Dual Channel Wi-Fi
R&D - Wireless

June 2019

revised August 2019

CableLabs®

Dual Channel Wi-Fi™ Performance Test Report

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Executive Summary

The Wi-Fi industry has made advancements to increase the speed of delivering data to multiple clients, but the issue of real-time data delivery persists. CableLabs has developed Dual Channel Wi-Fi technology to help address the real-time delivery issue.

Dual Channel Wi-Fi adds one or more Wi-Fi channels to be used as downstream data-only channels in addition to the typical bidirectional (upstream and downstream) Wi-Fi channels. In using these data-only channels, the access point (AP) no longer faces contention with other devices for airtime when sending data to clients and thus can deliver large amounts of data in real time.

This report outlines the portion of the Dual Channel Wi-Fi testing focused on performance increases gained through implementation. The testing was done at the CableLabs test house and used laptops and a set-top box to mirror residential Wi-Fi deployment and usage. Applications used were IP video streaming, YouTube Live streaming, other video streaming, and FTP downloading. In scenario A, three of the four clients were Dual Channel Wi-Fi capable, and the fourth was a non-Dual Channel Wi-Fi device to show the effect on both types of clients. In scenario B, all four clients were Dual Channel Wi-Fi capable.

Two testing scenarios were used. The first scenario began with two typical Wi-Fi channels, each hosting two clients. The second began with a primary channel and a data-only channel, with all clients on the primary channel. In the first stage of each scenario, Dual Channel Wi-Fi was disabled. The applications were executed, and quality and traffic data were collected. In the first scenario, channels on the AP were designated as primary and data-only channels at this point. In the second stage of each scenario, Dual-Channel Wi-Fi was enabled, putting the clients in Dual Channel Mode. The applications were executed again, and quality and traffic data were collected.

The results showed an improvement in streaming video quality or user experience and an increase in the amount of data moved between the AP and the clients. In both scenarios, prior to enabling Dual Channel Wi-Fi, streaming video exhibited hesitation, pixelation, loss of

audio, and buffering. Enabling Dual Channel Wi-Fi in either scenario resulted in almost instantaneous correction to all video, eliminating all video artifacts. With regards to the FTP download application, the amount of data that could be moved increased 7–12 times.

The results also highlighted several benefits of Dual Channel Wi-Fi: improved user experience, increased downstream data delivery capability, and the flexibility to support clients that are Dual Channel Wi-Fi capable and non-Dual Channel Wi-Fi clients simultaneously.

1 Introduction

1.1 Objective

This test report outlines the results of performance testing conducted on the Dual Channel Wi-Fi implementation. The testing was done at the CableLabs test house and covered two performance scenarios of Dual Channel Wi-Fi: first, with the clients equally distributed across two Wi-Fi channels as the baseline, and second, with all clients on a single Wi-Fi channel as the baseline. The testing environment included a Dual Channel Wi-Fi capable access point (AP) and clients as well as a non-Dual Channel Wi-Fi client (also known as a legacy client).

1.2 Scope

The performance testing was done at the CableLabs test house to mirror a typical Wi-Fi deployment and use case. The testing collected Key Performance Indicators and airtime utilization measurements.

2 Test Strategy

2.1 Equipment and Configuration

- Access point (cable modem) that supports Dual Channel Wi-Fi
- 4 Wi-Fi clients/stations: 3 laptops and 1 set-top box (STB)
  - 3 clients that support Dual Channel Wi-Fi (2 laptops and 1 STB)
    - These clients had one or two radios embedded for support. For the clients with only a single radio embedded, a USB Wi-Fi dongle was used.
  - 1 client that does not support Dual Channel Wi-Fi functionality (1 laptop)
- Traffic end points
  - Server installed on the network to serve as one end point
- Video end points and server
  - Laptop with Plex server installed, including videos
- Laptop capable of running Wireshark on two channels at one time

2.2 Methodology

APs and clients (L1–L4) were positioned at commonly used locations on the two above-ground levels of the test house to best represent a “normal” residential deployment. Details on the test house are given in the next section. The locations and client numbers were recorded along with the test results.

2.3 Test House

The test house is located on a semi-isolated plot (~1.5 acre) in a neighborhood in Brighton, CO. The internal construction includes sheetrock, stone, hardwood, carpet, and ceramic floors, and the external construction is clapboard and brick. The house has a living space of approximately 5,690 ft^2 (553.7 m^2).

Figure 1 - CableLabs' Test House

The test house has three levels or floors: a basement level below-ground and two levels above-ground. Testing devices were placed on the two above-ground levels. Figure 2 shows the floor plan for the lower level (first floor), and Figure 3 shows the floor plan for the upper level (second floor). These figures also show the placement of the AP, test laptops, and STB.

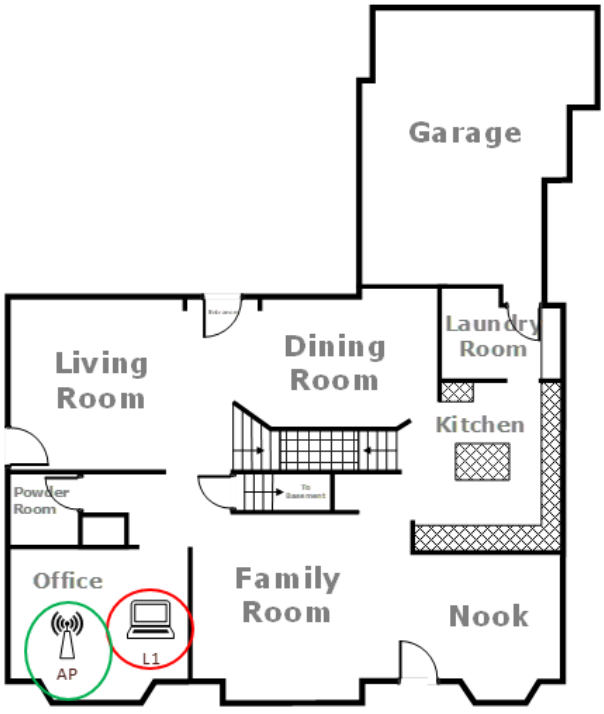

Figure 2 - Floor Plan for First Floor with Test Locations

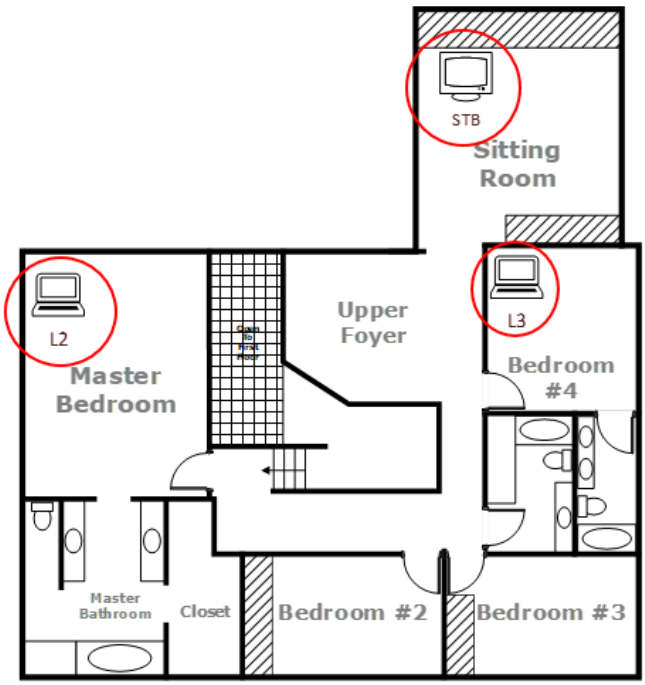

Figure 3 - Floor Plan for Second Floor with Test Locations

3 Dual Channel Performance Test

The performance testing was done in two scenarios, both using 1 AP and 4 clients: three clients were Dual Channel Wi-Fi clients, and one client was a non-Dual Channel Wi-Fi client (Table 1). This configuration was used to show the performance increase for both Dual Channel Wi-Fi and non-Dual Channel Wi-Fi clients. The configuration also shows that Dual Channel Wi-Fi is backward compatible, allowing Dual Channel Wi-Fi and non-Dual Channel Wi-Fi clients to coexist.

TABLE 1 CLIENT TYPE AND CONFIGURATION

	Device	Configuration	Dual Channel Wi-Fi Capable	Location
Client 1	Laptop	Video streaming	No	L3
Client 2	Laptop	Downlink throughput	Yes	L1
Client 3	STB	Video streaming	Yes	STB
Client 4	Laptop	Video streaming	Yes	L2

Three of the clients were configured to execute video streaming applications from different sources: a local video server, an IP video service, and a common video provider (streaming video). The fourth client was configured to perform a high-speed downlink throughput test. One of the video clients was a set-top box; the remaining three clients were laptops.

In the first scenario (Scenario A), the test began with Dual Channel Wi-Fi disabled on the AP. The clients were connected to the AP, with two clients on each of the two channels being used for the testing. The video applications and throughput test were executed, and data and observations were collected. Then, Dual Channel Wi-Fi was enabled on the AP and configured so that one of the channels acted as the primary channel and the other channel as the data-only channel. The video applications and throughput test were executed, and data and observations were collected.

In the second scenario (Scenario B), the test began with Dual Channel Wi-Fi disabled on the AP. The AP was configured with two channels, one acting as the primary channel and the other as the data-only channel. All clients were connected to the AP on the primary channel only. The video applications and throughput test were executed, and data and observations were collected. Then, Dual Channel Wi-Fi was enabled on the AP, putting all clients into Dual Channel Mode, allowing them to connect to the data-only channel. The video applications and throughput test were executed, and data and observations were collected.

3.1 Scenario A Test Results

3.1.1 Introduction

This section provides the test results for scenario A, in which the 4 clients were distributed equally on two unassigned channels during the Non-Dual Channel Mode. After Dual Channel Wi-Fi was enabled, all clients used the primary and data-only channels appropriately.

3.1.2 Observations

Table 2 shows the observations from all four clients for both parts of the scenario. Observations show that issues with video playback were corrected and the throughput speed increased after enabling Dual Channel Wi-Fi. Note that during the Non-Dual Channel Mode portion of the test, which ran for about 3 minutes, client 1 had no observed video artifacts. However, client 1 exhibited video hesitations or glitchy video during longer Non-Dual Channel Mode runtimes; these issues were not observed during the Dual Channel Mode portion of the test.

TABLE 2 SCENARIO A OBSERVATIONS

	Non-Dual Channel Mode	Dual Channel Mode
Client 1	No issues	No issues
Client 2	~8 Mbps	~60 Mbps
Client 3	Video freeze	No issues
Client 4	Slow loading and buffering	No issues

3.1.3 Throughput

In addition to general performance observations, measurements of data throughputs as experienced by the clients were collected. This information shows to which channels the data were moved during Dual Channel Mode and how the data amounts were affected. Table 3 shows the throughput in megabits (Mb) over a 60-second period. The downstream data to the Dual Channel Wi-Fi clients (2, 3, and 4) are split between the primary channel and data channel, with the majority of the downstream data moved over the data channel.

TABLE 3 SCENARIO A THROUGHPUTS

	Non-Dual Channel Mode		Dual Channel Mode: Primary Channel		Dual Channel Mode: Data Channel	
	Downstream	**Upstream**	**Downstream**	**Upstream**	**Downstream**	**Upstream**
Client 1	183.6 Mb	2.9 Mb	229.9 Mb	3.4 Mb	NA	NA
Client 2	163.6 Mb	2.3 Mb	0.016 Mb	8.9 Mb	2212.0 Mb	0
Client 3	58.0 Mb	1.6 Mb	0.089 Mb	1.6 Mb	68.2 Mb	0
Client 4	307.1 Mb	2.6 Mb	0.003 Mb	1.9 Mb	317.9 Mb	0

Table 4 shows the percent difference in throughput between Non-Dual Channel Mode and Dual Channel Mode. All clients saw an increase in downstream throughput after Dual Channel Wi-Fi was enabled. In the upstream direction, however, throughput increased for only two of the clients. Investigation of the decreased upstream throughput for clients 3 and 4 found a reduction in downstream packet loss and errors and the creation of larger packet segments, which resulted in less need for upstream traffic retransmission requests and packet acknowledgement.

TABLE 4 SCENARIO A THROUGHPUT PERCENT DIFFERENCE

	Downstream	Upstream
Client 1	25.6%	17.8%
Client 2	1251.7%	282.1%
Client 3	17.7%	-3.4%
Client 4	3.5%	-25.2%

3.1.4 Airtime Utilization

Information on airtime utilization was also collected in scenario A to show how the AP, clients, and other devices use the airtime of the two channels. Results are shown in Figure 4 (next page). Because this test was run on existing APs that support only dual band configurations, the 2.4 GHz band was used for the primary channel, and the 5 GHz band was used for the data-only channel.

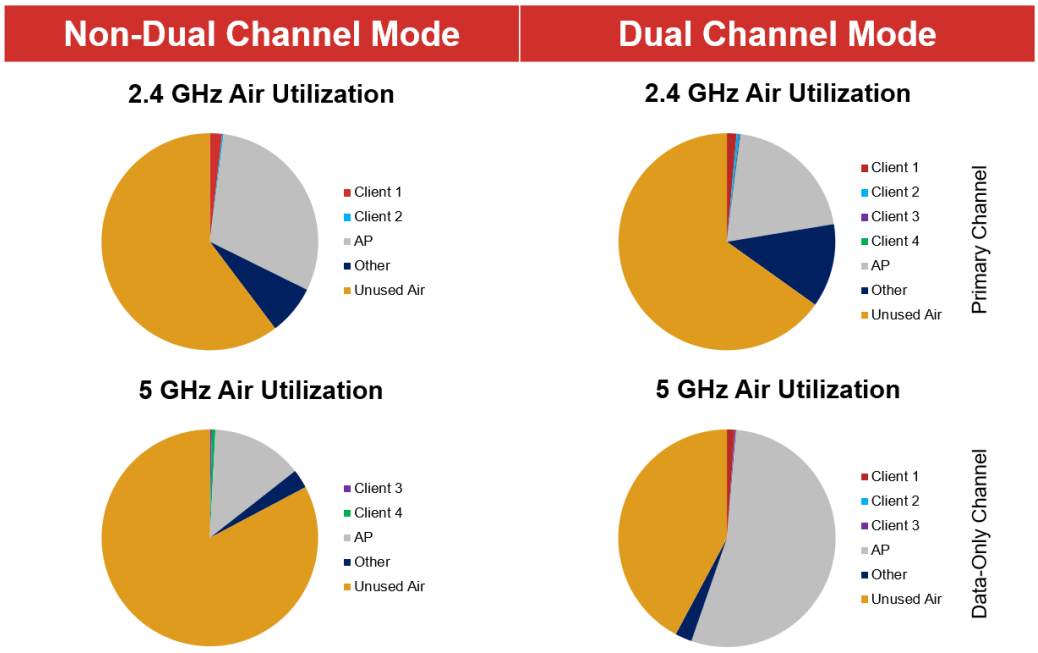

Figure 4 - Scenario A: Airtime Utilization

The airtime utilization measurements for the Non-Dual Channel Mode show that more than half of available airtime was not used (yellow). The results also show that a large portion of the airtime was used by the AP (gray) to deliver data to the clients. The AP used more airtime on the 2.4 GHz channel because the high-throughput client (client 2) was located on this channel.

During the Dual Channel Mode portion of the test, the AP was able to use more than half of the airtime on the 5 GHz channel, where the data-only channel was located, because of reduced contention for use of the channel. Because no other device is using the channel, the Listen-Before-Talk and Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) functions indicate the channel is clear, allowing the AP to transmit data as needed. This freedom to use the data-only channel resulted in the increase in downstream data seen in the throughput results (Table 3). The results also show an increase in airtime utilization by other devices on the channel, showing how Dual Channel Wi-Fi can help the Wi-Fi ecosystem overall.

3.2 Scenario B Test Results

3.2.1 Introduction

This section provides the test results for scenario B, in which the 4 clients used only the primary channel during the Non-Dual Channel Mode. After Dual Channel Wi-Fi was enabled, all clients use the primary and data-only channels appropriately.

3.2.2 Observations

Table 5 shows the observations from all four clients for both parts of the scenario. Observations show that issues with the video playback were corrected and the throughput speed increased after enabling Dual Channel Wi-Fi.

TABLE 5 SCENARIO B OBSERVATIONS

	Non-Dual Channel Mode	Dual Channel Mode
Client 1	Video glitchy	No issues
Client 2	~5 Mbps	~40 Mbps
Client 3	Video freeze	No issues
Client 4	Video glitchy	No issues

3.2.3 Throughput

In addition to general performance observations, measurements of data throughputs as experienced by the clients were collected. This information shows to which channels the data were moved during Dual Channel Mode and how the data amounts were affected. Table 6 shows the throughput in megabits (Mb) over a 60-second period. The downstream data were split between the primary channel and data channel, with the majority of the downstream data moved over the data channel.

TABLE 6 SCENARIO B THROUGHPUTS

	Non-Dual Channel Mode		Dual Channel Mode: Primary Channel		Dual Channel Mode: Data Channel	
	Downstream	**Upstream**	**Downstream**	**Upstream**	**Downstream**	**Upstream**
Client 1	221.9 Mb	3.4 Mb	0.22 Mb	4.1 Mb	246.9 Mb	0 Mb
Client 2	283.1 Mb	3.0 Mb	0.02 Mb	10.6 Mb	2302.1 Mb	0 Mb
Client 3	130.8 Mb	4.6 Mb	0.23 Mb	17.2 Mb	139.0 Mb	0 Mb
Client 4	3083.7 Mb	2.9 Mb	0.04 Mb	4.0 Mb	644.4 Mb	0 Mb

Table 7 shows the percent difference in throughput between Non-Dual Channel Mode and Dual Channel Mode. In this scenario, all clients saw an increase in throughput in both directions after Dual-Channel Wi-Fi was enabled.

TABLE 7 SCENARIO B THROUGHPUT PERCENT DIFFERENCE

	Downstream	Upstream
Client 1	11.4%	20.4%
Client 2	7131.9%	256.9%
Client 3	6.4%	2.7%
Client 4	20.9%	35.3%

4 Dual Channel Performance Test Conclusions

Based on the results of CableLabs testing, the user experience was improved by the introduction of Dual Channel Wi-Fi. Testing also showed that, in addition to improving the user experience, Dual Channel Wi-Fi aided in the delivery of data to devices and improved utilization of available airtime. Dual Channel Wi-Fi implementation has positive impacts on both Dual Channel Wi-Fi clients and non-Dual Channel Wi-Fi or legacy clients, which enables deployment of Dual Channel Wi-Fi into the ecosystem without requiring all clients to be Dual Channel Wi-Fi enabled.

Additional testing not reported on here covered the areas of protocol exchange, stability, and reconfiguration or moving of devices across multiple data-only channels. Results of those tests supported expanded functions of Dual Channel Wi-Fi suitable for use not only in the home but also in large venues where multiple data-only channels would benefit the user experience.

Revision History

Date	Nature of change
July 24, 2019	Table 1: Column added to identify clients by test house location IDs
August 9, 2019	Tables 3 and 6 and related text: Unit of measurement corrected from “MB” to “Mb”