprise-grade" video. These measurements were taken twice. Once with the VideoStream feature disabled and then again with it enabled while simulating 5 clients for both Standard Definition (SD) 5Mbps and High Definition (HD) 20Mbps video streams. The QoE was measured in MDI which rates the user experience in terms of DF and MLR and is a convenient way to address SLAs.

Test Bed 2



The objectives for Test Bed 2, Phase 1, were to employ a battery of tests on the Cisco 5508 Wireless Controller and other competitive 802.11n products to evaluate the performance, QoE, bandwidth consumption and scalability. Dell and Lenovo notebooks with built-in Intel 802.11n adapters were used to play multicast video streams using a Video LAN Client (VLC) player. This test was performed using 15 client PCs in a clean RF environment and in open air. Initially, the infrastructure was loaded with one multicast stream of low quality video 1-2 Mbps, delivered to five clients. After that, another medium bandwidth stream of 3-6 Mbps was added to the network with five additional clients. This was repeated for another media stream with DVD quality bandwidth of (7-9 Mbps). Between each step, the quality of video and scalability was observed.

Using Test Bed 2 in the second phase of testing, the Cisco 5508 Wireless Controller with AP 1250/1140 and the Aruba Controller with AP125 were tested for end-to-end performance and bandwidth utilization. For this test, we created 6 geographical areas, each with 10 clients. Each area had one Cisco and one Aruba Access Point. Starting with Area 1, we switched on Cisco Access Point (AP1) and ten clients and started a 3-6 Mbps stream using resource allocation from the Cisco Controller. We then started the second AP (AP2) in Area 2 and had 10 more clients stream video from AP2 while Area 1 with AP1 was running. We repeated the same in Area 3 to Area 6 with a total of 40 additional clients and four additional APs all connected to the Cisco Controller. The same test scenario was conducted with the Aruba 6000 Controller with 6 Aruba 124/125 APs installed in the same 6 geographical areas. This test was continued until the system could no longer handle the additional clients. Then we measured the uplink utilization between the core and edge switch for each area as shown in the test bed diagram.

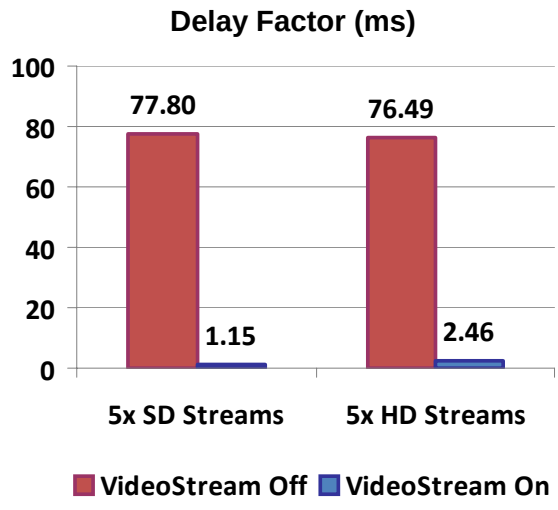
(continued from page 1) reported by the Veriwave test and measurement equipment. Scalability and utilization were then measured by analyzing the bandwidth consumption and observing the overall video quality, as we scaled the testing up to 60 concurrent Wi-Fi clients, over the wired and wireless networks using enhanced multicast capability for each of the systems.

Miercom evaluated QoE required to support business video in enterprise-level networks. Further tests were performed to calculate the effectiveness of VideoStream technology on multicast video quality by measuring the Delay Factor (DF) and Media Loss Rate (MLR). We also evaluated the effect that Cisco VideoStream has on the scalability of clients per Access Point (AP). The effectiveness of VideoStream compared to the Aruba Optimized Dynamic Multicast feature in the Aruba 6000 Controller was examined in terms of scalability and overall efficiency. Hewlett-Packard and Motorola use standard multicast (802.11n) capabilities and do not offer any advanced enhancements for multicast video, and they were not included in the bandwidth utilization test scenarios.

Video Quality with VideoStream:
Delay Factor (DF), Media Loss Rate (MLR)

Video applications are changing the way business is done. As video applications are integrated into business processes, applications must have the same level of access, quality, performance, scale and reliability on wireless networks as currently on their wired networks. Typical enterprise class video streams range from 1 to 3Mbps and can be problematic when used over Wi-Fi with standard multicast capabilities. Since video traffic is delay sensitive, Quality of Service (QoS) is used to prioritize and ensure these applications have sufficient bandwidth available.

Figure 2: Delay Factor and VideoStream
Delay factor reduction with Cisco VideoStream

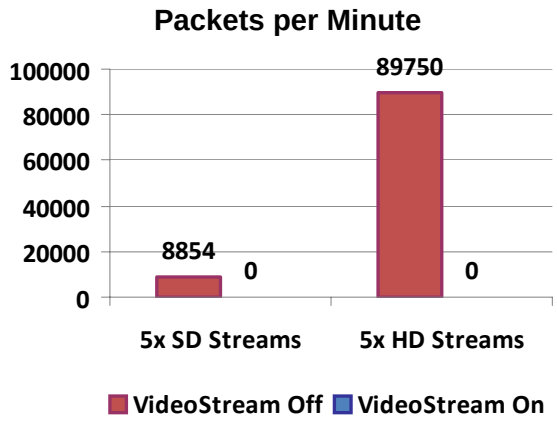


Cisco 5508 with VideoStream enabled allows a greatly reduced delay factor for both standard and high definition video which allows for better QoE when using video over wireless connections.

Cisco VideoStream technology provides a preferential QoS treatment for streams considered business critical. This traffic will override Web videos, searches, non-critical or non-business usage. At the same time, Cisco VideoStream protects video clients through Resource Reservation Control (RRC). It denies new multicast video requests that may cause bandwidth and channel oversubscription.

Cisco VideoStream provides reliable multicast delivery, by increasing the quality and number of streams/clients that an individual AP can deliver. With Cisco VideoStream disabled at the controller, the DF was recorded at 78 and 76 ms for both Standard Definition (SD) and High Definition (HD) streams. This delay factor is considered unacceptable and will result in poor video QOE / poor user experience. When Cisco VideoStream was enabled, the DF was reduced to 1 ms from 78 ms for SD and to 2 ms from 76 ms for five HD streams. *See Figure 2.*

Figure 3: Media Loss Rate (MLR)
Media Loss Rate measured in packets per minute for SD and HD video streams



Cisco 5508 Wireless Controller with VideoStream provides a substantially reduced Media Loss Rate (MLR) for both SD and HD video streams.

In addition to the improved DF, MLR was reduced to nearly zero when Cisco VideoStream was enabled for both SD and HD video streams indicating clean network delivery. *See Figure 3 on page 3.* By combining the DF:MLR measured values, the test equipment calculated an MDI score. The resulting score was 2.46:0 for HD and 1.15:0 for SD. 50:10 is the defined MDI score for SLA industry standard QoE for Enterprise Class Video Streams. *See Figure 2 on page 3.*

Video Quality Scalability with Multicast

Video quality was measured and recorded while employing each product tested to maximum effective scalability while using multicast video.

A Video Mean Opinion Score (VIDMOS) rating for QOE was determined for each product tested.

Figure 4: Video Quality or VIDMOS

Score	Quality	Impairments
5	Excellent	Not noticeable
4	Good	Some
3	Fair	Noticeable
2	Poor	Annoying
1	Bad	Unusable

Scoring, ratings and descriptions for video quality (VIDMOS).

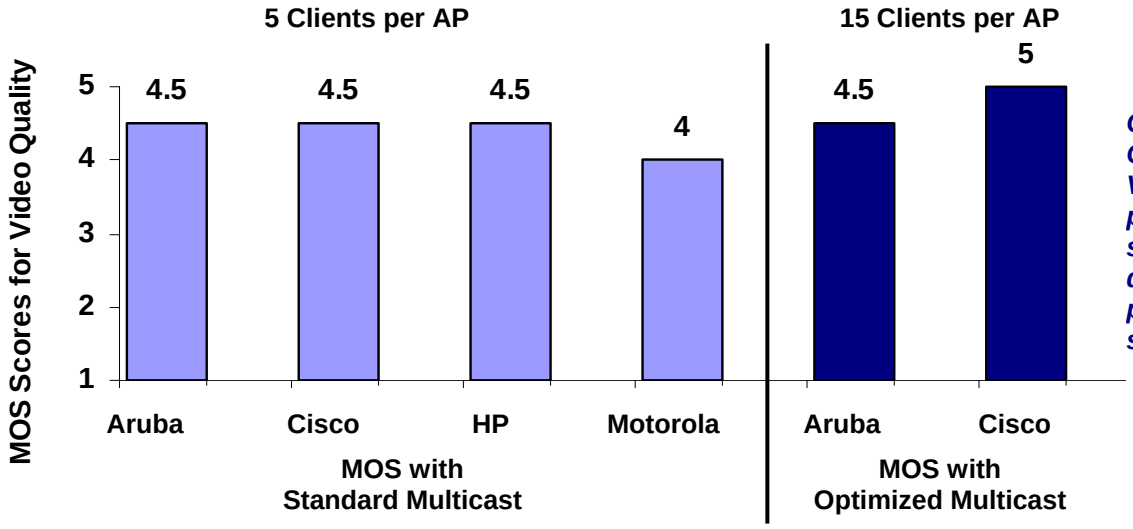
A rating relative to observable video is shown in *Figure 4* above. Using the multicast feature available for the Cisco (VideoStream) and Aruba (DMO) we were able to scale the tests up to 15 clients per access point. For products that rely solely on 802.11n for multicast video, testing was limited to five clients per access point. Applying a similar technique used previously for measuring DF and MLR, while simultaneously observing the QoE, the VIDMOS scores were determined for each product tested when configured for maximum scalability.

As shown in *Figure 5*, all the controllers were able to support up to 5 clients for low bit rate video stream using standard multicast. The VIDMOS scale is a subjective rating based on the average of the multiple observers' ratings of the visible video quality of streams played by each client. The graph shown in *Figure 5* details the VIDMOS scoring of each product. Aruba and Cisco products were tested with and without their multicast optimization feature enabled.

The Cisco 5508 Wireless Controller with VideoStream enabled offered the best overall QoE with a perfect 5.0 VIDMOS score while supporting 15 clients per access point. Enterprises can deliver needed QoE even in conference room or classroom environments.

We noticed while testing these products with standard multicast that as we added medium bandwidth (3-6 Mbps) media streams, the quality of video streaming on those clients was rated poor (2 VIDMOS). This test confirmed the known limitations of multicast. However when we enabled VideoStream on the Cisco 5508 Wireless Controller, and added 5 clients playing medium

Figure 5: Video Quality Assessment with Scalability



Cisco Wireless LAN Controller 5508 with VideoStream enabled provides for superior scalability and video quality compared to products that rely on standard multicast.

bandwidth video stream and 5 clients playing DVD quality video stream to the AP, the video quality was rated 5.0. Similarly when the Dynamic Multicast Optimization was enabled on the Aruba controller, we were able to scale up to 15 clients with a VIDMOS score of 4.5. While Cisco and Aruba both offer optimization for multicast through an add-on feature for the controller, when testing Aruba, we noted visible distortion in images on 2 to 3 clients when the DVD quality video stream was added to the last 5 clients. Cisco VideoStream technology was able to scale up to 15 clients per AP while ensuring the best QoE. Hewlett-Packard and Motorola support standard multicast and do not have the ability to optimize multicast video nor do they make claims for bandwidth optimization.

Multicast Video Delivery Efficiency

Successful and efficient delivery of multicast traffic over both wired and wireless is necessary in the enterprise for scalability and consistency in end-user experiences. Both Cisco and Aruba perform multicast-to-unicast packet conversion to improve the delivery. This processing is handled differently for each vendor. Tests were performed to assess the efficiency of each vendor at delivering multicast across the entire end-to-end network.

Aruba converts multicast packets to unicast within their controller and then sends the packets in a unicast tunnel to the Access Point. This architecture creates a centralized bottleneck in the controller and causes unneeded stress on the wired infrastructure.

Cisco's VideoStream technology leverages the Access Point to perform the multicast to unicast conversion, allowing the video stream to remain as multicast traffic until the very edge of the network. The Cisco 5508 Wireless Controller provides efficient multicast delivery across the entire end-to-end network.

The 5508 Controller showed high efficiency in scalability reaching 60 clients without compromising quality of video streaming. Aruba peaked at 30 clients. Adding clients to the Aruba Access Point in Area 4 lead to a video streaming crash for all the clients in Area 1. *See Test Bed 2, Phase 2 on page 2* for descriptions of testing and areas. When a client was added with a low bandwidth stream video of 1-2Mbps, we were able to scale up to 32 clients. The addition of another client to the Aruba controller caused the video streaming for all the clients in Area 2 to freeze. The Cisco 5508 Wireless Controller can handle double the amount of client connections without affecting the streaming quality across the network.

Figure 1 on page 1 shows that the Cisco 5508 Wireless Controller maintains port utilization at 0.7% Edge Switch as clients are added to the network for video streaming. Port utilization for Aruba increased at a linear rate as clients were added in each area and reached 20.9% with 30 clients. The Cisco Controller with VideoStream technology provides an efficient delivery of multicast traffic. Aruba consumes more bandwidth than the Cisco controller.

Bottom Line

The Cisco 5508 Wireless Controller with VideoStream technology enabled was capable of delivering video streaming at enterprise level expectations for quality of service. Bandwidth prioritization allows the enterprise clients the ability to dynamically allocate bandwidth resources as needed. Corporate communications, training and other business critical traffic will be given preference, over other usage that can be placed on hold until resources become available.

The Cisco VideoStream feature increased the QoE for multicast video by decreasing the Delay Factor to less than 3ms and the Media Loss Rate to zero in our hands-on testing conducted. The Cisco 5508 Wireless Controller proved it can scale up to 15 clients per Access Point with VideoStream enabled. Without the added capabilities of VideoStream, a typical access point can only support 5 clients with HD video streams.

Enterprises that require video applications on the wireless network will benefit from investing in the Cisco 5508 Wireless Controller with VideoStream.

Cisco VideoStream feature offers the enterprise market an efficient and effective solution for delivery of high definition video over wireless networks. Network resources are conserved while Cisco VideoStream provides high scalability and the best quality video. The Cisco 5508 Wireless Controller with VideoStream answers the call for prioritization of business critical video traffic with superior management and control of the network.

Miercom Performance Verified

Based on lab testing of the Cisco 5508 Wireless Controller with VideoStream enabled, Miercom verified that the performance and scalability of the Cisco solution is superior to competing products.

Hands-on testing confirmed that the Cisco 5508 Wireless Controller with VideoStream enabled offers bandwidth prioritization and delivers better QoE for video than competing wireless products.

The Cisco 5508 Wireless Controller with VideoStream technology enabled has earned the Miercom Performance Verified Certification.

Cisco 5508 Wireless Controller

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