Introduction

Thanks

We'd like to express our sincere gratitude to everyone who has supported us in this project: Users, Journalists, Analysts, Activists, Community Groups, the ISPs, Ofcom and most recently Stephen Carter and his team. We'd also like to thank the Broadband Stakeholder Group.

SamKnows

Incorporated in 2008, SamKnows.com started in 2003 to track the rollout of Broadband and LLU.

SamKnows runs a free broadband availability service via SamKnows.com, we also comment on Broadband and 'Digital Britain' related events and news on the site and will shortly be adding a sample of data from our Performance Network Project with Ofcom.

The site also provides data via feeds to analysts, retailers and researchers on a subscription basis.

Background to Project

This is a project that has been in the back of our minds for a while as something that would interest us as users. We developed the solution and posted an article on SamKnows.com asking for volunteers. (SamKnows receives approx. 1.5 million page impressions a month).

Our article was picked up by The Register (thank you to Chris Williams) and we received over 1,250 volunteers within 5 hours.

In August 2008 we published our first report based on this volunteer panel, this was covered by a number of media outlets, notably Barry Collins at PC Pro and again Chris Williams at The Register. This also led to a number of interesting calls, one of which was from a research team at Ofcom.

We met with Ian Macrae and Richard Moore for an initial conversation about our respective projects, we subsequently agreed to combine the projects with SamKnows as Ofcom's technical partner.

The outcome of this is the 2008 UK Broadband Speeds Report. This concentrated on aggregated data, the follow-up, due in Spring of 2009 is planned to be significantly more detailed.

Methodology

Overview

The project uses hardware units installed in participants' homes to perform the tests. The chosen hardware is the Linksys WRT54GL router (although it should be noted that the device operates in a bridging mode, rather than routing). The unit sits between the participant's existing router and the rest of their network, so allowing the performance monitoring unit to determine when the network is free to run tests.

A customised FreeWRT firmware image has been developed and is installed on the units. At the point of delivery, this is all that is present on the device; apart from a single script that checks for the availability of the software component at boot-up, the physical unit contains no additional software. This is beneficial both from a security perspective (everything is destroyed when the power is lost) and also from a support perspective (any problems with a unit's configuration can be undone simply by power-cycling it). New versions of the software can be delivered remotely without requiring a reboot.

The software uses standard Linux tools (where possible) to perform the tests, such as ping, dig, curl, iperf and tcpdump/.

All monitoring units maintain accurate time using ntp.

Speed tests

The project uses a wide variety of speed tests in order to monitor performance under different conditions. A subset of those tests is being used to form the speed-test results detailed in this report:

- HTTP download on port 80, single-threaded
- HTTP upload on port 80, single-threaded

All units use a 1MB file on the download test and a 512KB file on the upload test. The relatively small size of these files is compensated for by having a 100KB lead-in download/upload (which is dropped from the actual test results). This lead-in enables the TCP window to reach a sufficient size before the real transfer begins. The real transfer is then performed over the same HTTP connection (through the use of HTTP Keep-Alive to ensure the connection remains open).

Additionally, it is understood that some ISPs operate transparent HTTP proxy servers on their networks. To overcome this, the webservers are configured to respond with the specific headers, which should disable caching in standards-compliant proxy servers.

All speed tests run once every hour (although each unit's tests may occur at any fixed point within that hour period). This predictability of traffic volumes allowed us to accurately predict the capacity that we would have to cater for.

Five speed-test servers are deployed in a range of different datacenters in and immediately around London to handle the traffic. Each server is monitored constantly for excessive network load and CPU, disk and memory load. The test results gathered by each server are compared against one another daily to ensure no significant variation in the speed attainable per server. Units cycle through the speed-test servers in a round-robin fashion when testing.

Testing web page loading times

This test utilises the curl utility to fetch the main HTML body of a website. Note that additional resources, such as images, embedded media, stylesheets and other external files are not fetched as a part of this test.

The time in milliseconds to receive the complete response from the webserver is recorded, as well as any failed attempts. A failed attempt is deemed to be one where the webserver cannot be reached, or where a HTTP status code of something other than 200 is encountered.

Three popular UK-based websites are used for the purposes of this test and tests are run every hour.

Testing ICMP latency and packet loss

Testing latency and packet loss is most commonly performed using the Unix utility ping and this solution is no different. In keeping with good practice, the first ping reply from any host is ignored (due to the delay in potentially having to ARP for the gateway) and an average of the following two is recorded as the result. This in keeping with how Cisco's IPSLA solution performs its ping tests.

Three external hosts were "pinged" for the purposes of this test. The average round trip time of the tests as well as the number of packets lost was recorded.

Ping tests were performed every 20 minutes.

Testing recursive DNS resolver responsiveness and failures

Testing an ISP's recursive DNS resolution can be accomplished using many tools, such as nslookup, dnsip and dig. For the purposes of our solution, dig was chosen for the flexibility it offers. Typically, an ISP will have two or more recursive DNS resolvers. Rather than using the DNS servers provided by the DHCP leases to the testing units, the software on the units tests the ISP DNS resolvers directly. This allows us to determine failure of a single DNS server.

Furthermore, it also overcomes another issue – that of people changing the DNS servers being returned in DHCP leases from their router (this proved quite common with customers of some ISPs). The tests record the number of milliseconds for a successful result to be returned. A successful result is deemed to be one when an IP address was returned (the validity of the IP address is not checked). A failure is recorded whenever the DNS server could not be reached or an IP address was not returned. The hostnames of four popular websites were queried every 20 minutes.

Testing VoIP capability

This test emulates the properties of a Voice over IP phone call in an attempt to determine how suitable the line is for VoIP purposes. Note that an actual VoIP call is not made – but the characteristics of it are emulated.

The test sends a 10 second burst of UDP traffic to one of three target servers residing on our network. Each UDP packet contains 160 bytes, and the traffic is sent at 64kbps. These characteristics match those of the G.711 [4] voice codec. Tests are run every hour.

Please note: This only tests upstream bandwidth. Due to NAT implementation issues on some volunteers' routers, downstream *testing proved too unreliable.*

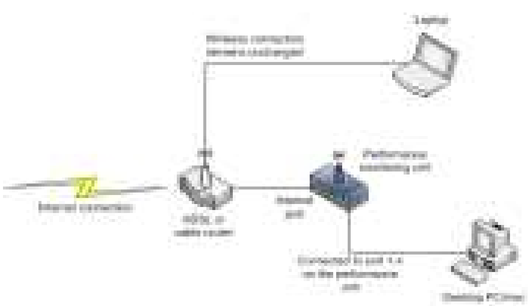
The test records the three major characteristics that determine the quality of a VoIP call: delay, loss and jitter. From these an R-value can be derived, and subsequently an estimated MOS (Mean Opinion Score) value. MOS is rated on a level from 1 (poorest) to 5 (perfect audio). The absolute maximum MOS value for G.711 is 4.4.

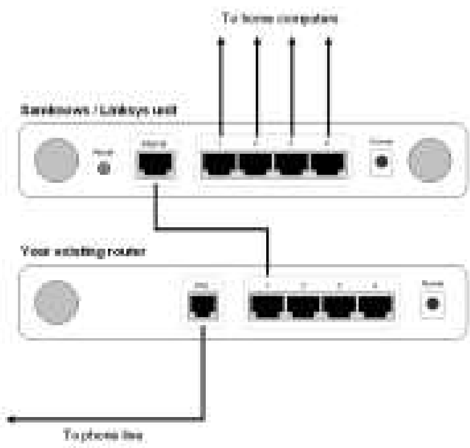
Also note: Our test assumes a worst case jitter buffer of zero milliseconds. Most VoIP capable routers (those that natively support VoIP channels) incorporate a small ~20ms jitter buffer nowadays.

Connections with usage caps

Some of the test units were deployed on broadband connection with relatively low usage caps. To avoid using a significant proportion of the available download limit each month the test schedule for the test units on these connections was reduced.

Position in home network



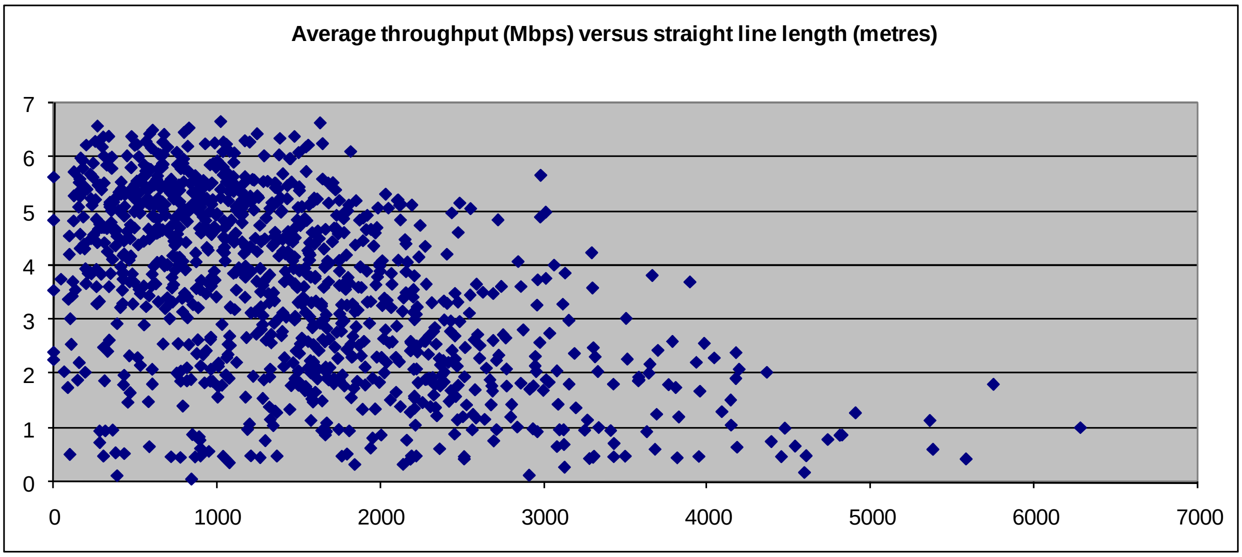


Sample Results

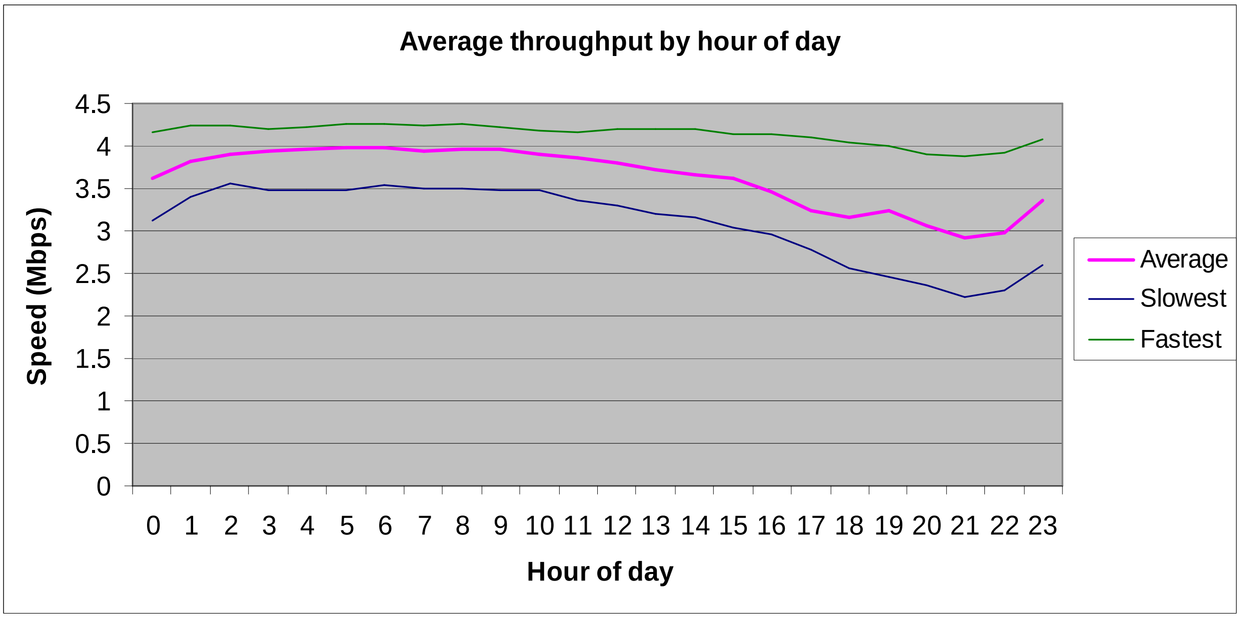
Summary of throughput by headline product band

Headline product band	Average of average speeds	Average of maximum speeds	avg(avg) / avg(max)	avg(avg) / avg(headline)
up to 2Mbps	1.586876887	1.718832408	92.32%	79.34%
up to 8Mbps	3.608088244	4.456824594	80.96%	45.10%
over 8Mbps	9.425959725	11.12343635	84.74%	47.13%

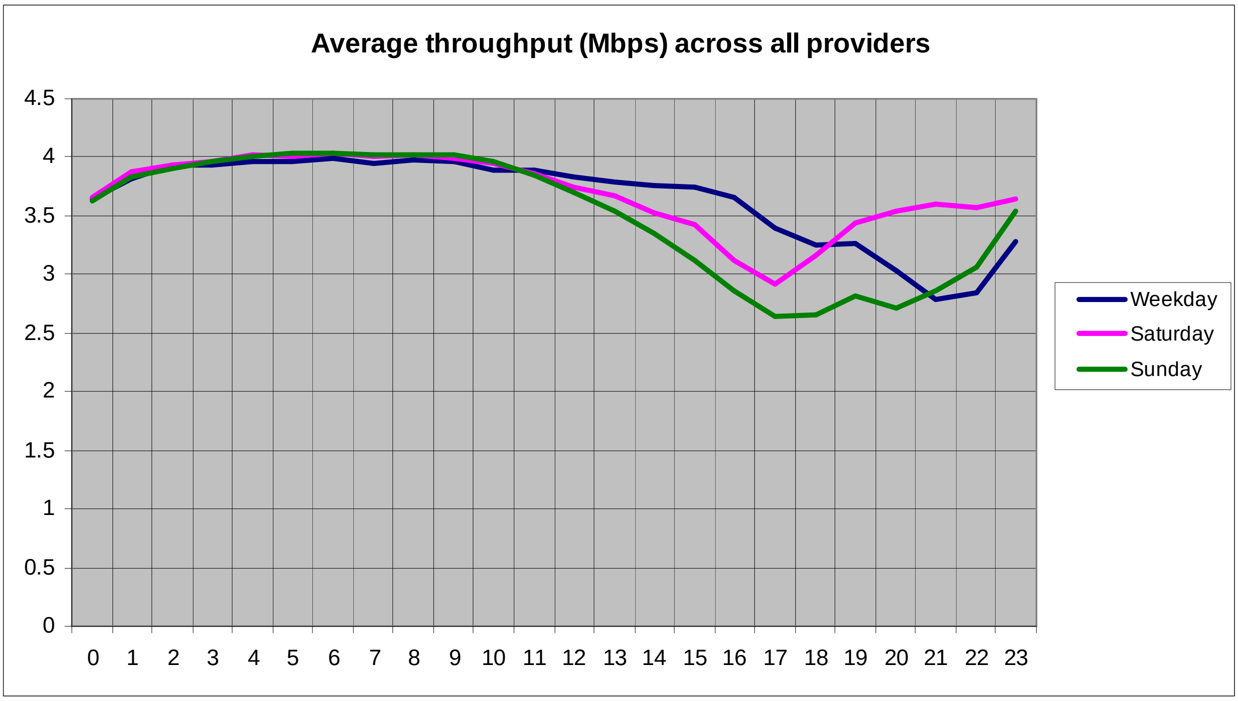
Average throughput (Mbps) versus straight line length (metres)



Average throughput by hour of day



Average throughput (Mbps) across all providers



Future developments, 2 streams

Open data model: Much like the Ofcom project, but this time we're going to make the technology platform available to researchers around the world. The aim is to create a number of panels similar to the Ofcom one, but on a global basis to enable international comparisons. We would look to contribute our data to the Google Measurement Labs project.

Closed data model: ISP owned panels, where the ISPs license the testing units to create their own panels for trouble shooting, data gathering and analysis.