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Client Density and Video Performance Comparison of Mid-range 802.11ac Access Points

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Executive Overview

This document details the performance of multiple vendors' mid-range 802.11ac Wave 2 access points (APs) in a high client density environment, using video as the primary data traffic type. Historically, competitive testing has tended to focus on aggregate data throughput using file transfer as the means of establishing load on the APs. Seemingly, the most recent public stress testing that included video was published in 2013.

In this test suite, video traffic is chosen as the primary data load for the simple reason that video dominates network data traffic volume in many of today's networks. According to the latest Cisco Visual Networking Index[1]:

- Global IP video traffic will grow threefold from 2016 to 2021, a CAGR of 26 percent. Internet video traffic will grow fourfold from 2016 to 2021, a CAGR of 31 percent.
- Business IP traffic will grow at a CAGR of 21 percent from 2016 to 2021. Increased adoption of advanced video communications in the enterprise segment will cause business IP traffic to grow by a factor of 3 between 2016 and 2021.

According to the latest Ericsson Mobility Report[2]:

- Mobile video traffic is forecast to grow by around 50 percent annually through 2022 to account for nearly 3 quarters of all mobile data traffic
- The share of mobile data video traffic approached 60% on tablets in the second half of 2016

In addition to its high bandwidth consumption, video is distinguished from most data applications, e.g., email, file transfer, browsing, by its effect on end-user quality of experience. Whereas users are unlikely to notice or care if it takes a few extra seconds to download an email attachment, users immediately notice a stalled video. The likelihood that a user will experience poor video quality (stalling) increases when that user is in a high client density environment which, in this test suite, is defined as sixty (60) clients.

In summary, this set of tests is designed to stress APs using a combination of video traffic and high client density, both of which are now commonplace in WLAN network environments.
A technical team from Ruckus procured the test site and equipment and conducted all tests described in this document. The author witnessed and validated all test equipment, software, configurations, and results. The physical AP and client setup within the facility was "real-world" and within best practice design parameters. In this validated configuration, all vendors were on equal footing.

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[1] Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2016–2021 White Paper
[2] Ericsson Mobility Report, June 2017

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About the author

Devin Akin is co-founder of CWNP, the de-facto global standard for vendor-neutral training and certification. Devin (CWNE #1) has 20+ years of experience in IT with 15+ years in WLAN specifically. He is the founder and CEO of [Divergent Dynamics](http://DivDyn.com), a Wi-Fi systems integrator and training organization that specializes in innovative Wi-Fi design, validation, and performance solutions.

What is this test?

This report describes a series of tests designed to measure AP performance under video traffic load. Mid-range 802.11ac Wave 2 3x3:3 APs were selected to reflect likely real-world deployments. For cases in which a 3x3:3 AP model was not available from a manufacturer, the next highest model was used.

Chromebooks with 2x2:2 802.11ac radio specifications were chosen both for their affordability and for their utility as a stand-in for a wide variety of low to mid-range wireless devices likely to be found in many WLAN environments. Chromebooks are also widely used in K-12 and primary education, making this test suite especially relevant to that environment.

Apple Mac Minis were used to load the network with non-video data traffic during video testing.

Why is this testing relevant?

Video traffic makes up the majority of all data traffic and is more likely than most other types of data traffic to significantly affect end-user experience when the network carrying it is performing sub-optimally. Thus, the ability of a WLAN to ensure quality of service for video is a fundamental requirement for organizations of all types.

A robust quality of service (QoS) mechanism is fundamental to reliable and consistent application delivery. Such QoS control is crucial for any organization, from enterprise to education to any number of enterprise verticals. Quality of service is also critical in the context of the onslaught of Internet of Things (IoT) devices. Many IoT devices communicate over Bacnet, a UDP protocol, necessitating performance goals similar to those of video and voice devices (time/delay sensitive).

Testing Environment

Tests were conducted in two adjacent classrooms in a middle school in Union City, California. The fact that this location was empty and had a clean radio frequency (RF) environment were the primary reasons for choosing it.

Each WLAN manufacturer's equipment was installed and configured with a single SSID to carry video and data traffic. Each AP under test was located in one room, on the opposite side of the wall separating the first room from the second room.

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Tested Access Points

The following hardware and firmware was used in these tests.

Vendor	AP/Controller	Software Version	MIMO Type
Ruckus	R610 with SZ100	3.5.0.0.832	3x3:3 11ac
Aruba	AP-305 with 7205	6.5.1.2	3x3:3 11ac
Aerohive	AP250	HiveOS 8.0r1 build-161337	3x3:3 11ac
Meraki	MR42	Cloud	3x3:3 11ac
Cisco	1850i with 5508	8.3.102.0	4x4:4 11ac

Figure 1 - AP models tested

Testing Methodology

WLAN Configuration

All tests were run in the 5 GHz band, which is the industry-recommended best practice for high density environments. All clients were connected to the WLAN via a single SSID, secured with a PSK, using a 40 MHz-wide channel. Although 802.11ac supports higher data rates when using 80 MHz-wide channels, such large channel widths are not recommended for use in high-density environments due to channel contention and poor channel reuse.

To prevent APs from changing channels in the middle of a test, each AP was manually assigned to channel 149+. The spectrum was swept to ensure no other devices were using this channel.

Because one of the APs (Aerohive AP250) supports the configuration of the second radio as a 5 GHz radio (dual-5 GHz radio mode), the AP250 was tested twice: once with a single 5GHz radio enabled and once with both 5GHz radios enabled. As recommended by the manufacturer, the first and second radios were separated by 80 MHz. The first radio was configured to use channel 40 and the second was configured for channel 149.

Ethernet Switch Configuration

A Ruckus ICX 7150 switch was used for the wired infrastructure. All devices were connected to gigabit Ethernet ports using Layer 2 VLANs.

Video Configuration

Six Microsoft Windows media servers were used to deliver a 1.6 Mbps unicast TCP video stream to each Chromebook client. In order to avoid caching, the video was run in a Chrome browser operating in “incognito” mode. The video was not looped and was restarted for each test. All video traffic was marked with DSCP 40 on the wired switch.

All clients were given one minute to run and be counted for stalls before a data load was introduced. Since video stalls can be fleeting, a conservative method was used to define video

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stalling. In order to be considered stalled, a video must either not have started or be in a stalled state at the conclusion of each test phase.

Once the video clients were running, non-video data traffic was added to the WLAN for one minute by configuring Mac Mini clients as Ixia Chariot 7.3 EA end points (1 pair each). Enough network load was introduced to trigger competition for available bandwidth between the different classes of traffic (video and data). To allow for precise control and to create consistent loading, data traffic in the form of UDP was chosen.

In cases for which video didn't begin immediately, it was retried twice. If it still failed to start it was considered stalled and counted against the initial tally (supported video clients without network load) and the number of stalled clients during network load (assuming it was still stalled).

At the end of the one-minute data-loading run time, the number of stalled video clients was counted again using the same stall criteria. The final aggregate throughput of the data clients (Mac Minis) was the value reported by Chariot[3].

Clients

60 2x2:2 Chromebook and 30 Mac Mini clients were used. The number of clients and client mix differed between the two tests described below.

[3] The Chariot script was a standard performance testing script with UDP_RFC768 disabled. This is as per Ixia recommendations for UDP throughput testing.

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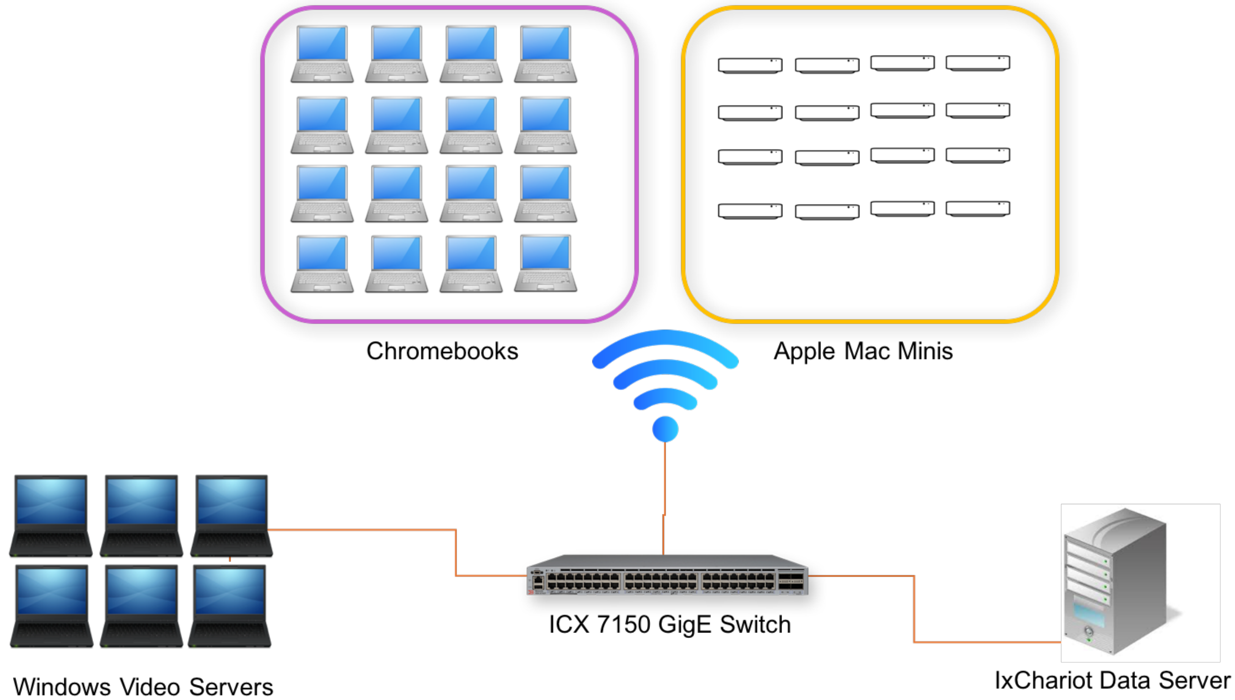

Figure 2 - Testbed Network Topology

Test 1: Thirty (30) Video Clients and Thirty (30) Data Clients

Objective

Determine the impact of the addition of 30 data-only clients in an adjacent room on the video quality of 30 Chromebook clients in the primary room by measuring the number of simultaneous videos supported by the AP before and after a data load was introduced.

Description

Video streams were manually initiated on thirty Chromebooks. One minute after all videos were started, data was pushed to thirty Mac Mini clients in the adjacent room. The number of clients with stall-free video was recorded along with the aggregate data throughput associated with the data-only clients. Each test also recorded the number of previously stalled videos that restarted once the network load stopped. Each test was run three times.

Success Criteria

The AP must successfully deliver stall-free video to all 30 video clients before and during network loading while simultaneously delivering data to the data-only clients. For cases in which video stalls occur under load, the video is expected to restart when the load is removed. Doing so shows consistent performance before, during, and after network loading. There were no absolute success criteria values for aggregate data throughput.

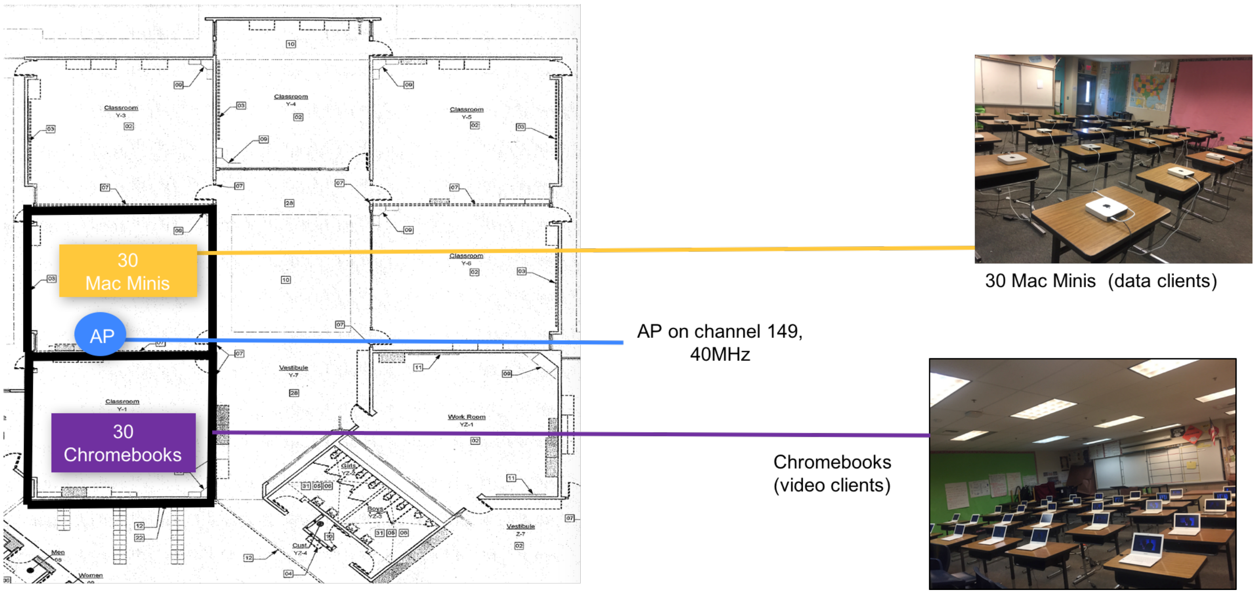

Figure 3 - Simultaneous streaming video on Chromebooks (30 clients) and data download on Mac Minis (30 clients)

Results

All APs tested were able to successfully serve 30 video-streaming clients when the network was unloaded and the AP was delivering only video traffic. When a data load was applied, most APs were unable to support all of the video streams. As shown below (Figure 4), the number of stall-free video connections ranged from 30 clients (best) to zero (worst).

All results shown are the median values of three test runs.

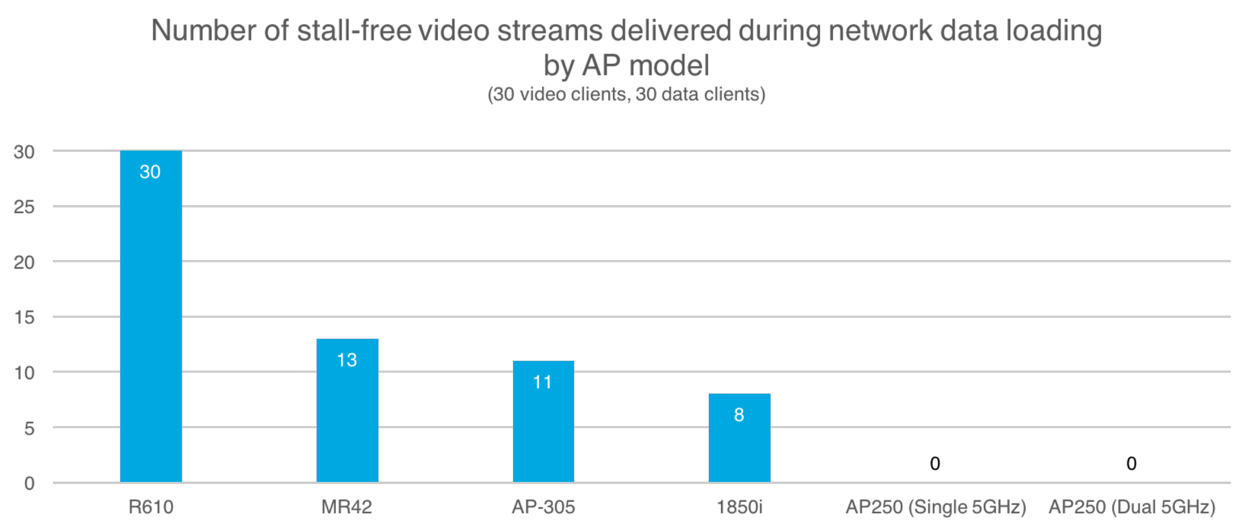

Figure 4 – Test 1 results for stall-free video under load

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Since network loads fluctuate over time, a more thorough performance analysis can be effected by measuring how well the network recovers from a load. The following chart shows the number of stall-free videos before, during, and after the data load was applied.

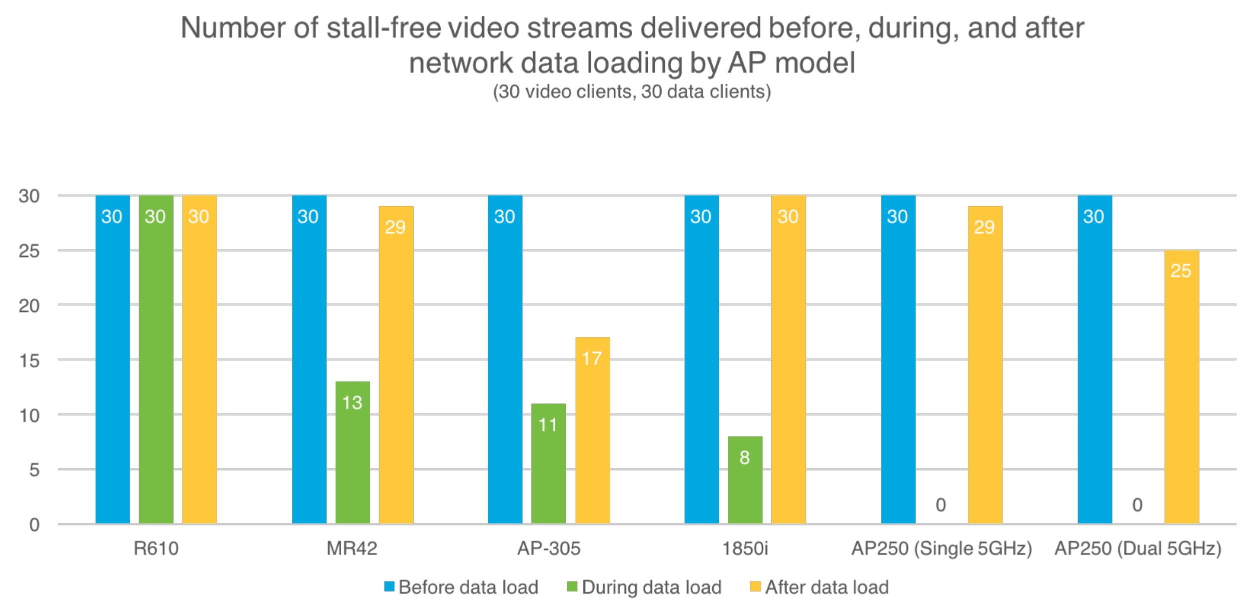

Figure 5 - Test 1 results before, during, and after network data load

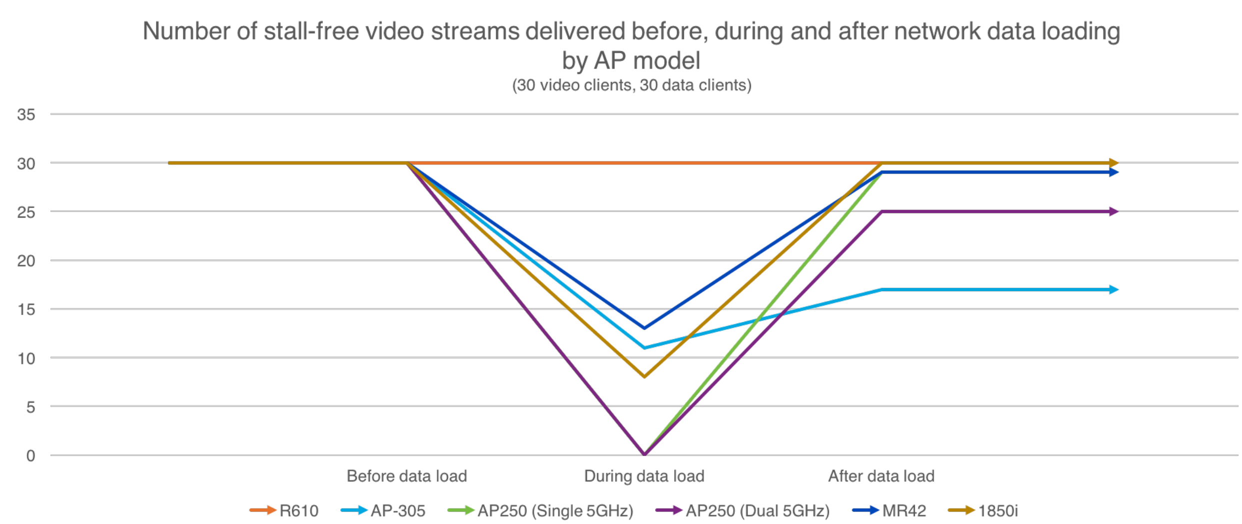

Figure 6 - Test 1 results before, during, and after network data load

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Only one AP (Ruckus R610) was able to deliver stall-free video to all 30 clients both with and without a data network load. The R610 also delivered the highest aggregate data throughput to the data-only Mac Mini clients.

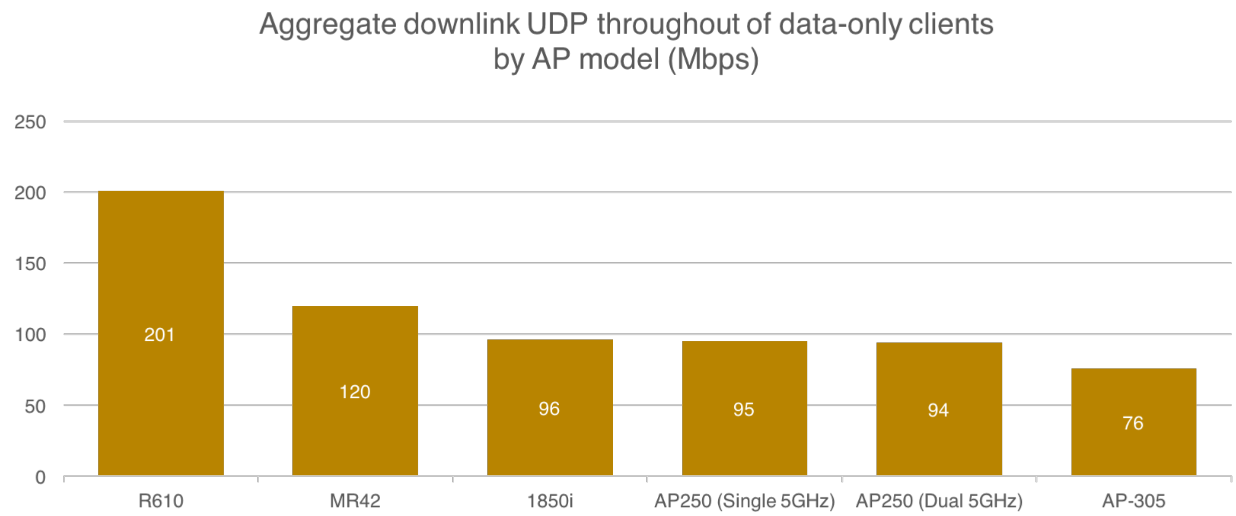

Figure 7 - Test 1 results for aggregate data throughput

Conclusions

Streaming high resolution video to a classroom of 30 laptops, while simultaneously pushing over 200Mbps of data throughput to 30 additional contending clients (Mac Minis), shows tremendous high-performance radio driver tuning. The R610 bested all competitors handily while being the only access point to meet the video delivery goals for each client device.

Test 2: Sixty (60) Video Clients and Two (2) Data Clients

Objective

Determine the impact of the addition of two data-only clients in an adjacent room on the video quality of 60 Chromebook clients in both rooms by measuring the number of simultaneous videos supported by the AP before and after a data load was introduced.

Description

Video streams were manually initiated on 60 Chromebook clients. One minute after all videos were started, data was pushed to two Mac Mini clients in the adjacent room. The number of clients with stall-free video was recorded along with the aggregate data throughput associated with the data-only clients. Each test also recorded the number of previously stalled videos that restarted once the network load stopped. Each test was run three times.

Success Criteria

The AP must successfully deliver stall-free video to all 60 video clients before and during network loading while simultaneously delivering data to the data-only clients. There were no absolute success criteria values for aggregate data throughput.

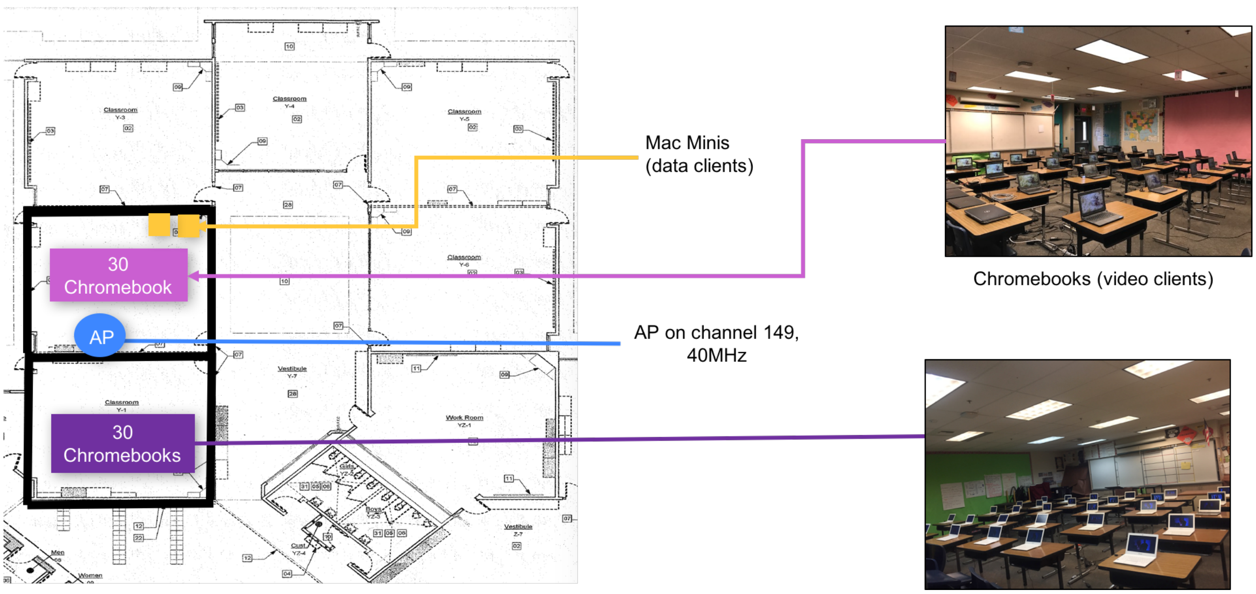

Figure 8 - Simultaneous streaming video on Chromebooks (30 clients) and data download on Mac Minis (2 clients)

Results

Unlike the results of first test case, only two APs (Ruckus R610, Aruba AP-305) were able to deliver stall-free video to 60 clients in the absence of simultaneous data loading. As in the first test case, the number of stall-free videos dropped for most vendors when a data load was applied. As shown below (Figure 9), the number of stall-free video connections ranged from 60 clients (best) to five (poor).

All results shown are the median values of three test runs.

Only one AP (Ruckus R610) was able to deliver stall-free video to all 60 clients both with and without a data network load.

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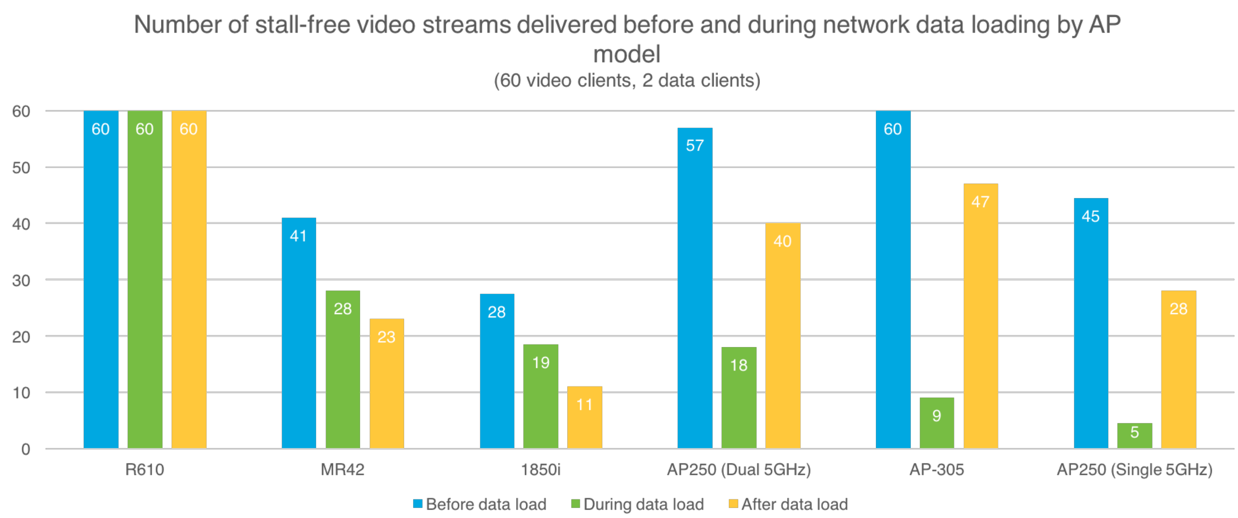

Figure 9 - Test 2 results for number of video supported video clients with and without load

All APs were able to successfully deliver data traffic to the data-only clients during the video test. The Ruckus R610 and the Cisco 1850 delivered near-equivalent aggregate throughput to the data-only clients but, in the Cisco case, at the expense of stalled video on two-thirds of the video-streaming clients.

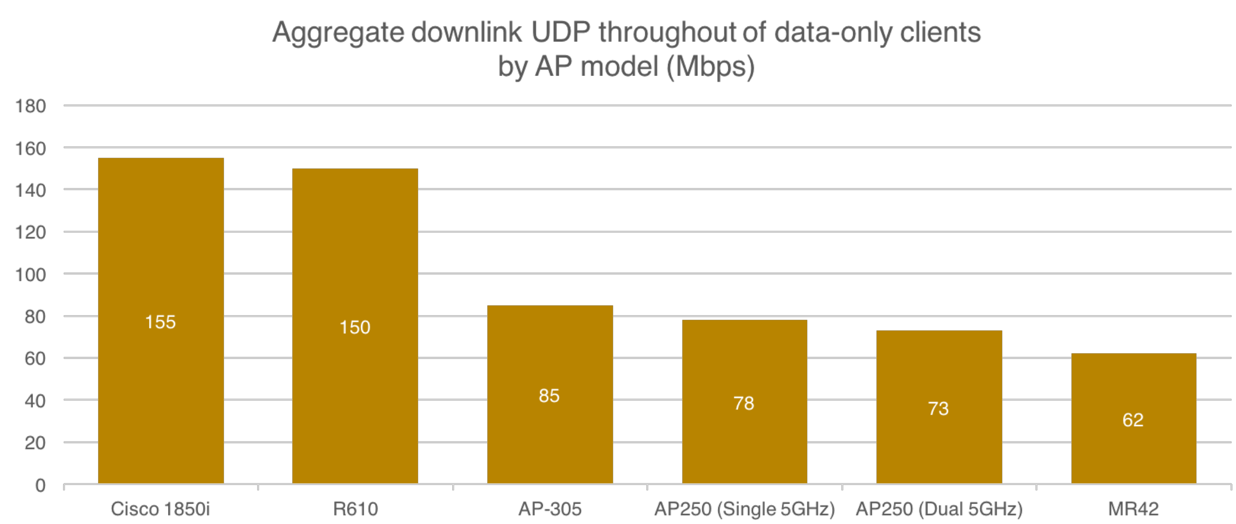

Figure 10 – Test 2 results for aggregate data throughput

Conclusions

Streaming high resolution video to two classrooms of 30 laptops each (total of 60 video laptops), while also having the QoS chops to simultaneously handle 150Mbps of UDP data, is nothing short of impressive. The Ruckus R610 was the only AP to achieve the 60-client video delivery goals of this test. This level of validated execution proves that Ruckus can deliver on its price/performance promises.

Summary and Conclusions

While observing each test procedure, a combination of diagnostic tools, including spectrum analyzers, protocol analyzers, and handheld diagnostic platforms were used to capture and validate each result. System configuration was validated against best practices and manufacturer recommendations. Airtime consumption was monitored for consistency across all tests. All results were visually verified and recorded by the author at the time of the testing.

Each metric listed herein significantly contributes to the overall performance picture and to the real-world validity of the test. For example, it would be rare to have only video traversing an AP, so the impact of data traffic on a high number of video flows was assessed. The specific video client counts were chosen based on real-world classroom scenarios, so that prospective customers could understand what to expect from each vendor in their actual scenarios.

Overall network capacity is a function of available airtime, protocol efficiency, and QoS-enabled traffic delivery. In all tests, the airtime consumption (channel utilization) was understandably high, often around 75%, indicating that the channel was near its point of saturation. Yet, the Ruckus R610 alone was able to effect strong enough QoS and traffic handling efficiency to achieve the goal of delivering high quality video to each client device, during all tests, despite near-saturated channels.

The author commends the Ruckus team for keeping each test vendor-neutral and fair, and, in fact, always gave the benefit-of-the-doubt, in favor of the competitor, as needed. All results herein were pulled directly from the raw data collected during the testing, without rounding or massaging in any way. The test methodology was fair to and the same for all, and the cards fell where they fell for each vendor.

It is a given that there are more wireless devices and applications running across our networks today than ever before, and understanding *how* these devices are used is critical. With every 802.11 standards upgrade (802.11, 802.11n, and now 802.11ac), data rates increase but better throughput is not a foregone conclusion. Coupled directly to enabling better throughput and ultimately a better user experience are mobility challenges that every network must address. The issues of ping pong, sticky, dominant, and chatty devices are problematic in smaller networks but devastating in high-density venues. Network infrastructure that addresses all of these issues ultimately provides the best aggregate throughput and the best user experience.

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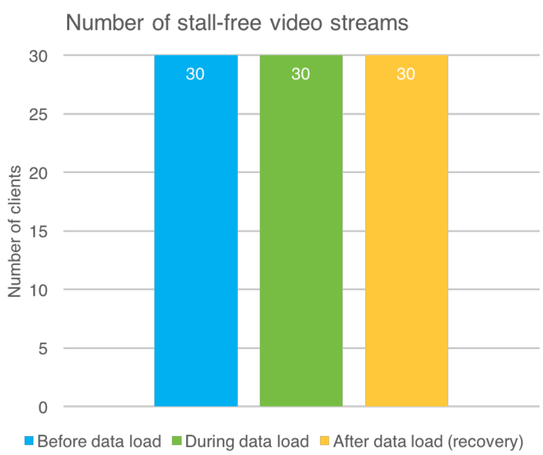
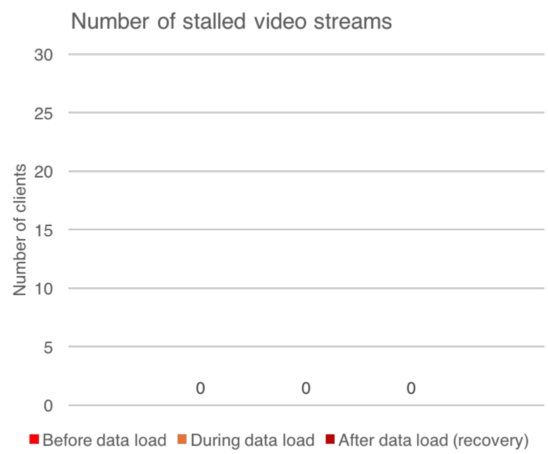
Appendix A: Ruckus R610 Results

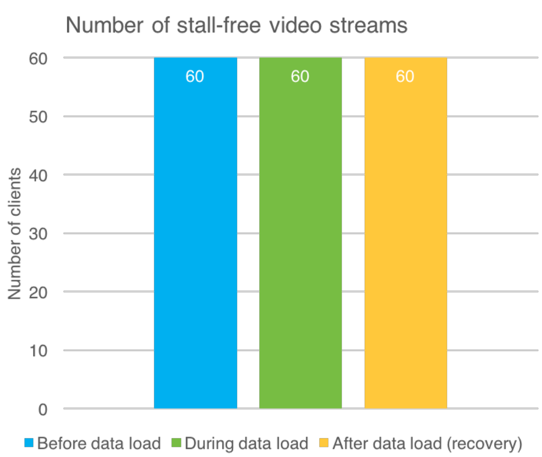
Test 1: 30 Video Clients and 30 Data Clients

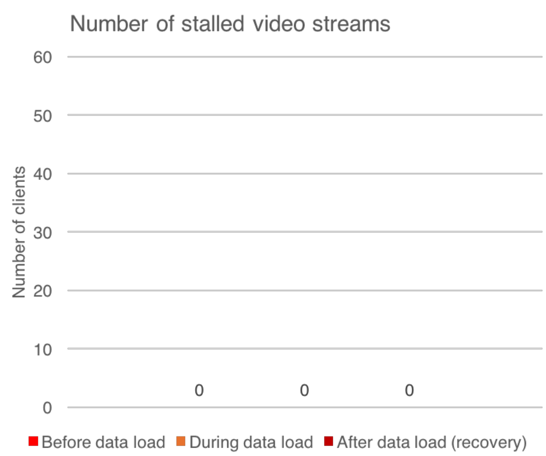




Total stall-free video streams supported with no data load	30 out of 30 (100%)
Total stall-free video streams supported under data load	30 out of 30 (100%)
Total aggregate downlink UDP throughput (30 clients)	201 Mbps

Test 2: 60 Video Clients and 2 Data Clients





Total stall-free video streams supported with no data load	60 out of 60 (100%)
Total stall-free video streams supported under data load	60 out of 60 (100%)
Total aggregate downlink UDP throughput (2 clients)	150 Mbps

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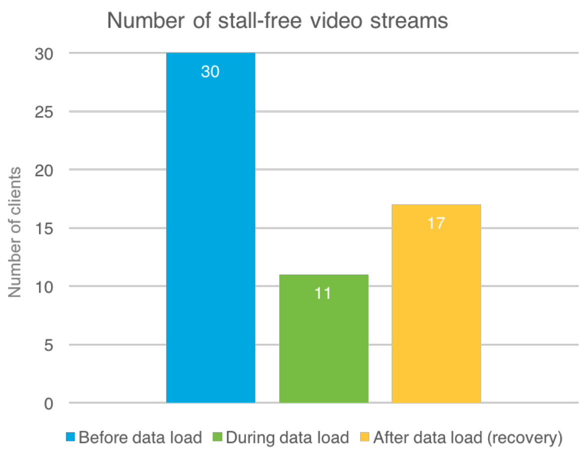
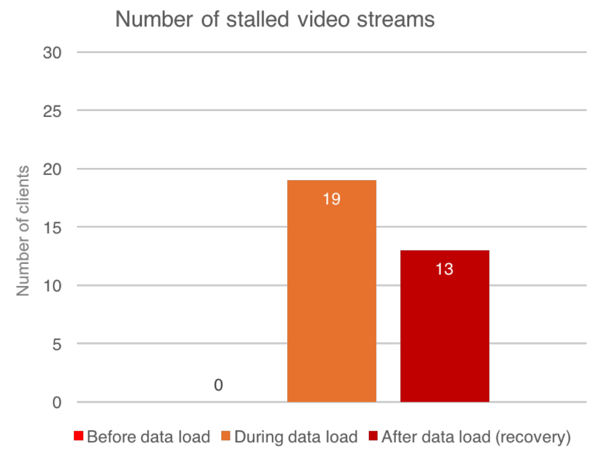
Appendix B: Aruba 305 Results

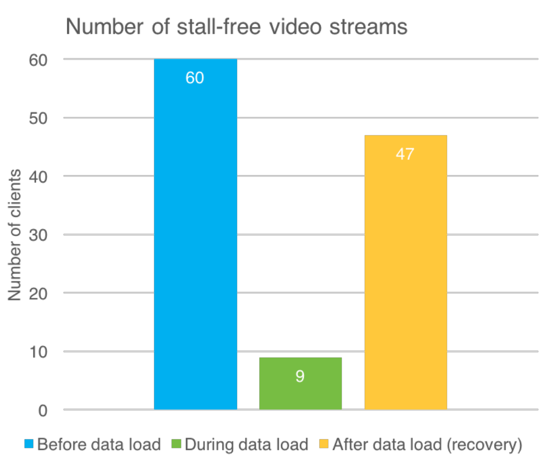
Test 1: 30 Video Clients and 30 Data Clients

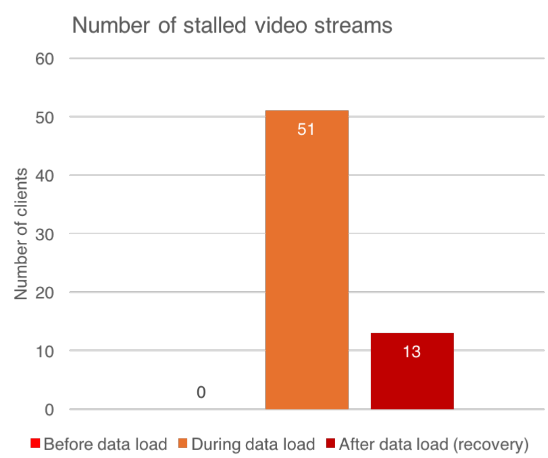




Total stall-free video streams supported with no data load	30 out of 30 (100%)
Total stall-free video streams supported under data load	11 out of 30 (37%)
Total aggregate downlink UDP throughput (30 clients)	76 Mbps

Test 2: 60 Video Clients and 2 Data Clients





Total stall-free video streams supported with no data load	60 out of 60 (100%)
Total stall-free video streams supported under data load	9 out of 60 (15%)
Total aggregate downlink UDP throughput (2 clients)	85 Mbps

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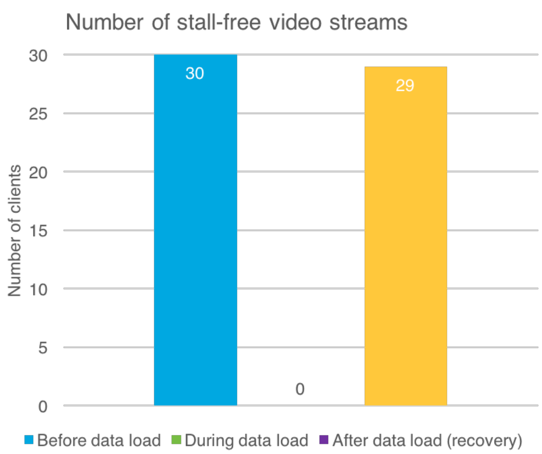
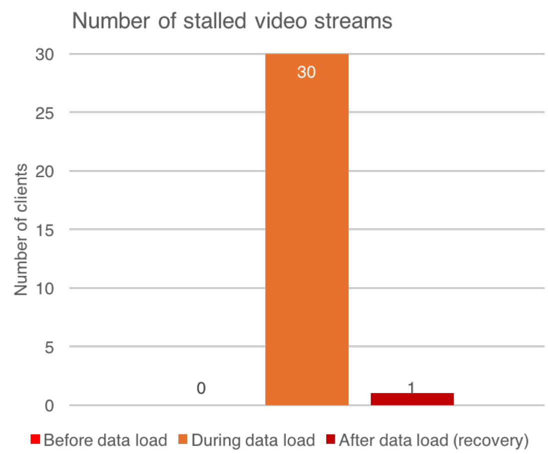
Appendix C: Aerohive AP250 Results

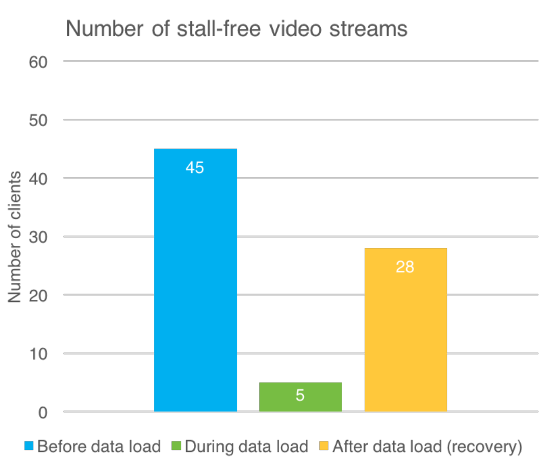
Test 1: 30 Video Clients and 30 Data Clients (Single 5 GHz Radio)

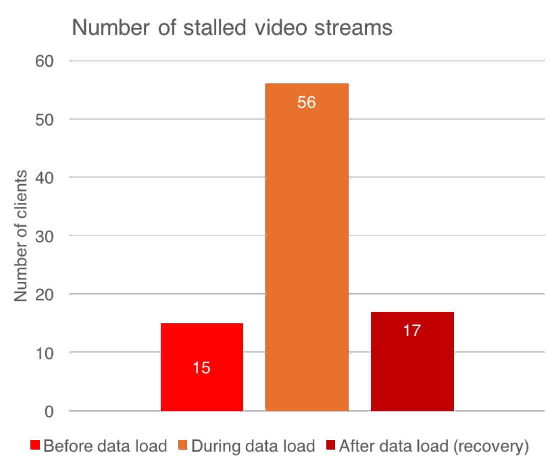




Total stall-free video streams supported with no data load (out of 30)	30 out of 30 (100%)
Total stall-free video streams supported under data load (out of 30)	0 out of 30 (0%)
Total aggregate downlink UDP throughput (30 clients)	95 Mbps

Test 2: 60 Video Clients and 2 Data Clients (Single 5 GHz Radio)





Total stall-free video streams supported with no data load	45 out of 60 (75%)
Total stall-free video streams supported under data load	5 out of 60 (8%)
Total aggregate downlink UDP throughput (2 clients)	78 Mbps

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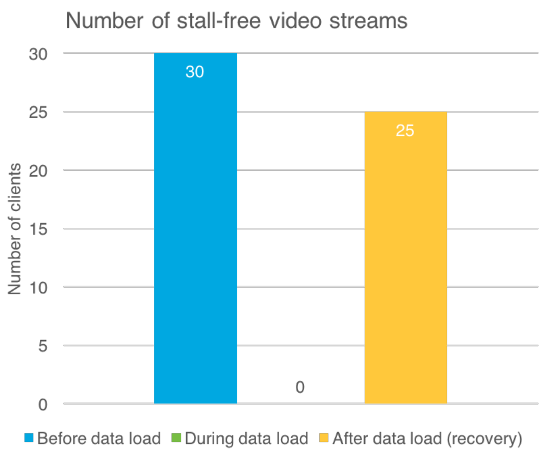
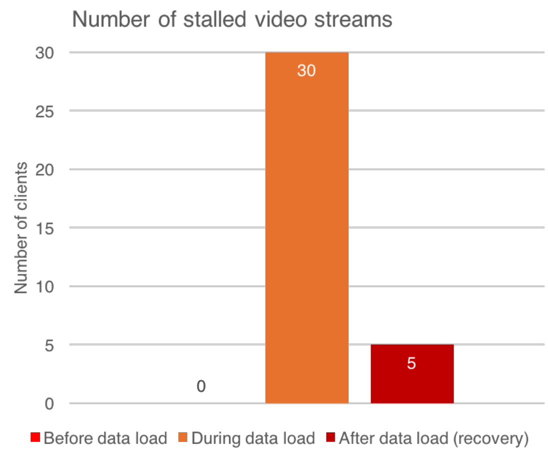
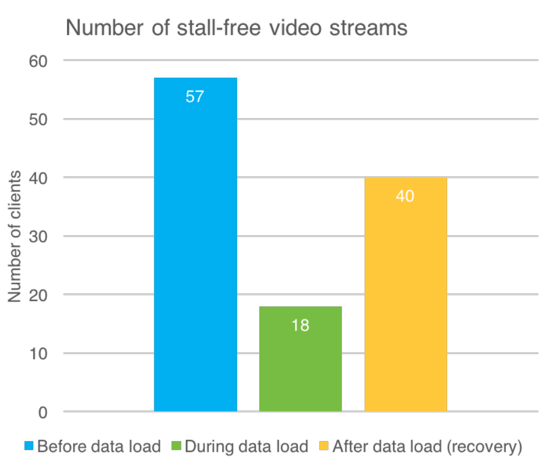
Test 1: 30 Video Clients and 30 Data Clients (Dual 5 GHz Radios)

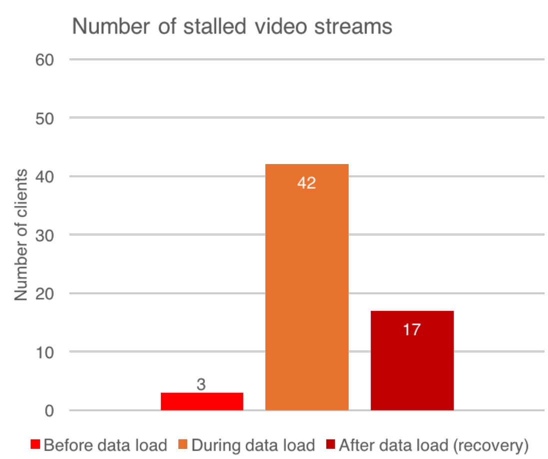




Total stall-free video streams supported with no data load	30 out of 30 (100%)
Total stall-free video streams supported under data load	0 out of 30 (0%)
Total aggregate downlink UDP throughput (30 clients)	94 Mbps

Test 2: 60 Video Clients and 2 Data Clients (Dual 5 GHz Radios)

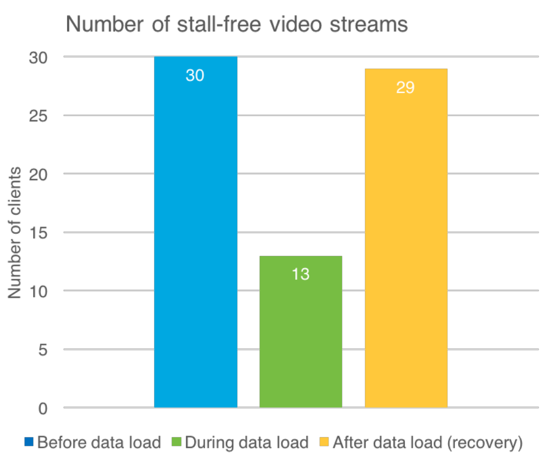


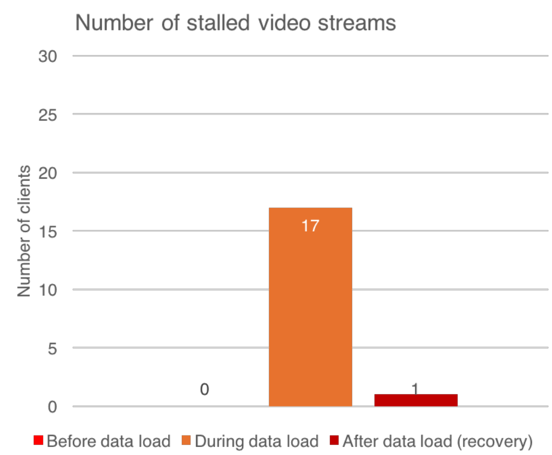


Total stall-free video streams supported with no data load	57 out of 60 (95%)
Total stall-free video streams supported under data load	18 out of 60 (30%)
Total aggregate downlink UDP throughput (2 clients)	73 Mbps

Appendix D: Meraki MR42 Results

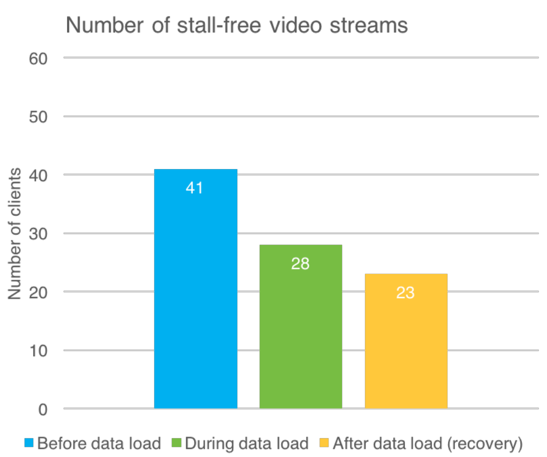
Test 1: 30 Video Clients and 30 Data Clients

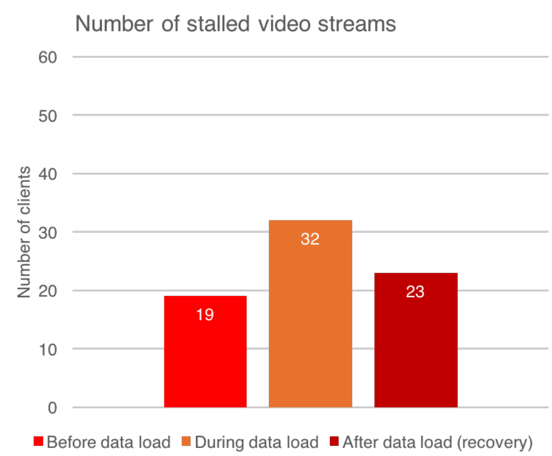




Total stall-free video streams supported with no data load	30 out of 30 (100%)
Total stall-free video streams supported under data load	13 out of 30 (43%)
Total aggregate downlink UDP throughput (30 clients)	120 Mbps

Test 2: 60 Video Clients and 2 Data Clients

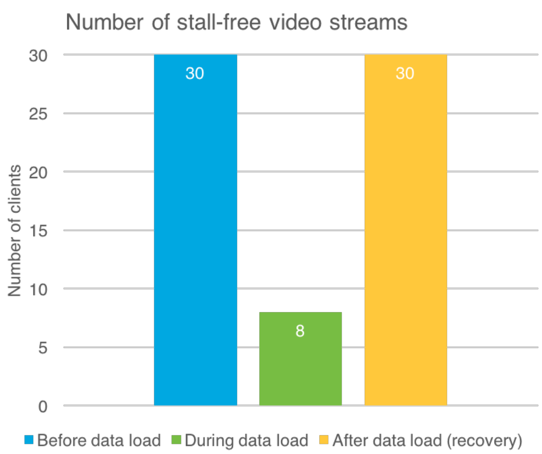


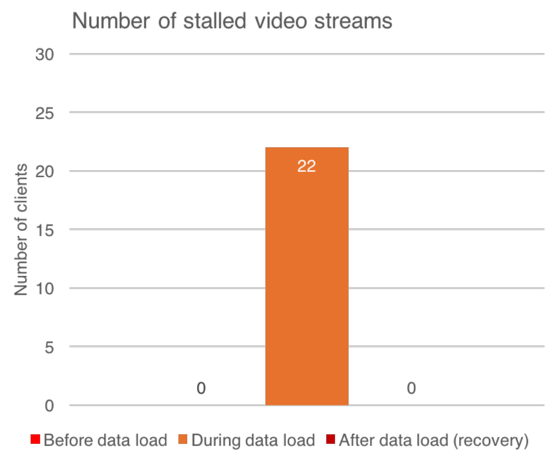


Total stall-free video streams supported with no data load	41 out of 60 (68%)
Total stall-free video streams supported under data load	28 out of 60 (47%)
Total aggregate downlink UDP throughput (2 clients)	62 Mbps

Appendix E: Cisco 1850i Results

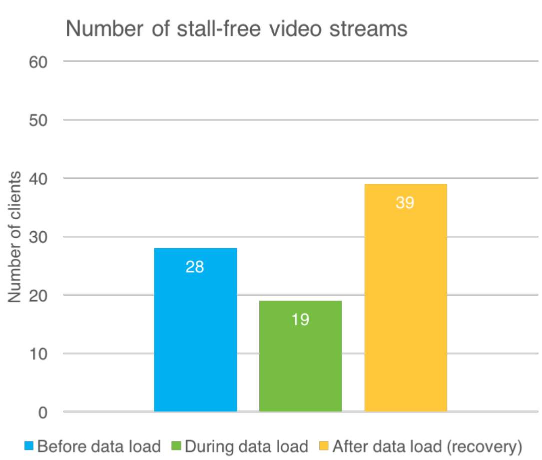
Test 1: 30 Video Clients and 30 Data Clients

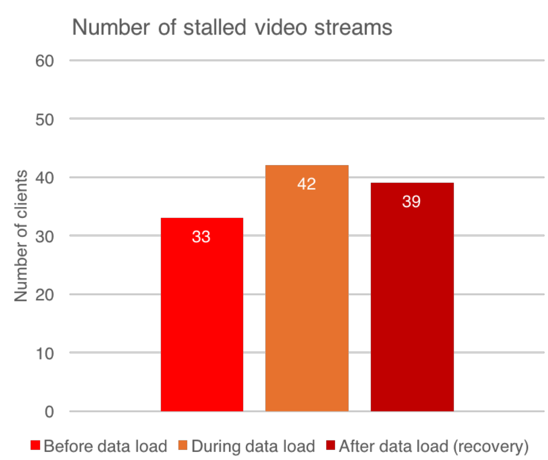




Total stall-free video streams supported with no data load	30 out of 30 (100%)
Total stall-free video streams supported under data load	8 out of 30 (27%)
Total aggregate downlink UDP throughput (30 clients)	96 Mbps

Test 2: 60 Video Clients and 2 Data Clients





Total stall-free video streams supported with no data load	28 out of 60 (47%)
Total stall-free video streams supported under data load	19 out of 60 (32%)
Total aggregate downlink UDP throughput (2 clients)	155 Mbps

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