TalkTalk Wi-Fi Hub
Marketing Claims Substantiation

July 2018
Version 1.0

Contents

Introduction

The TalkTalk Wi-Fi Hub offers a Wi-Fi signal that can't be beaten by any of the other big providers. This report details the rigorous independent testing of the TalkTalk Wi-Fi Hub compared to the routers from the other big providers. It also evidences the data we gathered that allows us to make the claim that no other router from a big provider can outperform the TalkTalk Wi-Fi Hub in terms of Wi-Fi signal performance.

The testing was conducted by Cartesian, a highly-respected independent telecommunications consultancy company. The tests were developed with consideration to previous ASA rulings on claims around Wi-Fi and router performance.

Testing was carried out in a controlled environment using clients that represent the types of devices found in UK homes. A detailed description of the test methodology is given below.

Additional tests were carried out comparing the TalkTalk Wi-Fi Hub with the BT Smart Hub (Type A) in the presence of co-channel interference. See page 11.

We also carried out performance tests on the BT Smart Hub (Type B) which BT supply under the brand name "BT Smart Hub". See *13BT Smart Hub Type B* on page 13 for further detail.

How we tested the TalkTalk Wi-Fi Hub

Which routers did we test?

Testing was carried out against the routers from the major broadband providers in the UK market. The table below details the routers tested, and their Wi-Fi specification.

Most modern Wi-Fi routers, including all that we tested, feature dual-band Wi-Fi. This means that the routers use both 2.4 GHz and 5 GHz frequencies to deliver a Wi-Fi signal. These bands differ in terms of performance over distance:

- 5 GHz offers faster data rates over a shorter distance
- 2.4 GHz travels further but at slower speeds.

Router Name	**2.4 GHz Wi-Fi Band**	**5 GHz Wi-Fi Band**
TalkTalk Wi-Fi Hub	3x3 b/g/n	4x4 a/n/ac
BT Smart Hub (Type A)	3x3 b/g/n	4x4 a/n/ac
Sky Q Hub (ER110)	2x2 b/g/n	3x3 a/n/ac
Virgin Media Hub 3.0	2x2 b/g/n	3x3 a/n/ac
Plusnet Hub One	2x2 b/g/n	3x3 a/n/ac
Vodafone HHG2500	2x2 b/g/n	3x3 a/n/ac

Test location

Testing was conducted at Cartesian's 'Rose Farm' Wi-Fi test house, a two-storey, three-bedroom brick-built building. Located in a quiet rural location in the south of England, Rose Farm is a detached house, with trees to one side of the house and open arable land to the other side.

There are no immediate neighbours, so the test house suffers no Wi-Fi interference. This is measured before and during each test.

What did we test?

When considering Wi-Fi performance, Transmission Control Protocol (TCP) throughput matters the most. This is what customers would experience as Wi-Fi performance in their homes. The protocol determines the performance of the Wi-Fi experience; how applications connect to the internet and the activities they perform: browsing the web, downloading a file, streaming a film.

The most representative measure for Wi-Fi performance is the download and upload TCP throughputs.

The testing looked to determine the raw Wi-Fi TCP throughput performance of the routers, measuring their performance when devices were placed at various test locations throughout the Wi-Fi test house.

Devices used in the tests

Wi-Fi client devices can be categorised according to the number of antennae the device has. A device with one transmit and one receive antenna, which are usually combined into a single physical antenna, is called 1x1. Likewise, a device with two antennae for transmit and two for receive is called 2x2, and one with three antennae for transmit and three for receive is called 3x3.

We selected one of each device category, as all three device categories are seen in UK homes:

- MacBook Pro Retina 13 laptop (Wi-Fi 3x3, Windows 10)
- iPad Air 2 tablet (Wi-Fi 2x2, iOS)
- HTC One M8 smartphone (Wi-Fi 1x1, Android)

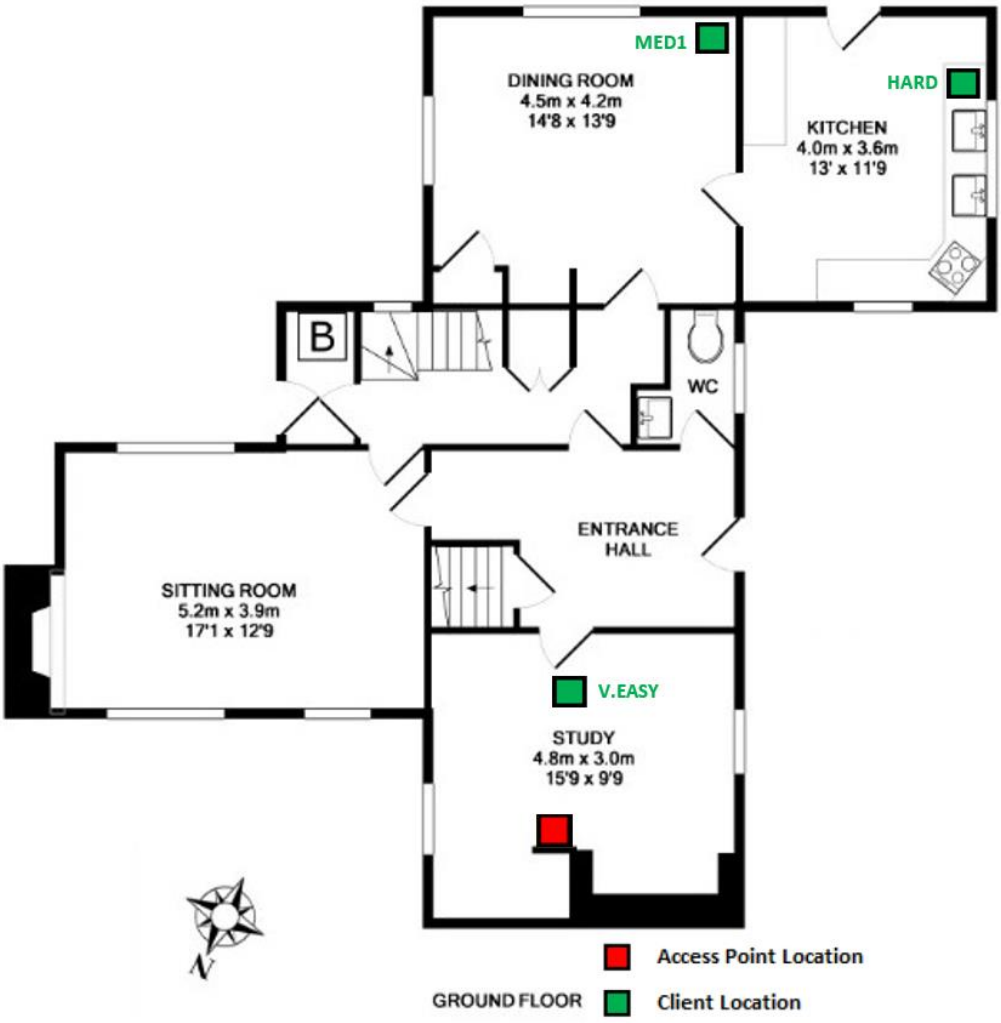
How the tests were conducted

Given that the testing was looking to measure Wi-Fi performance, the Wi-Fi range was the variable in the test. Different locations were chosen within the test home to test the ranges of the routers. Each router was located in the same spot within the home, with the position on the table permanently marked to allow for repeatability. The three test devices were then placed in these various locations, and the Wi-Fi signal tested for each of the routers.

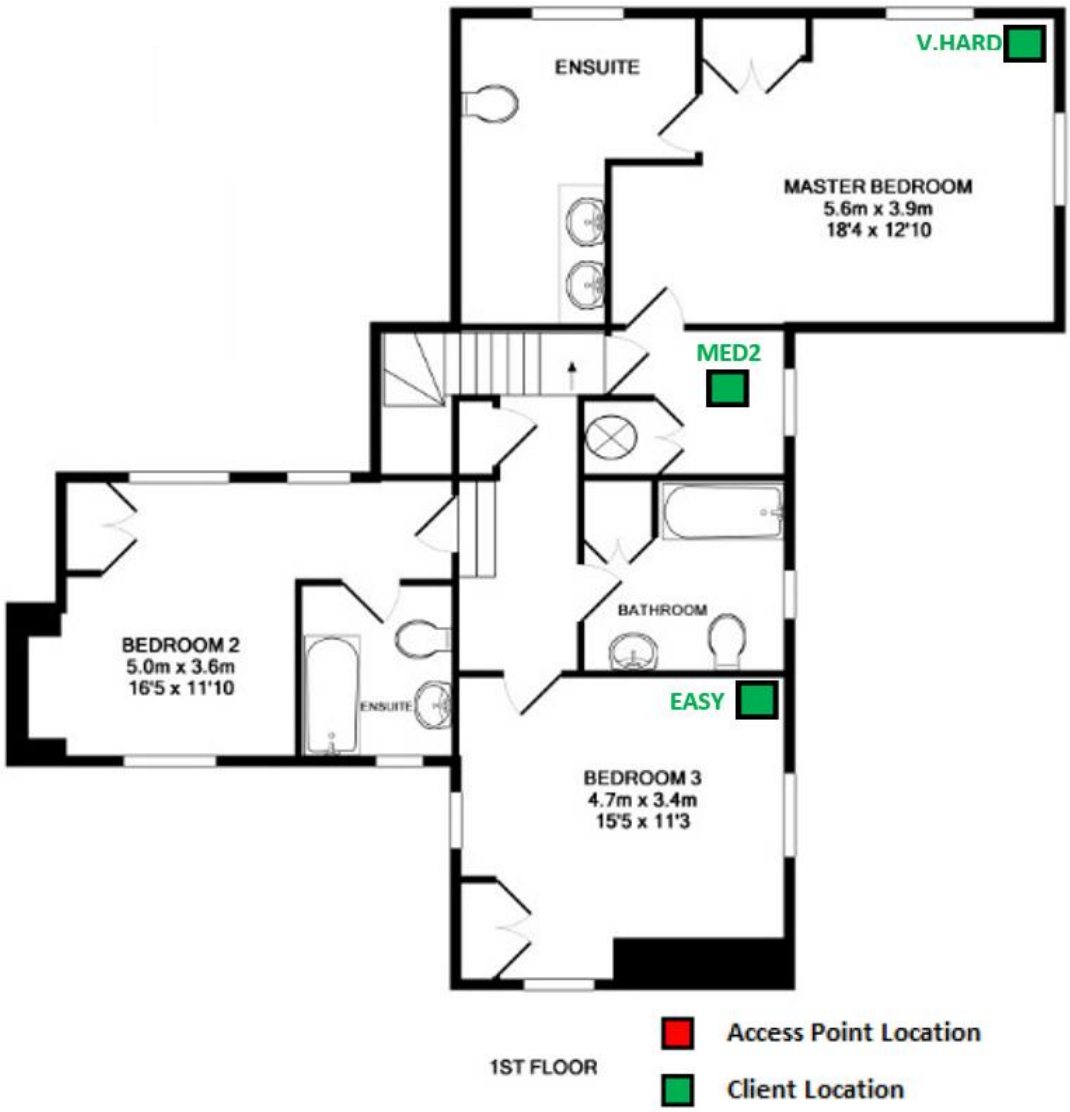
Six client locations were chosen to represent varying degrees of difficulty connecting to the router. The floorplans of the Wi-Fi test house, shown below, clearly show the environment and the walls between the router under test and the six client locations.

Type	Location	Client Code
Very Easy Location	Study (Line of Sight)	CL LOS
Easy Location	Bedroom 3	CL BR3
Medium Location	Dining Room	CL DR
Medium Location	Dressing Room	CL BR0
Hard Location	Kitchen	CL KI
Very Hard Location	Master Bedroom	CL MBR

Each router under test was placed in the study, on the ground floor. The clients were then placed in the marked locations, upstairs and downstairs and the results of the Wi-Fi throughput performance tests were recorded in spreadsheets which itemised each run. This included each of the three 1-minute test runs.



Router and Client Locations – Ground Floor



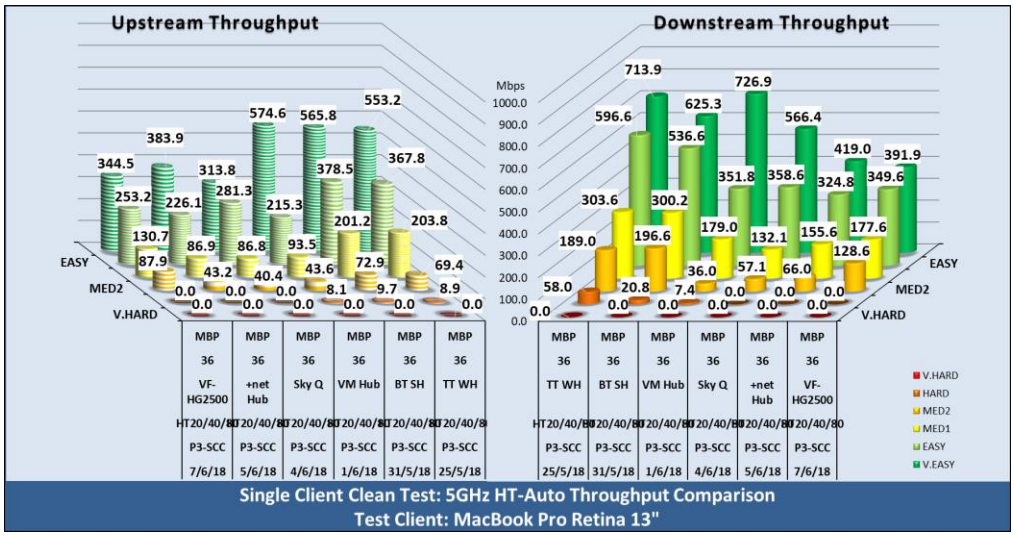
Router and Client Locations – First Floor

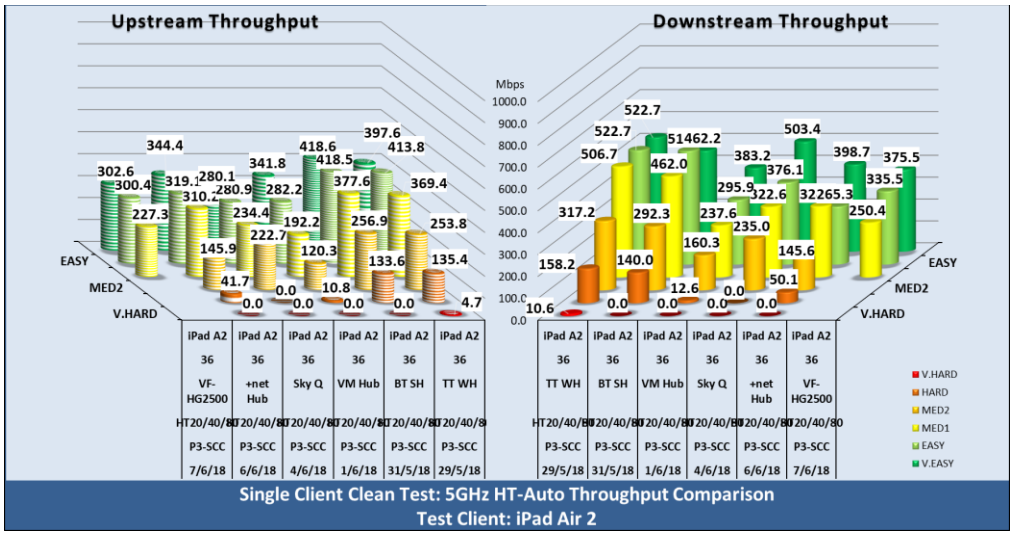
Wi-Fi Testing Methodology

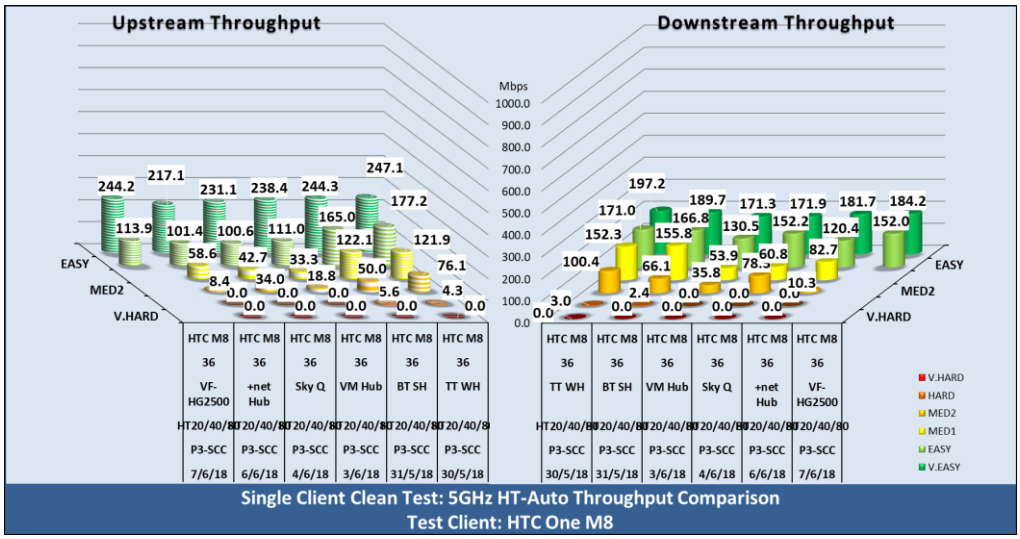
- Testing takes place in an environment the best approximates ‘real-world’ conditions.
- The industry-standard IxChariot tool was used to generate network traffic and measure the Wi-Fi throughput performance of the router under test.
- For each location of the client, IxChariot is used to conduct several tests to measure the data throughput between the router and the client.
- Each test was run for a duration of 1 minute and is averaged by repeating 3 times. Test files are transmitted using Transmission Control Protocol (TCP) except where noted.
- Tests were run using IxChariot in batch mode with out-of-band management (if wired connection available).
- Throughput measurements were taken uni-directionally, from router to client (downstream) and client to router (upstream).
- Only non-intrusive empirical performance throughput testing was conducted.
- 2.4 GHz tests were conducted in HT20 mode (Channel 6); 5 GHz tests were conducted in HT80 bandwidth mode (Channel 36).
- AirMagnet running in passive mode would alert the test engineer if the ongoing test is not within the desired band and channel.
- Continuous passive monitoring of the RF spectrum (technology agnostic) ensured interference free testing and also ensured testing was being carried out in desired band.
- There was no external internet access to/from router under test.
- All tests were performed with the WPA2-personal encryption turned on.
- Ethernet connectivity was provided via LAN port 1 on each test router.
- All router settings were as default.
- The routers and clients were tested as they are designed to stand, either vertical or horizontal with the face pointing forward and sitting on shelves as they would typically be used.
- Clients device were oriented in a single position only, with the front of the client facing in the direction of the router.

Test Results

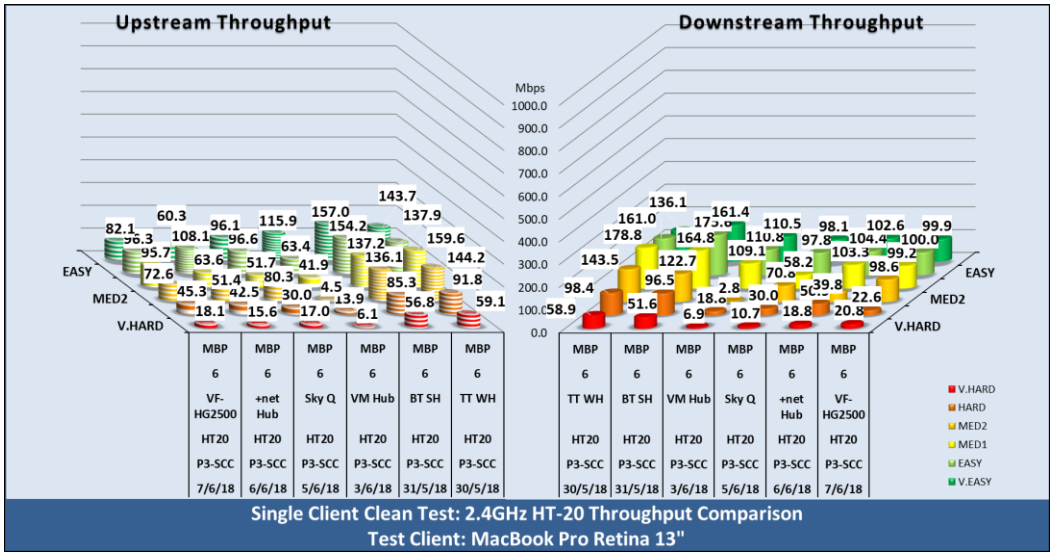
Results for the 5GHz testing

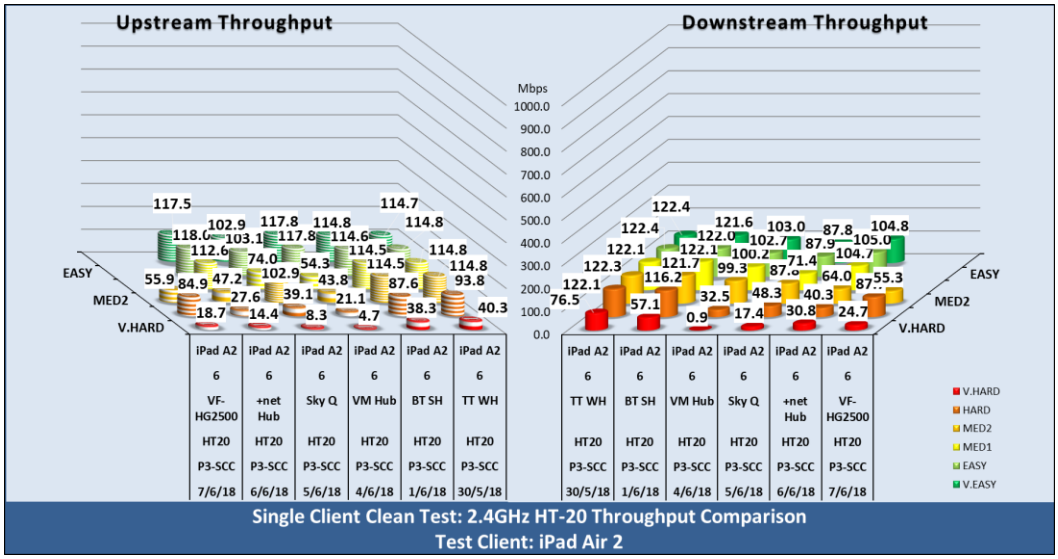


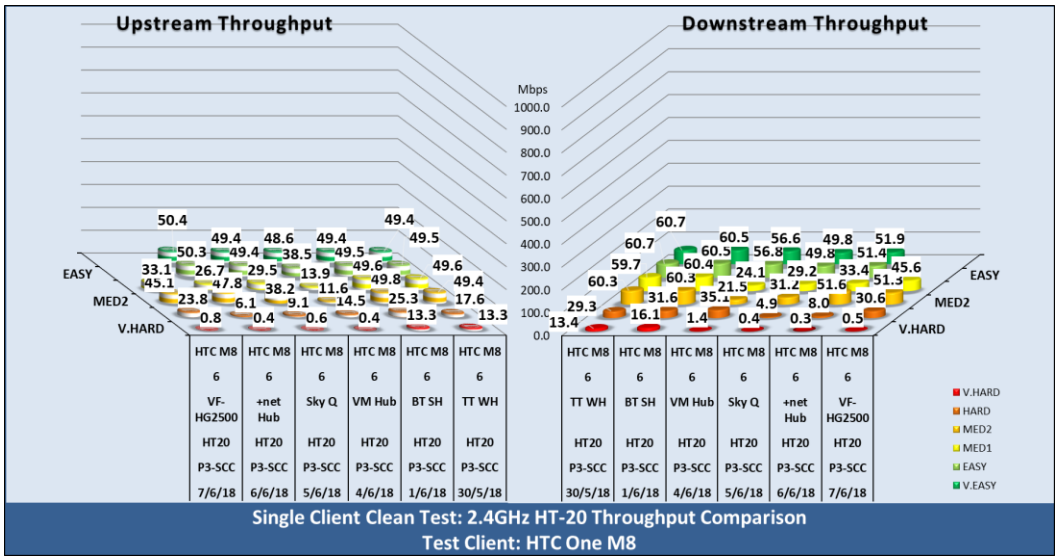




Results for the 2.4 GHz testing







The effect of interference on Wi-Fi performance

It is generally accepted that in order to establish a Wi-Fi performance baseline, all testing is done in a 'clean' environment, free from Wi-Fi, Bluetooth, microwave oven and other interference. By testing in a clean environment, it is possible to establish the relative performance of one router to another, in a manner that is repeatable, and that generates data which can be relied upon.

Cartesian's test house, Rose Farm, is isolated from other homes, to prevent unwanted interference. Before and during each test, the radio frequencies (RF) environment is monitored to ensure there is no interference.

Most real homes have sources of RF interference that reduces Wi-Fi performance from the 'clean' baseline. To understand how interference from a neighbouring Wi-Fi router affects the performance of the TalkTalk Wi-Fi Hub and the BT Smart Hub (Type A), further tests were carried out using the following method:

- Throughput tests were performed in the presence of congestion, called "co-channel interference"
- The test house was configured as per Cartesian's "Apartment Scenario" where the ground floor hosts the devices under test and the upper floor acts as a neighbouring apartment where interfering routers and clients are located.
- A Neighbouring Access Point (NAP) located in Bedroom 3, streaming 10 Mbps (2.4 GHz) or 20 Mbps (5 GHz) Wi-Fi traffic to each of the two clients (an iPad Air placed at the NAP and a Dell Venue 11 Pro Tablet placed on the landing), were used to create Wi-Fi congestion.
- The NAP provided co-channel interference (Channel 6, HT20, 2.4 GHz; Channel 36 HT-Auto, 5 GHz).
- Three downstairs client device locations were used – Easy (Study/LoS), Medium (Dining Room) and Hard (Kitchen) – these being the three downstairs test locations for the earlier Single Client Clean Test.
- Download and upload throughput performance measurements were performed in the following operational modes:
    - 2.4 GHz 802.11n HT20 mode on Channel 6.
    - 5 GHz 802.11ac HT-Auto mode on Channel 36.
- TCP traffic was used for these empirical tests.
- The NAP used was a Virgin Media Super Hub 2ac and it was configured as per the same settings in DUT.

The results show that both routers experienced a decrease in performance, which is to be expected, and that the TalkTalk Wi-Fi Hub and the BT Smart Hub (Type A) experience similar levels of performance decrease.

	Client Devices					
	HTC M8s		iPad Air 2		MacBook Pro	
Client Location	BT Smart Hub (A)	TalkTalk Wi-Fi Hub	BT Smart Hub (A)	TalkTalk Wi-Fi Hub	BT Smart Hub (A)	TalkTalk Wi-Fi Hub
Very Easy	26% ▼	25%▼	38%▼	20%▼	30%▼	17%▼
Medium (1)	34%▼	26%▼	30%▼	30%▼	46%▼	39%▼
Hard	34%▼	43%▼	46%▼	48%▼	8%▼	55%▼

Performance decrease in average upload and download throughput with co-channel congestion

BT Smart Hub Type B

The BT Smart Hub is produced by two different manufacturers. Despite featuring different components, these two products are both marketed under the same name of 'BT Smart Hub'. They are visually identical and even have the same user interface.

Upon testing the two versions (Type A and Type B), it was found that there was a difference in the Wi-Fi performance between the two. The testing conducted shows that the Wi-Fi performance of the BT Smart Hub (Type B) is materially worse than the BT Smart Hub (Type A).

The first variant is the BT Smart Hub (Type A) which features Broadcom Wi-Fi processors and is manufactured by Sagemcom Broadband SAS. The second is the BT Smart Hub (Type B) which has Qualcomm Wi-Fi processors and is manufactured by the Arcadyan Technology Corporation.

Hundreds of tests were conducted to compare the relative performance of the BT Smart Hub (Type A) and the BT Smart Hub (Type B) and the results presented below represent the average decrease in performance for the three client device types (1x1, 2x2 and 3x3) in six test locations.

Test Location	**BT Smart Hub (Type B)** 2.4 GHz relative performance	**BT Smart Hub (Type B)** 5 GHz relative performance
V.EASY	2% ▼	2% ▼
EASY	14% ▼	17% ▼
MED1	18% ▼	2% ▼
MED2	19% ▼	13% ▼
HARD	16% ▼	80% ▼
V. HARD	25% ▼	100% ▼ (no coverage)

Percentage decrease in relative performance of the BT Smart Hub (Type B) vs the BT Smart Hub (Type A)

These results clearly show that the BT Smart Hub (Type B) performs worse than the BT Smart Hub (Type A).

Conclusion

The purpose of this report is to evidence the facts that support our claim, that the TalkTalk Wi-Fi Hub offers a Wi-Fi signal that can't be beaten by any of the other big broadband providers.

In this context, "Wi-Fi signal" means the signal at both 2.4GHz and 5GHz bandwidths. Consideration must be made of both bands, as all routers supplied by the big providers are dual band (i.e. they use both 2.4GHz and 5GHz).

It is clear from the tests that the TalkTalk Wi-Fi Hub and the BT Smart Hub (Type A) both offer significantly better Wi-Fi performance than the routers provided by Virgin Media, Sky, Plusnet and Vodafone.

What the data shows is that the Wi-Fi performance of the TalkTalk Wi-Fi Hub and the BT Smart Hub is very similar. In most tests the TalkTalk Wi-Fi Hub performs better than the BT Smart Hub (Type A) and in a few tests the BT Smart Hub (Type A) performs better than the TalkTalk Wi-Fi Hub.

When all results are looked at and compared, it is true to say that the TalkTalk Wi-Fi Hub offers a Wi-Fi signal that can't be beaten by any of the other big providers.

Appendices

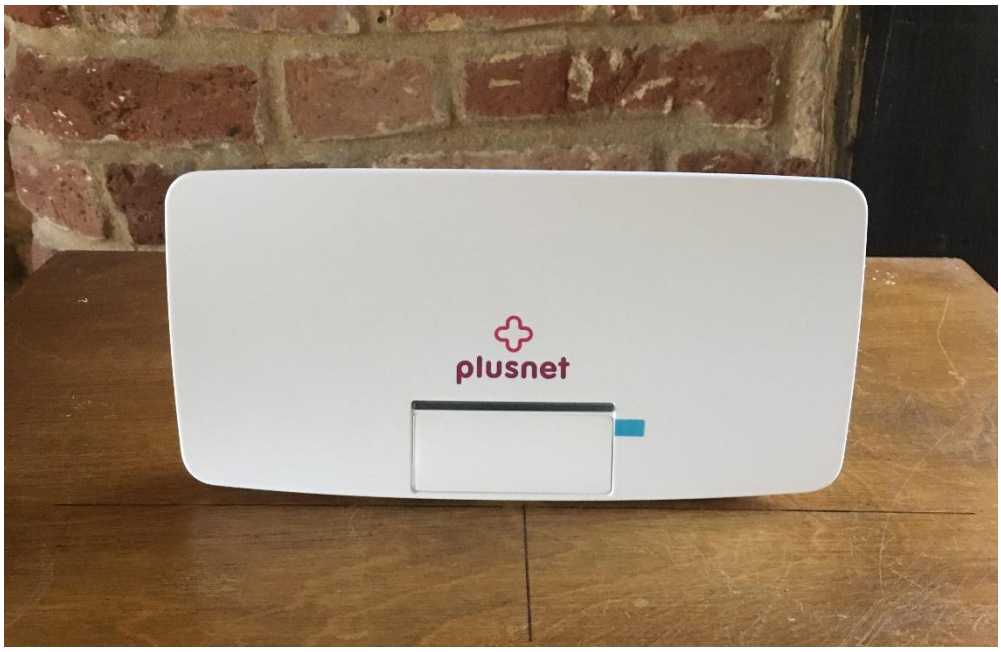
Appendix A: Router Photos

TalkTalk Wi-Fi Hub

BT Smart Hub (Type A)

Virgin Media Hub 3.0

Sky Q Hub (ER110)



Plusnet Hub One

Vodafone HHG2500

Appendix B: Router Details

Router 1	TalkTalk Wi-Fi Hub
Manufacturer/Model	Sagemcom/Wi-Fi Hub
Serial Number	N7173624N000042
MAC Address	D8:D7:75:40:8E:32
Router 2	**BT Smart Hub (Type A)**
Manufacturer/Model	BT Hub 6A (Smart Hub)
Serial Number	+084319+NQ73121154
MAC Address	B8:D9:4D:5A:D4:31
Router 3	**Virgin Media Hub 3.0**
Manufacturer/Model	Arris/Hub 3.0
Serial Number	AAAP63377437
MAC Address	C0:05:C2:FF:50:A3
Router 4	**Sky Q Hub (ER110)**
Manufacturer/Model	Sky/ER110
Serial Number	AC10165B003728
MAC Address	90:21:06:54:D5:C8
Router 5	**Plusnet Hub One**
Manufacturer/Model	Sagemcom/253633882
Serial Number	NQ74805770
MAC Address	D8:D7:75:B9:BA:E4
Router 6	**Vodafone HHG2500**
Manufacturer/Model	Huawei/HHG2500
Serial Number	51211H0005843
MAC Address	74:A5:28:21:E5:26

Appendix C: Client Details

Client 1	Wi-Fi 44	
Manufacturer / Model	MacBookPro12,1 (MacBook Pro Retina, 13-inch, Early 2015)	
Capability	802.11ac	
Antennae	2.4 GHz – 3 x3	5 GHz – 3 x 3
Chipset	BCM43602	
Software Version	Dual-Boot MacOS 10.11.2 / Windows 10	
Hardware Version	15E65	
Serial Number	C02QFV7RFVH3	
MAC Address	AC:BC:32:A5:5E:61	
Client 2	**Wi-Fi 65**	
Manufacturer / Model	Apple iPad Air 2	
Capability	802.11ac	
Antennae	2.4 GHz – 2 x 2	5 GHz – 2 x 2
Chipset	Apple	
Software Version	iOS 10.3.2	
Serial Number	DMPQ75HXG5VT	
MAC Address	04:69:F8:0D:CC:2D	
Client 3	**Wi-Fi 52**	
Manufacturer / Model	HTC One M8	
Capability	802.11ac	
Antennae	2.4 GHz – 1 x 1	5 GHz – 1 x 1
Chipset	QUALCOMM WCN3680	
Software Version	Android 6.0.1	
Serial Number	FA55SYS01858	
MAC Address	90:E7:C4:E6:6E:B4	

Appendix D: IxChariot Configuration Details

Home Network (Test 1)	
IxChariot Console Version	9.5 EA SP3 Build 9.4.15.5
IxChariot Console System Details	Power Edge T430 Server, Dual Intel Zeon E5 3 GHz
IxChariot Endpoint Version	9.5 EA 102
Network Protocol	TCP High Performance (using default settings shown below)

Parameter	Current Value	Default Value	Comment
Initial Delay (ms)	0	0	Delay before starting …
Source Port	Auto	Auto	What port to use for s…
Destination Port	Auto	Auto	What port to use for d…
Data Rate	Unlimited	Unlimited	How fast to send data
Data Type	NOCOMPR…	NOCOMPRESS	What type of data to s…
Send Buffer Size	65535	65535	How many bytes of d…
Receive Buffer Size	65535	65535	Maximum number of …
MSS	Default	Default	Maximum payload si…
Send Socket Buffer for Source	Default	Default	The send socket buffe…
Send Socket Buffer for Destination	Default	Default	The send socket buffe…
Receive Socket Buffer for Source	Default	Default	The receive socket bu…
Receive Socket Buffer for Destinat…	Default	Default	The receive socket bu…
Nagle Algorithm for Source	Enabled	Enabled	Enable or disable the …
Nagle Algorithm for Destination	Enabled	Enabled	Enable or disable the …
TCP Disconnect Type	Reset	Reset	How TCP connection…

Details of IxChariot Test Setup

Client	OS	Endpoint Version
MacBook Pro (Wi-Fi 44)	Windows 10	9.5 EA 102
iPad Air 2 (Wi-Fi 65)	iOS	9.5 EA 102
HTC One M8 (Wi-Fi 52)	Android	9.5 EA 112

Details of IxChariot Client Endpoints

Cartesian have been commissioned by TalkTalk to test the Wi-Fi performance of their Wi-Fi Hub against routers from other big providers. We hereby certify that the results in this report are accurate and were measured under controlled conditions as described in the test methodology section of the report.

Graham Harvey
Head of Wi-Fi Testing
Cartesian