Infrastructure Report

2013 Update

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Section 1

Summary

1.1 This report provides a snapshot of the state of the UK communications infrastructure. This is our third annual report and, as in previous years, it focuses on the coverage and capacity of the networks which are used by the large majority of UK consumers.

1.2 There is currently a significant level of public debate about the importance of investment in communications infrastructure. This debate is taking place across Europe[1], as well as being a key policy issue for the UK Government[2] and for individual nations and local authorities[3]. The information we publish in this Infrastructure Report is intended to provide an objective evidence base for both the development of public policy, and individual consumer choice.

1.3 As highlighted in our Communications Market Report[4], consumers are demanding more from communications networks. They are connecting more devices and using more services than ever before and are increasingly multitasking – using multiple devices and multiple services at the same time. The boundaries between broadcast and broadband networks are also blurring as connected TVs and set top boxes allow consumers seamlessly to switch between services delivered on different networks.

1.4 This Infrastructure Report considers the implications of these shifts in consumer behaviour for the networks which underpin the provision of all communications services. We look at the ability of existing networks to support current demand, and consider how this is likely to evolve over time.

1.5 The UK is currently in a phase of significant investment in new networks and technologies. Over the last year notable infrastructure developments have included:

- strong growth in availability and take-up of superfast broadband;
- the initial deployment of new 4G mobile broadband networks;
- significant increase in availability and use of public Wi-Fi hotspots; and
- preparation for the launch of new HD and local TV services on terrestrial TV.

1.6 Most of these developments have been driven by private sector investment. However, the business case for building communications networks in some of the more rural parts of the UK can be challenging. In recognition of this, Government has intervened to substantially extend the reach of superfast broadband, and Ofcom has

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[1] For example, the European Commission has recently set out its proposals to build a 'Connected Continent' http://ec.europa.eu/digital-agenda/en/connected-continent-single-telecom-market-growth-jobs
[2] For example, the UK government recently announced its intention to develop a Digital Communications Infrastructure Strategy https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/225783/Connectivity_Content_and_Consumers_2013.pdf
[3] For example, the Scottish Government recently published a study on the quality of mobile coverage in Scotland http://www.scotland.gov.uk/Publications/2013/09/6141/downloads
[4] http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr13/

included a demanding coverage obligation in one of the 4G spectrum licenses. As a result, we expect there to be near universal availability to UK households of next generation fixed and mobile services. The precise date is difficult to predict at this stage, but we expect it to be significantly before the target date of 2020 which has been set by the European Commission, with many of the most rural households seeing improved availability between 2015 and 2017.

1.7 There are some continuing concerns about the availability of services, for a small number of households, and on parts of the UK's road and rail networks. Some targeted interventions are already in place to address these concerns, but we will be carrying out further analysis to consider whether these are likely to be sufficient.

1.8 As the availability of next generation data services improves, there will be an increased focus on quality of service and the resulting consumer experience. We will therefore also be undertaking further work to explore how the quality of experience on fixed and mobile networks can be measured and the extent to which it varies between operators and in different parts of the UK.

Fixed broadband networks

1.9 The availability and take up of superfast broadband (SFBB) is of particular interest. SFBB networks support download speeds of at least 30Mbit/s[5]. They typically use fibre optic cables to deliver very high bandwidths to street cabinets or, in some cases, directly to the customer's home.

1.10 The data provided for this report shows that SFBB networks are now available to 73% of UK premises, up from 65% in 2012. This is mainly due to BT's 'Fibre To The Cabinet' (FTTC) network, which in June 2013 passed 57% of premises, and Virgin Media's cable network, which offers superfast broadband services to 48% of premises.

1.11 In addition to the SFBB networks provided by BT and Virgin Media, whose networks account for over 98% of all SFBB homes passed, a number of other smaller providers are building and operating SFBB networks, including KCom in the Hull area, WightFibre on the Isle of Wight, Small World Cable in North West England and Western Scotland and a number of commercial schemes in new housing developments and community projects in rural areas.

1.12 The commercial roll out of SFBB networks has focussed on areas of higher population density, where network build costs per household are lower. Extending SFBB coverage into the last third of the country is commercially challenging, but additional public funding has been made available.

- The Government has made funding of £530m available, to be supplemented with additional funding from local authorities and devolved administrations, with the aim of achieving SFBB coverage of at least 90% which it expects to reach in 2016. The programme is being coordinated by Broadband Delivery UK, and by the end of September, 42 of the Local Authority-led procurement contracts covered by the main scheme had been signed, with only two remaining to be finalised.

[5] Ofcom and the European Union define SFBB services as those delivering download speeds of 30Mbit/s or more. DCMS defined SFBB as more than 24Mbit/s (24Mbit/s being the maximum speed of ADSL technology).

- Additional funding of £250m has been allocated by Government, to be matched by local authorities, to extend coverage from 90% to 95% by 2017.

- Government is currently exploring options with industry as to how coverage could be extended to up to 99%.

1.13 The Government's targets for superfast broadband availability are broadly consistent with a target set by the European Commission as part of its 'Digital Agenda'. The Commission's target is that all homes should have access to superfast broadband by 2020.

1.14 As availability of SFBB increases, we are also now starting to see significant growth in take-up. As of June 2013, 22% of broadband connections were superfast, compared to 10% in 2012. Take-up until now has been driven mainly by the retail provision of services from BT and Virgin Media, but other major retailers have now also started marketing their SFBB services more actively.

1.15 We expect that take-up of higher speed services will accelerate over the next year as SFBB networks are rolled out further, more ISPs offer services based on these networks and customers demand higher speeds to support higher quality internet TV services and connect multiple devices to their broadband connection.

1.16 In addition to its target of universal superfast broadband availability, the Commission also has a target that at least 50% of broadband connections are 100Mbit/s or more by 2020.

1.17 The future growth in take-up is inherently less predictable than the availability of SFBB, and this is particularly true for services with very high bandwidths. Therefore, whilst it is likely that the Digital Agenda target for SFBB availability will be met, the target for take-up is intrinsically less certain. We do however note that, if demand for higher bandwidth services does materialise, then there are a number of technologies which should enable it to be met. Specifically:

- VDSL 'vectoring', which allows FTTC access network performance to be maintained as take-up increases;

- technologies such as G.Fast and DOCSIS 3, which support bandwidths well in excess of 100Mbit/s; and

- BT's 'fibre on demand' scheme, which allows those households which might benefit from 'fibre to the home' to do so.

1.18 Figure 1 summarises the overall effect of the developments described above on the 'modem sync speeds'[6] provided to UK consumers, and compares this to last year's data. Notable developments include:

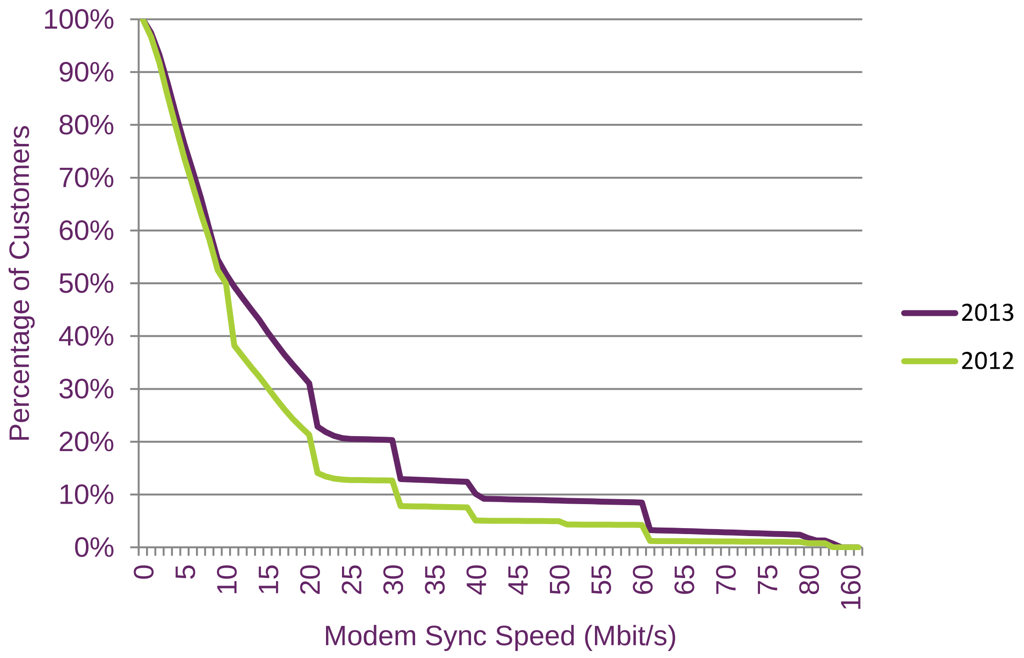
- the average modem sync speed has increased from 12.7Mbit/s to 17.7Mbit/s[7], mainly due to the increased take-up of SFBB;

[6] The modem sync speeds is the speed at which the modem in a customer's home connects to the equipment in a street cabinet or telephone exchange. It is not directly comparable with the speeds measured by Ofcom in its research with SamKnows and typically results in a higher average speed. See section 2 and annex 1 for details.

- the take-up and performance provided by standard broadband has been relatively stable. Therefore, whilst the average sync speed across all lines has increased, the median performance has been fairly stable, at just over 10Mbit/s; and

- the speed doubling programme currently being undertaken by Virgin Media is evident in the prominent shifts in the proportion of customers on 10Mbit/s, 20Mbit/s and 30Mbit/s services.

Figure 1 - Distribution of modem sync speeds across UK broadband customers



Source: Ofcom/operators

1.19 Where SFBB networks are not available, consumers rely on standard broadband, typically delivered by ADSL technology over conventional copper exchange lines. Standard broadband has been available to almost 100% of UK premises for a number of years, and offers a theoretical maximum speed of 24Mbit/s. However, the speed actually delivered varies depending on the length and quality of individual telephone lines and, as a result, some lines operate at much slower speeds. The Government has committed to ensuring that virtually all households benefit from a speed of at least 2Mbit/s by 2017 - the ‘Universal Service Commitment’ (USC).

1.20 Figure 1 shows that 8% of all broadband connections in the UK currently operate at less than 2Mbit/s. However our analysis also shows that two thirds of these slow connections are in areas where SFBB networks are already available and so many of these consumers have the option to switch to faster services. Approximately 3% of UK households are currently receiving speeds less than 2Mbit/s and do not have the option of switching to SFBB.

[7] The average actual speed measured in May 2013 in research conducted for Ofcom by SamKnows was 14.7Mbit/s.

1.21 Looking forward, there are two areas where future policy development may assist those customers who are on slower connections who are currently outside of SFBB network footprints:

- Firstly, and most importantly, the options that are being considered by the Government with industry to extend SFBB into the final 10% of the country may, if implemented, further reduce the number of households that do not have this as an option.

- Secondly, for the small number of households that continue to be unable to access SFBB, the government may wish to consider whether it is appropriate to increase the speed commitment set out in the USC. As we noted in last year's report, consumers on connections of less than 10Mbit/s tend to use less data, suggesting that internet usage is constrained by lower speeds. However, a relatively modest improvement in the USC could ease this constraint significantly.

Mobile networks

1.22 Levels of mobile 2G and 3G coverage to premises have remained relatively static over the last year, with the notable exception of Northern Ireland where 3G coverage has improved significantly following investment by a number of operators. The number of premises in Northern Ireland with no outdoor 3G coverage has fallen from 12% to 3%.

1.23 Although coverage levels have not changed significantly, mobile operators have embarked on major upgrades and reconfigurations of their networks. There have been two primary drivers for developments in mobile infrastructure during the last year:

- Reducing costs through consolidating mast assets. EE has been consolidating the Orange and T-Mobile networks (and also has a 3G and 4G network sharing agreement with Three) and Vodafone and O2 have begun to roll-out a network sharing arrangement. Both initiatives should result in improved coverage for individual operators but a reduction in total mast numbers.

- Deployments of new equipment on masts which not only support 4G, but also upgrade existing 2G and 3G equipment and improve coverage.

1.24 Ofcom's auction of radio spectrum at the beginning of the year paved the way for the deployment of 4G networks by the four main mobile operators.[8] Part of the spectrum, known as the 800 MHz band, became available as a result of the switch from analogue to digital TV and is well suited to providing cost effective mobile coverage in more rural areas.

1.25 One of the 800MHz spectrum licences we auctioned carries an obligation on the holder to provide indoor coverage to 98% of consumers at speeds of 2Mbit/s by 2017, with at least 95% coverage being provided in each of the nations. This spectrum was purchased by O2 and it has subsequently said that it intends to hit the UK target by the end of 2015[9]. We expect the 98% indoor coverage obligation to result in outdoor coverage of over 99%.

[8] BT also acquired spectrum in the auction but has yet to announce details of how it will be used
[9] http://www.o2.co.uk/network/future

1.26 We expect that other mobile operators will seek to match O2's coverage, meaning the large majority of consumers will be able to access 4G services in their home. Vodafone has said it intends to achieve similar levels of coverage by 2015[10] and EE has declared that it will achieve 98%[11] premises coverage by the end of 2014. Three has plans to cover 98% of population by end of 2015[12].

1.27 Even once 4G roll out has been completed, there will be a small percentage of homes where the provision of mobile services in not commercially viable. In recognition of this Government, through the DCMS 'Mobile Infrastructure Project' (MIP), is spending up to £150m to build new mobile infrastructure to bring services to homes which have not had them before. The first of these masts went live in mid September in Weaverthorpe in North Yorkshire, providing service to 200 premises in what was previously a complete 'not-spot'.

1.28 As part of our ongoing work, we intend to ensure that information on the indoor and outdoor coverage provided by each operator is available to consumers, both to ensure that competition is an effective means of driving improved coverage in general, and also so that consumers who do not receive coverage from all operators can choose the service which is best for them.

1.29 In recognition that coverage information is insufficient to predict overall quality of experience we will also be undertaking work to understand the impact of other factors, such as device type, use case and network load. If consumers have information about both coverage and quality of experience it will help them to compare the overall experience delivered by mobile networks and enable them to make more informed purchasing decisions, which will in turn drive competition between providers. For example, comparative information on the percentage of calls and data sessions that are successful on each of the mobile networks could provide consumers useful information when deciding which network to choose.

1.30 O2's coverage obligation relates to in-home coverage but, of course, consumers do not just use mobile phones in their own home. Mobile coverage away from the home is also important, especially on roads and rail. We have for the first time included statistics on mobile coverage on roads in this report. The data show that, while coverage for voice calls (using 2G) on motorways is very good, there are significant gaps in coverage on A and B roads, particularly for data services (using 3G). For example, as shown in figure 2, we estimate that 77% of the length of A and B roads are served by all 2G networks, but just 35% are served by all four 3G networks and 9% have no 3G coverage at all.

[10] http://www.vodafone.co.uk/cs/groups/configfiles/documents/contentdocuments/vftst044690.pdf
[11] https://explore.ee.co.uk/our-company/newsroom/ee-switches-on-4g-in-12-more-towns; EE has not specified whether this will be indoor or outdoor coverage
[12] http://blog.three.co.uk/2013/08/29/get-ready-for-4g/

Figure 2 - Mobile coverage on Roads (based on Predicted coverage)[13]

	2G	3G
Motorways with signal from all operators	99%	76%
Motorways without any signal	0%	0%
A&B Roads with signal from all operators	77%	35%
A&B roads without any signal	4%	9%

Source: Ofcom/Operators

1.31 Government is seeking to address some of the gaps in voice (2G) coverage on 10 major A roads as part of the £150m DCMS 'Mobile Infrastructure Project', bringing coverage to these areas for the first time. We also expect coverage in areas where some, but not all, operators offer service to improve as network-sharing arrangements between operators are rolled out further.

1.32 For coverage of data services, we expect that the roll out of 4G services will go a substantial way to addressing the shortfall, as the 800MHz spectrum allocated for 4G mobile data services has significantly better propagation characteristics than the 2.1GHz spectrum currently used for 3G services.

1.33 Despite these initiatives, it is likely that some roads will remain unserved, especially in more rural areas. We will be conducting further analysis over the coming year on how coverage of roads is likely to develop. If information on the road coverage provided by each operator is available to consumers it should drive competition and incentivise operators to improve road coverage.

1.34 There are particular challenges associated with the provision of voice and data services on trains. These are partially due to the difficulties associated with providing outdoor coverage along rail routes, especially in tunnels and cuttings, and partially due to the difficulties associated with translating outdoor coverage into carriages.

1.35 The Department of Transport recently announced that the rail industry is to roll out high speed mobile broadband on the busiest parts of Britain's rail network. Seventy percent of rail passengers are expected to benefit by 2019, and passengers are expected to begin noticing improvements to their journey during 2015. We have been seeking progress on this issue for a number of years and so we welcome this announcement and urge the rail industry to drive this initiative forward as quickly as possible. We will offer technical support and advice to help ensure the approach adopted provides widespread availability of such services as early as possible.

Public Wi-Fi

1.36 Most smartphones now have Wi-Fi capability, and the majority of the data consumed on mobile devices is currently carried using this Wi-Fi capability, rather than over cellular networks[14].

[13] Road coverage refers to the percentage of road length that is served.
[14] http://www.informatandm.com/wp-content/uploads/2012/02/Mobidia_final.pdf

1.37 Wi-Fi networks can be either private or public. Private WiFi networks are typically found either in consumers' homes, or their place of work. Public Wi-Fi hotspots are provided by fixed and mobile operators in high footfall areas such as retail stores, tourist attractions, food chains, coffee shops etc, while a number of councils across the UK are also investing in wide area Wi-Fi networks. At present, most Wi-Fi traffic is carried on private Wi-Fi networks.

1.38 There has however been strong growth in the number and use of public Wi-Fi hotspots over the last year. The number of public Wi-Fi hotspots has more than doubled and the average data consumed at each hotspot has also increased. The combined effect is that public Wi-Fi traffic has grown by over 190% over the last year.

1.39 The growth in the availability and use of public Wi-Fi hotspots is an indication that such networks are becoming established as a key part of the UK communications infrastructure, allowing 'off-load' of services where conventional cellular network coverage is unavailable, has capacity issues or is regarded as uneconomic.

1.40 Despite this, public Wi-Fi off-load is still small when compared with off-load onto private Wi-Fi. We expect operators and equipment vendors to make discovering and connecting to public Wi-Fi networks more seamless over the coming year, using technology standards such as Passpoint, and this should result in significant further growth.[15]

Data use

1.41 The amount of data consumed over fixed, mobile and Wi-Fi networks continues to grow as consumers connect more devices and access higher quality video and other rich media services. On fixed networks, in June 2013 the average household was using 30GB of data (up from 23GB in 2012).

1.42 As more customers subscribe to fixed SFBB services, particularly those currently on slow lines, we expect to see significant growth in data use, which will have implications for investment in network capacity and interconnection with the wider internet.

1.43 Compared to last year, the rate of growth in mobile broadband data consumption appears to have slowed: having doubled between 2011 and 2012, growth from 2012 to 2013 was 48%.

1.44 We hypothesise that mobile operators are using data caps to manage limited capacity in 3G networks. The data shows that consumers spend less time using data- intensive services on mobile networks than they do on fixed broadband, possibly deterred by the risk of exceeding their data cap as well as other factors such as typically slower connection speeds and smaller device screens. The roll out of 4G services will introduce greater capacity to the mobile networks and we will monitor subsequent developments.

International comparison

1.45 This report focuses on the coverage and capacity of networks and how these vary in different parts of the UK. However, in order to benchmark the UK's infrastructure we

[15] http://www.wi-fi.org/discover-and-learn/wi-fi-certified-passpoint%E2%84%A2

also compare availability, take-up and use of fixed and mobile networks with that in other countries.[16]

1.46 The UK compares favourably with other large European countries in the availability and take-up of fixed broadband services. This is particularly the case for superfast broadband services. Even though BT was only part way through its roll-out of fibre services, the availability of fibre services at the end of 2012 (49%, FTTC and FTTP) was considerably higher[17] than in the other large European economies. The proportion of connections which were superfast (15%)[18] was also higher in the UK than in the other big-5 EU countries[19].

1.47 The UK also compares reasonably favourably with the US in the provision of superfast services: availability in the UK is lower, largely due to only 48% of households being passed by cable, compared to 97% in the US (and around 82% being provisioned for superfast services); however, take-up of superfast services in the UK was higher with 15% of broadband households subscribing to broadband at a speeds of 30Mbit/s or higher at the end of 2012, compared to 12% in the US.

1.48 We use the Cisco Virtual Networking Index to compare data usage across countries, although we note that due to the different methodology this data for the UK is different to that collected by Ofcom for the Infrastructure Report Update. Cisco data shows that IP traffic per capita in the UK (22.4GB in 2012) was more than double that in other European comparator countries, although data usage is much higher in the US (due partly to much higher take-up of over-the-top IP television services in the US, such as those provided by Netflix and Hulu).

Figure 3 – International comparisons: fixed broadband networks

	UK	FRA	GER	ITA	ESP	USA	CAN	JPN	AUS
Broadband availability, end 2012 (% of population)[1]									
- DSL	100%	100%	99%	97%	99%	86%	87%	95%	92%
- VDSL (FTTC)	48%	0%	32%	10%	11%	21%	56%	0%	0%
- Cable	48%	26%	53%	0%	55%	97%	82%	70%	49%
- FTTP	0.7%	21%	3%	11%	18%	18%	5%	91%	3%
Broadband take-up, end 2012[1]									
- Subscribers per 100 households	80	84	69	53	65	75	85	76	68
- Proportion of broadband connections which are superfast (>=30Mbit/s)	15%	5%	12%	5%	10%	12%	9%	-	20%
Broadband usage (2012)[2]									
- IP traffic per capita (GB)	22.4	11.5	11.1	7.5	10.4	40.1	23.7	11.9	14.4

Sources: [1] IDATE and Ofcom; [2]Cisco Virtual Networking Index: http://www.cisco.com/web/solutions/sp/vni/vni_forecast_highlights/index.html

1.49 Recently, in the context of the European Commission's *Connected Continent* proposals[20], there has been discussion about the different characteristics of the US

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[16] Making comparisons with other countries is more complex due to a lack of comparable data. Where data is available, it cannot always be directly compared with the data that we collect from operators for this report. To make international comparisons we have therefore turned to third party sources and used 2012 data.
[17] Note that the somewhat higher availability of cable services in some of these countries means that overall superfast availability may be close to that in the UK.
[18] 15% of broadband connections were superfast in the UK at the end of 2012, and this had increased to 22% by June 2013 as detailed in paragraph 1.14.
[19] UK, France, Germany, Spain, and Italy
[20] http://ec.europa.eu/digital-agenda/en/connected-continent-single-telecom-market-growth-jobs

market and European markets. Comparisons are problematical, not least because of the large variation between national markets in Europe. However, a few general conclusions are evident regarding fixed broadband availability and take-up:

- The US has much higher availability of cable broadband, which is the legacy of cable being the leading television platform. The relatively low cost of upgrading these analogue cable networks to the DOCSIS standard which supports superfast broadband means that there is high availability of superfast cable broadband in the US.

- High cable availability in the US has led to infrastructure-based competition between local incumbent telcos and local cable companies. Faced with the need to compete with cable operators for the delivery of triple-play services (phone, broadband and pay-TV), telcos such as AT&T and Verizon were relatively early to invest in superfast networks (although the rate of investment has now slowed).

- By contrast, in Europe fixed-infrastructure competition is less common, so to promote competition regulators have required that incumbent telcos provide wholesale access to their networks, thereby ensuring competition in retail markets (for example, in the UK, Sky, TalkTalk and BT Retail are among those competing to deliver broadband over BT's infrastructure).

- These different market structures have led to different patterns of superfast investment. Local duopolies in the US have driven early investment in fibre, but while investment has been slower in Europe there are signs that it will catch up as networks are built to meet the demand for superfast services. The availability of cable networks is likely to remain higher in the US for the foreseeable future, but by the end of 2012 the availability of FTTx in the UK (around 49%) was higher than in the US (around 39%), and Germany was only narrowly behind (around 35%). Investment in FTTx networks has slowed in the US, while it continues apace across much of Europe.

- Different market structures have also contributed to differing levels of take-up. Perhaps due to higher levels of retail competition (in contrast to infrastructure-based competition between local duopolies in the US), broadband and triple-play prices are typically lower in the Big-5 European countries than in the US.[21]

- Household broadband take-up is higher in the UK and France than in the US, and the take-up of superfast services across the big-5 EU countries is comparable to that in the US, despite much higher availability in the US. This may be due to the prevalence of speed-based pricing in the US, where a significant premium is typically charged for superfast services, resulting in many consumers taking a slower service even when they connect via a fibre or DOCSIS3.0 cable service:

- A consequence of speed-tiered pricing in the US is that a much larger proportion of fixed broadband connections are at speeds of 2Mbit/s or less than in Europe: based on data collected for Ofcom by IDATE, 21% of fixed broadband connections in the US at the end of 2012 were at a headline speed of 2Mbit/s or less, compared to just 8% of connections across the UK, France, Italy, Germany and Spain.

[21] Ofcom, International Communications Market Report 2012, Comparative International Pricing, http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr12/icmr/ICMR_Section_2.pdf

- The prevalence of lower speed products in the US has resulted in lower average speeds by technology in the US than in Europe. SamKnows has conducted research on the performance of broadband in the EU and in the US and finds that average speeds for ADSL broadband, cable broadband and fibre broadband are higher across European Union countries.[22] However, higher cable take-up in the US means that it is likely that average broadband speeds across all technologies are higher than in Europe.[23]

1.50 The UK's mobile infrastructure also compares reasonably well with other countries, particularly in Europe, with 99% of the population having access to at least one 3G mobile network, although 4G availability still lags in comparison with a number of countries, notably the USA.

1.51 The UK also has comparatively high take-up of 3G mobile services, and this is likely to be one of the reasons why Cisco data finds that average traffic per mobile connection in the UK in 2012 (406MB) was significantly higher than in other European countries. As with fixed-line broadband, mobile data use is higher in the US (617MB) which may be due to higher smartphone and tablet take-up, as well as greater use of video services

1.52 LTE services launched in the UK earlier than in France, Italy and Spain, and rapid roll-out is expected in the coming years from all four UK operators, with population coverage set to exceed 98% by 2015.

Figure 4 – International comparisons: mobile networks

	UK	FRA	GER	ITA	ESP	USA	CAN	JPN	AUS
Network availability, end 2012 (% of population)[1]									
- 2G	100%	100%	99%	100%	100%	100%	99%	100%	99%
- 3G	99%	99%	90%	98%	98%	93%	99%	100%	99%
- LTE	17%	5.5%	59%	0%	0%	91%	72%	70%	40%
Mobile take-up, end 2012[1]									
- Mobile connections per 100 population	134	111	139	159	113	104	81	101	139
- 3G & LTE connections per 100 population	72	50	41	68	78	63	45	101	80
Data usage (2012)[2]									
- Average traffic per mobile connection per month(MB)	406	199	162	252	333	617	592	952	403

Sources: [1] IDATE; [2]Cisco Virtual Networking Index: http://www.cisco.com/web/solutions/sp/vni/vni_forecast_highlights/index.html

1.53 LTE (4G) deployment has, on the whole, occurred earlier in the US than in Europe due, in part, to earlier release of spectrum in the US. Large scale deployment by Verizon began in 2010 following a spectrum award in 2008; whereas in the UK 4G spectrum was awarded in March 2013, although EE launched 4G services in its 1800MHz band in October 2012. This has resulted in much higher take-up of 4G in the US than in Europe – data from the industry body Global Mobile Suppliers

[22] European Commission, Quality of Broadband Services in the EU, March 2012, http://ec.europa.eu/information_society/newsroom/cf/dae/document.cfm?doc_id=2319

[23] Although not directly comparable with the data collected by SamKnows, Akamai data on the speed of internet connections making requests to it servers finds that in Q1 2013 the average speed of connection in the US was 8.6Mbit/s, compared to 7.9Mbit/s in the UK and 5.9Mbit/s across the EU5, http://www.akamai.com/stateoftheinternet/

Association finds that in Q2 2013 North America accounted for 51% share of global LTE subscriptions compared to just 4% in Europe.

1.54 However, within the next couple of years it is likely that LTE availability in many European countries will be comparable to that in the US. By the end of 2012, LTE was available from at least one operator to 91% of the population in the US, and both Verizon and AT&T in the US are aiming to cover around 260 million people (just under 85% of the US population) by the end of 2013.[24] The UK roll-out plans should lead to a comparable coverage to the US by 2015, while across Europe some operators are already making progress to achieving these levels – in July 2013 Tele2/Telenor had around 99% population coverage in Sweden, Portugal PT had around 90% coverage and Vodafone Spain had around 85% coverage.

1.55 Ofcom's annual International Communications Market report benchmarks communications services in the UK against those in other countries. The 2013 edition is scheduled for publication in December and will include more data on how the UK's communications infrastructure compares with that in other countries.

Digital terrestrial television and digital radio

1.56 Following the completion of the switchover from analogue to digital TV in 2012, further reconfiguration of the Digital Terrestrial Television network was undertaken to clear the radio spectrum required to allow the introduction of 4G mobile services. This work was completed by 31 July 2013, five months ahead of the original deadline.

1.57 Ofcom has issued spectrum licences to Arqiva which will allow the introduction of up to 10 new High Definition channels on DTT multiplexes. These multiplexes are expected to be available to 70% of UK households. The BBC has announced plans to launch 5 HD Channels (BBC News, BBC Three, BBC Four, CBeebies and CBBC), and we expect further announcements to follow.

1.58 These developments are of strategic importance for the future of DTT, since as well as increasing the range of HD services available, they will also increase the take-up of DVB-T2 receivers. A transition of DTT from DVB-T to DVB-T2 would be an effective means of ensuring that DTT is able to continue offering a wide range of attractive broadcast content.

1.59 Another strategically important development is the increased use of broadband networks to deliver broadcast content. A good example is the YouView hybrid TV platform, which integrates channels delivered over DTT and broadband within a single electronic programme guide.

1.60 The commercial viability of these services is improved by the use of multicast IP technology within the TalkTalk and BT broadband networks. This technology opens up the possibility of delivering High Definition TV channels over superfast broadband without the ISP incurring incremental costs as the number of viewers increases. For example, BT is using this technology to deliver BT Sport 1 & 2 HD to customers with BT Infinity and a Youview set top box.

[24] http://www.fcc.gov/document/16th-mobile-competition-report

1.61 Significant progress has also been made with the introduction of local TV services on DTT. Comux UK was appointed on 28 January 2013 to provide transmission services for each of the 19 local TV stations.

1.62 Ofcom recently published a report[25] on the adoption and use of digital radio in the UK, which is intended to inform Government plans for a switchover from analogue to digital radio.

Traffic management and interconnection

1.63 We have previously committed that the Infrastructure Report will serve as the main means by which we monitor traffic management by telecom network operators, and determine whether there are concerns arising with respect to the principles which we set out in our policy statement on Net Neutrality[26].

1.64 We requested information from the major ISPs and mobile operators on their current traffic management practices. A review of their responses shows that there have been no significant developments over the last year. Some mobile operators do block VoIP services on certain mobile tariffs, but the level of blocking has not changed significantly. Where mobile operators do block services, this is set out in the 'Key Facts Indicators' (KFIs) required by the Industry Code of Practice, providing a degree of transparency.

1.65 We do however have concerns as to the actual level of transparency provided to consumers. Consumer research carried out earlier this year[27] has shown that most consumers are unaware of the existence of the KFIs, and that the information presented is not always as clear and coherent as we consider it should be. Our current policy position is that we rely on competition to address concerns related to blocking, but competition cannot be effective if consumers are not well informed. We are working with industry, via the Broadband Stakeholders Group, to explore ways in which this situation can be improved.

1.66 The quality of service provided to consumers depends not just on the traffic management practices applied by ISPs, but also on the way in which they interconnect with providers of content and services. Data collected for this report shows that there has been a major shift away from traditional public peering arrangements, towards direct interconnection between ISPs and Content Delivery Networks (CDNs). Traffic from CDNs such as those operated by Google and Akamai, delivering video content from services such as YouTube and BBC iPlayer, now makes up approximately half of all internet traffic.

Network resilience

1.67 As in previous years we have included statistics on the number and nature of network outages in this report. Looking at the overall pattern of outage reports, there are no specific trends that we wish to highlight.

1.68 In last year's report, we looked at the readiness of core ISP networks for a potential migration from IPv4 to IPv6, should this be required due to the exhaustion of IPv4 addresses. The take-up and use of IPv6 remains low but, compared to last year, ISPs have firmer plans for addressing IPv4 exhaustion and introducing IPv6.

[25] http://stakeholders.ofcom.org.uk/binaries/research/radio-research/drr-13/2013_DRR.pdf
[26] http://stakeholders.ofcom.org.uk/binaries/consultations/net-neutrality/statement/statement.pdf
[27] http://stakeholders.ofcom.org.uk/market-data-research/other/telecoms-research/traffic/

Ofcom interactive maps and data

1.69 We have published updated interactive maps on our website that provide more detailed information on the coverage of fixed and mobile networks in different parts of the country:

http://maps.ofcom.org.uk

1.70 We have also made available for download detailed information on the availability of fixed SFBB across the UK and in June 2013 modem sync speeds.

UK infrastructure dashboard

1.71 We have updated the Infrastructure Dashboard that we have included in previous reports; we now have three years of time series data. The data primarily relates to a one-month period starting on 3 June 2013.

Figure 5– UK infrastructure dashboard 2013

UK network coverage	
Fixed telephony (PSTN)	
Coverage of fixed line telephony	100% of premises
Fixed broadband	
Coverage of broadband at 2Mbit/s or more	92.2% of existing connections
Coverage of superfast broadband	73% of premises
Mobile 2G (outdoor)	
Premises served by all operators	94.1% of premises
Premises not served by any operator	0.4% of premises
Geographic area coverage by all operators	62.4% of land area
Geographic area not served by any operator	12.7% of land area
Coverage of A&B roads by any operator	96% of roads
Coverage of A&B roads by all operators	77% of roads

Mobile 3G (outdoor)	
Premises served by all operators	79.7% of premises
Premises not served by any operator	0.9% of premises
Geographic area coverage by all operators	21.0% of land area
Geographic area not served by any operator	22.9% of land area
Coverage of A&B roads by any operator	91% of roads
Coverage of A&B roads by all operators	35% of roads
Digital terrestrial television	
Households served by three multiplexes (public service broadcasting channels)	99%
Households served by six multiplexes (all digital terrestrial television channels)	90%
Digital radio	
Households served by BBC national multiplex	94% of households
Roads served by BBC national multiplex	83% of roads
Households served by the national commercial multiplex	87% of households
Roads served by the national commercial multiplex	73% of roads

Capacity (for June 2013)	
Fixed broadband	
Average fixed broadband modem sync speed	17.6Mbit/s
Total data throughput[28] on residential fixed lines	650,000,000 GB
Average data throughput per residential connection for June 2013	30 GB
Mobile	
Total number of active mobile connections[29]	84.2 million
Total mobile data throughput	28,890,000 GB
Average mobile data throughput per connection for June 2013	0.34 GB
Public Wi-Fi	
No of Public Wi-Fi hotspots	34,000
Total data uploaded/downloaded	1,991,268 GB
Average mobile data throughput per Hotspot for June 2013	58 MB

See Annex 1 for details of how each metric is calculated and what it represents.

[28] Total throughput includes downloads and uploads
[29] In Ofcom's annual *Communications Market Report* (http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr13/2013_UK_CMR.pdf), we reported that 94% of the UK adult population use or own a mobile phone. Therefore around a third of the mobile connections are used by adults with more than one active mobile device.

Section 2

Introduction and background to the report

2.1 Under the Communications Act 2003[30] ('the Act') (as amended), Ofcom is required to submit a report to the Secretary of State every three years, describing the state of the electronic communications networks and services in the UK. We published the first report in November 2011.

2.2 However, we recognised in our first report that some aspects of communications infrastructure were developing rapidly and/or were of particular interest to government and industry stakeholders, and therefore committed to providing updates on an annual basis, focussing on the areas of greatest change such as superfast broadband, mobile networks and the overall growth in data use by consumers. We published the first such update in November 2012.

Approach and context

2.3 This report consists of data already held by Ofcom and additional data gathered from the largest operators in each sector. Where possible we have re-used data already submitted to Ofcom by industry, in order to minimise the input required from stakeholders. We have also used other reliable data sources, such as direct consumer research findings where appropriate. Data sources and analysis methodologies are summarised in Annex 1. Where new information has been collected, this is for June 2013.

2.4 In the fixed-line market, we gathered data from the communications providers (CPs) which together comprise over 90% of the fixed broadband market. We collected data from all the mobile network operators. The operators are listed in Figure 6.

Figure 6 - Providers, networks and services within scope of the Infrastructure Report

Name of provider	Types of network or service
BT	Fixed telecommunications infrastructure: voice and broadband
Everything Everywhere	Mobile telecommunications infrastructure: voice and broadband, fixed broadband services
KCOM	Fixed telecommunications infrastructure: voice and broadband (Hull only)
O2	Mobile telecommunications infrastructure: voice and broadband
Sky	Fixed telecommunications infrastructure: voice and broadband services,
TalkTalk	Fixed telecommunications infrastructure: voice and broadband services
Three	Mobile telecommunications infrastructure: voice and broadband,
Virgin Media	Fixed telecommunications infrastructure: voice and broadband,
Vodafone	Mobile telecommunications infrastructure: voice and broadband
Arqiva	Communication Infrastructure, and media services

[30] http://www.legislation.gov.uk/ukpga/2010/24/section/1

2.5 Data were gathered over a 30-day period in the month of June 2013.

Publication of data

2.6 We have updated the maps on our website (http://maps.ofcom.org.uk) to reflect the new data in this report. The underlying data for the maps is also displayed on the website, and is available for download.

2.7 We are also publishing a more detailed set of data on fixed broadband and superfast broadband availability. For each postcode, this notes whether there are any sub-2Mbit/s broadband lines, the average sync speed[31], the median sync speed and the maximum sync speed. We hope this information will allow local authorities to analyse the provision of broadband and superfast broadband in their region, to support their Local Broadband Plans (LBP) and roll-out support initiatives. The data presented in this report is a snapshot view of the UK communications infrastructure in June 2013. The state of some networks may have changed since then.

2.8 We welcome comments from stakeholders on the data included in this year's report. Please contact us at infrastructurereporting@ofcom.org.uk.

Outline of this report

2.9 The rest of this document reports on each type of network, on matters relating to coverage, capacity, resilienceand future developments.

- Section 3 reports on fixed networks
- Section 4 reports on mobile networks and Wi-Fi hotspots
- Section 5 reports on broadcast networks
- Section 6 summarises the plans for resilience and reported availability of the networks and services
- Section 7 reports on traffic management, both within a CP's own network and the management of interconnection traffic, and IPv4 address exhaustion and mitigation plans

[31]The average maximum speeds of existing broadband connections. Speeds achieved in the home will be slower. See paragraph 3.38 for a more detailed explanation.

Section 3

Fixed broadband networks

Overview

3.1 Fixed broadband networks provide a physical connection to each home or business, connecting a modem in the customer's premises with the Internet Service Provider's (ISP) equipment in a nearby street cabinet or local telephone exchange. There are two types of fixed broadband network:

- First generation broadband networks, or 'standard broadband', are typically provided over copper wires running from telephone exchanges to the customer's home (known as the 'local loop'). These networks can theoretically support download speeds of up to 24Mbit/s using ADSL2+ technology.

- 'Next Generation Access' (NGA) networks utilise technologies such as fibre to the cabinet (FTTC) and fibre to the premises (FTTP) which take optical fibre closer to the end-user, thereby increasing broadband attainable speeds. These networks can offer 'superfast'[32] broadband services. Cable networks have utilised fibre optic technology for many years, and have been upgraded to support superfast broadband services by replacing equipment in the consumer's home and at the cable headend.

3.2 First generation broadband networks are available to close to 100% of premises in the UK, and NGA networks are available to 73% of premises.

3.3 Openreach (part of the BT Group) operates the local loop in most of the UK, with the exception of Hull where Kingston Communications (KCom) is the sole provider. Virgin Media is the largest operator of cable networks in much of the UK, with Wight Fibre providing cable services on the Isle of Wight and Smallworld Cable providing services in parts of north west England and south west Scotland. There are a number of smaller scale NGA network deployments in other parts of the country (see Annex 2).

3.4 Improving the coverage and capacity of these fixed access networks is the subject of significant private investment by BT, Virgin Media, KCom and a number of smaller infrastructure providers. It is also a key Government policy aim, supported where necessary with public funding. Government has an objective of ensuring that at least 95% of households have access to superfast broadband services by 2017 and is exploring whether this target can be increased to 99%. It has also made a Universal Service Commitment (USC) that virtually all homes should be able to receive at least 2Mbit/s by 2017.

Consumer context

3.5 Household take-up of fixed-line broadband was 72% in Q1 2013. Where superfast broadband services are available we have seen encouraging take up figures, with over one in five broadband connections superfast in June 2013. In Northern Ireland,

[32] Ofcom defines superfast broadband as connections with downstream speeds of 30Mbit/s or more. In this report a network is described as a NGA network if it can provide superfast broadband speeds, however, for some technologies (e.g. FTTC/VDSL) not all connections will be able to achieve superfast broadband speeds.

where NGA availability is available to 96% of premises, the highest of the four nations, 29% of broadband connections were superfast and in Belfast this proportion increases to 38%.

3.6 The growth in the proportion of consumers with superfast broadband services has resulted in a rapid increase in the UK's average broadband speeds. The average modem sync speed[33] in June 2013 was 17.6Mbit/s, up from 12.7Mbit/s in June 2012.

3.7 Superfast broadband customers tend to consume more data than non-superfast broadband customers. The average data used on uncapped superfast broadband services in June 2013 was 55GB, whereas customers on uncapped ADSL2+ technologies used an average of 26GB. We have investigated how use of the internet differs between these user groups (see section 3.59).

Broadband coverage

First generation broadband services

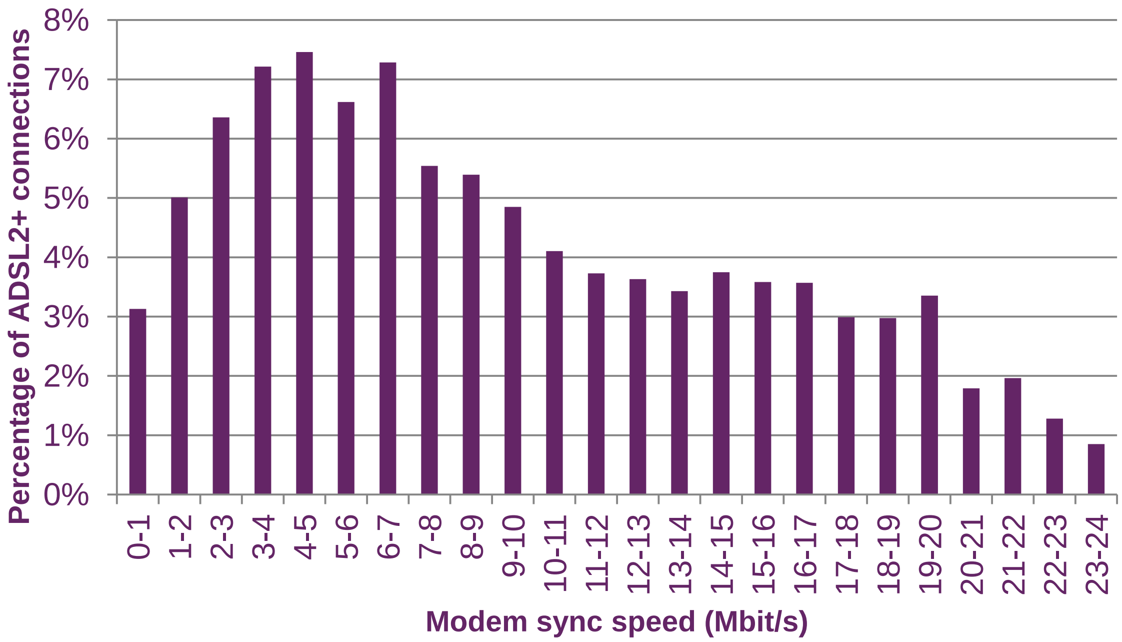
3.8 First generation broadband has been available from virtually every telephone exchange in the UK for a number of years, although the ability to receive a service at a given property is dependent on the length and quality of the telephone line. In last year's report we estimated that up to 140,000 lines may not be able to receive fixed-line broadband. We have made available postcode level data alongside this report to allow interested parties to repeat this analysis.

Availability of 2Mbit/s broadband

3.9 While fixed access broadband is available to the vast majority of premises, due to the way broadband is delivered (using xDSL technologies) speeds vary significantly, primarily due to line length and quality. To illustrate this, Figure 7 shows the distribution of modem sync speeds in the data we have collected from ISPs. While the theoretical maximum speed of ADSL2+ connections is 24Mbit/s, 59% of customers had speeds less than 10Mbit/s in June 2013.

[33] See annex 1 for details of how we report on broadband speeds.

Figure 7 – Distribution of modem sync speeds for ADSL2+ connections



Source: Ofcom/operators

3.10 Government is committed to ensuring that virtually every home in the UK has access to a broadband service providing speeds of at least 2Mbit/s by 2017 – known as the Universal Service Commitment (USC). Figure 8 shows the percentage of all fixed broadband connections operating at less than 2Mbit/s by nation[34].

Figure 8 – Connections operating below 2Mbit/s

	Percentage of connections receiving less than 2Mbit/s		
	June 2011	June 2012	June 2013
England	14%	10%	8%
Scotland	13%	10%	8%
Northern Ireland	23%	15%	12%
Wales	19%	15%	12%
Total UK	14%	10%	8%

Source: Ofcom/operators

3.11 Figure 8 shows that the year-on-year reduction in the percentage of lines receiving less than 2Mbit/s has slowed compared to the change between 2011 and 2012, despite the increased availability and take-up of services on NGA networks.

3.12 There are consumers on these slow lines who are in postcodes where NGA networks are available and, by upgrading their service, could receive much higher speeds.

[34] See annex 1 for details of how we calculate the percentage of connections receiving less than 2Mbit/s.

When slow lines in postcodes where NGA is available are excluded, the percentage of connections operating at below 2Mbit/s reduces from 8% to just 3%.

3.13 The effect is well illustrated in Northern Ireland, where NGA networks are available to 96% of premises, and superfast services have been taken up by 29% of broadband customers. However, 14% of connections are still operating below 2Mbit/s, but of these around 95% should be able to switch to the faster NGA-based services. We recognise that the distance from the fibre cabinet to some homes is too long to support superfast speeds (see below), but for the large majority of customers a service provided from an NGA network will be significantly better than that delivered by first generation broadband technology.

3.14 Even where NGA is not available, significant improvements are possible based on consumer ‘self-help’. This is because the line-speed provided by xDSL technologies does not just depend on line length; variations in the quality of the in-home installation can also affect performance. For example, incorrectly installed ADSL filters or faulty telephone wiring within the home can reduce speeds. These faults can often be corrected by the consumer, increasing speed without the need for major infrastructure upgrades.

3.15 Of the sub 2Mbit/s connections in postcodes outside of NGA network footprints, 51% were in postcodes where the average modem sync speed was in excess of 2Mbit/s. This suggests that the reasons for slow speed on individual lines may be within the consumer’s home and could be rectified.

3.16 Finally, we have considered whether the postcodes which appear to have persistent speed problems are served by 3G mobile networks and could consider using mobile broadband. Our analysis indicates that 85% of the premises that have less than 2Mbit/s and are not in the NGA footprint are served by all 3G operators and 99% of these are served by at least one 3G operator35.

3.17 We will repeat this analysis next year as we expect the combination of increased NGA availability and take-up, in addition to extended coverage of 3G and 4G networks, and the efforts to improve current connections should provide consumers with more opportunities to increase their speeds. However, our analysis of how data use varies by speed of connection suggests that there may be grounds for reviewing the 2Mbit/s target. See ‘Data Use’ section below.

Availability of NGA networks

3.18 The number of premises that have the option of subscribing to a superfast broadband service has increased since last year thanks primarily to the continued roll-out of Openreach’s FTTC network. Figure 9 shows the availability, by nation, of NGA networks provided by Virgin Media, BT Openreach and KCom.

[35] Based on a signal strength threshold sufficient to establish a 3G connection in outdoors. The proportion of homes premises with good indoor coverage will be lower.

Figure 9 – Availability of NGA services by nation

	Percentage of premises with access to NGA networks	
	2012	2013
England	68%	76%
Scotland	45%	52%
Northern Ireland	95%	96%
Wales	37%	48%
Total UK	65%	73%

Source: Ofcom/operators

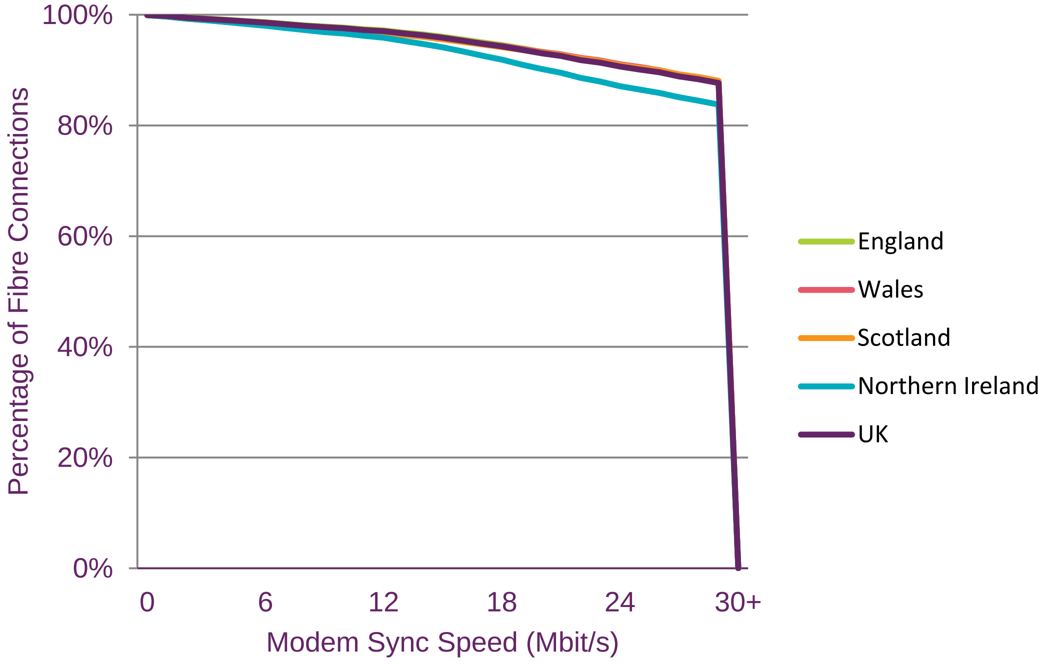
3.19 We have defined superfast broadband services in this report as those that provide a download speed of at least 30Mbit/s. This is consistent with the definition used in last year's Infrastructure Report Update and with the definition adopted by the European Commission. We note however, that Government targets are based on a definition of superfast broadband of 24Mbit/s or more.

3.20 It should be noted that not all broadband connections provided by NGA networks will necessarily achieve speeds of 30Mbit/s or more. In particular, the speed achieved on a given line using FTTC/VDSL technology will depend on the length of the copper connection to the consumer's premises. Our analysis indicates that over 86% of current FTTC/VDSL connections have modem sync speeds of 30Mbit/s or more and over 90% are more than 24Mbit/s. In this report, when we report on superfast broadband take-up, we report only on lines with speeds of 30Mbit/s or more.

3.21 Figure 10 shows the distribution of existing FTTC speeds by nation. The chart shows that FTTC speeds are typically lower in Northern Ireland than in the other nations. Following public sector intervention, the vast majority of cabinets in Northern Ireland have been upgraded to FTTC, and the lower speeds are likely to reflect the high proportion of cabinets in rural areas (where line lengths tend to be longer). As FTTC deployment in England, Scotland and Wales extends into the more rural areas we would expect the speed distributions to align more closely with Northern Ireland.

3.22 The Northern Ireland Executive is planning further improvements to the region's broadband infrastructure. The Northern Ireland Broadband Improvement Project aims to meet the UK-wide objectives of delivering 2Mbit/s broadband services to all premises and 24Mbit/s broadband services to 90% of premises by 2015. Around £19.3m of public sector funding is available across a number of sources including DETI, DARD, BDUK and the European Union in support of this project. It is anticipated that a contract will be awarded before the end of the year.

Figure 10 – Speed distribution on FTTC connections[36]

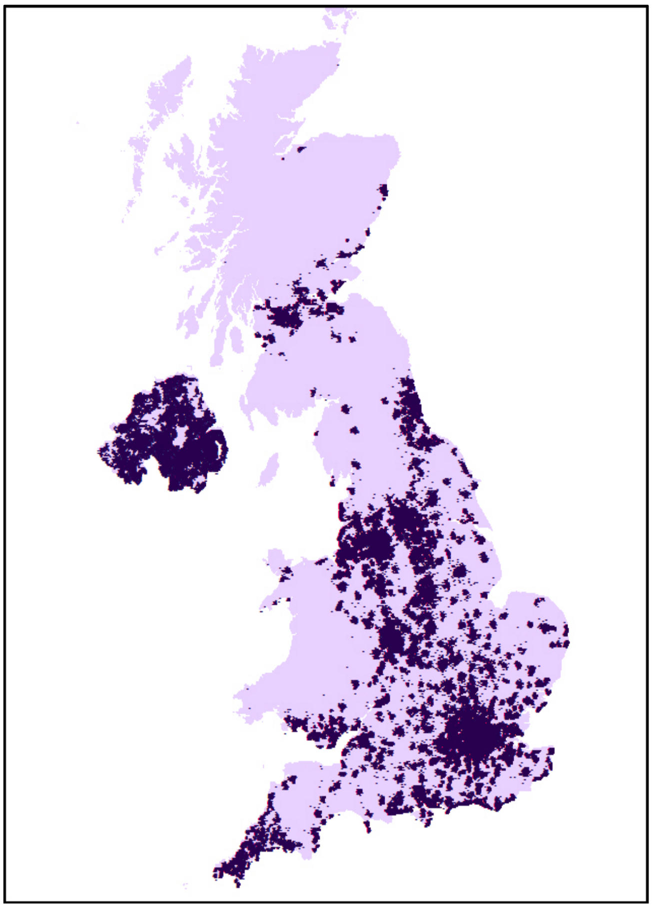


Source: Ofcom/operators

3.22 Figure 11 maps the postcodes where NGA networks are available; it shows that superfast broadband roll out is largely concentrated in urban areas, where it is cheaper to deploy new infrastructure per premise due to the higher population density. The impact of public sector interventions to extend NGA availability in Northern Ireland and Cornwall is clearly visible.

[36] Speeds more than 30 Mbits/s are capped at 30 Mbits/s in the graph

Figure 11 – Postcodes where NGA networks are available



Source: Ofcom/operators

3.23 Figure 12 summarises the availability of NGA networks by the degree of settlement, both for the UK as a whole, and for each of the nations in the UK. There is currently a significant disparity in the availability of superfast broadband services between rural and urban areas. Whereas 88% of urban premises have access to superfast broadband, the figure is 78% in semi-urban areas and just 25% in rural areas (see Annex 1 for how rural and urban areas are defined).

3.24 The disparity in superfast broadband coverage between rural and urban areas is due to the fact that cable broadband is predominantly available in urban and semi-urban areas, and because BT has generally prioritised urban and semi-urban areas for roll-out of its superfast broadband network. This underlines why the Government has decided to spend £780 million to increase the roll-out of superfast broadband; most of this additional funding will be used to provide superfast broadband access in semi-rural and rural areas (see 3.25).

3.25 Superfast broadband projects are being administered at a local authority level; a list of the projects is summarised in Annex 4.

Figure 12 – NGA coverage in the UK by the degree of settlement

	Urban areas	Semi-urban areas	Rural areas
England	89%	79%	24%
Scotland	78%	56%	9%
Northern Ireland	98%	97%	91%
Wales	92%	49%	9%
Total UK	88%	76%	25%

Source: Ofcom/operators

3.26 In addition to superfast broadband network coverage from BT Openreach and Virgin Media, there are a number of other smaller providers of superfast broadband networks. These are listed in Annex 2.

Broadband capacity

3.27 The capacity that ISPs need to provision in their networks is a function of the number of customers that are connected and the volume of data they use during peak hours. In last year's report we also identified that the speed of the network can also affect how much data is consumed (analysis which we have repeated this year).

3.28 In assessing the capacity of broadband networks we have therefore considered the overall take-up of services, the actual speeds received and data used.

Overall broadband take-up

3.29 Overall for the UK, the number of residential and small to medium (SME) fixed broadband connections increased to 21.7 million of premises from 20.6 million in 2012[37].

3.30 Figure 13 shows take-up by UK nation in June 2013. Information at a local authority level is provided on the interactive maps published on our website. It can be seen that 22% of broadband connections were superfast; in Northern Ireland 29% of connections were superfast.

[37] http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr13/2013_UK_CMR.pdf

Figure 13 – Fixed access broadband take up

	Premises with fixed access broadband (including superfast broadband)	Premises with superfast broadband fixed access	Percentage of BB connections that are superfast broadband
England	72%	16%	22%
Scotland	70%	13%	18%
Northern Ireland	66%	19%	29%
Wales	70%	9%	14%
Total UK	72%	16%	22%

Source: Ofcom/operators

3.31 As Virgin Media continues its programme of increasing the speeds of its customer lines (and offering 30Mbit/s as its standard service to new customers), Openreach extends the reach of its network, and more ISPs offer superfast broadband services, we expect strong growth in superfast broadband take-up in the next year, in line with the experience in Northern Ireland, where a Government-led funding initiative has already delivered near ubiquitous NGA availability and higher take-up.

Overall broadband speeds

3.32 Using the data provided by the major ISPs we have calculated the average modem sync speeds in different parts of the UK. Average speeds vary according to the technologies available in each area, the relative take-up of services on these networks and other factors, such as the average length of the telephone lines.

3.33 The overall average modem sync speed in the UK increased to 17.6Mbit/s in June 2013 (see Figure 14) from 12.7Mbit/s in June 2012. The increase is due to the network and service upgrades outlined above. Data at a local authority level are available on the interactive maps published on the Ofcom website (http://maps.ofcom.org.uk).The average speed of superfast broadband connections was 50Mbit/s, up from 46Mbit/s in 2012.

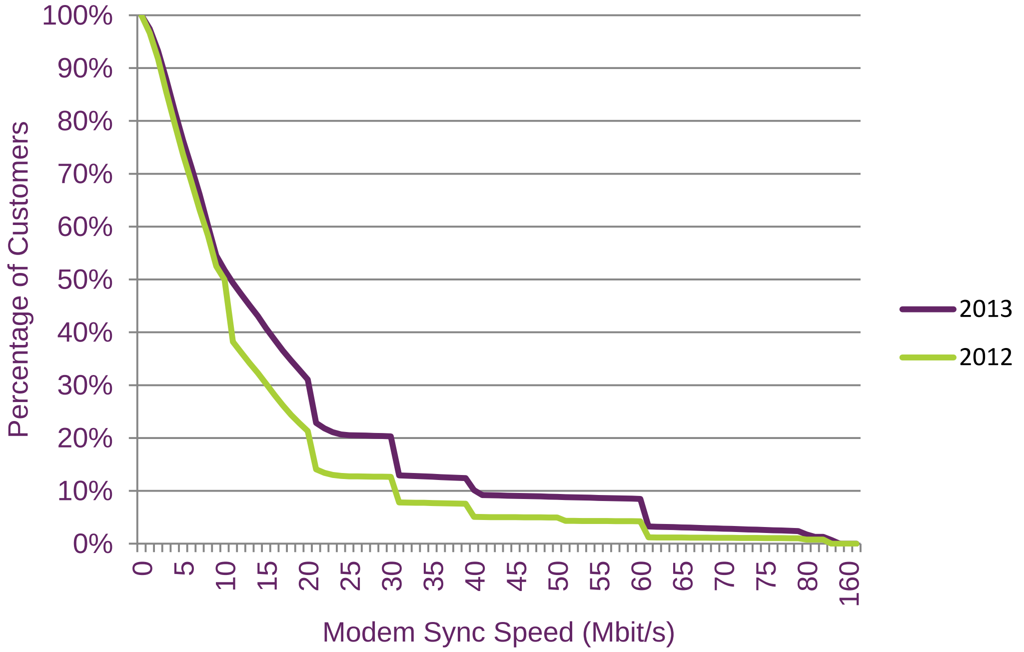
Figure 14 – Average modem sync speeds

	Average modem sync speed (Mbits/s)	
	2012	2013
England	12.9	18.0
Scotland	12.1	15.8
Northern Ireland	14.4	20.4
Wales	9.9	13.2
Total UK	12.7	17.6

Source: Ofcom/operators

3.34 Figure 15 shows the distribution of modem sync speeds and how they have changed in comparison to 2012. The step changes at higher speeds reflect the speed doubling programme being undertaken by Virgin Media. It is notable that around 50% of connections are still operating below 11Mbit/s, this reflects that the majority of customers have not yet upgraded from ADSL to fibre-based services.

Figure 15 – UK Download sync speed distribution



Source: Ofcom/operators

3.35 It should be noted that the sync speed information published here represents the highest possible download throughput speed that a connection is capable of delivering and as such is not directly comparable with actual speed test data measured on an end-to-end basis by companies such as SamKnows. In our latest report using data collected by SamKnows in May 2013 we measured an average residential broadband download speed of 14.7 Mbit/s[38].

3.36 The two measurement techniques are complementary:

- End-to-end measurements determine the network performance from the home to a typical web-site. They take into account not just the performance of the access network, but also protocol overheads, core network contention and, in some instances, traffic management practices. They provide the best available measure of the consumer experience, since this depends on all the above factors.

- The sync speed provides a direct means of determining the performance of the access network, as reported by the modems which maintain each broadband connection.

Broadband speeds in rural areas

3.37 It is widely recognised that broadband speeds in rural areas tend to be lower than those in urban areas. On ADSL networks this is due to telephone line lengths in rural areas tending to be longer (and hence modem sync speeds are lower). Rural areas also typically have lower NGA network availability as the lower population density increases the cost per household of deploying NGA networks.

3.38 Figure 16 summarises the difference in modem sync speeds in urban, semi-urban and rural parts of the UK nations.

Figure 16 – Average modem sync speeds in rural and urban areas (Mbit/s)

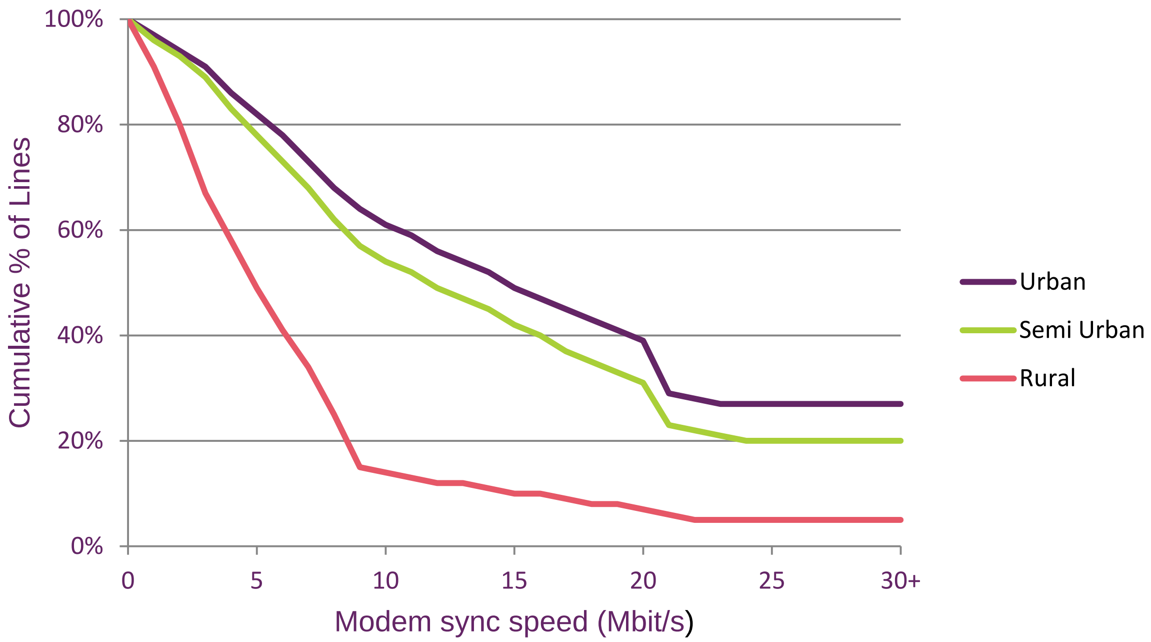
	Urban areas	Semi-urban areas	Rural areas
England	21	19	7
Scotland	21	17	7
Northern Ireland	26	22	14
Wales	22	13	6
Total UK	21	18	7

Source: Ofcom/operators

3.39 Figure 17 shows how the modem sync speeds achieved depends upon the type of geographical location within each of the nations and how only around 15% of rural users have speeds over 10 Mbit/s compared to their urban counterparts whereby 64% of users attain this speed.

[38] http://stakeholders.ofcom.org.uk/binaries/research/broadband-research/may2013/Fixed_bb_speeds_May_2013.pdf

Figure 17 – A comparison of the percentage of lines which receive a given modem sync speed in rural and urban areas[39]



Source: Ofcom/operators

<u>Data use</u>

3.40 As in last year's report, we are using the amount of data downloaded and uploaded by customers (together with the number of customers) as a proxy for the capacity of the networks. We do however recognise that other factors, such as traffic management policies and data caps, can vary the relationship between demand for data and network capacity (see Section 7 for more details on traffic management techniques).

3.41 Figure 18 summarises data use across residential fixed broadband connections. The average data usage per connection for June 2013 was 30GB. This is an increase of 20% from our previously reported figure of 23GB in June 2012.

39 Speeds Over 30Mbit/s appear graphically as 30.

Figure 18 – Fixed broadband data use

	June 2012	June 2013
Active broadband connections	20.6million	21.7million
Total data uploaded/downloaded	484,000,000 GB	650,000,000 GB
Data per connection	23GB	30GB
Percentage of data transferred between 6pm and midnight (peak usage hours)	34%	31%

Source: Ofcom/operators

How big is a GB?

- **1 Kilobyte (KB) – A single page text document is 10KB**
- **1 Megabyte (MB) – A song download is 4MB**
- **1 Gigabyte (GB) – A two hour film downloaded from iTunes is 1.5GB**
- **1 Terabyte (TB) – 1TB will hold 2000 copies of the Encyclopaedia Britannica**
- **1 Petabyte (PB) – Over 13 years of HD video content**

(These are approximations; as the size of a media file will depend on other factors such as the compression standard used and (for video content) the output frame size.)

3.42 There are slight variations between different parts of the UK (Figure 19). In large part this reflects the variation in average connection speeds, which are in turn linked to availability and take-up of superfast broadband as described above.

Figure 19 – Fixed broadband data use, by nation

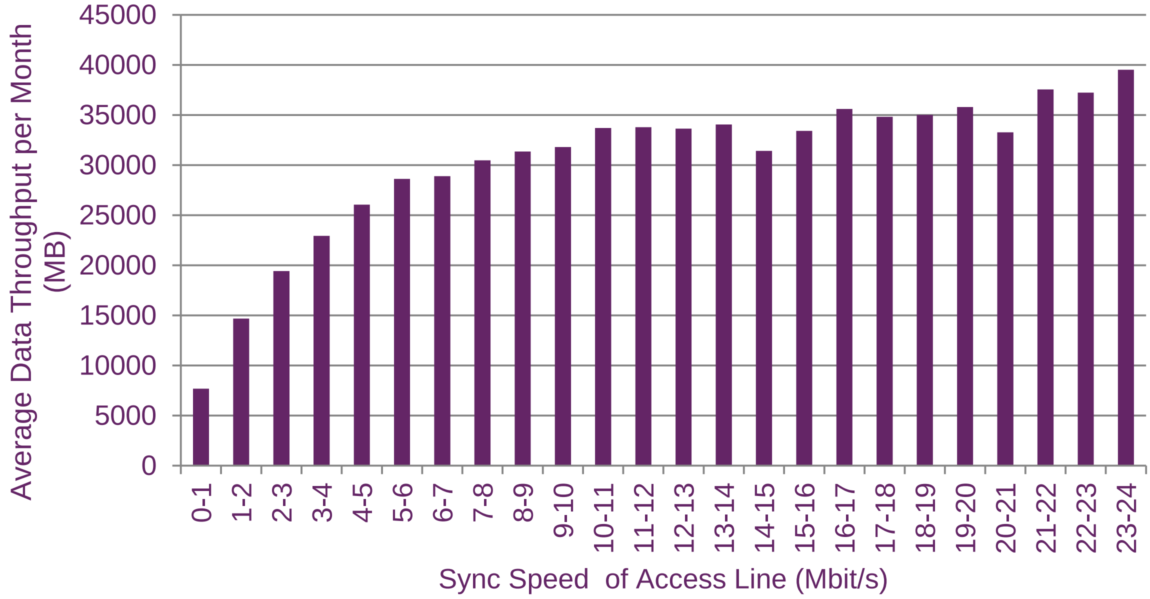
Nations variation in broadband data traffic in June 2012 (Data downloaded and uploaded per connection)		
	June 2012	**June 2013**
England	24 GB	31 GB
Wales	20 GB	26 GB
Scotland	22 GB	27 GB
Northern Ireland	22 GB	32 GB
UK	23 GB	30 GB

Source: Ofcom/operators

Impact of connection speed on data use

3.43 As we highlighted in last year's report, there is a strong correlation between data use and speed of connection on first generation networks. Figure 20 shows the average data use per customer for customers on ADSL2+ connections who have an unlimited data package. Although average data consumption has increased, the profile of use vs. speed is very similar to last year. However the threshold at which data consumption 'plateaus' has increased from around 8Mbit/s to around 10Mbit/s.

Figure 20 – Variation in broadband data use for ADSL2+ customers on unlimited broadband packages grouped by sync speed of the connection



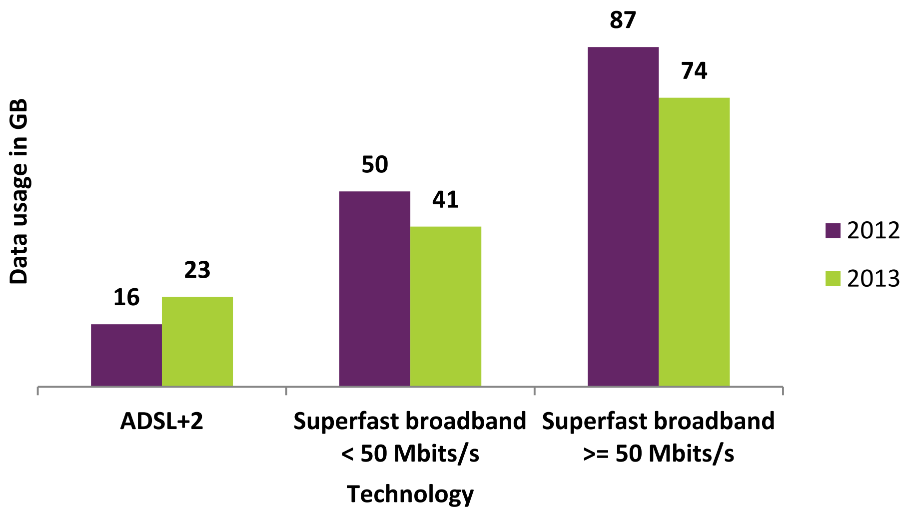
Source: Ofcom/operators

3.44 As we highlighted last year, this finding suggests that Government may wish to review the appropriateness of the 2Mbit/s Universal Service Commitment for the small percentage of premises which will not have access to NGA networks by 2017.

Data use on superfast broadband connections

3.45 In addition to considering the relationship between connection speeds and data use on slower connections, we have analysed data use on superfast broadband connections. In June 2013 the average data use for superfast broadband connections was 55GB. Our analysis suggests that there is a strong correlation between data use and connection speed even for superfast broadband connections.

Figure 21 – Variation in broadband data use on different Technologies year on year



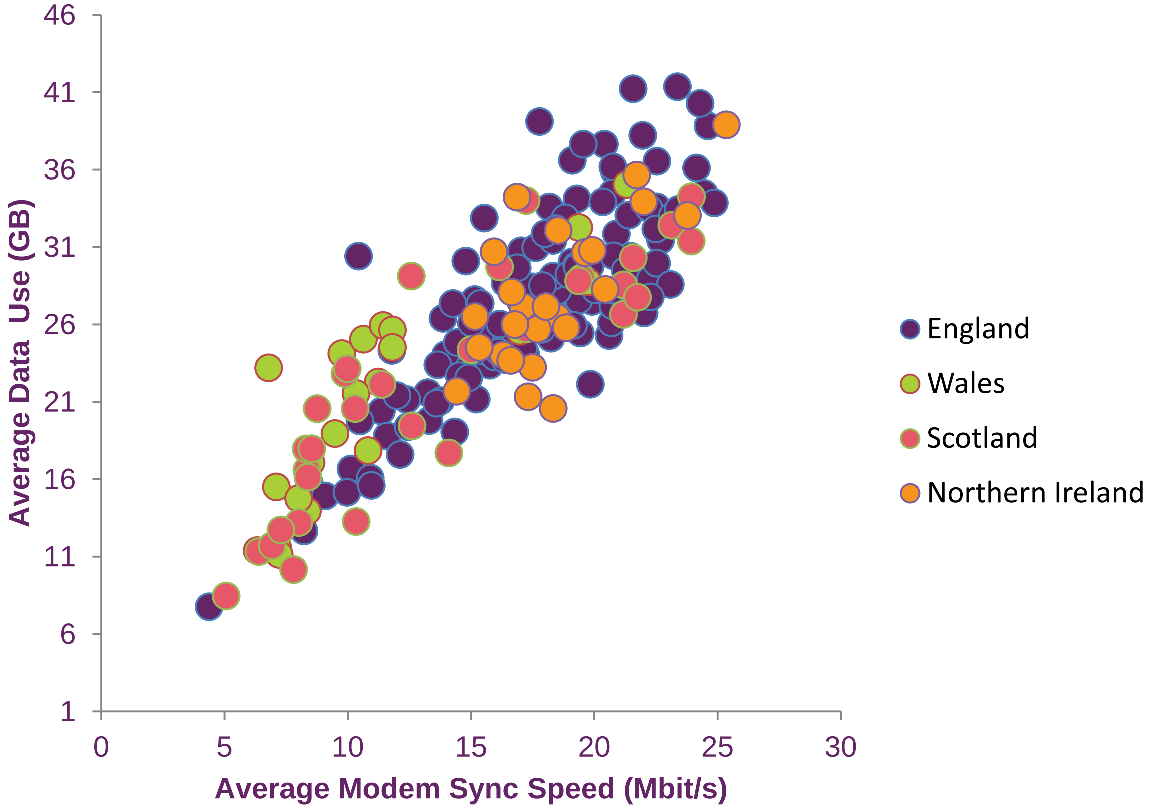
Source: Ofcom/Operators

3.46 Based on the data we collected in June 2012 and 2013, average data consumption on superfast broadband connections appears to have fallen. One explanation is that internet use is affected by various external events, including the weather (during hot spells less people are indoors using their broadband). Cultural and media events may also affect use. Last year the build up to the Olympics and the Jubilee may have resulted in more on-line activity as people accessed streaming video and news sites.

3.47 Another reason why average data use may have fallen is the ‘dilution’ of early adopters with more ‘average’ users. Early adopters are more likely to be heavy users, but as superfast broadband achieves mass market appeal the usage profile of the average users is likely to be lighter. However, it should be noted that whilst the average data use of superfast broadband users has fallen, because of the increase take up of superfast broadband services, total data traffic across networks have increased by over 30%.

3.48 The variation in data use by speed of connection is the primary driver for variation in data use in different local authority areas. Figure 22 shows the average data use in each local authority compared to their average modem sync speed. It can be seen that those local authorities with higher speeds use more data. Each point on the chart represents one of the 200 local authorities that we publish data on.

Figure 22 – Data use vs Average sync speed by local authority



Source: Ofcom/Operators

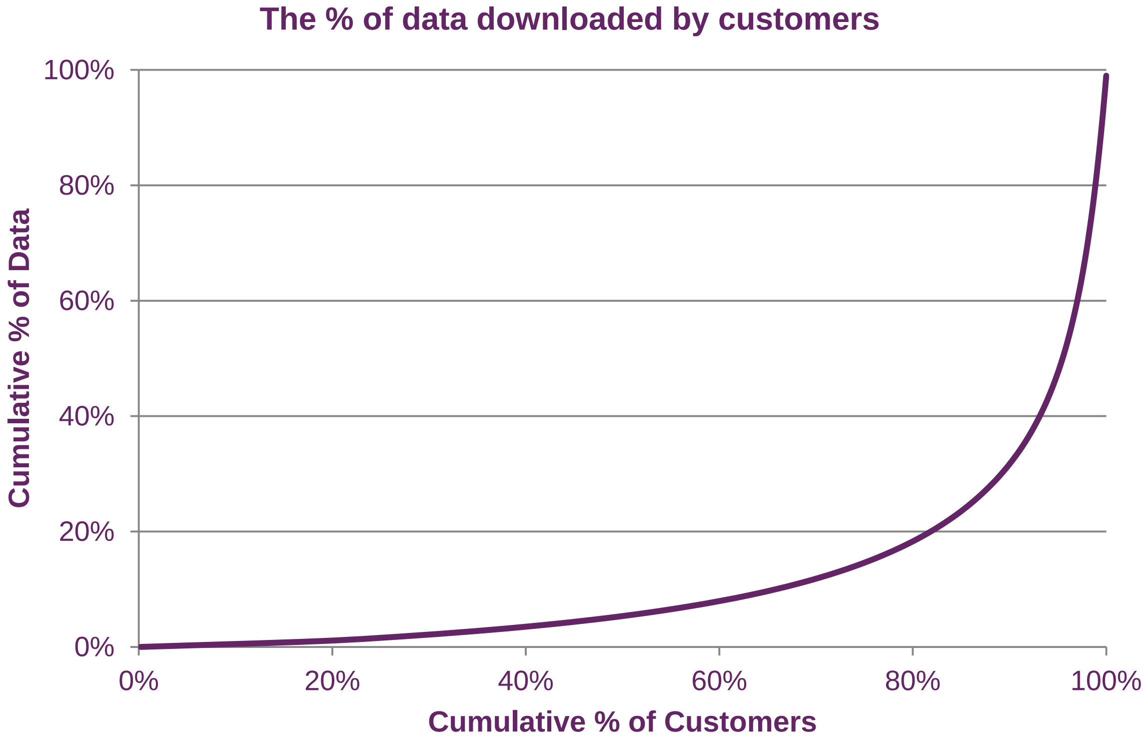
Heavy internet users

3.49 As we reported last year, there are a small proportion of consumers who consume a large proportion of data.

3.50 Figure 23 shows the cumulative data use across customers on uncapped ADSL2+ packages from different ISPs. We find that 5% of customers are using approximately half of the total data, while 50% of customers use less than 5% of the total data. We see a similar profile on other packages.

3.51 We explore how heavy users are using the internet and how this differs from other users in our case study below, using data provided by KCom(KC) .

Figure 23– Cumulative data use across customers on ADSL2+ uncapped packages



Source: Ofcom/operators

Case study: consumer broadband data traffic in Kingston-upon-Hull

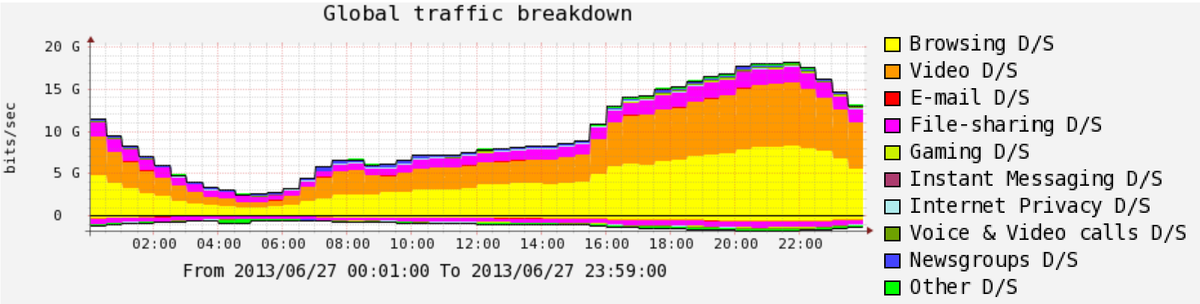
Background

3.52 In order to gain further insight into the characteristics of fixed-line home broadband use, we requested detailed data from KCom (KC), the incumbent fixed telecoms provider for the Hull area. Although home broadband use in Hull may not be wholly representative of use across the rest of the UK, the data enables us to examine how data use varies by time of day, by heavy and light users and by fibre and ADSL users.

Variation of traffic use by time of day

3.53 A challenge for network operators is to provide capacity to meet demand during peak hour, and analysis of data throughput across the whole KC network on a weekday in June (Thursday 27 June) indicates that traffic in the peak evening hours of 8-10pm is more than five times that during the off-peak hours of 4-6am. For KC, as for other ISPs, the focus of network investment is on protecting the network from capacity exhaustion during peak hours. Across the whole day, around 90% of traffic is data being downloaded to users, with the remainder being data uploaded. In the off-peak hours of 4-6am the proportion of uploaded data rises to 18%, primarily due to use of file-sharing, which accounts for 30% of all data uploaded in the off-peak hours (compared to 13% in peak hours).

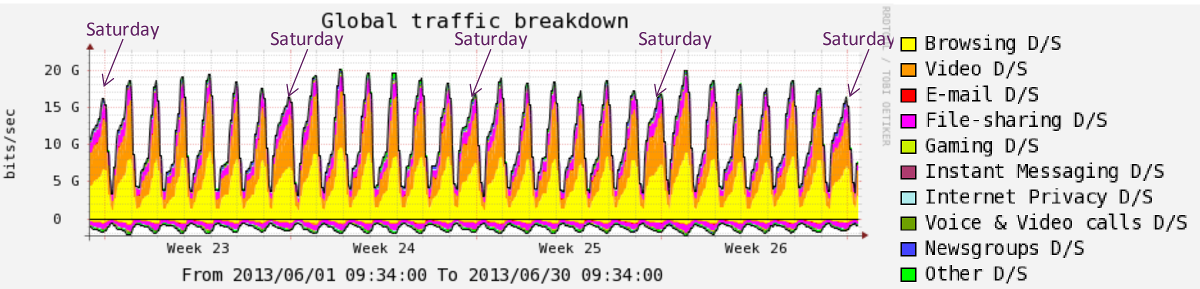
Figure 24 – Traffic by time of day across the KC network, 27 June 2013



Source: KC

3.54 Looking at data for the whole month of June 2013, a similar pattern is evident for each day of the week, with earlier and longer periods of peak use at the weekends.

Figure 25 –Traffic by day of week across the KC network, June 2013



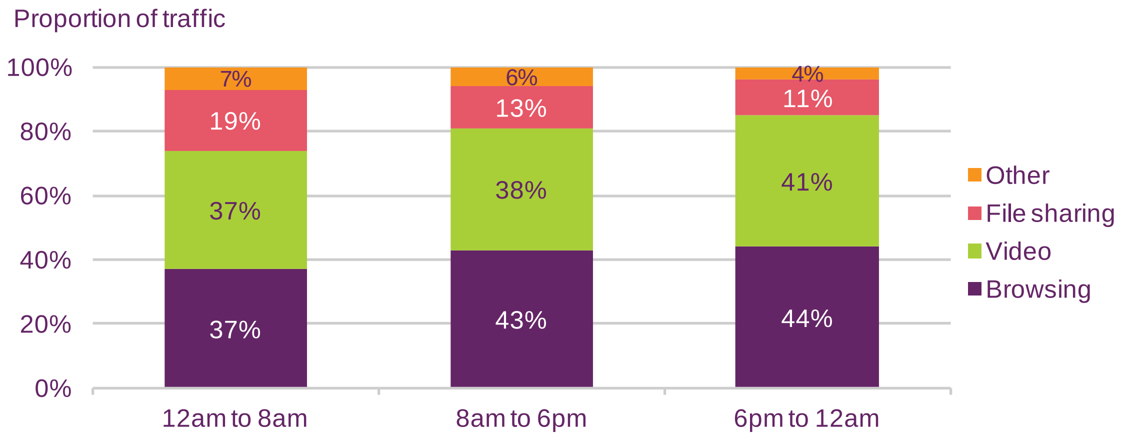
Source: KC

3.55 There were some variations in the type of traffic transferred across the KC network by time of day. Browsing, video and file sharing account for around 95% of total traffic across the whole day, with browsing and video content accounting for 85% of traffic during the evening period (6pm to midnight).

3.56 Increasing demand for video, and in particular long-form video (i.e. television programmes and movies rather than short-form video clips) may be placing increasing demand on consumer broadband networks in peak evening hours. Consistent with traffic mix of all fixed operators, video accounted for 41% of peak hour traffic on the KC network in June 2013, but there are signs that this may increase. According to data from Cisco, across Western Europe as a whole, video traffic as a proportion of all consumer internet traffic increased from 51% in 2011 to 57% in 2012, and in the US video accounted for 74% of all consumer internet traffic in 2012.[40] In next year's Infrastructure Report we will seek to examine how the traffic mix is changing over time.

[40] Cisco Visual Networking Index

Figure 26 – Traffic mix by time of day across the KC network, June 2013



Source: KC

3.57 The evolving traffic mix whereby video is accounting for a higher proportion of traffic makes the use of caching more attractive both for ISPs and for content providers. Peering agreements are also used to manage operational costs. In June 2013 more than twice as much data was interconnected via peering arrangements with content providers rather than (the more expensive) transit, and 23% of data served to consumers was locally cached. We discuss this further in Section 7.

Data consumption by heavy users

3.58 It has always been the case that a disproportionate amount of data traffic is generated by a small number of heavy users, which is why traffic management policies are often targeted at constraining the use of these heavy users, particularly during peak times (See Section 7). However, KC does not apply any traffic management policies to heavy users and so the data provides an insight into the unconstrained demand of these customers.

3.59 Data provided by KC finds that the top 10% of data users account for more than 50% of overall data use. These heavy users account for 47% of data use in the peak evening hours.

Figure 27 – Traffic mix by time of day across the KC network, June 2013

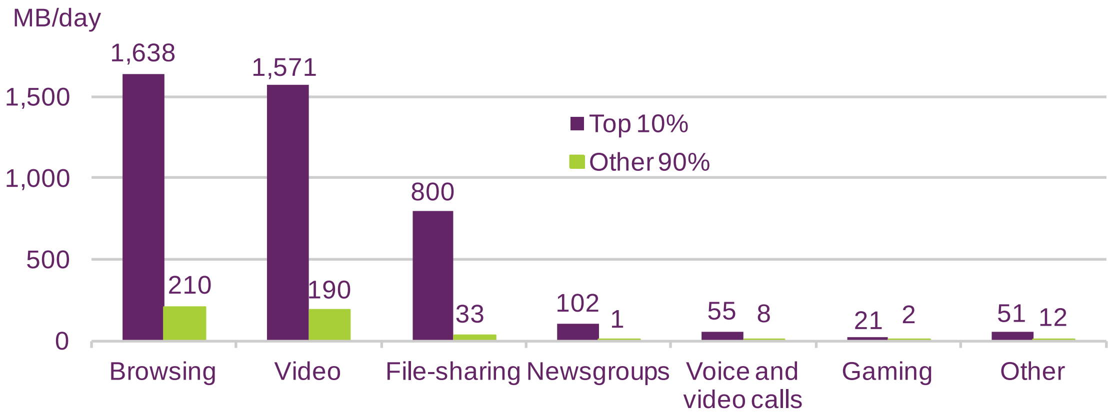
Period	Customer profile	Proportion of data consumption	Average consumption per customer
12am to 8am	Top 10%	63.4%	28.7GB
	Other 90%	36.6%	1.8GB
8am to 6pm	Top 10%	48.8%	49.4GB
	Other 90%	51.2%	5.8GB
6pm to 12am	Top 10%	47.4%	48.9GB
	Other 90%	52.6%	6.0GB

24 hours	Top 10%	50.9%	127.0GB
	Other 90%	49.1%	13.6GB

Source: KC

3.60 The top 10% of data users on the KC network generate a much higher proportion of all types of traffic than other users; however, it is also notable that there are some types of traffic use (file-sharing, newsgroups) where these top 10% of users on average generate more than 20 times as much traffic as the average for the other 90%.

Figure 28 – Average daily traffic use by traffic type, June 2013



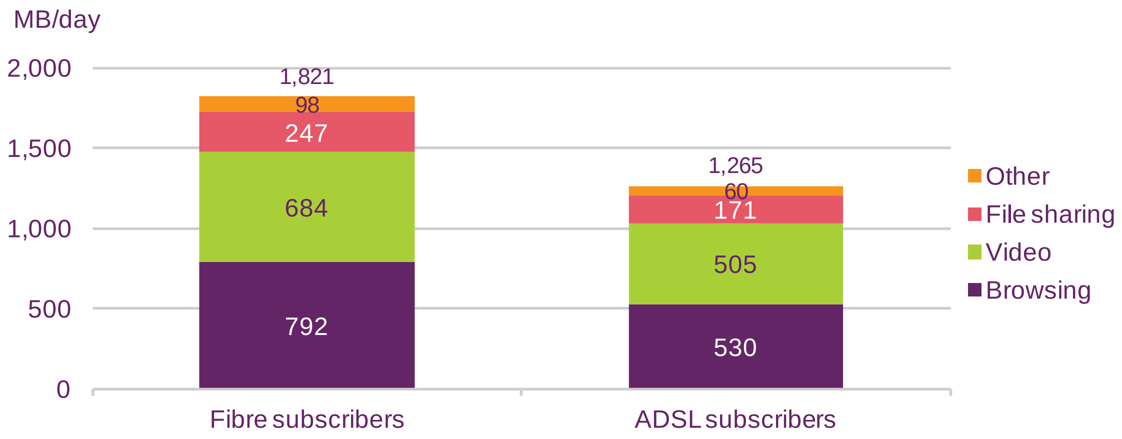
Source: KC

<u>Variations in data usage between ADSL and fibre customers</u>

3.61 As BT has been deploying fibre networks to the rest of the UK, KC has been upgrading its access network to fibre in the Kingston-upon-Hull area, and has deployed a fibre-to-the-cabinet service to 2% of households and a fibre-to-the-premises service to a further 11% of households. Depending on the package selected by the customer these fibre services offer speeds of between 50Mbit/s and 350Mbit/s compared to ADSL services which offer an average speed of around 11Mbit/s.

3.62 Data provided by KC finds that fibre customers on average use 44% more data than ADSL customers. This may be due to the better performance offered by fibre (for example, enabling a consistently good experience for high definition video, and for multiple simultaneously connected devices in the same household). However, it may also be the case that heavier users are more likely to have opted for a fibre service, which costs an additional £5 a month from KC. Average browsing traffic generated by fibre subscribers was 49% higher than for ADSL subscribers, and average video traffic – where it might be expected that fibre connections would provide a superior consumer experience – was 35% higher for fibre subscribers.

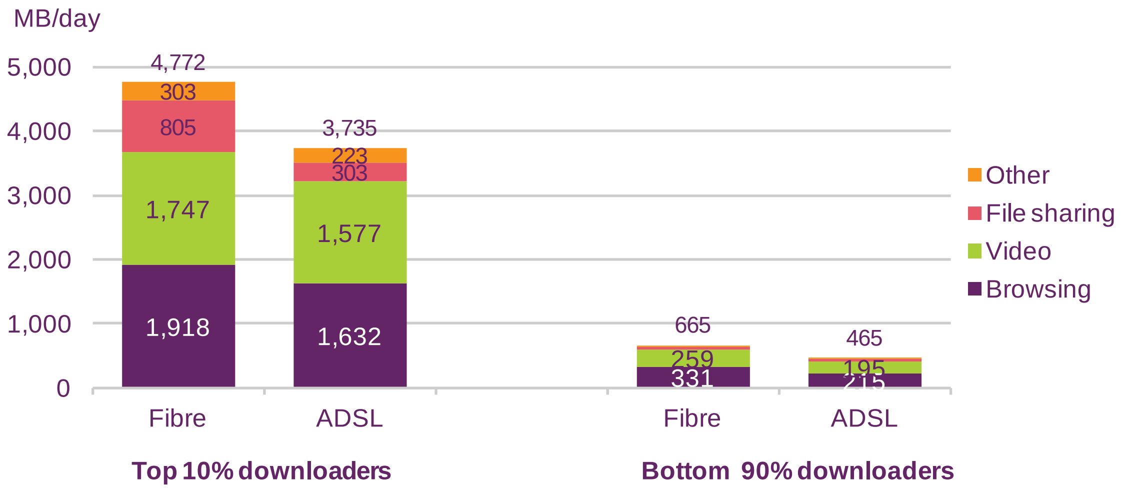
Figure 29 – Average daily data consumption, June 2013



Source: KC

3.63 Although fibre connections typically use more data, some ADSL customers are amongst the heaviest users. There are only comparatively small differences in the amount of data consumed by heavy fibre users and heavy ADSL users. In June 2013, the top 10% of fibre users consumed 28% more data on average than the top 10% ADSL users. Differences were more marked for the lower 90% downloaders, where fibre customers used 43% more data on average than ADSL customers.

Figure 30 – Average daily data consumption by heavy and lighter users, June 2013

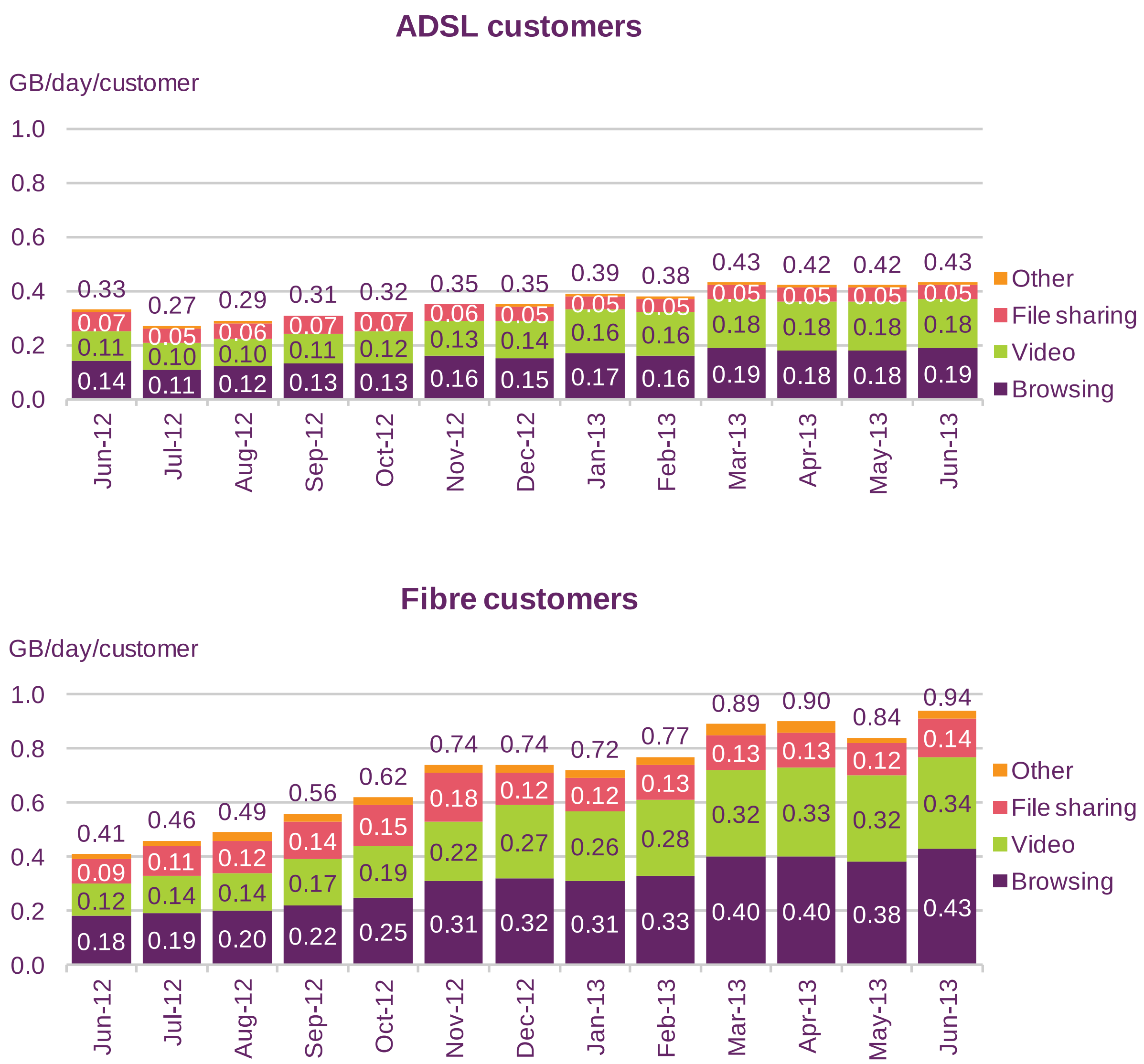


Source: KC

3.64 Analysis of how average data use of KC fibre and ADSL customers changed between June 2012 and June 2013 indicates that fibre customers are increasing their data use significantly faster than ADSL customers. ADSL consumers on average increased their peak-time (6pm-12am) use by over 30% in the year – KC report that this pattern of increase has been observed for several years. However, average peak-time data use among fibre customers more than doubled in the same period, with video use nearly tripling. This could indicate that fibre customers have gradually changed their behaviour to exploit the higher bandwidth available – for example by getting into the habit of using their internet connection to watch on-demand television programmes or films.

3.65 This tentative conclusion seems to be supported by KC's mix of interconnect traffic (the "upstream elements" of the Internet) where the 73%/15%/11% split between CDN/Transit/Peering respectively is at the top end of fixed network CDN usage[41]. More evidence is needed before firm conclusions can be drawn, and it will be interesting to monitor data use and consumer behaviour in the coming years to identify the extent to which widespread take-up of superfast broadband will result in sizeable shifts in the type and frequency of internet use.

Figure 31 – Average daily data downloaded in peak hours (6pm-12am), June 2013



Source: KC

[41] See section 7 for more general analysis of this issue.

Traffic Mix on Fixed Networks

3.66 For the first time, we asked operators to help us understand the proportion of total data associated with various applications accessed by consumers. Video and streaming applications are dominant traffic types in consumer application mix in the data we have collected, contributing to around 44% all internet traffic on fixed networks as shown in Figure 32. This is in line with Cisco's estimates[42] of consumer internet video traffic contributing 40% of all consumer internet traffic on fixed networks.

Figure 32 – Traffic mix on Fixed Networks, June 2013

Traffic Type	% Data downloaded
Video including streaming applications	44%
Web browsing	27%
Peer to Peer including Bit torrent applications, file transfers, new groups	19%
Other	10%

Source: Ofcom/operators

International comparisons

3.67 This report focuses on the coverage and capacity of networks and how these vary in different parts of the UK. Making comparisons with other countries is more complex due to a lack of comparable data. Where data is available, it cannot always be directly compared with the data that we collect from operators for this report. To make international comparisons we have therefore turned to third party sources.

3.68 Drawing conclusions from international comparisons is further complicated by the different characteristics of telecoms markets, telecoms infrastructures and population distribution. For example:

- In the UK and in Germany the typically relatively short lengths of the copper telephone line between a user and the street cabinet has made FTTC viable for delivering superfast services to large proportions of the population, whereas in France longer line lengths and the nature of competition has lead to early deployment of FTTP in cities, and FTTC has only recently been introduced.

[42] http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-481360.pdf

- In Japan, one of the contributory factors to early roll-out of fibre to the building was high population density, with installation costs per household lower than in other countries because of the predominance of people living in multiple-dwelling units.

- In Australia, the Government's National Broadband Network - a national wholesale-only, open-access data network – set out to bring FTTP to 93% of the population by 2021. This early intervention in the market has resulted in a different pattern and timetable of broadband investment than in countries where broadband deployment is driven by the commercial considerations of individual telecoms operators.

3.69 The UK compares favourably with other large European countries in the availability and take-up of fixed broadband services. This is particularly the case for superfast broadband services. Even though BT was only part way through its roll-out of fibre services, the availability of fibre services at the end of 2012 (49%, FTTC and FTTP) was higher than in France, Italy, Spain and Germany[43]. The proportion of broadband connections which were superfast (15%) was also higher in the UK than in the other big-5 EU countries.

3.70 The UK also compares reasonably favourably with the US in superfast services: availability in the UK is lower, largely due to only 48% of households being passed by cable, compared to 97% in the US (with around 82% provisioned for superfast services); however, take-up of superfast services in the UK is higher with 15% of broadband connections at 30Mbit/s or higher at the end of 2012, compared to 12% in the US.

3.71 We use the Cisco Virtual Networking Index to compare data usage across countries, although we note that due to the different methodology this data for the UK is different to that collected by Ofcom for the Infrastructure Report Update. Cisco data finds that IP traffic per capita in the UK (22.4GB in 2012) was more than double that in other European comparator countries, although data usage is much higher in the US (due partly to much higher take-up of over-the-top IP television services in the US, such as those provided by Netflix and Hulu).

Figure 34 – International comparisons: fixed broadband networks

	UK	FRA	GER	ITA	ESP	USA	CAN	JPN	AUS
Broadband availability, end 2012 (% of population)[1]									
- DSL	100%	100%	99%	97%	99%	86%	87%	95%	92%
- VDSL (FTTC)	48%	0%	32%	10%	11%	21%	56%	0%	0%
- Cable	48%	26%	53%	0%	55%	97%	82%	70%	49%
- FTTP	0.7%	21%	3%	11%	18%	18%	5%	91%	3%
Broadband take-up, end 2012[1]									
- Subscribers per 100 households	80	84	69	53	65	75	85	76	68
- Proportion of broadband connections which are superfast (>=30Mbit/s)	15%	5%	12%	5%	10%	12%	9%	-	20%
Broadband usage (2012)[2]									
- IP traffic per capita (GB)	22.4	11.5	11.1	7.5	10.4	40.1	23.7	11.9	14.4

Sources: [1] IDATE and Ofcom; [2]Cisco Virtual Networking Index: http://www.cisco.com/web/solutions/sp/vni/vni_forecast_highlights/index.html

[43] Note that the slightly higher cable services availability in some of these countries means that overall super fast availability may be close to that in the UK.

3.72 Recently, in the context of the European Commission's *Connected Continent* proposals[44], there has been discussion about the different characteristics of the US market and European markets. Comparisons are problematical, not least because of the large variation between national markets in Europe. However, a few general conclusions are evident regarding fixed broadband availability and take-up:

- The US has much higher availability of cable broadband, which is the legacy of cable being the leading television platform. The relatively low cost of upgrading these analogue cable networks to the DOCSIS standard which supports superfast broadband means that there is high availability of superfast cable broadband in the US.

- High cable availability in the US has led to infrastructure-based competition between local incumbent telcos and local cable companies. Faced with the need to compete with cable operators for the delivery of triple-play services (phone, broadband and pay-TV), telcos such as AT&T and Verizon were relatively early to invest in superfast networks, although the rate of investment has now slowed.

- By contrast, in Europe fixed-infrastructure competition is less common, so to promote competition regulators have required that incumbent telcos provide wholesale access to their networks, thereby ensuring competition in retail markets (for example, in the UK, Sky, TalkTalk and BT Retail are among those competing to deliver broadband over BT's infrastructure).

- These different market structures have led to different patterns of superfast investment. Local duopolies in the US have driven early investment in fibre, but while investment has been slower in Europe there are signs that it will catch up as networks are built to meet the demand for superfast services. The availability of cable networks is likely to remain higher in the US for the foreseeable future, but by the end of 2012 the availability of FTTx in the UK (around 49%) was higher than in the US (around 39%), and Germany was only narrowly behind (around 35%). Investment in FTTx networks has slowed in the US, while it continues apace across much of Europe.

- Different markets structures have also contributed to differing levels of take-up. Perhaps due to higher levels of retail competition (in contrast to infrastructure-based competition between local duopolies in the US), broadband and triple-play prices are typically lower in the Big-5 European countries than in the US.[45]

- Household broadband take-up is higher in the UK and France than in the US, and the take-up of superfast services across the big-5 EU countries is comparable to that in the US, despite much higher availability in the US. This may be due to the prevalence of speed-based pricing in the US, where a significant premium is typically charged for superfast services.

- A consequence of speed-tiered pricing in the US is that a much larger proportion of fixed broadband connections are at speeds of 2Mbit/s or less than in Europe: based on data collected for Ofcom by IDATE, 21% of fixed broadband connections in the US at the end of 2012 were at a headline speed of 2Mbit/s or less, compared to just 8% of connections across the UK, France, Italy, Germany and Spain.

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[44] http://ec.europa.eu/digital-agenda/en/connected-continent-single-telecom-market-growth-jobs
[45] Ofcom, International Communications Market Report 2012, Comparative International Pricing, http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr12/icmr/ICMR_Section_2.pdf

- The prevalence of lower speed products in the US has resulted in lower average speeds by technology in the US than in Europe. SamKnows has conducted research on the performance of broadband in the EU and in the US and finds that average speeds for ADSL broadband, cable broadband and fibre broadband are higher across European Union countries. However, higher cable take-up in the US means that it is likely that average broadband speeds across all technologies are higher than in Europe.[46]

Figure 33 – Broadband average actual download speeds by technology, March 2012[47]

	DSL	Cable	Fibre(including VDSL)
EU	7.2 Mbits/s	33 Mbits/s	41 Mbits/s
US	5.3 Mbits/s	17 Mbits/s	30 Mbits/s

3.73 Ofcom's annual International Communications Market report benchmarks communications services in the UK against those in other countries. The 2013 edition is scheduled for publication in December and will include more data on how the UK's fixed-line infrastructure compares with that in other countries.

Conclusions

3.74 With NGA networks now available to almost three quarters of UK homes, plans in place to extend this to 95% by 2017 and a Government ambition of 99% soon thereafter, prospects for near universal availability of superfast services are good, although the precise date by which this achieved is difficult to predict at this stage. However, we expect it to be significantly before the target date of 2020 which has been set by the European Commission, with many of the most rural households seeing improved availability between 2015 and 2017

3.75 Take-up of superfast services is encouraging, and as NGA network coverage increases, competition between retail ISPs intensifies and consumers demand higher speeds to meet their growing needs, we expect growth to remain strong – which will result in average broadband speeds in the UK increasingly rapidly,

3.76 Superfast customers are doing more on the internet, and with content providers delivering higher quality video feeds over faster connections, superfast broadband customers are using significantly more data than those on slower lines.

3.77 This growing demand for data has implications for the investment in backhaul network and how ISPs choose to interconnect to content providers, particularly high quality video services. We explore this further in section 7.

[46] Although not directly comparable with the data collected by SamKnows, Akamai data on the speed of internet connections making requests to it Servers finds that in Q1 2013 the average speed of connection in the US was 8.6Mbit/s, compared to 7.9Mbit/s in the UK and 5.9Mbit/s across the EU5, http://www.akamai.com/stateoftheinternet/

[47] European Commission, Quality of Broadband Services in the EU, March 2012, http://ec.europa.eu/information_society/newsroom/cf/dae/document.cfm?doc_id=2319

Section 4

Mobile networks and Wi-Fi

Overview

4.1 There are four Mobile Network Operators (MNOs) in the UK (Everything Everywhere, Telefonica UK (which operates the O2 brand), Three and Vodafone) providing services using a variety of mobile technologies. The last twelve months have seen the introduction of 4G networks[48] providing a faster data service to consumers, joining 2G and 3G networks (which provide voice and slower data services). EE was the first network to offer these services, in October 2012 and Vodafone and O2 launched their services at the end of August 2013. Three is due to launch its 4G services in December 2013.

Consumer Context

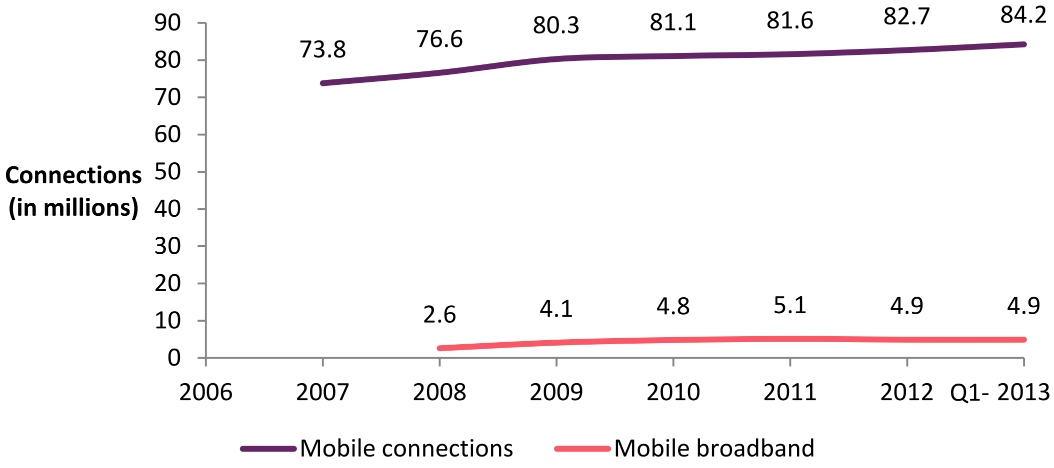
4.2 Use of mobile services is widespread among consumers; consumer research in Q1 2013 found that 94% of UK adults used a mobile phone and 53% of UK adults accessed internet services on their mobile phone[49]. Furthermore, 15% of homes are mobile-only for telephony. There has been increasing take up of smartphones; smartphone sales made up almost three-quarters (74%) of handset sales in Q1 2013, when 51% of all UK adults owned a smartphone. Among mobile internet users take-up is even higher, with 96% of users owning a smartphone. Household take-up of tablet computers (such as an Apple iPad or Google Nexus) has undergone an even sharper rise, more than doubling over the past year, rising from 11% in Q1 2012, to 24% in Q1 2013.

4.3 The number of mobile subscribers has continued to increase; however there has been a small decrease in the number of mobile broadband subscribers (i.e. consumers using a mobile ‘dongle’ to connect their PC to the internet via a cellular network).

[48] In the UK, operators are rolling out 4G networks using a new mobile technology called Long Term Evolution (LTE)

[49] Data from 2013 CMR, Fig 4.3, p261

Figure 35 - Mobile connection, by type: 2007- 2013



Source: Ofcom/Operators

4.4 Public Wi-Fi hotspots are also playing a vital role in complementing mobile networks for data services, and there has been a growing trend for metro public Wi-Fi access services as more and more councils have been providing public Wi-Fi either for free or for a subscription fee. Examples include those in Blackpool, Bristol, Newcastle County Down (NI), Norwich, Manchester, Brighton & Hove and City of Westminster.

Coverage

4.5 We continue to track the coverage of mobile networks in the UK. As in previous years, we have considered two measures of coverage: premises coverage and geographic coverage. For the first time, we are also reporting on the coverage on motorways, and A and B roads, to illustrate the likely coverage for consumers on the move. Note that because consumers use their mobile phones in a variety of different circumstances there is no one measure which completely reflects the consumer experience. Nevertheless, we believe that the metrics we have adopted provide useful comparators of mobile experience in each local authority area.

4.6 We have based our analysis of coverage on Mobile Network Operators' predictions from computer models, assuming a signal strength that should be sufficient to make or receive a call outdoors. Accurately predicting mobile reception for a specific location and handset is complex, due to the effects of local geographic features and buildings, signal loss into buildings and variations in handset performance. As a result, while the predictions provide a useful indication of coverage, they will not be accurate in every case.

4.7 We have updated the interactive maps on our website, displaying the metrics for 2G and 3G networks for local authorities across the UK. The maps are available at http://maps.ofcom.org.uk/mobile-services/.

4.8 As in last year's Infrastructure Report Update we have selected to report based on two simple metrics:

- the percentage of geographic locations and the percentage of premises that do not have coverage from any operator (these are complete 'not-spots'); and

- the percentage of geographic locations and the percentages of premises that are covered by all operators.

4.9 These two metrics provide a useful upper and lower bound for mobile network availability in a local authority area.

4.10 A summary of coverage for each of the UK nations is shown in Figure 36.

Figure 36 - Mobile coverage (based on predicted coverage)

Mobile Coverage on Geographic coverage and premises								
	2G				3G			
	Geographic coverage		Premises coverage		Geographic coverage		Premises coverage	
	no signal from any operator	signal from all operators	no signal from any operator	signal from all operators	no signal from any operator	signal from all operators	no signal from any operator	signal from all operators
England	4.6%	72.8%	0.2%	95.2%	6.0%	32.7%	0.5%	82.6%
Scotland	26.2%	41.7%	0.7%	91.9%	50.5%	4.9%	3.4%	69.8%
Northern Ireland	8%	56.5%	1.5%	81%	13.3%	16.7%	2.6%	62.9%
Wales	15.7%	52.8%	1.2%	87%	21.9%	11.49%	2.3%	58.4%
UK	12.7%	62.4%	0.4%	94.1%	22.9%	21%	0.9%	79.7%

Source: Ofcom / operators

4.11 As noted earlier, we are reporting on coverage on roads for the first time, and we intend to track coverage on roads in future reports. Figure 37 below shows that, while there is generally good coverage on motorways, significant complete and partial not spots remain on A and B roads particularly for data services using 3G.

Figure 37 - Mobile coverage on Roads (based on predicted coverage)[50]

Mobile Coverage on Roads	2G				3G			
	Motorways		A&B Roads		Motorways		A&B Roads	
	no signal from any operator	signal from all operators	no signal from any operator	signal from all operators	no signal from any operator	signal from all operators	no signal from any operator	signal from all operators
England	0%	99%	1%	88%	0%	78%	3%	50%
Scotland	0%	99%	8%	65%	0%	58%	28%	15%
Northern Ireland[51]	N/A	N/A	6%	63%	N/A	N/A	10%	21%
Wales	0%	97%	7%	66%	0%	79%	11%	20%
UK	0%	99%	4%	77%	0%	76%	9%	35%

Source: Ofcom/Operators

2G coverage

4.12 The data shows that 2G mobile not spots by premises appear to have increased slightly by 0.3 percentage points to 0.4 % over the last year. The main cause for this is the apparent reduction in 2G coverage by one of the operators. We are currently investigating whether this reduction is due to changes in the way this operator models coverage, but has not affected the actual coverage experience by consumers, or whether there has been a material affect ‘on the ground’, for example, due to a reduction in the number of 2G masts.

4.13 UK Motorways are well served by 2G networks, with coverage from all networks on virtually all stretches of motorways. The large majority of A and B roads and roads in Northern Ireland are served by at least one operator, and as a result motorists that need to make an emergency call will be able to do so in most circumstances[52]. Coverage from all operators is, however, lower. These ‘partial notspots’ can result in motorists passing in and out of coverage – so even when overall coverage of a road is good, motorists trying to maintain a call when travelling may experience dropped calls.

3G coverage

4.14 Both geographic and premises coverage of 3G networks continues to be lower than for 2G networks. This is partly due to the propagation characteristics of the

[50] Road coverage refers to the percentage of road length that is served.
[51] In Northern Ireland a different set of road classification has been used to the rest of the UK.
[52] When making an emergency call in an area where a customer’s home network is not available the handset will connect to any available network.

frequencies used for 3G networks which means that the signals do not travel as far as the frequencies used for 2G networks, and require more mobile masts to provide equivalent coverage to 2G networks.

4.15 While the proportion of UK premises without signal from any operators has not changed significantly since last year, there has been a small improvement in the proportion of UK premises with 3G coverage from all operators, up from 77.3% in 2012 to 79.7% to 2013. Northern Ireland has seen the biggest improvement in the reduction of complete not-spots (i.e. where there is no coverage from any operator) falling from 11.7% of premises to 2.6% of premises, in part due to investments made by EE and Three over the last year (see 4.23).

4.16 The interactive maps on our website provide further statistics, on a local authority basis, for population and geographic coverage. As in 2012, we have also provided data on the percentage of geographic area and premises that are served by zero, one, two, three (and four for 3G) operators and this is available for download from our website. We intend to include statistics on road coverage by local authority in next year's report.

4.17 There is generally good 3G coverage on the motorways in each nation: all have coverage from at least one operator. 3G coverage on A and B roads is not as good, particularly in Scotland where 28% of A and B roads do not have 3G coverage from any operator, and only 15% of these roads have 3G coverage from all operators. There are a number of reasons why 3G coverage on A and B roads in Scotland is not as high as elsewhere in the UK, these include its size and that it has the highest proportion of rural geographic area in the UK[53]. Therefore its A and B roads are more likely to be serving less densely populated parts of the country with fewer users and hence are areas which are more expensive per capita to roll out mobile infrastructure.

4.18 Ofcom is continuing to support the Government's Mobile Infrastructure Project, which is aimed at improving mobile coverage and the quality of coverage in the UK[54]. The Government has committed £150m to secure mobile voice services for up to 60,000 premises that currently do not receive any mobile service from any operator (approximately 75% of total not-spots) and to improve coverage on at least ten of the UK's busiest A roads. The rollout programme has started with the rural North Yorkshire village of Weaverthorpe[55]. The first of these masts went live in mid September providing service to 200 premises in what was previously a complete not-spot.

Coverage on Trains

4.19 We have not collected data on coverage on railways for this report. This is in part due to the complexities faced by operators in accurately predicting track side signal levels because of the unpredictable impact of cuttings and tunnels on signal propagation. Even where track side signal is strong, some types of train carriage can significantly degrade the signal and prevent reliable service.

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[53] Table 1 from the report on availability of communications services in the UK http://stakeholders.ofcom.org.uk/binaries/research/markets-infrastructure/economic-geography.pdf

[54] http://www.culture.gov.uk/what_we_do/telecommunications_and_online/8757.aspx

[55] https://www.gov.uk/government/news/first-homes-benefit-after-government-investment-to-improve-mobile-coverage-nationwide

4.20 In recognition of the challenge of delivering reliable voice and data services on trains the rail industry has announced plans to roll out high speed mobile broadband on the busiest parts of Britain's rail network by 2019. This will require upgrades to existing track side infrastructure as well as equipment on trains.

Signal coverage and quality of experience

4.21 As we note above, coverage is not the only factor which affects the ability to make a call. Network loading, device choice and exact location can also play a part. Providing uninterrupted coverage on trains and roads is further complicated by the speed at which vehicles pass between cell sites and areas of unpredictable and intermittent high demand can be created by traffic jams on main roads.

4.22 In recognition that consumers ultimately care about the 'quality of experience' when using mobile services, in 2014 we will be undertaking further work to better understand and measure the actual experience delivered by the mobile operators.

4.23 There are a number of metrics that are typically used by mobile operators to quantify quality of experience. For voice calls the percentage of calls that are 'blocked' and 'dropped' are key metrics, as well as the sound quality of the call. For data services, the likelihood that a data connection can be established and the speed and responsiveness of the connection are important to consumers. We will be exploring which metrics are the most relevant to consumers and we plan to include results of our work in this area in next year's report.

3G coverage improvements in Northern Ireland – investment by EE and Three

4.24 Improved mobile coverage in Northern Ireland follows investment in mobile network infrastructure by some of the mobile network operators.

- Three has spent £12m since February 2012 in improving its network infrastructure, increasing the number of mobile sites to 400 and now covering 95% of the population[56]; and

- EE has invested £37 million in upgrading its network to upgrade the existing 2G and 3G services and to facilitate the rollout of 4G services across Northern Ireland.

4.25 EE provided details to Ofcom on its network upgrade in the Northern Ireland which has involved increasing the total number of masts on the EE network from 380 to 428.

4.26 New 2G equipment is being installed across the network to improve network efficiency and provide better call reliability, and 3G coverage is increasing as new transmitters are added to existing masts. By September 2013, 386 of the 428 sites were 3G activated, with planned 3G activation of all sites by the end of 2013. The upgrade programme will increase EE's overall 3G outdoor coverage in Northern Ireland from 62% population coverage to 95%. DC-HSDPA (Dual Carrier High Speed Downlink Packet Access; see below for explanation of this technology) provisioning increases the speeds available to consumers, while capacity has been increased with an upgrade in backhaul.

[56] http://www.mobiletoday.co.uk/News/26514/12m_boost_for_Threes_Northern_Ireland_network.aspx

4.27 EE also launched 4G services in Belfast in December 2012, and double-speed 4G services were launched in July 2013. In September 2013, 39 EE sites were 4G-activated, providing 28.5% population coverage in Northern Ireland. The provision of 4G services entails upgrading existing sites rather than the construction of new sites and involves deploying new antennas, and upgrading backhaul.

Case study: Three's upgrade of its 3G network to DC-HSDPA

4.28 Upgrades to 3G networks can offer significantly improved data speeds without the requirement for additional spectrum. Three will be the last of the UK's four mobile operators to commercially offer 4G services, with launch planned before the end of 2013. However, it has upgraded much of its 3G network to DC-HSDPA, which offers speeds significantly higher than earlier 3G technologies (such as HSPA+) and which are in many cases comparable to speeds available by fixed-line ADSL broadband.

4.29 DC-HSDPA doubles the bandwidth that is used to transmit data services to customer's devices from the cell site (the downlink). Previous technologies used a single 5MHz "carrier" to send data to customers; DC-HDSPA is able to use two carriers, or 10MHz, which has the effect of significantly increasing the speed at which customers can download data because the pipe is twice the size. Sometimes referred to as 3.9G or 3G Turbo, Three has been marketing its DC-HSDPA roll-out as part of its ultrafast campaign.

4.30 Three began large-scale roll-out of DC-HSDPA in March 2012. As a result of earlier investments in the latest 3G site hardware and high speed backhaul, DC-HSDPA could be rolled out without the need for physical changes to cell sites. By September 2012, Three's DC-HSDPA services were available to around 84% of the UK population, with over 90% of the population scheduled to be covered by the time the upgrade programme completes at the end of 2013. Three claims to be the most advanced of the UK MNOs in upgrading to DC-HSDPA, although Everything Everywhere, Vodafone and O2 also offer DC-HSDPA services in some areas.

4.31 An increasing number of devices support DC-HSDPA services, including handsets and tablets from Apple, Samsung, Nokia, Sony, HTC and LG.

4.32 The theoretical maximum speed of DC-HSDPA is 42Mbit/s (compared to maximum theoretical speeds over single carrier HSPA+ deployments of 21Mbit/s). However, factors such as the type of device being used, other data traffic on the network and the location of the user in relation to the cell site make it unlikely that customers would receive this speed. Three reports that in locations where it has excellent coverage users of mobile broadband dongles may see speeds of around 17Mbit/s and mobile phone users around 8Mbit/s, and its measured average speeds across a range of conditions exceed 5Mbit/s.

4.33 DC-HSPDA technologies use existing spectrum more efficiently and by aggregating radio channels can offer higher peak speeds, but unlike the roll out of new 4G services in new spectrum, they do not result in a step change in overall capacity.

4G coverage

4.34 2013 has seen the introduction of 4G services in the UK, which are capable of delivering faster mobile data services.

4.35 EE launched its 4G services in late 2012 reusing spectrum which had been previously used for 2G services. As of September 2013, the services were available in 117 towns and cities across the UK, covering 60% of the population.

4.36 In April 2013 Ofcom ran an auction for additional spectrum to support 4G services, and all four UK mobile operators were awarded spectrum as a result of this process. BT was also awarded spectrum.

4.37 Both O2 and Vodafone launched their 4G services over the summer, with Vodafone providing services in London and O2 providing services in London, Leeds and Bradford. Both network operators are planning to roll out 4G services in at least ten other towns and cities before the end of the year. Three is due to begin the 4G services in December.

4.38 Under the terms of its licence, O2 is required to roll out 4G indoor coverage to 98% of the UK population by 2017 and at least 95% in each individual nation. We expect that other mobile operators will seek to match O2's indoor coverage commitment, meaning the large majority of consumers will be able to access 4G services in their home. Vodafone has said it intends to achieve similar levels of coverage by 2015[57] and EE has declared that it will achieve 98%[58] premises coverage by the end of 2014. Three has plans to cover 98% of population by end of 2015[59].

Capacity

4.39 As in previous years, we collected data from mobile network operators on the volume of data uploaded and downloaded over their 2G and 3G networks. We use this as a proxy of network capacity demand[60]. This data was gathered from the throughput on mobile transmitters and therefore it includes both residential and business customers. It also includes customers of Mobile Virtual Network Operators.

4.40 Figure 38 compares the number of active connections and data throughput for June 2011, June 2012 and June 2013. Note that although every device which uses a mobile network requires a unique active SIM, not every SIM will be used in a device which is capable of accessing mobile data. Some consumers may only use their mobile phone for voice calls, whilst other consumers may only use their SIM to access data services (e.g. on tablets or 3G dongles for mobile broadband). The analysis in this section considers the average use per active SIM, regardless of whether the SIM is used exclusively for voice or data services or for both. In reality, the average amount of data used by consumers who access mobile data services would be higher.

4.41 The data shows that the rate of growth in the consumption of mobile data across all networks has slowed, with an increase of 48% from last year. The data use per active SIM in June 2013 was 343 MB. This represents a slowing of growth in average

[57] http://www.vodafone.co.uk/cs/groups/configfiles/documents/contentdocuments/vftst044690.pdf
[58] https://explore.ee.co.uk/our-company/newsroom/ee-switches-on-4g-in-12-more-towns; EE has not specified whether this will be indoor or outdoor coverage
[59] http://blog.three.co.uk/2013/08/29/get-ready-for-4g/
[60] For this year's Infrastructure Report update we have only considered the demand for data on mobile networks. We will report on voice in the next full Infrastructure Report in 2014. More up to date information about the volume of telephone calls on mobile networks is available on our website. http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/tables/

mobile data consumption, which more than doubled between March 2011 (110MB) and June 2012 (240MB). Unlike previous years we have not collected data on the throughput on 2G and 3G networks separately but due to the higher capacity of 3G networks, we would expect that the vast majority of data would have been on 3G networks.

Figure 38 – Data use on Mobile networks

	March 2011	June 2012	June 2013
Active connections	81.1 million	81.7 million	84.7 million
Total data uploaded/downloaded	9,000,000 GB	19,700,000 GB	28,900,000GB
Data per active SIM	0.11 GB	0.24 GB	0.34 GB
Percentage of data transferred between 6pm and midnight (peak usage hours)	32%	30.5%	31.0%

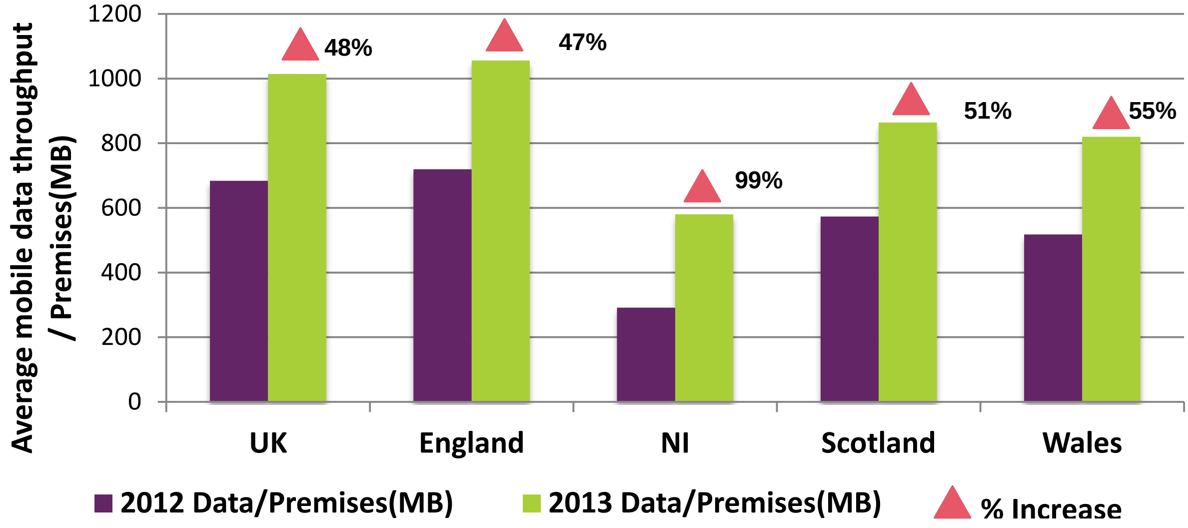
Source: Ofcom/Operators

4.42 The interactive maps published on our website also include a breakdown of the volume of mobile data transferred in different parts of the UK. This is shown at a per premises level (rather than a per SIM connection) as we do not hold data on the distribution of SIMs by geographic area. Mobile subscribers will register with different sites as they use their mobile phone on the move.

4.43 There could be a number of reasons why the growth of mobile data use has slowed. It could be due to congestion in the networks because of increasing use of mobile data or changing consumer behaviour, such as consumers moderating their use of data to fit within the data cap for their package, the increased use of Wi-Fi both in and out of the home or the reducing take up of mobile dongles. It could also be that that the increase in smartphone use in the past year may have been driven by casual users of mobile data. If the increase in mobile data use between 2011 and 2012 was driven by early adopters who tended to use more data-hungry applications, then the slowing growth between 2012 and 2013 could be attributed to less data hungry users.

4.44 Figure 39 below compares the average use of data per household in the UK and in each of the nations. The chart shows that year-on-year increase in average data consumption is highest in Northern Ireland, although it still has the lowest average data use. This growth is likely to be due to improvements to 3G coverage in Northern Ireland.

Figure 39 – Average mobile data use by nation



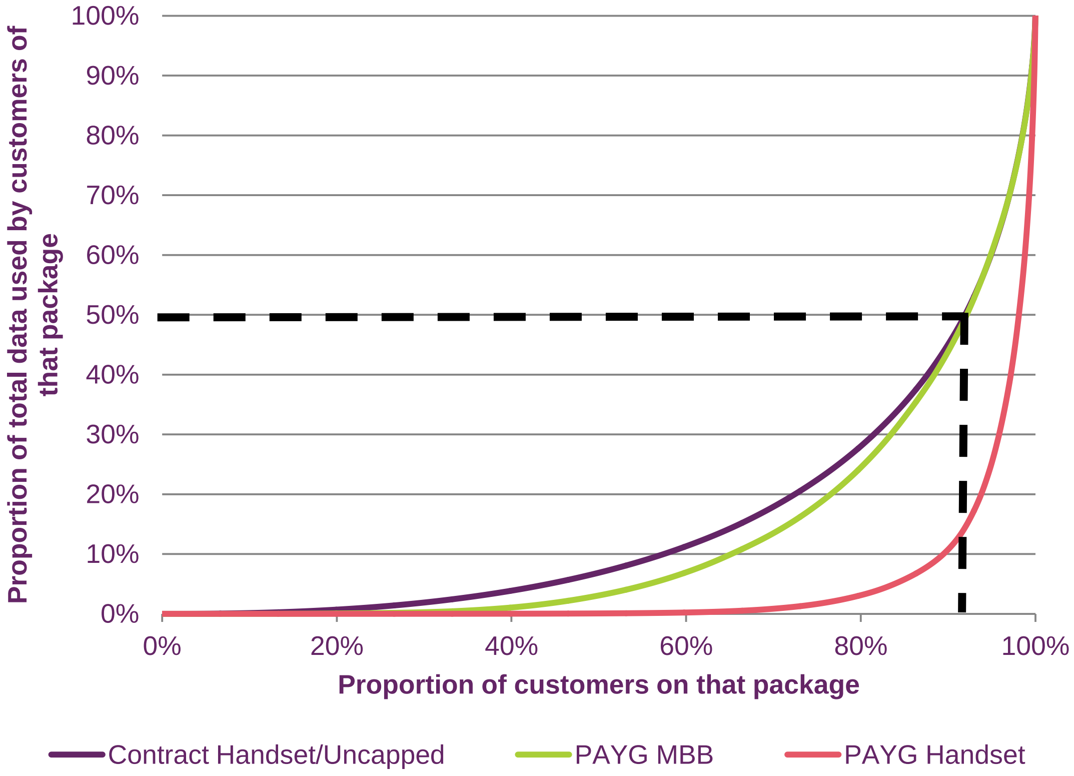
Source: Ofcom / Operators

Distribution of data use

4.45 In the Infrastructure Report Update 2012, we considered the distribution of mobile data consumed by customers on the same package. We found that fewer than 10% of customers within the same mobile package used over half the total amount of data consumed by all customers on that package. However, this also varied depending on the type of mobile package, with a greater variance in the data consumption for pay-as-you-go (PAYG) customers using handsets compared to mobile customers using mobile data on their handsets with a contract or PAYG for mobile broadband.

4.46 Repeating that analysis with similar packages this year suggests that this has not changed, as shown in Figure 40 below.

Figure 40 – Cumulative distribution of mobile data consumption for different types of packages



Source: Ofcom / Operators

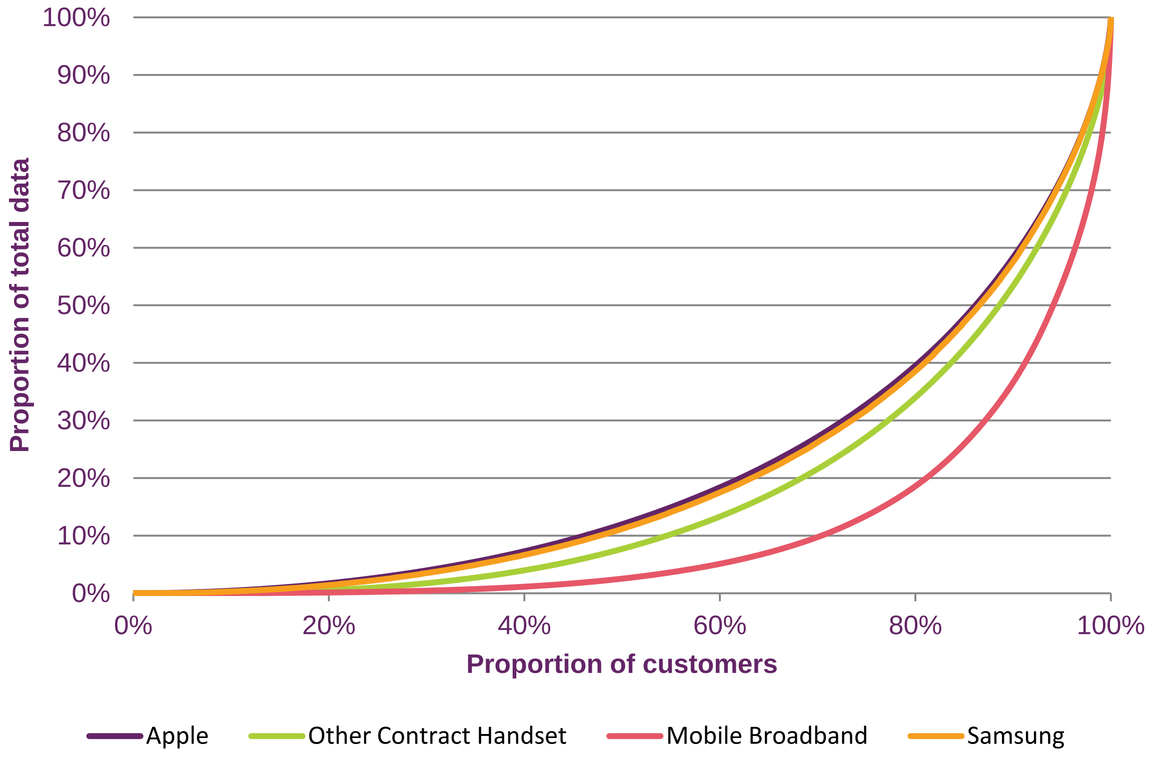
4.47 Over 50% of the data used by customers on a particular mobile package is still being consumed by less than 10% of the customers on that package. Forty- four percent of the PAYG handset SIMs had used less than 1MB[61] in June compared to 7.6% of the PAYG SIMs for mobile broadband. This is not surprising, since PAYG handset SIMs are for both voice and data services and some users may have bought their SIM solely to make mobile calls. Therefore it is very likely that a significant proportion of customers on this package would not need to access data services. On the other hand PAYG (mobile broadband) SIM users will have purchased their SIM solely for using mobile data.

4.48 However, in contrast to the PAYG packages, only 1.0% of handset customers with a contract used less than 1MB in June. This suggests that having an inclusive data allowance might encourage consumers to use mobile data services.

4.49 Figure 41 considers the distribution data use by different types of handsets, based on sample data reported by some mobile operators about customers who were on packages that were specific to a particular brand of handset.

[61] A threshold of 1MB was used to account for those users who may not have accessed mobile data services on purpose. 1MB is smaller than the size of an average webpage.

Figure 41 – Cumulative distribution of mobile data consumption for different types of devices

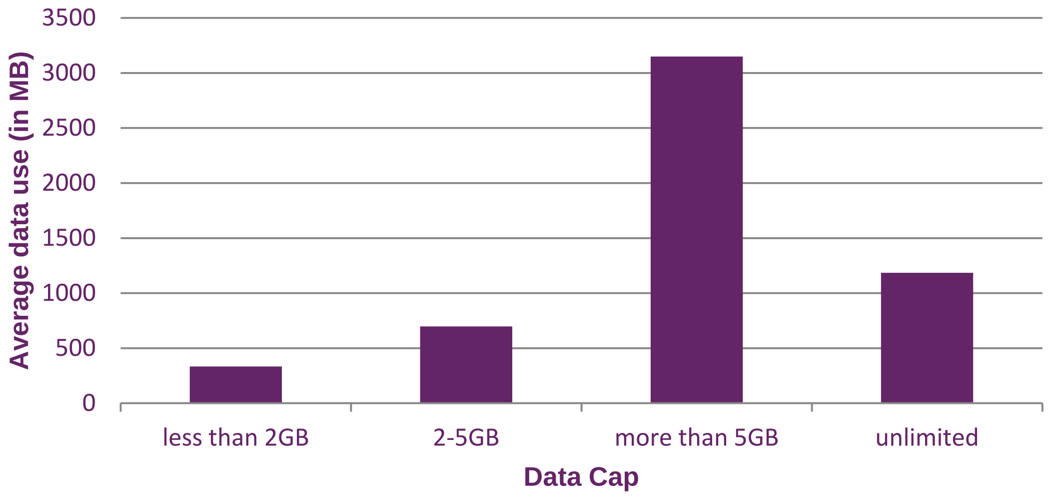


Source: Ofcom / Operator

4.50 Analysing the distribution of data consumption in the same way, it suggests that consumers using high-end smartphones, such as Apple and Samsung handsets, tend to use a similar amount of data, with 15% of the customers using 50% of the total data. In comparison, the data for contract customers with other handsets shows a slightly smaller proportion of customers (12%) using half the total data. The distribution varied the most for mobile broadband customers, where 6% of the customers used half the total data. This could be due to two factors: firstly heavy users of mobile broadband using more data than other customers on that package and secondly a greater proportion of customers on this package using very little data at all.

4.51 Using data provided by mobile operators, we find that customers are typically well within their data caps and that the average amount used by consumers increases with the cap.

Figure 42 – Average data use by customers on different data caps



Source: Ofcom / Operators

4.52 As consumers on unlimited or higher data caps tend to consume more data, we expect total data use in future will increase with increases in data allowance on mobile data packages. Additionally, rollout of faster 4G networks in the UK will also increase data usage on mobile networks as consumers will be able to stream data intensive applications such as HD videos. This is likely to have implications for investment in backhaul capacity from mobile masts and future demand for additional spectrum or the deployment of additional masts.

Case study: use of 4G by EE customers

4.53 In October 2012, EE was the first UK operator to launch a 4G network. By September 2013 it had over one million customers and claimed that its 4G network covered 60% of the UK population. The experience and behaviour of these early 4G adopters provides some insight into how the availability of 4G networks, offering significantly greater speeds and capacity than 3G networks, may change consumer behaviour.

4.54 It may be the case that the higher and more consistent speeds delivered by 4G means that consumers substitute some fixed line broadband use for mobile (EE reports that it has seen average speeds on its 4G network of more than 16Mbit/s and peak speeds in excess of 100Mbit/s). Consumer research commissioned by EE and conducted in May 2013 found that 43% of its 4G customers claimed to use fewer or no public Wi-Fi hotspots since using 4G, and 23% claimed that they needed to use their home broadband less.[62]

4.55 Substantial usage peaks can be created by specific events, for example, on the day of the men’s Wimbledon final (Sunday 7 July 2013) EE reports that 4G data traffic was 20% higher than on any previous day as consumers used their mobile phone to watch the tennis.

[62] 4GEE Mobile Living Index, First Half 2013 Report, https://explore.ee.co.uk/our-company/newsroom/4gee-transforming-britain-into-nation-of-nomadic-sharers-streamers-and-shoppers

4.56 The use of 4G for video streaming is changing the traffic profile. EE reports that streaming is predominantly an evening activity, whereas web browsing peaks during commuting times and lunchtime. Use of video streaming in the evening is particularly a characteristic of those with 4G tablets; 25% of traffic for 4G customers using an iPhone 5 is video streaming compared to 39% of the traffic for 4G customers using an iPad.

4.57 EE's 1GB (£41/month) price plan was its most popular tariff in June 2013 and its 3GB (£46/month) plan the second most popular. In the same month, 75,000 data passes were purchased, enabling users to top-up on their monthly allowance, of which 48% were for the lowest price of £6 for the 500MB booster.

High speed broadband in rural areas using 4G networks – case study

4.58 It is challenging to provide superfast broadband to some areas of the UK, where low population density combined with challenging topography means that deployment costs can be prohibitive. It is likely that mobile solutions will be necessary to provide superfast broadband to parts of the final 10% which are hardest to reach with fixed broadband solutions, and indeed it is the case that once LTE networks have been fully rolled out they should offer at least 98% population coverage.

4.59 EE's trial of 4G services in the Northern Fells, Cumbria has highlighted the opportunities and benefits, as well as some of the issues, in using LTE as an alternative to fixed-line services to provide superfast broadband to rural communities.

4.60 The Northern Fells is an area of relatively poor fixed-line infrastructure where long telephone line lengths between consumer premises and the local exchange mean that many members of the community struggle to achieve download speeds of 2Mbit/s.[63] Since May 2012, EE has been trialling a 4G service using its 1800MHz spectrum with approximately 30 business consumers and has plans to extend to further sites in Cumbria and make the service commercial in Q4 2013.

4.61 Trialists have reported that the connections have transformed their internet use, providing a stable and high speed connection that was not available over fixed-lines, delivering download speeds of 30Mbit/s and higher.

4.62 However, although deployment of LTE may be more cost effective than deploying fixed-line access infrastructure, EE's experience has highlighted that there are still significant challenges in building a commercial case for LTE investment in remote areas.

- Rural sites are often in Greenfield areas far from other infrastructure such as energy supply and fibre backhaul. The cost of running energy and backhaul to a site adds to the cost of a site build and could potentially render the site uneconomic. Long power/transmission cables may be required to cross many landowner properties, and microwave links may require two or more hops therefore increasing operating expenditure and impacting on performance. EE

[63] 18% of broadband connections in the Carlisle postcode area have modem sync speeds of less than 2Mbit/s (compared to 9% of connections across the UK as a whole), while the average speed is 8.4Mbit/s (compared to a UK average of 17.6Mbit/s) and just 2.4% of connections are over 30Mbit/s (compared to 22% across the UK as a whole). The Northern Fells area is among the most rural of the postcode area, so speeds in these areas are likely to be much lower than those for the Carlisle postcode area as a whole.

report that they recently removed a site from Cumbria's list due to prohibitive installation cost of £90,000.

- Planning controls may be greater in rural areas, particularly in National Parks or Areas of Outstanding National Beauty[64].

- Reaching agreement with multiple landowners for installation of energy and backhaul has been an issue. Sometimes, landowners seek to prevent operators from upgrading infrastructure by restricting the technologies or frequencies which can be operated from a site.

- Using 4G effectively as a fixed-line replacement service means that a high quality service needs to be delivered indoors to the property. Frequently, due to the nature of building construction in rural areas, high propagation loss is experienced. To mitigate against these propagation losses, which they estimate to affect around 15% of the properties in the Cumbria deployment, EE has successfully experimented with ways to increase the reach of each 4G cell using a range of devices including outdoor 4G routers and high gain directional antennas. However, these place further pressure on the business case due to the added costs of equipment and installation.

Traffic Mix on Mobile networks

4.63 For the first time, we have gathered information on the type of applications consumers are accessing on mobile networks. Similar to fixed networks, video traffic contributes between 30 to 40% of the overall traffic. However, for those operators with a higher proportion of their customers on unlimited data packages, video traffic represented more than 50% of total traffic on that network. This suggests that consumers with capped packages may be moderating their use of data-hungry services to stay within their data allowance. The data also shows that peer-to-peer traffic is lower on mobile networks compared to fixed networks. This is very likely due to the stringent traffic management policies on peer to peer (P2P) traffic by mobile operators.

Figure 43 – Traffic Mix on Mobile Networks

Traffic Type	% Data downloaded
Video including streaming applications	40%
Web browsing	32%
Peer to Peer including Bit torrent applications, file transfers, new groups	8%
Other	20%

[64] Planning Policy Guidance 8 (PP8) promotes the non-proliferation of masts in such areas and therefore directs operators to certain locations, which may not be optimal for an operator's network topology – for example a site may suit a 900MHz operator, but not 1800MHz or 2100MHz operators.

4.64 We will monitor how traffic mix evolves in coming years and its impact on total data use as video file sizes are typically significantly larger than file sizes of other applications.

Heterogeneous Networks (Femto cells, and Wi-Fi)

4.65 As consumers' usage of mobile data increases, mobile networks are evolving in order to meet growing demand. Operators have deployed a number of improvements, from using more spectrum, using more efficient technologies such as LTE and rolling out more network infrastructure (i.e. macro cells) to increase the density of cells. In addition, complementing a network of large cellular transmitters (macro cells), there are increasingly a combination of different transmitter/receiver networks, which could be used to support wireless access to data services.

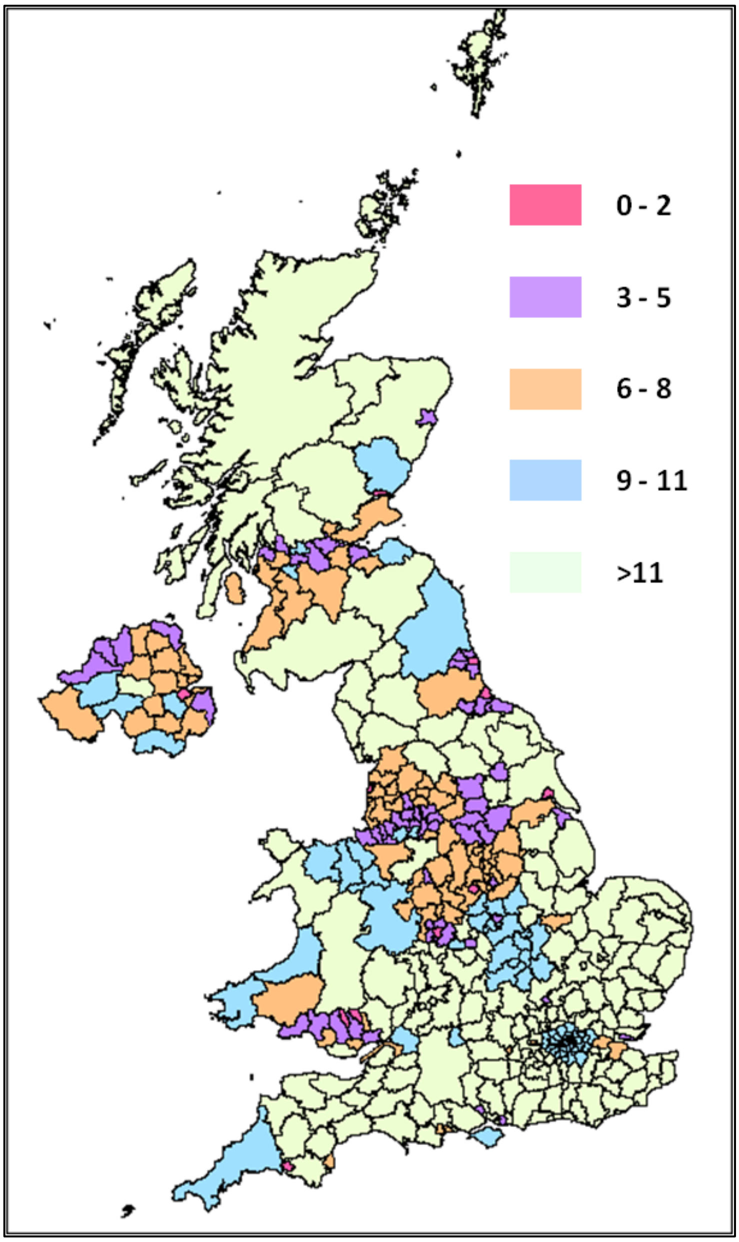
4.66 As well as changes at a network level, improvements at the smaller, user level can also improve the consumer experience, such as the use of Femtocells and offloading onto Wi-Fi. Thus wireless networks are becoming 'heterogeneous networks' or HetNets, i.e. networks which work over a range of different technologies integrating macro level networks which provide coverage, and micro level cells for capacity and speed.

Femto cells

4.67 Femtocells are low powered mobile access points which are connected to the consumer's fixed broadband in the home. These are particularly useful for consumers who have poor indoor coverage from their network, or where their network is not available at all, and can be used to offload both mobile voice and data traffic. Vodafone and Three offer femto cells to their customers.

4.68 Voice calls and data use on mobile devices connected to a Femtocell are carried to the operator's network via the consumer's fixed broadband line thereby offloading data from the local mobile mast and associated backhaul circuits. There are over 300,000 (200,000 in 2012) Femtocells in the UK, an increase of 47% on 2012. Our analysis indicates that across the UK, take up of Femtocells in rural areas is three times as high as in urban areas. Femtocells per premise are lowest in Kingston upon Hull with 1.8 (1.2 in 2012) per 1000 premises, and highest in the Shetland Isles with 85 per 1000 (68 in 2012) premises. Geographic distribution of Femtocells per 1000 premises is shown in Figure 44. As we have previously explained in the Infrastructure Report update in 2012, mobile coverage tends to be poorer in rural areas, suggesting that consumers are using Femtocells to improve coverage for voice and data services.

Figure 44 – Location of femto cells (femto cells per 1000 premises)



Source: Ofcom/operators

Public Wi-Fi hotspots

Coverage

4.69 Many mobile devices are also Wi-Fi enabled and can be connected to a residential Wi-Fi network or public Wi-Fi hot spots. Public Wi-Fi networks are increasingly used as a complement to mobile 3G, and 4G networks. For this report, we gathered data from the main fixed and mobile operators and, for the first time, Arqiva[65]. In total, these operators manage around 34,000 public Wi-Fi hot spots in the UK (excluding BT Fon[66] hotspots; BT claims to have 5 million hotspots[67] throughout UK and Ireland

[65] BT, BSkyB, O2, Virgin Media, T-Mobile, Kcom, EE, and Arqiva

[66] BT Fon provides public Wi-Fi access through residential and business customer's Wi-Fi routers and hence are in predominantly residential areas.

which includes their Fon hotspots[68]). Wi-Fi hotspots mainly in the transport sector such as Wi-Fi access in buses and trains are excluded from our analysis.

4.70 Unlicensed mobile access (UMA) which allows subscribers to switch seamlessly between Wi-Fi access and mobile cellular networks is an alternative strategy for mobile operators to extend coverage and capacity and offload the data from mobile networks to fixed networks. O2 has a network of Wi-Fi hotspots which are freely available to O2 and non-O2 customers, while mobile operators also partner with Wi-Fi networks to provide their customers with access to Wi-Fi hotspots – for example, EE and Vodafone both offer customer access to BT Openzone hotspots.

4.71 Access to these Public Wi-Fi spots can be:

- free of charge: e.g. Wi-Fi access on Westminster Public Wi-Fi;
- free based on mobile or broadband subscription: e.g. access to Wi-Fi on the London Underground is free for Virgin Media, EE, O2 and Vodafone customers ;or
- chargeable by hourly fee or monthly subscription: e.g. use of BT Wi-Fi is £4 for a 1 hour or £39 for 30 days

4.72 Most public Wi-Fi hotspots are situated in urban areas as they are predominately located in the premises of high street locations such as fast food chains, hotels, retails banks, supermarkets and coffee shops. London has at least 15% of all Wi-Fi hotspots in UK, while only approximately 7% (4% in 2012) of public Wi-Fi hot spots operated by the largest fixed and mobile providers are located in rural areas.

4.73 In addition to those commercially run hotspots, there are also other initiatives to provide public Wi-Fi access. For example the following councils are among those offering public Wi-Fi access services; Bradford, Camden[69] ,Hounslow[70], Leeds, Southampton[71] and Westminster.[72]

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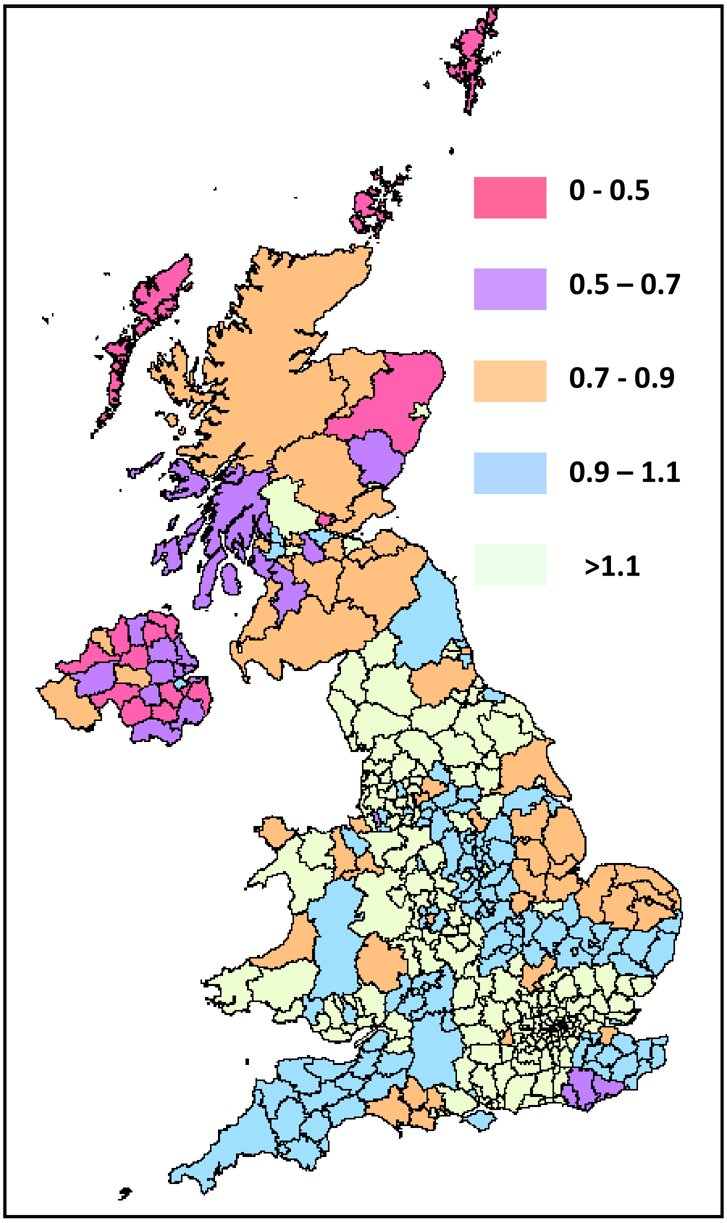
[67] http://www.btwifi.com/find/uk/
[68] Use of Fon hotspots are not included in the data provided in this section.
[69] http://internetretailing.net/2013/05/camden-council-to-boost-local-businesses-with-launch-of-free-public-wifi/
[70] http://www.v3.co.uk/v3-uk/news/2268672/barnet-islington-and-hounslow-councils-to-offer-free-wifi-in-next-six-months
[71] http://m.dailyecho.co.uk/news/10624623.Street_lights_to_bring_free_wi_fi_to_city/
[72] Some of these city networks are provided by the main fixed and mobile operators or Arqiva, and these are included in our reporting statistics.

Figure 45 – Geographical distribution of Public Wi-Fi hotspots (hotspots per 1000 premises)



Source: Ofcom/operators

Capacity

4.74 The data we gathered from our sample of operators shows that 1,991,268 GB of data was downloaded and uploaded on public Wi-Fi hotspots in June 2013. The significant growth of 188% in data usage could be ascribed to the increase in number of public Wi-Fi hotspots (hotspots increased by 114%[73]). However, the average data consumed per hotspot in June has also increased by 26% compared to June 2012 from 48MB to 58MB. Recent market initiatives by Wi-Fi operators could have contributed to increased awareness of public Wi-Fi hotspots leading to growth in data

[73] Wi-Fi hotspots growth, and data growth includes both organic growth from Wi-Fi operators reported in last year's Infrastructure report update, and growth from new Wi-Fi service providers.

use, while growth in smartphone and tablet PC take-up may be increasing demand for Wi-Fi access.

Figure 46 –Public Wi-Fi hotspots 2013 vs 2012

	June 2012	June 2013
No of public Wi-Fi hotspots	16,000	34,000
Total data uploaded/downloaded	757, 861 GB	1,991,268 GB
Data per Hotspot	48 MB	58 MB

Source: Ofcom/operators

4.75 Seamless connection between Wi-Fi hotspots is still an issue. However, there are initiatives from the industry to address these problems and to improve the customer experience. For example, BT has a smartphone/tablet app which will automatically authenticate the user on Wi-Fi to BT public Wi-Fi hotspots without the need for the user to log in. Similarly, Sky (who owns the Cloud network of Wi-Fi hotspots) also has its own app for this purpose. Other Wi-Fi providers have different approaches to reduce the need to log in at every hotspot, and therefore reduce the complexity of using public Wi-Fi within their own network.

4.76 The Wi-Fi Alliance, the industry body that promotes developments in Wi-Fi technologies, is currently introducing a new set of technology standards called PassPoint which will enable seamless handover between Wi-Fi hotspots known as Wi-Fi roaming. PassPoint-certified mobile devices are able to automatically discover and connect to the best available network, using the latest in enterprise grade WPA2 security protection. To enable Wi-Fi roaming using PassPoint technologies, both handheld devices (smartphones, tablets, and notebooks), and Wi-Fi network infrastructure equipment must be certified by the Wi-Fi alliance. The Wi-Fi alliance has been issuing PassPoint certifications from June 2013, and so far a number of smart smartphones, tablets, wireless routers, and enterprise access points have been PassPoint certified.

Case Study on Public Wi-Fi

4.62 A number of free-of-charge wide area public Wi-Fi networks have launched in the last 18 months. Typically a partnership between a council and a network operator, these services are designed to provide wireless connectivity to residents, businesses and visitors. Councils offering public Wi-Fi access services include Bradford, Camden, Hounslow, Leeds, Southampton and Westminster. They typically provide faster connectivity than 2G or 3G networks as well as providing consumers with the opportunity to use mobile data services without using up the data allowance of their mobile subscription.

4.63 The service launched by O2 in partnership with Westminster City Council in July 2012 provides an example of how such public Wi-Fi services are extending wireless access to data connectivity and complementing cellular mobile networks. The O2 Wi-

Fi service in Westminster has multiple access points using unlicensed spectrum in the 2.4GHz and 5GHz bands. Backhaul is mainly provided by fibre from the access point and O2 report that average speeds in peak periods are around 20Mbit/s, with speeds of up to 70Mbit/s delivered to 5GHz devices.

4.64 Average data use per unique user in June 2013 was 20.2MB (5.8MB per session). The usage profile for a week in June 2013 shows flatter peaks than that typical of cellular data traffic, with reasonably consistent data traffic between 9am and 9pm, seven days a week. This may reflect the usage of visitors to the City (tourists, shoppers and nightlife) as well as of those who work and/or live in Westminster, so is unlikely to be reflective of public Wi-Fi networks in other locations.

4.65 The large majority of traffic was to smartphones with just over 50% of data traffic to the iPhone, and 22% to Android devices (which will include some tablets); 9% of traffic was to iPad tablets. Only a very small proportion of traffic went to laptop PCs (less than 0.2% of total data traffic in June 2013), suggesting that business users are only making limited use of the service. The most popular websites in terms of number of web requests were Apple (iTunes), Google, Instagram, YouTube and Facebook, while a majority of the data traffic was accounted for by streaming applications with YouTube, iTunes, BBC iPlayer and Sky accounting for the most data usage.

4.66 Comparable data between the O2 Wi-Fi network in Westminster and cellular networks in Westminster are not available. However, O2 consider that traffic levels on the metro Wi-Fi network are several times higher than that carried over its cellular network in a similar area, and that there has been traffic levels perhaps up to six times higher (although it should be noted that the Wi-Fi network is available to everyone, whereas O2's cellular network is of course used only by O2 mobile subscribers). However, O2 also report that since the Westminster Wi-Fi network went live they have seen no reduction in the traffic carried locally over its cellular network. Therefore it considers that the Wi-Fi traffic is incremental to that carried over the cellular network, as opposed to being 'off-loaded'.

4.67 Wi-Fi networks are also increasingly being made available on transport networks and transport hubs. Rail companies offering free Wi-Fi on trains include Grand Central and First Hull, while trials are in place on other networks including First Great Western. Virgin trains offer Wi-Fi on all their services which are free to first class passengers and available for an additional fee to standard class passengers. Bus companies offering free Wi-Fi services on some routes include Stagecoach and National Express. Wi-Fi provider The Cloud launched services to London Overground stations in February 2013, with all 57 stations now covered, offering Wi-Fi services free-of-charge for up to 60 minutes a day.

4.68 Since launching in June 2012 Virgin Media's London Underground public Wi-Fi services are available from 121 Underground stations, providing coverage across the ticket halls, escalators, interchanges, concourses and platforms via around 2,000 access points. Wi-Fi on the Underground provides insight into the capabilities of communications infrastructure in an environment where demand is concentrated by location and time.

4.69 Virgin Media's Wi-Fi service on the London Underground launched in time for the London Olympics and was free-of-charge to everyone until the end of January 2013. It is now available at no extra cost to customers of Virgin Media broadband, Virgin Mobile, EE, Vodafone and O2, and is available for a fee to everyone else. Virgin Media report that since launch there have been over 1.2 million unique users on the services. Use is very concentrated around the commuting times, with weekday peaks between 8.30 and 9am and 5.30 and 6.30pm. During these peak times there are around 60,000 concurrent sessions, of which around 20,000 are online and authenticated. The maximum number of concurrent sessions on the busiest access points is 80-100. Data on how performance varies by time of day is not available, but Virgin Media report that testing has shown average download speeds of around 20Mbit/s, with a peak of more than 50Mbit/s.

4.70 The nature of travelling on the London Underground means that user sessions are typically short – Virgin Media estimate an average session time of around 150 seconds. The large majority of connections are via smartphones, with Apple's iOS accounting for around 75% of connections in June 2013, and the Android OS accounting for around 20%.

4.71 Wi-Fi is provided over two license-free spectrum bands, 2.4GHz and 5GHz. As demand for Wi-Fi increases, a challenge is to manage capacity by efficient use of the spectrum available. Currently there is generally greater spare capacity at 5GHz; however fewer devices support 5GHz. The Cloud has confirmed that in a sample of its hot spots in high density user areas they are already experiencing high volumes of data traffic on 5GHz. Currently, although only 15-20% of total Wi-Fi users connect via 5GHz, they account for approximately 50% of total data traffic.

Whitespaces

4.72 Ofcom has recently announced the participants in a pilot that next year could lead to a nationwide rollout of "white space" technology. White spaces are the unused gaps in the radio spectrum all around us. The use of whitespace technology will make UK one of the first countries to test a technology which will allow for more efficient use of available spectrum. It could deliver a wide range of applications, such as providing rural locations with broadband.

4.73 Whitespaces could also be used for what is known as machine-to-machine (M2M) communications. The technology has the potential to deliver large and widely varied benefits to society. One application is intelligent crop irrigation. With M2M this could significantly reduce water wastage and crops could be fed with fewer fertilisers. Another is healthcare; wireless patient monitoring could improve mortality rates and reduce the pressure on hospitals. In energy, smart grids, with M2M at their heart, could intelligently match supply to demand, potentially reducing the need for new generators. In the transport sector M2M embedded in vehicles and road networks could reduce congestion and improve safety.

International comparisons

4.74 The UK's mobile infrastructure compares well with other countries particularly in Europe, with 99% of the population having access to at least one 3G mobile network. LTE (4G) services launched in the UK earlier than in France, Italy and Spain, and rapid roll-out is expected in the coming years from all four UK operators, with population coverage set to exceed 98% by 2015.

Figure 47 – International comparisons: mobile networks

	UK	FRA	GER	ITA	ESP	USA	CAN	JPN	AUS
Network availability, end 2012 (% of population)[1]									
- 2G	100%	100%	99%	100%	100%	100%	99%	100%	99%
- 3G	99%	99%	90%	98%	98%	93%	99%	100%	99%
- LTE	17%	5.5%	59%	0%	0%	91%	72%	70%	40%
Mobile take-up, end 2012[1]									
- Mobile connections per 100 population	134	111	139	159	113	104	81	101	139
- 3G & LTE connections per 100 population	72	50	41	68	78	63	45	101	80
Data usage (2012)[2]									
- Average traffic per mobile connection per month(MB)	406	199	162	252	333	617	592	952	403

Sources: [1] IDATE; [2]Cisco Virtual Networking Index:
http://www.cisco.com/web/solutions/sp/vni/vni_forecast_highlights/index.html

4.75 4G deployment has, on the whole, occurred earlier in the US than in Europe due, in part, to earlier release of spectrum in the US. Large scale deployment by Verizon began in 2010 following a spectrum award in 2008; whereas in the UK 4G spectrum was awarded in March 2013, although EE launched 4G services in its 1800MHz band in October 2012. This has resulted in much higher take-up of 4G in the US than in Europe – data from the industry body GSA finds that in Q2 2013 North America accounted for 51% share of global LTE subscriptions compared to just 4% in Europe.

4.76 However, within the next couple of years it is likely that 4G availability in the UK and in many other European countries, will be comparable to that in the US. By the end of 2012, LTE was available from at least one operator to 91% of the population in the US, and both Verizon and AT&T in the US are aiming to cover around 260 million people (just under 85% of the US population) by the end of 2013.[74] The UK roll-out plans should lead to a comparable coverage to the US by 2015, while across Europe some operators are already making progress to achieving this level – in July 2013 Tele2/Telenor had around 99% population coverage in Sweden, Portugal PT had around 90% coverage and Vodafone Spain had around 85% coverage.

4.77 The UK also has comparatively high take-up of 3G mobile services, and this is likely to be one of the reasons why Cisco data finds that average traffic per mobile connection in the UK in 2012 (406MB) was significantly higher than in other European countries.[75] As with fixed-line broadband, mobile data use is higher in the US (617MB) which may be due to higher smartphone and tablet take-up, as well as greater use of video services.

4.78 Ofcom's annual International Communications Market report benchmarks communications services in the UK against those in other countries. The 2013 edition is scheduled for publication in December and will include more data on how the UK's mobile infrastructure compares with that in other countries.

[74] http://www.fcc.gov/document/16th-mobile-competition-report
[75] We use the Cisco Virtual Networking Index to compare data usage across countries, although we note that due to the different methodology this data for the UK is different to that collected by Ofcom for the Infrastructure Report Update.

Conclusions

4.79 Whilst coverage of 2G and 3G networks has been relatively stable over the last year, mobile operators have been re-engineering their networks and investing in new 4G technology. The combination of the Government Mobile Infrastructure Project and the 98% coverage obligation introduced by Ofcom are expected to lead to near universal population coverage of voice and data service indoor by 2017.

4.80 Despite these initiatives, it is likely that some roads will remain unserved, especially in more rural areas. We will be conducting further analysis over the coming year on how coverage of roads is likely to develop.

4.81 Whilst the past year has seen a slowdown in the rate of mobile data consumption, we expect that the increasing availability and take-up of 4G services and their improved speed and capacity will allow consumers to more easily access services on their smartphones and tablets, and encourage the take-up of high quality video and rich media services. As demand increases, we expect operators to deploy 4G services using spectrum at 2.6GHz, which will offer additional capacity, delivered from smaller cells. We will monitor whether the introduction of these new networks will result in an acceleration of data growth.

4.82 In light of significant growth of Wi-Fi networks we will closely monitor whether Wi-Fi networks are acting as a complement or substitute to mobile networks and the extent to which the removal of barriers to connecting to hotspots results in greater use.

Section 5

Broadcast Networks

Overview

5.1 Following the completion of the switch from analogue to digital TV in October 2012, digital terrestrial television (DTT) coverage now reaches over 98.5% of UK households in the case of the three 'Public Service Broadcaster (PSB) multiplexes, and around 90% of households are also covered by the three 'commercial' multiplexes.

5.2 For DAB radio, there have been no changes to the coverage of the BBC National DAB network, but slight improvements in the coverage of the 'Digital One' commercial services.

DTT Network Coverage

5.3 Maps showing the coverage of the DTT network are available on Ofcom's website. http://maps.ofcom.org.uk/dtt/.

Channel 61 and 62 (800 MHz) Clearance

5.4 The clearance of channels 61 and 62 was completed on 31 July 2013, paving the way for the launch of new high-speed mobile broadband services using 800MHz spectrum across the UK. The project, co-ordinated by Digital UK in conjunction with the DTT broadcasters, transmission provider Arqiva, and Ofcom, finished five months earlier than originally planned and was delivered under budget.

Why 61 and 62 channel clearance was needed

5.5 As the UK switched from analogue to digital TV, it was possible to the release some of the spectrum previously used by analogue TV broadcasting (commonly known as the "digital dividend"). Across Europe, much of this digital dividend spectrum has been used to accommodate the current roll out of fourth generation (4G) mobile technology.

5.6 In 2003, before Ofcom came into existence, the UK Government decided to release 112 MHz of this valuable spectrum in two bands – at 600MHz and 800MHz - once digital switchover (DSO) was complete. A few years later, other European countries also started to develop plans for a digital dividend, but with a larger band of cleared spectrum at 800MHz than the UK had been planning. It was therefore necessary to align the UK's frequency plan with rest of Europe, though there were implications: in particular DTT services needed to be cleared from channels 61 and 62 (covering 790 to 806MHz at the bottom of the 800MHz band) and had to be relocated to lower frequencies.

5.7 A decision to clear channels 61 and 62 was taken in 2009. At that stage the UK was partway through the digital switchover (DSO) project, a process which involved switching off analogue TV services, and using the vacated spectrum to substantially increase the coverage of the DTT networks (in the case of the three PSB multiplexes, coverage was increased to match the near-universal coverage historically achieved by the main four analogue TV channels).

5.8 In order to minimise impacts on viewers and cost, the clearance of channels 61 and 62 was integrated into the DSO programme where possible, with the remainder of the channel 61 and 62 clearance project being carried out after the end of the DSO programme. DSO was completed as planned during October 2012, and the clearance of channels 61 and 62 was completed earlier than originally planned during July 2013.

5.9 The clearance of channels 61 and 62 required engineering work at more than 630 transmitter sites during late 2012 and 2013. At around 500 of these locations, some TV services moved to new frequencies, requiring viewers to retune DTT televisions and set-top boxes.

600 MHz Multiplexes

5.10 Ofcom has recently awarded licences to Arqiva to provide two new DTT multiplexes. These services will use the ‘600 MHz’ (550MHz to 606MHz) band which was released by digital switchover, and the services have been licensed on an interim basis with a minimum licence term to 2018. The new multiplexes will use the advanced DVB-T2 transmission standard, meaning they can support around six HD channels each, or a much larger number of standard definition channels. The new services can be received by viewers with Freeview HD equipment, which is compatible with the DVB-T2 transmission standard being adopted.

5.11 The award of these multiplex licences represents the largest increase in capacity in the history of the UK DTT platform, and 30 of the UK’s largest transmitter masts will carry the services. The BBC has announced its plans[76] to launch five new high definition channels by early 2014, three of which (BBC News HD, BBC Four HD and CBeebies HD) will use capacity on the new 600MHz multiplexes. Al Jazeera has also announced plans to launch an HD service on the new 600MHz multiplexes[77].

5.12 Initial frequency planning work indicates that the new services will be available to around 70% of the UK population[78].

5.13 The introduction of the two new multiplexes is of strategic importance for the future of DTT, since as well as increasing the range of HD services available, they will also increase the take-up of DVB-T2 receivers. A transition of DTT from DVB-T to DVB-T2 would be an effective means of ensuring that DTT is able to continue offering a wide range of attractive broadcast content.

Local TV

5.14 In 2012, Ofcom was given new powers and duties by Parliament to license a new generation of local television services. In the first phase, licences to provide local digital television programme services (L-DTPS) in 19 towns and cities have been awarded. These are: Belfast, Birmingham, Brighton & Hove, Bristol, Cardiff, Edinburgh, Glasgow, Grimsby, London, Leeds, Liverpool, Manchester, Newcastle, Norwich, Nottingham, Oxford, Preston, Sheffield, and Southampton. Ofcom has also awarded a licence to Comux UK Ltd to build the multiplex and transmission

[76] http://www.bbc.co.uk/mediacentre/latestnews/2013/BBCHDChannels.html
[77] http://www.digitaltveurope.net/104662/al-jazeera-to-launch-hd-service-as-uk-dtt-expands-into-600mhz/
[78] http://www.arqiva.com/documentation/reference-offers/600mhz-national-dtt-interim-proposals/OFCOM%20Interim%20600%20doc%20July%202013%20start%20v9.pdf

infrastructure that will broadcast the local TV services, along with two additional TV services.

5.15 The first local TV channel will start broadcasting from late 2013. The local TV services will be available on position 8 of the Freeview in England and Northern Ireland, and position 34 in Wales and Scotland (where position 8 is already occupied by another service). More information on local TV is available at: http://localtv.org.uk.

DAB Digital Radio

5.16 The BBC has plans to build-out indoor coverage of its national DAB multiplex to 97% of households by March 2017. Recent increases to the coverage of national commercial DAB services mean they now reach 87% of households (indoor coverage) and 73% of roads. Specifically the Digital One network has expanded its coverage into Northern Ireland, and added a new transmitter at Sedgley Beacon (Wolverhampton).

5.17 The DAB coverage maps on our website have been updated to reflect this year's changes. http://maps.ofcom.org.uk/dab/index.html.

5.18 The Government launched its Digital Radio Action Plan in July 2010. Ofcom was asked in the Action Plan to publish an annual report on the availability and take-up of digital radio services. The Action Plan emphasises that any future digital radio switchover should begin only when the market is ready, and that it should be predominantly consumer-led. The Action Plan stated that a decision on setting a date for digital radio switchover will be made when the following criteria are met:

- when 50% of all radio listening is via digital platforms; and
- when national DAB coverage is comparable to FM, and local DAB reaches 90% of the population and all major roads.

5.19 Ofcom published this year's report on 25 September[79]. The report contains data on digital radio coverage, the proportion of all radio listening via digital platforms, and take-up of DAB equipment.

Co-existence of DTT Services and 4G Mobile Services

5.20 4G mobile services in the 800MHz band have the potential to cause interference to the reception of existing DTT services in the adjacent band. This issue is not unique to the UK. Other European countries which have DTT services in bands adjacent to the 800MHz band face the same issue and are adopting a variety of approaches to mitigate the interference risk.

5.21 In 2012, the Government took decisions on how co-existence should be managed, and required comprehensive interference mitigation arrangements to be put in place. Ofcom implemented these decisions by requiring the 800MHz mobile network operators (EE, Telefónica UK - O2, Three and Vodafone) to set up and fund an organisation, at800[80], tasked with mitigating and resolving interference to DTT reception for households whose Freeview services are affected by the deployment of 800MHz 4G services.

[79] http://stakeholders.ofcom.org.uk/binaries/research/radio-research/drr-13/2013_DRR.pdf
[80] https://at800.tv/

5.22 In most cases, interference can be resolved by installing a small filter which will be supplied free of charge by at800. Different arrangements are in place for households which rely on a communal DTT aerial system where filtering is required at the system headend. Additional installation support is available to vulnerable householders.

5.23 Following a series of technical trials to better understand the potential impact of 4G services on DTT reception, at800 estimated in June[81] that only a small minority of households (less than 1%) are likely to need a filter or any other remedial measures.

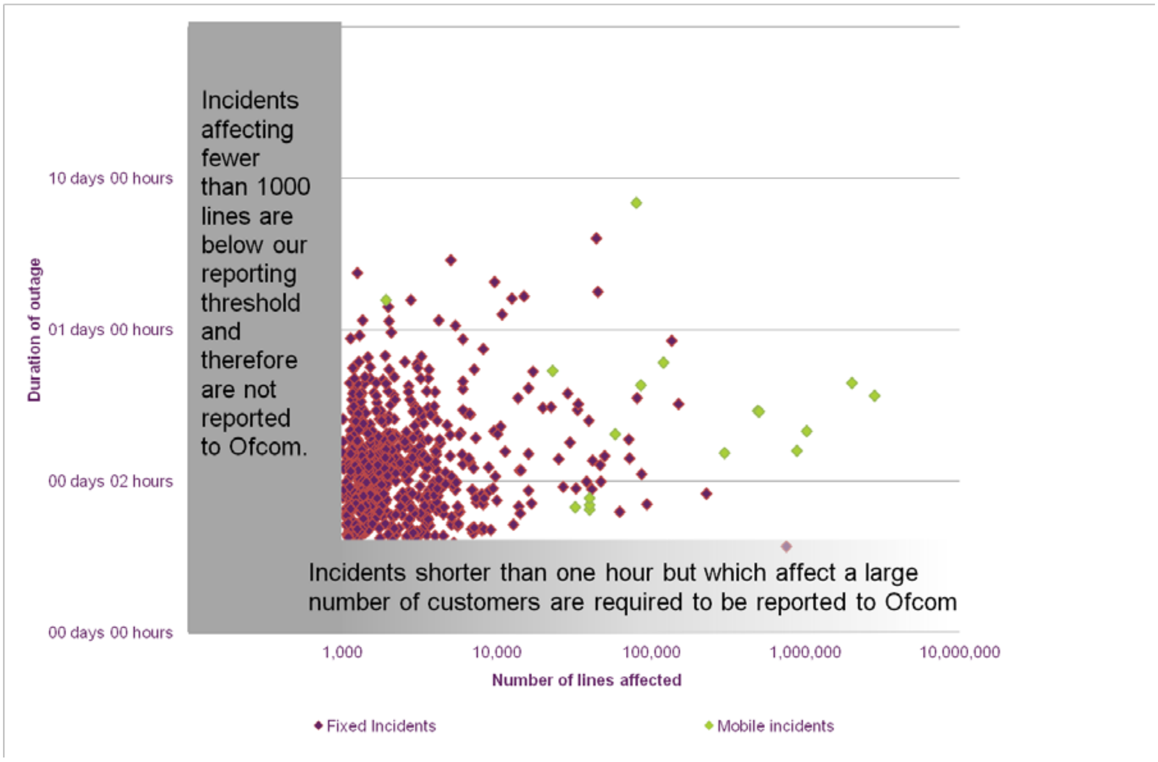
[81] https://at800.tv/press-releases/at800-updates-estimate-of-likely-impact-of-4g-at-800-mhz-on-freeview/

Section 6

Resilience

6.1 Section 105 A-D of the Act 2003, which was introduced in May 2011, places requirements on Communication Providers (CPs) and Ofcom regarding the security and resilience of communications networks and services. As a part of these requirements CPs are required to notify Ofcom where there has been a breach of security or a reduction in the availability which has had a significant impact on their networks or services. Since May 2011, we have received regular reports from CPs about these significant incidents. The diagram below summarises the incidents reported to Ofcom which occurred between October 2012 and August 2013.

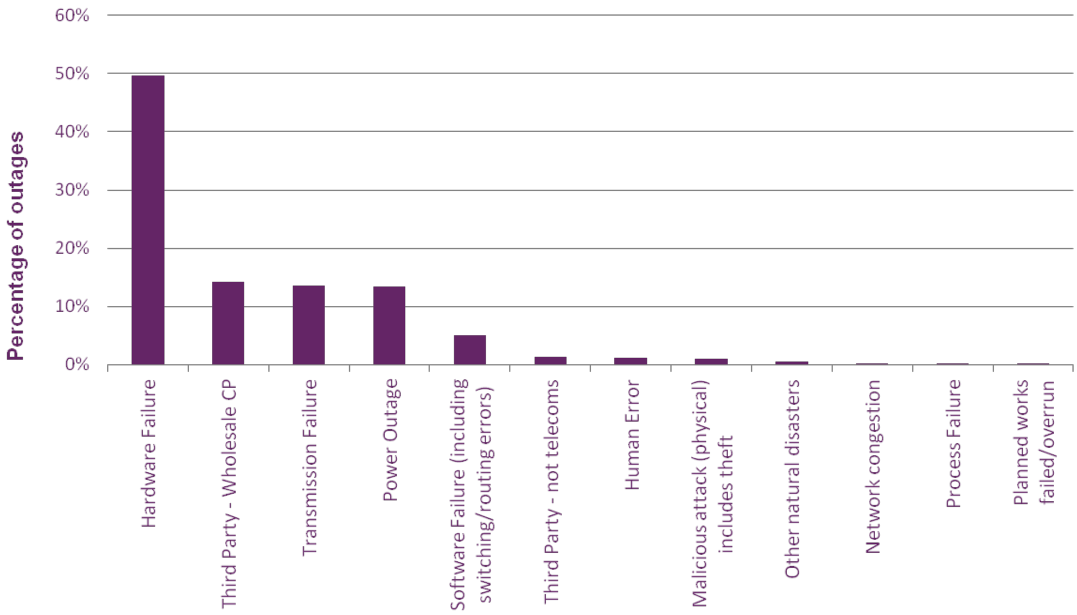
Figure 48 – Scale of incidents reported to Ofcom (Oct 2012 – Aug 2013)



Source: Ofcom/Operators

6.2 As with the incidents summarised in last year's Infrastructure Report Update, the majority of outages reported continue to be of a relatively short duration, affecting a small number of customers. We continue to receive more reports about outages on fixed networks than mobile networks, possibly due to our reporting thresholds which are lowest for the loss of ability to make emergency calls. As mobile users are generally able to roam on to a different mobile network for emergency calls, mobile operators do not tend to report outages against this threshold. Figure 49 sets out analysis of the root causes of the incidents reported between October 2012 and August 2013.

Figure 49 – Root causes of incidents reported to Ofcom (Oct 2012 – Aug 2013)



Source: Ofcom/Operators

6.3 We have introduced a number of new root cause categories, compared to previous years, so that incidents can be recorded more accurately. However, as in previous years, Figure 49 shows that the failure of a hardware component continues to be the main cause of outages.

6.4 As required under the Communications Act, we submitted to ENISA a summary of the most significant incidents reported in 2012. This year, our report contained descriptions of ten incidents. Using the reports submitted by us along with reports from other regulators, ENISA published a summary of all the incidents it has received[82]. It found that system failures was the most common root cause of outages and that most incidents reported were the result of a mobile outage, which also tended to affect a greater number of customers.

Significant outages

6.5 In January, an arson attack on a television transmitter[83] affected TV services as well as mobile services from a mobile base station which had been co-located on the same mast. Due to site access issues, services could not be restored from that site for a number of days and led to a lengthy outage. Another source of malicious damage is the deliberate theft of telecoms equipment, such as the attempted theft of Virgin Media broadband equipment[84]. This attempted theft resulted in the loss of broadband services for Virgin Media customers in West London for almost a day.

[82] http://www.enisa.europa.eu/activities/Resilience-and-CIIP/Incidents-reporting/annual-reports/annual-incident-reports-2012
[83] http://www.thisisbath.co.uk/blamed-arsonists-blacks-TV-Bath/story-17747489-detail/story.html
[84] http://www.ispreview.co.uk/index.php/2013/04/virgin-media-uk-confirm-major-west-london-outage-caused-by-vandals.html

6.6 Physical damage to networks could also occur accidentally as in the outage experienced by Virgin Media customers in Cosham[85]. Engineering works on a road outside Portsmouth damaged multiple Virgin Media fibres and disrupted broadband services for the customers involved. The vast majority of customers who were affected had their services restored within eight hours, but some customers experienced a longer outage which lasted over a day.[86]

6.7 A source of major incidents described in last year's report was the outages due to systems issues within a CP's own network. We noted that O2 experienced repeated user registration problems which left large number of customers unable to make calls. In October 2012, O2 experienced a similar outage but caused by a different failure in the network[87]. Three also experienced a significant outage with the mobile data service in November with a fault in a network component which affected customers' access to mobile data.[88]

6.8 It has become increasingly clear this year that the reported duration and scale of an incident often do not contain enough information to allow an accurate evaluation of its true significance. It has proved important to understand more detail before reaching firm conclusions. For example, in the case of mobile incidents, there are incidents where CPs have deliberately delayed engineering work that would restore service for affected customers, to avoid potentially interrupting the service of many more customers. For these networks, the rush hour can be the busiest time in terms of signalling traffic, as many customers are travelling rapidly between base stations, requiring the network to keep track of them all. This can make it a bad time to try and fix any of the network elements involved; despite initially appearing to make the reported figures worse, overall customer detriment might actually be minimised by waiting until the busiest periods are over.

6.9 Another example of how data on duration and scale alone is not sufficient for an accurate evaluation of an incident, is the way that the reported metrics reflect the maximum number of customers affected and the total duration of the incident before services are restored to customers. In many cases, some customers may have been affected later than the initial start time or have their services restored sooner and therefore the total impact of the outage would be less than that based on the reported metrics.

6.10 These incidents illustrate the varied nature of significant outages in both fixed and mobile networks. Where appropriate, we follow these incidents up with the operators concerned and consider whether these outages have a wider impact on other CPs in the UK.

Improving the resilience of networks

6.11 Aside from the incident reporting duty, Section 105 A-D of the Act also places requirements on CPs to take the appropriate measures to manage the risks to security and availability of their network. We continue to work with industry to identify the improvements which could be made to maintain the availability of communications services.

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[85] http://www.ispreview.co.uk/index.php/2013/06/portsmouth-uk-virgin-media-users-suffer-lengthy-outage-after-cable-cut.html
[86] http://www.portsmouth.co.uk/news/business/local-business/remaining-virgin-media-services-are-all-fixed-1-5163041
[87] http://news.o2.co.uk/2012/10/12/o2-network-disruption-12-october/
[88] http://www.coolsmartphone.com/2012/11/04/3g-issues-on-3/

6.12 Most of the main UK CPs continue to collaborate via the EC-RRG[89]. Their work includes pre-emptively considering issues which may threaten, or can be used to improve, the sector's resilience. Examples of this work over the past year have included:

- review of the successful resilience arrangements put in place for the Olympic Games, and consideration of lessons learnt;
- adaptation to the long term effects of climate change;
- consideration of the threat to the sector from severe space weather events (such as solar flares);
- agreeing information sharing arrangements for use during any security incidents while the G8 in Northern Ireland was taking place. This was based on a new system put in place for the Olympics;
- the impact of cross-sector dependencies, such as the link between the telecoms and energy sectors; and
- fuel supply arrangements during emergencies.

6.13 These CPs have put in place network security arrangements that conform to guidelines that were published in 2011 with the coming into force of sections 105 A-D of the Act that implemented Article 13 of the Amended Framework Directive. With two years' experience of their application to the requirements on CPs to take the appropriate measures to manage the risks to security and availability of their network, we consider it appropriate to review their relevance and adequacy. We are also minded to examine the thresholds for reporting as part of an overall review of the complete package.

6.14 Therefore we will shortly be issuing a Call For Inputs to stakeholders, together with a consultancy report we have commissioned to help identify new and emerging systemic network security and resilience issues. We will determine from this CFI and our internal analysis whether any changes to the guidelines are necessary, with our conclusions likely to be announced early in 2014.

[89] Electronic Communications Resilience and Response Group

Section 7

Traffic management, IPv4 address exhaustion and interconnection

Overview

7.1 In earlier sections of this document we focused on the access networks that Communication Providers (CPs) use to provide the connection to the customer, either as the direct physical line to the home via fibre or copper for fixed networks or the radio coverage from masts for mobile networks. However, the data services that are consumed over these connections depend upon upstream connectivity to the servers and other infrastructure of the actual providers of these services. Thus the actual customer experience is as dependent on the quality and effective functioning of these upstream links as on the bandwidth and performance of the access network.

7.2 This means that the arrangements CPs have to manage their customers' data traffic, both within their own networks through traffic management and via their interconnection arrangements with other networks, are key factors in determining whether the consumer has a good or bad experience of the services they consume. Therefore, in addition to reporting on the state of access networks, Ofcom needs to address particular elements of both access provider network management practice and the nature and capacity of their links to the other networks that collectively form the "Internet" in order to report effectively on the adequacy of the UK's telecoms infrastructure.

7.3 In addition, the underlying technology that has been used to implement the internet "network of networks" continues to evolve. Some of these technology changes are aimed at improving the functionality, resilience and security of the internet, others at maintaining its capacity to expand to meet the continuing rapid growth in demand both for connections and services. How and when these new technologies are adopted in the UK will have a profound impact on the future capability of the internet services accessible to consumers and businesses and, hence, may be critical to the future economic and social well-being of the country. In this report we focus on two aspects of this evolution: how the apparent exhaustion of IPv4 addresses and subsequent migration to IPv6 will be handled; and the introduction of enhanced security and trust through changes to DNS technology.

Traffic management within ISP networks

Introduction

7.4 As reported earlier in this document, consumer use of broadband networks continues to evolve and grow. New patterns of use are emerging, new applications are being adopted and overall volumes continue to increase. With the rapid expansion in use of more bandwidth-intensive services, ISPs and MNOs are using more sophisticated ways to manage the traffic on their networks. Broadly ISPs have three approaches to managing use, which can be used individually or in combination:

- usage caps, e.g. a limit of 10GB per month;

- traffic management, i.e. speed limits on the services and applications that place the most demands on a network and/or prioritisation of traffic that is most time-dependent (such as video calling); and

- restrictions on what consumers can do with the service, such as not allowing consumers with smartphones to connect them to laptops ('tethering') or blocking access to specific applications.

7.5 These restrictions are aimed at ensuring that those who place the greatest demand on communications infrastructure pay the most for their service while light users (such as those who only use email or web browsing) pay less and are not inconvenienced by heavier users. In this way, usage restrictions can help to pay for investment in new infrastructure and can help ensure that users are not denied access to economically and socially important services by high minimum service charges.

7.6 There might however be other motivations for adopting some traffic management practices, which may be less beneficial, if for example they are used by ISPs as a means to reduce competition to existing services from new internet-based service providers.

7.7 More generally, we would be concerned if network operators were to prioritise managed services in a manner that leaves insufficient network capacity for 'best-efforts' access to the open internet. If the quality of service provided by 'best-efforts' internet access were to fall to too low a level, then it may place at risk the levels of innovation that have already brought such substantial economic and social benefits from the internet.

Usage caps

7.8 Usage caps exist in a number of different forms. For example:

- Most typically, operators impose limits on how much data consumers can use in a particular month

- Some ISPs impose limits on how much data can be used during the day or during peak periods with unconstrained use during the rest of the time.

7.9 Data caps serve as a means of ensuring that users who use the most data pay more – there is significant variation between consumers in the amount of data they use and it may be inequitable for light users to pay the same as those who consume much more. Nevertheless it is important that ISPs make clear to consumers both the practical impact of caps (e.g. what they can do within their caps and/or warnings if they approach or exceed their caps) and the consequences of doing so (e.g. excess usage charges or temporary restrictions on the bandwidth available to the user). This prevents consumers having to pay unexpectedly high bills if they exceed their caps.

7.10 Guidance[90] from the Advertising Standards Authority (ASA), introduced in 2011, has helped ensure that fixed and mobile broadband services are advertised as 'unlimited' only when there are genuinely no restrictions on the amount of data that can be used. Previously some ISPs and mobile operators advertised 'unlimited' packages

[90] http://www.cap.org.uk/~/media/Files/Copy%20Advice/Help%20Notes%20new/Help20Note20on20use20of20unlimited20claims20in20telecommunications20advertising202.ashx

which had 'fair use' limits applied to them and consumers were charged extra or had significant limitations imposed on them if these 'fair-use' limits were exceeded.

Traffic management

7.11 Traffic management is used by operators to control the speed of data for certain applications or services, including giving priority to services which are sensitive to time delay (such as VoIP) and giving lower priority and/or actively slowing down services/applications that are less time-dependent such as peer-to-peer (P2P) traffic[91]. At the extreme, traffic management techniques can be used to completely block classes of services or services from a specific provider.

7.12 There is often significant variation in fixed ISPs' and mobile operators' traffic management practices. A number apply traffic management in some form, others do not and use the fact that they have no traffic management as a part of their promotional message (e.g. advertising their service as 'truly unlimited' in terms of both data use and throttling of certain services).

7.13 Most commonly, ISPs tend to apply traffic management to P2P services such as BitTorrent. P2P traffic is most likely to have restrictions placed on it because of the way it works: the nature of P2P software is such that it increases data usage along a network to fill whatever capacity is available. That, and the fact that P2P downloads are not typically as time-dependent as other types of application, mean that many ISPs and mobile operators find that controlling P2P traffic is a way to keep down network infrastructure costs.

7.14 P2P traffic on core networks may increase further as more customers adopt superfast broadband. To date, the volume of P2P traffic in core networks is partially constrained by the download and uploads speeds available on access networks. Increased take-up of superfast broadband may result in ISPs increasing the level of traffic management applied to P2P traffic, as many P2P applications will increase their aggregate speed of operation as access speeds increase. The impact of traffic management on users of P2P services can be significant – in some cases speeds of P2P traffic can be reduced to a fraction of the speed of other traffic on the network.

7.15 In some cases, particular types of traffic are given greater priority and consumers who particularly value a type of service can choose packages that prioritise such traffic. For instance, some ISPs offers a premium broadband service which gives priority to gaming traffic and traffic for virtual private networks (VPN).

Restrictions

7.16 Another means of restricting traffic on a network is to impose restrictions on what customers can do with their service, in particular to limit the use of applications that place heavy demands on the network.

7.17 We found in some cases that ISPs and MNOs imposed restrictions in ways which encouraged customers who want to use particular services to pay a premium. For example, as indicated on their websites, both Vodafone and Everything Everywhere only allow VOIP calls with specific price plans. They offer this on packages that are typically at higher price points.

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[91] Peer to Peer is a distributed application that uses end users' computers as nodes to deliver service applications.

7.18 This type of restriction does not necessarily serve to limit demand on the network – since VoIP calls do not necessarily consume a lot of bandwidth. However it does give consumers who particularly want to use VoIP services (including video calling services such as Skype or Apple's FaceTime over 3G) the incentive to upgrade to (often) more expensive price plans. This is an example of commercially-driven traffic management that may, in some circumstances become problematic, if it is aimed at protecting existing revenue streams by discouraging access to new services.

7.19 Of course, traffic management policies and usage restrictions evolve over time, in response to changing customer use and competition in the marketplace. Over time we might expect greater adoption of 'over the top'[92] communications services such as VoIP and video calling, and consumers may decide to avoid operators or packages that do not allow them to use such services. As discussed below if competitive pressure is to work effectively consumers need clarity on the specific policies applied by each operator and the differences between operators so they can compare the options available to them.

Compatibility with Net Neutrality principles

7.20 In our policy statement[93] on Net Neutrality published in 2011 we set out that our approach to traffic management will continue to rely primarily on there being effective competition among ISPs, adding that effective competition requires that:

- sufficient information is available to enable consumers to make the right purchasing decisions; and
- consumers are able to act on this information by switching providers where appropriate.

7.21 The central concern in relation to "Net Neutrality" is the risk that ISPs will seek to manage their subscribers' access to online services in order to further commercial objectives – for example, that BSkyB might prevent access to third party Video on demand (VoD) services like Netflix, to favour their own pay television offering; or that ISPs may seek to charge online service providers for access to their subscribers, and block those who do not pay (as Free sought to do to Google in France). Ofcom considers that the widespread adoption of such practices could pose a risk to the operation of the internet as an open platform, and limit its potential to support the rapid growth and broad span of innovation which has characterised it until now.

7.22 Some traffic management practices, often described as "reasonable traffic management" are generally accepted (for example to manage network congestion or to block access to identified unlawful content). "Unreasonable traffic management" would be intended to secure commercial advantage for the ISP, and give rise to net neutrality concerns.

7.23 While we think unreasonable traffic management is highly undesirable, we believe that there is no evidence that such practices are currently causing harm to UK consumers' overall ability to access the open internet, since unrestricted service options are generally available from a number of competing providers. As a result, we do not think there is a present need to intervene to prohibit such behaviour.

[92] Over the top services are communications services which are delivered to customers over data networks without involvement from the CP.
[93] http://stakeholders.ofcom.org.uk/binaries/consultations/net- neutrality/statement/statement.pdf

Transparency

7.24 ISPs are subject to a statutory obligation[94] to be transparent with consumers about their traffic management practices. Without the need for formal regulation, operators have already attempted to implement these principles. Since 2011, operators have agreed to publish details of their traffic management practices[95]. Under this model each ISP commits to:

- provide more information to consumers about what traffic management takes place, why and with what impact;
- provide customers with clear, easy-to-understand information on traffic management so that they can better compare broadband packages; and
- publish a common Key Facts Indicator (KFI) table, summarising the traffic management policy for each package on offer. These tables have been available on signatories' websites since July 2011.

7.25 In order to assess whether this industry activity has been effective, we have been doing further work to consider the real transparency of information on traffic management, to ensure consumers are getting all that they need to make effective choices. This work, in collaboration with the BSG and the ISPs has resulted in our recent publication of a Consumer Guide to Traffic Management[96]. This outlines what traffic management is and how it might affect the consumer experience. It also provides direct links to major fixed and mobile CP traffic management KFIs and related information.

7.26 The Guide was developed following consumer research[97] undertaken to understand how consumers are buying and using fixed broadband services, and their knowledge of traffic management policies. The research revealed a general lack of awareness of traffic management, with one in 10 internet consumers (11 %) familiar with the term and only 1% claiming to have considered this when choosing their broadband service. The research also found, however, that the traffic management information provided by ISPs is broadly transparent. Seventy-three per cent of consumers that were aware of their ISP's traffic management policy claimed that the information provided was easy to understand.

7.27 The research identified a number of ways in which the quality of existing traffic management information could be further improved. Consumers participating in the research suggested that ISPs should:

- provide an introduction to the traffic management information that summarises the relevance of the policy and how it affects their range of products;
- ensure that technical terms are explained in clear and simple language;
- provide specific and meaningful measurement criteria for when high usage or 'fair usage' policies are applied (for example hours of streaming allowed as opposed to how many megabytes);and

[94] In General Condition 9.2e.
[95] http://www.broadbanduk.org/component/option,com_docman/task,doc_download/gid,1335/Itemid,63/
[96] http://consumers.ofcom.org.uk/2013/09/internet-traffic-management/
[97] http://stakeholders.ofcom.org.uk/market-data-research/other/telecoms-research/traffic/

- use clear symbols to represent 'yes,' 'no' and 'not applicable' in the key information tables.

7.28 Ofcom has asked the BSG to consider the research findings and how ISPs can implement the practical improvements outlined above. We also plan to discuss the results of the research with consumer representatives and industry to explore ways of improving awareness of traffic management. This may result in modifications to the current code or the integration of its content with other Ofcom-sponsored Codes such as that on broadband speeds. These potential outcomes will, however, be determined by an analysis of how well the existing Code fulfils the intended goal of providing sufficient transparency so that consumers can make informed decisions, and in the context of the broader regulatory and legislative agenda, particularly at the EU level.

7.29 We are currently unaware of any active blocking on any fixed line services, although Vodafone and EE block VOIP services on some of their mobile packages. These factors, and the intensity of competition in the UK internet access market underpin our decision not to pursue a regulatory intervention to impose traffic management obligations on network operators. However, we will continue to monitor the state of the market, and have taken important steps to improve the ease of switching and to work with industry to ensure that transparency measures are effective.

7.30 We also said that if ISPs offer a service to consumers which they describe as 'internet access', this creates an expectation that this service will be unrestricted, enabling the consumer to access any service lawfully available on the internet. Therefore, if a service does not provide full access to the internet, we would not expect it to be marketed as internet access.

7.31 Under the auspices of the BSG a number of fixed and mobile broadband operators have also agreed to go further and offer an internet service where no specific services are restricted or blocked, even though traffic management can still be used to manage their network. The Open Internet Code of Practice[98] builds on the earlier agreement and adds three new commitments:

- ISPs promise open and full access to the internet across their range of services;
- firms cannot market a subscription package as including "internet access" if certain kinds of legal content or services are barred; and
- members must not target and degrade content or applications offered by a specific rival.

7.32 The agreement was signed in July 2012 by Be, BT, BSkyB, KCOM, giffgaff, O2, Plusnet, TalkTalk, Tesco Mobile and Three. Some of the providers who are using more restrictive practices have not signed and implemented the agreement, including Everything Everywhere and Vodafone.

Our findings

7.33 In compiling data for this report, we used our formal information gathering powers under the Act to request information on operators' traffic management practices. Failure to respond accurately to a formal information request can result in enforcement action being taken by Ofcom, which can lead to substantive financial

[98] http://www.broadbanduk.org/index.php?option=com_content&task=view&id=485&Itemid=7

penalties. We found that the information provided by operators in response to our request was consistent with their published KFIs.

7.34 The evidence we have seen suggests that there are no substantiated concerns about current traffic management practices in the fixed sector. Some fixed ISPs have now adopted a policy under which there is no active management at all and, of those who do apply some degree of prioritisation, there is no overt blocking of any legal traffic or the application of levels of prioritisation (often known as “throttling”) that would make particular services or applications unusable.

7.35 There is, however, an emerging concern that in some cases in the mobile sector, contractual terms and conditions with respect to constraints on the use of VoIP appear to be in conflict with the published KFIs. In the work that we will ask the BSG to undertake, we will be proposing that they address this issue to make sure that signatories ensure that their messages regarding such practices are both clear and consistent. As noted above, however, we have not identified any traffic management practices which are in use by mobile operators and which are not publicly reported.

Interconnection with other networks

Introduction

7.36 While ISPs use different techniques to manage their customers’ traffic within their own networks, the way that ISPs connect to content outside their network will also have an impact on the customer’s experience. There are two main ways in which ISPs connect to content providers and other ISPs:

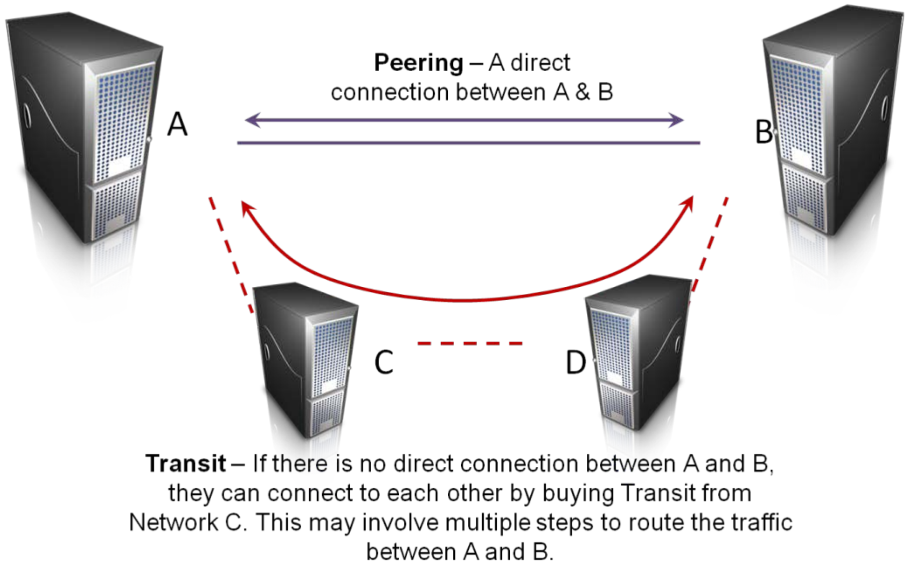
- **Peering** - A mutual agreement between two network providers to exchange traffic, either in private or via a public peering internet exchange. Peering is usually free (due to the symmetry in the benefits each party receives and, traditionally, the roughly symmetrical traffic flows), but in some circumstances, payment may flow from one party to the other.

- **Transit** – The ISP pays for bandwidth from a provider of core internet connectivity. All internet access providers will need a transit connection to provide access to data hosted on services with which they are not directly peered. Transit is often used to connect to services hosted in other countries.

7.37 In addition, content providers may use Content Delivery Networks (CDN) to store their content at a location nearer to the end user, usually at a data centre[99]. The ISP will peer with the CDN for a more direct connection between the content provider and the end user. This provides bandwidth savings for the ISP as it does not have to carry the content from a distant server (potentially via a paid for transit circuit) every time it is requested by a customer, and it benefits the content provider as the customer has a better experience of accessing that content. Figure 50 illustrates the differences between peering and transit.

[99] Some content providers also provide caching servers with commonly viewed content at internet peering points or, in some cases, embedded between access networks. Google and Netflix are among those adopting this approach.

Figure 50 – Peering and Transit



Source: Ofcom

7.38 Peering will take place at a location that is mutually convenient for both parties. In some cases these will be at Internet Exchange Points (IXPs), locations which have been built to facilitate peering. Each ISP installs a circuit from its network to the peering site in order to connect with another network. As multiple networks all have presence at the same physical location it becomes cheaper for all these networks to interconnect with each other. In the UK a large number of public Internet Exchange points are located in London. London Internet Exchange (LINX) and London Network Access Point (LONAP) are two of the largest not-for-profit organisations providing these interconnect locations. Some exchange points are located elsewhere, such as Leeds and Manchester, and a number of ISPs, notably those with an international network footprint, also choose to peer at other leading IXPs, such as AMS-IX in Amsterdam.

7.39 Traditionally peering, as the name implies, took place between broadly equivalent actors in the internet value chain, e.g. access providers or so-called "Tier 1" providers of core internet connectivity. These arrangements were predicated on roughly symmetrical traffic flows, broadly equivalent benefits and, consequently, the base case assumption that each side should bear their own direct costs. Increasingly, however, "peering" arrangements are being put in place that are not like this at all, involving different actors in the value chain and with highly asymmetric traffic flows. For example, the BBC has "peering" arrangements with a number of ISPs which means that its iPlayer services are delivered over a peered link, freeing up the ISP's transit connections for other traffic and leading to improved speeds and/or reliability for particular types of services and so giving consumers a better quality of service. Other content providers are adopting the same approach.

7.40 It can be argued that, the extensive use of peering, particularly for this type of content delivery connectivity[100], is a development of the internet away from its traditional form in which all traffic had equal 'best efforts' treatment. However, the development can have benefits for consumers as it can allow them to receive services faster. If the development leads to consumer detriment, such as consumers not being able to access the type of services they would expect to receive over the internet or

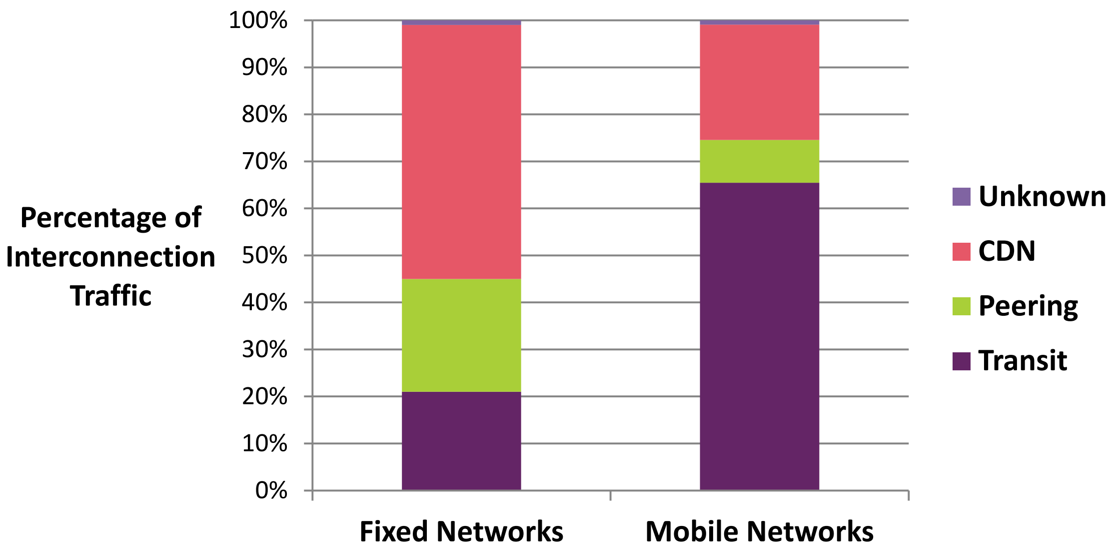
[100] Which may or may not involve CDN type assets.

receiving a significantly poorer quality of experience for non-“peered” services (for example, if the ISP were to reduce its investment in transit services), then its use could limit the scope for new innovative services to establish themselves in the marketplace.

Internet Interconnect arrangements in the UK

7.41 Data collected from UK internet and mobile data service providers show that fixed and mobile operators continue to use both transit and peering. However, as shown in Figure 51, fixed providers use a larger proportion of peering compared to mobile operators.

Figure 51 – Share of Peering and Transit interconnections for a typical fixed and mobile operators



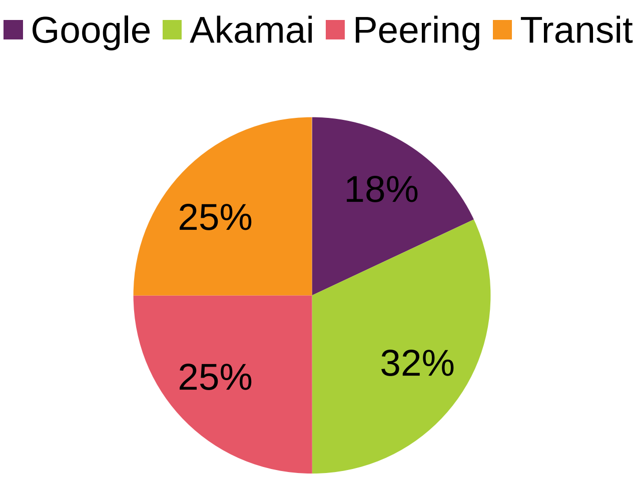
Source: Ofcom/operators

7.42 The different approaches to interconnection adopted by fixed and mobile operators may be the result of the different types of use on these networks. Fixed networks have traditionally carried more video content, and hence have peering arrangements with CDNs for the delivery of the more popular video content.

7.43 The differences may also be a result of the different amount of data use on the networks. 650PB of data went through the fixed networks in June 2013 compared to 29PB of data on mobile networks. As there is significantly less traffic on mobile networks, transit fees are not as expensive and therefore mobile operators may not yet see the need to invest as much in peering arrangements. However, as data use on mobile networks increases, this arrangement may change.

7.44 Like last year, we asked operators about their IP interconnect arrangements. In addition to traditional “peering” and paid for internet transit, we found that ISPs now commonly connect to a small group of key CDNs. For both fixed and mobile networks, the most popular as individual “peers” are Google and Akamai. LINX as an internet exchange point providing interconnection between many different ISPs and some content providers, also ranks highly as a point for “peering”, but is carrying a diminishing proportion of overall traffic. Overall, Google and Akamai both provide a similar volume of traffic and this is now significantly more than any other interconnect providers. Where available, internal caches are also provided by Google and Akamai, where Google and Akamai servers are located within the CP's network. As shown in Figure 52, traffic from all CDNs (both third party and service provider specific) makes up approximately half of all Internet traffic. In some fixed networks, of the total volume of traffic served to end customers, as much as 60% to 70% may come directly or indirectly from a very small number of CDN sources.

Figure 52 – Typical ISP mix of interconnection



Source: Ofcom/operators

7.45 Public peering and transit arrangements make up the rest of the traffic flow with, on average for fixed providers, a roughly equal split, although the proportions do vary quite widely, probably for historic reasons. Mobile providers are typically more reliant on transit with less public peering.

7.46 This situation represents a fundamental shift in "interconnection" practice away from the traditional "public peering" model where roughly symmetric traffic is exchanged at agreed peering points and both sides bear their own capex and opex costs. Transit capacity is charged to the access provider on the basis of peak traffic flows. CDN commercial arrangements are confidential but are known to range from the public peering model to some form of contribution by the CDN operator/content provider to access provider "costs".

7.47 Directly connected CDN servers can provide a better experience for the users, making better use of superfast broadband connections, avoiding congestion on the open internet and delivering a higher quality of service. However, we will continue to monitor whether ISPs are providing sufficient general capacity to the internet to allow access to content and services which have not entered into such bilateral peering/hosting arrangements with the ISP.

7.48 As so much data is delivered via CDNs, this year we asked operators for more information about the types of traffic using their network. From their responses we found that the majority of traffic (between 40-50%) is video streaming followed by web browsing (between 30-40%). VoIP and instant messaging make up less than 1% of the bandwidth used. P2P traffic is usually throttled, but where it is not throttled it is typically the highest user of bandwidth on the network.

Internet Protocol addressing

7.49 The internet is a critical element of the UK communications infrastructure; its widespread availability and use helps support economic growth and innovation, the provision of government services as "digital by default", and the wider accessibility of a variety of communications and content services among other public policy objectives.

7.50 Each device connecting to the public internet requires access via a publicly routable, Internet Protocol (IP) address. Each "packet" of data on the network carries its source and destination IP addresses. A useful analogy for an IP address is a telephone number or a door number and postcode. When written in a decimal form, an IP address is referred to as a "dotted quad" notation. For example, the Ofcom website IP address is 194.33.160.25.

7.51 The length of an IPv4 address currently predominating in use is fixed at 32 bits (a bit is a binary digit which is either 1 or 0). The 32-bit length effectively limits the IPv4 address space to over four billion publicly routable IP addresses. Global growth in demand for internet services, and of internet-connected devices has resulted in the pool of IPv4 addresses available for new allocation approaching exhaustion.

7.52 The registry RIPE, which allocates IPv4 addresses in Europe and the Middle East, reached its final large block of IPv4 addresses available for allocation on 14 September 2012. In last year's report, we looked at the readiness of core ISP networks for the imminent exhaustion of IPv4 addresses available for new assignment to end-users and their proposed strategy for the adoption of the successor, IPv6.

7.53 This year we are also publishing independent reports[101] [102]on the overall state of readiness for and adoption of IPv6 across UK ISPs and users, and the possible impact of the adoption of the IPv4 address conservation technology known as Carrier Grade NAT (Network Address Translation), which mobile networks are already using. IPv6 take-up and use remains low but, compared to last year, ISPs have firmer plans for addressing IPv4 exhaustion and introducing IPv6. We will continue to monitor the situation with a view to determining whether consumer experience is being adversely impacted.

Internet Protocol version 6 (IPv6)

7.54 IPv6 is a technology standardised in the mid 1990s to address the potential problems that would arise from the limited stock of IPv4 addresses as it offers a greatly expanded address space. However, almost twenty years after the standard was first created, its adoption has been limited. IPv6 uses a 128 bit address length and in doing so creates a massive address space, providing an alternative to scarce IPv4 addresses.

7.55 Unfortunately, IPv6 and IPv4 are not directly compatible. A service available only on IPv4 would not be directly accessible to a device using only IPv6 networking software, and vice versa. Consequently, since a hard "cut over" is not feasible, it is likely that IPv4 and IPv6 network protocols will need to co-exist for some

[101] http://stakeholders.ofcom.org.uk/binaries/research/technology-research/2013/internet-protocol.pdf
[102] http://stakeholders.ofcom.org.uk/binaries/research/technology-research/2013/cgnat.pdf

considerable time, conceivably a decade or more, to allow for service and device upgrade.

7.56 To support both the “dual stack” of IPv4 and IPv6 protocols, networking equipment located within the carrier networks and customer premises may require software/firmware updates or, in the event of non-support, complete replacement.

7.57 Many consumers choose to purchase and install their own home networking equipment to connect to their ISP service. The number of overall UK customer-owned IPv6 capable network routers or modem is unknown, but many, lower cost, devices available are still not IPv6 capable. Our initial view of the retail market for IPv6 capable home routers does, however, suggest a small, but growing level of support for dual stack connectivity.

7.58 Most of the leading fixed ISPs supplying the consumer market provide CPE routers as part of their core package, or as a relatively low cost option. Estimates received by Ofcom of such ISP supplied CPE IPv6 readiness ranged from 90% to 5%, with some that are IPv6 “capable” requiring firmware upgrades to be functional.

Figure 53 - Estimated levels of IPv6 readiness supplied CPE[103]

Operators	% ISP supplied CPE IPv6 Ready
A	52%
B	5%
C	12%
D	90%
E	53%

Source: Ofcom/operators

7.59 The picture for IPv6 readiness within the mobile internet sector is more complex. Mobile internet providers are often subject to the technical strategy, software support and development plans of large global handset and dongle manufacturers. In many cases, as with fixed line internet access, mobile customers may supply their own equipment to connect to the internet.

7.60 However, another factor is the extensive use within mobile networks of address sharing. Mobile subscribers are already routinely assigned special IPv4 addresses which are reserved for use within a private network and, hence, mobile operators are much less concerned about public IPv4 address exhaustion as they are able to share their existing allocation between users (see below).

7.61 Generally, the networks of the large retail ISPs are now able to support both IPv4 and IPv6 traffic. Although none of them currently provide an IPv6 address to

[103] Data has been anonymised as it is provided on a confidential basis

residential customers[104], some are able to provide services to larger business customers. These ISPs have no pressing concerns about the exhaustion of IPv4 addresses as they either have a clear roadmap towards IPv6 adoption or are planning to deploy other approaches to mitigate the threat, such as reusing addresses allocated to old customers and through the adoption of technologies such as Carrier Grade NAT (CGN), in effect adopting the approach already in use in mobile networks described at 7.60.

7.62 Whilst UK IPv6 traffic is reportedly low, there is some degree of readiness within UK internet infrastructure. Nominet, the .uk domain name registry, estimate around 35% of their namespace is reachable via IPv6.

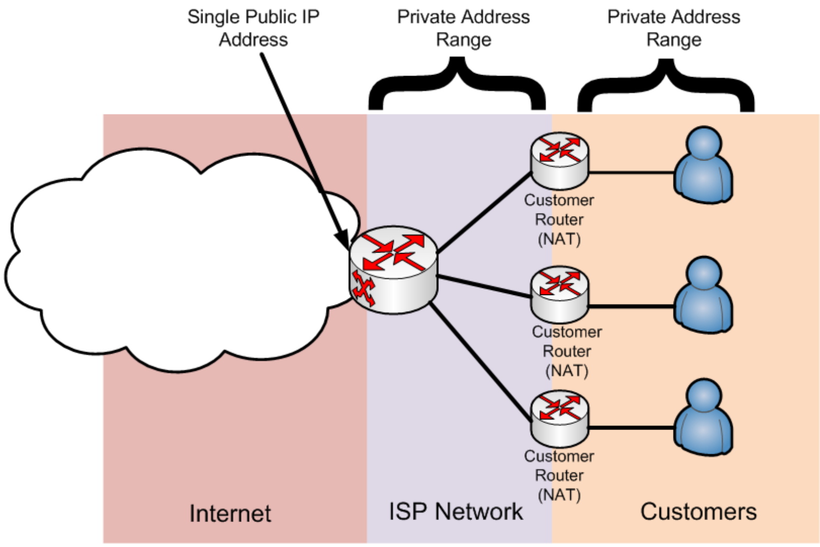
Internet Protocol address sharing

7.63 The use of Carrier Grade Network Address Translation (CGN) technology provides a mechanism for multiple subscribers to share a single IP address. This is particularly useful where a communications provider has exhausted its supply of IPv4 addresses.

7.64 CGN is not a new technology; it has been used in mobile broadband networks for some time. However, there are key differences between the available applications, services, devices, and usage scenarios between fixed and mobile networks. It is known that some applications fail when operating behind a CGN, although a number of mitigating techniques have been developed that can be used by application and service developers maintain functionality.

7.65 ISPs in the UK are beginning to pilot the use of CGN to allow multiple subscribers to share a single IPv4 address. For instance, PlusNet conducted a CGN trial in early 2013, and in May 2013 BT introduced CGN to customers of its basic BT Total Option 1 Broadband service.

Figure 54 - Example high level CGN



Source: Ofcom

7.66 To further understand the consequences of IPv4 exhaustion and the progress of IPv6 adoption in the UK, Ofcom commissioned two independent reports from InterConnect

[104] Although IPv6 addresses are available from a number of smaller, niche providers

Communications (ICC). The first report, Internet Protocol Version 6 (IPv6) Deployment Study, commissioned in early 2012, examines the status and prospects of transition to the IPv6 addressing system, including the current position with regard to IPv4 usage and the potential implications of IPv4 exhaustion. The second report, commissioned in December 2012, focuses on the implications of Carrier Grade Network Address Translation (CGN), a technology that is being used to facilitate the transition from IPv4 to IPv6, and on the potential implications of the introduction of this technology. These reports are published separately[105] [106].

7.67 The second report found that some consumer services and applications are likely to suffer functionality impairment of varying severity as a result of the implementation of CGN on fixed ISP networks. There are a number of reasons for this, but the critical issues arise because CGN introduces a significant new element in the management of internet traffic on a network.

7.68 CGN implementations are unlikely to interfere with simple internet use such as email, or basic web browsing, but are more likely to cause problems with services which require inbound connections to the end-users, consume a high number of ports[107] or rely on source IP address for authentication.

7.69 The ICC report found that there could be difficulties with services that use Peer-to-Peer technology and other more sophisticated networking techniques, including some Voice over Internet Protocol (VoIP) telephony services, streaming music services, games consoles, applications that use Peer-to-Peer overlay networks for content distribution, and other more advanced internet services. The problems users face may be intermittent and unpredictable, and it may be very hard for them to determine that service problems arise from the operation of CGN, as opposed to other application or connectivity issues.

7.70 Although it is possible to mitigate the effects of CGNs, individual applications or services may require different specific solutions; for applications developers, the CGN solutions adopted by individual ISPs may similarly cause specific and different problems, unless there is a widespread adoption of standardised CGN implementations and mitigation technologies.

7.71 In addition to difficulties faced by internet users, the report predicted that CGN implementation may lead to increased costs and technical complexity for ISPs and for online service providers, who may struggle to maintain the accessibility and quality of the full range of online services offered to consumers.

7.72 These increased costs may arise for ISPs in network operations and in customer service and support. ISPs may also face increased costs in logging subscriber data (for both network operations and to respond to requests made by law enforcement agencies for communications data under statutory provisions), as well as additional technical challenges to maintain current levels of privacy and security.

[105] http://stakeholders.ofcom.org.uk/binaries/research/technology-research/2013/internet-protocol.pdf
[106] http://stakeholders.ofcom.org.uk/binaries/research/technology-research/2013/cgnat.pdf
[107] A port is an application-specific or process-specific software construct serving as a communications endpoint in a computer's host operating system. A port is associated with an IP address of the host, as well as the type of protocol used for communication. The purpose of ports is to uniquely identify different applications or processes running on a single computer and thereby enable them to share a single physical connection to a the Internet.

7.73 Ultimately CGN use, at least in fixed networks, may be of limited use as part of the transition to IPv6, given the increased technical burden on ISPs of network operations and customer support; and as the benefits of CGN solutions to ISP will decline once IPv4 exhaustion has been resolved through end-to-end IPv6 adoption.

7.74 Through our understanding of the different approaches for mitigating the exhaustion of IPv4 addresses, the information gained from the consultants reports and from operators in the UK, there does not appear to be any immediate concern that the use and growth of internet addresses in the UK is at risk. Operators have a clear understanding of how they will continue to provide services to meet demand. In addition, we are not aware of any insurmountable barriers or regulatory hurdles which hinder the implementation of IPv6 addresses.

7.75 The solutions being developed by industry might however impact on other aspects of the internet which the Government is interested in, such as on-line copyright infringement, national security and child protection.

7.76 We will continue to work with operators to understand how they plan to ensure that they have sufficient addresses to provide services to their customers. In addition, we will be considering whether to add CGN impacts to the "KFI" required to be published by CPs under transparency rules over Traffic Management practices.

Domain Name System Security Extensions

7.77 The Domain Name System (DNS) is a globally distributed system that performs a number of important functions for the internet. A DNS name query is the translation of a domain name into an IP address. For example, when queried against DNS the domain name ofcom.org.uk returns the IPv4 address 194.33.160.25.

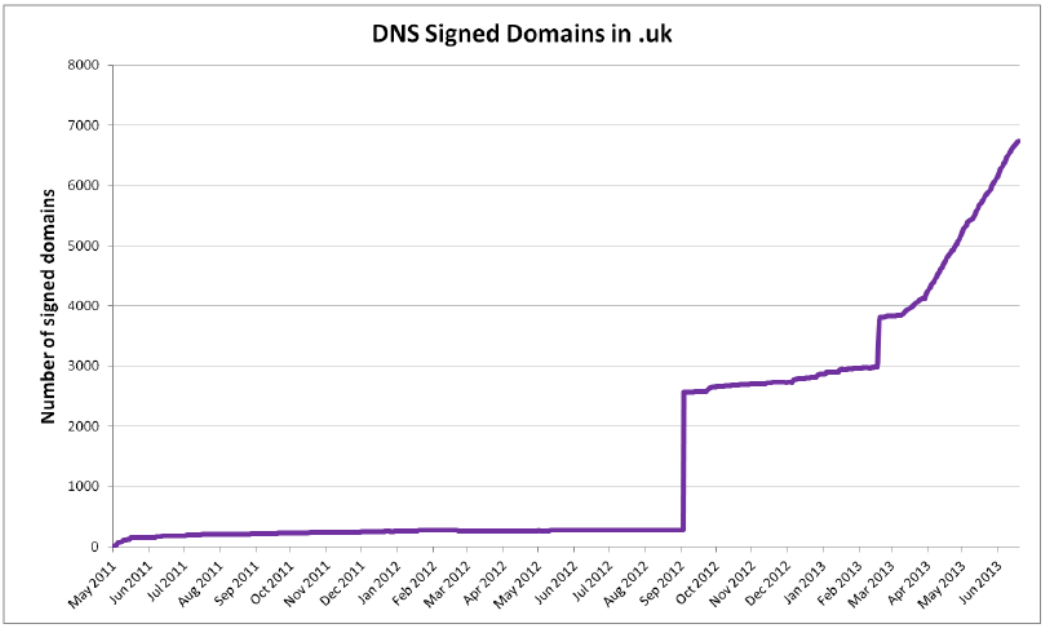
7.78 The unauthenticated nature of the DNS name query has made it vulnerable to malicious interception and tampering, as requests can be "highjacked" and the "wrong" IP address returned by a malicious actor. Domain Name System Security Extensions (DNSSEC) provides a means to cryptographically authenticate the response of a DNS name query, amongst other potential uses.

7.79 In 2011 Ofcom commissioned an independent study into the deployment of DNSSEC[108]. The study revealed that at the time the UK was at similar levels of preparedness for further DNSSEC adoption. However, the study also noted the non-trivial nature of DNSSEC deployment and management, and lack of perceived demand for DNSSEC.

7.80 For this report we asked Nominet, the UK country-code top level domain registry, about their view concerning levels of DNSSEC adoption observed within their name space. Nominet reported 6,736 DNSSEC signed domains within their domain space (.uk). There are over ten million domains registered in the .uk registry.

[108] Domain Name System Security Extensions Deployment
http://stakeholders.ofcom.org.uk/binaries/internet/domain-name-security.pdf

Figure 55: DNS Signed Domain in .uk



Source: Nominet

7.81 Whilst this accelerating rate of adoption shown in Figure 54 is encouraging, attaining the desirable position where it is the norm is a long way off. This may be a concern with respect to the increasing occurrence of exploits based on DNS vulnerabilities. It also, potentially, threatens the attainment of some aspects of Government cyber security policy. This may justify some form of policy or regulatory intervention.

7.82 In the meantime, we are committed to further engagement with Nominet and other key stakeholders on options for ensuring that DNSSEC is taken up by relevant sites. As the key domain registry governance structure for the UK, Nominet has a critical role here. We note their recent proposals for increasing take-up which were, unfortunately, rejected by their members[109]. We will continue to work with stakeholders to ensure take-up growth continues.

[109] See http://www.nominet.org.uk/sites/default/files/SecondLevelDomainRegistrationInUK%E2%80%93BackgroundAndFurtherDetail_4.pdf at page 10

Annex 1

Data assumptions/methodology

Fixed networks

A1.1 Data relating to each broadband connection operated by BT, Virgin Media, Everything Everywhere, O2, KCom, TalkTalk and Sky were collected and aggregated. For each connection, the data included the postcode, modem sync speed, data use and package details.

Average modem sync speeds

A1.2 For broadband delivered over telephone lines using the family of Digital Subscriber Line (DSL) technologies, the modem sync speed is the downstream data rate at which the ISP's equipment in the local exchange or cabinet sends data to the customer's broadband modem. Speeds will vary depending on what technology is deployed (e.g. ADSL supports a maximum of 8Mbit/s, ADSL2+ supports up to 24Mbit/s, current VDSL technologies support up to 80Mbit/s) and the quality of the telephone line (which is primarily driven by its length).

A1.3 The modem sync speed represents the highest possible speed at which data can be transferred across the line (when using the particular DSL technology variant). In practice, the speeds achieved by the end user will always be lower because some of the capacity of the connection is required for information to help send the users' data across the internet. Speeds may also reduce further when there is network congestion or when web servers are heavily loaded.

A1.4 While modem sync speeds do not therefore directly reflect end user experience, they are a very useful proxy of the state of the UK's broadband-over-telephone-line infrastructure, and provide a metric that can be tracked over time.

A1.5 Our calculations of average modem sync speeds also include existing cable broadband connections. For these connections we have used the headline speed of the broadband package of each existing consumer to calculate the average (e.g. 10Mbit/s, 20Mbit/s etc.). In practice, the modem sync speeds set by the cable operator are usually higher than the headline package speed to ensure that end users can experience the advertised speed.

A1.6 The average modem sync speeds presented in the report are based on our analysis of over 13m broadband connections. The composition of the sample reflects the mix of technologies (ADSL, ADSL2+, VDSL, FTTP, cable) and telephone line lengths in use across the UK.

Receiving less than 2Mbit/s broadband

A1.7 Using the same sample of DSL connections used to derive the average modem sync speeds, we have identified the percentage of customers receiving broadband over their telephone line at speeds of less than 2Mbit/s.

A1.8 As outlined above, speeds experienced by end users will always be less than their modem sync speed. To account for this, we have identified those connections that have modem sync speeds of less than 2.2Mbit/s, thereby allowing for a 10% overhead on the connection.

A1.9 Some customers may be on low speed legacy broadband packages e.g.1Mbit/s and hence are included in the metric. While these customers may simply need to switch to a different package (e.g. up to 8Mbit/s) to achieve higher speeds, some customers will have been placed on these slower speed packages because it has already been established that their line cannot support higher speeds and restricting the speed can improve the stability of the connection. We have therefore chosen not to exclude these customers from our calculations.

Data processing

A1.10 Data manipulation and auditing took place over a number of stages. These included:

- Data cleansing to remove impossibly large values and any fields where data was missing. Aggregating data provided by operators into a common format and carrying out validation to ensure the dataset is of the correct magnitude.
- Appending geographical data, including the local authority, country and urban/semi-urban/rural code based on postcodes. This stage also provided a summary as to how many properties exist in each type of location which is aggregated on a local authority or county basis.
- Data were split both by local authority and by individual postcode, and this was repeated for urban, semi-urban and rural areas.

Take-up

A1.11 The data provided by the largest ISPs were weighted up such that the total amount of lines was that of the entire market size of 21.7 million as reported in the Communication Market Report and the weightings were applied to the results at a local authority level.

A1.12 Data provided by other providers is listed in Annex 2 but has not been reflected in the overall takeup analysis since this would provide little difference to the overall capacity analysis. Data were not provided by other, smaller network operators and are therefore not reflected in our analysis.

Data use

A1.13 Where we have reported on data use, the figures represent the total of uploaded and downloaded data.

Mobile networks

Mobile coverage

A1.14 Data were collected from mobile operators on predicted outdoor coverage of 2G and 3G networks. A signal strength of -86dBm was used as the threshold for making 2G calls and a threshold of -100 dBm (CPICH[110]) for 3G. Two operators provided 2G and 3G data in May 2012.

A1.15 Geographic coverage has been calculated by assessing the percentage of land area in each local authority that is served by zero, one, two, three (and four for 3G)

[110] Common Pilot Channel

operators. While some local authority areas extend into river estuaries and sea inlets, the data were trimmed to the coastline to provide an accurate measure of land coverage. Analysis was based on aggregating 200mx200m grid squares, with each square deemed 'served' or 'not served' by each operator based on the predicted signal strength for the centre of that square.

A1.16 Premises coverage has been calculated by overlaying the location of each postal delivery address in Great Britain (aggregated into 200mx200m grid squares) with the predicted outdoor coverage of each 2G and 3G operator. The proportion of premises served by zero, one, two, three (and four for 3G) operators was then calculated. For Northern Ireland, we did not hold data on the location of individual premises, so coverage was based on postcodes' centres (if the centre of the postcode was served, we have assumed that all premises in the postcode were served). Data have been aggregated up to county/unitary authority level.

A1.17 When calculating rural and urban coverage, signal strengths at the centre of each postcode in the UK were used to determine whether all premises in the postcode are served or not. Each postcode was designated as being urban, semi-urban or rural.

Mobile capacity demand

A1.18 Data were gathered from all four network operators relating to the data traffic throughput at each of their mast sites for a one-month period. Therefore the data collected represents 100% of the mobile market, including MVNOs and both residential and business users. We used the number provided to our quarterly data updates for the total number of active subscriptions in June[111].This includes MVNO customers.

A1.19 In aggregating data use at a local authority level, data associated with each mast were allocated to the local authority in which the mast was located (even though some masts may serve customers in a neighbouring authority).

Postcode data

A1.20 In calculating take-up of services we have used data from the Post Office Address File (PAF). In any given postcode we have taken the sum of residential and small business premises as representing the market opportunity for broadband services (where we refer to 'premises' or 'households' in this report we are referring to the sum of residential and small business postal delivery points). We have excluded PO boxes and assumed that large organisations (which make up a very small percentage of UK premises) would be more likely to purchase higher speed leased lines rather than copper or DOCSIS based broadband services.

A1.21 Where we have referred to urban, semi-urban and rural areas, these have been classified as follows[112]:

[111] http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/tables/
[112] See also http://www.ukgeographics.co.uk/images/locale.pdf

Figure 56 – Urban, semi-urban and rural coverage of mobile networks by premises

Classification	Type	% UK Premises
Urban	Large city, small city, large town,	34%
Semi-urban	Medium town, small town with <15,000 population	51%
Rural	Rural area with <2,000 population	14%

Annex 2

List of alternative broadband providers

A2.1 In January 2011 Ofcom published a report by Analysys Mason on current and planned deployments of superfast broadband by providers other than the main infrastructure providers in the UK[113]. More recently, Point Topic published a report on the availability and take-up of superfast broadband services in the UK[114]. This is an update on the deployment plans for these providers.

A2.2 These networks are categorised as follows:

- Property development – networks installed for new housing developments
- Local community based – community- led investment superfast broadband services
- Urban – network rollout in pre-built areas which are not community-led
- Regional Projects – network investment for both residential and business services
- Urban economic developments – network investment primarily for business services

Figure 57 – List of superfast broadband providers excluding the largest CPs

Company	Category	Location	Status of network
Atlas Communications	Property-development	Belfast	Live
Hyperoptic	Property-development	London	Live
Independent Fibre Networks Limited (IFNL)	Property-development	Swindon, Corby, Andover, Aylesbury, Milton Keynes, Bridgwater, Dartford, Peterborough, Bristol, London, Melksham, Exeter, Hythe, Oakham, Didcot, Fleet	Live
IsRightHere	Property-development	Liverpool, Leeds, London	Live
Velocity 1	Property-development	Wembley,	Live

[113] http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/local-fibre-access.pdf
[114] http://www.callflowsolutions.com/assets/resources/files/Superfast%20broadband%20update%20full%20report%20March%202012%20on%20site.pdf

		Bournemouth, Bristol	
Cybermoor	Local community based	Cumbria	Live
Gigaclear	Local community based	Appleton, Eaton, Boars Hill, Fyfield and Tubney, Stanton Harcourt, Kingston Bagpuize and Southmoor, Frilford and Frilford Heath, Otmoor, Rutland	Live
Whitcomm Co-operative	Local community based	Cambusiang	Live
Callflow Solutions	Urban	Parts of Kent	Live
CityFibre Holdings	Urban	Bournemouth	Live
Smallworld Cable	Urban	North West England and Western Scotland	Live
Wightcable	Urban	Isle of Wight	Live
Digital Region Limited	Regional projects	South Yorkshire	Live
Gateshead Technology Innovation	Urban economic development	Baltic Business Quarter	Live
Manchester Digital Development Agency	Urban economic development	Central Manchester	Live

A2.3 This is not an exhaustive list of NGA networks and services in the UK. We invite contributions from providers of these networks and services to provide us with more up-to-date information about the coverage of superfast services. However, data is included here from Hyperoptic, Velocity One, Gigaclear and Digital Region Limited.

A2.4 Gigaclear has been rolling out NGA near Abingdon in Oxfordshire and to a small development near Rutland.

A2.5 In late 2012, Digital Region South Yorkshire was using a series of public grants in order to roll out superfast broadband to residents and commercial premises across the whole of South Yorkshire with the aim of providing coverage to around 1.3 million customers and over half a million homes. The rollout was due to cover both business and residential consumers, many of whom reside in rural localities. In August 2013, it was announced by shareholders that the public-private partnership was no longer financially viable. Existing customers were reverted on to other ISPs and the service was terminated. It is noted that in many of the areas served by Digital Region HFC is also available.

A2.7 Velocity One is a FTTH technology owned by Magnet and covers Wembley City in North West London. Large majority of the customers are receiving over 50 Mbit/s and business customers across the two different developments receive slightly higher speeds.

A2.8 Hyperoptic is a medium scale fibre optic network serving customers across several postcodes in London, and all of their customers receive speeds between 80 and 100 Mbit/s.

Annex 3

Glossary

2G Second generation of mobile telephony systems. Uses digital transmission to support voice, low-speed data communications, and short messaging services.

3G Third generation of mobile systems. Provides high-speed data transmission and supports multi-media applications such as video, audio and internet access, alongside conventional voice services.

4G Fourth generation of mobile systems. It is designed to provide faster data download and upload speeds on mobile networks.

Access network An electronic communications network which connects end-users to a service provider; running from the end-user's premises to a local access node and supporting the provision of access-based services. It is sometimes referred to as the 'local loop' or the 'last mile'.

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 ('downstream' towards the customer) than the other.

Backhaul The part of the communications network which connects the local exchange to the ISP's core network

Base station This is the active equipment installed at a mobile transmitter site. The equipment installed determines the types of access technology that are used at that site.

BDUK Broadband Delivery UK

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

Bonding A technique which could be used in DSL networks to improve data speeds by using multiple copper lines between the cabinet and the customer's premises.

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

Core network The central part of any network aggregating traffic from multiple backhaul and access networks.

Data packet In networking, the smallest unit of information transmitted as a discrete entity from one node on the network to another.

DCMS Department for Culture, Media and Sport.

DOCSIS Data Over Cable Service Interface Specification. It is a standard for the high speed transmission of data over cable networks.

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 and VDSL (very high speed digital subscriber line) are variants of xDSL).

Femtocell A small base station, typically installed indoors to improve indoor mobile coverage. A residential femtocell uses the consumer's broadband connection to offload the mobile data onto the fixed network.

FTTC Fibre to the Cabinet. Access network consisting of optical fibre extending from the access node to the street cabinet. The street cabinet is usually located only a few hundred metres from the subscribers' premises. The remaining segment of the access network from the cabinet to the customer is usually a copper pair.

FTTH Fibre to the Home. A form of fibre optic communication delivery in which the optical signal reaches the end user's home.

GPON Gigabit Passive Optical Network. A point to multipoint network (as opposed to a point to point network), where a single optical fibre is used to serve multiple premises using passive splitters at higher speeds.

GSM Global Standard for Mobile telephony. This is the standard used for 2G mobile systems.

Headline connection speed marketed speed.

HFC Hybrid Fibre Coaxial. A combined optical fibre and coaxial cable (a cable made up of a conductor and a tubular insulating layer) commonly used in cable networks.

IP Internet Protocol. This is the packet data protocol used for routing and carrying data across the internet and similar networks.

IPTV Internet Protocol Television. The term used for television and/or video signals that are delivered to subscribers or viewers using internet protocol (IP), the technology that is also used to access the internet. Typically used in the context of streamed linear and on-demand content, but sometimes for downloaded video clips.

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

Leased lines A transmission facility which is leased by an end user from a public carrier, and which is dedicated to that user's traffic.

LLU Local Loop Unbundling. LLU is the process where incumbent operators (in the UK this is BT and KCom) make their local network (the lines that run from the customers' 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.

LTE Long Term Evolution. This is a 4G technology which is designed to provide faster upload and downloads speeds for data on mobile networks.

MNO Mobile Network Operator, a provider who owns a cellular mobile network.

Mobile Broadband Various types of wireless, high speed internet access through a mobile telephone or a mobile data dongle.

Modem Snyc Speed The modem sync speed represents the highest possible speed at which data can be transferred across the line.

MVNO Mobile Virtual Network Operator. An organisation which provides mobile telephony services to its customers, but does not have allocation of spectrum or its own wireless network and instead, buys a wholesale service from a mobile network operator.

Narrowband A service or connection providing data speeds up to 128kbit/s, for example via an analogue telephone line.

Not-spot An area which is not covered by fixed or mobile networks.

Peer to Peer (P2P) It is a distributed application that uses end users' computers as nodes to deliver service applications.

Point-to-Point A network topology where the end user is connected to the network via a dedicated fibre.

PSTN Public Switched Telephone Network. The network that manages circuit switched fixed-line telephone systems.

SIM Subscriber Identity Module. A SIM is a small flat electronic chip that identifies a mobile customer and the mobile operator. A mobile phone must have a SIM before it can be used.

Smartphone A mobile phone that offers more advanced computing ability and connectivity than a contemporary basic 'feature' phone.

superfast broadband Super-Fast Broadband. The next generation of faster broadband services, which delivers headline download speeds of greater than 30Mbit/s.

SLU Sub-Loop Unbundling. This is where the unbundling of the access line takes place at the street side cabinet (rather than the exchange as for LLU) for a communications provider to gain control of the access line to the customer.

Telecommunications Conveyance over distance of speech, music and other sounds, visual images or signals by electric, magnetic or electro-magnetic means.

Transmitter A device which amplifies an electrical signal at a frequency to be converted, by means of an aerial, into an electromagnetic wave (or radio wave). The term is commonly used to include other, attached devices, which impose a more simple signal onto the frequency, which is then sent as a radio wave. The term is sometimes also used to include the cable and aerial system referred to above, and indeed the whole electrical, electronic and physical system at the site of the transmitter.

UMA Unlicensed Mobile Access. A technology that provides roaming between GSM and 802.11 Wi-Fi

UMTS Universal Mobile Telecommunications System. The 3G mobile technology most commonly used in the UK and across Europe.

Unbundled A local exchange that has been subject to local loop unbundling (LLU).

Usage cap Monthly limit on the amount of data that users can download, imposed by fixed and mobile operators for some of their packages.

VDSL Very High Speed DSL. A high speed variant of DSL technology, which provides a high headline speed through reducing the length of the access line copper by connecting to fibre at the cabinet.

Vectoring A technique used in DSL networks to increase the data speeds by using real time digital signal processing techniques to reduce the interference on the line.

Wi-Fi A short range wireless access technology that allows devices to connect to a network through using any of the 802.11 standards. These technologies allow an over-the-air connection between a wireless client and a base station or between two wireless clients.

WiMAX A wireless MAN (metropolitan area network) technology, based on the 802.16 standard. It can be used for both fixed and mobile data applications.

WLR Wholesale Line Rental. This is a regulatory instrument requiring the operator of local access lines to make services available to competing providers at a wholesale price.

xDSL The generic term for the Digital Subscriber Line (DSL) family of technologies used to provide broadband services over a copper telephone line.

Annex 4

List of Broadband UK delivery projects

English Local Authority Areas

Devon & Somerset
Wiltshire, South Gloucestershire
Highlands and Islands
Lancashire, Blackpool, Blackburn with Darwen
Rutland
North Yorkshire
Wales
Surrey
Cumbria
Herefordshire and Gloucestershire
Norfolk
Suffolk
Cambridgeshire and Peterborough
Lincolnshire
Northamptonshire
Kent and Medway
Hampshire
Shropshire
Northumberland
Durham, Gateshead, Tees Valley and Sunderland
Cheshire Councils
West Sussex

Staffordshire and Stoke-on-Trent
East Sussex, Brighton and Hove
North Lincolnshire, North East Lincolnshire
Scotland rest of
Dorset, Bournemouth and Poole
Oxfordshire
Derbyshire
Worcestershire
Nottinghamshire
Essex, Southend-On-Sea, Thurrock
Merseyside
West Yorkshire
Newcastle upon Tyne
Central Beds, Bedford Borough, Milton Keynes
East Riding of Yorkshire,
Leicestershire
Berkshire Councils
Isle of Wight
Northern Ireland
Greater Manchester
Coventry, Solihull, Warwickshire
Buckinghamshire, Hertfordshire