UK broadband speeds 2009
Consumers’ experience of fixed-line broadband performance

Research Report
Publication date: 28 July 2009
# Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background</td>
<td>2</td>
</tr>
<tr>
<td>Using this report</td>
<td>4</td>
</tr>
<tr>
<td>1 Executive summary</td>
<td>7</td>
</tr>
<tr>
<td>2 Introduction</td>
<td>11</td>
</tr>
<tr>
<td>3 Objectives and methodology</td>
<td>16</td>
</tr>
<tr>
<td>4 Broadband speed performance</td>
<td>20</td>
</tr>
<tr>
<td>5 Consumer perceptions</td>
<td>28</td>
</tr>
<tr>
<td>6 Drivers of variation in broadband speed</td>
<td>40</td>
</tr>
<tr>
<td>7 Variation by internet service provider (ISP)</td>
<td>54</td>
</tr>
<tr>
<td>8 Other metrics affecting performance</td>
<td>68</td>
</tr>
<tr>
<td>9 Conclusion and next steps</td>
<td>75</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Annex</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Glossary</td>
<td>77</td>
</tr>
<tr>
<td>2 Technical methodology</td>
<td>80</td>
</tr>
<tr>
<td>3 Statistical methodology</td>
<td>83</td>
</tr>
<tr>
<td>4 Additional data</td>
<td>94</td>
</tr>
<tr>
<td>5 Significance testing</td>
<td>103</td>
</tr>
<tr>
<td>6 GfK full research report</td>
<td>112</td>
</tr>
</tbody>
</table>
Background

Broadband internet services are playing an ever more central role in the lives of the UK’s consumers and citizens. Recent research by the Communications Consumer Panel concluded that households with broadband regard it as an essential utility, as important as electricity, gas or telephony. In its Digital Britain report, the Government confirmed its intention to deliver broadband access of at least 2Mbit/s to virtually all UK households by 2012. It has also proposed the creation of a new independent fund to extend next-generation super-fast broadband services to areas where it is not commercially viable to do so.

This research report provides important insights into the current performance of the UK’s broadband networks, and in particular the actual download speeds that consumers receive. Speed has become more significant as people increasingly use the internet to download video and audio, but consumers have lacked reliable information on the actual speeds delivered by ISPs. Our consumer research has shown that speeds are the single biggest cause of dissatisfaction in relation to broadband.

The research has been a huge undertaking, involving the installation of hardware monitoring equipment in the homes of a representative sample of over 1600 UK broadband users. During the six months of data collection we have run around 60 million tests in total. We believe that this research is a step change from other research into broadband speeds in terms of providing a robust analysis of the variables that affect broadband speeds and we have taken great care to ensure that the data we present is representative of UK broadband users as a whole, and also enables like-for-like comparison between providers. We are very grateful to technical partner SamKnows both for supplying the technical methodology and also assisting in the collection and interpretation of the data, to market research partner GfK NOP Ltd for recruiting and managing a representative panel of UK broadband users and collecting and collating survey data, and to Professor Andrew Chesher (Fellow of the Royal Statistical Society) for his contribution to and independent expert validation of the statistical methodology we have employed in this analysis.

Our research has confirmed that actual broadband speeds are significantly below the advertised headline speeds. In part, this is because DSL broadband slows as customers get further from the exchange. But we also found that speeds slowed down during peak times and that this affects both DSL and cable broadband services.

We have already taken steps to help ensure that consumers are not misled on speeds as a result; under the voluntary Code of Practice on Broadband Speeds (‘the Code’) which came into force in December 2008, internet service providers (ISPs) are required to tell customers the maximum speed they can expect and must also explain why actual speeds differ from headline speeds. It is essential that ISPs comply with the Code’s requirements, particularly as faster broadband services with higher headline speeds are introduced.

Our research found that there are small but significant differences between the performance of individual ISPs over the period we conducted the research, largely driven by the access technology employed and the capacity of their networks.

This report is an important step in understanding the factors that affect broadband speed and performance. Publication of this research should help consumers understand more about the factors which determine broadband performance. In turn, operators will have greater incentive to compete on actual performance, and invest in newer access technologies and increased backhaul capacity in order to provide consumers with faster broadband services. Publication of this research is part of our broader strategy in relation to super-fast broadband of stimulating timely investment through effective competition and
promoting consumer understanding. It provides much new valuable insight into the UK’s broadband market and we hope it proves to be a useful reference source for consumers and our other stakeholders.
Using this report

Purpose of this report

We commissioned this research to gain an understanding of broadband performance in the UK and relate it to consumers’ perceptions of their broadband services. This report sets out our findings over the six month period from November 2008 to April 2009. The results provide extremely useful insights into the factors that affect broadband performance, but with the following limitations:

- The information presented in this report relates to broadband speeds and other performance measures such as upload speeds, latency, jitter etc. Other factors relevant to purchasing broadband – such as price, customer service, etc – are not discussed in this report.

- Broadband performance depends to a large extent on where consumers are located. Reporting of average performance information in this report therefore does not necessarily reveal the performance available to any individual consumer. Furthermore, the particular broadband services available to a particular consumer will also depend on where they are located.

- In the UK there are over 200 different broadband ISPs and we have not been able to report on the performance of each of these ISPs. Instead, we have been able to gain a sufficient sample of panellists to be able to report the performance of the nine largest ISPs by retail market share which collectively represent over 90% of broadband subscribers. However, consumers should bear in mind that there are many other ISPs available, which may perform better or worse than those specifically featured in this report.

- Our research relates only to cable and DSL broadband services. Mobile broadband services were out of scope since the technical methodology we used was not suited to testing the performance of mobile broadband. We are currently considering how we can conduct research into the network quality of mobile services, including mobile broadband¹. Other broadband platforms such as fibre-based broadband or satellite broadband are also not included as they currently represent a small proportion of the total broadband market.

- This research report presents information on the state of broadband performance from November 2008 to April 2009. However, the broadband market continues to evolve rapidly and the speeds and general performance results set out in this report are therefore liable to change.

- Despite these limitations we hope that this report can serve as a useful reference source for consumers and our other stakeholders.

We welcome feedback on all of Ofcom’s reports. Please email comments to Ofcom’s Market Intelligence team at market.intelligence@ofcom.org.uk.

¹ See Mostly Mobile: Ofcom’s mobile sector assessment second consultation, 8 July 2009, www.ofcom.org.uk/consult/condocs/msa/
Key terms used to describe broadband speeds

In this report we use three key terms to describe download speeds:

- The ‘headline speed’ or ‘advertised speed’ is the download speed at which broadband services are typically marketed, usually expressed as ‘up to’ X Mbit/s (megabits per second).
- The ‘maximum line speed’, or ‘access line speed’, is the maximum download speed that a line is capable of supporting.
- The ‘average download throughput’ speed or ‘average download’ speed, represents the average actual speeds that a consumer receives, which drives the speed at which web pages and files can be downloaded. (See the Glossary in Annex 1 for fuller definitions of these terms).

Key statistical concepts used in this report

This report presents the findings from research which has involved the collection and interpretation of around 60 million data points. It has been a complex process, both technically and statistically, and as a consequence the analysis may not be as easy to understand as that in many of our research publications.

The methods of analysis for the provider-specific comparison have had expert review by econometrician Professor Andrew Chesher of University College London. His review of the methodology we have used is included in Section 3.

The Glossary in Annex 1 provides a detailed definition of the technical terms we use throughout the report. However, knowledge of the following is important in order to understand how we have analysed the performance data which follows.

- We present estimates only in cases in which there is sufficient data to deliver a statistically sound result. This means that we only report estimates when statistical analysis indicates that they are accurate enough to be useful. Accuracy is determined by the size of the sample and also by the variation within this sample. It is for this reason, for example, that we are able to compare the performance of ISPs offering ‘up to’ 8Mbit/s broadband services whereas we cannot compare those offering ‘up to’ 16Mbit/s broadband services. For this latter group the small sample sizes and the large variation within these samples mean that the error margin is so large that comparisons are not statistically robust.

- In order to acknowledge the limited accuracy of the estimates and ensure that we are only highlighting differences which are statistically significant, for many charts we do not show a value but instead show a range around the mean value which indicates the statistical confidence we have in our results. The range we use is called a 95% confidence interval, which is a statistically derived range calculated from the standard error (which is itself calculated from the sample size and the variation within the sample). A 95% confidence interval means that if we repeated the research again with a different sample assembled in the same way there would be a 95% probability that the results would be in the range shown. Where we have large samples and/or little variation within the sample, the confidence interval is much smaller than where we have smaller samples and/or large
variation within the sample. Differences are reported as “significant” if they are significantly different as judged by a 5% test of statistical significance.  

- In addition to the steps we took to ensure that our panel was as representative of UK broadband users as a whole, we have weighted the data by ISP, by region and by rural/urban split in order to ensure that what we present is as representative as possible of UK broadband users as a whole. As a theoretical example, if the composition of our panel contained a smaller proportion of consumers in Wales than was actually the case, then we would give greater weight to each panellist in Wales in order to ensure that Welsh consumers were correctly represented. Similarly if our panel had more BT Retail consumers than the actual proportion of BT Retail consumers, then we would give less weight to each panellist with BT Retail in order to ensure a correct representation by ISP.

- We have ‘normalised’ the data where we are comparing the performance of individual ISPs, or groups of ISPs, in order to ensure that comparisons are made on a like-for-like basis and that the analysis provides a fair comparison of actual performance rather than reflecting differences in ISP customer profiles.

- Normalisation for distance from exchange was particularly important for DSL broadband providers because with this technology speeds degrade as the length of the line from local telephone exchange to premises increases. Therefore operators that have a higher proportion of consumers in rural areas, where line lengths are typically longer, may be expected to deliver lower speeds than those which focus on towns and cities simply because they have a different customer profile. In order to normalise for distance we used the straight line distance between the panellist’s location (using the relevant postcode) and their exchange. We then checked to ensure this was appropriate and robust using a number of means including ensuring that straight-line distance was a suitable substitute for line attenuation, and comparing the normalised with the un-normalised results. A full description of our normalisation process and the checks we applied is provided in Annex 3. The methodology we used for normalisation has been reviewed and endorsed by an external reviewer (see section 3).

- For Virgin Media’s cable service, which is available to around 49% of UK homes, we normalised by rural/urban and by region in order to ensure that it was fairly compared against operators offering nationwide services. We did not normalise by distance from exchange as cable services do not degrade significantly over the length of the line.

\[ A \text{ 5\% test of statistical significance is a test which falsely rejects hypotheses that are true only 5\% of the time.}\]
Section 1

Executive summary

Background

1.1 Ofcom’s primary duty under the Communications Act 2003 (the “Act”) is to further the interests of UK citizens and consumers in carrying out our functions. In addition to securing the availability of a wide range of electronic communications services including broadband services, encouraging investment and innovation in relevant markets and the availability and use of high-speed data services, we must have regard to the interests of consumers’ interests in respect of price, quality and value for money. Our duties include the requirement to carry out research into consumers’ experiences of the way services are provided and to publish and take account of the results of our research.

1.2 Broadband speeds are an important factor in determining consumers’ internet experience. Broadband is typically sold by its advertised ‘up to’ speed, while consumers can also get information on the maximum speed their line is capable of supporting. However, there is currently a lack of robust information on the actual speeds that are delivered.

1.3 To address this issue, and to gain a better understanding of broadband performance in the UK, Ofcom, in association with technical partner SamKnows Ltd and market research company GfK NOP Ltd, set up a panel of more than 2,500 UK broadband users, of whom over 1,600 connected monitoring equipment to their router and provided performance data during the six-month period from November 2008 to April 2009. We ran over 60 million tests over the course of the research and we believe that the integrity of our hardware-based technical methodology combined with the scale of the project and the sophistication of the statistical analysis makes this research a step change from other research into broadband speeds in terms of providing a robust analysis of the variables that affect broadband speeds.

1.4 We also asked 2,128 panellists for their views on their broadband service, including speeds, which we were then able to relate to the performance they received.

1.5 This report sets out our findings.

Broadband performance matters to consumers

1.6 Our results show the importance of broadband speeds to consumers:

- While a large majority (83%) of our panellists were satisfied overall with their broadband service, speed was the single biggest cause of dissatisfaction among those who were dissatisfied.

- More than one in five consumers (21%) expressed dissatisfaction with broadband speeds, compared to 16% who were dissatisfied with value for money and 13% with the reliability of their connections.

- Over a quarter of consumers (26%) said that the speeds they received were not what they expected when they signed up for their broadband service.
Consumers who received lower actual speeds said that they were less satisfied overall with their broadband service.

**Average broadband speeds in the UK are significantly below headline speeds**

Broadband is often advertised and sold on the basis of headline speeds (e.g. ‘up to’ 8Mbit/s). However, a number of constraints on broadband performance, including distance from premises to the exchange, congestion on ISPs’ networks and the general internet, and home wiring, combine to make actual speeds significantly lower than headline speeds:

- Our research found that in April 2009 average broadband speeds in the UK were 4.1Mbit/s, which was equivalent to 57% of the average advertised headline speed. (We found little change in performance month to month for the duration of the research).
- Actual speeds were significantly lower in the peak evening hours. Average speeds between 8pm and 10pm were 3.7Mbit/s. This is equivalent to around 90% of those between 9am and 5pm on weekdays and around 77% of the average maximum speeds received at any point during the day (which we call the maximum line speed).
- Of those customers on headline packages of more than 2Mbit/s, 17% received average speeds below 2Mbit/s (the speed which the Government’s Digital Britain report has said should be universally available by 2012). Eleven per cent never achieved a speed in excess of 2Mbit/s. This is consistent with the analysis within the Digital Britain report which has estimated that 11% of all lines are currently unable to deliver a 2Mbit/s service.

**Access technology and network capacity underlie variations in performance**

Our research found that the actual speeds delivered by different ISP packages varied significantly.

Our sample sizes were sufficient to enable us to compare the ‘up to’ 8Mbit/s services of the eight largest DSL operators alongside the ‘up to’ 10Mbit/s cable broadband service offered by Virgin Media. Our results showed the following:

- On average, customers on Virgin Media’s ‘up to’ 10Mbit/s cable service received speeds over twice as high as ‘up to 8Mbit/s’ DSL customers.
- Among ‘up to’ 8Mbit/s services, those delivered using ADSL2+ were, on average, significantly faster than those using ADSL1. Access technology alone, however, is not the sole factor in determining broadband speeds: we found that Plusnet (which predominantly uses ADSL1 at present) produced similar speeds to ADSL2+ ‘up to’ 8Mbit/s packages, while speeds delivered by AOL Broadband (which uses ADSL2+) were slower than those delivered by Plusnet.
- Consumers subscribing to ADSL2+ services of ‘up to’ 16Mbit/s or higher received average speeds of around 8Mbit/s – nearly twice as fast as subscribers on ‘up to’ 8Mbit/s ADSL2+ services. Speeds delivered by ADSL2+ services of ‘up to’ 16Mbit/s were similar to those delivered via ‘up to’ 10Mbit/s cable.
• The fastest speeds within our sample were delivered by Virgin Media’s ‘up to’ 20Mbit/s packages, although the average speed of around 13Mbit/s was significantly lower than the headline package speed (we did not have a sample of Virgin Media’s ‘up to’ 50Mbit/s customers).

1.10 The other main factor affecting broadband speeds was the capacity of ISPs’ networks. All consumers experienced a slowdown in actual speeds during peak evening hours (8-10pm). But there was typically less of a slowdown where consumers received their broadband through operators which employed local loop unbundling (LLU). This may be a reflection of higher backhaul capacity. A notable exception was Plusnet (which uses BT Wholesale services), where customers on average experienced less of a slowdown than customers with most other operators, including those using LLU.

**Measures other than download speed also affect broadband performance**

1.11 As download speed is one of many factors which affect performance we also researched other metrics such as upload speeds (the time taken to send information over a broadband connection), latency (the time it takes a single packet of data to travel from a user’s PC to a third-party server and back again), packet loss (the loss of data packages during transmission over an internet connection) and jitter (a measure of the stability of a connection). Our results were as follows:

• In general, the pattern for these performance metrics was similar to that of download speed, with poorer performance for packages with lower headline speeds, and poorer performance in the evening.

• Average actual upload speeds were 0.43Mbit/s, or less than 10% of download speeds. Even on DSL packages with headline download speeds of 16Mbit/s and more, and on cable packages of 20Mbit/s, the average upload speed was less than 0.7Mbit/s.

• The average performance of web browsing, latency, packet loss, DNS Domain Name Service) resolution and failure rates and jitter, for all access technologies at all headline speeds, were sufficient to have no significant detrimental impact on the overall consumer experience of using most internet applications.

• DSL services offer significantly better performance than cable services on jitter. However, this is unlikely to have a significant effect on the user experience for most internet applications, although for some online games jitter is a very important measure as the stability of connection can be paramount.

**Conclusions and next steps**

1.12 This research report is a representative snapshot of the current state of broadband performance from November 2008 to April 2009 and we have noted the limitations of the research. The broadband market is changing rapidly, driven by consumers’ growing demand for faster broadband. Operators, in turn, are continuing to invest in their networks in order to make faster broadband available. Therefore the results set out in this report will not necessarily reflect the future performance of networks and providers.

1.13 However, we believe our research is a valuable and important step in understanding the key factors that currently affect broadband speed and performance and it has
some important findings of interest to consumers. We have also separately published a consumer guide on factors that we think consumers might wish to consider when buying broadband services.

1.14 The research has given us valuable insights into consumers’ perceptions of and experience of their broadband services. The survey and performance results suggest that ISPs need to do more to ensure they are giving their customers enough information about the services they provide and the types of factors that may impact on the actual speed they will receive.

1.15 We will consider the results of this report, in particular in respect of the Code, and also consider whether there are any implications for how broadband services are advertised and promoted to consumers.

1.16 Reliable and current information benefits consumers by giving them the information they need to make informed decisions about their services and it provides important incentives to operators to invest in their infrastructure to ensure their services meet the needs of consumers.

1.17 We therefore plan to repeat this research in the future in order that we can take into account the changing broadband market. We will discuss with stakeholders how we can best update the research to ensure that reliable and timely information on broadband performance continues to be made available to consumers.
Section 2

Introduction

Relationship with Ofcom’s other broadband initiatives

2.1 Ofcom has implemented a number of measures to help consumers understand more about buying broadband services, what they should expect from their service and what they can do if they are unhappy with their broadband performance. These measures include the following:

- In June 2008, Ofcom and leading ISPs agreed a voluntary Code of Practice\(^3\) (the “Code”), which came into force on 5\(^{th}\) December 2008. It requires ISPs signing up to the Code to commit to providing customers with information at the point of sale, including an estimate of the maximum speed they will obtain. ISPs must also explain to customers that their actual broadband speeds are likely to vary for a host of different reasons, and provide information and advice on how consumers can improve their broadband performance.

- Also in June 2008, we commissioned this research to identify consumers’ perception of broadband services in the UK, together with research into the actual speeds delivered to UK consumers.

- In December 2008, we published a consumer guide to broadband speeds\(^4\) which tells customers about the Code and informs them about the steps they can take to improve their broadband performance.

- In January 2009, we published an initial research report\(^5\) which detailed high-level findings from our consumer survey. It also included findings from the first month (23 October to 22 November) of collecting broadband performance data from our panel of broadband users.

- To coincide with the publication of this research report, we have published a new consumer guide to buying broadband\(^6\) which is designed to better inform consumers about the considerations they might wish to take into account when purchasing a broadband service. These include price, customer service, usage limits as well as network performance. The guide also explains that the availability of broadband services and the actual performance of these services depends on a customer’s precise location.

Rationale for the report

2.2 Ofcom’s primary duty under the Act is to further the interests of UK citizens and consumers in carrying out our functions\(^7\). In doing this we are required to secure a number of things, in particular, the availability throughout the UK of a wide range of electronic communications services\(^8\). When carrying out our duties we must have

---

\(^3\) Voluntary Code of Practice: Broadband Speeds, www.ofcom.org.uk/telecoms/ioi/copbb/


\(^6\) www.ofcom.org.uk/advice/guides/broadband

\(^7\) Section 3(1) of the Act.

\(^8\) Section 3(2)(b).
regard to the desirability of encouraging investment and innovation in relevant markets and encouraging the availability and use of high-speed data services throughout the UK\(^9\). We are also required to have regard to the interests of consumers in respect of price, choice, quality of service and value for money. The Act requires us to make arrangements to find out about the experiences of consumers using electronic communications services and the way they are provided and we do this by carrying out research into their experiences of these services\(^10\). We have a duty to publish the results of our research and to take account of it in carrying out our functions.\(^11\)

2.3 To help promote consumer understanding and awareness, Ofcom agreed with leading ISPs a Voluntary Code of Practice on Broadband Speeds (‘the Code’), which came into force in December 2008. The Code requires that ISPs inform consumers of the access line speeds associated with their connection before they make their purchase. The Code also makes clear that actual speeds (referred to as throughput speeds) were also an important consideration for consumers. Specifically, the Code states that: “In addition to having information on access line speeds, consumers would also benefit from having information about the average throughput speeds which each ISP achieves in practice. Throughput speeds are an important metric for consumers since this is the download speed which they actually obtain in practice whilst using the internet.”

2.4 The Code goes on to state that: “Ofcom’s aim is to develop a methodology and process which is sufficiently robust to accurately assess ISPs’ average throughput speed performance. To this end, Ofcom is undertaking a research programme to look at this issue in more detail and to assess the role that each of actual and average throughput speed measurements can play. Ofcom will consider revisions to the Code in the light of this research.”\(^12\)

2.5 It was necessary to commission our own independent research into broadband speeds as there is currently limited robust research into actual broadband performance. Other research into UK broadband performance 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. In order to ensure that the results are representative of the experience of UK broadband consumers as a whole, or that comparisons between providers are provided on a like-for-like basis it is also important to apply appropriate statistical analysis. For example, we believe it is necessary to weight the sample to ensure it is representative of broadband users, and also to apply appropriate statistical techniques to ‘normalise’ the data for DSL broadband by distance from exchange. Normalisation ensures that the final results are representative of the performance of ISPs rather than simply being a representation of the customer profile of ISPs (i.e. ISPs which focus on urban areas are presented as delivering faster speeds than ISPs which have nationwide coverage simply as a result of having typically shorter line lengths between exchange and premises).

\(^9\) Sections 3(4)(a) and (e),
\(^10\) Section 14.
\(^11\) Section 15.
\(^12\) Voluntary Code of Practice, Broadband Speeds, [www.ofcom.org.uk/telecoms/ioi/copbb/copbb/](http://www.ofcom.org.uk/telecoms/ioi/copbb/copbb/)
The scope of the research

2.6 An initial report was published on 8 January 2009 which contained key findings from a survey undertaken in September and October 2008 into the perceptions of broadband services among our panel of UK broadband users. The report also included performance data from the first 30 days of data collection (from 23 October to 22 November 2008).

2.7 This report is the final report of this research project and it includes performance data from 1 November 2008 to 30 April 2009. We show changes over the six-month duration of data collection (see Annex 4), but focus in particular on data collected in April 2009, as the most recent available. This report also includes a review of the 2008 survey data, focusing on findings relating to consumer perceptions of broadband speeds, and analyses the relationships between consumer perceptions and behaviour and the actual speeds they received. (The full survey report, produced by market research partner GfK NOP Ltd, is published in Annex 6).

2.8 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 connections), geographical region and access technology.

2.9 We include comparative data for the ‘up to’ 8Mbit/s packages of those ISPs for which we had large enough sample sizes to make analysis statistically meaningful, and for the ‘up to’ 10Mbit/s cable package from Virgin Media.

2.10 Throughout the report 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, although we also include analysis of other speed packages where appropriate and where we have meaningful data.

2.11 As 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. However, we do not include provider-specific comparisons for these metrics. This is because download throughput speed is the metric by which broadband is sold and also because the lower range of performance of the other indicators will still deliver performance which is sufficient for most internet applications. Our analysis also identifies that there is a close correlation between download throughput speeds and the other performance metrics, making it appropriate to consider download throughput speed as the single measure which best represents overall broadband performance.

Outside the scope of the research

2.12 We began collecting data from 23 October 2008. However, this report only looks at data from full calendar months from November 2008 to April 2009.

2.13 ISPs with less than 2% market share across the UK are excluded from the analysis as we did not have a sufficiently large sample for them. This means, for instance, that Kingston Communications, the incumbent in Kingston-upon-Hull, was excluded from the scope of the research (therefore, as Kingston Communications are the largest supplier by retail market share in the Hull area, the findings in this report are less relevant to consumers in the Hull area than to consumers in other parts of the UK).

---

2.14 We looked only at the performance of fixed-line broadband, which accounts for nearly 90% of the UK’s broadband connections. Outside the scope of our research was broadband accessed by dedicated fibre networks (this currently accounts for less than 0.1% of all broadband customers in the UK) and satellite broadband (which also has very low take-up) because we were unable to recruit a sufficiently large sample to generate robust data.

2.15 In addition, ‘mobile broadband’, that is broadband delivered ‘over the air’ by cellular mobile network operators typically via a USB modem or ‘dongle’, was excluded. Our hardware-based technical solution is too cumbersome to be portable, and would not have captured issues such as location which is a key driver of mobile performance. In our Mobile Sector Assessment report, published on 8 July 2009\(^\text{14}\), we committed to addressing this by initiating a programme of research on mobile network quality with the aim of establishing if, and how, we can get an up-to-date understanding of the network quality of UK mobile services and how this changes according to different environments, for example, outdoors, indoors and in transit.

2.16 This report is a research report. While the research was undertaken for Ofcom to improve its evidence base in order to inform our policy making, this report does not draw any policy conclusions.

Structure of this research report

2.17 This report is structured as follows:

- **Section 3** sets out the objectives of the research and provides an overview of the survey methodology and the broadband performance methodology.

- **Section 4** provides an overview of broadband speed performance indicating how and why the actual speeds delivered differ from the headline speeds and the maximum line speeds.

- **Section 5** details the key findings from the survey into broadband speeds and includes an analysis of the relationships between consumer use of, satisfaction with and understanding of their broadband service and the actual speeds received.

- **Section 6** examines how broadband speeds vary by a number of factors including time of day, distance from exchange (for DSL customers), rural versus urban location, access technology.

- **Section 7** looks in more detail at how ISPs vary in their performance, and considers the reasons why this may be the case.

- **Section 8** looks at metrics other than download speed which affect broadband performance: upload speeds, web browsing, latency, packet loss, DNS resolution and jitter.

- **Section 9** concludes the report with an overview of the implications of the findings for consumers, ISPs and our proposed next steps.

\(^{14}\) Mostly Mobile: Ofcom’s mobile sector assessment second consultation, www.ofcom.org.uk/consult/condocs/msa/
• Annex 1 contains a Glossary explaining the technical terms used throughout the report.

• Annex 2 explains our technical methodology.

• Annex 3 explains our statistical methodology, including the ways we have weighted and ‘normalised’ data to ensure that the findings are representative of UK broadband users as a whole, and that ISP performance is presented in an accurate and robust way.

• Annex 4 provides additional data detailing month-on-month performance data over the six-month duration of data collection.

• Annex 5 provides details on significant differences between the performance of access technologies, and the performance of ISPs to a 95% confidence level and a 99% confidence level.

• Annex 6 is the full GfK survey report.
Section 3

Objectives and methodology

Research objectives

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

3.2 The objectives of measuring broadband performance were:

- To measure actual throughput download speeds across the UK and assess 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), region, access technology and ISP.
- To measure a number of other factors which affect overall broadband performance: upload speeds, loading web pages, latency, packet loss, DNS and jitter.

3.3 The objectives of the consumer 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 the following:
  - Headline and actual throughput speeds and the factors that drive throughput speed.
  - Other quality of service factors.
  - Download limits.
- To test the importance of broadband speed and other quality factors in the purchase decision.

Methodology

Survey methodology

3.4 Market research company GfK NOP Ltd (‘GFK’) was commissioned to assemble a representative panel of UK broadband users.

3.5 During September 2008, they recruited a total of 2,128 UK broadband decision-makers from online panels and asked them 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. 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 Statistical results are reported after consideration of the accuracy of estimates as measured by 95% confidence intervals. The confidence interval is a statistically derived range calculated from the standard error (which is itself calculated from the sample size and the variation within the sample). Differences are reported as “significant” if they are significantly different as judged by a 5% test of statistical significance (Annex 5 provides further detail on significance differences as judged by a 1% test of statistical significance).

**Broadband performance methodology**

3.10 The technical methodology chosen was based on that created by broadband performance specialist SamKnows Limited (‘SamKnows’). 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. This avoided 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 significant improvement 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 from being based on a representative panel of UK consumers, and should therefore contain less bias than other surveys which have relied on broadband users to ‘opt in’ to participate in the research.

---

15 A 5% test of statistical significance is a test which falsely rejects hypotheses that are true only 5% of the time.
3.13 The performance data in this report are based on 1610 panellists who had a broadband monitoring unit connected to their router in the six months from 1 November 2008 to 30 April 2009 and provided valid data. Figure 3.1 details the geographical spread of the panellists, which is broadly in line with UK geographic population distribution.

**Figure 3.1 Geographical distribution of panellists**

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

3.14 The technical methodology is described in Annex 2.

3.15 Data were analysed on a month-by-month basis. In order for a panellist to be considered valid they must have provided a minimum of five download throughput speed test results in any month.

3.16 We have used statistical techniques to adjust our results to ensure that they are representative of the UK broadband population as a whole. This includes weighting the results from our panel by region, rural/urban and ISP. For the provider-specific comparisons we have also 'normalised' the data for DSL operators by distance from exchange (using the straight-line distance from the panellist's location to the exchange), which we believe is necessary in order to provide like-for-like comparisons of ISPs who have different customer profiles. We also applied some checks to ensure that straight-line distance was an appropriate metric to carry out normalisation, including comparing this distance with the line attenuation. Full detail on the statistical methodologies we have used is provided in Annex 3. The methods of analysis for the provider-specific comparison have had expert review and endorsement by econometrician Professor Andrew Chesher of University College London.
Peer review statement

I have reviewed the statistical methodology that Ofcom has used to detail the relative performance of individual ISPs and it is sound and appropriate for the analysis that has been undertaken.

Within this analysis Ofcom has taken a number of measures to ensure that the findings are representative of UK broadband consumers as a whole and to ensure that ISP-data are compared in a fair and statistically sound manner. These measures include the following:

- Applying appropriate weighting to ensure that ISP-performance is compared on a like-for-like basis by normalising the data by distance from exchange.
- Applying appropriate weighting to ensure that ISP-performance is a fair representation of their overall performance by weighting by the proportion of consumers who receive on-net or off-net services.
- Cleansing the data to ensure that outliers do not distort the overall findings.
- Calculating measures of accuracy of estimates and presenting findings accompanied by 95% confidence intervals.

I have also reviewed the way in which the performance of individual ISPs has been presented and it is a fair and accurate representation of the data which has been collected.

Professor Andrew Chesher
Fellow of the Royal Statistical Society
Section 4

Broadband speed performance

Why broadband speeds matter

4.1 The user experience of virtually all types of internet use is affected to some extent by connection speed and this has become even more important as the use of bandwidth-hungry applications such as downloading video and audio has grown. Indeed, some services are only possible at faster speeds; the BBC, for example, recommends a minimum speed of 500kbit/s to use its iPlayer, and 3.2Mbit/s for its high-definition iPlayer service. Figure 4.1 below details the theoretical time taken to perform some of the most common online activities at different speeds.

Figure 4.1 Theoretical time taken to perform online activities

<table>
<thead>
<tr>
<th>Connection speed</th>
<th>56kbit/s</th>
<th>512kbit/s</th>
<th>2Mbit/s</th>
<th>8Mbit/s</th>
<th>16Mbit/s</th>
<th>24Mbit/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Download 250kB webpage</td>
<td>36 seconds</td>
<td>4 seconds</td>
<td>1 second</td>
<td>0.3 seconds</td>
<td>0.9 seconds</td>
<td>0.1 seconds</td>
</tr>
<tr>
<td>Download 5MB music track</td>
<td>12 minutes</td>
<td>1 minute 22 seconds</td>
<td>21 seconds</td>
<td>5 seconds</td>
<td>3 seconds</td>
<td>2 seconds</td>
</tr>
<tr>
<td>Download 25MB video clip</td>
<td>1 hour</td>
<td>6 minutes 50 seconds</td>
<td>1 minute 45 seconds</td>
<td>26 seconds</td>
<td>13 seconds</td>
<td>9 seconds</td>
</tr>
<tr>
<td>Download low quality film (750MB)</td>
<td>31+hours</td>
<td>3 hours 20 minutes</td>
<td>52 minutes</td>
<td>13 minutes 6 seconds</td>
<td>6 minutes 30 seconds</td>
<td>4 minutes 22 seconds</td>
</tr>
<tr>
<td>Download DVD quality film (4GB)</td>
<td>7+ days</td>
<td>19 hours 38 minutes</td>
<td>4 hours 48 minutes</td>
<td>1 hour 11 minutes</td>
<td>36 minutes</td>
<td>24 minutes</td>
</tr>
</tbody>
</table>

Source: Ofcom

4.2 In the early days of the internet, access speeds were typically 14.4kbit/s to 64kbit/s, delivered via 'dial-up' telephone modems. As DSL broadband take-up accelerated from 2003, advertised headline speeds jumped to an average of 512kbit/s in 2005. Following the introduction of ADSL2+ technology, as well as higher speed cable connections, the average advertised headline speed was 7.2Mbit/s April 2009. Developments in recent months include the deployment of cable broadband services of 20Mbit/s and 50Mbit/s, and BT’s roll-out of fibre broadband services, capable of even higher speeds, (currently available in Ebbsfleet and at two pilot exchanges). It is the widespread availability of higher broadband speeds which have allowed high-bandwidth services like the iPlayer to develop. In turn, this has led to a virtuous circle whereby consumer demand for higher speeds has increased further thereby leading to the development of more high-bandwidth applications.
4.3 The Government’s Digital Britain report\textsuperscript{16} published in June 2009 emphasises that the UK’s communications infrastructure is a vital enabler for the country’s society, economy, safety, security and well-being. It sets the objective of ensuring that current generation broadband services are universally available, and that next generation broadband availability is also extended.

- The Government’s report contends that lack of broadband availability creates social and economic disadvantage. It details a ‘Universal Service Commitment’ to extend broadband (through upgrades to existing fixed and mobile networks) to within reach of virtually all parts of the country at speeds of 2Mbit/s (downstream) by 2012.

- The Government’s report also states that it is desirable for next generation broadband networks to be made available to the large majority of the UK population. Accordingly it details plans to promote the availability of next-generation access broadband, which will offer a step-change in download speeds to 30Mbit/s and over, with potentially even bigger relative jumps in uplink speeds. The report argues that this super-fast broadband will enable innovation and economic benefits, as well as offering new applications such as tele-presence, e-healthcare in the home, and, for small businesses, more effective access to cloud computing.

4.4 Speeds are central to the way in which broadband is packaged and marketed, with residential services typically advertised according to their theoretical maximum download speed (for example, ‘up to 2Mbit/s’, ‘up to 8Mbit/s or ‘up to 16Mbit/s’). Figure 4.3 details the distribution of these packages by headline speed based on data provided by the nine largest ISPs in the UK by retail market share (who have a combined market share of over 90%). It indicates some shift in the market towards higher headline speeds between November 2008 and April 2009, with much of the change attributable to Virgin Media upgrading all its 4Mbit/s cable customers and many of its 2Mbit/s cable customers to an ‘up to’ 10Mbit/s package. We have presented the data in bands rather than detailing specific packages in order to preserve the confidentiality of this data. All of the analysis in this report uses this weighting (in addition to weighting by ISP market share and region) in order to ensure that it is representative of residential UK broadband consumers as a whole.

Download and maximum line speeds are significantly below headline speeds

4.5 In this report we use three key terms to describe download speeds:

- The ‘headline speed’ or ‘advertised speed’ is the download speed at which broadband services are typically marketed, usually expressed as ‘up to’ X Mbit/s.

- The ‘maximum line speed’, or ‘access line speed’, is the maximum download speed that a line is capable of supporting.

- The ‘average throughput’ speed or ‘average download’ speed, represents the average actual speeds that a consumer receives, (see the Glossary for fuller definitions of these terms).

4.6 In practice, advertised headline ‘up to’ speeds are rarely delivered (our research found that consumers received actual average download speeds of 4.1Mbit/s, only 57% of the average headline speed of ‘up to’ 7.1Mbit/s) (Figure 4.4). It is in this context that Ofcom introduced the Voluntary Code of Practice for Broadband Speeds, implemented in December 2008, which requires all signatory ISPs to commit to notifying users of the maximum speed their line is capable of supporting at the point of purchase. Although maximum line speeds represent a better indicator of the actual speeds that consumers can expect than headline speeds, we found that average speeds were still only 83% of maximum speeds. (Note that as we were not able to run specific access line tests for our panellists, we use the highest download throughput speed test recorded during the month as the maximum line speed).
Why actual broadband speeds vary from headline speeds

4.7 Typically, a number of constraints combine to make actual broadband speeds significantly lower than headline speeds:

- For DSL broadband, the maximum line speed available is constrained by the length of the copper wire connection between the premises and the local telephone exchange, with speeds slowing down as the length of the line increases.

- For all broadband connections, speeds are constrained by contention in the ISP’s own network; this is a particular problem during peak periods as multiple users put demand on backhaul networks.

- Poor wiring and interference within the home can severely impact performance. In June 2009, BT launched an initiative to address this by offering the BT Broadband Accelerator (a filter which consumers install into their phone socket in order to reduce electrical interference from telephone-extension wiring) free of charge (save postage and packing) to all customers where BT believes performance can be improved.

- Congestion on the wider internet causes individual web sites and applications to slow down. (Our research runs tests to multiple sites across the day in order to minimise the impact this has on our results).

- Consumer equipment performance, in particular computers and routers, can affect speeds received. (Again our hardware-based technical solution, in which the monitoring unit is plugged directly into the router, minimises the impact that this has).

4.8 As DSL broadband is currently the only broadband technology which is available nationwide, the maximum speeds available to many consumers are defined by the length of the copper wire between their home and the local telephone exchange.
4.9 Figure 4.5 depicts the theoretical degradation of the maximum speeds achievable by DSL broadband as the length of line from local telephone exchange to premises increases. It shows that although second-generation DSL services (ADSL2+) offer significantly faster speeds than first-generation ADSL speeds to customers with a short line length, beyond a distance of 3km from the exchange there is little difference between the two technologies.

**Figure 4.5** Theoretical maximum DSL speeds by length of line from exchange to premises

![Graph showing DSL speeds vs distance](http://www.tpg.com.au/dslam/faq.php)


4.10 Another major driver of variation in performance is contention in the ISP’s network, which affects both DSL and cable broadband. Figure 4.6 shows how speeds during the peak evening period of 8-10pm are on average across all panellists only around 77% of the maximum speed ever recorded (typically during an off-peak hour when there is very little contention in the network). Average speeds in this peak evening period are around 90% of the average speeds recorded throughout the day. Speeds in the ‘working’ hours of 9am-5pm Monday to Friday are marginally faster than overall average speeds.
The implications of varying broadband speeds

4.11 The research findings that follow in section 5 examine consumer perceptions of broadband speeds and how these perceptions vary according to the headline and actual speeds they received. In sections 6 and 7 we assess how these speeds vary by a number of factors including time of day, geographical location, access technology and ISP. Collectively, these findings provide an evidence base through which to examine the state of broadband performance across the UK and explore the following issues:

- The extent to which broadband speeds are perceived as important to consumers and influence their behaviour.
- The relationship between the headline speed of broadband packages and the actual speeds that consumers receive.
- The constraints on broadband speeds which prevent certain consumers from getting speeds which may be necessary (now or in the future) to engage fully in digital Britain.

4.12 As referenced above, a key commitment in the Government’s Digital Britain report is the universal availability of broadband at a speed of at least 2Mbit/s to virtually all households in Britain by 2012. Figure 4.7 below looks at our findings in this context and identifies that 22% of households never received a speed of at least 2Mbit/s during April 2009, with 30% of households receiving overall average speeds of below 2Mbit/s and 36% of households receiving average speeds of below 2Mbit/s in the peak evening period of 8-10pm.

Source: SamKnows measurement data for all panel members with a connection in April 2009
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
4.13 However, half of the people who never received speeds of higher than 2Mbit/s were subscribers to packages with a headline speed of 2Mbit/s or less and would therefore never receive speeds higher than this. As a majority of these subscribers are choosing a low-speed package, a better indicator of the capability of the UK’s current broadband network to deliver against the ‘2Mbit/s or more’ criteria is provided when subscribers to these low-speed packages are excluded (although it should be noted that some customers with a 2Mbit/s service will have chosen that service having been advised that their line is incapable of delivering speeds in excess of 2Mbit/s).

4.14 When only customers with packages above 2Mbit/s are considered we find that 11% of connections never received speeds above 2Mbit/s, while 17% received overall average speeds of less than 2Mbit/s and 20% received average speeds of less than 2Mbit/s during the peak evening hours of 8-10pm. Of the customers on 8Mbit/s packages, 13% never received a speed of more than 2Mbit/s.

4.15 This figure of 11% of households being unable to achieve speeds in excess of 2Mbit/s is consistent with analysis in the Government’s Digital Britain report which reported that in June 2009 11% of all lines in the UK were unable to deliver a 2Mbit/s service. The Digital Britain report estimates that self-help solutions such as the iplate (a filter which consumers can connect to their phone socket to reduce electrical interference) will reduce this number to 7%.\(^{17}\)

---

Although the figures from our research and in the Government’s Digital Britain report are similar, they are derived from different types of analysis. We highlight the following:

- The Digital Britain value was computed from modem synchronisation speeds rather than broadband remote access servers (BRAS), hence we should expect the number of people who achieve a maximum speed of 2Mbit/s in our tests to be lower than the number who have a modem synchronisation speed of 2Mbit/s.

- The Digital Britain analysis assumes that everyone who cannot get 2Mbit/s using DSL but has the option of getting cable will switch to cable; this may apply to some of our panel, but others may not have switched to cable.

- Some consumers cannot get broadband at all due to distance from exchange. These consumers are represented in the 11% of consumer which the Digital Britain report finds are incapable of receiving speeds in excess of 2Mbit/s, but clearly not in our analysis which is based on consumers who evidently can get broadband.

- Our 11% value excludes all consumers who have subscribed to services of less than 2Mbit/s. However, we have no way of knowing if these consumers are on 2Mbit/s packages because they are choosing a lower speed product despite the availability of higher speeds, or if they are on 2Mbit/s packages because they cannot receive higher speeds.
Section 5

Consumer perceptions

Introduction

5.1 To help us understand attitudes towards broadband, we surveyed consumers on their use of, satisfaction with, and understanding of their broadband service, focusing on speed-related issues in particular. We then asked these consumers to connect a performance measurement unit to their broadband router, thereby allowing us to relate use, satisfaction and understanding to actual speeds received.

5.2 The survey was conducted in September 2008 by market research company GfK NOP, which recruited 2,128 broadband decision-makers willing to take part. Of these, 1,634 went on to connect a performance measurement unit to their router. (GfK’s methodology and full research report is published as Annex 6). We have compared these results with performance data from November 2008 - the first full month for which we gathered information - in order to align the reference periods as closely as possible.

Key findings

5.3 We can draw the following conclusions from the survey data:

- Overall levels of satisfaction with broadband services are high (83% satisfied, only 9% dissatisfied).

- However, the speed of connection appears to be the key cause of dissatisfaction with broadband. Furthermore, those on higher headline speed packages and those who receive higher actual speeds are more satisfied with both their overall service and with their speed.

- The speed of connection is an important consideration when consumers choose their broadband provider but 26% do not get the speeds they expected when they signed up.

- Levels of awareness about broadband speed issues are mixed, with consumers reasonably well informed about the factors which can affect speed, but less than 40% able to identify their headline speed correctly. Those who are better informed are significantly more likely to be satisfied with their broadband connection.

- Consumers with broadband packages with a higher headline speed are more likely to use their broadband service for applications which benefit from a higher speed connection.

Satisfaction with broadband high but speed the main cause of dissatisfaction

5.4 Overall satisfaction with broadband services was high (83% satisfied, just 9% dissatisfied) although this dropped in rural areas (78% satisfied, 14% dissatisfied).
Figure 5.1  Overall satisfaction with broadband service

<table>
<thead>
<tr>
<th>Overall (2,128)</th>
<th>2MB speed or less (425)</th>
<th>8MB speed (1,359)</th>
<th>Over 8MB speed (303)</th>
<th>Urban (1,636)</th>
<th>Rural (492)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall satisfaction with broadband service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1%</td>
<td>8%</td>
<td>8%</td>
<td>3%</td>
<td>7%</td>
<td>12%</td>
</tr>
<tr>
<td>8%</td>
<td>9%</td>
<td>8%</td>
<td>6%</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>36%</td>
<td>30%</td>
<td>27%</td>
<td>32%</td>
<td>30%</td>
<td>32%</td>
</tr>
<tr>
<td>33%</td>
<td>40%</td>
<td>39%</td>
<td>38%</td>
<td>35%</td>
<td>38%</td>
</tr>
<tr>
<td>12%</td>
<td>13%</td>
<td>24%</td>
<td>14%</td>
<td>13%</td>
<td>13%</td>
</tr>
</tbody>
</table>

Q7: Overall, how satisfied are you with your current broadband service?

Base: All UK broadband decision makers

However, more people (21%) expressed at least some level of dissatisfaction with speed than with any other aspect of their broadband service (rising to 28% in rural areas, where speeds tend to be slower). And it was most frequently cited (30%) as the main reason for dissatisfaction, marginally ahead of reliability (27%).

Figure 5.2  Main reason for dissatisfaction with ISP

0% 10% 20% 30%

<table>
<thead>
<tr>
<th>Reason for dissatisfaction</th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed of connection</td>
<td></td>
<td></td>
<td></td>
<td>30%</td>
</tr>
<tr>
<td>Connection is unreliable</td>
<td></td>
<td></td>
<td></td>
<td>27%</td>
</tr>
<tr>
<td>Charges generally too expensive</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tech support could not help</td>
<td></td>
<td></td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>Customer service unhelpful</td>
<td></td>
<td></td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>Hidden or additional costs</td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tech support hard to reach</td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customer service hard to reach</td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Download limit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td>11%</td>
<td></td>
</tr>
</tbody>
</table>

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

5.6  We can derive further insight into how the performance of different service aspects has an impact on overall consumer satisfaction with broadband by cross-relating question responses. Figure 5.3 shows a regression analysis which places service...
aspects according to how satisfied consumers felt with them (on the vertical axis, the higher the value the greater the level of satisfaction) and how important they were as a driver of overall satisfaction (on the horizontal axis, the higher the value the more important the service aspect is considered). Further detail on this regression analysis is provided in Annex 6.

5.7 Figure 5.3 shows that connection speed is considered the most important aspect of broadband service, just ahead of reliability. However, while consumers are relatively satisfied with the reliability of their service, connection speeds score much lower. Speed of connection is therefore placed in the lower right quadrant – a service aspect which is considered to be important, but which does not generate strong customer satisfaction.

**Figure 5.3  Regression analysis: perceived importance and satisfaction with aspects of broadband service – all respondents**

![Regression analysis chart]

*Base: All UK broadband decision makers*

*Source: Key driver regression analysis by GfK based on GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008*

**Those with higher headline and actual speeds, are more satisfied with their broadband service overall, and with their speed in particular**

5.8 Although speed was the biggest cause of dissatisfaction, it also elicited greater levels of consumer satisfaction than many other factors, including value for money and customer service. We begin to see the reason for this apparent disparity if we break down the satisfaction figures by headline speed.

5.9 Significantly more consumers with a headline speed of over 8Mbit/s are satisfied both with the speed of their connection and with their overall broadband service than consumers with lower speed packages (Figure 5.4). Among consumers on headline speeds of over 8Mbit/s, 55% say they are extremely or very happy with the speed of connection and just 2% say they are extremely or very dissatisfied. This compares to 38% satisfaction (extremely or very) among consumers on up to 8Mbit/s packages and 8% dissatisfaction. A similar pattern is evident for overall satisfaction, although
for consumers of all speed bands overall satisfaction is higher than satisfaction with the specific aspect of speed of connection.

Figure 5.4  
Satisfaction with broadband service by headline speed

Q7: Overall, how satisfied are you with your current broadband service; Q8: How satisfied are you with these factors of your 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

5.10 We repeated the regression analysis detailed above to examine how the drivers of satisfaction differ among consumers with broadband headline speeds of more than 8Mbit/s (Figure 5.5). This group still perceived connection speed as the most important broadband service aspect (perhaps not surprisingly, given that they have usually opted to pay for their higher speed). However, they were significantly more likely than those on lower speeds to be satisfied with their speed (although they were even more satisfied with download limits, reliability and service bundling). In other words, speed is less likely to be a driver of overall dissatisfaction with broadband provision for consumers on higher speed packages. (Little difference was found between consumers on services of ‘up to’ 2Mbit/s and those on services of ‘up to’ 8Mbit/s when this analysis was repeated.)
Figure 5.5  Regression analysis: perceived importance and satisfaction with aspects of broadband service – those with more than 8Mbit/s headline speed

\[\text{Proportion of consumers 'extremely' or 'very' satisfied with overall broadband service} \]

| Importance of service aspect as a driver of overall satisfaction (Statistically derived) |
|---------------------------------|---------------------------------|
| Download Limit                  | Reliability                     |
| Bundled with other services     | Value for Money                 |
| Connection Speed                | Technical Support               |
| Customer Services               |                                 |

Base: All UK broadband decision makers with broadband packages with a headline speed of more than 8Mbit/s

Source: Key driver regression analysis by GfK based on GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

5.11 The same pattern occurs if we examine the impact of the actual broadband speeds received on satisfaction with broadband services. Figure 5.6 shows that those with higher actual connection speeds are, unsurprisingly, more satisfied with the speeds they receive than those who receive slower actual speeds. They are also more satisfied overall with their broadband service.
Figure 5.6  Broadband satisfaction by actual speed received for consumers on ‘up to’ 8Mbit/s packages

Satisfaction data:
Q7: Overall, how satisfied are you with your current broadband service; Satisfaction is measured on a 7-point semantic scale where 1 is ‘extremely satisfied’ and 7 is ‘extremely dissatisfied’ with their connection speed
Source: GfK broadband speeds survey among 1,087 online panel respondents who are broadband decision makers, September-October 2008, and who had an active ‘up to’ 8Mbit/s broadband connection in November 2008.
Actual speed data.
Base: 0-1Mbit/s (74), 1-2Mbit/s (152), 2-3Mbit/s (169), 3-4Mbit/s (216), 4-5Mbit/s (276), 5-6Mbit/s (104); sample sizes too small for higher speeds.
Source: SamKnows measurement data for all panel members with an ‘up to’ 8Mbit/s broadband connection in November 2008 (1,087 panellists)

5.12 Speeds can be much reduced where two or more PCs are using the broadband connection simultaneously (often via a wireless network). In households with only one PC connected, 55% of consumers were extremely or very satisfied with their overall broadband service, this fell to 50% in households with two or more PCs connected. The difference was most pronounced in households subscribing to packages with a headline speed of more than 8Mbit/s, where 77% of households with one PC connected were extremely or very satisfied with their broadband connection compared to 59% of households with more than one PC connected.

Connection speeds are important when choosing a broadband supplier…

5.13 Ninety-one per cent of respondents said that connection speed was an important consideration in their choice of broadband provider (67% said it was either very or extremely important).

5.14 And 45% said that they had compared the speeds offered by different providers, although only 31% found this extremely or very easy to do. (This compares with 67% who compared prices, and 50% who found this a simple task) (Figure 5.7 and Figure 5.8)
Q15. Which if any of the following internet service features have you tried to compare from different broadband suppliers?
Base: All respondents (2,128)
Source: GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

Figure 5.7  Broadband features compared by consumers

Q16. How easy was it to compare the following internet service features from different broadband suppliers?
Base: Those who have compared service features (1417)
Source: GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

... but 26% say they don’t get the speeds they expected when they signed up

5.15  More than a quarter (26%) of consumers thought that their actual connection speed was not what they expected when they signed up, and in rural areas this rose to
almost one in three (32%). This compares with 17% whose expectations on reliability were not met, and 9% who thought they would receive a higher download limit.

**Figure 5.9: Agreement that service matches initial expectations**

<table>
<thead>
<tr>
<th></th>
<th>Agree</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed (2,128)</td>
<td>63%</td>
<td>26%</td>
</tr>
<tr>
<td>Reliability (2,128)</td>
<td>73%</td>
<td>17%</td>
</tr>
<tr>
<td>Download limit (457)</td>
<td>75%</td>
<td>9%</td>
</tr>
</tbody>
</table>

**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

**Levels of awareness on broadband speed issues are mixed but consumers with the greatest awareness show significantly higher levels of satisfaction**

5.16 Our research gave a mixed picture of levels of awareness of broadband speed issues.

5.17 Over a quarter (28%) said that they did not know the headline speed of their current broadband package, and by cross-relating survey questions and comparing survey responses to actual speeds delivered we estimate that a further 15% misreported their headline speed.

5.18 However, respondents appeared reasonably well-informed about the factors which can affect speed, with between 57% and 75% correctly identifying each of the factors listed in the chart below as having at least a moderate impact on broadband performance. (Awareness was lowest for the role that home wiring can play in securing higher actual speeds).
**Figure 5.10 Perceived impact of various factors on broadband speed**

<table>
<thead>
<tr>
<th>Factor</th>
<th>High impact</th>
<th>Moderate</th>
<th>Low / None</th>
<th>Don’t know / unaware</th>
</tr>
</thead>
<tbody>
<tr>
<td>How near you live to exchange</td>
<td>55%</td>
<td>20%</td>
<td>15%</td>
<td>9%</td>
</tr>
<tr>
<td>The speed of router / modem</td>
<td>43%</td>
<td>37%</td>
<td>15%</td>
<td>6%</td>
</tr>
<tr>
<td>Your choice of ISP</td>
<td>37%</td>
<td>40%</td>
<td>18%</td>
<td>5%</td>
</tr>
<tr>
<td>Speed of individual web sites</td>
<td>35%</td>
<td>45%</td>
<td>14%</td>
<td>7%</td>
</tr>
<tr>
<td>No of people in area using net</td>
<td>35%</td>
<td>34%</td>
<td>22%</td>
<td>9%</td>
</tr>
<tr>
<td>Processing speed of computer</td>
<td>35%</td>
<td>35%</td>
<td>24%</td>
<td>4%</td>
</tr>
<tr>
<td>Your choice of package</td>
<td>32%</td>
<td>36%</td>
<td>26%</td>
<td>4%</td>
</tr>
<tr>
<td>Sharing connection with others</td>
<td>26%</td>
<td>39%</td>
<td>28%</td>
<td>7%</td>
</tr>
<tr>
<td>Quality of the cable in home</td>
<td>26%</td>
<td>31%</td>
<td>35%</td>
<td>8%</td>
</tr>
</tbody>
</table>

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

5.19 If we classify those who correctly identify all factors which can affect speed at least moderately as being ‘high awareness’, and those who fail to identify one or more factor as ‘low awareness’, we see that ‘high awareness’ customers tend to be significantly more satisfied overall with their broadband service. (Note, for cable customers, for whom distance from the exchange does not affect speed, results were adjusted accordingly).

5.20 This may suggest an opportunity for ISPs to improve satisfaction by better informing consumers on the factors that can have an impact on their broadband performance. This has been partially addressed by Ofcom’s voluntary Code of Practice on Broadband Speeds, to which all of the largest ISPs are signatories, and which requires them to advise consumers on the speeds they can expect to receive at the point of purchase. The Code came into force on 5 December 2008, after this survey was conducted.
Figure 5.11  Impact of consumer awareness on overall broadband satisfaction

Q7: Overall, how satisfied are you with your current broadband service? Q18. Please read the statements below and for each one rate how much you think they can influence broadband download speeds

High knowledge = 392, Low knowledge = 84
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

Consumers with higher headline speeds more likely to use their broadband connection for downloading audio and video

5.21 While virtually all consumers said that they used their broadband connection for surfing the internet or looking at websites at least once a week, consumers on higher headline speed packages were more likely to use applications which benefit more from higher download speeds.

5.22 Seventy-four per cent of consumers on headline speeds of ‘up to’ 10Mbit/s or more said that they downloaded short video clips, compared to 62% of those on ‘up to’ 8Mbit/s and 55% of those on ‘up to’ 4Mbit/s and less. A similar pattern was true for downloading full length TV programmes using applications such as the BBC iPlayer, which 32% of people on the higher speed packages said they did compared to 21% on the lower speed packages, and downloading music (45% compared to 29%). By contrast, there appeared to be no relationship between headline speed and the use of broadband connections for playing online games or making phone calls over the internet (VoIP). (Figure 5.12)
Q6: Please state how often you use the internet to do any of the following? Surf the internet, looking at websites / Watching or downloading SHORT VIDEO CLIPS such as music videos, or comedy clips (e.g. from Youtube or a similar service) / Watch or download a full length TV programme (e.g. using BBC iPlayer) / Make telephone calls using the internet / Playing games online / Downloading music (e.g. to an iPod)

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

To explore this further, we compared stated uses of the internet with actual speeds received for all consumers on packages of ‘up to’ 8Mbit/s. Figure 5.13 shows that there is very little difference in type of internet use between those receiving actual speeds of 4-6Mbit/s and those receiving 2-4Mbit/s. However, both are more likely than those on 2Mbit/s to use their broadband connection to download short videos, watch full length TV programmes and make VoIP calls.
Figure 5.13 Internet services used at least once a week by actual speed (for consumers on ‘up to’ 8Mbit/s packages)

Behaviour data:
Q6: Please state how often you use the internet to do any of the following? Surf the internet, looking at websites / Watching or downloading SHORT VIDEO CLIPS such as music videos, or comedy clips (e.g. from Youtube or a similar service) / Watch or download a full length TV programme (e.g. using BBC iPlayer) / Make telephone calls using the internet / Playing games online / Downloading music (e.g. to an iPod)
Source: GfK broadband speeds survey among 2,128 online panel respondents who are broadband decision makers, September-October 2008

Actual speed data:
Base: 0-2Mbit/s (226), 2-4Mbit/s (385), 4-6Mbit/s (380); sample sizes too small for higher speeds.
Source: SamKnows measurement data for all panel members with an ‘up to’ 8Mbit/s broadband connection in November.
Section 6
Drivers of variation in broadband speed

Overview

6.1 Broadband is generally promoted and sold in terms of its theoretical maximum or ‘headline’ speeds – for example as ‘up to’ 2Mbit/s, 8Mbit/s, 10Mbit/s, 16Mbit/s, 20Mbit/s or 24Mbit/s. Our research found, however, that the actual broadband speeds received varied widely but most people in our sample got speeds which were well below headline speeds. For example, less than one in ten of our sample on 8Mbit/s headline packages received actual speeds of over 6Mbit/s and nearly one in five received less than 2Mbit/s.

Figure 6.1 Average download speeds for panellists on ‘up to’ 8Mbit/s packages

Source: SamKnows measurement data for all panel members with a connection in April 2009
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

6.2 This section of the report examines why actual download speeds are typically below headline speeds and examines how broadband speeds vary according to certain factors. In particular we look at the influence of the following factors:

- Distance from the exchange.
- Rural versus urban location.
- Nation within the UK.
- Time of day.
- Use of local loop unbundling.
- Access technology.
In the next section of the report (Section 7) we look at the results for individual ISPs

6.3 Our technical approach to speed measurement did not allow us to isolate other factors which influence actual download speeds, including:

- Wiring into the home, and internal wiring within the house.
- Electrical interference (which may be reduced if a filter is being used).

6.4 It is also important to note that the download throughput speeds which we measure are not always the speeds experienced by the end user, which may be degraded by:

- Bandwidth being shared by more than one PC using the same broadband connection simultaneously.
- The quality of the connection from the modem to the PC or the wireless connection.
- The speed of the particular websites visited or applications used by the consumer.

6.5 In addition, the measure which we focus on in this section of the report – actual download (or ‘throughput’) speed – is not the only driver of broadband performance. Other indicators which can affect the overall broadband experience include upload speeds, web browsing, latency, jitter, DNS look-up times and DNS failure times. These can be more important than download throughput speed for some internet applications and we examine them further in Section 8.

6.6 Nevertheless, we believe that focusing on download throughput speed is useful because, other than price, it is the principal metric by which broadband is sold and is the single most important metric in determining the quality of the user experience (we found that the lower range of performance for all the other metrics was sufficient for most internet applications – see Section 8 for details). In addition, there is a close correlation between download throughput speed and the other performance metrics, so the drivers of variation in download throughput speed are likely to be similar to the drivers of variation in the other indicators.

6.7 In order to provide like-for-like comparisons we compare the actual speeds of broadband services which offer the same headline speed. As our largest sample is for consumers on ‘up to’ 8Mbit/s services (which accounts for 57% of UK broadband connections) we focus our attention here. However, where relevant, and where we have sample sizes sufficient to deliver statistically meaningful data, we also look at the performance offered by broadband packages with other headline speeds.

Distance from exchange

6.8 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 therefore 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.
6.9 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’) from the six-digit postcodes of the panellist and the local exchange. As Figure 6.2 illustrates, there was a wide range of distances from premises to exchange among our panellists, with an average of around 1.6km. It should be noted that straight-line distances can differ significantly from line lengths; it is the latter which have an impact on the speed of DSL broadband. 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 6.2 Distribution of distance from exchange among panellists

![Distribution of distance from exchange among panellists](image)

Source: Ofcom using data supplied by SamKnows

6.10 Nevertheless, there is a relationship between the distance from exchange and the maximum line speed achieved (Figure 6.3). 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. However, the relationship between maximum speed and distance from exchange is not as close as we might expect if distance was the only driver of variation (even allowing for the limitations of ‘as the crow flies’ calculations of distance rather than line lengths). The large variation of maximum speeds between consumers living 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 and differences in ISP performance, as well as differences between the ‘as the crow flies’ distance and the actual length of the wire connection.
6.11 Figure 6.3 also highlights that hardly any consumers on packages with a headline speed of 'up to' 8Mbit/s ever receive speeds in excess of 7Mbit/s indicating that even those customers living very close to an exchange do not experience the headline speed when downloading files. 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 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), systems such as the BT broadband Remote Access Server (BRAS) system limit user traffic to 7.15Mbit/s.

Figure 6.3  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 April 2009.

6.12 As might be expected, there is also a relationship between distance from exchange and the average speeds delivered (Figure 6.4). The pattern for average and maximum speeds by distance from exchange is similar. Average speeds are lower than maximum speeds primarily due to speeds being constrained by contention within ISPs' networks. Close examination of Figures 6.3 and 6.4 indicates that consumers living closer to the exchange and with higher maximum speeds are more affected by contention than those living further away with lower maximum speeds.\(^{18}\)

---

\(^{18}\) This was explored in more detail in our January report into the speeds delivered in October and November 2008 where we found that among panelists on an 8Mbit/s connection, for those 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 had significantly more consistent speeds, with average throughput in the slowest hour 87% of that in the fastest hour (See Section 7.8 in Ofcom's report, *UK Broadband Speeds 2008*, www.ofcom.org.uk/research/telecoms/reports/bbspeed_jan09
Figure 6.4 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 April 2009.

Rural versus urban location

6.13 Overall, consumers living in urban areas received average download speeds of 4.3Mbit/s compared to an average of 3.3Mbit/s among those living in rural areas (Figure 6.5). This indicates the greater availability of higher-speed services in urban areas where consumers are more likely to have a choice of cable services and LLU services offering headline speeds of ‘up to’ 16Mbit/s and higher.

Figure 6.5 Average and maximum download speeds for all broadband connections in rural and urban areas

Source: SamKnows measurement data for all panel members with a connection in April 2009
6.14 In addition to lower availability of higher speed packages, the speeds available to rural users are also constrained by longer average line lengths from local exchange to premises. Among consumers on ‘up to 8Mbit/s’ packages, average download speeds in urban areas were 4.0Mbit/s, 11% faster than average speeds in rural areas (3.6Mbit/s) (Figure 6.6). This is partly due to typically longer line lengths in rural areas; across our panel the average ‘as the crow flies’ distance from premises to exchange for rural consumers was 1.73km, compared to an average distance of 1.36km for urban consumers.

6.15 However, maximum line speeds were just 6% higher in urban areas than in rural areas (4.9Mbit/s vs 4.6Mbit/s) and, on average, rural lines achieved 78% of the maximum speed, compared to urban areas receiving 82% of maximum speeds. This suggests that rural exchanges may, on average, have poorer or more highly contended backhaul than urban exchanges.

Figure 6.6 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 April 2009

UK nations

6.16 Among ‘up to 8Mbit/s subscribers, those in England and Northern Ireland received significantly faster speeds than those in Scotland and Wales (Figure 6.7). In the case of England this is likely to be due to shorter average line lengths. However, the relatively fast speeds delivered in Northern Ireland compared to Scotland and Wales are more difficult to explain, but are likely to be driven by a combination of the following factors:

- A small sample size (63 panellists) combined with a wide geographic variation among these panellists (approximately a third live within 1km of the exchange, while a relatively large proportion live more than 3km away) means that the error margin is up to 0.4Mbit/s (i.e. the average speed could be as low as 3.7Mbit/s or as high as 4.5Mbit/s)
- Maximum line speeds in Northern Ireland are higher than in the other three nations. This may reflect better average electrical line quality in Northern Ireland than in the rest of the UK.

- A lower proportion of homes in Northern Ireland have access to either cable broadband or LLU services. This means that a larger proportion of Northern Ireland consumers are on ‘up to’ 8Mbit/s DSL services than in the rest of the UK. Hence a larger proportion of those with high access line speeds are taking ‘up to’ 8Mbit/s services than is the case in the other nations thereby increasing average speeds for ‘up to’ 8Mbit/s subscribers.

**Figure 6.7 Average and maximum download speeds for ‘up to’ 8Mbit/s by UK nation**

![Average and maximum download speeds for ‘up to’ 8Mbit/s by UK nation](image)

*Source: SamKnows measurement data for all panel members with a connection in April 2009*

**Time of day**

6.17 Figure 6.8 shows the average speeds delivered to panellists on packages of ‘up to’ 8Mbit/s by the hour of the day. It indicates speeds in the peak evening hours of 8-10pm are more than 25% slower than in the fastest hours of 4-6am. 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 these data relate 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 (although some ISPs ‘throttle’ a small proportion of all of the traffic of their heaviest users during peak times).
Figure 6.8 Average download speeds by hour of day for panellists on DSL packages of ‘up to’ 8Mbit/s, April 2009

Source: SamKnows measurement data for all panel members with a connection in April 2009
Note: Data have not been weighted or normalised so should be considered as indicative only

The profile by time of day was similar for cable, although the decrease in speeds for cable customers on packages of ‘up to’ 10Mbit/s was less marked on average than for DSL customers (it should be noted, however, that there is considerable variation between DSL providers in terms of peak-time performance, see section 7). On ‘up to’ 10Mbits cable packages, speeds in the slowest hour were 13% slower than in the fastest hour (Figure 6.9).

Figure 6.9 Average download speeds by hour of day for panellists on cable packages of ‘up to’ 10Mbit/s, April 2009

Source: SamKnows measurement data for all panel members with a connection in April 2009
Note: Data have not been weighted or normalised so should be considered as indicative only
6.19 Broadband services in the UK are delivered using a number of different technologies. Our research examined DSL broadband (that is, broadband delivered over the double-loop copper wires which form the Public Switched Telephone Network - fixed voice network) and cable broadband (Virgin Media has over 99% of all cable customers in the UK, and all of our cable panelists were customers of Virgin Media).

6.20 Outside the scope for our research was broadband accessed by dedicated fibre networks (this currently accounts for less than 0.1% of all broadband customers in the UK) and satellite broadband (which also has very low take-up) because we were unable to recruit a sufficiently large sample to generate robust data.

6.21 In addition, ‘mobile broadband’, that is broadband delivered ‘over the air’ by cellular mobile network operators typically via a USB modem or ‘dongle’, was excluded. Our hardware-based technical solution is too cumbersome to be portable, and would not have captured issues such as location which is a key driver of mobile performance. In our Mobile Sector Assessment report, published on 8 July 2009, we committed to addressing this by initiating a programme of research on mobile network quality with the aim of establishing if, and how, we can get an up-to-date understanding of the network quality of UK mobile services and how this changes according to different environments, for example, outdoors, indoors and in transit.

6.22 Around 75% of fixed-line broadband connections in the UK are delivered by DSL broadband, via two different technology standards:

- **ADSL1** (sometimes referred to simply as ADSL) was the first generation of DSL technology and can currently deliver broadband speeds up to a theoretical maximum of 8Mbit/s. However, speeds of 8Mbit/s are not achieved by most customers because DSL broadband degrades as length of the line from the exchange gets longer (see Figure 4.5 above). Indeed, ISPs typically cap speeds at less than 8Mbit/s in order to ensure connections are stable. (For example BT Wholesale’s broadband Remote Access Server (BRAS) system sets a maximum speed of 7.2Mbit/s). ADSL1 is the standard currently used by BT Wholesale for most of its services. Operators predominantly offering broadband via ADSL1 include BT Retail, Tiscali (now owned by Carphone Warehouse) and all operators offering services from exchanges which they have not ‘unbundled’ (i.e. they use wholesale services from BT Wholesale or another wholesale provider).

- **ADSL2+** is an upgrade to ADSL1 and requires the installation of different equipment within the local telephone exchange and at the customer premises, where a modem compatible with ADSL2+ must be used. It enables the delivery of broadband to a theoretical maximum of 24Mbit/s, although is more commonly marketed as an ‘up to’ 16Mbit/s or ‘up to’ 20Mbit/s service. As illustrated in Figure 4.5 above, the speed of ADSL2+ broadband degrades more quickly over the length of the copper wire from exchange to premises than ADSL1, meaning that at a distance of more than 3km there is little difference between the two technologies. ADSL2+ has been widely rolled out in the UK since 2006 by local loop unbundlers (LLU) such as Sky, Orange and O2, all of which offer ADSL2+ services at higher headline speeds than those offered by operators using solely ADSL1, while AOL Broadband offer ADSL2+ services, but only at ‘up to’ 8Mbit/s. By the end of 2008, ADSL2+ services were available to around 70% of the UK.

---

population and were increasingly offered as wholesale services. In June 2009, BT Retail announced that it will upgrade connections to 40% of its customers to ADSL2+ with a further roll-out to offer ADSL2+ services to 55% of its customers by 2011.

6.23 Around 21% of broadband connections in the UK are made via cable and Virgin Media’s cable services are available to around 49% of the UK population, delivering broadband via its hybrid fibre and co-axial cable network. Unlike DSL, cable broadband does not degrade with distance from exchange, although it is subject to the same constraints of limited network capacity. Virgin Media is currently upgrading its network (to the DOCSIS 3.0 standard) which has allowed it to offer 20Mbit/s and 50Mbit/s services, as well as migrating its 2Mbit/s and 4Mbit/s broadband customers to a 10Mbit/s service. Virgin Media does not offer an ‘up to’ 8Mbit/s cable broadband package, so we have compared its ‘up to’ 10 Mbit/s product with the up to 8Mbit/s offered by DSL operators, as this is Virgin Media’s standard offering for new subscribers and also because it is offered at similar price points to offerings from other ISPs.

6.24 We have attempted to attribute all panellists to a specific broadband technology, however, the following caveats should be noted:

- We have attributed all consumers using wholesale services from another supplier as using ADSL1 technology. However, BT Openreach is in the process of upgrading exchanges to ADSL2+, and other suppliers such as Cable & Wireless and Tiscali may also be offering some ADSL2+ services. While these are not generally used for retail customers it is possible that a few panellists who we have categorised as ADSL1 users are in fact using ADSL2+.

- In order to receive ADSL2+ services a consumer needs to have a compatible modem (otherwise the services they receive will be ADSL1). We have not been able to identify panellists’ modems and therefore all who are connected to ADSL2+ services at their exchange have been attributed as ADSL2+ users. (Note that as routers are typically supplied as standard to new customers it is likely that this will affect only a very small proportion of panellists.)

6.25 It should be noted, however, that both of the above caveats would result in a narrowing of the differences in performance between ADSL1 and ADSL2+. Hence, the differences in performance we found between ADSL1 and ADSL2+ are likely to be significant.

6.26 We have also adjusted the raw data for DSL operators offering ‘up to’ 2Mbit/s and ‘up to’ 8Mbit/s services by distance from the exchange in order to make comparisons as accurate as possible (see Annex 3 for further details). This adjustment is necessary because ADSL2+ tends to have higher availability in urban areas where line lengths are likely to be shorter. We have adjusted ADSL2+ service by region and rural/urban rather than by distance from exchange as ADSL2+ operators typically do not offer ‘up to’ 16Mbit/s services to consumers who live more than a certain distance from the exchange. We have also adjusted cable services by region and rural/urban in order to provide like-for-like comparison with DSL (it is not appropriate to adjust cable

---

20 In June 2009, Virgin Media were offering their up to 10Mbit/s cable broadband service at a cost of £14 per month if taken with a phone line, or £20 a month without a phone line. By way of comparison, BT’s up to 8Mbit/s Option 1 broadband service is offered at a cost of £15.65 a month (in addition to the cost of a phone line at £11.25 per month).
services by distance from the exchange as the performance of a cable connection is not affected by line length).

6.27 Our results demonstrated significant differences in performance between different broadband technologies. Figure 6.10 below compares the average speeds delivered to panellists in April 2009 by access technology and by headline speed. It details both the average speeds delivered across every hour of every day, and the average speeds in the peak evening hours of 8pm to 10pm. The bars are 95% confidence intervals showing a range of speeds which, with a 95% probability capture the actual speeds. The sample size for each group and the variation of performance among panellists within the same group combine to determine the size of the bars. The largest bar is the ‘16Mbit/s and more’ ADSL2+ group, followed by the cable ‘up to’ 20 Mbit/s bar; both have relatively small samples and ADSL2+ services at 16Mbit/s or more also has relatively high variation. Figure 6.11 highlights the differences that are significant at a 95% level of confidence.

Figure 6.10 Average download throughput speeds by technology and headline package, April 2009

Source: SamKnows measurement data for all panel members with a connection in April 2009
*Caution: small sample size (<50)
Notes: (1) Data for ADSL1 up to 2Mbit/s and ADSL1 and ADSL2+ up to 8Mbit/s have been weighted by distance from exchange; data for ADSL2+ services up to 16Mbit/s and all cable services have been weighted by region and rural/urban; (2) The ‘error margin; shown represents a 95% confidence interval
significant differences to a 95% level of confidence between average download speeds by technology and headline package, over 24 hours and in the peak period 8-10pm, April 2009

<table>
<thead>
<tr>
<th></th>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADSL ‘up to’ 2Mbit/s</td>
<td>Cable up to 2Mbit/s, ADSL1 up to 8Mbit/s,</td>
<td>ADSL up to 2Mbit/s</td>
</tr>
<tr>
<td></td>
<td>ADSL2+ up to 8Mbit/s, Cable up to 10Mbit/s,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ADSL2+ up to 16Mbit/s and more, Cable up to</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20Mbit/s</td>
<td></td>
</tr>
<tr>
<td>Cable ‘up to’ 2Mbit/s</td>
<td>ADSL1 up to 8Mbit/s, ADSL2+ up to 8Mbit/s,</td>
<td>ADSL up to 2Mbit/s</td>
</tr>
<tr>
<td></td>
<td>Cable up to 10Mbit/s, ADSL2+ up to 16Mbit/s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and more, Cable up to 20Mbit/s</td>
<td></td>
</tr>
<tr>
<td>ADSL1 ‘up to’ 8Mbit/s</td>
<td>ADSL2+ up to 8Mbit/s, Cable up to 10Mbit/s,</td>
<td>ADSL up to 2Mbit/s</td>
</tr>
<tr>
<td></td>
<td>ADSL2+ up to 16Mbit/s and more, Cable up to</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20Mbit/s</td>
<td></td>
</tr>
<tr>
<td>ADSL2+ ‘up to’ 8Mbit/s</td>
<td>Cable up to 10Mbit/s, ADSL2+ up to 16Mbit/s</td>
<td>ADSL up to 2Mbit/s</td>
</tr>
<tr>
<td></td>
<td>and more, Cable up to 20Mbit/s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ADSL1 up to 8Mbit/s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ADSL2+ up to 16Mbit/s and more, Cable up to</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20Mbit/s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cable ‘up to’ 10Mbit/s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cable up to 20Mbit/s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ADSL up to 2Mbit/s, Cable up to 2Mbit/s,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ADSL1 up to 8Mbit/s, ADSL2+ up to 8Mbit/s,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and more, Cable up to 8Mbit/s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cable ‘up to’ 16Mbit/s and more, Cable up to</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20Mbit/s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cable up to 20Mbit/s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ADSL up to 2Mbit/s, Cable up to 2Mbit/s,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ADSL1 up to 8Mbit/s, ADSL2+ up to 8Mbit/s,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and more, Cable up to 8Mbit/s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cable ‘up to’ 20Mbit/s*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ADSL up to 2Mbit/s, Cable up to 2Mbit/s*,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ADSL1 up to 8Mbit/s, ADSL2+ up to 8Mbit/s,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and more, Cable up to 8Mbit/s, Cable up to</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10Mbit/s, ADSL2+ up to 16Mbit/s and more,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cable up to 20Mbit/s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ADSL up to 2Mbit/s, Cable up to 2Mbit/s*,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ADSL1 up to 8Mbit/s, ADSL2+ up to 8Mbit/s,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and more, Cable up to 8Mbit/s, Cable up to</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10Mbit/s, ADSL2+ up to 16Mbit/s and more,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cable up to 20Mbit/s</td>
<td></td>
</tr>
</tbody>
</table>

Source: Ofcom
*Caution: small sample size (<50)
Note: The same significant differences were observed in both the average speeds over 24 hours, and in the average speeds during the peak period of 8-10pm; significant differences to a 99% level of confidence are provided in Annex 5

6.28 The average actual download speeds received by cable customers are significantly higher than those available to DSL customers; on average, cable customers on ‘up to’ 10Mbit/s packages receive speeds around twice as high as DSL customers on ‘up to’ 8Mbit/s packages. The average performance of cable services at ‘up to’ 10Mbit/s are comparable to those of ADSL2+ services at ‘up to’ 16Mbit/s and more.

6.29 The difference between cable and DSL was also repeated for higher-speed packages. Cable customers on a headline speed of 20Mbit/s on average receive speeds around 50% faster than ADSL2+ packages at 16Mbit/s or more. For both sets of customers, actual speeds were well below advertised headline speed.

6.30 Mobile broadband (i.e. broadband services delivered via cellular networks typically to a USB modem or ‘dongle’) was outside the scope of our research. Data published by Eptiro in June 2009 suggest that mobile broadband at headline speeds of ‘up to’ 3.6Mbit/s or ‘up to’ 7.2Mbit/s typically deliver average actual speeds of less than 1Mbit/s, significantly slower than any DSL or cable packages.21

6.31 Figure 6.10 also shows that ADSL1 services and the cable services are significantly slower during the evening peak period of 8pm to 10pm than over the full 24 hour period. By contrast there is little slowdown on the ADSL2+ packages. This indicates

that there is less congestion on the networks of the ADSL2+ operators, which are all offering services via local loop unbundling and which therefore may have more backhaul capacity available (see below).

6.32 It is also notable that, on average, ADSL2+ services offer significantly faster download speeds to a 95% level of confidence than ADSL1 services (see Figure 6.11\(^{22}\)), even when both are offered as ‘up to’ 8Mbit/s. These differences are greater in the peak period. We also found, however, that there was considerable variation between ISPs and that some ADSL1 providers were able to produce similar speeds to those produced by ADSL2 providers (this is discussed in the next section).

6.33 It should also be remembered, however, that the performance of DSL services is highly dependent on distance from exchange. Consumers living more than 3km from an exchange will typically experience little difference between ADSL1 and ADSL2+. Conversely, consumers living within 1km of the exchange can expect a much faster performance than the averages detailed above.

6.34 A consumer’s location not only determines the length of their connection to the local exchange, it also determines what services are available since, as described earlier, ADSL2+ and cable broadband are only available in some parts of the country. Also, it will not always be clear to consumers whether they will receive ADSL1 or ADSL2+ services since some operators offer ADSL1 services from some exchanges and ADSL2+ services from others. Consumers should ask operators to provide them with their access line speed in order to compare the speeds available from different operators.\(^{23}\) A more detailed set of factors on what should be considered when purchasing broadband is available in Ofcom’s consumer guide to broadband\(^{24}\)

Local loop unbundling (LLU) and wholesale DSL services

6.35 DSL broadband services are supplied by two different methods.

- Those which are delivered by ISPs who have installed their own equipment within local telephone exchanges and established a backhaul connection between this equipment and its own network; this is known as local loop unbundling (LLU).

- Those which are delivered via wholesale broadband services. This is when operators do not have equipment within an exchange, but instead rent connections from wholesale providers (the large majority take wholesale services from BT Wholesale although there are other wholesale providers in the UK) and also rent the backhaul capacity to connect from the local exchange to the operators’ core network.

6.36 Figure 6.12 illustrates the difference in speeds between broadband services delivered using unbundled exchanges and those which use wholesale network access. While there are no significant differences between the average speeds delivered over a 24-hour period, nor in the average speeds delivered during ‘working hours’ of 9am to 5pm Monday to Friday, the speeds provided by wholesale

\(^{22}\) The difference between the speeds delivered by ADSL1 and ADSL2+ at ‘up to’ 8Mbit/s was not found to be significant at a 99% level of confidence (see Annex 5).

\(^{23}\) All operators who have signed up to Ofcom’s Voluntary Code of Practice on Broadband Speeds are required to advise consumers of the maximum line speed before broadband is purchased. The Code is available at www.ofcom.org.uk/telecoms/ioi/copbb/

broadband are significantly slower during the late afternoon and evening peak period. This is most notable in the peak of 8pm to 10pm, but there are also significant differences in performance in the extended peak of 3pm to 11pm.

6.37 This slowdown during peak periods is the result of contention on the network as multiple users share the same backhaul bandwidth. The faster average speeds delivered by LLU operators are likely to be a reflection of the lower cost per unit of backhaul capacity for operators using their own network compared to the cost of renting capacity from wholesale suppliers (such as BT Wholesale or Cable & Wireless).

Figure 6.12 Average download throughput speeds for ‘up to’ 8 Mbit/s LLU and non-LLU subscribers, April 2009

Download throughput speed (Mbit/s)

Source: SamKnows measurement data for all panel members with a connection in April 2009
Notes: (1) Data have been weighted to normalise for distance and exchange (2) the range shown represents a 95% confidence interval around the mean
Section 7

Variation by internet service provider (ISP)

7.1 The results described in the previous section indicate that in addition to the demographics of the consumers they serve (particularly in terms of line length for DSL consumers) there are two main reasons why broadband performance is likely to vary between ISPs: the technology used by the ISP and the capacity per user of their network (often described as level of contention). In this section we examine the effects of these factors on individual ISPs’ performance.

ISPs for whom we had a representative sample

7.2 We compared the performance of the ISPs offering advertised speeds of ‘up to’ 8 or ‘up to’ 10Mbit/s. We are not able to offer provider-specific analysis for any other packages (other than the ‘up to’ 2Mbit/s and ‘up to’ 20Mbit/s cable packages from Virgin Media which are detailed above in the section on access technology), as we do not have sufficiently large sample sizes to derive statistically significant data.

7.3 The following provides further detail on the factors which determined which ISPs we were able to include in this analysis:

- Consumers on packages with an advertised speed of ‘up to’ 8 or ‘up to’ 10Mbit/s represented around 64% of the market in April 2009, with 27% of consumers on packages of ‘up to’ 2Mbit/s or below and 9% of consumers on higher speed packages.

- Our sample sizes allow us to provide statistically sound analysis for the full six months of research for the ‘up to’ 8Mbit/s DSL services of the UK’s six largest DSL operators by retail market share: AOL Broadband, BT, Orange, Sky, TalkTalk and Tiscali. (Although AOL Broadband, TalkTalk and Tiscali are all owned by Carphone Warehouse we report on them separately as they are marketed as different services and, to varying extent, utilise different networks. Any references to AOL throughout this report are to the internet service provider AOL Broadband).

- These are compared alongside Virgin Media’s ‘up to’ 10Mbit/s cable service (a more direct comparison is not possible as Virgin Media does not offer an ‘up to’ 8Mbit/s cable service). Virgin Media’s up to 10Mbit/s cable service is now the standard offering to its new subscribers.

- For the month of April 2009 only, we are also able to include the ‘up to’ 8Mbit/s DSL offers from O2 and Plusnet (which is owned by BT, but marketed as a different service). This is because a boost to the sample during March 2009, enabled by changes to the composition of research partner GfK’s national panel, allowed us to achieve statistically significant numbers of subscribers for these two ISPs.

- We were only able to generate enough data to deliver statistically reliable results for ISPs which have over 2% market share; these accounted for over 90% of broadband connections in April 2009. However, there are many other smaller ISPs available, many of which may match or better the performance of the ISPs for which we do not have statistically significant data. We have therefore
aggregated the data for the 40 ‘other’ ISPs used by our panellists, in order to provide a complete picture for the whole of our sample.

Methodological considerations

7.4 In order to provide like-for-like comparison, we have weighted the data for the DSL operators to ‘normalise’ for distance from exchange. The following points should be noted about this normalisation process:

- This adjustment is necessary in order to ensure that an ISP with nationwide coverage is not represented as having poor performance compared to an ISP focused on more densely populated areas simply because it has customers with typically longer line lengths between premises and exchange. (A characteristic of DSL broadband is that performance degrades over the length of the copper wire.)

- Data have been normalised using the straight-line distance from exchange to six-digit postcode. We detail the methodology we have used to do this in Annex 3. This Annex also sets out the checks we applied to ensure that straight-line distance is a suitable metric for normalisation. Specifically, we illustrate that straight-line distance is an appropriate substitute for normalising by an alternative method (using attenuation data), and that the unnormalised results indicate that there is little variation in the distance-profile of the ISPs whose performance results we describe.

- Data for the cable operator, Virgin Media, have been weighted by rural/urban split and by region in order to enable direct comparison with DSL services, which are available nationwide. It is not appropriate to weight by line length as the performance of cable is not affected to any significant extent by the length of the line.

- The normalisation techniques we have used may not be readily understood by the lay reader. However, the statistical methods we have used to detail provider-specific data, including the way in which we have normalised for distance from exchange, have had expert review by econometrician Professor Andrew Chesher (Fellow of the Royal Statistical Society). He has confirmed that they are appropriate for the analysis we have undertaken. He has also reviewed the way in which the performance of individual ISPs has been presented and has confirmed that it is a fair and accurate representation of the data which has been collected (see Section 3.16 for his review of the methodology used).

7.5 The data below represents an accurate assessment of the comparative download throughput speeds achieved by the ‘up to’ 8 and ‘up to’ 10Mbit/s services from the largest operators between November 2008 and April 2009. However, caution should be applied in drawing conclusions from this research given its limitations. In particular we highlight the following constraints:

- The data represent a ‘snapshot’ of the market for the period November 2008 to April 2009. While there was considerable consistency in the data during this period, it should be noted that this is a dynamic market and that the performance levels we found may not be representative of current or future performance. In particular, we highlight the two changes in the market which have occurred since April 2009:
  
  i) In June 2009 BT Retail announced that it is upgrading its services to offer ADSL2+ services to 55% of the UK’s households and
businesses by March 2010. This is likely to have a significant impact on the performance of its own network and may well prompt the increased use of ADSL2+ by other operators, both LLU and non-LLU. Such changes may well improve the performance of those operators which currently use ADSL1 only, and could increase the proportion of consumers who take packages with advertised headline speeds of higher than 8Mbit/s.

ii) Also in June 2009, Sky announced that it was upgrading all its ‘up to’ 8Mbit/s services to ‘up to’ 10Mbit/s. Theoretically, all Sky customers with a line length of less than 2.5km from exchange to premises could expect to receive higher speeds as a result of this change, and the impact may be to increase the average performance of Sky.

- As explained above, we have only been able to include the largest ISPs within our analysis. It should be noted that in other published third-party research some smaller ISPs have performed better than many of the nine ISPs for which we have statistically significant representation.  

- The findings by ISP combine data from on-net and off-net customers. This means that we have included both services provided over the operator’s own network (via LLU) and also services provided using wholesale line rental for each of AOL Broadband, O2, Orange, Sky, TalkTalk and Tiscali. We have weighted the results to ensure that our findings are representative of the nationwide split between off-net and on-net customers (using data provided by operators for April 2009). We then also separately detail the performance of the on-net customers of these ISPs. While it is likely that there are significant differences between the performance of on-net and off-net services by ISP, we do not have sufficient sample sizes to enable us to compare the performance of off-net services. Nevertheless, to understand the likely performance of a broadband connection it is important for consumers to identify whether it is served on the operator’s own network (via LLU) or via a wholesale service. For example, some ISPs use ADSL2+ for on-net broadband services while using ADSL1 for their off-net services, and, as illustrated earlier, ADSL2+ is generally faster than ADSL1 for the same headline speed. It is also possible that on average speeds are slowed down more for off-net than for on-net customers by contention, reflecting typically lower costs per unit of backhaul capacity for operators using their own network compared to the cost of renting capacity from a wholesale operator. Figure 6.12 above and Figures 7.11 and 7.14 below provide some insight into the variations between LLU and non-LLU services.

- The analysis below details findings at a nationwide level. However, the choice of broadband provider available to consumers and their performance are both to a large extent determined by geographical location. For DSL broadband, the length of the line between local exchange and premises is a more significant driver of broadband speeds than choice of provider. In general, the longer the distance between premises and exchange the less variation there is likely to between providers, and at over 2km there is very little difference between any DSL provider (see Figure 7.15 below). Consumers are advised to enquire about the length of their line and the maximum speed it can support before purchasing broadband.

---

25 See, for example: http://www.broadband-expert.co.uk/broadband/speedtest/
• Traffic management policies are also relevant to the user experience and are not generally captured in the data below. These may include policies which limit peer-to-peer traffic and which slow down the speeds available to heavy broadband users. Under Ofcom’s voluntary Code of Practice for Broadband Speeds, ISPs are required to advise consumers of these policies if they use them.26

• We only consider average download throughput speed. There are many other factors which affect the user experience, including upload speeds, time to load web pages, latency, packet loss and DNS resolution times and failure rates. These factors are considered later in this report.

Results over the 24-hour period

7.6 Annex 4 shows that there was strong month-to-month consistency in the average download throughput speeds delivered to panellists between November 2008 and April 2009 among the ISPs offering packages of ‘up to’ 8Mbit/s or ‘up to’ 10Mbit/s for which we had statistically robust sample sizes for the six-month duration of the research. The analysis below focuses on the performance in April 2009, the most recent month for which data are available.

7.7 Figure 7.1 illustrates the differences among ISPs for all the download throughput speed tests run 24 hours a day, every day in April 2009. As with the results by technology set out earlier, they are presented in terms of bars showing the 95% confidence interval. We also set out a table which describes where differences between ISPs are statistically significant using a 5% test of significance (tables detailing differences at a 1% test of significance are provided in Annex 5).26

7.8 Our research found that the average actual speeds received by Virgin Media cable customers on ‘up to’ 10Mbit/s (8.1 to 8.7Mbit/s) are significantly higher than those delivered by any of the largest eight DSL operators’ ‘up to’ 8Mbit/s packages. Among the DSL operators, average download throughput speeds sit in a range of 3.2 – 5.1Mbit/s, with significantly faster average speeds delivered by O227, Orange, Plusnet, Sky and TalkTalk than by AOL Broadband and Tiscali.

7.9 Two factors are likely to be driving this variation:

i) The access technology used. Services delivered via cable offer higher speeds on average than comparable DSL services because, unlike DSL broadband, there is no significant degradation of performance over the length of the line to a consumer’s premises. Among the DSL operators, we described in the previous section that ADSL2+ on average delivers faster speeds than ADSL1, although Figures 7.1 and 7.2 shows there is significant variation between providers. AOL Broadband, O2, Sky, TalkTalk and Orange all offer their on-net customers broadband services using the ADSL2+ access technology, while in April 2009, ADSL1 was used by all BT Retail and Tiscali customers. We have also categorised all Plusnet customers as using ADSL1. (See Section 6 for a review of the relative performance of ADSL2+ and ADSL1).

ii) Variations in backhaul capacity available per customer. Contention in the network (a slowdown in performance caused when multiple users share the same

26 Voluntary Code of Practice: Broadband Speeds, www.ofcom.org.uk/telecoms/ioi/copbb/
27 We have considered O2 and Be customers together
bandwidth within a network and the bandwidth available is less than the aggregate demand) constrains speeds delivered, particularly at peak times. This is likely to be the reason why consumers with AOL Broadband (an ADSL2+ operator) on average receive speeds slower than other ADSL2+ operators. Similarly, a relative lack of contention in the Plusnet network is likely to explain why its customers receive average speeds higher than Tiscali and AOL Broadband, and similar to those offered by ADSL2+ operators.

Figure 7.1  Average download throughput speeds, 24 hours, April 2009

Download throughput speed (Mbit/s)

Source: SamKnows measurement data for all panel members with a connection in April 2009.
*Caution: small sample size (<50)
Notes: (1) Includes combined LLU and non-LLU customers, data have been weighted to splits provided by ISPs (2) data for DSL operators have been weighted to normalise for distance and exchange; data for Virgin Media’s cable service have been weighted to normalise for region and rural/urban; (3) the range shown represents a 95% confidence interval around the mean.

Figure 7.2  Significant differences to a 95% level of confidence between average speeds on ‘up to’ 8Mbit/s or ‘up to’ 10Mbit/s packages, 24 hours, April 2009

<table>
<thead>
<tr>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOL ‘up to’ 8Mbit/s</td>
<td>O2, Orange, Plusnet, Sky, TalkTalk, Virgin Media</td>
</tr>
<tr>
<td>BT ‘up to’ 8Mbit/s</td>
<td>O2, Virgin Media</td>
</tr>
<tr>
<td>O2 ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Orange ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Plusnet ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Sky ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>TalkTalk ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Tiscali ‘up to’ 8Mbit/s</td>
<td>BT, O2, Orange, Plusnet, Sky, TalkTalk, Virgin Media</td>
</tr>
<tr>
<td>Virgin Media ‘up to’ 10Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Other ‘up to’ 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
</tbody>
</table>

Source: Ofcom
*Caution: small sample size
Note: Significant differences to a 99% level of confidence are provided in Annex 5
Results over peak periods

7.10 The effect of contention in ISPs’ networks is shown in Figure 7.3 which looks specifically during the peak period between 8pm and 10pm\textsuperscript{28} and shows that variation by ISP is greater than across the full 24-hour period. In aggregate, performance in this peak period is around 8% slower than over the 24-hour period although there is a wider range among the DSL operators, of 2.5 to 5.1Mbit/s.

7.11 During these peak hours, Virgin Media’s ‘up to’ 10Mbit/s cable service remains significantly faster than any DSL operator’s ‘up to’ 8Mbit/s package, delivering average speeds of 7.5-8.2Mbit/s, compared to the best performing DSL services speeds of 4.1 to 5.1Mbit/s. Among the DSL operators, O2, Plusnet, Sky, Orange and TalkTalk are significantly faster during these peak hours than BT, AOL Broadband and Tiscali.

7.12 The biggest differences between average speeds and peak-period speeds are experienced by panellists using broadband supplied by AOL Broadband, BT Retail, Orange and Tiscali. This indicates that these ISPs suffer greater contention in their networks. The smallest difference between average speeds and peak-period speeds are experienced by panellists with O2, Plusnet, Sky and TalkTalk, suggesting that these networks are least affected by contention among the ISPs for which we have data available.

Figure 7.3 Average download throughput speeds, 8-10pm, April 2009

Source: SamKnows measurement data for all panel members with a connection in April 2009.
*Caution: small sample size (<50)
Notes: (1) Includes combined LLU and non-LLU customers, data have been weighted to splits provided by ISPs (2) data for DSL operators have been weighted to normalise for distance and exchange; data for Virgin Media’s cable service have been weighted to normalise for region and rural/urban; (3) the range shown represents a 95% confidence interval around the mean.

\textsuperscript{28} Data from LINX indicates that in data transfer in these peak evening hours are around four times as high as in the off-peak early hours of the morning, [https://stats.linx.net/](https://stats.linx.net/)
Figure 7.4   Significant differences to a 95% level of confidence between average speeds on ‘up to’ 8Mbit/s or ‘up to’ 10Mbit/s packages, 8-10pm, April 2009

<table>
<thead>
<tr>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOL ‘up to’ 8Mbit/s</td>
<td>O2, Orange, Plusnet, Sky, TalkTalk, Virgin Media, Other</td>
</tr>
<tr>
<td>BT ‘up to’ 8Mbit/s</td>
<td>O2, Orange, Plusnet, Sky, TalkTalk, Virgin Media</td>
</tr>
<tr>
<td>O2 ‘up to’ 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Orange ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Plusnet ‘up to’ 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Sky ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>TalkTalk ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Tiscali ‘up to’ 8Mbit/s</td>
<td>O2, Orange, Plusnet, Sky, TalkTalk, Virgin Media, Other</td>
</tr>
<tr>
<td>Virgin Media ‘up to’ 10Mbit/s</td>
<td>AOL, BT, O2, Orange, Plusnet, Sky, TalkTalk, Tiscali, Other</td>
</tr>
<tr>
<td>Other ‘up to’ 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
</tbody>
</table>

Source: Ofcom
*Caution: small sample size
Note: Significant differences to a 99% level of confidence are provided in Annex 5

7.13 Figure 7.5 compares download speeds for the same operators in the longer peak period of 3-11pm. The results are consistent with the data from 8-10pm, with the same statistically significant differences between operators, but the magnitude of some of the differences reduced.

Figure 7.5   Average download throughput speeds, 3-11pm, April 2009

Source: SamKnows measurement data for all panel members with a connection in April 2009.
Caution: small sample size (<=50)
Notes: (1) Includes combined LLU and non-LLU customers, data have been weighted to splits provided by ISPs (2) data for DSL operators have been weighted to normalise for distance and exchange; data for Virgin Media’s cable service have been weighted to normalise for region and rural/urban; (3) the range shown represents a 95% confidence interval around the mean.
Figure 7.6  Significant differences to a 95% level of confidence between average speeds on ‘up to’ 8Mbit/s or ‘up to’ 10Mbit/s packages, 3-11pm, April 2009

<table>
<thead>
<tr>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOL ‘up to’ 8Mbit/s</td>
<td>O2, Orange, Plusnet, Sky, TalkTalk, Tiscali Virgin Media</td>
</tr>
<tr>
<td>BT ‘up to’ 8Mbit/s</td>
<td>O2, Orange, Plusnet, Sky, TalkTalk, Tiscali Virgin Media</td>
</tr>
<tr>
<td>O2 ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Orange ‘up to’ 8Mbit/s</td>
<td>O2, Virgin Media</td>
</tr>
<tr>
<td>Plusnet ‘up to’ 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Sky ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>TalkTalk ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Tiscali ‘up to’ 8Mbit/s</td>
<td>BT, O2, Orange, Plusnet, Sky, TalkTalk, Tiscali Virgin Media</td>
</tr>
<tr>
<td>Virgin Media ‘up to’ 10Mbit/s</td>
<td>AOL, BT, O2, Orange, Plusnet, Sky, TalkTalk, Tiscali Other</td>
</tr>
<tr>
<td>Other ‘up to’ 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
<tr>
<td></td>
<td>Tiscali</td>
</tr>
</tbody>
</table>

Source: Ofcom
Caution: Small sample size (<50)
Note: Significant differences to a 99% level of confidence are provided in Annex 5

7.14  There are smaller differences between ISPs in the residential ‘off peak’ hours of between 9am and 5pm, Monday to Friday, when contention in the networks has less impact (Figure 7.7). During this period, Virgin Media’s ‘up to’ 10Mbit/s cable service is again faster than any DSL operators, while among the DSL operators O2, Orange, Plusnet and Sky are significantly faster than AOL Broadband and Tiscali.

Figure 7.7  Average download throughput speeds, 9am-5pm, Monday to Friday, April 2009

Download throughput speed (Mbit/s)

Source: SamKnows measurement data for all panel members with a connection in April 2009
*Caution: small sample size (<50)
Notes: (1) Includes combined LLU and non-LLU customers, data have been weighted to splits provided by ISPs (2) data for DSL operators have been weighted to normalise for distance and exchange; data for Virgin Media’s cable service have been weighted to normalise for region and rural/urban; (3) the range shown represents a 95% confidence interval around the mean.
Figure 7.8  Significant differences to a 95% level of confidence between average speeds on ‘up to’ 8Mbit/s or ‘up to’ 10Mbit/s packages, 9am-5pm, Monday to Friday, April 2009

<table>
<thead>
<tr>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOL ‘up to’ 8Mbit/s</td>
<td>O2, Orange, Plusnet, Sky, Virgin Media</td>
</tr>
<tr>
<td>BT ‘up to’ 8Mbit/s</td>
<td>O2, Virgin Media</td>
</tr>
<tr>
<td>O2 ‘up to’ 8Mbit/s*</td>
<td>Virgin Media, AOL, BT, TalkTalk, Tiscali, Other</td>
</tr>
<tr>
<td>Orange ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Plusnet ‘up to’ 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Sky ‘up to’ 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>TalkTalk ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Tiscali ‘up to’ 8Mbit/s</td>
<td>O2, Orange, Plusnet, Sky, Virgin Media</td>
</tr>
<tr>
<td>Virgin Media ‘up to’ 10Mbit/s</td>
<td>AOL, BT, O2, Orange, Plusnet, Sky, TalkTalk, Tiscali, Other</td>
</tr>
<tr>
<td>Other ‘up to’ 8Mbit/s*</td>
<td>O2, Virgin Media</td>
</tr>
</tbody>
</table>

Source: Ofcom

*Caution: small sample size (<50)

Note: Significant differences to a 99% level of confidence are provided in Annex 5

7.15  Figure 7.9 depicts the average performance by ISPs in April 2009 over a 24-hour period and in the peak period of 8pm to 10pm, while Figure 7.10 summarises the speeds achieved by all ISPs in different time periods to a 95% confidence interval around the mean.

Figure 7.9  Average download throughput speeds, overall and in the peak period of 8-10pm, April 2009

Source: SamKnows measurement data for all panel members with a connection in April 2009

* Caution: small sample size (<50)

Notes: (1) Includes combined LLU and non-LLU customers, data have been weighted to splits provided by ISPs (2) data for DSL operators have been weighted to normalise for distance and exchange; data for Virgin Media’s cable service have been weighted to normalise for region and rural/urban; (3) the range shown represents a 95% confidence interval around the mean.
As discussed above, there are two key drivers of variation between ISP performance; (1) the backhaul capacity available (which determines the level of contention in the network); and (2) the access technology used (which is the main factor defining the line speed available). Figure 7.11 below shows the impact of contention in the network by examining the average speeds delivered against the maximum line speeds (defined as the maximum speed a customer ever received).

This is useful because it highlights the areas over which the ISP theoretically has control (as maximum speed is defined by the physical constraints of the connection into a home, the average speed as a proportion of the maximum speed reflects performance within these constraints). The maximum line speed is also important to the way in which broadband is sold, since under Ofcom's Code of Practice for Broadband Speeds[29], suppliers who have signed the Code have committed to advise customers of the maximum line speed (also known as the access line speed) at the time of purchase.

The analysis shows that there are some differences between operators, indicating that contention in the network is a bigger issue for some ISPs than for others. Average speeds delivered by Plusnet, Sky and Virgin Media are significantly closer to maximum line speeds than for any other operator, meaning it is likely that their customers will typically receive more consistent speeds throughout the day.

---

**Figure 7.11** Average speeds (24 hours) as a proportion of maximum speeds, April 2009

Source: SamKnows measurement data for all panel members with a connection in April 2009
*Caution: small sample size (<50)

Notes: (1) Includes combined LLU and non-LLU customers, data have been weighted to splits provided by ISPs; (2) Data have not been normalised by distance from exchange as it indicates average speed as a proportion of maximum speed and should not therefore be affected by differences in line length caused by differences in customer profile.

**LLU and non-LLU services**

7.19 As detailed in Section 6.36, overall the speeds delivered to customers who receive DSL services via local loop unbundling (LLU) (i.e. when operators have installed their own equipment within the local telephone exchange and established a backhaul connection between this equipment and its core network) are faster than those delivered to customers who receive services which are delivered via wholesale DSL (i.e. when operators do not have equipment within an exchange, but instead rent connections from wholesale providers).

7.20 However, as Figure 7.12 indicates, there are significant differences among LLU services offered by different ISPs. O2 delivered significantly faster speeds on average to its LLU (or 'on-net') customers than TalkTalk, Tiscali or AOL Broadband in both the peak period and overall. Speeds delivered to on-net AOL Broadband customers were significantly slower than those delivered to customers of the other five operators for which data are available, other than to Tiscali customers in the peak period of 8pm to 10pm, when there was no significant difference. Average speeds delivered to on-net customers are generally faster than to their combined on-net and off-net customer bases (See Figure 7.10 above). The exception is AOL Broadband, where average speeds delivered over a 24-hour period are slower to on-net than to off-net customers (although speeds delivered in the peak period are faster for on-net than off-net customers).
Figure 7.12 Average download throughput speeds for LLU customers, April 2009

Source: SamKnows measurement data for all panel members with a connection in April 2009
*Caution: small sample size (<50)
Notes: (1) Data for DSL operators have been weighted to normalise for distance and exchange; (2) the range shown represents a 95% confidence interval around the mean

Figure 7.13 Significant differences to a 95% level of confidence between average speeds for LLU customers over 24 hours and in the peak period (8pm to 10pm)

Source: Ofcom
*Caution: small sample size (<50)
Note: Significant differences to a 99% level of confidence are provided in Annex 5

7.21 We do not have sufficient sample sizes to enable comparison of the off-net (non-LLU) speeds delivered by AOL Broadband, O2, Orange, Sky, TalkTalk and Tiscali. However, we are able to compare the aggregate performance of off-net customers against those of BT and Plusnet (two operators who do not operate unbundled local loops themselves and instead use wholesale DSL). Figure 7.14 illustrates that the
speeds delivered to Plusnet customers are significantly faster than those delivered to BT customers in the peak period of 8-10pm, and in this peak period both Plusnet and BT customers receive significantly faster speeds than the average received by off-net customers of AOL Broadband, O2, Orange, Sky, TalkTalk and Tiscali. These data must be treated with caution as we do not have large enough sample sizes to be able to detail provider-specific analysis of off-net services by LLU operators, and it may be that some operators offer faster speeds to off-net customers than other operators.

**Figure 7.14** Average non-LLU download speeds, April 2009

![Graph showing average download speeds for BT, Plusnet, and Other providers from 24 hours to 8-10pm.](image)

*Source: SamKnows measurement data for all panel members with a connection in April 2009.*

*Notes: (1) Data have been weighted to normalise for distance and exchange; (2) the range shown represents a 95% confidence interval around the mean; (3) “Other” represents aggregated data for all off-net panellists with AOL Broadband, O2, Orange, TalkTalk, Tiscali and Sky*

**Variations by distance**

7.22 The analysis above considers ‘average’ variations by ISP based on a distribution of consumers representative of UK broadband consumers as a whole. However, it is important to note that, for DSL broadband, speeds are also heavily influenced by the length of the line between premises and local telephone exchange. Figure 7.15 below illustrates the distribution of broadband speed by ISP by distance from exchange. It shows that the variations by ISP are greater the shorter the distance from premises to exchange, while for consumers living more than 3km from the exchange there is little variation between the speeds offered by different suppliers.

7.23 In part this is a consequence of the fact that the difference in performance between ADSL1 and ADSL2+ declines with distance (as Figure 4.5 above details, the speed of ADSL2+ broadband degrades more quickly with distance). It is also a result of the lower maximum speeds that are available to consumers at more than a certain distance, meaning that these consumers require less backhaul capacity and operators are therefore better able to deliver speeds at close to maximum line speed as contention more frequently occurs at higher speeds.
Figure 7.15  Average download speed and distance from exchange for the ‘up to’ 8Mbit/s packages from the UK’s largest six DSL operators by market share

Source: SamKnows measurement data for all panel members with a connection in April 2009
Notes: Each line represents a different ISP; they are anonymised because data are illustrative only as sample sizes are not sufficient to provide accurate speeds by distance from exchange.
Section 8

Other metrics affecting performance

8.1 The performance of a broadband connection is not governed by download throughput speeds alone. This section of the report aims to examine the effect of other key factors using research results from April 2009, the most recent month for which data are available. (Annex 4 shows results for the full six-month data collection period and finds that performance was largely consistent during this time).

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 matter to those looking to share large files, use real-time video communications and for some games.

8.3 Figure 8.1 compares the upload and download speeds delivered to consumers by the headline speed of the package to which they subscribe. Overall the average upload speed received by UK consumers is 0.43Mbit/s, less than 10% of the average download speed, and even consumers on higher speed packages (20Mbit/s cable and 16-24Mbit/s DSL packages) receive an average of less than 0.7Mbit/s.

8.4 Whereas download speeds delivered over cable are significantly faster than those for equivalent DSL packages, there is little difference in upload speeds. The average upload speed delivered to consumers on ‘up to’ 8Mbit/s DSL packages was 0.42Mbit/s, compared to 0.46Mbit/s for consumers on ‘up to’ 10Mbit/s cable packages.

Figure 8.1 Average upload and download speeds, April 2009

Download throughput speed (Mbit/s)

Source: SamKnows measurement data for all panel members with a connection in April 2009.
*Caution: small sample size (<50)
Note: Data have been weighted by demographics and ISP in order to ensure that they are representative of UK broadband consumers as a whole.
8.5 There was less variation between the average and maximum upload speeds than was the case for download speeds. The ‘up to’ 2Mbit/s DSL products typically have an advertised upload speed of 256kbit/s or 400Mbit/s. The advertised upload speeds ‘up to’ 8Mbit/s products vary somewhat, although the most common is the 448kbit/s of ADSL Max (offered by all operators that use BT’s wholesale product). We found that ‘up to’ 8Mbit/s services achieved an average of 420kbit/s and a maximum of 450 kbit/s. DSL products with over 8Mbit/s in downstream also have a varying range of upstream speeds, and are often rate-adaptive in ADSL2+ (meaning that the connection speed varies according to line quality). In our tests they achieved an average of 580kbit/s and a maximum of 650kbit/s. Virgin Media advertises upload speeds of 256kbit/s for its ‘up to’ 2Mbit/s cable service, 512kbit/s for its ‘up to’ 10Mbit/s cable service and 768kbit/s for its up to 20Mbit/s cable service.

Figure 8.2 Average and maximum upload speeds, April 2009

Source: SamKnows measurement data for all panel members with a connection in April 2009
Note: Data includes all panellists, those with DSL connections and cable connections

8.6 Although there was a small slowdown during the peak evening hours, in general upload speeds remained fairly consistent at all times of the day, with 16 Mbit/s and over DSL services offering the best performance at all times.

Figure 8.3 Average upload speeds by hour of day, April 2009

Source: SamKnows measurement data for all panel members with a connection in April 2009.
* Caution: small sample size (<50)
Note: Data have been weighted by demographics and ISP in order to ensure that they are
representative of UK broadband consumers as a whole.

Web browsing

8.7 Download throughput speeds are of limited importance for web browsing, where file sizes are typically small (less than 100kb). A broadband connection’s latency and DNS resolution time are equally important (both are discussed in more detail below), and combine with server-side factors (for example the bandwidth of the host site) to determine how quickly web pages are loaded.

8.8 In order to assess the basic web browsing performance of packages with different headline speeds, 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. Note that tests were designed to ensure that pages were not cached.

8.9 As Figure 8.4 indicates, there was a significant slowdown during the peak evening hours, with average page loading times on the lowest speed DSL and cable packages slowing by over 25% compared to the fastest times of the day.

8.10 More notable however is the difference in web browsing performance between the different headline speed bands. On average, the ‘up to’ 16Mbit/s and over packages downloaded pages around three times more quickly than the ‘up to’ 2Mbit/s packages, indicating therefore that even the most basic web services perform better on higher speed packages. And, unlike the download throughput tests, the data suggest that the ‘up to’ 16Mbit/s and over DSL packages downloaded web pages faster than the ‘up to’ 20Mbit/s cable services throughout the day, although sample sizes are small here and results should be treated with caution.

Figure 8.4  Time to load web pages, by hour of day, April 2009

*Caution: small sample size (<50)
Source: SamKnows measurement data for all panel members with a connection in April 2009.

8.11 Due to the relatively small sizes of most web pages (often measured in tens of Kilobytes), there comes a point when increasing the raw download speed of the connection yields no tangible increase in the browsing performance. Latency becomes the limiting factor in determining webpage load times on next-generation connections (see below).
Latency

8.12 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, particularly some games, perform far better with lower latency.

8.13 Compared to web browsing, there is much more consistency throughout much of the day between packages with different headline speeds. However, the cable connections show a much more marked slowdown during the peak evening hours, with the latency of the 10Mbit/s cable product around 50% greater than during off-peak hours and the 2Mbit/s product more than 150% greater. However, even during these peak periods latency is less than 120 milliseconds (0.12 seconds), a level satisfactory for most internet activities.

Figure 8.5 Latency, by hour of day, April 2009

Packet loss

8.14 Packets of data can be lost during transmission over an internet connection. Packet loss can considerably degrade the performance of real-time applications, and although network protocols such as Transmission Control Protocol (TCP) automatically deal with packet loss to minimise the impact on the end user, there may still be a temporary slow-down. This 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).

8.15 Our data show that throughout the day levels of packet loss are very low for all packages, indicating minimal impact for most consumers. Indeed the ‘spiky’ nature of the output is a consequence of the very small number of failures. This means that there is a high standard error associated with each data point and much of the variation is likely to be caused by random variation rather than systematic differences between different headline speed bands or different hours of the day.
**DNS resolution**

8.16 DNS (the domain name service) plays 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 the internet while browsing.

8.17 The pattern of average DNS resolution times by headline speed band by hour of day is very similar to that of latency (see Figure 8.5 above), indicating that the two are linked. For most hours of the day, cable broadband performs better than its DSL equivalent; however whereas the performance of DSL broadband is generally fairly consistent across the day, in the peak evening period cable broadband suffers a significant slowdown in DNS resolution times. However, as with latency, even during the peak evening hours average times for all packages are sufficient for most internet applications.

---

*Caution: small sample size (<50)*

Source: SamKnows measurement data for all panel members with a connection in April 2009
8.18 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”.

8.19 During off peak hours, failure rates are comparable to those of packet loss. However, unlike packet loss there is a significant increase during the peak evening hours, coinciding with the times when average download throughput speeds slow down. This suggests that network contention plays a bigger role than DNS servers in these failures.

8.20 The higher headline speed packages (20Mbit/s cable and 16Mbit/s and more DSL) have very low failure rates throughout the day.

**Figure 8.8** DNS failure rate, by hour of day, April 2009

*Caution: small sample size (<50)
Source: SamKnows measurement data for all panel members with a connection in April 2009

**Jitter**

8.21 ‘Jitter’ is a measure of the stability of a connection (it can also be defined as the rate of change of latency). The lower the measure of jitter, the more stable a connection is. Jitter and packet loss are the two biggest contributors to the quality of a VoIP (Voice over IP) phone call. Online gamers will also desire low jitter (low latency is useless if the connection has a high jitter rate).

8.22 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.

8.23 There is little difference in the levels of jitter between DSL packages with different headline speeds, and between cable packages with different headline speeds. However, DSL broadband delivers significantly lower levels of jitter than cable broadband, and is consistent throughout the day. Nevertheless, the average jitter rate across all headline speed bands suggests a high level of connection stability.
Figure 8.9  Jitter, by hour of day

*Caution: small sample size (<50)

Source: SamKnows measurement data for all panel members with a connection in April 2009.
Section 9

Conclusion and next steps

Implications for consumers

9.1 This research report is a representative snapshot of broadband performance in April 2009 and we have noted the limitations of the research. The broadband market is changing rapidly, driven by consumers’ growing demand for faster broadband. Operators, in turn, are continuing to invest in their networks in order to make faster broadband available. Hence the results set out in this report will not necessarily reflect the future performance of networks and providers.

9.2 However, we believe our research is a valuable and important step in understanding the key factors that currently affect broadband speed and performance and it has some important findings of interest to consumers. In particular, our results indicate that there is significant variation in the performance of different ISPs and that these variations are largely attributable to the access technology used and the capacity of ISPs’ networks (Sections 6 and 7). It is also clear that performance of a DSL connection depends on a consumer’s distance from the exchange, and this is particularly the case for ADSL2+ services (Section 4).

9.3 We have separately published a consumer guide on factors we think consumers might wish to consider when buying broadband services.

Implications for ISPs

9.4 The research has given us valuable insights into consumers’ perceptions of and experience of their broadband services. The survey and performance results suggest that ISPs need to do more to ensure they are giving their customers enough information about the services they provide and the types of factors that may impact on the actual speed they will receive.

- **Complying with Ofcom’s voluntary Code of Practice for Broadband Speed.** This Code requires all ISPs who have signed up (and ISPs representing over 95% of consumers have done so) 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 – particularly those relating to the level of consumer dissatisfaction in relation to broadband speeds - indicate that there is both consumer demand for such information and room for further improvement in these areas. We are currently undertaking mystery shopping research to assess ISPs’ compliance with the Code and intend to discuss with ISPs the implications of that research, and this broadband performance research, which may lead to a revision of the Code in the future.

- **Advertising and promoting broadband services effectively in order to ensure consumers get proper information.** As broadband services develop, the scope for consumer confusion increases. For example, many ISPs are introducing ADSL2+ services and are advertising these services as ‘up to’ 20Mbit/s broadband. Our research suggests however that the large majority of households in the UK will not be able to receive speeds of 20Mbit/s through ADSL2+. And around half of households live further than 3.25km from their local exchange and hence will experience little or no improvement in broadband
speeds by upgrading from ADSL1 to ADSL2+. There is a significant possibility therefore that advertising broadband as ‘up to’ 20Mbit/s will lead to a mismatch between consumers’ expectations and reality. In order to avoid this, it is essential that ISPs promote and sell their broadband services responsibly. We will consider how Ofcom’s powers can be used to ensure that this is the case.

**Next steps**

9.5  We recognise the dynamic nature of this market and will consider how this research can be updated to take into account the rapidly changing broadband market. For example, a number of ISPs have announced their intentions to implement investments and upgrades to their services, such as the implementation of ADSL2+ and super-fast fibre-based broadband, which should lead to increased speeds and better overall performance.

9.6  Reliable and current information benefits consumers by giving them the information they need to make informed decisions about their services and it provides important incentives to operators to continue to invest in their infrastructure to ensure their services meet the needs of their customers.

9.7  We therefore plan to repeat this research in the future in order that we can take into account the changing broadband market. We will discuss with stakeholders how we can best update the research to ensure that reliable and timely information on broadband performance continues to be made available to consumers.
Annex 1

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 24Mbit/s can be delivered towards the customer.

**ATM** Asynchronous Transfer Mode (or ATP, Asynchronous Transfer Protocol) A telecommunications protocol used in networking. ATM enables all types of information (data, voice and video in any combination) to be transported by a single network infrastructure.

**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.

**BRAS** Broadband remote access server. Routes traffic to and from the digital subscriber line access multiplexers (DSLAM) on an Internet service provider’s (ISP) network. The BRAS sits at the core of an ISP’s network and its functions include enforcing quality of service policies and routing traffic into an ISP’s backbone network.

**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 July 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  A measure of the stability of an internet connection. 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 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.

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.
Annex 2

Technical methodology

Overview

The technical methodology was supplied by SamKnows Ltd, Ofcom’s technical partner in this research project.

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:

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*, *dnsp* 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 3

Statistical methodology

Sample size

A representative panel of UK broadband users was recruited by market research partner GfK NOP in September-October 2008. Quotas were set by ISP (for any ISP with greater than 5% market share) and by region (for ten regions in England, and for Scotland, Wales and Northern Ireland). Detail on the sample sizes and recruitment methodology is provided in Annex 6.

Additional recruitment was undertaken to maintain panel numbers in February-March 2009. Priority was given to geographic regions where total numbers had fallen, and to the smaller ISPs by market share in order to maintain reporting base sizes. Because of changes in the composition of research partner GfK NOP’s national panel, we were also able to recruit participants from O2 and Plusnet to enable us to include them in the analysis of April 2009 data.

A total of 2,527 measurement units were connected by participants between 23 October 2008 and 31 April 2009.

All measurement data was collated and stored for analysis purposes as a monthly average of the measurements obtained for each respondent for the relevant time interval (i.e. 24 hours, 8-10pm, 3-11pm, 9am-5pm Monday to Friday). Only participants who provided a minimum of five valid measurements across all the download speeds tests for each time interval were included in the monthly analysis. The average number of measurements in April, per respondent for the 24-hour download speed tests was 557, from a theoretical maximum of 744 per respondent (i.e. if all scheduled tests were run – tests were not run when the monitoring equipment was disconnected or when the monitoring unit detected concurrent use of the bandwidth).

Average speeds experienced by participants are generally very accurately estimated. So the main factor limiting the accuracy of the analysis reported here is the number of participants rather than the number of speed measurements. The numbers of connected participants, month-on-month, where each participant had at least five measurements on all of the download speeds test are shown in Figure 1 below. The total number of participants meeting this criteria (and the criteria below for having correctly assigned ISP and package) for any of the six calendar months was 1,610.
Figure 1  Overall sample size, November 2008 to April 2009

![Sample size graph]

Source: Sample sizes provided by GfK NOP Ltd based on data collected by SamKnows.

The results published in the main report and Annex 4, are obtained from the sample sets detailed in Figure 2.

Figure 2  Sample sets

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Sample set</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 2009</td>
<td></td>
</tr>
<tr>
<td>Participants with valid measurements and an identified IP address and/or named ISP</td>
<td>1,232</td>
</tr>
<tr>
<td>Participants with in addition no ISP or package, conflicts or stated/measured changes in the investigation period</td>
<td>1,169</td>
</tr>
<tr>
<td>Participants with in addition a ‘crow flies’ distance to exchange measurement of &lt;5000 m</td>
<td>1,140</td>
</tr>
<tr>
<td>November 2008 to April 2009</td>
<td></td>
</tr>
<tr>
<td>Participants with valid measurements and an identified IP address and/or named ISP in all calendar months</td>
<td>889</td>
</tr>
<tr>
<td>Participants across all calendar months with in addition no changes or conflicts with ISP, Package or Postcode</td>
<td>719</td>
</tr>
<tr>
<td>Participants across all calendar months with in addition a ‘crow flies’ distance to exchange measurement of &lt;5000 m</td>
<td>702</td>
</tr>
</tbody>
</table>

Source: Sample sizes provided by GfK NOP Ltd based on data collected by SamKnows.

Sample weighting

There were three weighting classifications applied to the data:

- **National or Overall.** Weighting by (i) Rural/Urban/Region; and (ii) ISP, package headline speed and market shares as at April 2009.
- **ISP and Technology.** Weighting to normalise by distance from exchange for all DSL packages at under ‘up to’ 16Mbit/s; and for on-net/off-net for ‘up to’ 8Mbit/s DSL packages; and weighting by Rural/Urban/Region for DSL packages of ‘up to’ 16Mbit/s and all cable packages. (DSL participants where ‘as the crow flies’ distance to exchange was more than 5,000m, or was missing, were excluded, as were participants where we were unable to assign the ISP and/or package – see below).

- **Time Series.** Weighting by Rural/Urban/Region and IS package headline and market shares as at April 2009 for participants with valid measurements for all months November to April (Respondents with conflicts/changes in ISP, Package and postcode in the period were excluded).

**Assigning participants to ISP and broadband package**

At the time of recruitment participants were asked to provide their ISP, package name, headline speed, price and download limit from drop down menus and/or text boxes provided in an online survey form.

There are two headline speed classifications, one used with the National or Overall sample, and one for the ISP and technology sample.

For both we applied the following criteria to allocate participants to ISP and package:

- The stated package name, headline speed, price and download limit (where they allowed identification of the correct ISP package) were used to assign participants to the correct package. In order to be considered valid at least two of package name, headline speed and price had to be consistent.

- The ISP allocation was also validated against IP address (which was captured during the performance data collection). When an IP address and stated ISP (from September or February survey) were missing from the records, the participant was excluded, when they were inconsistent the record was flagged. (In February 2009 a short survey was undertaken with active members to identify changes in ISP, package and connection address postcode).

- Any participant who received maximum speeds higher than the headline speed of the package they had stated they were on was reassigned to the next highest speed package offered by their ISP.

- Participants who did not specifically state 8Mbit/s as their headline speed, and received a maximum speed of less than 2Mbit/s were coded as 2Mbit/s packages (when their ISP offered 2Mbit/s packages)

For the national or overall sample we applied the following criteria:

- Participants who could not be definitively matched to a package, were assigned to the lowest headline package, based on the measured maximum speed in April, offered by their ISP (for example, if they never received speeds in excess of 2Mbit/s
and their ISP offered a package of ‘up to’ 2Mbit/s, they were assigned to this package). ³⁰

For the ISP and Technology analysis we applied the following more rigorous criteria in order to exclude participants from the comparative ISP/Technology analysis where we could not be confident in an assignation of the headline speed of their package or suspected that they had changed package and/or address during the duration of data collection.

- Those participants whose stated and measured package assignments or ISP were not consistent and could not be definitively reconciled were excluded from comparison data.

- Those participants who notified or featured measured changes in ISP, headline speed and postcode were excluded from the analysis.

Statistical analysis of maximum speed and distance from exchange identified a feature consistent with a number of participants self assigned as ‘up to’ 8Mbit/s customers receiving speeds capped at 2Mbit/s or less. The following selection criteria were used to eliminate those participants from the ‘up to’ 8Mbit/s analysis, this affected 1% of the ‘up to’ 8Mbit/s DSL participants:

- Participants with a DSL connection who lived closer than 1000m to the local exchange and received maximum speeds of between 1.5Mbit/s and 2.5Mbit/s were assumed to be on headline packages of ‘up to’ 2Mbit/s for analysis purposes.

Normalisation

As performance of DSL broadband is significantly affected by the length of the line between consumer’s premises and the local exchange, any comparison between ISPs or technology could be affected by the distribution of distance among the sample.

Therefore it was necessary to normalise the data by distance from exchange in order to provide like-for-like comparison between ISPs and technology to ensure that any differences identified were due to differing performance and not due to a differing distribution of line lengths.

We considered three distance measures for normalising or adjusting for deterioration of broadband speed by distance from exchange:

- Measured line attenuation (electrical line loss). The signal loss on the line is a function of the length of the line and its quality. Whilst the measured attenuation data are a parameter which is available via the administration interface of most broadband routers in our pilot study we found that the majority of consumers found it too complicated to access this information and report it accurately. Measured line attenuation was therefore not available to us.

- Estimated Line attenuation. An estimate of line attenuation can be derived by using a standard figure for electrical loss per Km of cable in conjunction with the line length. We did not have access to accurate line length data and so line length was estimated.

³⁰ This represents an improvement on the methodology used in the in January 2009 report( based on the first month of data collection), when participants who could not be definitively matched were assigned to the most popular package available from their ISP.
using the distance by road from the exchange to the participant’s post code. These attenuation estimates were available for around 70% of participants. However, we were not able to source this information for the remaining 30%. Moreover, those missing 30% were clearly not at random, for example we were missing data for all panellists in Northern Ireland. Therefore we could expect systematic biases within this data.

- The straight line distance. The ‘crow flies’ distance was calculated from the six-digit postcode addresses of each participant and their local exchange. This data was available for 97.5% of participants. We recognise that virtually all lines will be longer than the straight lines distance. However this distance can be measured for all participants and we undertook statistical analysis to see how closely straight line distance and estimated attenuation were correlated (see below). Additionally, there will be an error margin associated with using 6 digit postcode (rather than more precise co-ordinates), however this error is random and should not therefore introduce a systematic bias in the analysis.

In the absence of actual line attenuation, estimated line attenuation data would theoretically provide better data for normalising the data set than straight line distance. However, excluding the 30% of participants for whom data was missing would significantly reduce sample sizes and moreover would potentially create bias, as those missing were not at random. There were therefore, two alternatives:

1. Use estimated attenuation data for participants where actual attenuation data are not available. Figure 3 indicates that there is an approximately linear regression function (a flexible nonparametric fit is drawn in red), although there is much more variability in attenuation at longer distances. The squared correlation between attenuation and distance in the data for all participants on ‘up to’ 8Mbit/s DSL packages is 0.77, but there is significant variation in this correlation across ISPs (from a low value of 0.72 to a high value of 0.97). There is a small amount of variation in the attenuation-distance regression relationships across ISPs. Therefore using estimated attenuation risks introducing differential effects across ISPs.

2. Use the straight-line distance between premises and local exchange based on six-digit postcode. This has advantages in that this distance is available for 97.5% of participants, and the strength of the relationship between attenuation and distance (Figure 3) indicates that it is a reasonable proxy for attenuation.
Figure 3  Scatter plot of attenuation and distance and fitted nonparametric estimate of a regression line for ‘up to’ 8Mbit/s DSL participants

Source: Analysis by Prof Andrew Chesher, based on data supplied by Ofcom and SamKnows

Having selected ‘as the crow flies’ distance as the best available measure for normalising by distance from exchange for DSL participants, we applied the following methodology.

- The whole sample data (all participants, all packages), distribution of ‘as the crow flies’ distance to exchange, was estimated as a Gamma Distribution, excluding outliers with distances over 7000m, and parameter estimates were obtained: 2.223, 0.001. (See Figure 4.)
Figure 4  Plot of quantiles of sampled values of distance (horizontal) and fitted quantiles using a method of moments estimate of a gamma distribution.

Source: Analysis by Prof Andrew Chesher, based on data supplied by Ofcom and SamKnows

- All participants with a distance of over 5000m were excluded (as the relationship between attenuation and ‘as the crow flies’ distance gets weaker with distance).

- A weight adjustment was made to the contribution to the average speed, made by each respondent based on their ‘as the crow flies’ distance from the exchange, by matching the percentage observed in distance bands, to the percentage in the distribution of the total sample population.

The adjustment was determined in the following manner:

- For each ISP or category the observed crows flies distance distribution was divided up into bands containing equal numbers of participants using percentiles of the observed distance distribution. The distributions were divided into bands that contained at least 10 participants. For example, with 100 participants in our category to be normalised, the bands divided the distribution into deciles.

- Weights specific to each set of respondents, in a given band, were obtained as follows: the proportions (a) of all respondents falling in each of observed relevant percentile bands was compared to (b) those of the Gamma distribution fitted to data on all respondents. The ratio of the proportions b÷a was used as a weight for all respondents in that observed percentile band.

- A weighted average sum of the ISP or other category speed measurements, across all bands, was calculated using the band specific weight proportions.
The observed distribution of distances between ISPs, LLU and technology were consistent with sample population estimates with the exception of DSL packages of ‘up to’ 16Mbit/s and more. The weights required to adjust the numbers observed in the distance percentile band ranges were conservative in the ranges shown in Figure 5 below.

**Figure 5  Range of normalisation weights**

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-net/ISP</td>
<td>0.59</td>
<td>2.15</td>
</tr>
<tr>
<td>Off-net/ISP</td>
<td>0.63</td>
<td>1.80</td>
</tr>
<tr>
<td>LLU</td>
<td>0.58</td>
<td>1.93</td>
</tr>
<tr>
<td>Non-LLU</td>
<td>0.61</td>
<td>1.55</td>
</tr>
<tr>
<td>Technology</td>
<td>0.22</td>
<td>1.92</td>
</tr>
</tbody>
</table>

*Source: Ofcom*

Note that it was, of course, not appropriate to normalise cable services by distance from exchange as cable does not degrade over the length of the line. Cable participants were instead weighted by rural/urban and by region in order to ensure that they are compared on a like-for-like basis with DSL services which have nationwide availability. ADSL2+ participants at ‘up to’ 16Mbit/s were also weighted by rural/urban and region (normalising by distance was not appropriate for these high-speed DSL services as many operators do not offer these packages to consumers whose line length means that they would not be able to receive speeds in excess of 8Mbit/s.

The impact of the normalisation by ‘as the crow flies’ distance is small as there are few marked differences in the underlying distribution of crow flies distance (see Figure 6).

**Figure 6  Estimated probability function of distance by ISP**

*Source: Analysis by Prof Andrew Chesher, based on data supplied by Ofcom and SamKnows*
Figures 7 to 10 illustrate the impact that this normalisation and weighting has on the ISP data. It is notable that overall comparative performance is consistent when the data are weighted or not weighted/normalised.

**Figure 7** Comparison of average speeds by ISP, 24 hours, April 2009

Download throughput speed (Mbit/s)

Source: SamKnows measurement data for all panel members with a connection in April 2009
Notes: (1) Weighted data for DSL operators has been normalised by ‘as the crow flies’ distance from exchange and for Virgin Media by rural/urban and by region; (2) data combines both on-net and off-net customers; (3) The range shown represents a 95% confidence interval around the mean; (4) *Caution: small sample size (<50)

**Figure 8** Significant differences between average speeds for ISPs, April 2009

<table>
<thead>
<tr>
<th>Significant differences in normalised/weighted data</th>
<th>Significant differences in unnormalised/unweighted data</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOL</td>
<td>BT</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>AOL</td>
<td>LOWER</td>
</tr>
<tr>
<td>BT</td>
<td>LOWER</td>
</tr>
<tr>
<td>O2</td>
<td>HIGHER</td>
</tr>
<tr>
<td>Orange*</td>
<td>HIGHER</td>
</tr>
<tr>
<td>Plusnet</td>
<td>HIGHER</td>
</tr>
<tr>
<td>Sky</td>
<td>HIGHER</td>
</tr>
<tr>
<td>TalkTalk</td>
<td>HIGHER</td>
</tr>
<tr>
<td>Tiscali</td>
<td>LOWER</td>
</tr>
<tr>
<td>Other*</td>
<td>LOWER</td>
</tr>
<tr>
<td>Virgin</td>
<td>HIGHER</td>
</tr>
</tbody>
</table>

Source: Ofcom
*Caution: small sample size (<50)
Note: The tables describe the differences in speeds between the ISPs in the vertical axis, with those in the horizontal axis. For example, the top row of the normalised/weighted data, the speeds delivered by AOL Broadband are significantly lower to a 99% level of confidence than those delivered by O2, Sky and Virgin, and are significantly lower to a 95% level of confidence than those delivered by Orange and Plusnet.
Figure 9  Comparison of average speeds by ISP in the peak period, 8pm-10pm, April 2009

Source: SamKnows measurement data for all panel members with a connection in April 2009
*Caution: small sample size (<50)
Notes: (1) Weighted data for DSL operators has been normalised by 'as the crow flies' distance from exchange and for Virgin Media by rural/urban and by region; (2) data combines both on-net and off-net customers; (3) The range shown represents a 95% confidence interval around the mean; (4)

Figure 10  Significant differences between average speeds for ISPs, April 2009

Source: Ofcom
*Caution: small sample size (<50)
Note: The tables describe the differences in speeds between the ISPs in the vertical axis, with those in the horizontal axis. For example, the top row of the normalised/weighted data, the speeds delivered by AOL Broadband are significantly lower to a 99% level of confidence than those delivered by O2, Sky and Virgin, and are significantly lower to a 95% level of confidence than those delivered by Orange and Plusnet.
On net and off Net (LLU and non-LLU)

Operators who offer services via local loop unbundling (LLU) also provide services to customers who are connected to a local exchange which has not been unbundled (delivered via wholesale services provided by BT Wholesale or other wholesale suppliers). Our data finds that there are some significant differences in the speeds delivered by operators to on-net (LLU) customers and off-net customers (non-LLU, receiving services delivered by wholesale line rental).

Therefore, in order to provide like-for-like comparison it was necessary to identify which participants were receiving on-net (LLU) services and which were receiving off-net (non-LLU services). This enabled us to offer comparisons between on-net services, and also to weight overall performance by adjusting results according to the nationwide on-net/off-net split for each ISP (ISPs provided this data to us). In order to do this we used a list provided by BT Openreach to identify whether the relevant exchange was one where local loop unbundling (LLU) had been implemented by the participant’s ISP. If so, the participant was assigned as an on-net customer; if not, the participant was assigned as an off-net customer.

For each of the ISPs the individual On Net, and Off Net categories were separately normalised by the method outlined above, and a weighted sum combined in proportion to the on-net and off net splits provided by ISPs.
Annex 4

Additional data

Overview

The main research report focuses on data from April 2009 as the most recent month for which data were available. In this Annex we provide month-on-month data for the full six months of data collection.

This data are provided in three separate sections:

1. Overall download speed data. We provide comparative month-on-month data detailing average overall speeds and average speeds in the peak period of 8-10pm. for the performance of ADSL1, ADSL2 and cable services for headline speeds where we had a large enough sample size throughout the six months of data collection to provide meaningful data. This data have not been weighted or normalised, so data for April 2009 is not directly comparable with that published in the main report.

2. ISP data. We provide comparative month-on-month data for the seven ISPs for which we had a large enough sample size throughout the six months of data collection to provide meaningful data. In order to provide consistency and ensure that changes in performance are not the consequences of changes in the composition of the panel, we only use the data from panellists who were connected in every month of the trial. We have also excluded customers who changed ISP or package during the trial (this means, for example, that a number of Virgin cable panellists who were upgraded from 2Mbit/s or 4Mbit/s services to 10Mbit/s services are excluded). In addition, unlike the data in the main report, this data have not been weighted or normalised. This is because sample size issues for some ISPs were not sufficient to allow weighting in some months, and because the objective of providing this data are not to enable comparisons between ISPs, but rather to present change over time for each ISP. Therefore the data for April 2009 is not directly comparable with the data for April 2009 which is published in the main report.

3. Non-speed metrics. We provide month-on-month data for the other metrics we have collected data from: upload speeds, time to load web pages, latency, packet loss, DNS resolution time, DNS failure rate and jitter. We report by headline speed and by DSL/cable. This data differs from the download speeds data in that it includes all panellists who have provided five or more tests in any one month.

1. Overall download speed data

Figures 1 and 2 details the average download throughput speeds delivered to all panellists between November 2008 and April 2009 (DSL and cable packages at all headline speeds) , while Figure 2 looks at the average speeds delivered to panellists on ‘up to’ 8Mbit/s DSL services.

Two indicators are provided for each month: the average speed delivered across the full 24 hours of each day in the month, and the average speeds delivered during the peak evening period of 8-10pm (the hours when there is peak traffic and therefore peak contention
resulting in slower speeds being delivered). We show the range of performance as 95% confidence intervals.

There is general consistency throughout the duration of data collection. It is notable that average speeds in the peak period of 8pm to 10pm were faster in December than in other months, and again in April. This may be the consequence of different traffic profiles in the Christmas and Easter holiday periods.

**Figure 1** Average download throughput speeds for all panellists, November 2008 to April 2009

![Download throughput speed (Mbit/s)](chart1.png)

Source: SamKnows measurement data for all panel members with a connection in all six months, November 2008 to April 2009

**Figure 2** Average download throughput speeds for panellists on ‘up to’ 8Mbit/s DSL services

![Download throughput speed (Mbit/s)](chart2.png)

Source: SamKnows measurement data for all panel members with a connection in all six months, November 2008 to April 2009
2. ISP data

Figures 3 to 9 detail average download throughput speeds delivered to panellists between November 2008 and April 2009 for the ISPs for whom we had statistically robust sample sizes for the six-month duration of the research.

Two indicators are provided for each month: the average speed delivered across the full 24 hours of each day in the month, and the average speeds delivered during the peak evening period of 8-10pm (the hours when there is peak traffic and therefore peak contention resulting in slower speeds being delivered)

The indicators show the range of performance to a 95% confidence interval (the sample size for each ISP and the variation of performance among panellists with the same ISP combine to determine the statistical confidence we have in the results of our analysis – a 95% level of confidence means that the range shown contains the true value 95% of the time.

It is clear from this data that there is general consistency of performance among each ISP across the six-month period. Consistent with the overall data, a number of ISPs show slightly faster speeds in the peak periods during December and April, which may be explained by a different traffic profile during the Christmas and Easter holiday periods.

Figure 3  

AOL Broadband ‘up to’ 8Mbit/s service: average download throughput speeds, November 2008 to April 2009

Source: SamKnows measurement data for all panel members with a connection in all six months, November 2008 to April 2009
Figure 4  BT ‘up to’ 8Mbit/s service: average download throughput speeds, November 2008 to April 2009

Source: SamKnows measurement data for all panel members with a connection in all six months, November 2008 to April 2009

Figure 5  Orange ‘up to’ 8Mbit/s service: average download throughput speeds, November 2008 to April 2009

Source: SamKnows measurement data for all panel members with a connection in all six months, November 2008 to April 2009
Figure 6  Sky ‘up to’ 8Mbit/s service: average download throughput speeds, November 2008 to April 2009

Source: SamKnows measurement data for all panel members with a connection in all six months, November 2008 to April 2009

Figure 7  TalkTalk ‘up to’ 8Mbit/s service: average download throughput speeds, November 2008 to April 2009

Source: SamKnows measurement data for all panel members with a connection in all six months, November 2008 to April 2009
3. Non-speed metrics

Figures 10 to 16 detail average performance (throughout the full 24 hours of every day in every month) for metrics other than download speeds, by access technology (DSL or cable) and headline speed.

There is general consistency throughout the duration of data collection across all metrics.
Figure 10  Average upload speeds, November 2008 to April 2009

Source: SamKnows measurement data for all panel members with a connection in any month

Figure 11  Time to load web pages, November 2008 to April 2009

Source: SamKnows measurement data for all panel members with a connection in any month

Figure 12  Latency, November 2008 to April 2009

Source: SamKnows measurement data for all panel members with a connection in any month
Figure 13  Packet loss, November 2008 to April 2009

Source: SamKnows measurement data for all panel members with a connection in any month

Figure 14  DNS resolution time, November 2008 to April 2009

Source: SamKnows measurement data for all panel members with a connection in any month

Figure 15  DNS failure rate, November 2008 to April 2009

Source: SamKnows measurement data for all panel members with a connection in any month
Figure 16  Jitter, November 2008 to April 2009

Source: SamKnows measurement data for all panel members with a connection in any month
Annex 5

Significance testing

1. Overview

The main research report includes significance testing of the performance of different access technologies and different ISPs to a 95% level of confidence. In this annex we also provide differences to a 99% level of confidence (i.e. differences are detailed when they pass a 1% confidence test).
2. Significant differences between access technologies by headline speed

Figure 1 Significant differences to a 95% level of confidence between average download speeds by technology and headline package, over 24 hours

<table>
<thead>
<tr>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADSL 'up to' 2Mbit/s</td>
<td>Cable up to 2Mbit/s, ADSL1 up to 8Mbit/s, ADSL2+ up to 8Mbit/s, Cable up to 10 Mbit/s, ADSL2+ up to 16Mbit/s and more, Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>Cable 'up to' 2Mbit/s</td>
<td>ADSL1 up to 8Mbit/s, ADSL2+ up to 8Mbit/s, Cable up to 10Mbit/s, ADSL2+ up to 16Mbit/s and more, Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>ADSL1 'up to' 8Mbit/s</td>
<td>ADSL2+ up to 8Mbit/s, Cable up to 10Mbit/s, ADSL2+ up to 16Mbit/s and more, Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>ADSL2+ 'up to' 8Mbit/s</td>
<td>Cable up to 10Mbit/s, ADSL2+ up to 16Mbit/s and more, Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>Cable 'up to' 10Mbit/s</td>
<td>Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>ADSL2+ 'up to' 16Mbit/s and more*</td>
<td>Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>Cable 'up to' 20Mbit/s*</td>
<td>ADSL up to 2Mbit/s, Cable up to 2Mbit/s, ADSL1 up to 8Mbit/s, ADSL2+ up to 8Mbit/s, Cable up to 10Mbit/s, ADSL2+ up to 16Mbit/s and more, Cable up to 20Mbit/s</td>
</tr>
</tbody>
</table>

Source: Ofcom
*Caution: small sample size (<50)

Figure 2 Significant differences to a 99% level of confidence between average download speeds by technology and headline package, over 24 hours

<table>
<thead>
<tr>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADSL 'up to' 2Mbit/s</td>
<td>Cable up to 2Mbit/s, ADSL1 up to 8Mbit/s, ADSL2+ up to 8Mbit/s, Cable up to 10 Mbit/s, ADSL2+ up to 16Mbit/s and more, Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>Cable 'up to' 2Mbit/s</td>
<td>ADSL1 up to 8Mbit/s, ADSL2+ up to 8Mbit/s, Cable up to 10Mbit/s, ADSL2+ up to 16Mbit/s and more, Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>ADSL1 'up to' 8Mbit/s</td>
<td>Cable up to 10 Mbit/s, ADSL2+ up to 16Mbit/s and more, Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>ADSL2+ 'up to' 8Mbit/s</td>
<td>Cable up to 10Mbit/s, ADSL2+ up to 16Mbit/s and more, Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>Cable 'up to' 10Mbit/s</td>
<td>Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>ADSL2+ 'up to' 16Mbit/s and more*</td>
<td>Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>Cable 'up to' 20Mbit/s*</td>
<td>ADSL up to 2Mbit/s, Cable up to 2Mbit/s, ADSL1 up to 8Mbit/s, ADSL2+ up to 8Mbit/s, Cable up to 10Mbit/s, ADSL2+ up to 16Mbit/s and more, Cable up to 20Mbit/s</td>
</tr>
</tbody>
</table>

Source: Ofcom
*Caution: small sample size (<50)
Figure 3  Significant differences to a 95% level of confidence between average download speeds by technology and headline package, 8-10pm

<table>
<thead>
<tr>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADSL 'up to' 2Mbit/s</td>
<td>Cable up to 2Mbit/s, ADSL1 up to 8Mbit/s, ADSL2+ up to 8Mbit/s, ADSL1 up to 10Mbit/s, ADSL2+ up to 16Mbit/s and more, Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>Cable ‘up to’ 2Mbit/s</td>
<td>ADSL1 up to 8Mbit/s, ADSL2+ up to 8Mbit/s, Cable up to 10Mbit/s, ADSL2+ up to 16Mbit/s and more, Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>ADSL1 ‘up to’ 8Mbit/s</td>
<td>ADSL2+ up to 8Mbit/s, Cable up to 10Mbit/s, ADSL2+ up to 16Mbit/s and more, Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>ADSL2+ ‘up to’ 8Mbit/s</td>
<td>Cable up to 10Mbit/s, ADSL2+ up to 16Mbit/s and more, Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>Cable ‘up to’ 10Mbit/s</td>
<td>ADSL2+ up to 16Mbit/s and more</td>
</tr>
<tr>
<td>ADSL2+ ‘up to’ 16Mbit/s and more</td>
<td>Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>Cable ‘up to’ 20Mbit/s</td>
<td>ADSL2+ up to 16Mbit/s and more</td>
</tr>
</tbody>
</table>

Source: Ofcom
*Caution: small sample size (<50)

Figure 4  Significant differences to a 99% level of confidence between average download speeds by technology and headline package, 8-10pm

<table>
<thead>
<tr>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADSL ‘up to’ 2Mbit/s</td>
<td>Cable up to 2Mbit/s, ADSL1 up to 8Mbit/s, ADSL2+ up to 8Mbit/s, ADSL2+ up to 16Mbit/s and more, Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>Cable ‘up to’ 2Mbit/s</td>
<td>ADSL1 up to 8Mbit/s, ADSL2+ up to 8Mbit/s, Cable up to 10Mbit/s, ADSL2+ up to 16Mbit/s and more, Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>ADSL1 ‘up to’ 8Mbit/s</td>
<td>ADSL2+ up to 8Mbit/s, Cable up to 10Mbit/s, ADSL2+ up to 16Mbit/s and more, Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>ADSL2+ ‘up to’ 8Mbit/s</td>
<td>Cable up to 10Mbit/s, ADSL2+ up to 16Mbit/s and more, Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>Cable ‘up to’ 10Mbit/s</td>
<td>ADSL2+ up to 16Mbit/s and more</td>
</tr>
<tr>
<td>ADSL2+ ‘up to’ 16Mbit/s and more</td>
<td>Cable up to 20Mbit/s</td>
</tr>
<tr>
<td>Cable ‘up to’ 20Mbit/s</td>
<td>ADSL2+ up to 16Mbit/s and more</td>
</tr>
</tbody>
</table>

Source: Ofcom
*Caution: small sample size (<50)
3. Significant differences between ISPs

Figure 5  Significant differences to a 95% level of confidence between average speeds on 'up to' 8Mbit/s or 'up to' 10Mbit/s packages, 24 hours, April 2009

<table>
<thead>
<tr>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOL 'up to' 8Mbit/s</td>
<td>O2, Orange, Plusnet, TalkTalk, Virgin Media</td>
</tr>
<tr>
<td>BT 'up to' 8Mbit/s</td>
<td>O2, Virgin Media</td>
</tr>
<tr>
<td>O2 'up to' 8Mbit/s*</td>
<td>Virgin Media, AOL, BT, TalkTalk</td>
</tr>
<tr>
<td>Orange 'up to' 8Mbit/s</td>
<td>Virgin Media, AOL, TalkTalk</td>
</tr>
<tr>
<td>Plusnet 'up to' 8Mbit/s*</td>
<td>Virgin Media, AOL, TalkTalk</td>
</tr>
<tr>
<td>Sky 'up to' 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>TalkTalk 'up to' 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Tiscali 'up to' 8Mbit/s</td>
<td>BT, O2, Orange, Plusnet, TalkTalk, Virgin Media</td>
</tr>
<tr>
<td>Virgin Media 'up to' 10Mbit/s</td>
<td>AOL, BT, O2, Orange, Plusnet, TalkTalk, TalkTalk, Virgin Media</td>
</tr>
<tr>
<td>Other 'up to' 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
</tbody>
</table>

Source: Ofcom  
*Caution: small sample size (<50)

Figure 6  Significant differences to a 99% level of confidence between average speeds on 'up to' 8Mbit/s or 'up to' 10Mbit/s packages, 24 hours, April 2009

<table>
<thead>
<tr>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOL 'up to' 8Mbit/s</td>
<td>O2, Sky, Virgin Media</td>
</tr>
<tr>
<td>BT 'up to' 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>O2 'up to' 8Mbit/s*</td>
<td>Virgin Media, AOL, TalkTalk</td>
</tr>
<tr>
<td>Orange 'up to' 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Plusnet 'up to' 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Sky 'up to' 8Mbit/s</td>
<td>Virgin Media, AOL, TalkTalk</td>
</tr>
<tr>
<td>TalkTalk 'up to' 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Tiscali 'up to' 8Mbit/s</td>
<td>BT, O2, Orange, Plusnet, TalkTalk, Virgin Media</td>
</tr>
<tr>
<td>Virgin Media 'up to' 10Mbit/s</td>
<td>AOL, BT, O2, Orange, Plusnet, TalkTalk, TalkTalk, Virgin Media</td>
</tr>
<tr>
<td>Other 'up to' 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
</tbody>
</table>

Source: Ofcom  
*Caution: small sample size (<50)
Figure 7  Significant differences to a 95% level of confidence between average speeds on ‘up to’ 8Mbit/s or ‘up to’ 10Mbit/s packages, 8-10pm, April 2009

<table>
<thead>
<tr>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOL 'up to' 8Mbit/s</td>
<td>O2, Orange, Plusnet, Sky, TalkTalk, Virgin Media, Other</td>
</tr>
<tr>
<td>BT 'up to' 8Mbit/s</td>
<td>O2, Orange, Plusnet, Sky, TalkTalk, Virgin Media</td>
</tr>
<tr>
<td>O2 'up to' 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Orange 'up to' 8Mbit/s</td>
<td>O2, Virgin Media</td>
</tr>
<tr>
<td>Plusnet 'up to' 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Sky 'up to' 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>TalkTalk 'up to' 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Tiscali 'up to' 8Mbit/s</td>
<td>BT, O2, Orange, Plusnet, Sky, TalkTalk, Virgin Media, Other</td>
</tr>
<tr>
<td>Virgin Media 'up to' 10Mbit/s</td>
<td>AOL, BT, O2, Orange, Plusnet, Sky, TalkTalk, Tiscali, Other</td>
</tr>
<tr>
<td>Other 'up to' 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
</tbody>
</table>

Source: Ofcom
*Caution: small sample size (<50)

Figure 8  Significant differences to a 99% level of confidence between average speeds on ‘up to’ 8Mbit/s or ‘up to’ 10Mbit/s packages, 8-10pm, April 2009

<table>
<thead>
<tr>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOL 'up to' 8Mbit/s</td>
<td>O2, Orange, Plusnet, Sky, TalkTalk, Virgin Media</td>
</tr>
<tr>
<td>BT 'up to' 8Mbit/s</td>
<td>O2, Plusnet, Sky, TalkTalk, Virgin Media</td>
</tr>
<tr>
<td>O2 'up to' 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Orange 'up to' 8Mbit/s</td>
<td>O2, Virgin Media</td>
</tr>
<tr>
<td>Plusnet 'up to' 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Sky 'up to' 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>TalkTalk 'up to' 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Tiscali 'up to' 8Mbit/s</td>
<td>BT, O2, Orange, Plusnet, Sky, TalkTalk, Virgin Media</td>
</tr>
<tr>
<td>Virgin Media 'up to' 10Mbit/s</td>
<td>AOL, BT, O2, Orange, Plusnet, Sky, TalkTalk, Tiscali, Other</td>
</tr>
<tr>
<td>Other 'up to' 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
</tbody>
</table>

Source: Ofcom
*Caution: small sample size (<50)
**Figure 9** Significant differences to a 95% level of confidence between average speeds on ‘up to’ 8Mbit/s or ‘up to’ 10Mbit/s packages, 3-11pm, April 2009

<table>
<thead>
<tr>
<th></th>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOL ‘up to’ 8Mbit/s</td>
<td>O2, Orange, Plusnet, Sky, TalkTalk, Virgin Media</td>
<td></td>
</tr>
<tr>
<td>BT ‘up to’ 8Mbit/s</td>
<td>O2, Orange, Plusnet, Sky, TalkTalk, Virgin Media</td>
<td>Tiscali</td>
</tr>
<tr>
<td>O2 ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
<td>AOL, BT, Orange, Tiscali</td>
</tr>
<tr>
<td>Orange ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
<td>AOL, BT, Tiscali</td>
</tr>
<tr>
<td>Plusnet ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
<td>AOL, BT, Tiscali</td>
</tr>
<tr>
<td>Sky ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
<td>AOL, BT, Tiscali</td>
</tr>
<tr>
<td>TalkTalk ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
<td>AOL, BT, Tiscali</td>
</tr>
<tr>
<td>Tiscali ‘up to’ 8Mbit/s</td>
<td>BT, O2, Orange, Plusnet, Sky, TalkTalk, Virgin Media</td>
<td></td>
</tr>
<tr>
<td>Virgin Media ‘up to’ 10Mbit/s</td>
<td>ARL, BT, O2, Orange, Plusnet, Sky, TalkTalk, Tiscali, Other</td>
<td></td>
</tr>
<tr>
<td>Other ‘up to’ 8Mbit/s*</td>
<td>Virgin Media</td>
<td>Tiscali</td>
</tr>
</tbody>
</table>

*Source: Ofcom
*Caution: small sample size (<50)*

**Figure 10** Significant differences to a 99% level of confidence between average speeds on ‘up to’ 8Mbit/s or ‘up to’ 10Mbit/s packages, 3-11pm, April 2009

<table>
<thead>
<tr>
<th></th>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOL ‘up to’ 8Mbit/s</td>
<td>O2, Orange, Plusnet, Sky, TalkTalk, Virgin Media</td>
<td></td>
</tr>
<tr>
<td>BT ‘up to’ 8Mbit/s</td>
<td>O2, Sky, Virgin Media</td>
<td>Tiscali</td>
</tr>
<tr>
<td>O2 ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
<td>AOL, BT, Tiscali</td>
</tr>
<tr>
<td>Orange ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
<td>AOL, Tiscali</td>
</tr>
<tr>
<td>Plusnet ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
<td>AOL, Tiscali</td>
</tr>
<tr>
<td>Sky ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
<td>AOL, BT, Tiscali</td>
</tr>
<tr>
<td>TalkTalk ‘up to’ 8Mbit/s</td>
<td>Virgin Media</td>
<td>AOL, BT, Tiscali</td>
</tr>
<tr>
<td>Tiscali ‘up to’ 8Mbit/s</td>
<td>BT, O2, Orange, Plusnet, Sky, TalkTalk, Virgin Media</td>
<td></td>
</tr>
<tr>
<td>Virgin Media ‘up to’ 10Mbit/s</td>
<td>ARL, BT, O2, Orange, Plusnet, Sky, TalkTalk, Tiscali, Other</td>
<td></td>
</tr>
<tr>
<td>Other ‘up to’ 8Mbit/s*</td>
<td>Virgin Media</td>
<td>Tiscali</td>
</tr>
</tbody>
</table>

*Source: Ofcom
*Caution: small sample size (<50)*
**Figure 11** Significant differences to a 95% level of confidence between average speeds on ‘up to’ 8Mbit/s or ‘up to’ 10Mbit/s packages, 9am-5pm Monday-Friday, April 2009

<table>
<thead>
<tr>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOL 'up to' 8Mbit/s</td>
<td>O2, Orange, Plusnet, Sky, Virgin Media</td>
</tr>
<tr>
<td>BT 'up to' 8Mbit/s</td>
<td>O2, Virgin Media</td>
</tr>
<tr>
<td>O2 'up to' 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Orange 'up to' 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Plusnet 'up to' 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Sky 'up to' 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>TalkTalk 'up to' 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Tiscali 'up to' 8Mbit/s</td>
<td>O2, Orange, Plusnet, Sky, Virgin Media</td>
</tr>
<tr>
<td>Virgin Media 'up to' 10Mbit/s</td>
<td>ALO, BT, O2, Orange, Plusnet, Sky, TalkTalk, Tiscali, Other</td>
</tr>
<tr>
<td>Other 'up to' 8Mbit/s*</td>
<td>O2, Virgin Media</td>
</tr>
</tbody>
</table>

*Source: Ofcom
*Caution: small sample size (<50)*

**Figure 12** Significant differences to a 99% level of confidence between average speeds on ‘up to’ 8Mbit/s or ‘up to’ 10Mbit/s packages, 9am-5pm Monday-Friday, April 2009

<table>
<thead>
<tr>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOL 'up to' 8Mbit/s</td>
<td>O2, Sky, Virgin Media</td>
</tr>
<tr>
<td>BT 'up to' 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>O2 'up to' 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Orange 'up to' 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Plusnet 'up to' 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Sky 'up to' 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>TalkTalk 'up to' 8Mbit/s</td>
<td>Virgin Media</td>
</tr>
<tr>
<td>Tiscali 'up to' 8Mbit/s</td>
<td>O2, Sky, Virgin Media</td>
</tr>
<tr>
<td>Virgin Media 'up to' 10Mbit/s</td>
<td>ALO, BT, O2, Orange, Plusnet, Sky, TalkTalk, Tiscali, Other</td>
</tr>
<tr>
<td>Other 'up to' 8Mbit/s*</td>
<td>Virgin Media</td>
</tr>
</tbody>
</table>

*Source: Ofcom
*Caution: small sample size (<50)*
**Figure 13** Significant differences to a 95% level of confidence between average speeds for LLU customers on ‘up to’ 8Mbit/s packages, 24 hours, April 2009

<table>
<thead>
<tr>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOL ‘up to’ 8Mbit/s*</td>
<td>O2, Orange, Sky, TalkTalk</td>
</tr>
<tr>
<td>O2 ‘up to’ 8Mbit/s*</td>
<td>AOL, TalkTalk, Tiscali</td>
</tr>
<tr>
<td>Orange ‘up to’ 8Mbit/s*</td>
<td>AOL</td>
</tr>
<tr>
<td>Sky ‘up to’ 8Mbit/s*</td>
<td>AOL</td>
</tr>
<tr>
<td>TalkTalk ‘up to’ 8Mbit/s*</td>
<td>O2</td>
</tr>
<tr>
<td>Tiscali ‘up to’ 8Mbit/s*</td>
<td>O2</td>
</tr>
</tbody>
</table>

*Source: Ofcom

*Caution: small sample size (<50)*

**Figure 14** Significant differences to a 99% level of confidence between average speeds for LLU customers on ‘up to’ 8Mbit/s packages, 24 hours, April 2009

<table>
<thead>
<tr>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOL ‘up to’ 8Mbit/s*</td>
<td>O2, Orange, Sky, TalkTalk</td>
</tr>
<tr>
<td>O2 ‘up to’ 8Mbit/s*</td>
<td>AOL, Tiscali</td>
</tr>
<tr>
<td>Orange ‘up to’ 8Mbit/s*</td>
<td>AOL</td>
</tr>
<tr>
<td>Sky ‘up to’ 8Mbit/s*</td>
<td>AOL</td>
</tr>
<tr>
<td>TalkTalk ‘up to’ 8Mbit/s*</td>
<td>O2</td>
</tr>
<tr>
<td>Tiscali ‘up to’ 8Mbit/s*</td>
<td>O2</td>
</tr>
</tbody>
</table>

*Source: Ofcom

*Caution: small sample size (<50)*

**Figure 15** Significant differences to a 95% level of confidence between average speeds for LLU customers on ‘up to’ 8Mbit/s packages, 8-10pm, April 2009

<table>
<thead>
<tr>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOL ‘up to’ 8Mbit/s*</td>
<td>O2, Orange, Sky, TalkTalk</td>
</tr>
<tr>
<td>O2 ‘up to’ 8Mbit/s*</td>
<td>AOL, TalkTalk, Tiscali</td>
</tr>
<tr>
<td>Orange ‘up to’ 8Mbit/s*</td>
<td>AOL</td>
</tr>
<tr>
<td>Sky ‘up to’ 8Mbit/s*</td>
<td>AOL</td>
</tr>
<tr>
<td>TalkTalk ‘up to’ 8Mbit/s*</td>
<td>O2</td>
</tr>
<tr>
<td>Tiscali ‘up to’ 8Mbit/s*</td>
<td>O2, Orange, Sky</td>
</tr>
</tbody>
</table>

*Source: Ofcom

*Caution: small sample size (<50)*
Figure 16  Significant differences to a 99% level of confidence between average speeds for LLU customers on ‘up to’ 8Mbit/s packages, 8-10pm, April 2009

<table>
<thead>
<tr>
<th>... is slower than...</th>
<th>... is faster than...</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOL ‘up to’ 8Mbit/s*</td>
<td>O2, Orange, Sky, TalkTalk</td>
</tr>
<tr>
<td>O2 ‘up to’ 8Mbit/s*</td>
<td>AOL, Tiscali</td>
</tr>
<tr>
<td>Orange ‘up to’ 8Mbit/s*</td>
<td>AOL</td>
</tr>
<tr>
<td>Sky ‘up to’ 8Mbit/s</td>
<td>AOL, Tiscali</td>
</tr>
<tr>
<td>TalkTalk ‘up to’ 8Mbit/s</td>
<td>AOL</td>
</tr>
<tr>
<td>Tiscali ‘up to’ 8Mbit/s</td>
<td>O2, Sky</td>
</tr>
</tbody>
</table>

Source: Ofcom
*Caution: small sample size (<50)
Annex 6

GfK full research report

See:

Gfk NOP, *UK Broadband Speeds – Full Report*