OFFICE OF COMMUNICATIONS

UK broadband speeds 2008

Consumer experience of broadband performance: initial findings

Research Document

Publication date: 8 January 2009

Contents

Section 1

Executive summary

Background

1.1 Broadband speeds are important to consumers, helping inform their choice of ISP and affecting their experience of the internet. However, there is a lack of robust information available on the actual speeds that consumers receive and how these relate to both the maximum possible line speeds and the advertised 'up to' broadband speeds they pay for.

1.2 To help address this issue we have commissioned a two-part survey to provide an improved level of understanding of current broadband performance across the UK.

- Part one involves an assessment of consumer perceptions and behaviour through a standard survey methodology.
- Part two seeks to measure actual broadband speed and quality through a network of performance measurement hardware installed in UK households.

1.3 It is our intention that this research will provide an evidence base from which to inform Ofcom's policy making. Publication of the data will also provide information to consumers on how the performance of their broadband connection is likely to be affected by a range of factors, including where they live, the time of day they use their broadband and their choice of ISP.

1.4 We believe that the technical methodology we have selected, combined with our rigorous sampling approach, means that this research represents a step-change from any previous research into broadband speeds across the UK.

1.5 This initial report contains key findings from our survey and offers a high-level analysis of the performance data generated from the first 30 days of data collection (23 October to 22 November 2008). A more detailed report will follow in spring 2009.

Findings

1.6 The average speed (or more precisely the actual throughput download speed) received by panel members was 3.6Mbit/s in the 30 days from 23 October 2008. As we have weighted our panel carefully to reflect UK demographics, the market share of the leading ISPs and the distribution of headline speeds, our results offer a true reflection of the average speed experienced by UK consumers during this time.

1.7 This represents 49% of the average 'headline' speed (7.2Mbit/s) and 83% of the average maximum line speed (4.3Mbit/s)[1]. Consumers on the most popular broadband headline speed package ('up to' 8Mbit/s) received an average actual throughput speed of 3.6Mbit/s (45% of headline speed), and they had an average maximum line speed of 4.5Mbit/s (56% of headline speed).

[1] The 'headline' speed is the download speed at which an internet service is advertised. The 'maximum' speed represents the highest speed that the line is capable of, defined in this research by the highest speed ever achieved in the 30 days of data collection. See the Glossary for fuller definitions.

1.8 Speeds varied considerably between consumers: one in five people on an ‘up to’ 8Mbit/s package receive an average speed of less than 2Mbit/s.

1.9 Eighty-three per cent of consumers say that, overall, they are satisfied with their broadband service. Over a quarter of consumers claim that the speeds they receive are not what they expected when they signed up to their broadband service.

1.10 Twenty-one per cent of all consumers claimed to have some level of dissatisfaction with speeds, compared to 16% expressing dissatisfaction with value for money and 13% expressing dissatisfaction with the reliability of connection.

1.11 While 93% of users claim to be satisfied with their web browsing experience when using their broadband connection, satisfaction is significantly lower for all other types of internet use; ranging from 77% of those who listen to or download audio, to 60% of those who watch or download full feature films.

1.12 Despite its significance, 28% of consumers are unaware of the headline speed of the package they have purchased. The level of understanding of the factors which influence speed is also modest. For example, many consumers were unaware that the distance they live from the local exchange is a major determinant of speeds for DSL-based services.

1.13 Overall dissatisfaction with broadband is higher among rural users (12%) than among urban users (7%). This may be because they tend to receive slower speeds; rural consumers on ‘up to’ 8Mbit/s packages received average speeds 13% lower than their urban counterparts.

1.14 Much of this difference is likely to be explained by speed degradation among DSL connections caused by the fact that rural customers typically live further from their nearest exchange and therefore have, on average, a longer line length from the exchange to the premises. (Around 80% of UK broadband connections are DSL, whereby broadband is delivered via the copper telephone wire; and a characteristic of DSL broadband, in contrast to cable broadband, is that speeds degrade significantly with the length of the line).

1.15 Speeds vary significantly by time of day, generally becoming slower in the evenings. Across the UK, speeds were slowest between 5pm and 6pm on Sunday, indicating that this is when domestic use of the internet is at its highest. We found that for consumers on ‘up to’ 8Mbit/s packages average throughput speeds at the evening peak evening hours are over 30% slower than average throughput speeds during the off-peak hours of between 4am and 7am.

1.16 At a package level we have statistically robust data for the ‘up to’ 8Mbit/s product for the six operators with more than 5% retail market share in September 2007. We find that the average speed delivered by the slowest of these providers is around 70% of the fastest. This may be in part due to a different geographical profile of customers, resulting in different average line lengths. However, the fact that the worst-performing ISPs had much greater variation by hour of day suggests that degradation caused by contention is also a driver of this difference in performance.

1.17 Download speed is only one of many factors which affect performance. In this report we also analyse upload speeds, latency, packet loss, DNS and jitter; we find a similar pattern of poorer performance during the evening peak time. (See the glossary at the end of this document for definitions of key technical terms.)

Section 2

Scope of report

Rationale

2.1 Ofcom has statutory duties to further the interests of UK citizens and consumers by ensuring that a wide range of electronic communications services, including high speed data services, is available throughout the UK.

2.2 We have implemented a number of measures to ensure that consumers have a better idea of the broadband speeds they can expect to receive and are aware of what they can do if they are unhappy with their broadband performance.

- In June 2008, Ofcom and leading ISPs agreed a code of practice[2] which requires ISPs to provide customers with an estimate of the maximum speed which each customer will obtain. Under the code, ISPs must also explain to customers that their actual broadband speeds are likely to vary significantly for a host of different reasons, and give customers information and advice on how to improve their broadband performance.

- In December 2008, we published a consumer guide to broadband speeds[3] which tells customers about their rights under the code of practice and informs them about the steps they can take to improve their broadband performance.

2.3 We have also been engaging with consumer and industry stakeholders in developing a policy framework to facilitate the development of next-generation access networks which will deliver super-fast broadband. Conclusions following consultation into delivering super-fast broadband in the UK[4] will be published in spring 2009.

2.4 It is in this context that we commissioned research to identify consumers' perception of broadband services in the UK, together with research into the actual speeds delivered to UK consumers.

In scope

2.5 This initial research report details high-level survey findings from September 2008. It focuses on findings related to consumer satisfaction with broadband performance, consumer perceptions of the importance of broadband speed and consumer understanding of the drivers of broadband performance and its related terminology.

2.6 This report also includes findings from the first month (23 October to 22 November) of collecting broadband performance data from our panel of broadband users who have monitoring equipment connected to their router.

2.7 The focus of this report is on download throughput speed and how it varies by a range of variables including time of day, distance from exchange (for DSL

[2] Voluntary Code of Practice: Broadband Speeds, www.ofcom.org.uk/telecoms/ioi/copbb/
[3] Broadband Guide, www.ofcom.org.uk/media/features/broadguide
[4] Delivering super-fast broadband in the UK: setting the right policy framework, www.ofcom.org.uk/consult/condocs/nga_future_broadband/

connections) and the differences between rural and urban locations and across different UK regions.

2.8 In order to provide like-for-like comparison, and to represent the most common type of connection in the UK, we focus on services that offer speeds of 'up to' 8Mbit/s.

2.9 Because raw download speed is only one of many factors that determine the performance of a broadband connection, we also include analysis of upload speed, web browsing, latency, packet loss, DNS and jitter.

Out of scope

2.10 This is an initial report. Our measurement of broadband performance will continue for a minimum of six months and we will publish full findings following the end of the trial. The following are out of scope for this initial report.

- Cross-analysis between the survey and the broadband performance data; for example, in this report we do not analyse whether there is a relationship between dissatisfaction with broadband speeds and the actual throughput speeds received.
- Change in broadband performance over time.
- Analysis of broadband performance by named ISP.

Section 3

Objectives and methodology

Research objectives

3.1 The overall objective of our research was to gain understanding of broadband performance in the UK and relate it to consumer perceptions. The research has two components: a consumer survey and a performance-measuring trial.

3.2 The objectives of the survey were as follows:

- To measure overall satisfaction with broadband provision, speeds and other individual service factors, and identify reasons for dissatisfaction.
- To assess consumers' understanding of:
    - headline and actual throughput speeds and the factors that drive throughput speed;
    - other quality of service factors; and
    - download limits.
- To test the importance of broadband speed and other quality factors in the purchase decision.

3.3 The objectives of measuring broadband performance were as follows:

- To measure actual throughput download speeds across the UK and how they relate to maximum line speeds and advertised 'headline' speeds.
- To identify how speeds vary by a number of factors including time of day, distance from exchange (for DSL broadband) and region.
- To measure a number of other factors which affect overall broadband performance: upload speeds, latency, packet loss, DNS, jitter.

Methodology

Survey methodology

3.4 Market research company GfK Ltd was commissioned to recruit a representative panel of UK broadband users.

3.5 During September 2008, a total of 2,128 UK broadband decision-makers were recruited from online panels and asked to connect a broadband measurement unit to their router. As part of this process, respondents answered a series of questions on their broadband awareness, use and satisfaction.

3.6 Qualifying respondents had to be responsible for decisions related to their household's broadband use. For technical reasons, we excluded households which connect through USB modems, those without a spare power socket near the PC and those who tended to switch off their routers when not in use.

3.7 Profile controls were in place on age, gender, working status, region and rural/urban location as well as ISP use. Certain UK regions and ISPs were over-sampled to ensure sufficient analysis bases, but these have been weighted back in line with the universe to ensure results are representative of UK broadband decision-makers.

3.8 The demographic profile to which results were weighted is derived from a GfK face-to-face national omnibus of 988 respondents (17-22 July 2008). Weighting by ISP market share is based on data on subscriber numbers provided by operators to Ofcom and weighting by ISP package (i.e. headline speed) is largely based on profiles provided by operators or, where not available, on our best estimates of package take-up.

3.9 Results in this report have been assessed using confidence intervals. Where a difference is described as 'significant' this refers to a 95% confidence interval.

Broadband performance methodology

3.10 The technical methodology chosen was based on that created by broadband performance specialist SamKnows (www.samknows.com). As Ofcom's technical partner in the project, SamKnows developed and supplied the SamKnows monitoring units deployed to the panel of UK broadband users. SamKnows also managed the collection and aggregation of the performance data and made a major contribution to the analysis.

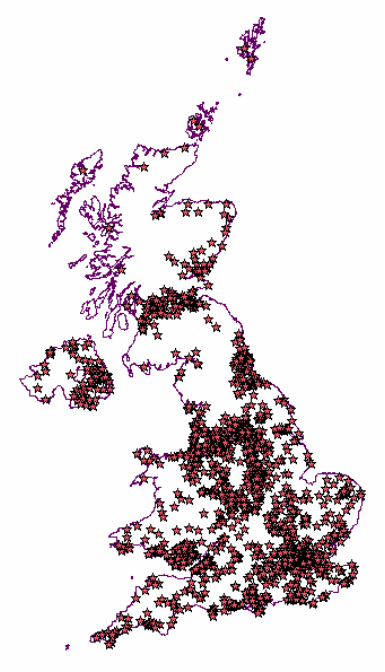
3.11 All survey respondents were sent a hardware monitoring unit which they were instructed to connect to their router. Software within this unit performed a range of tests to a set schedule, running over 7,000 separate tests from each panellist over the course of a month. The software was configured to identify other network activity and not to run tests when such activity was detected, thereby avoiding compromising results by running tests at a time when bandwidth was being used by other PCs in the household (including those using a wireless connection).

3.12 We believe that this technical methodology represents a step-change from previous research into UK broadband performance, which has typically relied on software solutions which do not account for the impact on speed of PC set-up, or the impact of having more than one computer using a broadband connection. Previous research which has used hardware solutions has been hampered by insufficient sample sizes. Our sampling approach also has benefits over most previous research in that it is based on a representative panel of UK consumers, and therefore should contain less bias than other surveys which have relied on broadband users to 'opt in' to participate in the research.

3.13 The performance data in this report are based on 1,621 panellists who had a broadband monitoring unit connected to their router in the 30 days from 23 October to 22 November 2008. Figure 3.1 details the geographical spread of the panellists, which is broadly in line with UK geographic population distribution.

3.14 The technical methodology is included in Annex A.

Figure 3.1 Geographical distribution of panellists



Source: Ofcom, based on distribution of GfK-sourced broadband speeds panel

Section 4

Broadband speed performance

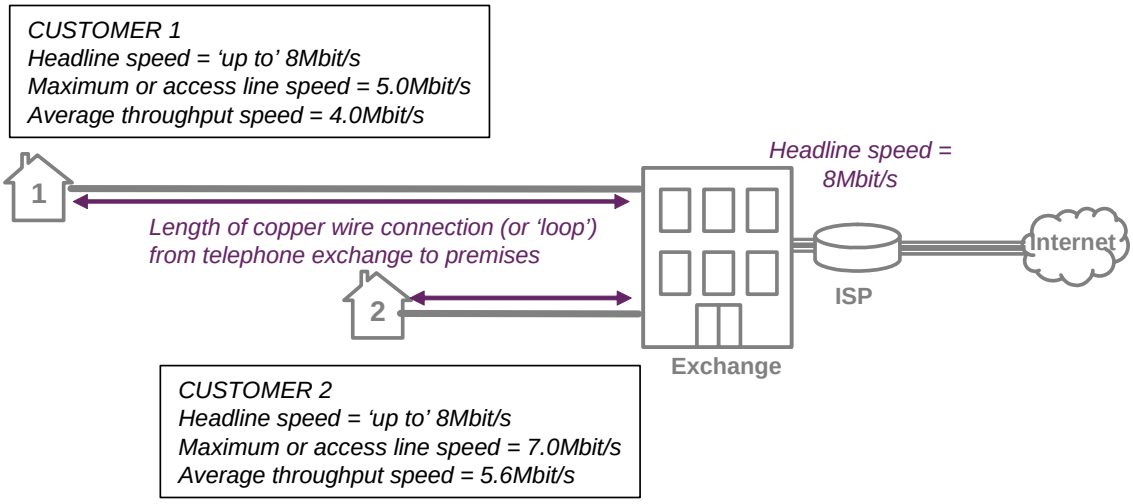
Why broadband speeds vary

4.1 Figure 4.1 provides an illustrative example of different metrics used to assess broadband speed. The 'headline speed' is the download speed at which the service is marketed, usually expressed as 'up to'; the 'maximum line speed', or 'access line speed', is the maximum download speed that a line is capable of supporting; and the average throughout speed represents the average actual speeds that a consumer receives. See the glossary for fuller definitions.

4.2 The example shown details two DSL connections from the same exchange via the same ISP. The two customers have purchased the same package at the same headline speed, but the maximum line speed varies because of the different lengths of the copper line between customer premises and exchange; the average throughput speeds received by both customers are also less than the maximum line speeds, reflecting the fact that speeds vary and are often significantly lower than the maximum speed.

4.3 It should be noted that this diagram represents two DSL connections. The maximum line speed for cable connections is typically much closer to the headline speed, as unlike DSL connections via copper wires, cable connections do not degrade significantly with distance. However, actual throughput speeds received by cable customers also vary and can also be below the maximum line speed as a result of other factors, such as contention in the ISP's network.

Figure 4.1 Illustrative example of speed metrics for DSL connections

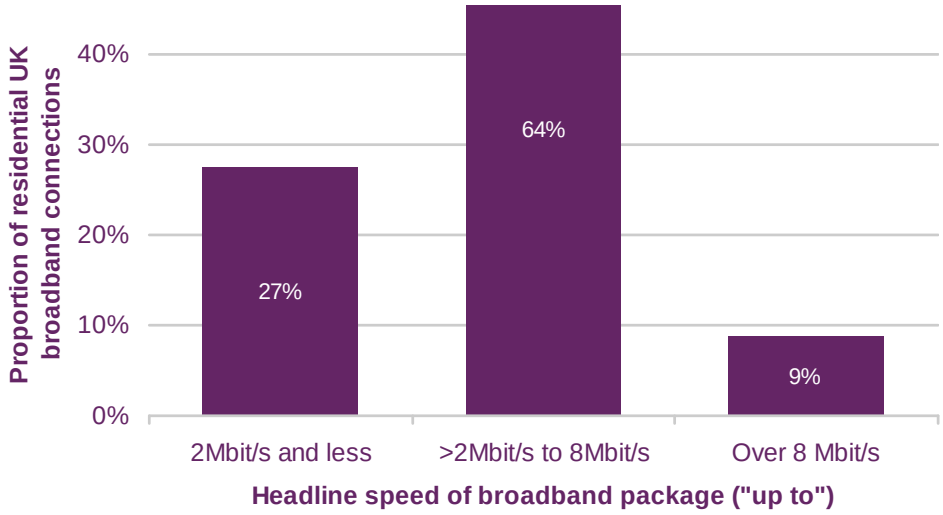


Source: Ofcom

4.4 A range of broadband speed packages are offered by providers to residential consumers in the UK. Figure 4.2 below details the distribution of these packages by the headline speed. This data is based on breakdowns of their consumer base provided by the six largest ISPs in the UK by retail market share. We have presented it in bands rather than detailing specific packages in order to preserve the

confidentiality of this data. All of our analysis has used this weighting (in addition to weighting by ISP market share and region) in order to ensure that it is representative of the residential UK broadband consumers as a whole.

Figure 4.2 UK residential broadband connections by headline speed



Source: Ofcom, based on data provided by the UK's six largest ISPs by retail market share in September 2008

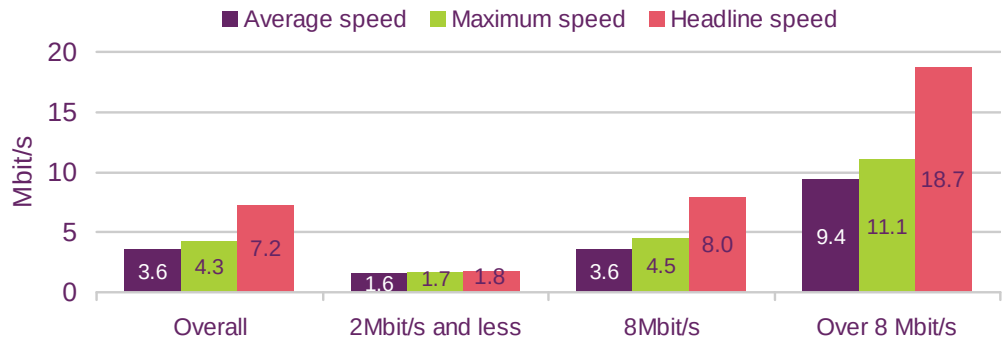
4.5 Overall, the average actual throughput download speed delivered to our panellists was 3.6Mbit/s (Figure 4.3).

- Consumers on packages with advertised headline speeds of 'up to' 2Mbit/s and less received average throughput speeds of 1.6Mbit/s. (The large majority of these panellists were on 'up to' 2Mbit/s packages, with a small proportion on 'up to' 1Mbit/s packages).

- Consumers on packages with an advertised headline speed of 'up to' 8Mbit/s received average throughput speeds of 3.6Mbit/s.

- Consumers on packages with advertised headline speeds of over 8Mbit/s received average throughput speeds of 9.4Mbit/s. (This group consists of consumers on 10Mbit/s, 16Mbit/s, 20Mbit/s and 24Mbit/s packages; as our sample did not include large numbers of these types of consumer we are not able to report on the performance of each of the speeds in this group).

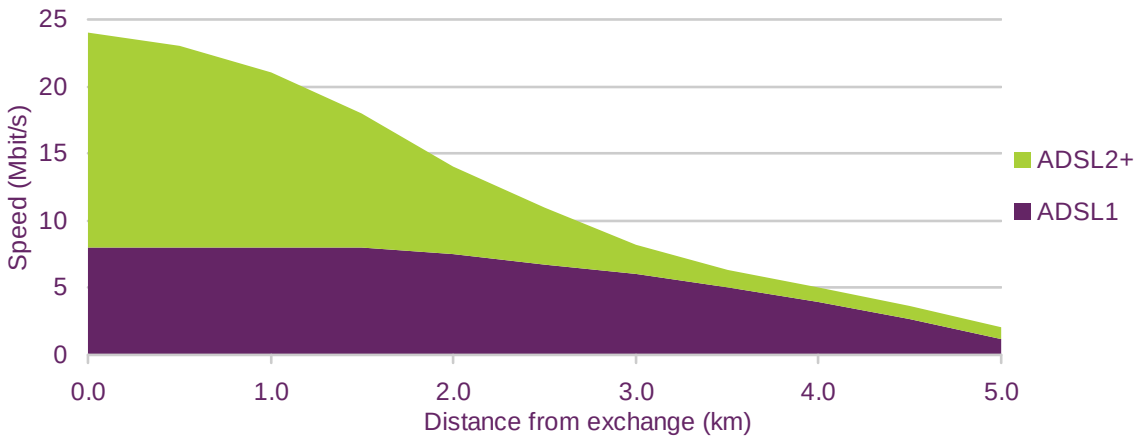
Figure 4.3 Average actual throughput download speeds



Source: SamKnows measurement data for all panel members with a connection in the 30 days from 23rd October 2008
Note: Data have been weighted by demographics, ISP and headline speed in order to ensure that they are representative of UK broadband consumers as a whole

4.6 As it is a characteristic of DSL broadband that speeds degrade with the length of the copper wire between the exchange and the consumer's premises, it is not possible for most customers to receive the headline speed of their package. Instead, the maximum speed available to customers with DSL broadband varies according to the length of the line between them and their telephone exchange5; this maximum line speed is often known as the 'access line speed'. Figure 4.4 is a theoretical depiction of how DSL speeds vary with length of line from exchange.

Figure 4.4 Theoretical maximum DSL speeds by length of line from exchange to premises



Source: http://www.tpg.com.au/dslam/faq.php

4.7 There are a number of other reasons why broadband speeds may be below headline speeds. These include the following:

- the capacity of an ISP's network;
- congestion on the wider internet;

[5] In addition to the physical length of the line, the quality of the line is also important. Collectively, the physical length and quality of the line are known as the 'electrical line length', and it is this which defines the theoretical maximum speeds available.

- problems within the home, e.g. poor internal wiring or absence of filters; and
- consumer's equipment, e.g. speed of computer or router.

Research findings

4.8 We use the maximum speed ever delivered during the 30-day research period as a proxy for the maximum speed a line is capable of.

- For panellists on 2Mbit/s or less products, the average maximum speed delivered was 1.6Mbit/s, 92% of the average headline speed (1.7Mbit/s). This close proximity arises because under all ADSL technologies a speed of 2Mbit/s can be sustained as far as 5km from the exchange. We do not have line length data for our panellists, but less than 1% live more than 5km from the nearest exchange 'as the crow flies'.
- For consumers on up to 8Mbit/s products, the average maximum speed delivered to panellists of 3.6Mbit/s is 45% of the headline speed. The gap between maximum speeds and headline speeds is largely explained by the degradation of ADSL 1 broadband which offers a theoretical maximum speed of 8Mbit/s, but declines with distance from exchange. However, even those customers living very close to an exchange may not experience the headline speed when downloading files or using on-line speed test sites. This is because some of the available capacity is used by critical communications protocols (e.g. ATM and TCP) which are required for the connection to operate. ISPs will typically limit the bandwidth available for end users data in order that there is sufficient capacity for this other 'overhead' data. For example, if a line synchronises (connects to the DSLAM at the exchange) at 8128kbit/s (~8Mbit/s), such systems may limit user traffic to 7.15Mbit/s. None of the 1,087 panellists on an 'up to' 8Mbit/s package received a maximum speed of more than 7Mbit/s.
- For panellists on over 8Mbit/s products, the average maximum speed delivered was 9.4Mbit/s, 50% of the average headline speed (18.7Mbit/s). This percentage is higher than for consumers on 8Mbit/s products because some operators offer higher speed products only to those whose lines can support it, and because of the inclusion of cable consumers. (Unlike DSL, speeds offered over cable do not decline with distance, so the maximum speeds available are typically much closer to the headline speeds than is the case for DSL).

4.9 It is also interesting to consider how average speeds relate to the maximum line speeds available, as this can provide insight into how speeds are degraded by 'contention', i.e. when speeds decline as a result of multiple users sharing bandwidth within a provider's network. This metric also provides some insight into how the service that consumers receive relates to the service they were sold; under Ofcom's Broadband Speeds Code of Practice signatories are obliged to advise an estimate of the maximum line speed at the point of sale.6

- Overall, the average speed delivered is 85% of the maximum line speed.
- For consumers on 2Mbit/s or less products, the average speed delivered is 92% of the maximum line speed.

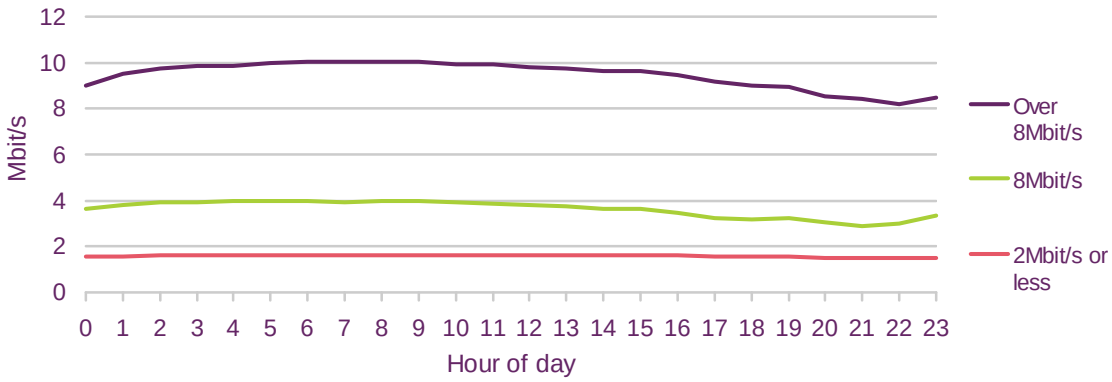
[6] The voluntary Code of Practice for broadband speeds is available at http://www.ofcom.org.uk/telecoms/ioi/copbb/copbb/

- For consumers on 'up to' 8Mbit/s products, the average speed delivered is 81% of the maximum line speed.

- For consumers on over 8Mbit/s products, the average speed delivered is 85% of the maximum line speed.

4.10 Contention is typically greatest at peak times of the day when the largest number of users is simultaneously connected. Figure 4.5 shows that download speeds typically slow down from around 5pm in the evening and then speed up from 11pm. It is notable that the greatest absolute and proportional decreases in speed occur for users on packages with faster headline speeds. Further analysis of the impact of time of day on download speeds is in Section 7 below.

Figure 4.5 Average download speeds by hour of day



Source: SamKnows measurement data for all panel members with a connection in the 30 days from 23rd October 2008

4.11 In order to understand the consumer impact of these speeds, Figure 4.6 below details the theoretical time taken to perform some of the most common online activities at different speeds.

Figure 4.6 Theoretical time taken to perform online activities

	Connection speed				
	56kbit/s	**512kbit/s**	**2Mbit/s**	**8Mbit/s**	**24Mbit/s**
Download 250kB webpage	36 seconds	4 seconds	1 second	0.3 seconds	0.1 seconds
Download 5MB music track	12 minutes	1 minute 22 seconds	21 seconds	5 seconds	2 seconds
Download 25MB video clip	1 hour	6 minutes 50 seconds	1 minute 45 seconds	26 seconds	9 seconds
Download low quality film (750MB)	31+hours	3 hours 20 minutes	52 minutes	13 minutes 6 seconds	4 minutes 22 seconds
Download DVD quality film (4GB)	7+ days	19 hours 38 minutes	4 hours 48 minutes	1 hour 11 minutes	24 minutes

Source: Ofcom

Section 5

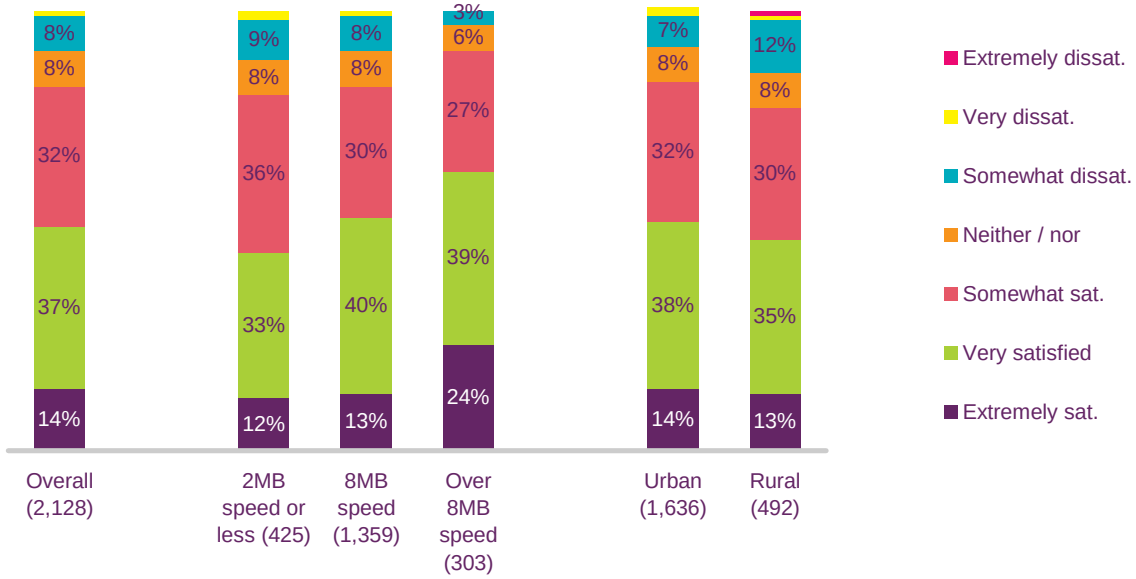
Consumer satisfaction

5.1 Consumers are generally satisfied with their broadband services. At an overall level, 51% are 'extremely' or 'very' satisfied and a further 32% are 'somewhat' satisfied. Conversely, a total of 9% express some degree of dissatisfaction (Figure 5.1).

5.2 Although consumers on packages of 'up to' 2Mbit/s receive average throughput speeds which are much closer both to headline speeds and to maximum speeds than those on faster packages (see Section 4 above), the consumers on lower speed packages are significantly less satisfied with their overall service. Moreover, broadband users who have purchased headline speeds of over 8Mbit/s are significantly more likely to be satisfied with their service; 90% in this category are satisfied and only 4% dissatisfied.

5.3 Consumers in rural locations are significantly less satisfied with their broadband connection than are urban consumers. Given the lower average headline speeds in rural locations, we would expect satisfaction to be lower in rural households. This was the case, with 78% of rural users satisfied with their overall broadband connection compared to 85% of urban users. Those in rural households also express relatively high levels of dissatisfaction (14% compared to 8% or urban users) (Figure 5.1).

Figure 5.1 Overall satisfaction with broadband service



Q7: Overall, how satisfied are you with your current broadband service?
Base: All UK broadband decision makers (see chart)

Source: GfK broadband speeds survey ,among 2,128 online panel respondents who are broadband decision makers, September-October 2008

5.4 When viewed by nation, satisfaction levels in England are slightly ahead of those in Northern Ireland, Wales and Scotland, although the only statistically significant difference is that with Scotland.

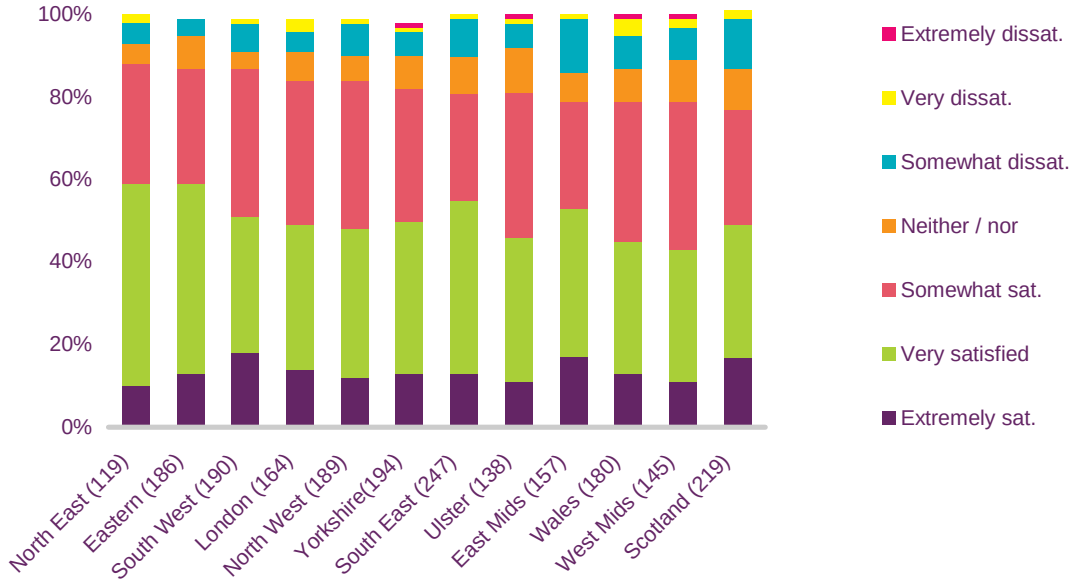
Figure 5.2 Overall satisfaction with broadband service, by nation

Q7: Overall, how satisfied are you with your current broadband service?
Base: All UK broadband decision makers.

Source: GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

5.5 At a regional level, differences are also fairly modest, although users in the North East, Eastern and the South West regions are significantly more satisfied than those in the East Midlands, Wales and Scotland.

Figure 5.3 Overall satisfaction with broadband service, by region



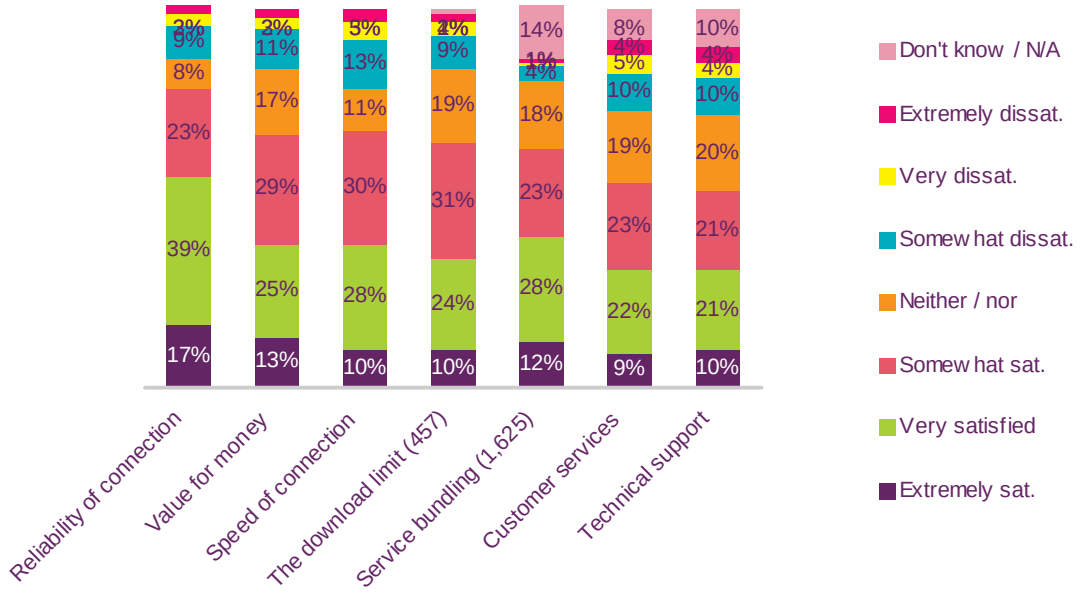
Q7: Overall, how satisfied are you with your current broadband service?
Base: All UK broadband decision makers (see chart).

Source: GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

5.6 Looking at the specific factors that drive overall satisfaction, *connection reliability* receives the highest ratings, with 78% satisfied. This is followed by satisfaction with *value for money* and then *speed of connection*.

5.7 However, it is important to note that views on *speed* are divided; 21% express dissatisfaction with this measure.

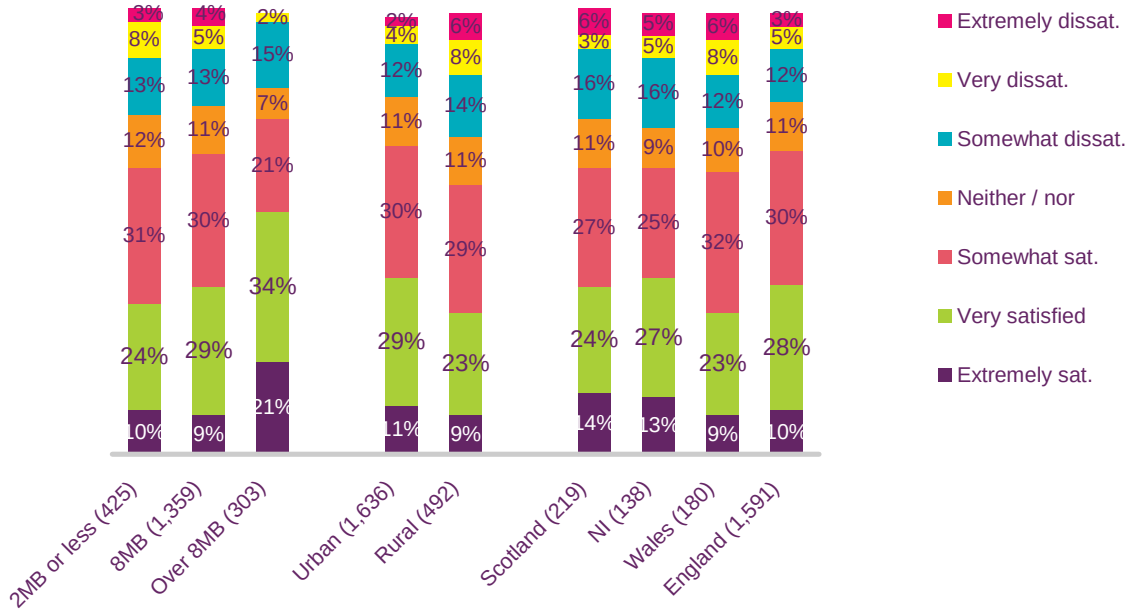
Figure 5.4 Satisfaction with broadband specifics



Q8: How satisfied are you with these factors of your broadband provider?
Base: All UK broadband decision makers (2,128 unless otherwise specific on chart);
Base: All UK broadband decision makers with download limits (457)
Base: All UK broadband decision makers where broadband provider also provides phone, TV or mobile services (1,625)
Source: GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

5.8 The perceptions of *connection speed* and *connection reliability* largely follow the same pattern observed for overall satisfaction; scores are significantly higher for those with headline speeds of over 8Mbit/s, and higher among those living in urban locations than among those in rural locations.

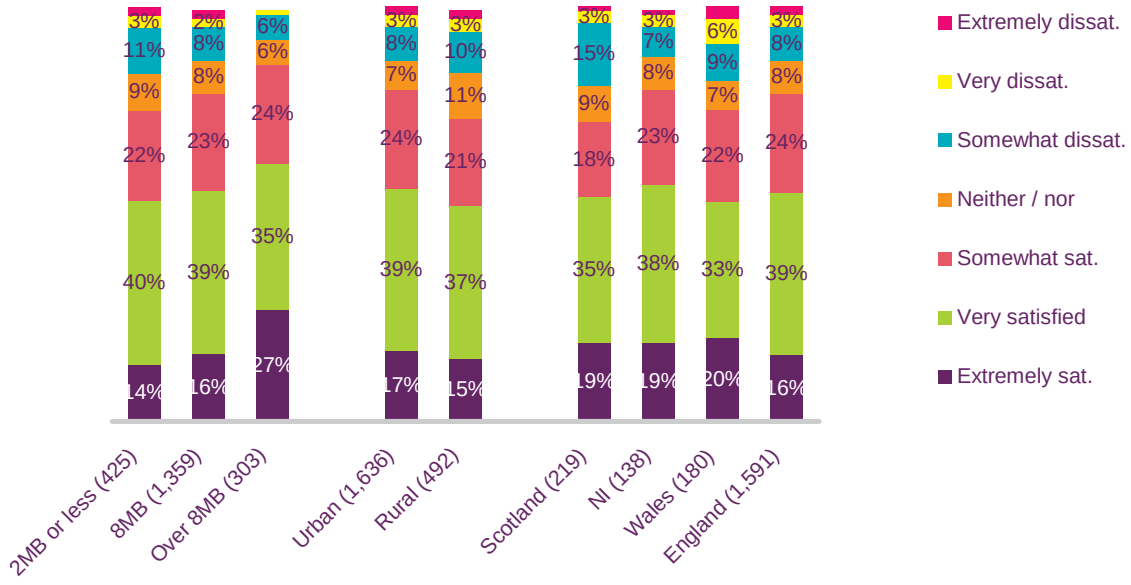
Figure 5.5 Satisfaction with speed of the connection



Q8B: How satisfied are you with the speed of the connection?
Base: All UK broadband decision makers (see chart)

Source: GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

Figure 5.6 Satisfaction with reliability of the connection

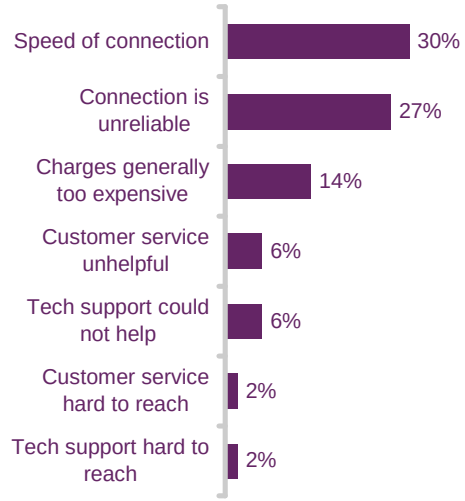


Q8A: How satisfied are you with the reliability of the connection?
Base: All UK broadband decision makers (see chart)

Source: GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

5.9 Among the 9% who are dissatisfied with their overall broadband service, the main reasons for dissatisfaction tend to focus on *speed*, *reliability* and *value*. Those living in rural areas are significantly more likely to mention *speed* as the main reason for their dissatisfaction (42% of rural users state speed as *the* main reason, compared to 22% of urban users).

Figure 5.7 Main reason for dissatisfaction with ISP

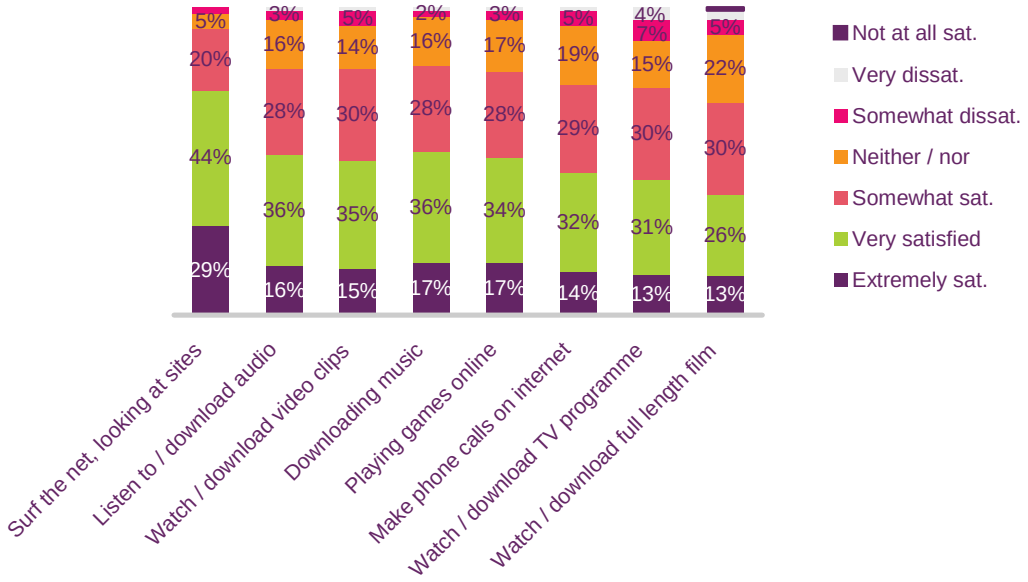


Q11: What is the MAIN reason you are dissatisfied with your Internet provider?
Base: All dissatisfied UK broadband decision makers (205)

Source: GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

5.10 The current level of broadband speed and quality is sufficient to generate very high satisfaction ratings for basic web browsing, with 92% of consumers satisfied with the experience of ‘surfing the net looking at websites‘.

Figure 5.8: Satisfaction with different web experiences

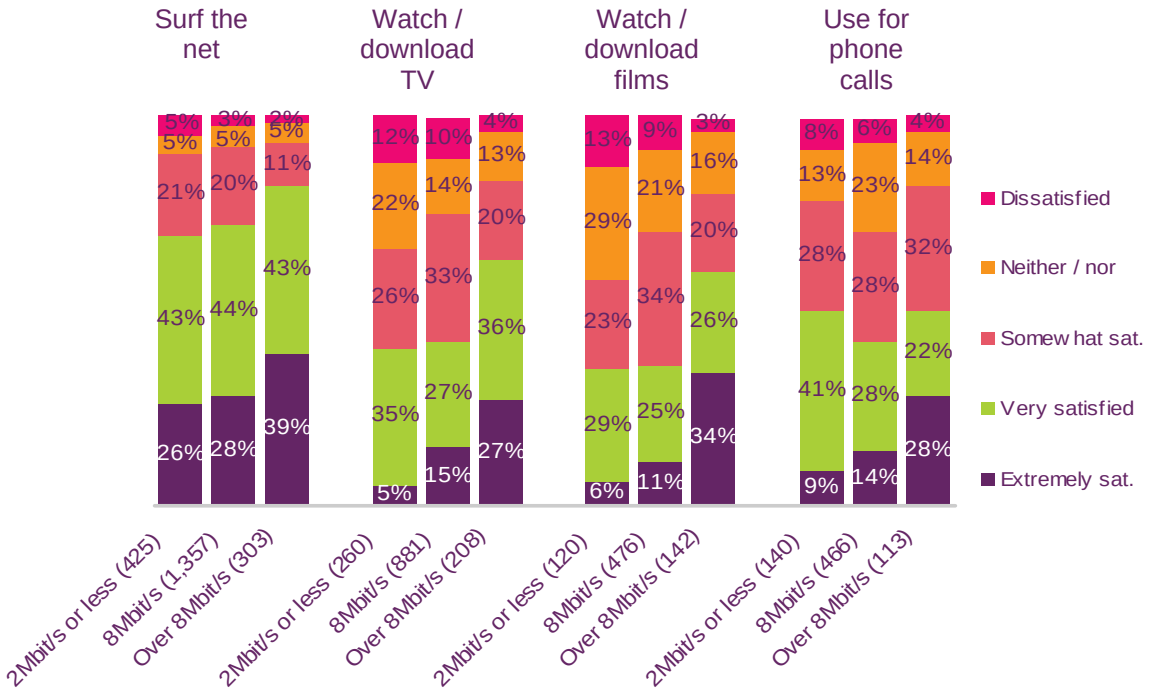


Q9: How satisfied are you with your experience of doing the following using your home internet connection?
Base: All UK broadband decision makers who have tried activity (bases vary from 737 to 2,126)

Source: GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

5.11 Satisfaction is significantly lower for all services which require the streaming or downloading of content and which therefore benefit from higher speeds and/or more consistent performance. Unsurprisingly, these reduced satisfaction levels are largely driven by users with lower headline speeds. For example, amongst those on 'up to' 2Mbit/s packages only 53% are satisfied with "watching / downloading full length film", compared to 75% of those with over 8Mbit/s packages. By contrast, there is no significant difference among consumers on packages with different headline speeds in their satisfaction with surfing the net.

Figure 5.9 Satisfaction with web experiences, by package headline speed

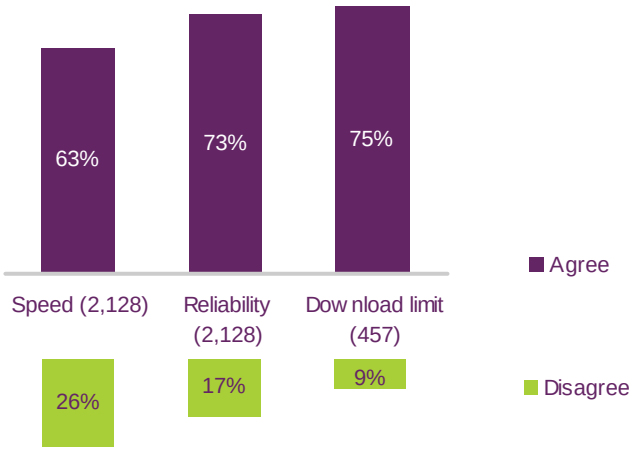


Q9: How satisfied are you with your experience of doing the following using your home internet connection?
Base: All UK broadband decision makers who have tried activity (see chart for bases)

Source: GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

5.12 Relatively few consumers are surprised by the *reliability* or the *download limits* of their broadband packages after they sign up. However, around one in four disagree that the speed they receive is as they expected when they signed up. In rural areas, this proportion approaches one in three (32%) (Figure 5.10).

Figure 5.10 Agreement that service match initial expectations



Q12A/B/C: To what extent do you agree or disagree that your [speed / reliability / download limit] is as you expected it to be at the time of signing up?
Base: All UK broadband decision makers (2,128) / All with a download limit (457)

Source: GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

Section 6

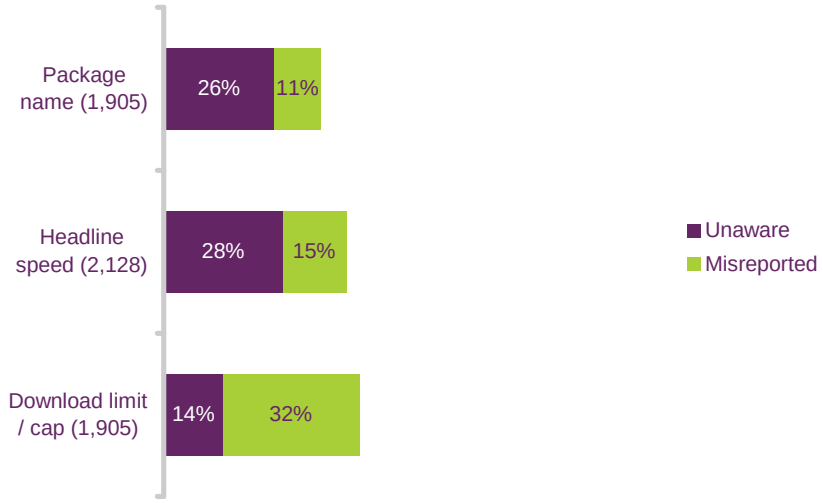
Consumer understanding

6.1 This section explores awareness of some of the fundamentals of broadband services, including headline speeds, download limits and package names. It also covers consumer understanding of some of the specific terms commonly used by ISPs when describing their broadband packages. Perceptions of factors influencing broadband speed are also tested.

6.2 The degree of awareness of broadband package specifics is often relatively low. More than one in three consumers were unable to correctly identify their household's broadband package from a list; more than one in four were unaware of the speed they had purchased and we estimate that an additional 15% misreported their headline speed.

6.3 In addition, 14% could not put a value on the size of their data download limit and we suspect that a further 32% have misreported their limit. More than half of this misreporting is found among consumers of high allowance packages (10/15/40GB) who believe they are on unlimited deals, with a smaller proportion of those on lower allowance packages believing they are on unlimited deals. On the other hand, around one in four of the misreported cases come from consumers who underestimate their allowance.

Figure 6.1 Proportions unaware of service specifics



S4B: Does your package give you unlimited downloads or do you have monthly usage caps?
Base: All UK broadband decision makers using a top 6 ISP (1,905)

S5: What broadband package do you have (from list of top 6 ISP package names)?
Base: All UK broadband decision makers using a top 6 ISP (1,905)

S7: What was the headline download speed of your broadband package when you signed up for it?
Base: All UK broadband decision makers (2,128)

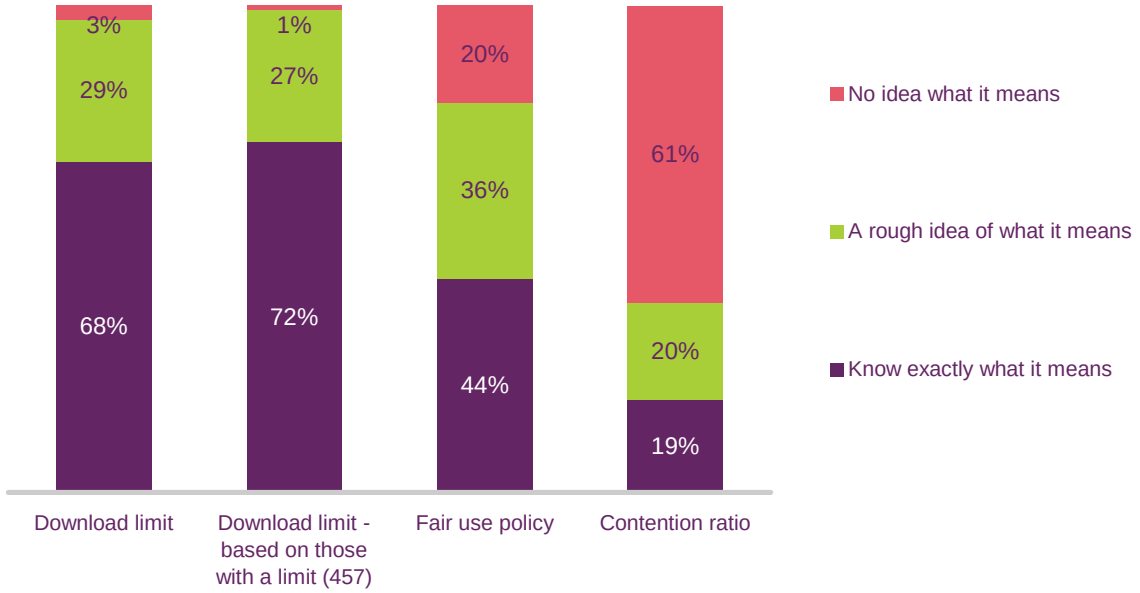
'Misreported' is estimated on the basis of survey responses given to questions about ISP used, headline speed, usage cap, spend and actual measured speed. The level of misreporting should be considered indicative only.

Source: GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

6.4 The questions on awareness of package download limits were followed up by a more conceptual line of enquiry in which respondents were asked to rate their level of understanding of some key technical service-related terms. The majority (68%) felt they knew exactly what the term 'download limits' means and most of the rest felt they had a "rough idea" (29%). Interestingly, this did not vary much when comparing the general sample to those on packages with usage caps.

6.5 There was significantly more confusion around the terms 'fair usage policy' and 'contention ratio', with 20% and 61% respectively having "no idea what it means". Understanding of these terms was lower among older age groups, females, those with lower headline speeds, and those with lower PC usage, suggesting they in particular might benefit from more consumer-friendly explanations of these terms.

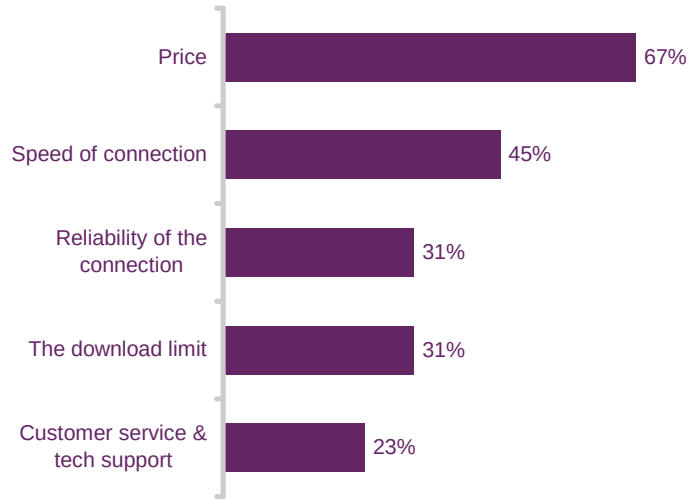
Figure 6.2 Understanding of technical service-related terms



Q19: Listed below are technical terms that relate to the quality of an internet connection. How well do you understand what they mean?
Base: All UK broadband decision makers (2,128) unless otherwise specified on chart
Source: GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

6.6 Price and speed were the two factors mentioned most frequently when broadband decision makers were asked about which features they had used to compare different broadband suppliers. Younger consumers were particularly likely to have done this, with 81% of 16-24 year olds having attempted price comparisons (and 62% having made speed comparisons).

Figure 6.3 Proportions having attempted to compare various service features



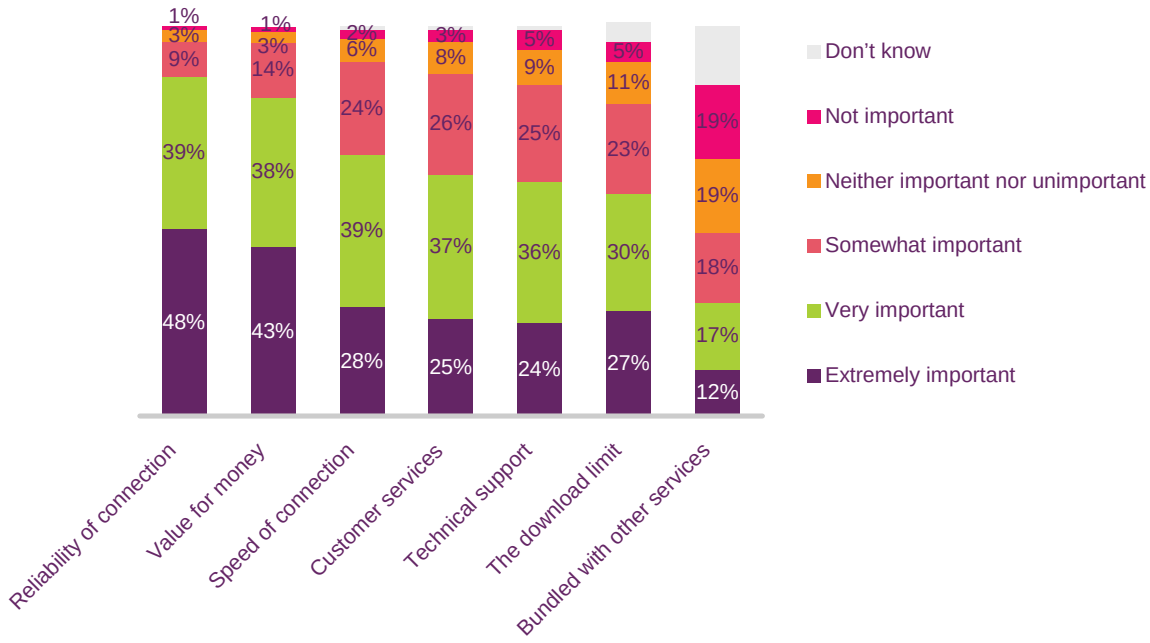
Q15: Which, if any, of the following internet service features have you tried to compare from different broadband suppliers?
Base: All UK broadband decision makers (2,128)

Source: GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

6.7 Connection reliability and value for money are the two factors that matter most to UK consumers when they decide which ISP to sign up to. This is closely followed by advertised connection speed. We also found that 18-24 year olds are significantly more likely than average to rate speed as extremely, or very, important (80%).

6.8 Predictably, those on high-speed packages (>8MB) paid more attention to speed when they signed up (77% said it was extremely, or very, important), but in relative terms speed also ranks third for this group of consumers.

Figure 6.4 Drivers of purchase decision



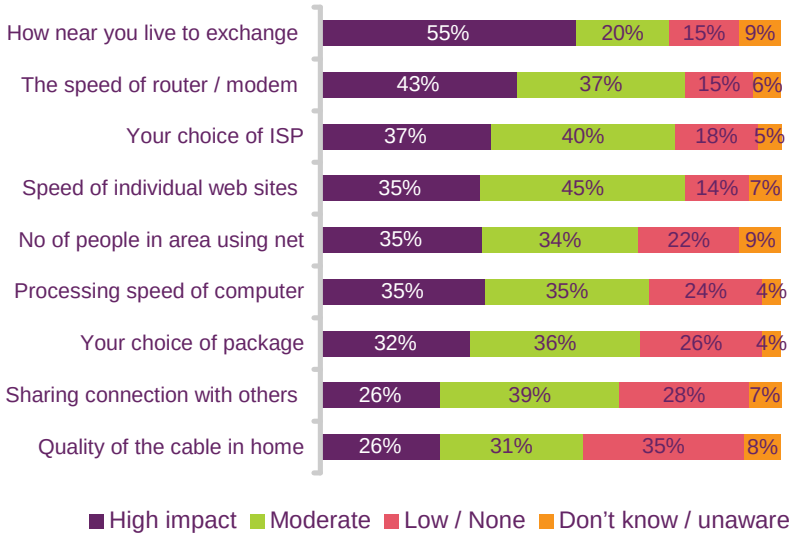
Q13: How important were the following factors when you decided to sign up to your current broadband provider?
Base: All UK broadband decision makers (2,128)

Source: GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

6.9 Proximity to the exchange is the factor most people perceive to have a high impact on the speed of their broadband connection (55%). This is followed by router / modem speed (43%), choice of ISP (37%) and speed of websites (35%). Apart from these four, other factors influencing speed are seen as much less significant, with between 22% and 35% believing that the remaining factors have little or no impact at all.

6.10 Quality of the cable in the home is among the factors least likely to be seen as an influencer of speed (only 26% say 'high impact'). Sharing connections with others in the home is seen as equally insignificant (26%). The low ranking of these two measures would suggest that consumers are more inclined to attribute speed issues to external factors rather than household set-up.

Figure 6.5 Perceived impact of various factors on broadband speed



Q18: Please rate how much you think the following can influence download speeds

Source: GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

Section 7

Drivers of variation in broadband speed

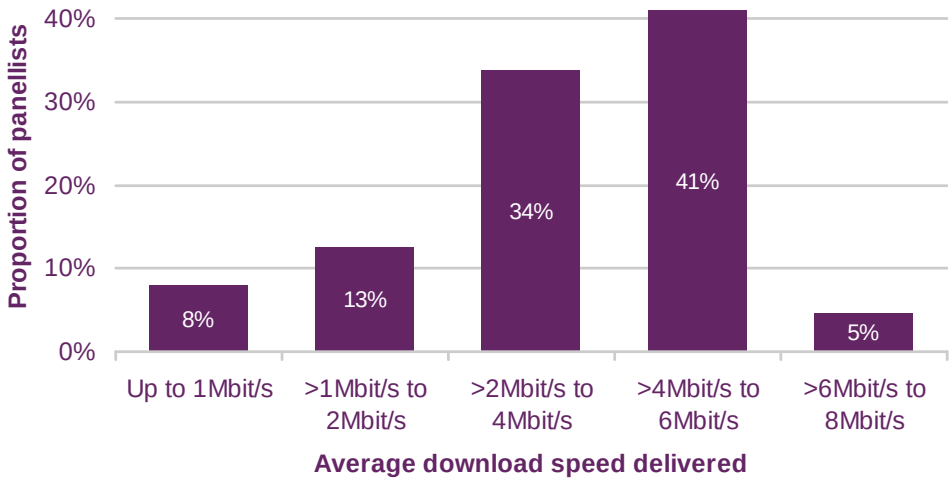
7.1 Probably because of typically shorter line lengths, London and other largely urban regions have the fastest maximum and average line speeds (Figure 7.7).

7.2 It is notable that the biggest gap between maximum line speeds and average line speeds appear in Scotland and Northern Ireland. This may indicate that there is higher contention in these nations than in Wales and the English regions.

7.3 However, all regional differences should be treated with some caution. The limitation of sample sizes, together with variation within the samples of both distance from exchange and urban and rural addresses means that there is a relatively large error margin for some regions. It should also be noted that there may be relative regional differences, exaggerated by geographic features such as mountains and islands, between the accuracy of 'the crow flies' distance we use and the actual electrical distance, which is dependent on a combination of the actual length of the line and the quality of the line.

7.4 In the case of Northern Ireland, the error margin is up to 0.3Mbit/s (i.e. the maximum speed of 4.6Mbit/s could actually be as low as 4.3Mbit/s or as high as 4.9Mbit/s). this is the consequence of a small sample size of less than 100 panellists together with a distinct distribution of distances from exchange (while average line length is longer than any other region, there are a relatively large proportion who live less than 1km from the exchange and receive maximum speeds in excess of 6Mbit/s).

Figure 7.1 Average download speeds for panellists on 'up to' 8Mbit/s packages



Source: SamKnows measurement data for all panel members with a connection in the 30 days from 23rd October 2008.
Note: Data have been weighted by demographics and ISP in order to ensure that they are representative of UK broadband consumers as a whole

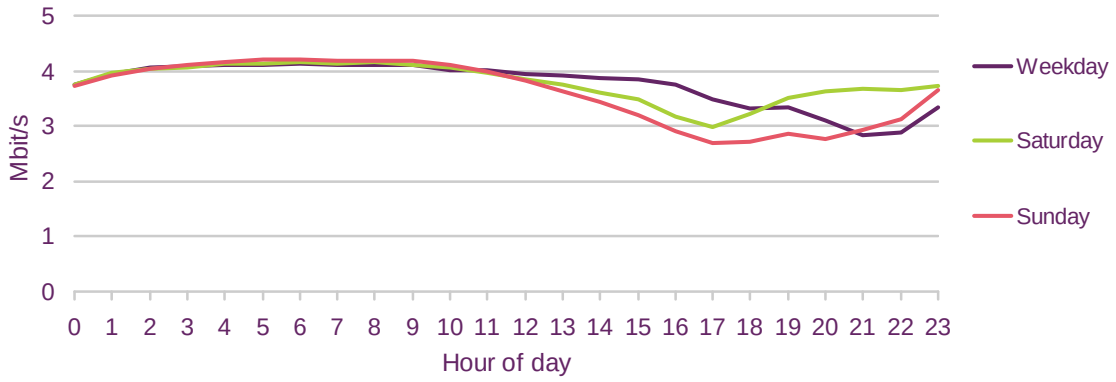
Time of day

7.5 Looking at the variation by time of day and day of week shows that average speeds at the peak hour of between 5pm and 6pm on Sundays are over 30% slower than average speeds during the off-peak hours of between 4am and 7am (Figure 7.2). This is likely to be the result of contention within ISP networks and the broader internet, meaning that speeds are degraded as multiple users share the same bandwidth. It should be noted that this data relates only to HTTP (web-based) traffic over port 80, thereby excluding most peer-to-peer traffic. If peer-to-peer traffic were also to be included, it is likely that there would be a greater difference between speeds at peak and off-peak times; it is peer-to-peer traffic which some ISPs 'throttle' during peak times as a way of managing their network capacity.

7.6 On weekdays, there is a sharp decline in speeds between 3pm and 4pm (school finishing time) followed by a levelling-off between 6pm and 7pm, which can perhaps be attributed to people leaving their computers for dinner (a similar resurgence in speed is seen on Sunday evening at the same time). During weekday evenings, speeds are slowest between 9pm and 10pm, suggesting that this is when most people are using the internet.

7.7 Saturday evenings exhibit their low point around 6pm and speeds then increase in for the rest of the evening. Again, this can probably be attributed to people spending their Saturday evenings away from their computers.

Figure 7.2 Average download speeds for panellists on 8Mbit/s packages, by hour of day and day of week

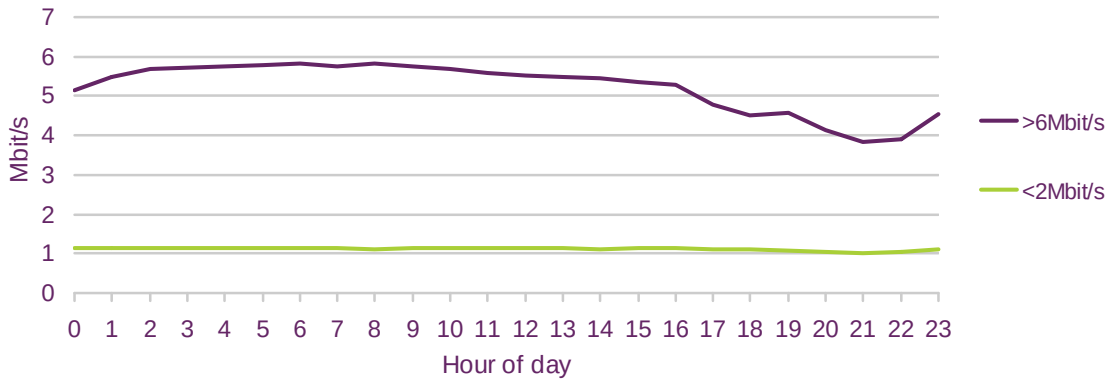


Source: SamKnows measurement data for all panel members with a connection in the 30 days from 23rd October 2008.

7.8 Consumers with higher maximum line speeds typically received more variable actual speeds than those consumers with lower line speeds. For the 357 panellists with a maximum line speed of over 6Mbit/s, average throughput speeds in the slowest hour slowed to 66% of those in the fastest hour; by comparison, consumers with a maximum line speed of less than 2Mbit/s (147 panellists) had significantly more consistent speeds, with average throughput in the slowest hour 87% of that in the fastest hour (Figure 7.3). It is also noticeable that customers with access line speeds above 6Mbit/s received speeds considerably below that at peak hours, i.e. the times of the day when they were most likely to be using the internet. This is likely to be largely a result of contention on ISPs' networks since our tests were designed

to minimise the impact of other factors, such as over loading of web servers at peak times or congestion on the wider internet.

Figure 7.3 Average download speeds for panellists on 'up to' 8Mbit/s packages, by hour of day and maximum speed



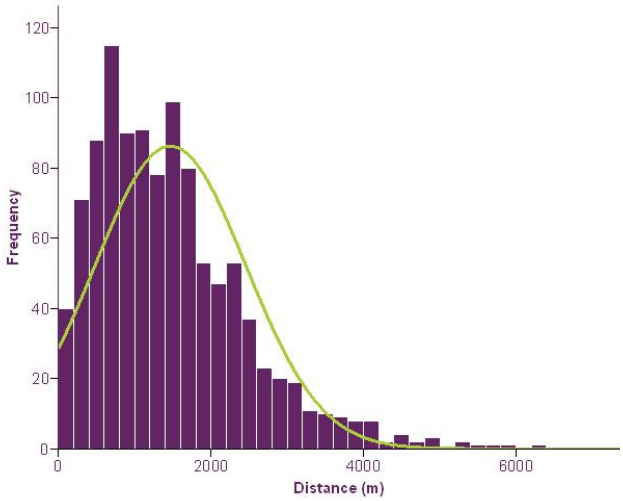
Source: SamKnows measurement data for all panel members with a connection in the 30 days from 23rd October 2008.
Note: 357 panellists received a maximum speed of >6Mbit/s; 147 panellists received a maximum speed of <2Mbit/s

Distance from exchange

7.9 As it is a characteristic of DSL broadband that speeds degrade with the length of the copper wire between the exchange and the consumer's premises, we would expect to see some relationship between the distance between a broadband connection and its local exchange and the speeds that are delivered through the connection.

7.10 Our research was not able to ascertain the length of the line between a panellist's address and their local exchange; we were only able to calculate the straight-line distance (i.e. 'as the crow flies'). As Figure 7.4 illustrates, there was a wide range of distances from exchange among our panellists, with an average of around 1.6km. It should be noted that there are some significant limitations in using straight-line distance as a proxy for distance from the exchange. In urban areas in particular, line lengths are often considerably longer than the straight-line distance as a consequence of the route taken; for example, in the Isle of Dogs in London's Docklands, it is not uncommon for lines to exceed 7km, despite being only 3km from the exchange.

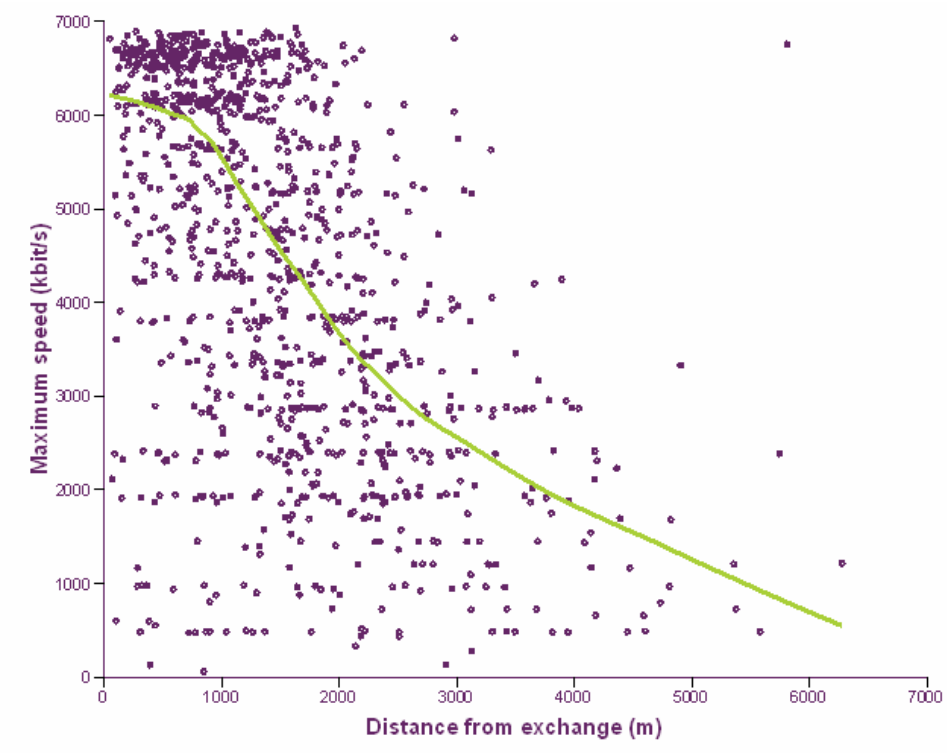
Figure 7.4 Distribution of distance from exchange among panellists



Source: Ofcom using data supplied by SamKnows

7.11 Nevertheless, there is clearly a relationship between the distance from exchange and the maximum line speed achieved (Figure 7.5). The majority of panellists living within 2km of their nearest exchange achieved a maximum speed in excess of 5Mbit/s, with only a small minority of those living more than 2km from the exchange achieving maximum speeds of over 5Mbit/s.

Figure 7.5 Distance from exchange and maximum download speeds achieved by panellists on packages of 'up to' 8Mbit/s

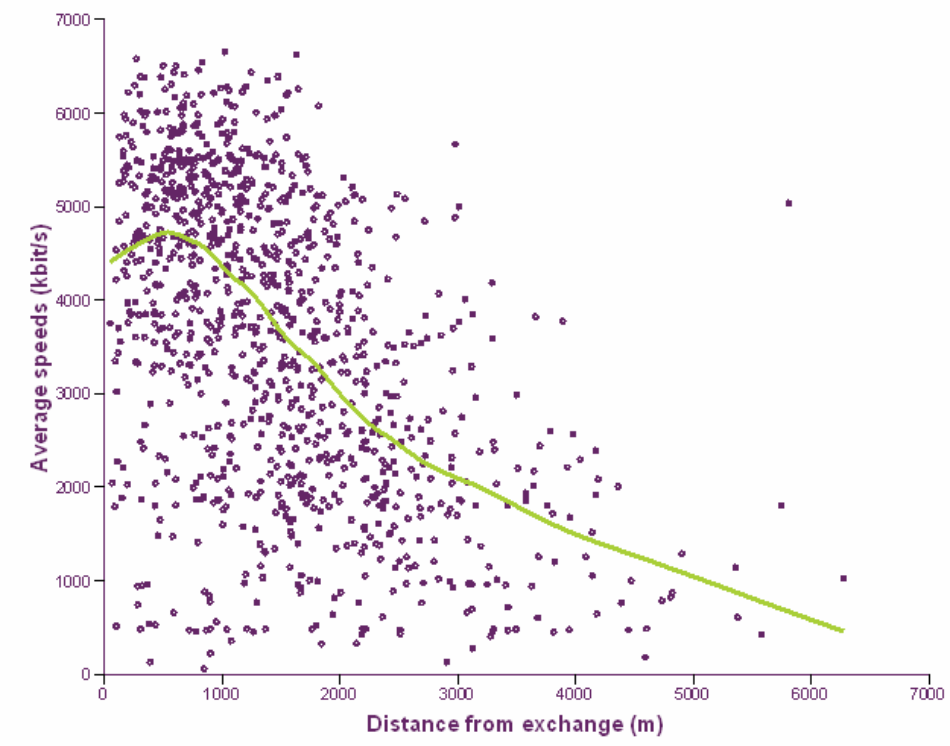


Source: SamKnows measurement data for all panel members with a connection in the 30 days from 23rd October 2008.

7.12 There is also a clear relationship between distance from exchange and the average speeds delivered (Figure 7.6).

7.13 However, while there is clearly a relationship between speeds delivered and distance from exchange, there is not as close a relationship as would be expected if this was the only driver of variation between DSL broadband subscriptions (even when allowing for the limitations of 'as the crow flies' calculations of distance rather than line lengths). The large variation of speeds between consumers who are approximately the same distance from the exchange may be explained by a number of factors including varying quality of in-house wiring, microfilters not being connected, or varying performance by the ISP.

Figure 7.6 Distance from exchange and average download speeds achieved by panellists on packages of 'up to' 8Mbit/s



Source: SamKnows measurement data for all panel members with a connection in the 30 days from 23rd October 2008

Geographic region

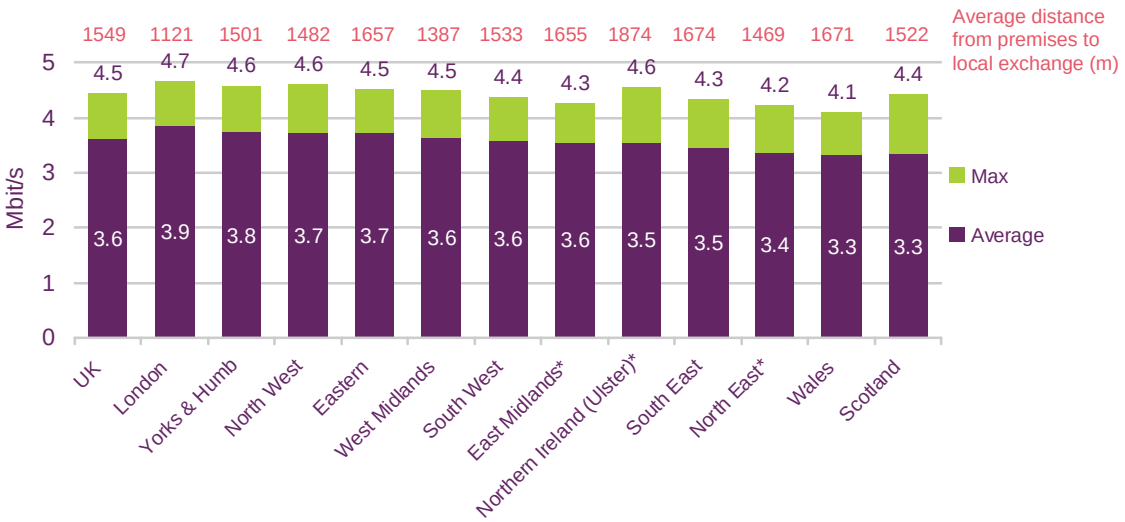
7.14 Probably because of typically shorter line lengths, London and other largely urban regions have the fastest maximum and average line speeds (Figure 7.7).

7.15 It is notable that the biggest gap between maximum line speeds and average line speeds appear in Scotland and Northern Ireland. This suggests that there may be higher contention in these nations than in Wales and the English regions.

7.16 However, these regional differences should be treated with some caution. The limitation of sample sizes, together with variation within the samples means that there is a relatively large error margin for some regions. In the case of Northern Ireland, a

small sample size of less than 100 panellists together with wide variation among these panellists (approximately a third of panellists live within 1km of the exchange, while there's also a relatively large proportion living more than 5km from the exchange), means that the error margin is up to 0.3Mbit/s (i.e. the maximum speed of 4.6Mbit/s could actually be as low as 4.3Mbit/s or as high as 4.9Mbit/s). It should also be noted that there may be relative regional differences among the nations and between the 'as the crow flies' distance we use and the actual electrical distance, which is defined by a combination of the actual length of the line and the quality of the line.

Figure 7.7 Average and maximum download speeds for 'up to' 8Mbit/s subscribers, by region



Source: SamKnows measurement data for all panel members with a connection in the 30 days from 23rd October 2008
*Note: * Caution small base (less than 100)*

Rural / urban

7.17 Average download speeds in urban areas were 3.7Mbit/s, 15% faster than average speeds in rural areas (3.2Mbit/s) (Figure 7.8). This is likely to be largely driven by the typically longer line lengths in rural areas; across our panel the average 'as the crow flies' distance from exchange for rural consumers was 1.93km, compared to an average distance of 1.43km for urban consumers.

7.18 However, maximum line speeds are just 11.6% higher in urban areas than in rural areas and, on average, rural lines achieve 78.8% of the maximum speed, compared to urban areas receiving 81.4% of maximum speeds. In some respects this may be surprising, as higher contention rates might be expected in urban areas, where exchanges typically serve a larger population. It suggests that rural exchanges may, on average, have poorer or more highly contended backhaul than urban exchanges.

Figure 7.8 Average and maximum download speeds for 'up to' 8Mbit/s subscribers in rural and urban areas

Source: SamKnows measurement data for all panel members with a connection in the 30 days from 23rd October 2008

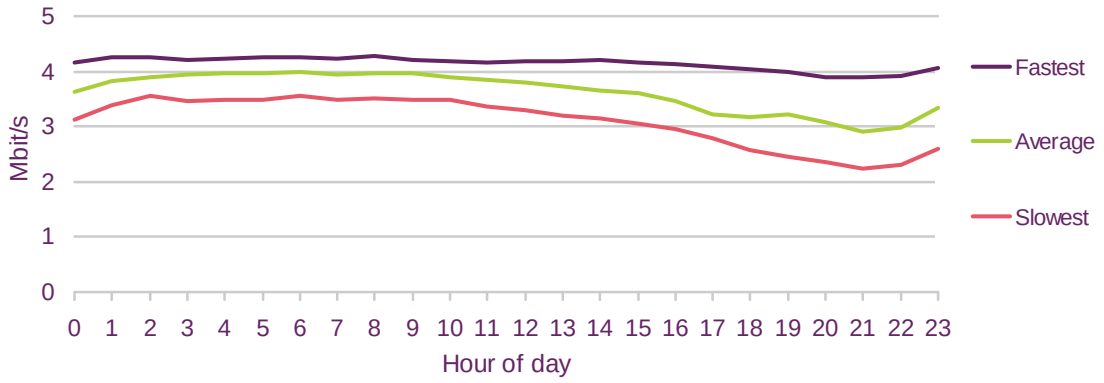
ISP

7.19 Our sample of 1,087 panellists with headline speeds of 'up to' 8Mbit/s allows us to have statistically significant data for six DSL operators (all with over 100 panellists). There is a marked difference between average download speeds delivered by the fastest provider among these six operators and average speeds delivered by the slowest provider (Figure 7.9). While the fastest provider is able to maintain a relatively stable average speed of between 3.9Mbit/s and 4.2Mbit/s, the slowest provider averages around 3.5Mbit/s in the early hours of the morning and slows to an average of around 2.3Mbit/s during the peak evening period.

7.20 It should be noted that these differences are not necessarily explained by good versus poor performance by particular ISPs, but may be the consequence of ISPs having different customer profiles. For example, LLU providers have typically focused on densely populated areas where the average line length will be shorter than the national average. The average 'as the crow flies' distance from exchange to local premises was 1.42km for the fastest provider and 1.61km for the slowest provider (the average for all panellists is 1.55km).

7.21 Nevertheless, the fact that the average speeds in the 'slowest hour' are 63% of those in the 'fastest hour' for the worst performing ISP, compared with 91% for the best performing ISP, suggests that speed degradation caused by contention is more of an issue for some ISPs than for others.

Figure 7.9 Average and maximum download speeds for 'up to' 8Mbit/s subscribers, by best and worst performing ISPs



Source: SamKnows measurement data for all panel members with a connection in the 30 days from 23rd October 2008

Section 8

Other metrics affecting performance

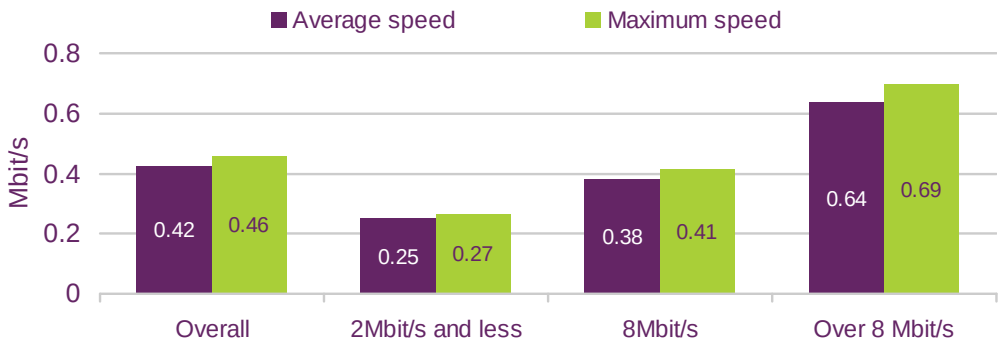
8.1 The performance of a broadband connection is not governed by download throughput speeds alone; raw speed is only one of the many factors that determine the performance of a broadband connection. The section of the report aims to demonstrate the effect of other key factors.

Upload speeds

8.2 Broadband connections do of course work both ways – they have an upstream as well as a downstream. While the market tends to focus on download speeds, as these are most important for most consumer applications, upload speeds are important for those looking to share large files, use real-time video communications and for some games.

8.3 There was less variation between the average and maximum upload speeds than was the case for download speeds, and overall results are largely as expected. The 'up to' 2Mbit/s products typically have an advertised upload speed of 256kbit/s, and this is very close to what was delivered. The 'up to' 8Mbit/s products vary somewhat in advertised upload speeds, although the most common is the 448kbit/s of *ADSL Max* (offered by all operators, using BT's wholesale product). Products over 8Mbit/s in downstream have a varying range of upstreams, and are often rate-adaptive in ADSL2+ too (meaning that the connection speed varies according to line quality).

Figure 8.1 Average and maximum upload speeds



Source: SamKnows measurement data for all panel members with a connection in the 30 days from 23rd October 2008

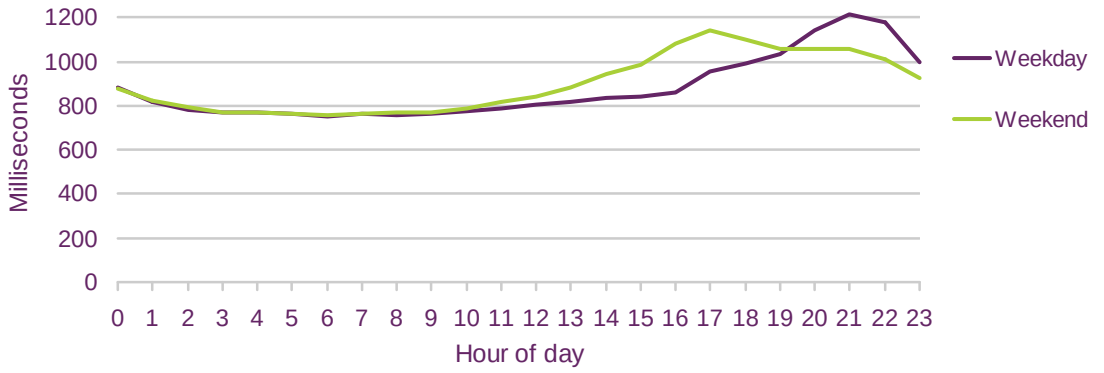
Web browsing

8.4 In order to assess the performance of basic web browsing, we measured the time in milliseconds to fetch the main HTML (i.e. text and basic code) from the home pages of three of the UK's most popular web sites.

8.5 As with the download tests, there is a noticeable difference between the results of weekend and weekday web browsing results. However, the much smaller variation

suggests that significant network optimisation has been undertaken to ensure web browsing performs well at all times.

Figure 8.2 Time to load web pages, by hour of day

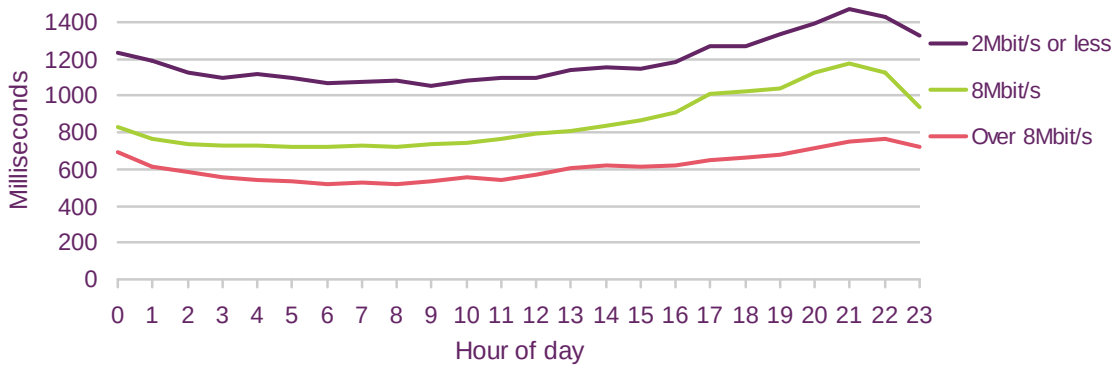


Source: SamKnows measurement data for all panel members with a connection in the 30 days from 23rd October 2008

8.6 Perhaps more interesting is the difference between the web browsing results over the three different headline speed bands. Figure 8.3 below demonstrates that the over 8Mbit/s products load web pages almost twice as quickly as the 'up to' 2Mbit/s products. The reduced latency, DNS resolution time and (obviously) throughput all contribute to the improvement demonstrated here.

8.7 Due to the relatively small sizes of most web pages (often measured in tens of Kilobytes), there should ultimately come a point when increasing the raw throughput of the connection will yield no tangible increase in the browsing performance. Latency will become the limiting factor in determining webpage load times on next-generation connections (see below).

Figure 8.3 Time to load web pages – variation by headline speed



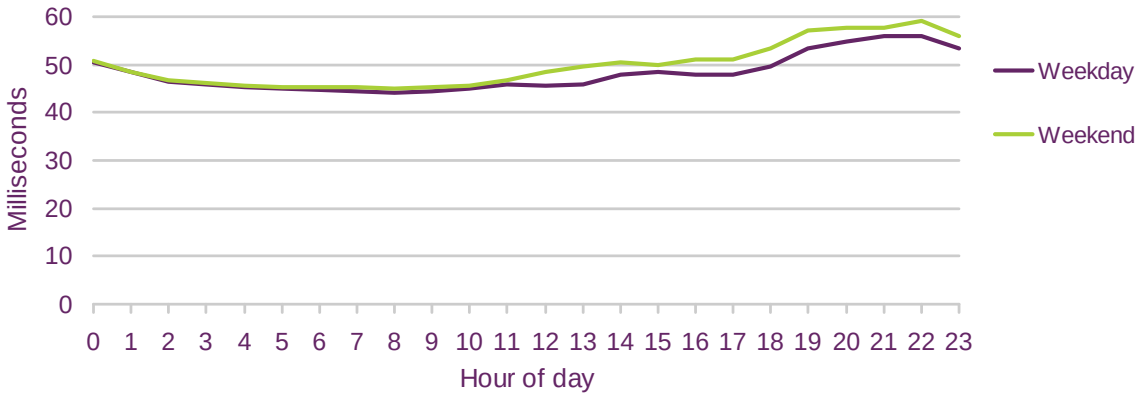
Source: SamKnows measurement data for all panel members with a connection in the 30 days from 23rd October 2008

Latency

8.8 Latency is the time it takes a single packet of data to travel from a user's PC to a third-party server and back again. The figure is most commonly measured in milliseconds, and a connection with low latency will feel more responsive for simple tasks like web browsing. Certain applications perform far better with lower latencies. Online gamers, for example, are particularly concerned with having a low latency connection, as a lower latency than another gamer can potentially give them an advantage.

8.9 Latency data (calculated across all participants in the survey) tells a similar story to the speed analysis above. The higher latency during the evening hours is indicative of increased contention in the networks. Again, we see some differences between weekdays and weekends, with weekends consistently producing a higher latency (and therefore worse performance) than the weekdays.

Figure 8.4 Latency, by time of day



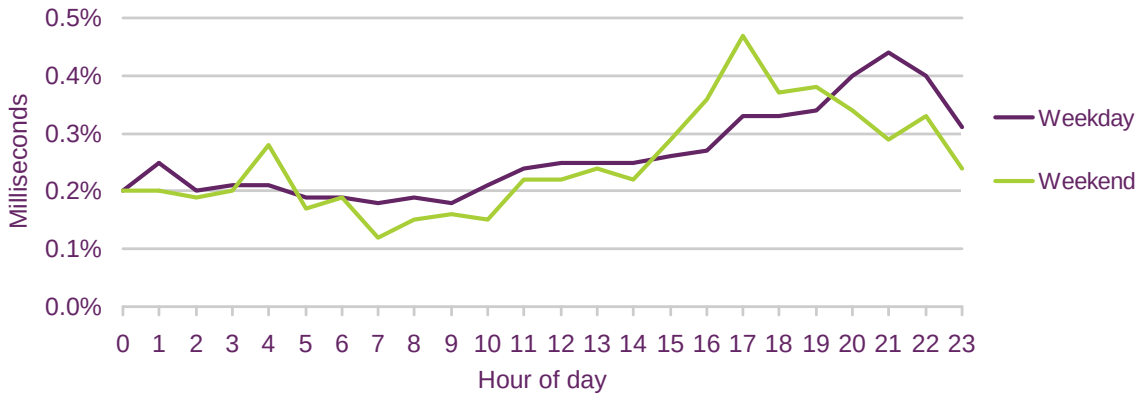
Source: SamKnows measurement data for all panel members with a connection in the 30 days from 23rd October 2008

Packet loss

8.10 Packet loss is the term used to describe the loss of data packages during transmission over an internet connection. It can considerably degrade real-time applications, and although network protocols such as TCP automatically deal with packet loss to minimise the impact on the end user, a temporary slow-down may still result. It can be a major concern for online gamers, and can also have a severe impact on voice over IP (VoIP) telephony or streaming audio or video (the odd dropped packet is generally acceptable as each packet in the test only accounts for 0.2 seconds, but extended periods of loss lead to choppy and broken-up video and audio). Packet loss is relatively rare in modern networks, although some small percentage is to be expected to occur on the internet.

8.11 Our data show that there is a three-fold increase in packet loss during peak hours (Figure 8.5). However, this represents an increase only from 0.15% loss to 0.45% loss, so the actual impact is likely to be minimal.

Figure 8.5 Packet loss, by hour of day



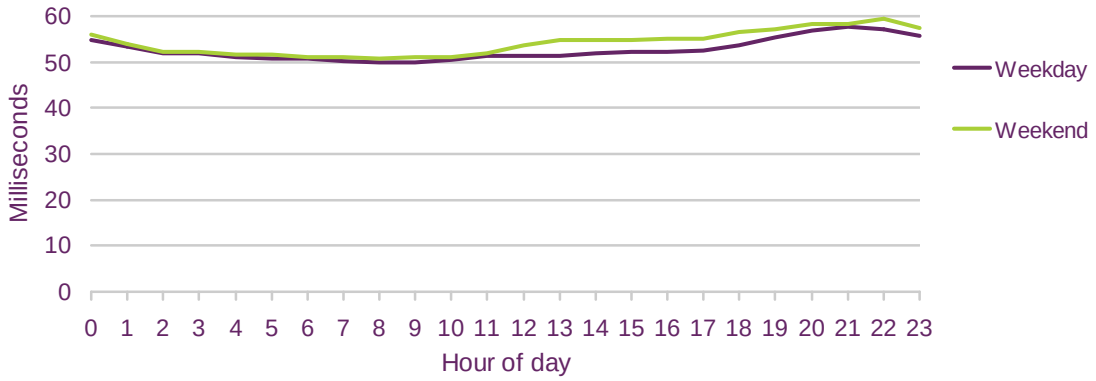
Source: SamKnows measurement data for all panel members with a connection in the 30 days from 23rd October 2008

DNS

8.12 DNS (the domain name service) provides a crucial role in the internet. This protocol translates domain names (such as google.com) into the IP addresses that are actually used to route traffic (e.g. 80.77.246.42). Every ISP maintains its own DNS servers through which customers' computers issue queries to translate names into IP addresses. When these servers fail or operate slowly, web browsing and other online activities suffer. A slow DNS time does not affect download speed, but can severely affect the responsiveness of browsing the internet.

8.13 As with latency, DNS performance decreases during evening hours and suffers particularly during the weekend (Figure 8.6).

Figure 8.6 DNS resolution time, by hour of day

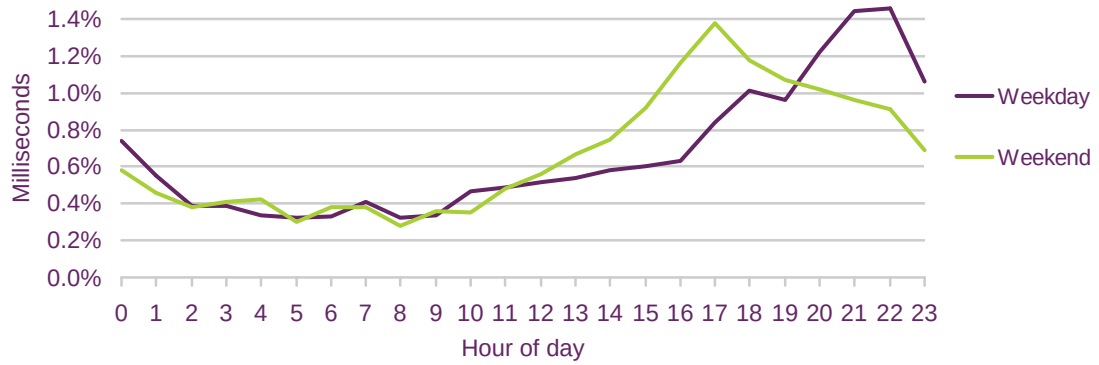


Source: SamKnows measurement data for all panel members with a connection in the 30 days from 23rd October 2008

8.14 When a DNS failure occurs the user is presented with an error message such as "This server is unavailable" or "Host could not be found". As with packet loss, DNS failures increase more than three-fold during peak hours to nearly 1.5% (Figure 8.7).

The peak failure rates on both weekdays and weekends coincide with the slowest speeds experienced in the download speed tests, suggesting that network contention (and thus packet loss) rather than the DNS servers are to blame for the failures.

Figure 8.7 DNS failure rate, by hour of day



Source: SamKnows measurement data for all panel members with a connection in the 30 days from 23rd October 2008

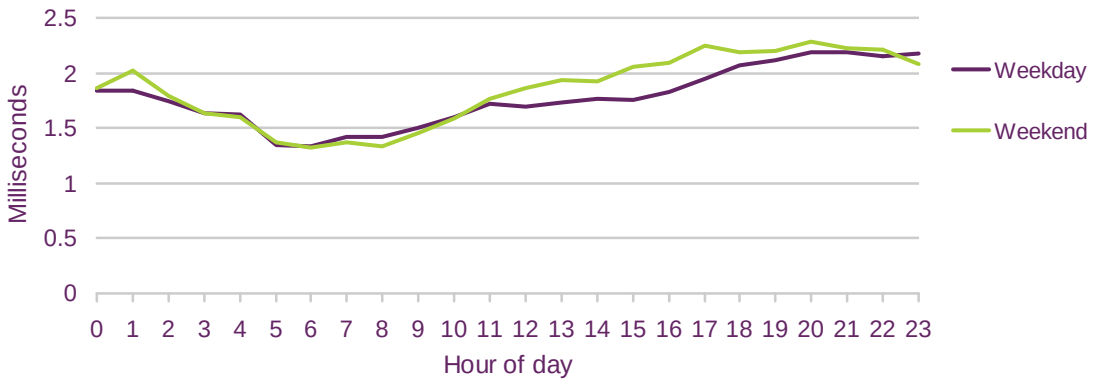
Jitter

8.15 'Jitter' can be defined as the rate of change of latency; it is the measure of the stability of a connection. Jitter and packet loss are the two biggest contributors to the quality of a VoIP (Voice over IP) phone call. Online gamers too will desire low jitter (low latency is useless if the connection has a high jitter rate).

8.16 It should be noted that modern specialist VoIP devices will often include a 'jitter buffer' of around 20 milliseconds. This effectively allows for up to 20 millisecond jitter with no noticeable effect for the end user.

8.17 As with all other metrics, the performance decreases noticeably in the evening, and weekend performance suffers particularly. However, the average jitter rate across all panellists suggests a high level of stability of connection.

Figure 8.8 Jitter, by hour of day



Source: SamKnows measurement data for all panel members with a connection in the 30 days from 23rd October 2008

Section 9

Conclusion

9.1 Ofcom's broadband speeds code of practice requires ISPs to better explain to new customers what speeds they are likely to obtain in practice, and also to tell them what steps they can take to improve their broadband performance. Our research findings indicate that there is both consumer demand for such information and room for further improvement in these areas.

9.2 Survey results show that while there are high levels of satisfaction with overall broadband performance, broadband speeds are a significant consumer issue.

- Twenty-one per cent of all consumers claimed to have some level of dissatisfaction with speeds, compared to 16% expressing dissatisfaction with value for money and 13% expressing dissatisfaction with the reliability of connection.
- Among those claiming to be dissatisfied with their overall broadband service, the speed of their connection was the most commonly cited cause for dissatisfaction, with 30% claiming that it was the main reason for dissatisfaction with their ISP.
- Twenty-six per cent of consumers claim that the speed of their broadband connection is not as they expected when they signed up.
- While 93% of broadband users claim to be satisfied with their experience of web browsing, satisfaction rates are lower for all other services which require the streaming or downloading of content and therefore benefit from higher speeds and/or more consistent performance.
- Ninety-one per cent of consumers say that speed was an important consideration when they signed up for their current broadband provider.
- However, despite the significance of speed, levels of understanding are poor for many consumers. Twenty-eight per cent of consumers are unaware of the headline speed of their broadband service, while levels of understanding of what drives the speed of a broadband connection are modest.

9.3 It must be noted that while our performance measurement very accurately captured the quality of the broadband connection being delivered into consumers' homes, there are other factors affecting performance which may contribute to dissatisfaction. These include:

- users being frustrated by the slow speed of the servers of websites they are visiting and applications they are using;
- speeds being reduced by simultaneous use of the same broadband connection by more than one computer;
- poorly configured wireless networks; and
- slow computers or networking equipment.

9.4 The quality of the connection into the home may also be affected by poor quality of in-home wiring or the absence of properly fitted filters.

9.5 Nevertheless, the findings from the broadband speed data relate well to the survey data.

- Rural users are both more likely than their urban counterparts to be dissatisfied with their overall broadband services and with the speed of their service. This is not surprising, as they typically receive slower speeds than urban users (among consumers on 8Mbit/s packages, the average speed for urban users is 15% higher than for rural users).

- Similarly, broadband users in Scotland are significantly less satisfied than those in England with their overall broadband service, and average speeds in Scotland are lower than in every English region.

9.6 The broadband speed data reveal that overall UK consumers typically receive broadband speeds sufficient for most current internet applications. For example, the average speed of 3.6Mbit/s is capable of supporting standard definition video. Similarly, the non-speed tests all show levels of overall performance acceptable for most internet applications, with average latency, jitter, packet loss and DNS resolution times being low.

9.7 However, there are a large minority of consumers who receive average speeds which are well below this overall average. Around one in five consumers on ‘up to’ 8Mbit/s packages receive average speeds of below 2Mbit/s.

9.8 There are also some variations in broadband performance which indicate that ISP-specific factors are also relevant to the broadband speeds consumers obtain:

- Consumers in the UK on average receive just 83% of their maximum line speed. A key constraint on actual speeds is therefore likely to be the capacity of the ISPs’ networks, since our tests were designed to minimise the impact of other factors, such as overloading of web servers at peak times, or congestion on the wider internet.

- Speeds are slowest at the times when consumers are most likely to be using the internet: in the peak usage hour, speeds are on average over 30% slower than during the fastest hour. As more broadband connections use more bandwidth-hungry services, further investment in infrastructure will be necessary to ensure that performance at peak times is not further degraded.

- In the UK, broadband penetration is higher in rural than in urban areas. However, rural consumers receive slower speeds. The predominance of DSL broadband in rural areas and the typically longer length of the line between exchange and premises means that maximum line speeds are likely to be lower in rural than urban areas for the foreseeable future; however, our data also show that average speeds as a proportion of maximum speeds are slightly lower in rural than urban areas, suggesting that backhaul contention is having an impact on speed for many rural consumers.

- There is significant variation between ISPs. The slowest of the six providers for whom we had statistically significant sample sizes on the ‘up to’ 8Mbit/s package delivered average speeds of just 71% of the fastest provider. Some of this difference may be explained by customer profile (for example, an ISP with a predominantly urban customer base will have a shorter average line length than ISPs with a higher proportion of rural customers). However, there is also some evidence that ISP-specific factors, specifically the capacity of their respective networks, also played a

part: the fact that the worst-performing ISP had much greater variation by hour of day suggests that contention is also a cause of this variation.

9.9 Many ISPs are putting significant investment into developing their infrastructures in order to deliver faster broadband speeds and better performance to consumers. We note in particular the upgrade from ADSL1 to ADSL2+ and the next-generation initiatives underway or in planning, including Virgin Media's upgrade of large sections of its cable network to the Euro DOCSIS 3.0 standard, which enabled the launch of broadband services at 'up to' 50Mbit/s in December 2008. Ofcom is committed to working to ensure a regulatory environment which encourages the investment necessary to deliver faster broadband across the UK. Conclusions following consultation into delivering super-fast broadband in the UK will be published in spring 2009.

9.10 We will consider further how consumers can get better comparative information on ISPs' respective performance, to enable them to choose the best broadband deal. This report details only high-level findings from the first 30 days of data collection. A fuller report, to be published in spring 2009, will further explore these issues and include the following:

- Full survey findings.
- Detailed cross-analysis between the survey and the broadband performance data; for example, to identify at an individual level the relationships between broadband performance, satisfaction and use.
- Change in broadband performance over time.

Annex 1

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 nstalled 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:

1. HTTP download on port 80, single-threaded

2. 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 following headers, which should disable caching in standards-compliant proxy servers:

Cache-Control: "private, pre-check=0, post-check=0, max-age=0"

Expires: 0

Pragma: no-cache

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.

Annex 2

Glossary

Access line speed The maximum broadband download speed that a line is capable of supporting. See also Maximum line speed.

ADSL Asymmetric Digital Subscriber Line. A digital technology that allows the use of a standard telephone line to provide high speed data communications. Allows higher speeds in one direction (towards the customer) than the other.

ADSL1 The first generation of ADSL, capable of data speeds of up to 8Mbit/s towards the customer and up to 640kbit/s from the customer.

ADSL2/ADSL2+ Improved versions of ADSL, offering high speeds, especially on shorter telephone lines. In the case of ADSL2+, up to 24Mb/s can be delivered towards the customer.

ATP Asynchronous Transfer Mode. A telecommunications protocol used in networking.

Backhaul The links by which data are transmitted from a local telephone exchange back to the core or backbone of the operator's network.

Bandwidth The maximum amount of data that can be transmitted along a channel.

Bit-rate The rate at which digital information is carried within a specified communication channel.

Bitstream A wholesale service providing conveyance of data traffic from an end user's premises to a point of interconnection made available by the incumbent to a competitive provider.

Broadband A service or connection generally defined as being 'always on' and providing a bandwidth greater than narrowband.

Broadband speed The speed at which data are transmitted over a broadband connection, usually measured in megabits per second (Mbit/s), and usually used to refer to the download speed

Contention A slowdown in performance caused when multiple users share the same bandwidth within a network and the bandwidth available is less than the aggregate demand.

Contention ratio An indication of the number of customers who share the capacity available in an ISP's broadband network. Figures of 50:1 for residential broadband connections and 20:1 for business are typical.

Download speed Also downlink or downstream speed. Rate of data transmission from a network operator's access node to a customer, typically measured in Megabits per second (Mbit/s).

DNS The Domain Name Service (or System) provides a crucial role in the internet. This protocol translates domain names (such as google.com) into the IP addresses that are actually used to route traffic (e.g. 80.77.246.42). Every ISP maintains its own DNS servers

through which customers' computers issue queries to translate names into IP addresses. When these servers fail or operate slowly, web browsing and other online activities suffer.

DSL Digital Subscriber Line. A family of technologies generally referred to as DSL, or xDSL, capable of transforming ordinary phone lines (also known as 'twisted copper pairs') into high-speed digital lines, capable of supporting advanced services such as fast internet access and video-on-demand. ADSL, HDSL (high data rate digital subscriber line) and VDSL (very high data rate digital subscriber line) are all variants of xDSL).

DSLAM Digital Subscriber Line Access Multiplexer. Allows telephone lines to make faster connections to the Internet.

Exchange The local telephone exchange is the building where all consumers' copper telephone lines are connected to enable telephone calls to be switched, and where network equipment is installed which enables consumers' data traffic to be routed via an operator's core network to its destination.

Headline speed The speed at which a broadband service is marketed, usually expressed as 'up to' (for example, in January 2009 all of BT's nationally available broadband services are advertised as "up to 8Mbit/s"). Typically, the headline speed represents the theoretical maximum download data speed that can be achieved by any consumer on this package. A number of factors, such as the quality and length of the physical line from the exchange to the customer, mean that a customer may never experience this headline speed in practice.

IP (internet protocol) The packet data protocol used for routing and carriage of messages across the internet and similar networks.

ISP Internet Service Provider. A company that provides access to the internet.

Jitter The variation in latency.

Kbit/s Kilobits per second. A unit measuring the bit-rate in multiples of 1,024 bits per second. 1,000Kbit/s is the same as 1Mbit/s.

Latency The time is takes a single packet of data to travel from a user's PC to a third-party server and back again. The figure is most commonly measured in milliseconds, and a connection with low latency will feel more responsive for simple tasks like web browsing.

LLU (local loop unbundling) LLU is the process whereby incumbent operators (in the UK this means BT and Kingston Communications) make their local network (the lines that run from customer's premises to the telephone exchange) available to other communications providers. The process requires the competitor to deploy its own equipment in the incumbent's local exchange and to establish a backhaul connection between this equipment and its core network.

Local loop The access network connection between the customer's premises and the local PSTN exchange, usually a loop comprising two copper wires.

Maximum line speed The highest download speed that a broadband connection is capable of delivering. Also known as the access line speed. As it is a characteristic of DSL broadband that speeds degrade with distance from exchange, the maximum line speed varies, and, for ADSL1 connections, only those users who have a line length of less than 1km typically achieve maximum speeds of close to a headline speed of 8Mbit/s.

Mbit/s Megabits per second. A unit measuring the bit-rate.1Mbit/s is the equivalent of 1,000Kbit/s.

Microfilter A small device which plugs into a normal phone socket and splits the line into both a standard BT telephone socket and an ADSL broadband socket. It is used to protect the ADSL signal from being contaminated by signal noise from a voice service, allowing both voice and data to share common inside wiring. Microfilters should be installed into all phone sockets within a house; if they are not installed broadband performance may suffer.

Next-generation access networks (NGA) Broadband access networks that connect the end-user to the core network, capable of a bandwidth quantity and quality significantly in excess of current levels (a benchmark of 20Mbit/s or more is often used).

Packet loss The loss of data packages during transmission over an internet connection.

PSTN Public Switched Telephony Network.

Router A broadband router enables a connection between more than one computer and the internet (unlike a broadband modem which is used to connect just one computer to the broadband connection). Wireless routers enable computers to connect to the broadband connection via a WiFi network.

Streaming content Audio or video files sent in compressed form over the internet and consumed by the user as they arrive. Streaming is different to downloading, where content is saved on the user's hard disk before the user accesses it.

TCP The Transmission Control Protocol (TCP) is one of the core protocols of the Internet Protocol Suite.

Throughput speed The actual speeds delivered to consumers over a broadband connection, usually measured in Megabits per second, and generally referring to the download speed.

Upload speed Also uplink or upstream speed. Rate of data transmission from a customer's connection to a network operator's access node, typically measured in Kilobits per second (Kbit/s).

USB modem A way of connecting to the internet via the USB socket on a computer. Unlike a router, a USB modem allows only one computer to connect at any one time to a broadband connection.

VoIP Voice over Internet Protocol. A technology that allows users to send calls using internet protocol, using either the public internet or private IP networks, rather than the PSTN.