# Connected Nations 2015

## Full document

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Ofcom

# About this document

High quality, widespread communications, fixed and mobile, are an engine of our economy and the pulse of our society.

They are not nice-to-haves, but essential enablers of our working and social lives.

As businesses and consumers drive an ever-increasing demand for communications, the infrastructure that serves them must keep pace with their demands and needs.

One of Ofcom's roles is to make sure that the UK has the communications infrastructure it requires. This means making services available where people live and work; call connections being clear and robust; and data being down- and up-loaded at speeds that deliver a good experience.

Ofcom is also responsible for providing clear, accurate, easy to use information. This equips businesses and consumers to make informed decisions about the services that can serve them best.

This report charts the UK's evolving communications infrastructure, and our progress towards becoming genuinely connected nations.

# Contents

Section 1

# Dashboard

The data for 2015 was collected during May and June. Data for 2014 is provided for comparison, where available[1].

| Fixed broadband | 2015 | 2014 |
|---|---|---|
| **Broadband, all speeds** | | |
| Coverage, premises | ≈100% | ≈100% |
| Take-up, premises | 78% | 73% |
| Average download sync speed | 28Mbit/s | 23Mbit/s |
| Average monthly data usage[1], per residential connection | 82GB | 58GB |
| **Superfast broadband (download speed between 30Mbit/s and 300Mbit/s)** | | |
| Coverage, premises | 83% | 75% |
| Take-up, premises | 27% | 21% |
| Average download sync speed | 63Mbit/s | 54Mbit/s |
| Average monthly data usage[2], per residential connection | 112GB | N/A |
| **Ultrafast broadband (download speed greater than 300Mbit/s)** | | |
| Coverage, premises | 2% | N/A |
| Take-up, premises | 0.003% | N/A |

| Mobile | 2015 | 2014 |
|---|---|---|
| **2G (voice services)** | | |
| Premises (outdoor) covered by all operators [threshold -81dBm] | 93% | 93% |
| Premises (outdoor) not covered by any operator [threshold -81dBm] | <1% | <1% |
| Geographic area covered by all operators [threshold -81dBm] | 55% | 55% |
| Geographic area not covered by any operator [threshold -81dBm] | 16% | 16% |
| Coverage of A and B roads by all operators [threshold -71dBm] | 41% | N/A |
| A and B roads not covered by any operator [threshold -71dBm] | 17% | N/A |
| **3G (voice and data services)** | | |
| Premises (outdoor) covered by all operators [threshold -100dBm] | 88% | 84% |

[1] Data for 2014 is taken from the Infrastructure Report published in December 2014. Where we have changed our methodology (e.g. in defining rural areas or levels of 2G coverage), the comparisons we provide are estimates and may not have been previously published.
[2] Usage figure combines both downloaded and uploaded data.

| Mobile | 2015 | 2014 |
|---|---|---|
| Premises (outdoor) not covered by any operator [threshold -100dBm] | 0.7% | 0.8% |
| Geographic area covered by all operators [threshold -100dBm] | 37% | 26% |
| Geographic area not covered by any operator [threshold -100dBm] | 21% | 22% |
| Coverage of A and B roads by all operators [threshold -90dBm] | 36% | N/A |
| A and B roads not covered by any operator [threshold -90dBm] | 16% | N/A |
| **4G (data)[3]** | | |
| Premises (outdoor) covered by all operators [threshold -115dBm] | 46% | 37% |
| Premises (outdoor) not covered by any operator [threshold -115dBm] | 10% | 27% |
| Geographic area covered by all operators [threshold -115dBm] | 7% | 6% |
| Geographic area not covered by any operator [threshold -115dBm] | 52% | 76% |
| Coverage of A and B roads by all operators [threshold -105dBm] | 8% | N/A |
| A and B roads not covered by any operator [threshold -105dBm] | 47% | N/A |
| **Mobile (data use)** | | |
| Total number of active mobile connections | 83.7 million | 83.2 million |
| Total mobile data usage[4] | 72.9PB | 44.3PB |
| Average monthly data usage[4], per SIM | 0.87GB | 0.53GB |

| Wi-Fi | 2015 | 2014 |
|---|---|---|
| Number of public Wi-Fi hotspots | 44,804 | 41,798 |
| Total data usage[4] in June 2015 | 3.3PB | 2.3PB |
| Average data usage[4] per hotspot in June 2015 | 73GB | 54GB |

[3] Since we collected this data, some mobile operators have started to offer a voice service using their 4G network.
[4] Usage figure combines both downloaded and uploaded data.

Section 2

# Executive summary

2.1 Access to high quality fixed and mobile internet services is vital to our increasingly online social and economic lives. The coverage of such services across the UK has increased over the past year. Superfast broadband services are now available to 24 million, or 83% of, UK premises, and 13 million, or 46% of, premises are now covered by the latest 4G mobile services.

2.2 However, there are many areas of the UK where fast broadband services remain unavailable and where mobile coverage is poor. We are continuing to work with industry, the UK Government and the devolved administrations to explore ways to improve the availability of these vital communications services.

2.3 As a key part of this work, every year we publish a report which summarises the coverage of fixed and mobile networks in the UK, along with important developments in broadcasting and internet services. We also track security incidents that affect communications networks and services.

2.4 The key findings from this year's report are summarised below.

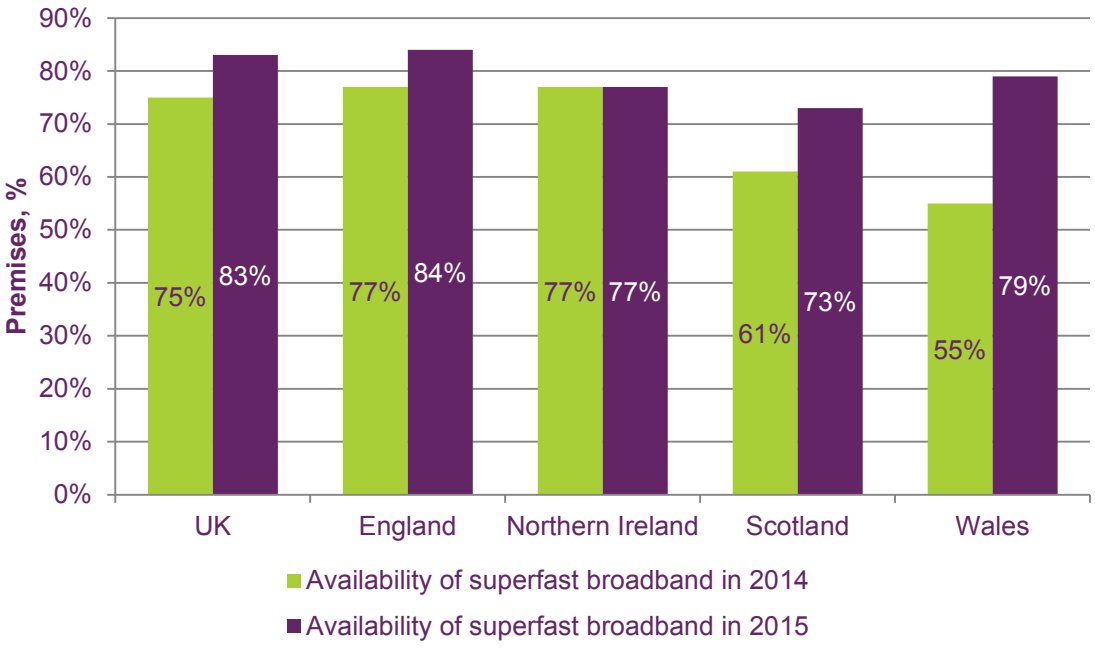
## Fixed broadband networks

### The coverage of fixed networks continues to improve for some, but many still cannot receive superfast broadband

2.5 Superfast broadband, offering download speeds of 30Mbit/s or more, is now available to around 24 million, or 83% of, UK premises, up from 75% last year. The situation has particularly improved in rural areas, where broadband coverage has always tended to be lower than in urban areas. This year, coverage of superfast in rural areas has increased significantly, from 22% in 2014 to 37% (over 1.1 million premises).

2.6 Superfast broadband has now been taken up by almost 8 million, or 27% of all premises in the UK, up from 21% in 2014. The percentage of premises not taking up broadband is now 22%, down from 27% in 2014. As a result of this greater take-up of superfast broadband, the average download speed is now 28Mbit/s, up from 23Mbit/s in 2014, which is an increase of 22%.

**Figure 1: Coverage of superfast services has improved**




*Source: Ofcom analysis of operator data*

2.7 However, while coverage and speeds have increased for some, many consumers and businesses have not seen improvements. Around 2.4 million, or 8% of premises in the UK are connected by lines that are unable to receive broadband speeds above 10Mbit/s.

2.8 Many of these premises are in rural areas, where about 1.5 million, or 48% of, premises are unable to receive speeds above 10Mbit/s. While coverage of broadband in rural areas and the nations has improved, it still lags behind the UK as a whole. Government programmes, such as those administered by Broadband Delivery UK (BDUK), are helping to address the problem of poor broadband coverage, particularly in rural areas. We would expect to see further improvements in rural broadband availability over the coming 2 to 3 years.

2.9 Small- and medium-sized enterprises (SMEs) still experience poorer superfast broadband coverage compared to consumers as whole. Only 68% of SMEs have access to superfast broadband in the UK, compared to 83% of all premises; this leaves over 400,000 SMEs without access to superfast broadband. Similarly, almost a half of SMEs (around 130,000) in certain business areas are unable to receive speeds above 10Mbit/s.

2.10 Delivering services across the internet, e.g. browsing the web or streaming a video, requires the interconnection of many different networks. This infrastructure, illustrated in Figure 2, is made up of many different technologies, each with different characteristics. Therefore it is not straightforward to predict what the consumer's broadband experience will be. For example:

2.10.1 **A home network:** This is increasingly the Wi-Fi network that extends the reach of the broadband connection throughout the home. In this case the consumer's broadband experience will depend on distance from the access point, the thickness of walls, the age of the equipment the consumer is

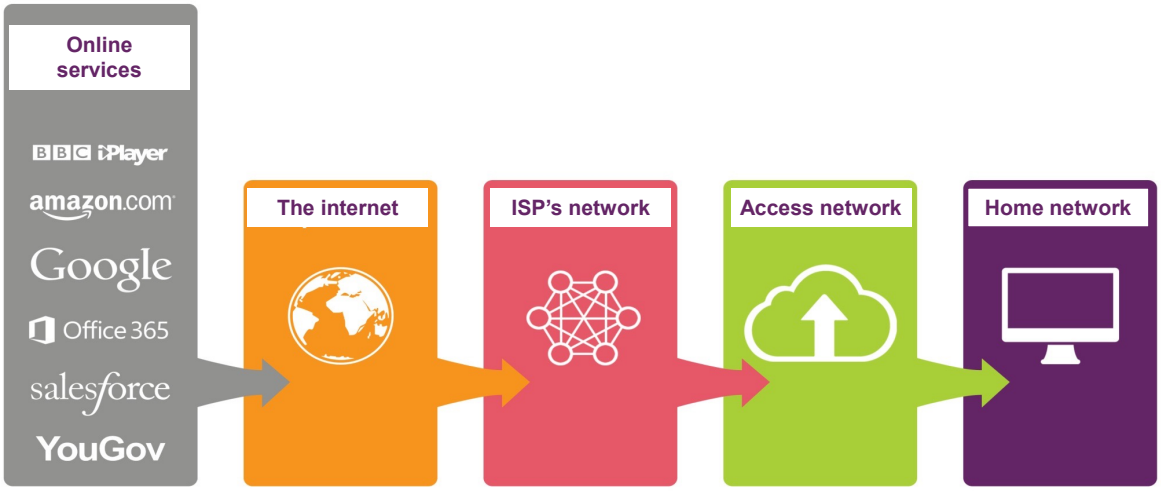
using and how many other people there are using the network at the same time.

2.10.2 **An access network:** This is the connection between the home and the internet service provider (ISP) or network operator, such as BT or Virgin Media. Originally, this connection was made of copper. In recent years, however, some or all of this connection has been replaced with fibre optic or a wireless technology such as 4G. The consumer's broadband experience may depend on how far their premises are from the street cabinet or exchange, and on the material from which the cables are made.

2.10.3 **The ISP's network:** This is the network that is internal to the ISP and which brings together the traffic of all of its customers. This network is mostly made up of fibre optic connections and high capacity/high speed core routing equipment. The consumer's broadband experience will depend on the number of users who are simultaneously trying to access content.

2.10.4 **The internet:** This is the collection of interconnected networks across the world that allows consumers in one country to access data in other countries. The consumer's broadband experience will vary depending on the content they wish to access, with some popular content delivered directly, and therefore more quickly, between networks.

**Figure 2: Simplified illustration of delivering services over the internet**

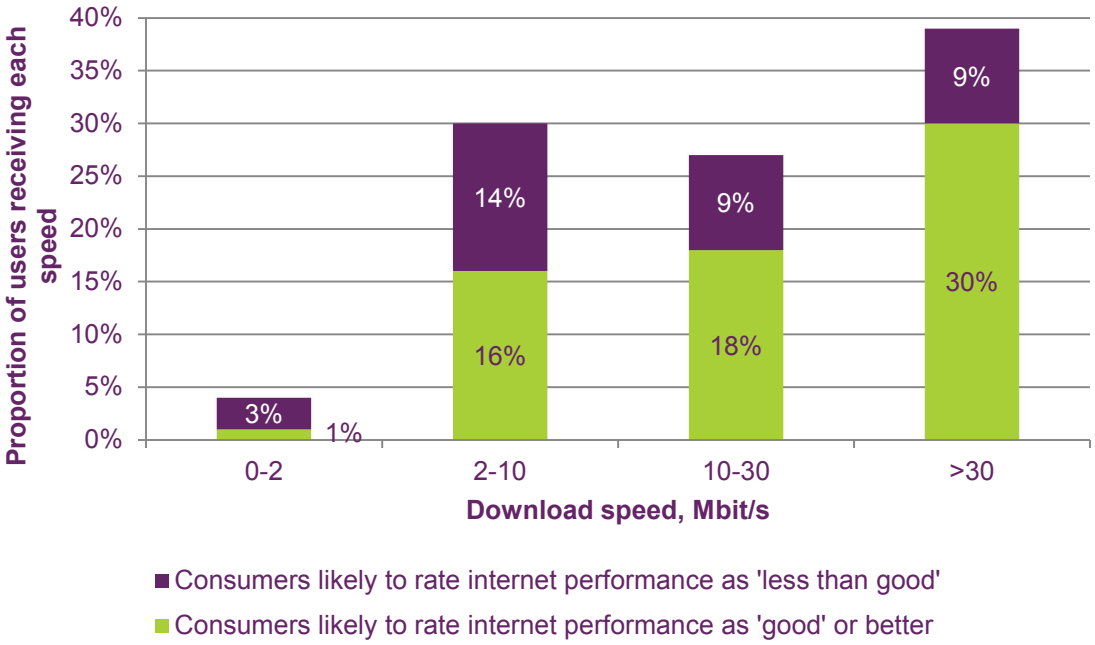



2.11 Over recent years, ISPs have been investing heavily in their networks to support higher speeds. Much of this investment has been focused on the access network, involving the replacement of some or all of the copper cables with fibre optic connections. These upgrades, alongside complementary enhancements in transmission and routing equipment, form the basis of many superfast broadband services.

## Better broadband matters to consumers

2.12 Evidence suggests that those consumers with faster connections are more likely to rate their broadband experience good, as shown in Figure 3. In general, 10Mbit/s appears to be the tipping point beyond which most consumers rate their broadband experience as 'good'. This continues to support our view that a minimum of 10Mbit/s is required by the typical household.

**Figure 3: Consumers with faster broadband speeds are more likely to rate their internet experience as 'good' or better**




*Source: Actual Experience for Ofcom*

2.13 Faster broadband also means that consumers can connect more devices to the internet at the same time. Wi-Fi is helping increasing numbers of consumers share their broadband connection throughout their homes. As a result, Wi-Fi has become vital to the broadband experience.

2.14 A new, innovative measurement approach[5] commissioned by Ofcom has found that Wi-Fi performance and congestion, occurring outside the ISP network in the wider internet, can combine to affect the broadband experience of consumers with both low speed and superfast connections.

2.15 In particular, we have found that the performance of in-home Wi-Fi networks plays a significant role in approximately 25% of households that experience problems with their broadband. We have launched an app for smartphones and tablets that tests Wi-Fi networks for performance issues. It will help consumers identify if their broadband is not performing as it should, and suggest simple troubleshooting steps to improve performance.

## Customers with superfast broadband are making greater use of their connections

2.16 Over the past year, the average amount of data used[6] by consumers has increased to 82GB a month – an average increase of over 40% on last year. We estimate that about 65% of this data is video traffic.

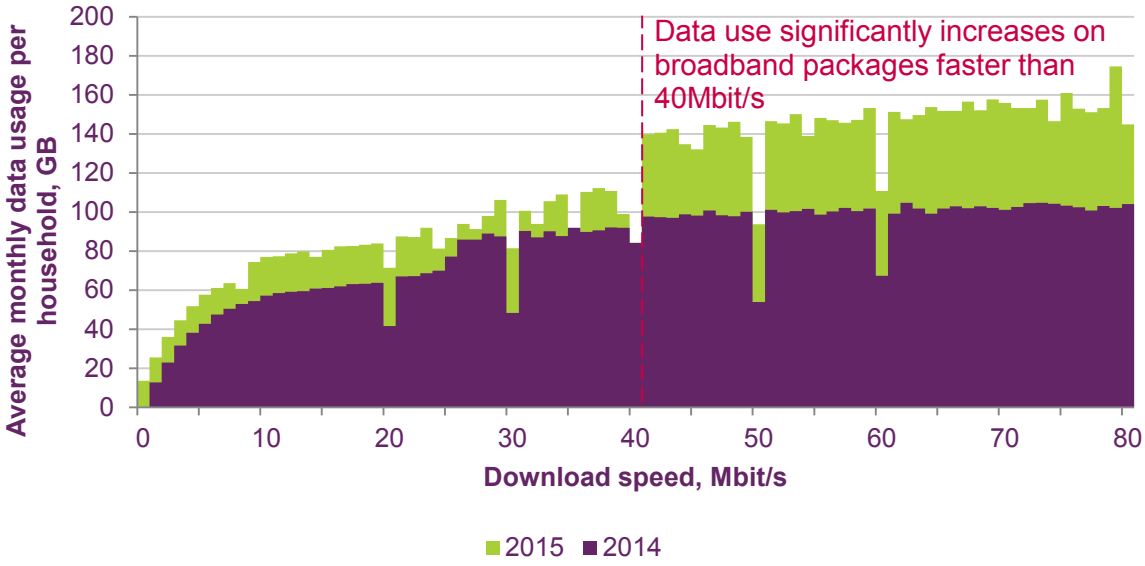
[5] http://stakeholders.ofcom.org.uk/binaries/research/infrastructure/2015/downloads/qoe-analysis.pdf http://stakeholders.ofcom.org.uk/binaries/research/infrastructure/2015/downloads/qoe_uk-analysis.pdf

[6] Both downloaded and uploaded.

2.17 In addition to rating their broadband experience more highly, there is evidence that households with connections above 40Mbit/s are consuming significantly more data, as shown in Figure 4. Previously, data use was relatively flat above 10Mbit/s.

2.18 This change indicates that consumers who particularly value and use their superfast broadband services are now opting for higher-speed packages.

**Figure 4: Users with the fastest broadband connections are driving the increase in data use**




*Source: Ofcom analysis of operator data*

## Broadcast TV platforms are becoming more integrated with the Internet

2.19 Linear broadcast TV remains the most important means of watching TV for the majority of people. However, the way in which we watch TV is continuing to evolve, with more viewing of video content over the internet. Younger people in particular are watching less broadcast TV, and the number of TV homes is continuing to fall.

2.20 The growth in internet-delivered TV is having major implications for providers of communications infrastructure. Video carried over fixed and mobile networks is growing; e.g. the proportion of video traffic delivered over fixed broadband networks in 2015 has risen to about 65%, from 48% in 2014. Network operators are continuing to invest in the additional capacity required to support this increase in traffic.

2.21 In the past 12 months a number of important and innovative devices and services have been launched, including the Freeview Play and Sky Q platforms. These illustrate the increasing integration of free-to-air and pay broadcast TV platforms with the internet. In addition, internet-based TV services such as Netflix, Amazon Prime and Apple TV are providing access to a greater variety of content, often on multiple devices. In particular, the ability to search for and easily locate content from multiple providers makes these product launches particularly attractive for consumers.

# Mobile networks

## Mobile voice coverage is largely unchanged from last year

2.22 As with fixed broadband, it is not straightforward to predict the experience a consumer will receive when using a mobile phone. The experience is likely to depend on a number of factors, including:

2.22.1 **the consumer's chosen mobile operator, which** may not have coverage at a particular location, or may not have installed equipment necessary to support the fastest speeds;

2.22.2 **where the consumer is;** e.g. whether they are in a city or in the countryside; and

2.22.3 Whether the consumer is **inside a building or car, or outdoors**.

2.23 Good coverage is fundamental to providing consumers with a good mobile experience. This year our focus has been on making information on mobile coverage available to consumers that is accessible, accurate and comparable. This is intended to enable consumers to make an informed decision on which operator best meets their needs and gives operators an increased incentive to compete on coverage.

2.24 Coverage of 2G and 3G services is broadly unchanged since 2014, covering around 93% and 88% of UK premises respectively[7]. While many areas are served by voice and basic data services, some areas continue to experience poor mobile coverage.

2.25 Mobile coverage is highest where the population density is high, such as in towns and cities. In rural areas, where population density is lower, mobile coverage also tends to be lower. For example, outdoor coverage of voice services from all operators in the UK's rural areas is 72% of premises, compared to 99% in urban areas. Indoor coverage in rural areas is lower, at 31%, as walls, buildings and doors block mobile signals as they pass through.

**Figure 5: Summary of outdoor mobile coverage from all operators in the UK and regions**

| | Percentage of premises covered | | | | |
|---|---|---|---|---|---|
| **Technology** (coverage threshold) | **Scotland** | **England** | **Wales** | **Northern Ireland** | **Whole of UK** |
| **2G** (-81dBm) | 90% | 94% | 84% | 83% | 93% |
| **3G** (-100dBm) | 79% | 91% | 67% | 73% | 88% |
| **4G** (-115dBm) | 37% | 50% | 20% | 0% | 46% |

*Source: Ofcom analysis of operator data*

[7] As explained in the next section, this year we are reporting on 2G mobile coverage based on the use of a higher signal strength than previously used.

### 2G coverage appears lower, but our new measurement approach better reflects consumer experience

2.26 This year we have revised our view on the levels of 2G coverage required for a reliable voice service. Our new approach is intended to reflect consumer experience, is based on the assumption that a modern smartphone is used and that a good service requires 90% of calls made or received to be successful.

2.27 We have found that the 2G mobile signal levels needed to provide a good consumer experience are higher than previously assumed. As a result, the levels of 2G coverage published in this report and in our online coverage maps[8] are lower than figures we have previously published.

### Coverage of the latest 4G networks has increased significantly

2.28 While coverage of 2G and 3G networks is broadly unchanged, operators are continuing their rapid roll-out of the latest 4G networks. All four operators now provide outdoor coverage to 46% of UK premises. Three of the four operators cover 67% of UK premises, compared to 37% in 2014.

2.29 To date, operators have generally rolled out their 4G networks in the same areas as their 3G networks. As a result, the increased availability of 4G services has not yet contributed to an overall improvement in *coverage* of mobile data networks. It has, however, improved the speeds consumers experience in certain, mostly urban, areas. We expect this to change in the future as the operators continue to roll out their 4G networks to meet, or match, coverage obligations.

## Network resilience and management

2.30 In addition to fixed and mobile network availability, we report on network and service resilience, and on developments in the provision of services over the internet.

### Resilience of emergency communications

2.31 The communications infrastructure plays a range of key roles during emergencies. It allows the public to contact the emergency services via 999, the emergency services to communicate within and between themselves, and the Government to send important messages to the population. The technology platforms behind all these functions are set to be replaced in the coming years with very different systems, offering features that can be exploited to improve on how emergency communications currently operate. This will include automatically collecting and transmitting detailed information about an emergency situation, allowing the response to be quicker and more precisely targeted.

2.32 These features have the potential to save lives, but emergency use may not typically be among the commercial drivers for deploying these new platforms. As a result, other features that are important in an emergency context, such as high levels of reliability, could be sacrificed. A recent UK Regulators Network project[9] has explored one aspect of this – the resilience of telecoms networks to widespread electricity failure – in more detail. The conclusion from this work is that the Government may need to weigh the wider societal benefits of increasing the resilience of these new

[8] http://www.ofcom.org.uk/mobile-coverage
[9] http://www.ukrn.org.uk/?page_id=647

platforms against the cost, and consider intervening if commercial deployment falls short of its public policy objectives.

## Resilience of general networks and services

2.33 Providers of communications networks and services are required to report any breaches of security or network failures to Ofcom. We publish guidance for network and service providers, which highlights the sources of industry best practice and details our incident reporting requirements. We also work closely with Government and relevant agencies on cyber security and related issues such as personal data breaches.

2.34 In the past year, 524 security incidents were reported to us by fixed and mobile providers; 486 affected fixed networks and 38 affected mobile. The vast majority of reports were from fixed providers regarding disruption to telephony services (including 999 access) for fewer than 10,000 customers and for less than one day. Hardware failure is the most common cause, and our data shows that incidents are more likely to occur in, or near, large population centres.

2.35 Incidents with a wider impact, which affect tens of thousands of customers over a number of days, are less common. In the reporting period of September 2014 to August 2015 there were 12 incidents in this category[10]: Seven affected mobile networks and five affected fixed networks. Hardware and software system failure is still the main root cause, at 75%.

2.36 We routinely revise the guidance we issue to network and service providers and plan to do so again over the next few months to reflect developments in security and resilience best practice and the changing threat profile, particularly with regard to cyber security in general and the specific risks highlighted by recent high-profile incidents.

## Net neutrality

2.37 Net neutrality refers to a policy debate about the way internet service providers (ISPs) manage the data carried on their networks, from content providers such as the BBC, YouTube and other websites, to consumers. The issue has gained prominence as the internet has become an essential platform for the delivery of all kinds of content, services and applications.

2.38 UK ISPs are obliged to be transparent with consumers about how they manage the data on their networks. There is an industry-wide code of practice explaining how ISPs should comply with this obligation (the Traffic Management Transparency Code of Practice[11]). We monitor ISPs' compliance with this code of practice and currently have no material cause for concern.

[10] Category includes incidents with an impact above one million customer hours. We measure the impact of an incident in customer hours, which is the product of an incident's duration and the number of consumers affected.

[11] http://www.broadbanduk.org/wp-content/uploads/2013/08/Voluntary-industry-code-of-practice-on-traffic-management-transparency-on-broadband-services-updated-version-May-2013.pdf

## Preparing this report

2.39 The information in this report is derived from a significant volume of raw data which is provided to us by a range of fixed and mobile network operators. The data are highly detailed and contain, among other things:

- actual measured download and upload speeds of every broadband line in the country;
- predicted signal strengths of the voice and data networks for every mobile operator and for each 100m$^2$ grid of the UK's landmass; and
- the amount of data downloaded and uploaded on all of the UK's fixed and mobile networks.

2.40 We also undertake technical studies, such as our continuing work to measure broadband quality of experience, and collect information from operators on matters concerning security and resilience of networks and services.

Section 3

# Introduction and background to the report

3.1 Under the Communications Act 2003 ('the Act') 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[12]. We published the first report in 2011 and the second report in 2014.

3.2 However, we recognised after publishing the first report that some aspects of the 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. These updates have mainly focused on the areas of greatest change, such as coverage and capacity of fixed and mobile networks. This year's report, renamed the *Connected Nations Report,*[13] will be an update following the full report in 2014.

## Approach and context

3.3 This report considers services provided to residential consumers and to businesses. We do not present statistics for large businesses, since the leased-line infrastructure on which they typically rely is widely available and services tend to be bespoke. We do present analysis for small and medium-sized enterprises (SMEs).

3.4 This report uses data gathered from the largest operators in each sector, as well as information already held by Ofcom. Where possible we have re-used data already provided to Ofcom, in order to minimise the burden on stakeholders. We have also gathered data from a number of other smaller network and service providers for various aspects of this report.

3.5 Data sources and analysis methodologies are summarised in Annex 1.

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

| Name of provider | Types of networks or service |
|---|---|
| Arqiva | Public Wi-Fi, national DTT and national DAB |
| BT | Fixed networks: voice and broadband, public Wi-Fi |
| EE | Mobile networks: voice and broadband, public Wi-Fi |
| KCOM | Fixed networks: voice and broadband, public Wi-Fi (Hull only) |
| $O_2$ Telefonica | Mobile networks: voice and broadband, public Wi-Fi |
| Sky | Fixed networks: voice and broadband, public Wi-Fi |
| TalkTalk | Fixed networks: voice and broadband |

[12] http://www.legislation.gov.uk/ukpga/2010/24/section/1..
[13] This report was previously called the *Infrastructure Report*

| Name of provider | Types of networks or service |
|---|---|
| Three | Mobile networks: voice and broadband |
| Virgin Media | Fixed networks: voice and broadband, public Wi-Fi |
| Vodafone | Mobile networks: voice and broadband |

3.6 We also gathered data from a number of other smaller network and service providers for different aspects of the report.

## Publication of data

3.7 We have launched an online consumer portal[14] along with the report with the following key features:

- an Ofcom app to check the performance of Wi-Fi hotspots;
- the mobile coverage checker, enabling consumers to check the predicted coverage for mobile voice and data for each of the mobile network operators; and
- links to frequently asked questions and consumer advice.

3.8 Much of the data underlying this year's report is available for download from the portal.

## The European Broadband Scorecard

3.9 The *Connected Nations* report focuses on connectivity within the UK. Ofcom has today also published its fourth annual *European Broadband Scorecard*[15], which compares availability, take-up and price of networks and services in the UK with other countries in Europe, with a particular focus on how the UK compares to France, Germany, Spain and Italy.

3.10 It should be noted that not all the metrics in the European Broadband Scorecard are directly comparable with those in this report. This is partly due to when and how the data were collected and how the metrics are defined. For example, for superfast broadband availability the European Scorecard reports on the availability of fixed broadband products which use technologies that can support 30Mbit/s or more, whereas in this report we consider a subset of these connections, where the actual speed delivered is expected to be 30Mbit/s or more.

## Outline of this report

3.11 The remainder of the report is structured as follows:

- **Section 3:** Fixed broadband networks

[14] http://stakeholders.ofcom.org.uk/market-data-research/market-data/infrastructure/connected-nations-2015/
[15] http://stakeholders.ofcom.org.uk/market-data-research/other/telecoms-research/bbresearch/european-broadband-scorecard-2015/

- **Section 4:** Coverage of mobile voice and data services
- **Section 5:** Internet access services
- **Section 6:** Resilient communications in emergencies
- **Section 7:** Security and resilience
- **Section 8:** TV broadcasting

3.12 We welcome comments from consumers and stakeholders on the report. Please contact us at connectednationsreport@ofcom.org.uk.

Section 4

# Fixed broadband services

4.1 Superfast broadband is available to more consumers than ever before, with both industry and Government investments driving improvements in coverage. However, almost 5 million (or 17% of) consumer households and small and medium-sized enterprises (SMEs) remain unable to take advantage of these services. While that number will reduce over the coming few years, a significant proportion of homes and businesses are still unlikely to be able to receive superfast broadband without further action.

4.2 This section explores the coverage, performance and take-up of broadband, and highlights the divide between those with access to the best and worst broadband. Given the potential for this divide to exclude citizens, consumers and businesses from full participation in internet-based services that are now vital for many aspects of economic and social activity, we discuss various current and possible future initiatives to improve broadband access for all.

4.3 The most important messages are:

4.3.1 **The coverage of superfast broadband continues to increase.** Around 24 million (or 83% of) UK premises are now able to receive superfast broadband, up from 75% in 2014. Coverage of superfast in rural areas has increased significantly, from 22% in 2014 to 37% (over 1.1 million premises).

4.3.2 **Many consumers and SMEs are still unable to receive even standard speed broadband.** In the UK as a whole, around 2.4 million (over 8% of) premises cannot receive a speed greater than 10Mbit/s, with around 1.5 million (or 48% of) premises in rural areas being affected.

4.3.3 This divide between the best and worst performing services suggests that intervention may be required to ensure that everyone has access to broadband. **We believe that a download speed of at least 10Mbit/s is necessary to deliver an acceptable user experience.**

4.3.4 Evidence is now emerging that **consumers who opt for higher speed services (greater than 40 Mbps) on average consume more data** as a result of using their service more intensively.

## Coverage and speed of superfast broadband services continue to increase

4.4 Superfast broadband is now available to 83% of UK premises, up from 75% in 2014. Download speeds[16] have also increased, with superfast broadband users in the UK

[16] The download speeds represented here are known as *line speeds*. For services based on the traditional telephone network, they are the stable speed of the link between the consumer's home or office and the street cabinet/exchange and are sometimes referred to as *sync speeds*. For cable networks broadband, or all-fibre networks based on FTTP, they are the speeds configured in the network equipment that are determined by the service the customer has contracted for. They are a

receiving, on average, 63Mbit/s. The average upload speed of superfast broadband in the UK has remained the same as last year, at 8Mbit/s.

4.5 Coverage and speed of superfast broadband in the constituent nations of the UK have also seen similar improvement, as shown in Figure 7. Coverage has improved most in Scotland and Wales, as a result of investment in new and upgraded networks by industry and governments. However, coverage in Northern Ireland has remained unchanged over the past year; we would expect coverage to increase again in coming years as a result of a current Government investment programme, intended to improve services for consumers living in rural areas.

**Figure 7: Coverage and speed of superfast services have improved across the UK**

| | Coverage of superfast broadband, premises | | Average download speed of superfast broadband | |
|---|---|---|---|---|
| | 2015 | 2014 | 2015 | 2014 |
| **UK** | 83% | 75% | 63Mbit/s | 54Mbit/s |
| **England** | 84% | 77% | 63Mbit/s | 56Mbit/s |
| **Northern Ireland** | 77% | 77% | 56Mbit/s | 50Mbit/s |
| **Scotland** | 73% | 61% | 67Mbit/s | 54Mbit/s |
| **Wales** | 79% | 55% | 59Mbit/s | 52Mbit/s |

*Source: Ofcom analysis of operator data*

**How is superfast broadband delivered to homes and small businesses?**

Broadband that supports download speeds of 30Mbit/s or more is known as superfast broadband. In order to deliver these speeds, service providers need to install fibre optic cabling, which supports higher speeds than the copper cables used in traditional networks.

The current generation of superfast broadband is typically delivered by replacing the copper cable between the local exchange and the street cabinet with a fibre optic cable. The cable between the street cabinet and the consumer's home or business is still made of copper. The replacement of copper with fibre in the connection enables higher speeds for the consumer. It is also possible to use fibre optic from the exchange all the way to the consumer's premises. This offers speeds that are even higher than superfast: ultrafast broadband.

Some common terms used to describe broadband services include:

*Fibre to the cabinet (FTTC):* This describes a superfast broadband connection that uses a fibre optic connection from the exchange to the street cabinet and a copper cable to connect the cabinet to the home or office, as described above. Providers such as BT, Sky and TalkTalk offer FTTC services.

better indication of the performance actually experienced by consumers than *headline speeds*, which are theoretical maximum speeds that are often not achieved in practice.

*Cable:* This is a similar concept to FTTC, but the connection between the cabinet and the home or office is made of a particular type of copper cable that can offer very high speeds. Virgin Media offers this kind of service, delivering superfast broadband and television services over its cable network.

*Fibre to the premises (FTTP):* This describes a service that uses fibre from the exchange directly to the consumer's home or office. FTTP can deliver superfast or ultrafast speeds and is offered to different extents by BT, KCOM in and around Kingston-Upon-Hull, and several smaller providers such as B4RN in rural Lancashire, Hyperoptic, CityFibre and Gigaclear.

*Wireless:* This describes a service that uses a wireless connection between the consumer's home or office and the provider's network. This kind of service is often based on similar technologies to those used in mobile networks, can deliver superfast speeds and is offered by providers such as Relish in London.

4.6 Coverage of broadband services is generally better in urban areas than in rural areas. This is mainly because it is easier and cheaper to provide services to consumers in more densely populated, urban areas. Figure 8 shows the coverage of superfast broadband in rural areas.

4.7 This year we have used a new approach, based on standard government definitions, to categorise whether a consumer's property lies in an urban or rural area. This change makes it difficult to make meaningful comparisons of changes in coverage in rural areas between 2014 and 2015[17]. However, we estimate that coverage of superfast broadband has increased most in Wales[18] and Scotland[19], albeit from a relatively low level of coverage in previous years.

**Figure 8: Rural areas have seen large increases in the availability of superfast broadband**

| | Availability of superfast broadband in rural areas, premises | | |
|---|---|---|---|
| | 2015 | 2014 (est.) | Approximate estimated year-on-year increase |
| **UK** | 37% | 22% | 1.7× |
| **England** | 36% | 23% | 1.6× |
| **Northern Ireland** | 40% | 38% | 1.1× |
| **Scotland** | 31% | 8% | 3.9× |
| **Wales** | 50% | 17% | 2.9× |

*Source: Ofcom analysis of operator data*

[17] We estimate that rural premises make up around 11% of the total number of premises in the UK. See paragraph A1.27 for more information.
[18] The growth in Wales has been largely due to the Superfast Cymru programme, which began in 2013 to provide access to fibre broadband in areas where the commercial sector has no plans to invest.
[19] The Scottish Government's ambition is to enable 85-90% of Scottish premises to receive broadband speeds of 40-80Mbit/s by March 2016, extending to over 95% by the end of 2017.

4.8 There are two main factors behind the increase in the coverage of networks capable of supporting superfast services:

4.8.1 **Investment by broadband providers** in an effort to deliver faster services to more customers. For example, BT and Virgin Media have announced plans to further increase their superfast coverage.

4.8.2 **Investment by Government, industry and local authorities** in order to deliver broadband to those areas unlikely to be served by purely commercial deployments, such as rural areas. The UK Government aims to deliver superfast broadband to at least 95% of UK premises by 2017[20].

4.9 In summary, many consumers are benefiting from the continuing increase in the coverage and speeds of superfast broadband. However, these services are not available everywhere, and there is the potential for consumers who have access only to standard broadband services to become excluded from important online services. In the following section we explore the reasons why superfast broadband is not available everywhere.

## Many are still unable to experience superfast broadband

4.10 While the coverage and speeds of superfast broadband continue to increase for many, a significant number of consumers are still unable to access these services.

4.11 For some consumers, the local infrastructure has been upgraded, but for specific technical reasons their lines cannot receive superfast speeds. Around 2 million (or 7% of) UK premises are connected to upgraded networks but cannot currently receive download speeds of 30Mbit/s; on average, their download speeds are around 18Mbit/s.

4.12 Many of the affected consumers are in rural areas, where the relatively long copper cables between premises and street cabinets result in poorer performance, compared to the shorter cables used in urban areas.

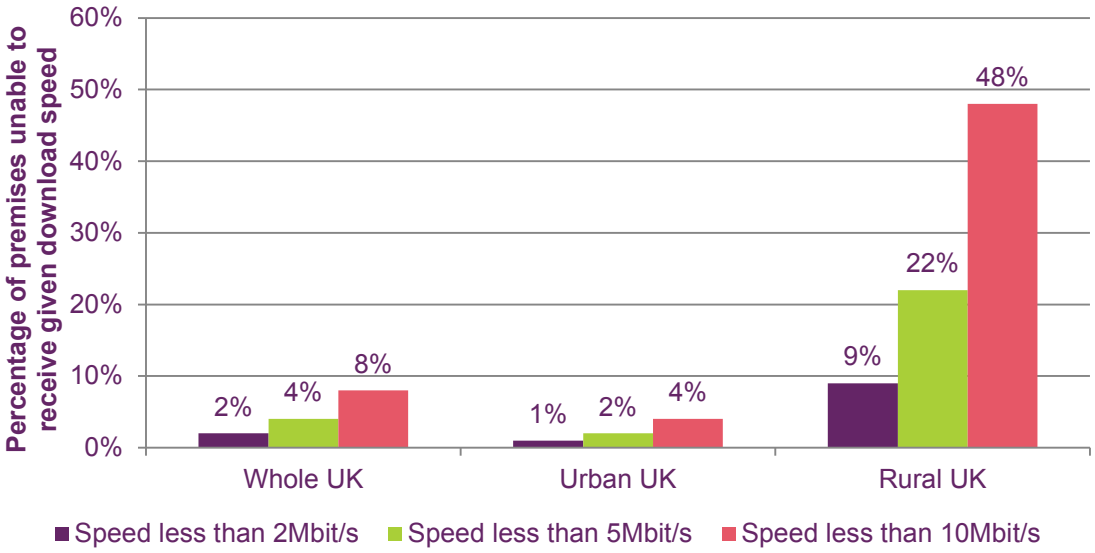
4.13 A further group of consumers (almost 5 million premises) are unable to receive superfast speeds because superfast broadband roll-out has not yet been extended to their area.

### Nearly half of all premises in rural areas across the UK are still receiving speeds of less than 10Mbit/s

4.14 These consumers have to rely on slower broadband. This continues to be a particular problem for many consumers in rural areas; around 1.5 million, or nearly 50% of, rural premises are connected by lines that are unable to receive speeds higher than 10Mbit/s and one in five rural premises are unable to receive speeds higher than 5Mbit/s.

[20] This commitment is with respect to a definition of superfast as having a download speed greater than 24Mbit/s, used in the BDUK procurement and subsequent contractual framework.

**Figure 9: Many UK premises are connected by lines that are unable to support fast speeds**




*Source: Ofcom analysis of operators' data*

4.15 Of the nations, Scotland has the highest proportion of rural premises (57%) that are unable to receive more than 10Mbit/s. This is largely because coverage of superfast-capable networks in Scotland's rural areas is relatively low compared to the other nations. However, given the recent increase in the coverage of superfast broadband in Scotland's rural areas, and ongoing Government programmes across the UK more broadly, we would expect the proportion of premises that are unable to receive at least 10Mbit/s to drop over time.

**Why are broadband speeds lower in rural areas?**

The distance between the premises and the exchange has an impact on the quality of service received, and in particular the speed of a consumer's connection. Consumers who live in less densely populated parts of the UK are more likely to live further from the exchange, and therefore achieve lower broadband speeds.

The resistance of copper wire increases with the length of the wire, so speeds decay as the distance between the premises and the exchange increases. Speeds typically start to decrease between 1 and 2km from the exchange and are reduced considerably at distances more than 3.5km.

FTTC-based broadband uses optical fibre to the cabinet and therefore the length of copper wire is reduced. It can currently support superfast speeds up to 80Mbit/s. However, as some copper wire remains between the cabinet and the premises, there can be some decay in speeds for customers located a long way from a cabinet. Customers further than 300m from a cabinet can expect their speeds to be less than half the maximum possible.

However, most consumers who live too far from the cabinet to receive superfast broadband may still benefit from the upgrade at the cabinet, as the reduction in the length of the copper access line will improve their broadband speeds.

## Slow broadband is also a significant problem for many smaller businesses across the UK

4.16 The UK's 5.4 million small and medium enterprises (SMEs)[21] constitute 99.9% of UK businesses, account for 60% of private sector employment and 47% of business revenue. High quality telecommunications services are essential to their ability to participate in and drive the digital economy. In June 2015 we published a report[22] which considered how well the broadband market is serving SMEs. This report updates some of that analysis.

4.17 We have analysed the availability of superfast broadband delivered to the approximately 1.3 million SMEs with at least one employee (i.e. not including sole traders). We have compared coverage of SMEs against the average, split by geography, shown in Figure 10.

4.18 Superfast coverage for SMEs has increased to around 890,000 (or 68% of) premises, up from 56% in 2014, although SMEs still experience lower coverage of superfast services than the population as a whole. We note, however, that some SMEs may have access to alternative sources of connectivity, such as shared facilities within incubator centres.

**Figure 10: Coverage of superfast broadband for SMEs compared to all premises**

| | | Superfast coverage for different sized SMEs, premises | | | |
|---|---|---|---|---|---|
| | Total superfast coverage, premises | 1 or more employee, premises | Micro (excl. sole traders) | Small | Medium |
| UK | 83% | 68% | 69% | 62% | 59% |
| England | 84% | 69% | 71% | 62% | 59% |
| Scotland | 73% | 55% | 56% | 53% | 50% |
| Wales | 79% | 66% | 66% | 66% | 62% |
| Northern Ireland | 77% | 66% | 64% | 71% | 75% |

*Source: Ofcom analysis of operator data*

4.19 There are broadly similar levels of superfast broadband coverage for SMEs in England, Wales and Northern Ireland. Coverage is lower in Scotland and reflects the lower availability of superfast broadband overall. More generally, the relatively low levels of superfast coverage for SMEs throughout the UK reflects the fact that many SMEs are based in rural areas or business parks, which to date have not been targeted for network upgrades.

4.20 Given the relatively low coverage of superfast services for SMEs, we would expect download speeds to also be slightly lower than for the wider population. On average

[21] Defined as businesses with fewer than 250 employees – around 3.7million of these are sole traders.
[22] *Broadband services for SMEs: Assessment and action plan*, http://stakeholders.ofcom.org.uk/market-data-research/other/telecoms-research/smes-research-jun15/

the download speed in UK postcodes with at least one SME is 28Mbit/s, compared to 29Mbit/s for the UK as a whole.

## Coverage for SMEs in business parks

4.21 The data in Figure 10 are based on an analysis of SMEs throughout the whole of the UK, including in residential areas. However, around 290,000 (or 25% of) all SMEs are located within SME-only areas, or business parks, that include no residential or large enterprise postal properties.

4.22 To date the deployment of superfast-capable networks has been driven by demand from the private consumer market. As a result, superfast coverage is greatest in residential areas, with non-residential areas often having no superfast coverage at all. Our analysis confirms that there is poorer coverage of superfast broadband in these SME-only areas, and that as a result average speeds are significantly lower, as shown in Figure 11.

**Figure 11: Broadband performance and superfast broadband coverage in business parks**

| | Average download speed (all broadband products) | Availability of superfast broadband, % premises | |
|---|---|---|---|
| | | In a postcode with any superfast coverage | In a postcode with 100% superfast coverage |
| **All UK postcodes** | 29Mbit/s | 95% | 81% |
| **Business parks** | 15Mbit/s | 92% | 56% |

*Source: Ofcom analysis of operator data*

4.23 We estimate that, as of August 2015, 46% of premises in SME-only postcodes had broadband connections with a maximum speed of less than 10Mbit/s, 24% had maximum speeds of less than 5Mbit/s and 12% had maximum speeds of less than 2Mbit/s.

## 18% of SMEs are still unlikely to have access to superfast broadband beyond 2017

4.24 To conclude, SMEs across the UK experience poorer coverage of superfast broadband than the population as a whole. There have been some improvements in coverage over the last 12 months and we expect further improvements as commercial and publicly-funded deployments continue. However, many SMEs are still unlikely to be able to access superfast broadband.

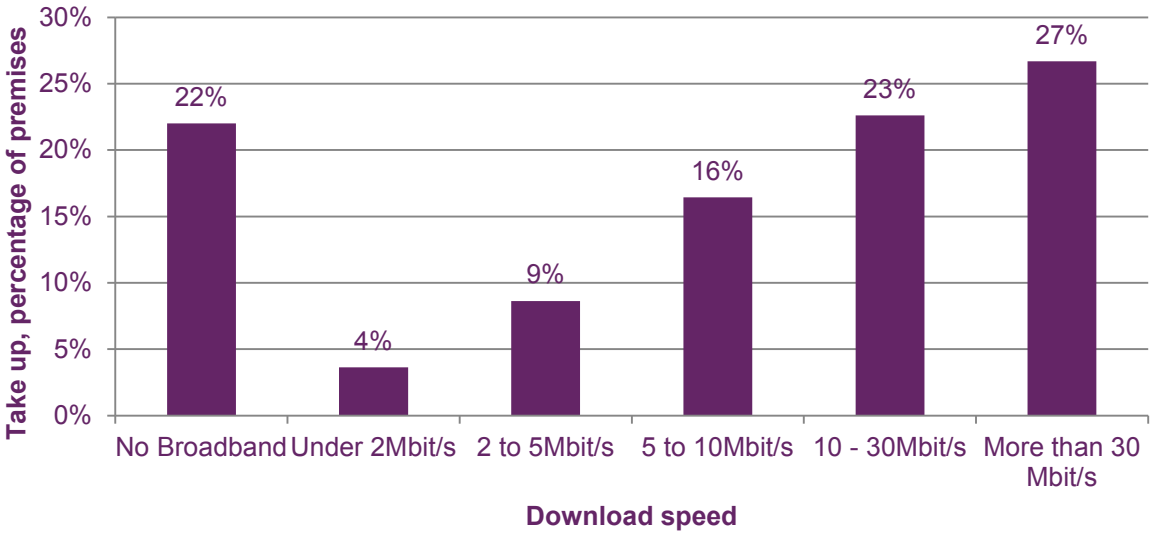
4.25 In our report[23] in June 2015 we estimated that by 2017, when 95% of all UK premises are likely to have superfast broadband, around 18% of SMEs (over 230,000) will still not have access to superfast broadband. We have updated this analysis for this report and have found that this conclusion remains valid.

[23] *Broadband services for SMEs: Assessment and action plan*, http://stakeholders.ofcom.org.uk/market-data-research/other/telecoms-research/smes-research-jun15/

## Increased take-up of superfast services is driving growth in data use

4.26 Superfast broadband has now been taken up by almost 8 million, or 27% of all premises in the UK, up from 21% in 2014, as shown in Figure 12. The percentage of premises not taking up broadband is now 22%, down from 27% in 2014.

**Figure 12: Take-up of fixed broadband**




*Source: Ofcom analysis of operators' data*

4.27 Consumers with superfast broadband services will be better able to take advantage of the range of multimedia services that are available, including:

- video streaming of films and TV programmes such as those offered by the BBC, Netflix and Amazon onto TVs and mobile devices;
- seven-day catch-up services streamed via the electronic programme guide on YouView and Freeview Play;
- libraries of downloadable content offering box sets and films, e.g. from Sky and Virgin Media;
- high-definition video calling through Skype and Viber; and
- cloud-based services for the storage and sharing of photos and videos.

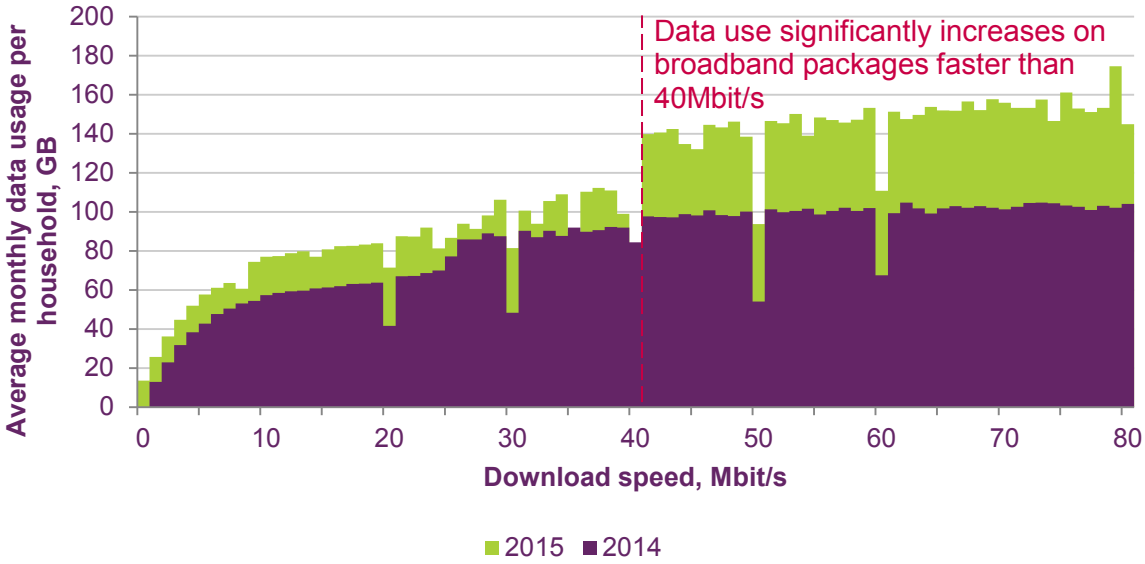
4.28 A combination of higher broadband speeds and the wider use of multimedia services is resulting in increased volumes of data being downloaded and uploaded by consumers. The average amount of data used[24] by consumers per month is now 82GB, an increase of 41% since 2014.

4.29 Figure 13 shows how users with broadband connections faster than 40Mbit/s are driving the increase in monthly data use, with an average increase of around 47%

[24] A combined figure of the volume of data downloaded and uploaded.

over the past year. This increased use of data by consumers on the fastest packages could be clear evidence of demand for superfast services.

**Figure 13: Users with the fastest broadband connections are driving the increase in data use**




*Source: Ofcom analysis of operator data*

4.30 While high-speed connections are important for the delivery of these multimedia services, a range of other factors can also affect the user's quality of experience. We return to these issues from 3.52 below and they are analysed and discussed further in Section 6.

## Ultrafast services are beginning to appear

4.31 Alongside the continuing roll-out of superfast broadband services, a range of new services are beginning to emerge that offer even faster speeds. These services are enabled by new technologies, such as:

4.31.1 Fibre optic networks connecting premises directly to local exchanges, without the need for slower, copper-based cabling. A range of large (e.g. BT, KCOM) and smaller (e.g. CityFibre) companies are beginning to offer these fibre-to-the-premises (FTTP) services.

4.31.2 Improved computational power and technology development, which is enabling the more efficient encoding and transmission of data across network links. For example, Virgin Media periodically updates its network equipment, including home routers, to enable faster speeds over its existing network.

4.31.3 In those areas where FTTP services are not economically possible, G.fast, an emerging technology capable of delivering speeds in excess of 100Mbit/s, is being deployed. It takes high-speed fibre connections closer to the consumer's premises and uses a short copper cable to complete the link.

4.32 There is not yet a consensus on a definition for these ultrafast services, with views on the minimum download speed ranging from 100Mbit/s to 1Gbit/s. Figure 14 shows the current coverage of broadband services in UK with download speeds of 100Mbit/s and 300Mbit/s.

**Figure 14: Coverage of faster broadband services with download speeds of 100 and 300Mbit/s**

| | Coverage of premises, % | |
|---|---|---|
| | Download speed is 100Mbit/s | Download speed is 300Mbit/s |
| **UK** | 46% | 2% |
| **England** | 49% | 2% |
| **Scotland** | 38% | 2% |
| **Northern Ireland** | 27% | 0% |
| **Wales** | 26% | 5% |

*Source: Ofcom analysis of operator data*

4.33 For this report, we have defined ultrafast services as those delivering a download speed of 300Mbit/s or more. We will continue to monitor the coverage of these faster services and may, if appropriate, refine our definition as the market evolves.

## Smaller providers are extending the reach of broadband to new areas

4.34 As we reported last year, a number of small, or non-major, providers are continuing to deploy networks offering superfast or ultrafast services. Recognising the important role played by these providers in improving the availability of superfast broadband services to consumers, we collected data from a sample of five of the providers from across the UK[25].

4.35 The combined coverage of the five providers is 1.3% of all the premises in the UK, or over 370,000 premises. As a result of this coverage, about 71,000 premises are able to receive superfast broadband and over 174,000 premises are able to receive ultrafast broadband that would otherwise not receive a broadband service.

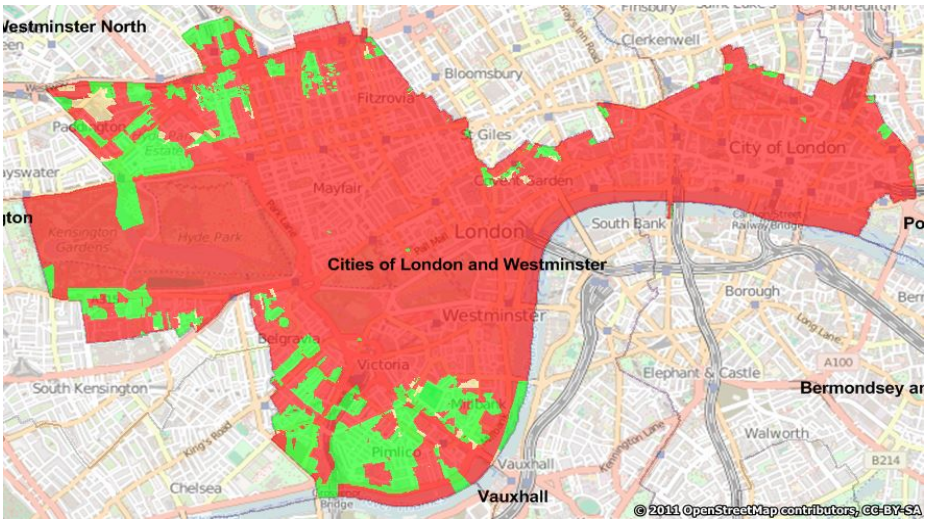
4.36 These providers often operate in areas where there is little or no existing provision of superfast broadband. As an example, Figure 14 compares the improvement in superfast broadband coverage due to the presence of non-major broadband providers in the Cities of London and Westminster constituency.

4.37 We have chosen this constituency as it is a good example of an urban “not-spot”. Although it is in the middle of a large city, it has low superfast broadband coverage due to a high number of “exchange-only lines”, which are unable to be upgraded easily, and limited cable rollout.

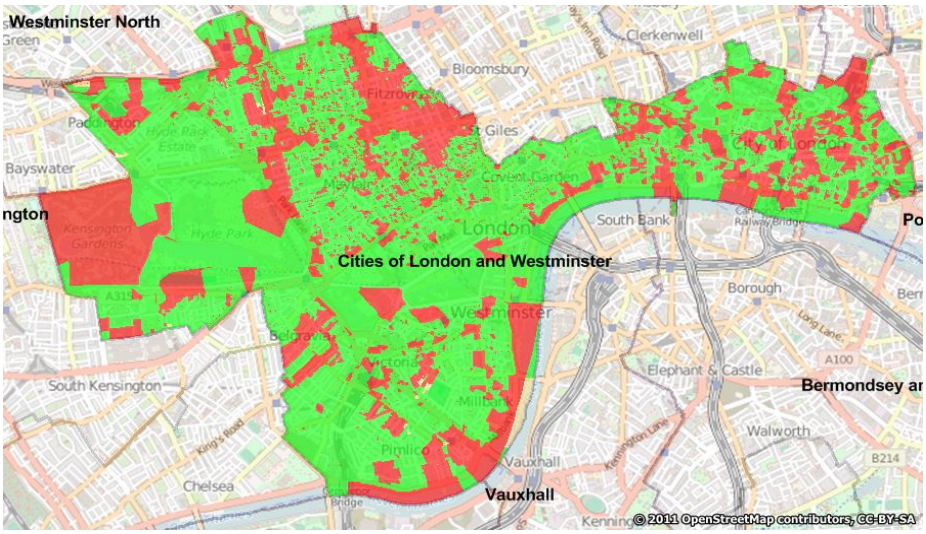
4.38 Due to the rollout of networks by non-major providers in this area, there has been significant improvement in coverage of superfast broadband, with 46% more premises having access to superfast broadband.

[25] We aim to collect and analyse data from a wider set of non-major broadband providers in the coming years.

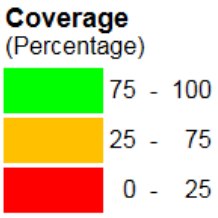
**Figure 15: Illustration of the improvement in superfast broadband coverage due to the presence of non-major network providers**




**Superfast broadband coverage from major broadband providers**




**Superfast broadband coverage from major and non-major broadband providers**




*Source: Ofcom analysis of operator data*
*Contains Ordnance Survey data © Crown copyright and database right 2015*
*Contains Royal Mail data © Royal Mail copyright and database right 2015*
*Contains National Statistics data © Crown copyright and database right 2015*

## The focus should now be on delivering better broadband to all, so everyone can benefit

4.39 As we have seen, a significant proportion of households and small businesses still cannot access standard broadband services, particularly in rural areas. Almost half of all rural premises cannot get broadband that delivers more than 10Mbit/s. There are also problems in urban areas, where 4% of premises cannot get 10Mbit/s broadband.

4.40 There have been a number of UK Government interventions under the Broadband Delivery UK (BDUK) initiative to improve broadband access:

4.40.1 **Rural Broadband Programme (Phase 1):** A £530m scheme aimed at rural areas to achieve 90% coverage of superfast broadband (in this case defined as having a download speed faster than 24Mbit/s).[26]

4.40.2 **Superfast Extension Programme (Phase 2):** A £250m scheme aimed at extending superfast coverage to 95% of premises by 2017.

4.40.3 **Competitive Fund (Phase 3 pilots):** A competition for a pot of £10m of funding to pilot potential solutions for the final 5% of premises not covered by phases 1 or 2.

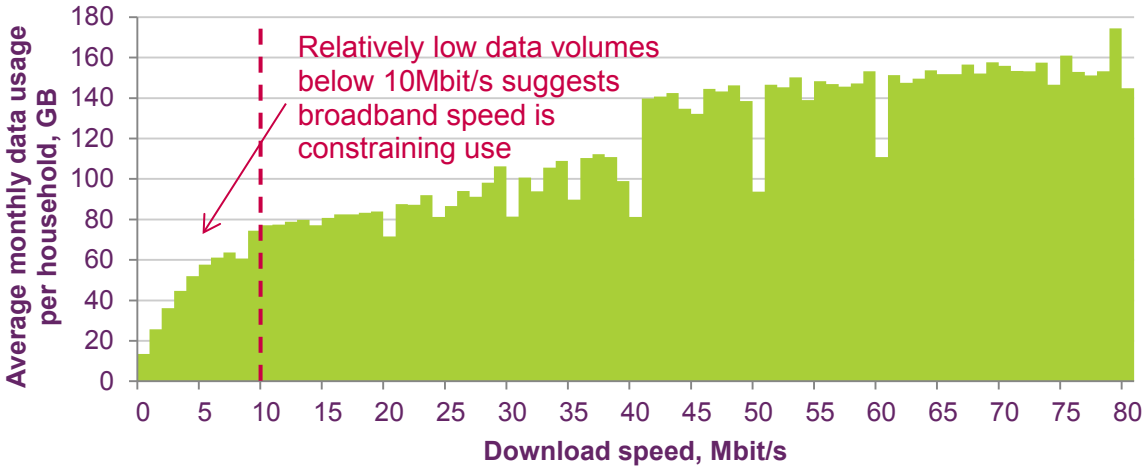
4.41 The current universal service commitment (USC), set by the Government in 2009, specifies that every household should have broadband access of at least 2Mbit/s. The Government aims to meet this target by the end of 2016 through its Rural Broadband Programme.

4.42 The Government is now beginning the process of implementing a broadband universal service obligation[27]. Its ambition is that this will give all users – consumers and small businesses – in the UK a legal right to request a broadband connection delivering speeds of 10Mbit/s or higher.

## Broadband use is constrained by download speeds lower than 10Mbit/s

4.43 As we have already seen, the amount of data that consumers download and upload each month has increased over the past year. Figure 15 shows that the volume of data used increases with download speed, and also suggests that the volume of data used is constrained by broadband speed.

**Figure 16: Average monthly data use increases with download speed**




*Source: Ofcom analysis of operator data*

[26] In practice, since this intervention is based on a 'gap funding' model, with industry intervention partners providing additional investment, the actual funding supporting the programme is considerably higher. Indeed, since contracts were awarded on the basis of only 20% take-up, which is in many cases already being exceeded, 'claw-back' mechanisms are being invoked, channelling the higher-than-anticipated revenues and consequent profits into further network deployment.

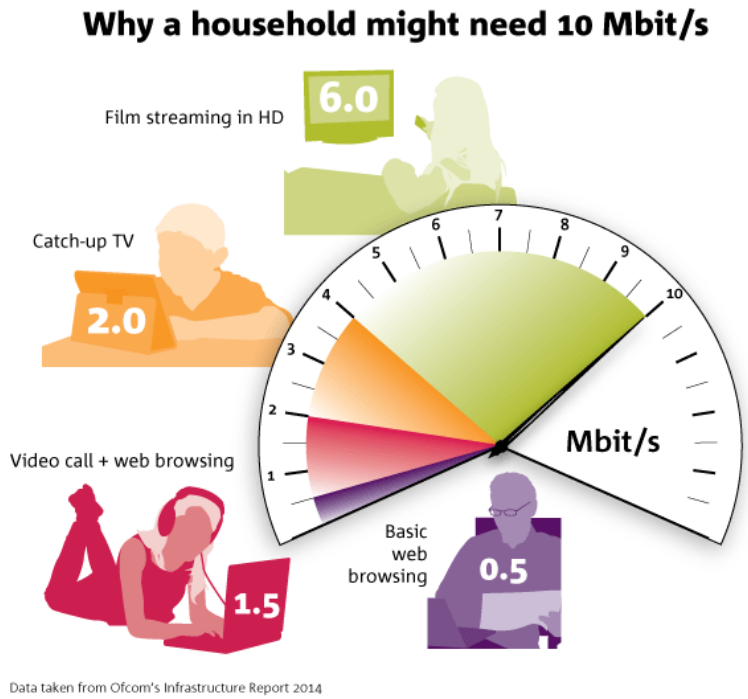
[27] https://www.gov.uk/government/news/government-plans-to-make-sure-no-one-is-left-behind-on-broadband-access

4.44 Those selecting superfast broadband (over 30Mbit/s) are likely to have done so in order to download more and use the internet more actively than those who have not chosen to, or been able to, upgrade. Below 20Mbit/s, there appears to be a restriction on the amount that households download. As the download rate falls below about 10Mbit/s, the volume of data used decreases rapidly. This may be evidence that users would use more data if their connections were faster.

## Connections faster than 10Mbit/s deliver a better quality of experience to the consumer

4.45 The types of service that should be achievable with download speeds of 10Mbit/s are shown in Figure 16 below. At peak time, some of these services may be being used simultaneously, in some cases requiring a download speed greater than 10Mbit/s.

**Figure 17: Data rate requirements for household use**




*Source: Ofcom*

4.46 The continued improvement in the efficiency of video transmission is likely to mean that the speed required for streaming video will fall over time. However, higher-quality video, such as 4K, will require higher data rates than high-definition video. Upload speeds are also important, particularly for voice and video internet calling.

## There is a requirement for a minimum download speed beyond the 2Mbit/s that is due to be available to all by the end of 2016

4.47 The current universal service obligation[28] (USO) provides a legal right for consumers to request a connection to a fixed location that provides voice, fax and functional (i.e.

[28] http://stakeholders.ofcom.org.uk/telecoms/ga-scheme/specific-conditions-entitlement/universal-service-obligation/designation-of-bt-and-kingston/. Other universal service obligations relate to,

non-broadband) internet access. It was introduced in 2003. At the time, it was intended to ensure the provision of narrowband services; the majority of those connected online at the time were using dial-up internet.

4.48 Since 2003, broadband has been taken up by almost 80% of households in the UK. The current USO has no provision for broadband. Some member states in the European Union have implemented broadband USOs, commonly at speeds of 1Mbit/s.

4.49 Broadband USOs are set at a specified download speed. This speed reflects the speeds available to the majority of users in the country. As illustrated by Figure 16, a minimum of 10Mbit/s enables an improved user experience with the capacity to operate numerous applications across the household, e.g. voice and video calls, video streaming and faster downloading of programmes and documents.

4.50 The Government has announced its intention to consult on the establishment of a 10Mbit/s USO early in 2016, and Ofcom will be continue to work with the Government to ensure that this target is implemented effectively.

## A variety of technologies could serve the final 5%

4.51 Regardless of what form the intervention takes, there will be a need to consider which technologies might be suitable for deploying high-speed broadband to remote rural areas.

### Fixed technologies

4.52 **Fibre to the cabinet** will continue to play an important role in upgrading the speeds of those in the final 5%. In areas where there are existing cabinets, the issue in the final 5% will be the number of households connected to the cabinet. The average BT cabinet in the UK will serve between 200-300 premises. In the final 5%, this can fall dramatically, making the economic case for installing a fibre-enabled cabinet difficult.

4.53 **Fibre to the remote node** is a newer technology that will deliver faster speeds by bring fibre connections even closer to the premises, and is likely to be a key element of G.fast deployment. The fibre line is deployed to a manhole or a pole outside the property, dramatically reducing the length of copper used. The key challenge will be to ensure a power supply to the remote node: reverse powering, where electricity is drawn from the premises rather than the exchange, could achieve this.

4.54 **Fibre to the premises** involves the deployment of fibre directly from the exchange to the property. There are two deployment options. The first involves a dedicated fibre connection to each property, which offers the fastest speeds but is expensive to deploy. The second option, which is cheaper and more commonly used in the UK, is for a single fibre connection to be shared by neighbouring properties. However, speeds may be limited, particularly at peak time, compared to the dedicated approach.

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among other things, directory services, public payphones, billing, payments and tariffs, and specific services for disabled users, as well as the public provision of telephone services

Wireless technologies

4.55 **Fixed wireless** includes various options using wireless technology to connect to consumer and business premises. Wi-Fi and LTE can be used in these scenarios. However, although these are useful in reaching a group of premises that do not have adequate fixed infrastructure, it could still be costly to roll out to individual isolated premises.

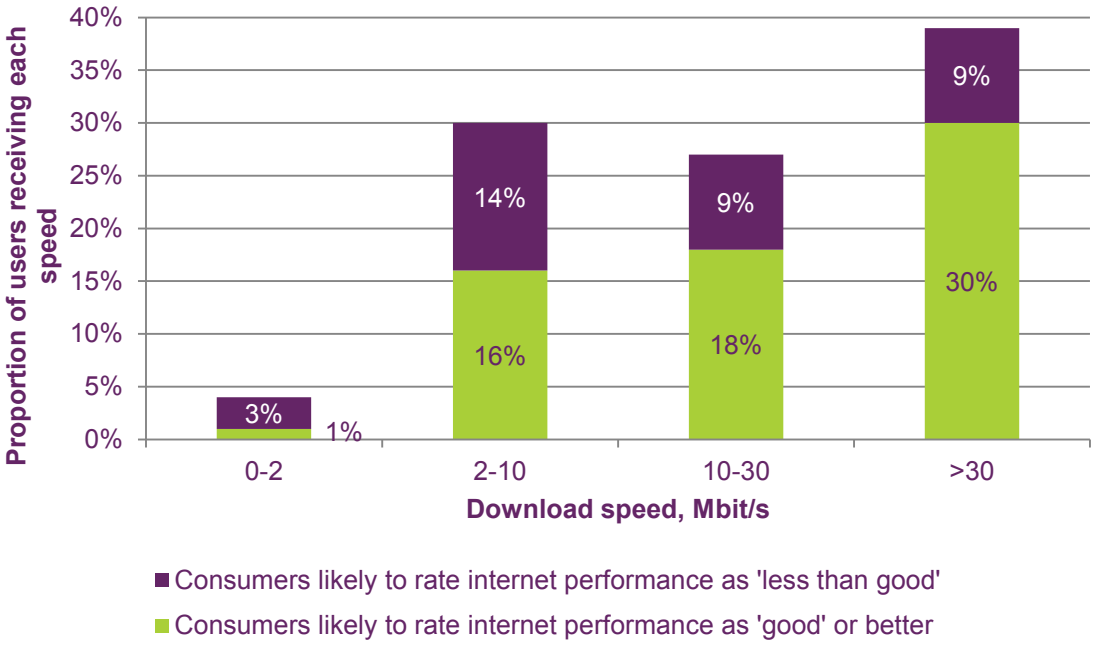
4.56 **Satellite** broadband has the advantage of being able to cover large parts of the country with a small number of satellites. This effectively means that satellite broadband can offer a variety of speeds (including superfast) to anywhere in the UK. However, the number of users that can be supported at a given time is relatively limited, compared to other broadband solutions. Satellite broadband is one of the applications being considered in our strategic review of satellite and space science use of spectrum.

4.57 Each of these technology options has advantages and disadvantages, so it is likely that any intervention for these locations will involve a mix of technologies. This reflects the variety of technical and economic challenges faced when upgrading broadband in these areas.

## Connection speeds provide a relatively good but incomplete picture of broadband performance

4.58 While there is a strong link between connection speeds and the likely consumer broadband experience (see Figure 17), factors such as data congestion in in-home broadband connections, the ISP's network or the wider internet, mean that speed does not always provide a full picture of broadband performance.

**Figure 18: Consumers with faster broadband speeds are more likely to rate their internet experience as 'good' or better**




*Source: Actual Experience for Ofcom*

4.59 Connections between the broadband home router and consumer devices using Ethernet, powerline or wireless (e.g. Wi-Fi) can affect the quality of internet services when accessed on consumer devices.

4.60 Over the past two years we have been conducting research into a new measurement method capable of assessing the effects of these additional factors[29]. The results of this work in relation to the in-home connection are described below, and those for the ISP network and wider internet in Section 6.

## The quality of in-home network connections plays a significant role in about 20% of homes with poor broadband performance

4.61 Our research has identified that for most households, most broadband performance problems occur in the access and ISP's network, but the quality of in-home network connections also plays a role in many households. In particular we have found that:

4.61.1 the quality of home-network connections plays some role in over 75% of households with poorly performing broadband connections (i.e. likely to be rated as 'less than good' by consumers); and

4.61.2 the quality of home-network connections is responsible for more than 25% of the connection problems in 20% of households with a poorly performing broadband connection.

4.62 Given the role played by the in-home network on broadband performance, and the increasing use of Wi-Fi to connect to consumer devices, Ofcom has made an app available to help consumers identify whether their Wi-Fi may be limiting the performance of their broadband connection and hence their experience of using online services.

4.63 The app can be installed on smartphones and tablets and works by testing both the in-home Wi-Fi connection and the connection to the wider internet. Using these tests the app determines the extent to which the Wi-Fi network may be the source of any performance problems. The app also provides consumers with advice on how to potentially resolve these issues. Our website[30] provides links to the Apple and Google app stores, from where the app can be downloaded.

[29] http://stakeholders.ofcom.org.uk/binaries/research/infrastructure/2015/downloads/qoe-analysis.pdf http://stakeholders.ofcom.org.uk/binaries/research/infrastructure/2015/downloads/qoe_uk-analysis.pdf

[30] http://stakeholders.ofcom.org.uk/market-data-research/market-data/infrastructure/connected-nations-2015/WiFi-checker-app/

Section 5

# Mobile voice and data services

5.1 Mobile services are playing an increasingly important role in our daily lives. This has created a growing expectation that mobile devices will work reliably wherever we are, whether at home, at work, in a car or out walking in the countryside. In this section we provide an update on the levels of mobile voice and data coverage being achieved in the different regions of the UK.

5.2 The key highlights are:

5.2.1 **4G roll-out:** There has been a significant roll-out of new, higher-speed 4G networks, which are now available in most major cities and towns.

5.2.2 **Rural coverage continues to lag behind urban coverage:** Levels of mobile coverage in rural areas continue to be lower than in urban areas. A new study has shown that this reflects the higher costs-per-user of providing coverage in less densely populated areas.

5.2.3 **Developments helping to improve mobile coverage:** There have been three main developments over the past year which are helping to improve mobile coverage:

i) *a new coverage commitment:* Mobile operators have agreed with the Government to achieve 90% geographic outdoor voice call coverage by the end of 2017;

ii) *interactive coverage maps:* We have launched interactive mobile coverage maps, enabling consumers and businesses to compare the coverage provided by different mobile operators in the locations that are most important to them. In addition to allowing consumers to make more informed choices of mobile operator, we anticipate that these maps will encourage mobile operators to further compete in providing better coverage;

iii) *voice over Wi-Fi:* All the mobile network operators now offer voice over Wi-Fi services. These new services are helping to improve coverage in buildings that have poor mobile coverage but good indoor Wi-Fi connectivity.

5.2.4 **Mobile data growth:** The rate of growth in mobile data use continues to outstrip that on fixed broadband networks; it grew by a factor of 64% over the past year. However, the volume of data carried over mobile networks is still a small proportion (around 1%) of data carried over all networks.

## Status of mobile coverage across the UK and in the nations

5.3 Figure 19 below summarises the mobile coverage available in different parts of the UK, both in terms of outdoor premises and geographic area. These figures relate to the:

5.3.1 three mobile technologies currently used to deliver mobile services, i.e. 2G, 3G and 4G (see text box below for more information on these);

5.3.2 locations where coverage is available from *all* mobile operators. These figures therefore do not include locations where coverage is available from some but not all operators, often referred to as partial not-spots; and

5.3.3 locations where mobile services are generally reliable and connections are unlikely to be lost, e.g. due to the signal being blocked by buildings or variations in mobile handset performance.

**Figure 19: Summary of outdoor mobile coverage from all operators in the UK and the nations**

| | Percentage of premises covered | | | | |
|---|---|---|---|---|---|
| **Technology** (coverage threshold) | **Scotland** | **England** | **Wales** | **NI** | **Whole of UK** |
| **2G** (-81dBm) | 90% | 94% | 84% | 83% | 93% |
| **3G** (-100dBm) | 79% | 91% | 67% | 73% | 88% |
| **4G** (-115dBm) | 37% | 50% | 20% | 0% | 46% |

*Source: Ofcom analysis of operator data*

**Mobile delivery technologies**

There are currently three generations of technology used to deliver mobile services to consumers in the UK.

**2G** was the first digital mobile technology, launched in the UK in 1992. It is used to deliver voice, text services and low-speed data services. 2G services are delivered by O2, Vodafone and EE. There has been no material change in coverage provided by 2G networks over the past year.

**3G** is a later generation of digital mobile technology, launched in 2003, and can provide download speeds[31] of over 5Mbit/s. 3G supports voice, text and data services, and services are operated by O2, Vodafone, EE and Three. Outdoor 3G coverage from all operators has increased over the past year by 5%.

**4G** is the latest generation of mobile technology, launched in 2012, and provides mobile data connection speeds of over 10Mbit/s. These services are operated by O2, Vodafone, EE and Three. There has been a significant roll-out of additional 4G services by all operators over the past year. Three has also recently upgraded its 4G network to support voice services. It is likely that other operators will introduce similar services over the coming months.

[31] Based on research into 3G and 4G mobile broadband speeds, November 2014, http://stakeholders.ofcom.org.uk/market-data-research/other/telecoms-research/broadband-speeds/mobile-bb-nov14

5.4 Mobile operators use different combinations of mobile technologies to deliver their voice and data services. An alternative way of presenting the data in Figure 19 is to express coverage in terms of voice and data services.

## Coverage of mobile voice services

5.5 EE, Vodafone and O2 use a combination of 2G and 3G technologies to deliver voice services. Three does not have a 2G network, and uses its 3G network for voice services. It has recently introduced the functionality to allow voice calls on its 4G network, although only a small percentage of its customers currently have compatible handsets to use this service. Given this, Figure 20 below shows only the combined voice call coverage for 2G and 3G services in the UK.

5.6 In the future, we expect coverage of voice services to improve further. One factor is likely to be the wider roll-out of 4G voice services by all operators, in particular those operating in the 800MHz spectrum band. The characteristics of this frequency band make it particularly good at covering wide areas and penetrating deep into buildings.

5.7 In addition, O2 has a coverage obligation in its wireless telegraphy licence, requiring it to provide indoor coverage to 98% of premises by the end of 2017; 4G is likely to play a leading role in this. Other operators have indicated their intention to match this level of coverage over the same timescale.

**Figure 20: UK coverage for mobile voice services, based on combined 2G and 3G coverage**

| | $O_2$ | Vodafone | EE | Three |
|---|---|---|---|---|
| **Outdoor coverage** | | | | |
| **Premises** | 98% | 98% | 99% | 98% |
| **Geographic** | 72% | 77% | 78% | 68% |
| **Indoor/In-car* coverage** | | | | |
| **Premises** | 93% | 92% | 94% | 93% |
| **Motorways** | 97% | 97% | 99% | 98% |
| **A & B Roads** | 67% | 73% | 81% | 73% |

** For in-car coverage we assume that the phone is used within the vehicle. Coverage would be better if a car kit with an external antenna were used.*

*Source: Ofcom analysis of operator data*

## Coverage of mobile data services

5.8 Mobile operators use both 3G and 4G technologies to deliver higher-speed data services. Figure 21 shows coverage of data services in the UK, based on combining the coverage of 3G and 4G networks. 2G networks are only capable of supporting lower-speed data connections and are therefore not included.

**Figure 21: UK coverage for mobile data services, based on combined 3G and 4G coverage**

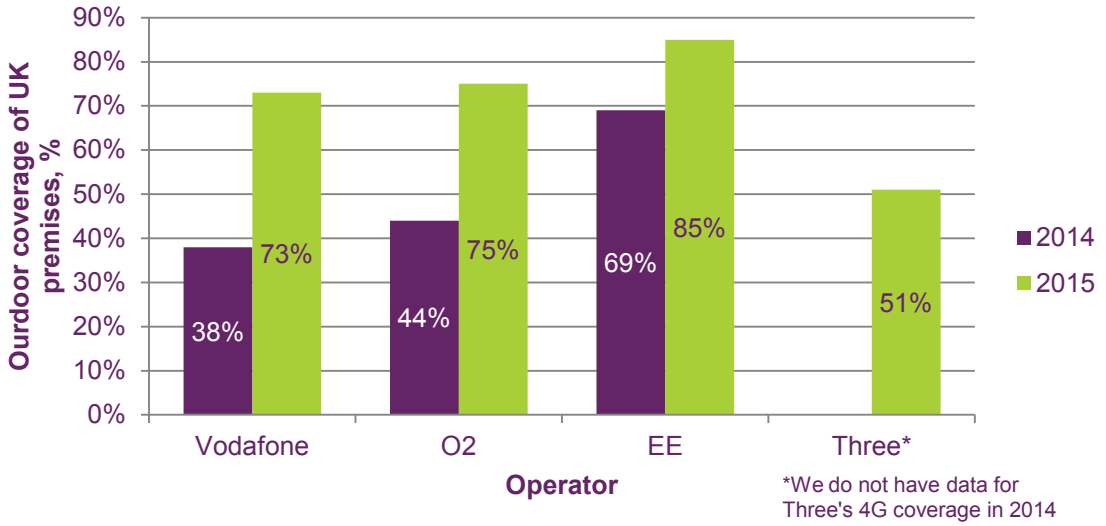
| | O2 | Vodafone | EE | Three |
|---|---|---|---|---|
| **Outdoor coverage** | | | | |
| **Premises** | 92% | 92% | 98% | 98% |
| **Geographic** | 47% | 49% | 75% | 68% |
| **Indoor/In-car* coverage** | | | | |
| **Premises** | 86% | 83% | 94% | 93% |
| **Motorways** | 83% | 83% | 99% | 98% |
| **A & B Roads** | 49% | 48% | 79% | 73% |

** For in-car coverage we assume that the phone is used within the vehicle. Coverage would be better if a car kit with an external antenna were used.*

*Source: Ofcom analysis of operator data*

5.9 There has been a significant increase in the roll-out of the latest generation of higher-speed 4G technology over the past year, albeit from a low base. As a result, most major towns and cities are now served by 4G services from all operators. A summary of the level of 4G coverage provided by different operators is shown in Figure 22.

**Figure 22: Increase in 4G coverage: 2014-2015**




*Source: Ofcom analysis of operator data*

## Mobile coverage is generally lower in rural areas and indoors

5.10 Figure 23 shows how 2G mobile networks provide coverage to a greater proportion of premises in urban areas than in rural areas. Reliable coverage is more difficult to achieve in rural areas, as there are fewer base stations, spread over a relatively large area, than in urban areas. This means that, generally, mobile signals will be weaker in rural areas.

**Figure 23: Voice network coverage (2G and 3G combined) in the UK's urban and rural areas**

| | None of the voice networks have coverage | Some, but not all voice networks have coverage | All voice networks have coverage |
|---|---|---|---|
| **Outdoor premises coverage** | | | |
| **Urban** | <1% | 1% | 99% |
| **Rural** | 3% | 25% | 72% |
| **Indoor premises coverage** | | | |
| **Urban** | <1% | 9% | 91% |
| **Rural** | 13% | 57% | 31% |

*Source: Ofcom analysis of operator data*

5.11 Coverage inside buildings tends to be worse than outside, in both urban and rural areas, as walls, doors and windows reduce the strength of mobile signals. This problem is likely to increase as consumers and builders improve the thermal insulation in their homes and other buildings; the materials used often contain metal, and while they are good at keeping heat within a building, they can also stop mobile signals from coming in.

5.12 The result is that indoor coverage in rural areas is particularly poor. For example, 72% of rural premises in the UK have voice call coverage from all networks *outdoors*; but only 31% of rural premises have the same level of coverage *indoors*.

5.13 We have looked in more detail into the underlying reasons why outdoor mobile coverage is often lower in rural areas than in urban areas[32]. This analysis sought to identify the factors that might explain the differences in the coverage of 3G and 4G mobile services in urban and rural areas. These factors fell into two broad categories:

5.13.1 **Consumer demand-related factors:** These include the size and density of the local population as well as its make-up in terms of age and affluence.

5.13.2 **Network infrastructure cost factors:** These included the differences in cost of providing mobile infrastructure in different locations, due to their remoteness and the topography of the local terrain.

5.14 The results of this study indicate that the consumer demand and network infrastructure factors, set out above, can explain many of the differences found in practice between mobile coverage in urban and rural areas. In addition, these factors can also be used to explain the differences in levels of coverage between the nations and regions of the UK, shown in Figure 19.

[32] Economic Geography: An Analysis of the Determinants of 3G and 4G Coverage in the UK, December 2015, http://stakeholders.ofcom.org.uk/market-data-research/other/technology-research/2015-reports/economic-geography/

## Developments that are helping to improve mobile coverage

5.15 There have been three significant developments over the past year, which are helping to improve mobile coverage:

5.15.1 **A new voice coverage commitment:** In December 2014, the UK Government signed a binding agreement[33] with the four network operators to improve mobile coverage. This was aimed, in particular, at reducing 'partial not spots', where coverage is provided by some but not all mobile operators. This agreement guarantees coverage of a mobile voice and text service from each operator to 90% of the UK's land mass by 2017[34].

5.15.2 **Providing better information to consumers:** In August 2015, Ofcom launched interactive online mobile coverage maps[35]. These enabled consumers and businesses to compare the voice and data coverage provided by different mobile operators in the locations that are most important to them. In addition to allowing consumers to make a more informed choice of mobile operator, we anticipate that these maps will further encourage mobile operators to compete on providing better coverage.

5.15.3 **Voice over Wi-Fi:** All mobile operators have launched voice over Wi-Fi services, which are helping improving coverage in buildings that have poor mobile signal coverage but good indoor Wi-Fi network coverage. EE's and Vodafone's services are integrated into the smartphone operating system and do not require the user to use a standalone app.

### Ofcom's interactive maps have been designed to represent the likely consumer experience

5.16 Ofcom's interactive maps are based on signal level predictions provided by the mobile operators. These predictions are also used to generate the mobile coverage statistics provided in this report.

5.17 To help ensure that the coverage shown on Ofcom's interactive maps was as representative as possible of the likely consumer experience of using mobile voice services, we conducted field research in different parts of the UK, to:

5.17.1 assess whether the signal level predictions provided by the mobile operators were accurate; and

5.17.2 identify the minimum mobile signal level needed to reliably make voice calls using different mobile technologies. As part of this, we measured the sensitivity of commonly-used handsets to find out how well they received weak signals[36]. The results of these measurements confirmed that the

[33] https://www.gov.uk/government/news/government-secures-landmark-deal-for-uk-mobile-phone-users
[34] The agreement is technology neutral and so could be delivered by a mix of 2G, 3G and 4G networks.
[35] http://www.ofcom.org.uk/mobile-coverage
[36] Mobile Handset Testing, December 2015, http://stakeholders.ofcom.org.uk/market-data-research/other/technology-research/2015-reports/mobile-handset-testing/

mobile handsets used in the field tests were representative of the handsets that consumers typically use.

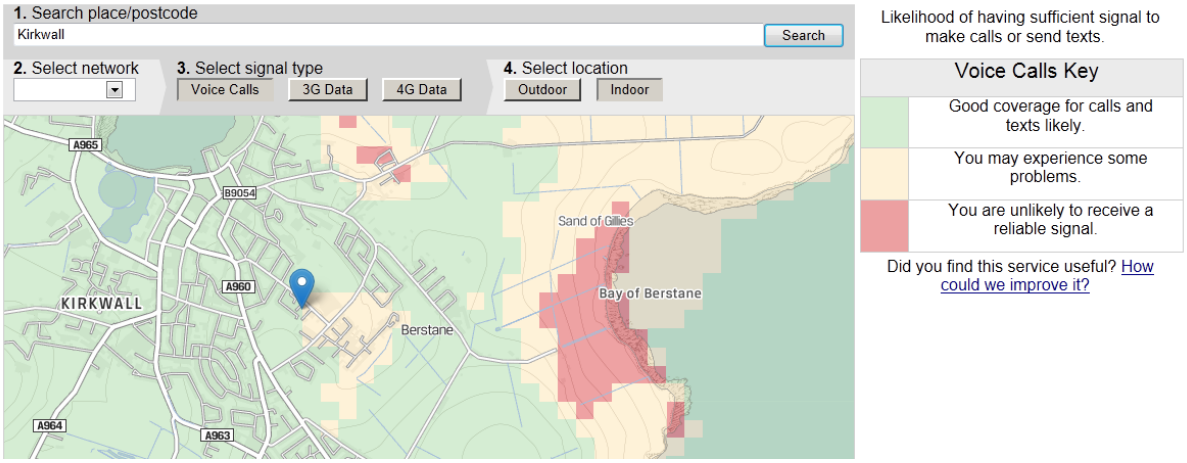
5.18 This research found that the mobile operators' predicted signal levels were generally being delivered in practice. We also found that a 2G signal level of -81dBm was needed to ensure a low likelihood that calls will not be interrupted or dropped. This is a higher level than assumed by operators in their coverage maps and is also higher than we assumed for last year's report. We have identified two main reasons why a higher signal level is required to achieve reliable 2G voice call coverage:

i) The sensitivity of modern smartphones is generally lower in the 2G frequency bands than that of earlier-generation mobile phones;

ii) A higher signal level is needed to compensate for the variability in 2G signals caused by blockages by trees and buildings.

5.19 As described above, we have reflected the need for a higher 2G voice call signal level in the coverage levels shown in this report. This is also reflected in our interactive maps, where a higher signal level threshold (-81dBm) is used to show where reliable 2G coverage is likely to be available (shown in green in Figure 24). A lower signal threshold of -93dBm is also used, to show on the maps where 2G mobile signals are likely to be sufficient to make calls, but where there is an increased likelihood that there will be problems establishing or maintaining a call (shown in yellow in Figure 24).

**Figure 24: Levels of 2G coverage in our online maps**




*Source: Screen-shot of mobile coverage map: http://www.ofcom.org.uk/mobile-coverage*

5.20 Our research confirmed that the minimum signal level needed to make reliable voice calls on a 3G network is -100dBm, which is the same figure that we used for last year's report. A slightly lower threshold (-103dBm) was agreed for the 90% coverage agreement between the UK Government and operators.

## Future improvements to the interactive coverage maps

5.21 In the three months since the launch of the mobile coverage maps, the site has been visited more than 330,000 times. In addition, over 4,000 people have provided feedback on the maps and the accuracy of the information they provide. Based on this feedback and our own review, we are releasing a new version of the maps alongside this report. The key changes are:

- A new choice of colours, to make the maps easier to use for those with colour blindness;
- maps showing coverage for difficult-to-reach locations indoors; and
- an updated feedback form to allow us to more precisely capture comments on the accuracy of the maps.

5.22 We intend to conduct further work in 2016 to allow us to better reflect the typical consumer experience of using mobile broadband data services and emerging 4G voice services.

## New technologies are helping to improve indoor mobile coverage

5.23 A number of new technologies, products and services are emerging that can improve indoor mobile coverage.

### Femtocells

5.24 Small low-power base stations, called femtocells, can be used to help improve indoor mobile coverage. They can be installed by the user, and connect to the mobile network using the user's fixed broadband connection. Femtocells are available from Vodafone, EE and Three. Our data show that there are now over 530,000 femtocells in use in the UK, up from around 400,000 in 2014.

5.25 One of the disadvantages of current femtocells is that a separate femtocell is needed for each mobile operator. This means that several femtocells are needed in homes and business where connections to different mobile networks are required.

### Mobile repeaters

5.26 A repeater is an alternative solution for improving indoor mobile coverage. Repeaters are signal boosters that amplify and retransmit the mobile signal; they do not need to be connected to the user's fixed broadband network. We are investigating the role that mobile repeaters may have in improving mobile coverage where there is no, or limited, access to a fixed broadband connection, e.g. in buildings and vehicles.

5.27 In the UK, the use of a repeater must be either licensed by Ofcom, or specifically exempted from such licensing[37]. Any other use of any such device is liable to be a criminal offence, unless an exemption applies (and the use complies with the terms of any exemption).

5.28 In order to better understand the role of repeaters in the UK, and whether repeaters with certain characteristics could be licence-exempt, we have issued a call for inputs[38] asking stakeholders to provide their view on the use of repeaters in licensed spectrum. More recently, we have commissioned a technical study[39] aimed at understanding the effects of repeaters on other mobile users. We are currently

[37] Under section 8 of the Wireless Telegraphy Act 2006.
[38] Mobile coverage enhancers and their use in licensed spectrum, May 2014, http://stakeholders.ofcom.org.uk/consultations/mobile-coverage-enhancers/summary
[39] An assessment on the effects of repeaters on mobile networks, November 2015, http://stakeholders.ofcom.org.uk/market-data-research/other/technology-research/2015-reports/assessment-effects-of-repeaters-mobile-networks/

considering the responses and identifying the next steps to evaluate whether it would be appropriate for consumers to buy and deploy repeaters with certain characteristics, in addition to their use by mobile operators.

Voice over Wi-Fi

5.29 All mobile operators now offer the ability to make voice calls and send text messages over Wi-Fi, to help improve indoor coverage. The main advantage of this approach is that it uses consumers' existing Wi-Fi networks and does not require them to install new equipment.

5.30 There are two approaches to delivering this service: via a smartphone app, or integrated into the operating system. O2 and Three currently take the first approach, while EE and Vodafone have both recently launched an integrated, or *native*, Wi-Fi calling service. The advantage of this second approach is that, provided they have a compatible handset, the consumer does not need to download or configure an app to use this service.

5.31 We expect that use of these services will grow, given the wide availability of Wi-Fi networks. We also expect the service will evolve to support more handsets and new functionality. For example, work is under way to allow seamless call handover between Wi-Fi and the mobile network.

## Data use is growing faster on mobile networks than on fixed networks

5.32 More consumers switched from traditional handsets to smartphones over the past year; over 66% of the adult population now has a smartphone, up by 27 percentage points since 2012[40]. The increasing use of smartphones and the wider coverage of higher-speed 3G and 4G networks have led to an increase in the amount of data used by consumers on their mobile devices.

5.33 On average, each consumer uses around 870MB of data per month, an increase of 64% since 2014. In comparison, the annual increase in data use on fixed broadband networks is lower, at 41% (although the monthly volume of data used over fixed networks is significantly higher, at 82 GB per connection – approximately 100 times greater than on mobile networks).

[40] The Communications Market Report, August 2015, http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr15/CMR_UK_2015.pdf

**Figure 25: Mobile data use continues to increase**

| Traffic type | June 2015 | June 2014 | June 2013 | June 2012 | March 2011 |
|---|---|---|---|---|---|
| Active connections (millions) | 83.7 | 83.2* | 82.7 | 82.2 | 81.1 |
| Total data uploaded/downloaded (GB, millions) | 72.9 | 44.3 | 28.9 | 19.7 | 9.0 |
| Data per active connection (GB) | 0.87 | 0.53 | 0.35 | 0.24 | 0.11 |

* Figure from March 2014

*Source: Ofcom analysis of operator data*

5.34 Figure 26 shows that video and web browsing continue to account for more than 80% of overall data use on mobile networks. The wider use of data services on smartphones has led to 'over-the-top' mobile data services that provide an alternative for traditional mobile voice and SMS services. In particular, there is growing use of services such as WhatsApp, at the expense of traditional mobile voice and SMS messaging services. For example, between 2013 and 2014 the proportion of consumers who claimed to use traditional SMS messaging fell by 1% while those who claimed to use internet messaging rose by 16%[41].

**Figure 26: Mobile connections are mostly used for web browsing and video streaming**

| Traffic type | % of data in 2015 | % of data in 2014 | % of data in 2013 |
|---|---|---|---|
| Video including streaming applications | 58% | 39% | 40% |
| Web browsing | 25% | 42% | 42% |
| Peer to Peer including Bit Torrent applications, file transfers and newsgroups | 7% | 2% | 8% |
| Other including VoIP, online gaming and email. | 10% | 17% | 10% |

Source: Ofcom analysis of operator data

5.35 The increasing demand for mobile data capacity continues to pose challenges for mobile network operators. This is being met by a combination of measures including:

5.35.1 the use of 4G technologies, which can transmit information more efficiently than previous generations of network;

5.35.2 the use of more radio spectrum, such as the frequency bands made available in 2013 following the switch-off of analogue terrestrial television.

5.35.3 the deployment of more base stations within a given area, to support more users and higher data rates; and

5.35.4 the increasing use of Wi-Fi, both in the home and office, and in public locations such as railway stations and cafés.

[41] The Communications Market Report, August 2015, http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr15/CMR_UK_2015.pdf

## Public Wi-Fi networks

5.36 In addition to the mobile data coverage provided by 3G and 4G networks, consumers can use public Wi-Fi networks, or hotspots, to connect to the internet. The geographic coverage of public Wi-Fi networks is much smaller than that of mobile networks and is mainly concentrated in urban areas, or in public areas such as stations and cafés. This year the number of public Wi-Fi hotspots in the UK continued to increase; to around 45,000, as shown in Figure 27.

**Figure 27: The number of public Wi-Fi hotspots has continued to increase**

| | June 2015 | June 2014 | June 2013 |
|---|---|---|---|
| No. of public Wi-Fi hotspots | 44,804 | 41,798 | 33,851 |
| Total data uploaded/downloaded (GB) | 3,291,293 | 2,262,049 | 1,514,630 |
| Data per Hotspot (GB) | 73 | 54 | 45 |

*Source: Ofcom analysis of operator data*

5.37 Public Wi-Fi hotspots provide consumers with a means to access the internet without using up their mobile data allowance. The average amount of data consumed in a month on public Wi-Fi hotspots grew to almost 3.3PB (3.3 million GB) and represents almost 5% of that consumed on mobile networks.

## The Internet of Things

5.38 The Internet of Things (IoT) describes the interconnection of everyday devices to create new and innovative services. Over the coming decade, the IoT is expected to grow to include hundreds of millions of devices in the UK alone, bringing benefits to citizens and consumers across a number of sectors, including transport, healthcare and energy.

5.39 Examples of IoT devices and services include:

5.39.1 **Healthcare**: Devices that monitor fitness and activity levels can help to prevent illness and encourage a healthy lifestyle. For the unwell, the IoT could enable a patient's condition to be monitored and managed remotely, allowing them to recover at home, rather than in hospital. This has the potential to reduce healthcare costs and to improve the medical treatment and care of patients.

5.39.2 **Transport**: Connecting vehicles to the internet could enable them to be tracked, and have the performance of their engine and other mechanical components remotely monitored. Connected vehicles should be better able to avoid accidents by detecting and monitoring the presence of other road users.

5.39.3 **Energy**: Connecting a wider range of household, office and industrial equipment to the IoT could enable their use of energy to be monitored and potentially changed; for example, to switch to a power-saving mode or to use electricity on a cheaper tariff during an off-peak period. In these cases, the IoT has the potential to both reduce costs for consumers and the

energy suppliers, and reduce environmental impacts through better management of scarce natural resources.

5.40 Mobile networks are capable of supporting many emerging IoT applications. New standards are being developed to enable their efficient delivery over 4G mobile networks, and looking further ahead, the IoT is expected to be one of the drivers for the development of 5G networks.

5.41 The past year has seen a 28% increase in the number of IoT devices individually connected to mobile networks (with a dedicated SIM[42] card) in the UK, as shown in Figure 28. The amount of IoT traffic carried over the mobile networks has almost doubled, but as the volume of traffic generated by IoT devices is very small, this makes up only a small proportion of traffic overall.

**Figure 28: IoT devices and traffic connected to all UK mobile networks**

| | 2015 | 2014 | Change |
|---|---|---|---|
| **Number of IoT devices** | 5,212,304 | 4,065,836 | 28% |
| **Average proportion of IoT data to total data carried** | 0.16% | 0.09% | 81% |

*Source: Ofcom analysis of operator data*

[42] The Subscriber Identity Module card, used in mobile phones, some tablets and some IoT devices, uniquely identifies the mobile customer.

Section 6

# Internet access services

## Overview

6.1 Much of the preceding analysis in this report has focused on the availability and performance of the access networks that network operators use to provide connections to customers, either via direct fibre or copper physical lines to the home, for fixed networks, or through radio coverage from masts, for mobile networks. In this section we explore the issues relating to the other parts of the internet connection chain linking consumers to online services.

6.2 Access networks now deliver an increasingly wide range of services, not just the traditional voice telephony and cable TV that many legacy networks were initially designed to deliver. In particular, consumers are increasingly using these networks to access a vast range of services available on the internet. These services now constitute the majority of traffic delivered over access networks. As a result, consumers are becoming increasingly concerned about the quality of their internet connection, in addition to the performance of the more traditional services such as voice telephony.

6.3 Internet service providers (ISPs) often do not have full control over the full end-to-end internet connection chain to consumers, and hence over the quality of internet services delivered to consumers. In this section we explore a number of topics related to how ISPs are supporting the delivery of internet services over their networks, including how they manage the flow of data over their networks and how they interconnect with other ISPs, content delivery networks and the wider internet. We also consider the effect of the performance of the ISP networks on the consumer and SME experience, and how ISPs manage the assignment of internet addresses to consumers' equipment.

6.4 The highlights are:

6.4.1 ISPs are simplifying their consumer broadband packages and **improving the information they provide to consumers about the use of traffic management on their networks**. Meanwhile, a broader international debate continues to explore whether regulatory authorities need greater powers to protect consumers if damaging traffic management practices emerge.

6.4.2 **An increasing amount of internet data is being delivered to consumers by major video content providers.** The use of content delivery networks (CDNs[43]) continues to increase: internet content is increasingly being served from caching servers embedded in the ISPs access networks and provided by the content providers.

6.4.3 The effects of different parts of the internet delivery chain on consumers' and SMEs' experience of using online services are materially **different for different connection speeds**;

[43] Akamai, Google, Amazon, Netflix and the BBC.

6.4.4 Larger-scale ISPs are likely to progressively **introduce support for the latest IPv6 internet addressing system over the next 12 to 18 months**.

## Managing data use within ISP networks

6.5 The growth of the internet has created both an opportunity and a major challenge for network operators: consumers' reliance on and use of their services continues to grow, but they are faced by a significant challenge in how they cope with the consequent huge growth in data traffic.

6.6 As consumers use more 'bandwidth hungry' internet services such as video, existing access networks are likely to experience congestion problems. Networks must have the capacity to accommodate overall data volumes as well as peak instantaneous demand. One way for ISPs to manage congestion is to increase the capacity of their networks. However, despite the ongoing deployment of superfast-capable networks across the country, congestion problems are still likely to persist in the ISPs' networks as demand continues to rise.

6.7 In addition to increasing network capacity, ISPs can adopt a range of approaches to manage how data travels across their networks; for example, ISPs can cap the amount of data that consumers can access or reduce speeds at peak times. These approaches are discussed in Figure 29.

**Figure 29: Operators have a range of tools for managing data use**

| | |
|---|---|
| **Fixed broadband usage caps** | ISPs may limit users to a certain amount of data per month, or at peak times. Exceeding the cap can result in additional charges or a reduction in speeds.<br><br>ISPs now offer 'unlimited' packages with no data caps[44] and over 80% of consumers are now taking such services.<br><br>Peak period usage restrictions are still used by cable-based ISPs, such as Virgin Media, to manage the inherent limitation in upload capacity in the DOCSIS systems they use. |
| **Mobile usage caps** | Most mobile operators impose data caps on their packages, and those who previously offered unlimited data packages, notably Three and GiffGaff, have changed their terms of use[45]. These changes probably reflect the impact of increased media streaming on overall network capacity. |
| **Traffic management (TM)** | ISPs may adopt TM techniques to alleviate network congestion at busy times. In practice, this is achieved by prioritising some types of traffic over others, or entirely blocking certain types of traffic, e.g. peer-to-peer (P2P) file sharing, or VoIP telephony on mobile |

[44] BT, Virgin, TalkTalk, Sky, EE, KCOM and PlusNet all offer one or more unlimited fixed broadband packages among their broadband product choices.

[45] Three announced last year that it would introduce caps, limiting the amount of data that customers can access via tethering, which refers to connecting a device, such as a mobile phone, to another device (e.g. tablet or laptop) in order to use the first device's internet connection. GiffGaff also dropped the unlimited aspect of a number of its plans - http://www.ispreview.co.uk/index.php/2014/09/giffgaff-uk-scraps-cheaper-unlimited-mobile-broadband-data-plans.html

| | |
|---|---|
| | networks.<br><br>We are seeing evidence that these techniques are now being used to manage the performance of heavily-used broadband connections, where multiple users within a given household are all simultaneously accessing the internet over a single connection and their aggregate demand exceeds its capacity.<br><br>All UK MNOs have now stopped offering packages with VoIP blocks although some users are still on packages to which VoIP restrictions apply. All major fixed ISPs and MNOs are now signatories to the BSG Open Internet Code of Practice which prohibits such blocking[46]. |

6.8 Better controlling the flow of traffic across an ISP's network by using traffic management (TM) can benefit consumers by improving the performance of their broadband connections at peak times. However, there are concerns that ISPs could use TM in a discriminatory manner. For example, an ISP could prioritise the delivery of its own services over others', so that they are more attractive to consumers, or better quality.

6.9 In 2011 we published a statement in which we set out the concerns we would have if ISPs were to apply TM in a manner that degraded access to the internet. Since then, we have used the *Infrastructure Report* series to monitor and report on what ISPs are actually doing, to determine whether we should have any such concerns. Two important concerns are:

- **transparency**, i.e. whether consumers know that TM is being performed on their broadband connections; and
- **net neutrality**, i.e. whether the use of TM has an adverse and unfair effect on the delivery of some traffic or applications, compared to others.

6.10 We discuss both of these in more detail below.

## Transparency

6.11 There is increased regulatory pressure on mobile and fixed operators to be transparent about the ways in which they manage consumers' data use. We believe that competition provides an important discipline for ISPs' network management practices. In order for competition to operate effectively, consumers need to have clear and transparent information about whether TM will affect the services they purchase, and it should be easy for them to switch provider.

6.12 ISPs in the UK are therefore subject to a regulatory obligation[47] to be transparent with consumers about their TM practices. There is an industry-wide code of practice explaining how they should comply with this obligation (the *Traffic Management*

[46] http://www.broadbanduk.org/wp-content/uploads/2012/07/BSG-Open-Internet-Code-of-Practice-amended-October-2014.pdf
[47] General Condition 9.2e.

*Transparency Code of Practice*[48]) which requires that each ISP publish a table summarising its TM policy for each package on offer. These tables have been available on signatories' websites since July 2011.

6.13 In late 2013, Ofcom conducted research on consumer awareness and use of the TM information provided by ISPs. It found that, while the information provided by ISPs was largely accurate and understandable, consumer awareness of TM generally was low. Following this, during 2014 we worked with ISPs to help them improve the impact of the information they provide, with a focus on improving consumer awareness and usability. The ISPs now provide introductory information explaining their policies and the impact of these policies on their services, and have updated their websites to include glossaries of technical terms.

6.14 We have reviewed the information provided by ISPs. Our conclusion is that, broadly, transparency about TM practices has improved, and in general TM policies are less restrictive than previously. For fixed networks, TM policies are rarely invoked.

## Net neutrality

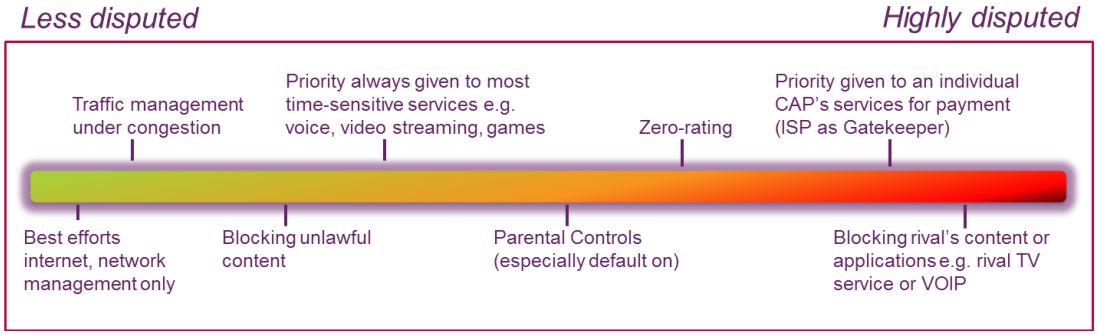
6.15 'Net neutrality' refers to a policy debate about the way ISPs manage the data carried on their networks, from content providers such as the BBC, YouTube and other websites to end-users. The issue has gained prominence as the internet has become an essential platform for the delivery of all kinds of content, services and applications.

6.16 Some argue that the use of some TM practices by ISPs could be discriminatory, in particular by undermining the ease with which innovative services can launch and become successful. Their concerns can be described in terms of constraining competition, innovation or freedom of expression.

6.17 Some TM practices are generally accepted as legitimate, e.g. to manage network congestion or to block access to unlawful content. On the other hand, TM intended to secure commercial advantage for the ISP is generally not accepted. This may happen if the ISP blocks a service provider's content in favour of its own. As Figure 30 shows, between these two extremes are 'grey areas' that might elicit different responses in different countries.

[48] http://www.broadbanduk.org/wp-content/uploads/2013/08/Voluntary-industry-code-of-practice-on-traffic-management-transparency-on-broadband-services-updated-version-May-2013.pdf

**Figure 30: The spectrum of traffic management practices**

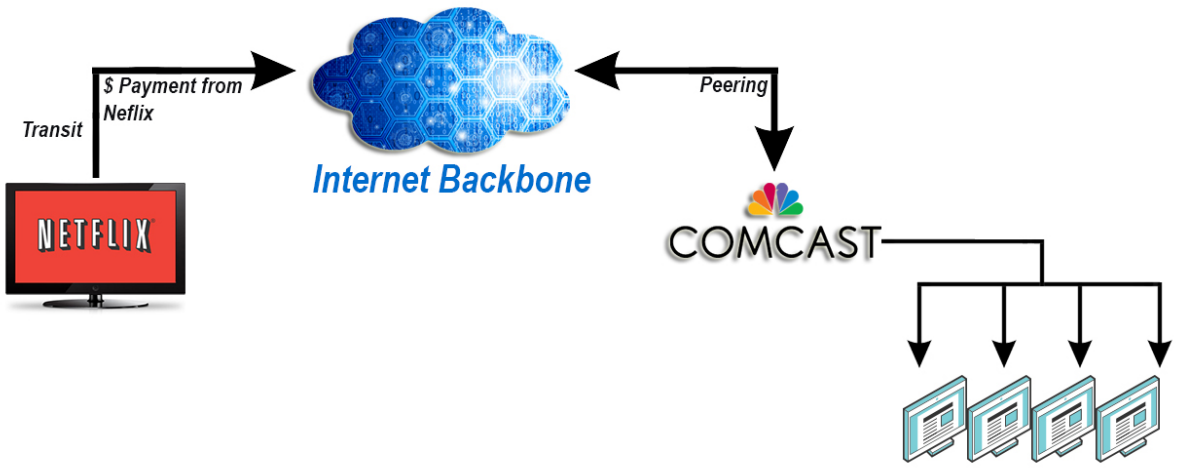



*Source: Ofcom*

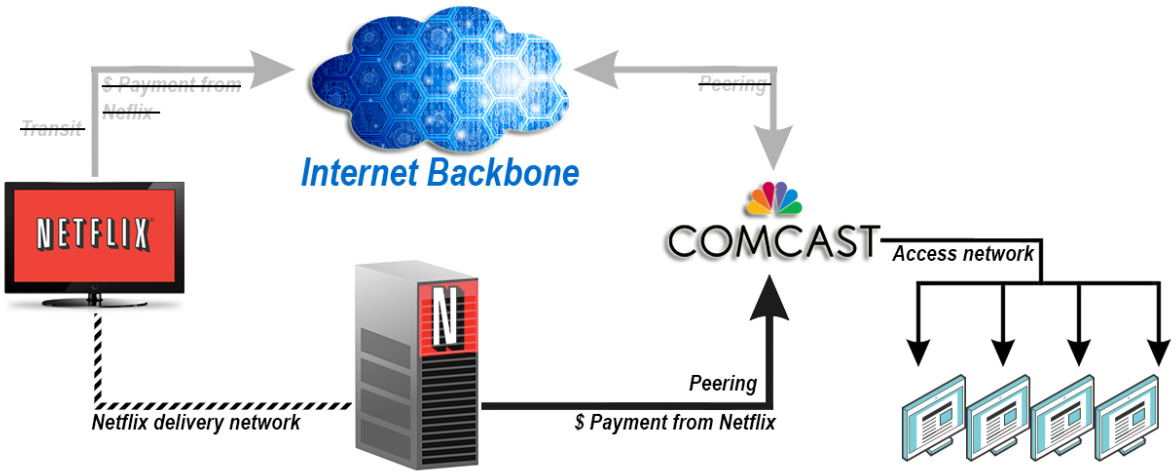
6.18 A recent addition to the net neutrality debate is ISP commercial practices that involve differentiated charges for data associated with specific services, i.e. consumers are charged different amounts for different classes of traffic. The most commonly cited commercial practice of this kind is known as 'zero-rating', e.g. an MNO offers a package with a 5GB download limit for general data, but zero-rated or unlimited access to Spotify. Zero-rating is a new hot topic in both the US and the EU.

6.19 Some aspects of the net neutrality debate address the delivery of services to consumers more broadly. For example, some of the largest content providers now operate their own delivery networks, which must interconnect with ISPs in order to deliver content to consumers. They can do this either by paying a transit network, which itself connects to the ISP (Figure 31a), or by interconnecting directly (Figure 31b). Direct interconnection is cheaper (for the content provider) for the delivery of large volumes of data.

**Figure 31: Changing approaches to interconnection**




a) Distribution in 2013




b) Distribution in 2015

*Source: Ofcom*

6.20 Particularly in the US, these 'direct' interconnection agreements between ISPs and content delivery networks have led to allegations that ISPs are attempting to become *gatekeepers*, extracting a charge from content providers such as YouTube to allow them to access the ISPs' subscribers.

6.21 The allegations are particularly prominent in those countries (like the US) where there is limited competition among ISPs, and hence the negotiating position of content providers is seen to be weaker. Conversely, in Europe (where there is a large degree of ISP competition, but where there is concern about the dominance of US content providers like YouTube and Netflix), these deals have led to allegations that large content providers are able to buy preferential access to ISPs' subscribers (to the detriment of smaller ones).

6.22 In fact, these arrangements are arguably no different from traditional network operator interconnection negotiations and arrangements that have always existed. We have no reason to believe that UK ISPs are abusing their position to extract payment from content providers, nor that large ones have been allowed to buy better quality content delivery to the detriment of their smaller competitors.

## The EU Regulation and its impact

6.23 The EU Telecoms Single Market Regulation[49], approved in the European Parliament in late October 2015, is likely to have a significant impact on how net neutrality is regulated when it comes into force at the end of April 2016. There are four relevant Articles in the Regulation:

6.23.1 **Article 3** imposes net neutrality/traffic management obligations on ISPs.

[49] Regulation (EU) 2015/2120 of the European Parliament and of the Council of 25 November 2015 laying down measures concerning open internet access and amending Directive 2002/22/EC on universal service and users' rights relating to electronic communications networks and services and Regulation (EU) No 531/2012 on roaming on public mobile communications networks within the Union - see http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32015R2120

6.23.2 **Article 4** imposes a range of specific transparency conditions on ISPs in relation to the speed and quality of the services they offer, and to their handling of complaints and unsatisfactory performance.

6.23.3 **Article 5** requires NRAs to monitor and enforce Articles 3 and 4, and to report annually on their findings. It reinforces NRAs' power to impose quality of service obligations on ISPs.

6.23.4 **Article 6** requires member states to introduce a sanctions regime to support enforcement of Articles 3-5.

6.24 The TSM requires BEREC to *"issue guidelines for the implementation of the obligations of national regulatory authorities"*. This process is under way, and should help provide clarity and guidance as to the requirements of the Regulation. BEREC[50] intends to publish the guidelines in August 2016, a few months after the Regulation comes into force.

6.25 We would encourage industry to work collectively, where possible, to develop their approach to new obligations under the Regulation. For example, it may be helpful to develop a common approach to the new transparency obligations set out in Article 4. It is helpful in this context that the Broadband Stakeholders Group is currently reviewing industry codes of practice dealing with net neutrality and traffic management[51]. This work (along with past industry collaboration in developing the common Traffic Management Key Facts Indicators template), may be able to form the basis for development of new industry codes intended to reflect the provisions of the new Regulation.

## Interconnection with other networks

6.26 In previous years we have reviewed and reported on the nature of the connection arrangements used by ISPs to deliver internet content. Last year we noted an increasing use of content delivery networks (CDNs) and direct connections between the access providers and the providers of content and services, and a reducing use of transit and public peering arrangements to deliver internet content[52].

6.27 This evolution is typified by the changes in interconnection used by the Netflix service illustrated in Figure 31. In particular, we note that its CDN arrangements, and those of other major internet content providers, are now being further extended into the access provider's own network using 'caching servers'[53]. This approach further reduces transit or backhaul connectivity costs, and can improve the customer experience by reducing the likelihood of data congestion in these parts of the network.

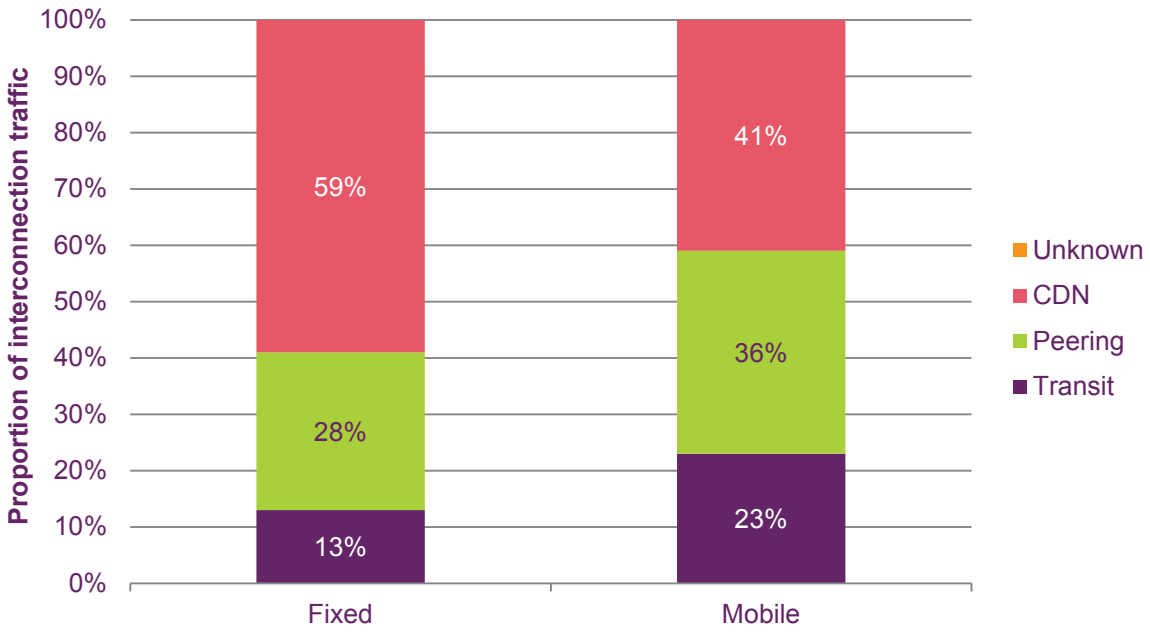
6.28 Peering takes place at a location agreed by both parties. In many cases this will be at internet exchange points (IXPs); locations built to facilitate peering. In the UK a large number of public peering points – 'internet exchanges' - are located in London. The

[50] The Body of European Regulators of Electronic Communications consists of the telecoms regulators of the EU member states.
[51] http://www.broadbanduk.org/2015/11/17/publication-of-review-of-the-uks-open-internet-codes/
[52] For an explanation of these terms, please see section 9, p161 onwards at http://stakeholders.ofcom.org.uk/market-data-research/market-data/infrastructure/infrastructure-2014/
[53] Caching servers are CDN servers which can be placed within the ISP's network or on a third-party network, storing the most popular content. This removes the need for the ISP to connect to the original source of the content every time a customer requests it.

London Internet Exchange (LINX) and the London Network Access Point (LONAP) are two of the largest not-for-profit organisations providing these interconnect locations. Other exchange points are located elsewhere: Leeds, Manchester, Edinburgh, and soon, Cardiff.[54] A number of ISPs, often those with an international network footprint, also peer at other leading IXPs, such as AMS-IX in Amsterdam.

6.29 The use of CDNs by both fixed and mobile operators has increased over the past year; Figure 34 shows that fixed operators use CDNs to deliver a larger proportion of their traffic than do mobile operators.

**Figure 32: Share of peering and transit interconnections for typical fixed and mobile operators**




*Source: Ofcom analysis of operator data*

6.30 The proportion of traffic provided by the top content providers which have individual interconnection arrangements has also increased. For some fixed networks, the proportion of traffic delivered via the BBC, Google, Netflix, Akamai and Limelight can make up 60% or more of all interconnecting traffic. On mobile networks, the proportion is lower. This shows that the source of internet data is increasingly consolidating into a small number of providers.

6.31 However, increasingly, the direct connectivity provided via CDNs is not the route that much of the content served actually takes to the end-user. Earlier we noted the increasing role of content providers' caching servers in 'local' delivery. Anecdotally, one fixed ISP has estimated that around 65% of the content downloaded by its customers is now served in this way.

6.32 Location of interconnection is consequently changing as, typically, each national ISP may have up to about ten sets of such content providers' servers distributed across

[54] The Welsh Government has been working with LINX, Cardiff County Council and other partners to bring an internet exchange to Cardiff.
http://wales.gov.uk/newsroom/businessandeconomy/2014/8838915/?lang=en

its network. Since the actual volume of traffic served to each individual server may be comparatively small, and since it may partly be carried over the ISP's own network, this makes analysis of the proportions of traffic exchanged at various locations increasingly difficult.

6.33 Peering connections, including public and private peering, have the largest proportion of their interconnect traffic exchanged in London. This is unsurprising, given that many operators are based in London. After London, around 20% of peering traffic is exchanged at other large co-location facilities in Europe, mainly in Frankfurt and Amsterdam.

6.34 Our data suggest that only a small proportion of traffic is carried across the other regional interconnections in the UK. This is probably due to the smaller number of networks currently present at these locations; these internet exchange points are relatively new.

## Factors other than connection speed can affect the consumer experience of using internet services

6.35 As discussed in Section 4, consumers with faster broadband connection speeds are more likely to rate their experience of using of internet services as 'good'. However, connection speeds relate to only one part of a larger chain of interconnected networks and systems that consumers use to access internet services. In this section we consider the effect of this wider connection chain on the consumer experience, which we have separated into four main parts (see Figure 33):

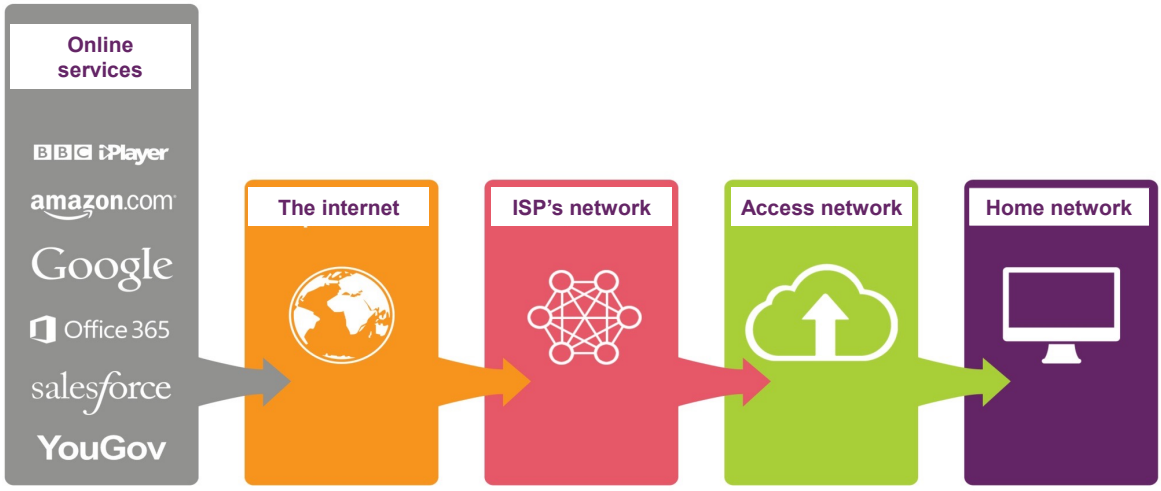
6.35.1 *The home network:* this includes connections from the home router to consumer devices, using, for example, Wi-Fi, Ethernet and powerline. The effect of the performance of this part of the connection was discussed in Section 4.

6.35.2 *The ISP's access network:* this includes the 'last mile' connections between the ISP's network and the user's premises (the availability and speed of these connections is set out in Section 4). For some ISPs, this part of the ISP's network may also include connections between smaller local exchanges and larger metropolitan locations.

6.35.3 *The ISP's network:* this relates to interconnections within the ISP's network between the 'last mile' connection and the wider internet;

6.35.4 *The internet:* this relates to the national and international connections to services hosted on the wider internet.

**Figure 33: The internet connection chain**




6.36 The performance of these different parts of the connection chain, and how they are perceived by consumers, is more widely dependent on:

6.36.1 **The internet application being used:** this is because different internet services have different levels of sensitivity to connection performance.

6.36.2 **The expectations of the consumer:** consumers may have differing broadband performance expectations. For example, those relying on their domestic broadband connection to run a small business, or those who have paid a higher price for a higher speed connection, may have greater expectations than those making infrequent use of a broadband connection using a lower price subscription.

6.37 Ofcom has commissioned research into a new, innovative internet measurement approach, to help identify how the four parts of the internet connection chain, as described above, are likely to affect the consumer experience of using differing online services[55]. Predictions made by this new approach about how consumers are likely to rate the quality of their broadband connections appear to correlate closely with actual consumer ratings.

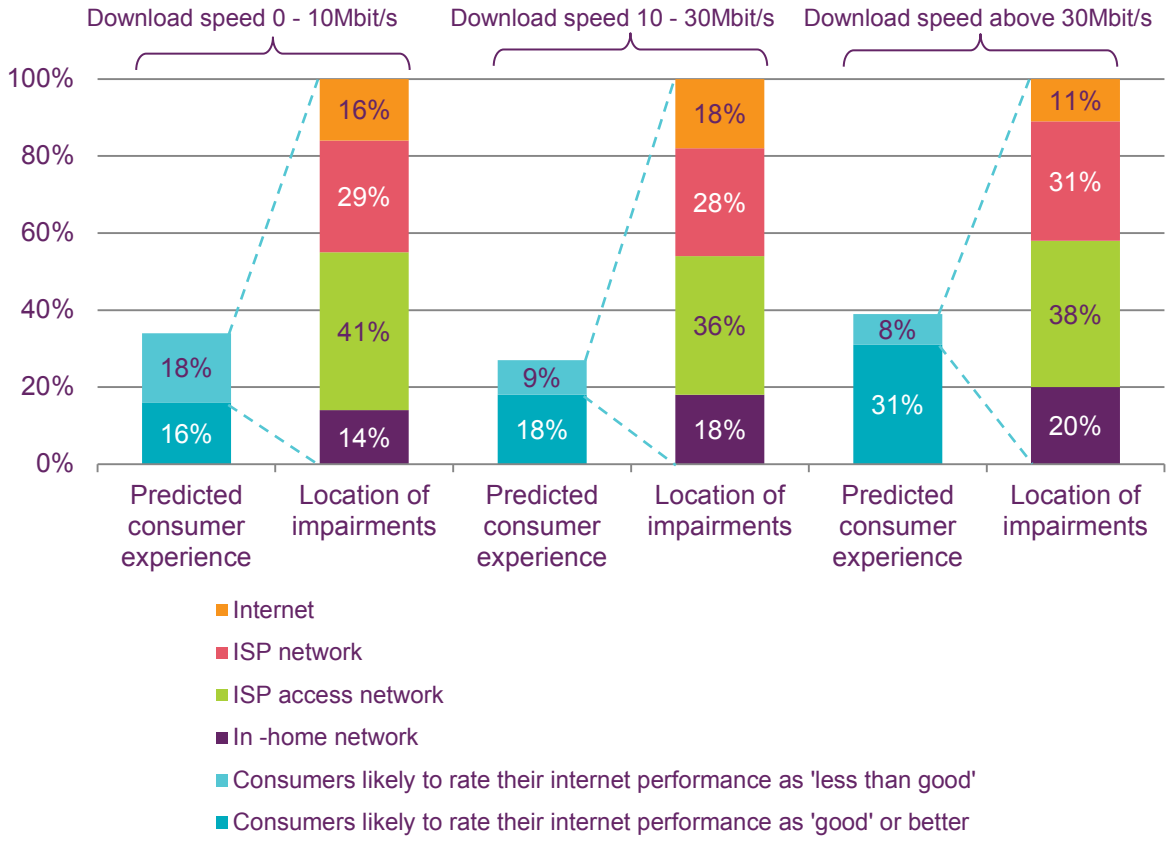
## The performance of other parts of the connection chain

6.38 As described in Section 4, the new measurement approach has found that the higher the connection speed that consumers have, the more likely they are to rate their broadband experience as at least 'good'.

6.39 The new measurement approach has also identified (see Figure 35) that factors beyond the speed of the access network can have a meaningful effect on broadband connections likely to be rated by consumers as 'less than good'.

[55] http://stakeholders.ofcom.org.uk/binaries/research/infrastructure/2015/downloads/qoe-analysis.pdf
http://stakeholders.ofcom.org.uk/binaries/research/infrastructure/2015/downloads/qoe_uk-analysis.pdf

**Figure 34: The parts of the internet connection chain affecting those who rate their broadband experience as 'less than good'**

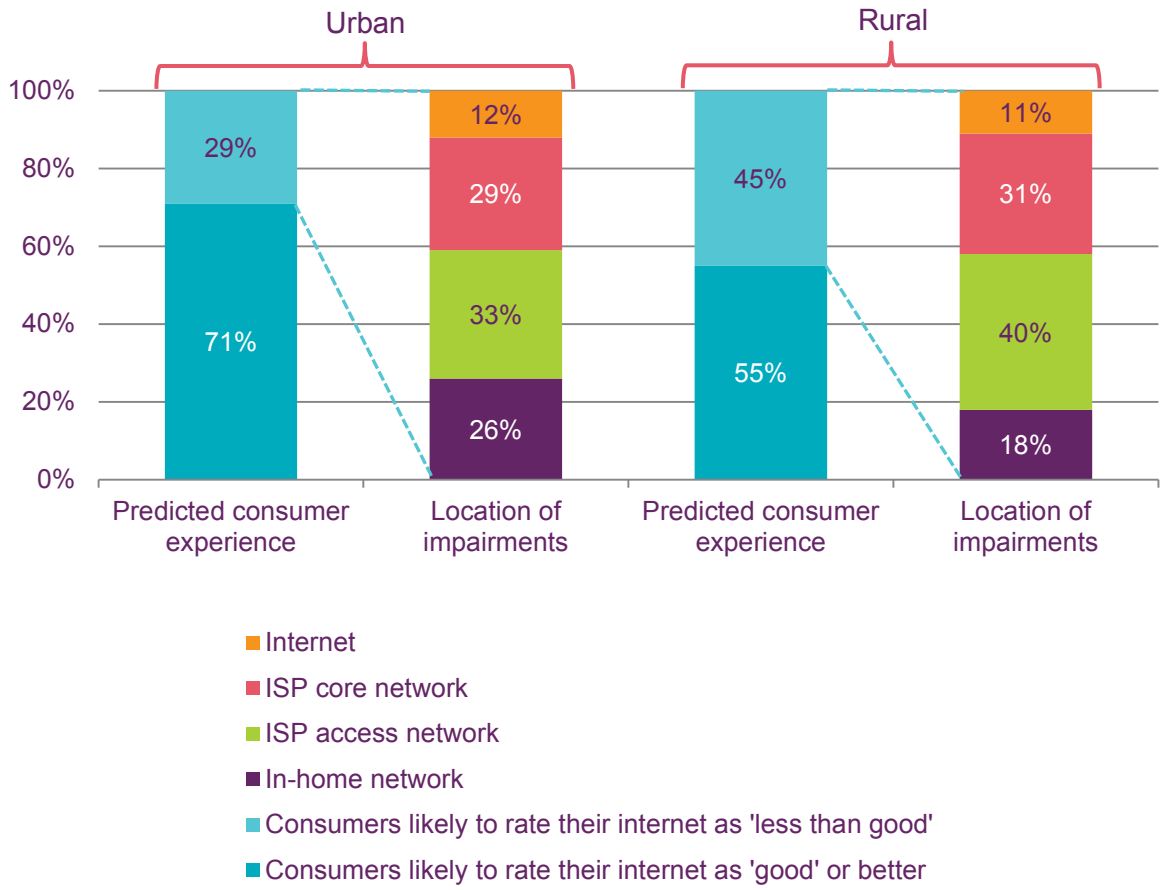



*Source: Actual Experience for Ofcom*

## The consumer experience of using broadband services is generally lower in rural than in urban areas

6.40 Using the new measurement approach, we find that a higher percentage of consumers in rural areas (45%) than in urban areas (28%) are likely to rate their broadband performance as 'less than good'. As already discussed in Section 4, this is in large part due to the availability of slower speed connections in rural areas. However, as shown in Figure 36, other parts of the connection chain can affect performance in rural areas. The impact of these other factors affect proportionally more households in rural than in urban areas, as a greater proportion of households experience lower performance in rural areas.

**Figure 35: The quality of experience of consumers in rural areas is likely to be affected by issues in the access network**



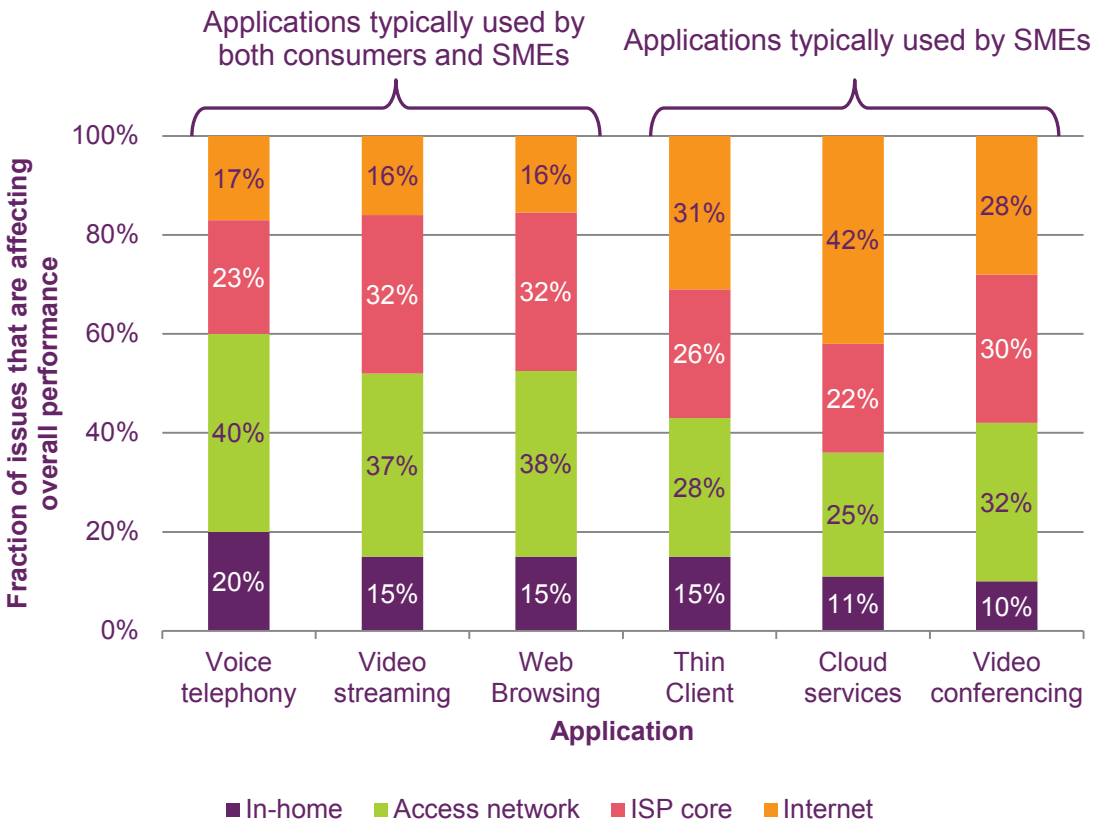

*Source: Actual Experience for Ofcom*

## The applications used by some small businesses are sensitive to broadband performance

6.41 Small- and medium-sized enterprises (SMEs) use a broad range of online services. Many of these are the same as those used by domestic consumers, such as email and web browsing. However, using the new measurement approach we have been able to identify that other types of services that they often use, including video-conferencing and cloud-based customer management and billing services, are more sensitive to end-to-end internet performance using residential broadband connections.

6.42 In particular, Figure 37 illustrates how connections between the ISP's network and the wider internet play a more significant role for many of the services likely to be used by SMEs..

**Figure 36: Many of the applications used by SMEs are more susceptible to performance issues in the wider internet**




*Source: Actual Experience for Ofcom*

## Internet addressing

### Introduction

6.43 The internet relies on a numeric address scheme to route data across the globe. For data to be delivered, each device connected to the internet must have access to a publicly-routable internet protocol (IP) address. The current, widely deployed, version of IP is version 4 (IPv4) which provides around 4 billion unique addresses and is administered by the US-based Internet Assigned Numbers Authority (IANA). IP address allocations in the UK are serviced by the RIR for Europe and the Middle East, Réseaux IP Européens Network Coordination Centre (RIPE NCC).

6.44 In 2011, IANA declared that the central pool of IPv4 addresses was "exhausted". Each of the RIRs is, in varying degrees, running out of its final block of IPv4 addresses. We asked providers to estimate the likely date of IPv4 exhaustion for their networks. They gave varying estimates of when they would run out of IPv4 addresses. Their estimates were between one and five years, based on the current rate of use.

6.45 The Internet Engineering Task Force (IETF) has long been aware of the potential exhaustion of IPv4 addresses. In 1998 it standardised a successor to IPv4: internet protocol version 6 (IPv6). However, the implementation of IPv6 is likely to present some significant challenges: it requires investment in the network by online service

providers, and in updating or replacing consumers' equipment to handle the new-format IP addresses.

6.46 Mobile operators are generally looking to introduce IPv6 addressing, as many of the latest generation of 4G handsets are already compatible. However, further software upgrades or configuration changes within the network and in consumer devices may be required before mobile operators can begin to use IPv6 addresses. In the meantime, a technology known as CGNAT[56] is used to share a single IP address among multiple users.

6.47 Fixed operators are also considering, or trialling, CGNAT and/or an approach in which both IPv4 and IPv6 run in parallel. None of the major providers we contacted are currently offering IPv6 addresses for their residential/ non-business users, although IPv6 services are available from some smaller fixed broadband providers, such as Andrews and Arnold. However, most major ISPs have told Ofcom that they intend to roll-out IPv6 addressing in the next 12 months, with BT recently announcing that it will make it available to all its customers by the end of 2016[57].

6.48 As mentioned, a potential barrier to the introduction of IPv6 addresses is the availability of compatible equipment in the home. Most of the main fixed-line providers that we contacted reported that the majority of the routers provided to customers were already IPv6-compatible. In aggregate, approximately 80% of consumer routers provided by these operators are IPv6-ready. For these routers, only a firmware upgrade was necessary. However, customers owning older routers will require new IPv6-compatible hardware.

## Next steps and further work

6.49 The analysis conducted in this section remains a key part of Ofcom's statutory duties to encourage investment and innovation and to improve the availability and use of high speed data transfer services throughout the United Kingdom. Helping industry to identify how and where network performance may be suffering degradation, we believe helps in this process. Similarly, highlighting the potential for in-home networks to affect overall performance can help consumers take steps to improve their experience.

6.50 We therefore plan to continue our work in this area. Given the many factors involved, work to further increase the number and distribution of participants remains a key priority. Moreover, we are conscious that the quality of experience relies not only on the end-to-end digital distribution chain, but also on the interaction between the data transmission layer (IP) and the sessions and applications that operate over it.

6.51 We anticipate our further work to divide into two areas. The first will be to agree a full set of consistent measurements and tests that can be conducted on a regular basis, either as part of, or in conjunction with, the existing broadband speeds work that we do. The second will be to conduct further research into how different network layers and elements affect quality of experience, over and above those that we already can measure. We expect to publish the results of both of these areas of activity in next year's *Connected Nations* report.

[56] Carrier Grade Network Address Translation.
[57] http://www.ispreview.co.uk/index.php/2015/09/uk-isp-bt-to-deploy-ipv6-to-entire-network-by-december-2016.html

6.52 An emerging, and as yet poorly-understood aspect of web services, which may adversely affect the consumer experience, is the increasing complexity of web pages and, in particular, the growing volume of advertising content that is an integral part of the web browsing experience. Many popular websites and services use advertising served to their users as an important part of their business model. In some cases the revenue arising from these advertisements represents the main, or only income to support their operations.

6.53 The adverts embedded in many consumer websites or other services are increasingly sophisticated in content and may be specifically targeted at the recipient through the use of tracking cookies and other techniques to identify perceived topics of interest. Video adverts are increasingly common, with many being 'auto-play' or taking over the full area of the user's screen while playing. Many users see this behaviour as annoying and take steps to prevent adverts being served, by using blocking software such as AdBlock[58].

6.54 The impact on the overall broadband experience may be even more significant. In many cases, the article content on a webpage may be far outweighed by the advertising and the software involved in serving it. In one case, the total download size of a single page was more than 9.5 MB, taking over 30 seconds to be completed over a good broadband link, and required 263 separate HTTP sessions involving more than 30 different web service companies. The actual article content represented less than 1% of the total data volume. These problems have also been identified in international media coverage[59].

6.55 The underlying issue has implications for the user experience, where the perception is that the service is 'slow'. For mobile users in particular, it has a potential financial impact as data caps may be exceeded earlier than anticipated. This has led to a number of major internet content and service providers supporting an approach developed by Google to strip out excess content in the network to alleviate these concerns[60].

6.56 In addition, the complex, multi-session nature of these emerging new norms for website design may be exposing the limitations of one of the fundamental building blocks of the internet, the transport protocol TCP. A number of technically-informed commentators have touched on these issues over the last few years; one of the most credible is Jim Gettys, a leading internet engineer who has been involved in many technical initiatives and projects that have made a major contribution to the success of the internet and world wide web.

6.57 A few years ago, Gettys and others identified a problem he referred to as "buffer bloat" – a phenomenon where apparently high-capacity network connections performed poorly because of excessively high buffer capacity in the routing software of the network elements. This measure, ostensibly done to improve performance, had the counter-intuitive effect of actually degrading it in some circumstances.

6.58 Gettys ascribed this problem to weaknesses in the way that TCP deals with flows of packets competing for processing resources in these network elements – essentially

[58] http://www.theguardian.com/commentisfree/2015/aug/23/beginning-of-the-end-for-web-ads
[59] http://www.nytimes.com/2015/10/01/technology/personaltech/ad-blockers-mobile-iphone-browsers.html?_r=0
[60] http://www.bbc.co.uk/news/technology-34465270 and https://www.telecomtvinsights.com/insights/introducing-the-accelerated-mobile-pages-project-for-a-faster-open-mobile-web-2078/

it operates on a simple 'FIFO' basis without any ability to prioritise flows that are more urgent or more likely to suffer from delay or latency.

6.59 In more recent work[61] Gettys has taken this diagnosis further to specifically address the problems caused by latency in the face of ever-increasing website complexity. In this he has identified that, in some instances, the cumulative impact of the round trip times of the packet requests and flows involved in complex web pages is the real determinant of page load time, not the bandwidth available[62]. This may help explain consumers' subjective perception that internet performance remains poor as, above a relatively low broadband speed threshold, little improvement is seen in page load time. Clearly, other factors are likely to have an influence on the user experience, as the Actual Experience work shows, but this does emphasise that a simple 'faster is better' perspective may be misleading.

[61] https://gettys.wordpress.com/2013/07/10/low-latency-requires-smart-queuing-traditional-aqm-is-not-enough/

[62] Gettys' answer to this problem is to promote the development and implementation of improved flow queuing algorithms in routing nodes, that allow for some degree of differentiation in how packet flows are treated, based on the applications that create them.

Section 7

# Resilient communications in emergencies

## Overview

7.1 The communications infrastructure plays a range of vital roles in dealing with emergencies affecting the public. This infrastructure is evolving, largely as a result of the new technologies that are affecting many other aspects of our lives. These changes bring opportunities and may save lives in the future, but some familiar processes will also change.

7.2 The key highlights are:

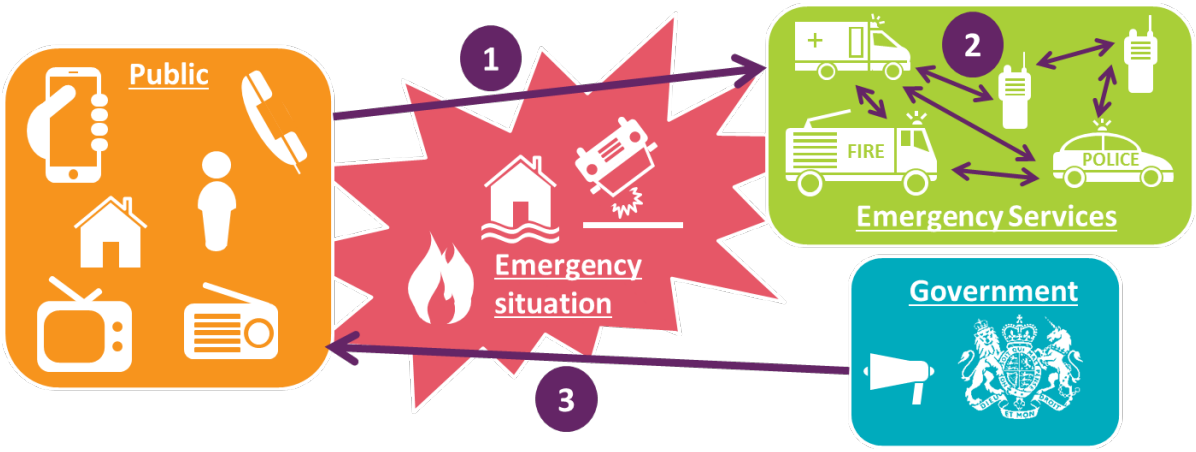
7.2.1 **The communications infrastructure is changing**: long-term plans are being drawn up by various operators to switch off the copper-based telephony network that has traditionally supported 999 calls. Similarly, the radios currently used by the emergency are due to be replaced with very different technology over the next five years. And the broadcast TV and radio platforms which can be used to communicate information to the public during emergencies are expected to gradually decline as new methods of content consumption continue to grow in importance.

7.2.2 **New technology brings new and potentially life-saving capabilities**: although emergency communications may be not be a major design consideration for many of the replacement networks, some of their new features will be useful in emergency situations. Examples include precise caller location, data from a wide range of sensors, and multimedia communications.

7.2.3 **Maximising these benefits while retaining reliability will be a challenge**: while the features they offer may not be as rich, legacy networks are generally very reliable, widely available and well understood by the majority of consumers. Ensuring that their replacements can fulfil these important criteria, while at the same time allowing their new features to be exploited, will require a strategic approach to the future of emergency communications. This is an important matter for Government, who may need to weigh the wider societal benefits of increasing the resilience of these new platforms against the cost, and consider intervening if commercial deployment falls short of its public policy objectives.

# The role of telecoms in emergencies

**Figure 37: Main roles of the communications infrastructure in emergencies**




*Source: Ofcom*

7.3 Communications systems play three important roles during emergencies, as illustrated in Figure 35:

1. **Contacting the emergency services:** The most common way to contact the emergency services is to dial 999. There are strict rules in place which require providers to offer this service and to ensure it works reliably.

2. **Communication within and between the emergency services:** the Government has announced that the contracts for the current service will not be renewed when they expire between now and 2020. Instead of using a dedicated private radio network, as they do currently, the emergency services will move to services carried on a public mobile network and made possible by new features included in 4G

3. **Warning and informing the public:** When an emergency requires information to be given to the public as quickly as possible, communications platforms are a uniquely well-placed option.

## The changing communications infrastructure presents opportunities and challenges

7.4 In all three of the roles set out above, the services and the infrastructure that underpins them are rapidly changing. New generations of technology almost always bring new capabilities with the potential to greatly benefit emergency communications.

### Mobile phones are now sophisticated communications devices

7.5 The communications capabilities of mobile phones have expanded hugely over recent years, adding text messaging, pictures, video and high speed data transfer to basic voice. Smartphones have developed many other features which can be useful in the context of emergency communications, including accurate knowledge of current location, sensors and apps able to monitor user health, environmental sensing, high-resolution cameras and large screens.

7.6 The wealth of data these capabilities make available is potentially very useful in dealing effectively with emergencies. There is an opportunity to integrate this data into the way the emergency services operate, minimising delay and errors, and at the same time greatly increasing the available information about any given situation.

7.7 Smartphones are also very flexible, offering multiple ways to make phone calls or send messages or other data. For example:

- voice calls can be made in either the traditional way (known as circuit switched), or via the internet using services like Skype or Facetime;
- video calls can be made over the internet using a variety of apps; and
- multimedia data can be sent via a range of messaging platforms, such as WhatsApp and iMessage.

7.8 This leads to greater diversity than has previously been available. Modern communications systems are also very flexible, adapting quickly to changing user demands. The unpredictable nature of emergencies makes this a valuable property.

However, there are challenges in using these new technologies for emergency communications

7.9 The motivation for many of us, particularly younger generations, to adopt new technology to better serve our day-to-day communications needs is clear. However, many of our needs in relation to emergencies don't actually change very quickly. Advice like "dial 999" and "listen to local radio" has been the same for generations and having to regularly relearn these norms in the future as technology change accelerates is likely to be challenging. Particular attention is likely to be needed to ensure that groups which are slower to adopt new technology, such as older people, are not left without the services they need.

7.10 Another challenge is the reliability of the platforms. We have already spoken about the diversity of modern communications, which serves to increase their overall resilience, but there are factors which pull in the other direction. The infrastructure is evolving to offer ever more capability, often within the constraints of finite resources like radio spectrum or copper cable bandwidth. Achieving this leads to more complex systems, often with more network equipment sited closer to the customer. This in turn increases vulnerability to threats such as mains electricity interruption, flooding, vandalism or simple hardware failure.

7.11 A recent UK Regulators Network project[63] has explored one aspect of this – the resilience of telecoms networks to widespread electricity failure – in more detail. The conclusion from this work is that the Government may need to weigh the wider societal benefits of increasing the resilience of these new platforms against the cost, and consider intervening if commercial deployment falls short of its public policy objectives.

## Contacting the emergency services

7.12 More than 75 years ago the UK was the first country to have a dedicated national telephone number, 999, which could be used to contact the emergency services. The

[63] http://www.ukrn.org.uk/?page_id=647

European equivalent, 112, is now mandatory in all member states, and similar services are present in most countries around the world. In the UK, 112 and 999 can be dialled interchangeably.

7.13 The ability for customers to dial 999, free of charge, from almost any telephone has remained largely unchanged since the service's introduction. One of the few outward signs of modernisation was the introduction of the *emergencySMS* service in 2010, which allows deaf, hard of hearing and speech-impaired people to contact the emergency services. Behind the scenes, however, there have been many improvements, and developments in communications technology suggest there could be many more.

## The regulation of emergency services access

7.14 Regulating the essential lifeline service provided by 112/999 is one of the most important things that Ofcom does. The primary mechanism for securing the service is through the General Conditions of Entitlement (or GCs), in which Ofcom sets out the legal obligations that apply to everyone who provides an electronic communications service or network[64].

7.15 The obligation to provide 112/999 access is set down in GC4. This GC applies to communications providers which provide electronic communications services to end-users, requiring them to allow free calls to the Emergency Services and to provide those services with accurate information about the caller's location. GC4 is underpinned by GC3[65] which requires that measures are taken to ensure there are no interruptions to the operation of the public communications network. GC15[66] requires mobile operators to offer the emergencySMS service.

7.16 The GCs are reviewed regularly and updated when required, for example, to extend them to cover mobile and internet telephony services. In terms of enforcement, our focus is most often on the reliability of the service and the provision of accurate location information. We have an ongoing enforcement programme looking at compliance with GC4 across the industry[67].

7.17 The performance of telecoms and its regulation play an important part in the overall user experience of the 999 service. However, these aspects extend only to the ability to make the call and have it routed to the correct emergency service with information about the caller's location.

7.18 The majority of the work in providing the service, including taking the details of the incident, deciding what help is required, attending the incident and ultimately resolving it, falls to the emergency services themselves. As a result, the successful operation of the service requires the coordination of everyone involved - all four emergency services across the many regions, various government departments and telecoms operators. Similarly, the adoption of new technology needs coordinated action from the many parties involved, which can act as a barrier to change.

[64] The General Conditions of Entitlement, or 'GCs' are made by Ofcom under section 45 of the Communications Act 2003.
[65] General Condition 3 - "Proper and effective functioning of the network"
[66] General Condition 15 - "Special measures for end-users with disabilities"
[67] http://stakeholders.ofcom.org.uk/enforcement/competition-bulletins/open-cases/all-open-cases/cw_996/

## Future opportunities for the 112/999 service

7.19 Since its launch until quite recently, the original voice-only fixed telephone service facilitated by 999 was well aligned with the telecoms needs of most consumers. One of the most significant developments in recent years, the growth of mobile, has been mirrored by the service, with over 60% of calls received now originating from mobile phones. However, it could be argued that in many other respects the service has not kept pace with changes in how people use telecoms services and devices.

7.20 For the vast majority of users, interaction with the 999 service is still entirely voice-based. This is contrast with general telecoms use, which has seen voice traffic in steady decline on fixed networks and showing minimal growth on mobile, at a time when broadband data traffic on both platforms has been growing hugely. There is a risk that for many users, and particularly younger users for whom these trends are strongest, the communications methods they turn to first will not allow them to access the emergency services.

7.21 Modern data-centric communications services offer the potential to improve all aspects of interaction with the emergency services. Some examples are given below:

7.21.1 **Advanced mobile location (AML)** is a system for smartphone users to improve the accuracy of location information provided to the emergency services[68]. When an emergency call is made, AML seamlessly sends a message to the call handler with the best location information available to the handset. The location information is calculated from nearby Wi-Fi networks or global positioning system (GPS) satellite signals. It is usually much more precise than the information received for standard mobile calls, sometimes hundreds of times better in rural areas.

7.21.2 **REALRIDER** is a ride recording smartphone app for motorcyclists. It includes a feature which uses sensors in the phone to detect if the rider is likely to have been involved in a crash. If so, it will contact the relevant ambulance control room automatically, after giving the rider the opportunity to cancel the activation in the event that they don't need medical assistance. The app was developed independently, but tested extensively with a regional ambulance service before launch.

7.21.3 **999Eye** is a system which allows a 999 call taker to send an SMS containing a special web link to callers with a smartphone. When opened by the caller, this link establishes a live video stream from their phone, allowing the call taker to more accurately allocate the correct resources to the reported incident. The system, developed by West Midlands Fire Service, is expected to enter a pilot phase with a range of other UK emergency services and local authority services during 2015.

7.21.4 **eCall** is a system developed by the European Commission, which will be mandatory for all new vehicles launched in Europe from 2018. The system will use the mobile phone system to alert the emergency services of the need for assistance via a 112 call if the vehicle's airbags are activated.

[68] AML was developed by BT, EE and handset manufacturer HTC and launched in 2014. It is now being made to other networks and handsets from other manufacturers. http://www.btplc.com/News/Articles/ShowArticle.cfm?ArticleID=F8FD34BB-7E05-499D-8778-08A3F39F6015

Although offering more basic functionality, the system is similar to the proprietary systems increasingly included by manufacturers including BMW, Ford, Mercedes, Peugeot and Volvo.

7.21.5 **NG9-1-1 and NG112** are North American and European specifications for next-generation emergency access systems. Both are based on the same technical standard for an internet-based network for contacting the emergency services. Along with other technical enhancements, this allows them to take advantage of features of mobile phones such as text messaging, still images and video capture.

7.22 It is clear that new technology offers great potential to allow emergency access to function more effectively, and ultimately save additional lives. There is no shortage of examples, ranging from small independently-produced apps through to full specifications for continent-wide next-generation systems. However, there is no current UK strategy setting out how the whole service is expected to evolve to take advantage of the opportunities presented by technology developments, or indeed how to meet the potential challenges.

7.23 A further concern is that it is not clear from where such a strategy will emerge. This issue has been highlighted several times in recent years, with the most recent effort to find a way forward being led by the IET[69]. This is an important matter for Government to consider further.

## The challenge of ensuring a resilient service

7.24 Understanding the resilience of the 999 service, whether to power cuts or other threats, is complex. But given a sufficient level of investment, all the networks discussed below can generally be engineered to offer whatever level of resilience and reliability is required.

7.25 Providers take the importance of 999, and their regulatory obligations, into account when making investment decisions. They do this in the context of needing to operate profitably and to offer customers the services and features they want and are willing to pay for. As a result, they may invest less in protection than we might wish from a public policy perspective, or if emergency access was the main purpose of the service.

### Calling the emergency services from home

7.26 While not as flexible as modern communications services, the traditional fixed phone service has other advantages, in particular its resilience to power cuts.

7.27 The network is designed to send electricity over the copper wires linking customers' homes to their local telephone exchange, sufficient to power their telephone. This, combined with the provision of large batteries and generators at the exchanges, means that the fixed telephone service, and with it the 999 service, will typically continue to work even during widespread power cuts lasting several days.

7.28 This long-established arrangement accounts for much of the historic reliability of the 999 service, but it is being challenged by current and expected future changes. Today the many households which only use cordless phones are already vulnerable

[69] http://www.theiet.org/factfiles/comms/999-digital-page.cfm

to power cuts affecting their home. This is because cordless phones cannot be line-powered, and if local mains power fails, consumers will be unable to make 999, or any other, calls.

7.29 Looking to the future, the traditional telephone network is reaching the end of its life, with BT stating that it aims to switch it off by 2025[70]. The expectation is that over time an increasing proportion of fixed voice calls will be carried over broadband connections. Consumer broadband services do not generally offer the same levels of resilience to power interruptions as the traditional phone network, as the home router requires a mains power connection.

### Calling the emergency services from a mobile phone

7.30 With around 60% of 999 calls coming from mobile phones, the resilience of mobile networks is already a more relevant consideration for many customers. The architectures are so different that a direct comparison between fixed and mobile networks is very difficult.

7.31 Firstly, mobile telephones have their own batteries rather than relying on line or mains power, as fixed phones do. This is an advantage over in-home cordless phones, but the limited battery life, particularly in the case of smartphones, means that corded fixed phones are still likely to be more reliable in longer power cuts.

7.32 The reliability of the network itself must also be considered, and in general, mobile basestations have much lower levels of back-up power provision than their fixed network equivalent, the local telephone exchange. Any analysis of likely reliability rapidly becomes complex, because a given mobile phone may receive signal from another base station, or indeed be able to move until it can. In the case of an attempted 999 call, the phone will connect to any available base station, regardless of which network it belongs to, further increasing the chances of success.

## Communication within and between the emergency services

7.33 Today, the digital radios used for the majority of communication within and between the emergency services operate on a dedicated national network provided by Airwave. This network uses terrestrial trunked radio (TETRA) technology to deliver high reliability push-to-talk voice and low speed data services. The contracts with Airwave to supply the various emergency services are due to expire within the next five years, and the Government is in the closing stages of procuring a replacement communications system, known as the emergency services network (ESN).

7.34 The three main objectives of the ESN procurement are to enable services which are:

i) **enhanced:** to provide integrated broadband data services;

ii) **flexible:** to better match and be responsive to user needs; and

iii) **affordable:** to address financial pressures on central and user budgets.

7.35 At the time of writing, the only remaining bidder for ESN is EE, and a final contract award is due shortly. The expectation is that the ESN will be hosted on the winning bidder's existing 4G network, which is already used to deliver mobile services to the

[70] https://event.webcasts.com/viewer/event.jsp?ei=1051301 – Slide 19

general public. Additional features are being added to the international 4G technical standards to better allow the technology to support the types of communication required by the emergency services.

7.36 The Airwave network was originally designed, and has been further developed during its life, to be highly resilient to a range of threats such as power interruptions, severe weather and equipment failure. Ensuring an appropriate level of resilience for ESN has been an important element in the procurement of the new network. Balancing the needs of the emergency services and public users of the network will be a significant new challenge, particularly during times of stress. In our previous analysis[71] we found that, in principle, 4G networks are capable of meeting this challenge.

## Warning and informing the public

7.37 As part of the Government's ongoing programme of work to better prepare the country for dealing with civil emergencies, the Cabinet Office leads a 'Warning and Informing' workstream. This work considers how best national and local authorities can keep the public informed during emergencies. There are a number of options which may be applicable, depending on the nature of the incident:

- police officers knocking on doors;
- audible announcements from sirens, public address systems in buildings, shops and transport hubs and loud-hailers from cars or helicopters;
- messages displayed on roadside systems;
- media announcements via radio and television; and
- automated messages to users of telecoms services.

7.38 The last two options rely on the communications infrastructure and are arguably the most effective for distributing a message quickly to members of the public nationally or regionally.

7.39 Today, and for many years in the past, national broadcast networks have achieved very high reach within the population. Analogue radio has often been seen as the communications channel of last resort in a crisis, as it is particularly resilient, with many households able to listen from their car or battery-powered receiver even during a power cut. Broadcast television, although generally requiring mains electricity for reception, has also had an important role because it is present and regularly watched in so many homes.

7.40 These platforms are expected to continue to operate and be widely received for many years to come, but listening and viewing habits are starting to change. As users spread their attention over more channels, between live and on-demand content, and from broadcast to online platforms, the best strategies to reach them mayl need to be reassessed.

[71] Assessing the Potential of LTE to Enable New Services, November 2013, http://stakeholders.ofcom.org.uk/market-data-research/other/technology-research/2013/Future-LTE-Services/

7.41 The ubiquity of mobile telephones may provide an important alternative in the future. There are already services in place, such as the Environment Agency's Floodline Warnings Direct, which use phone, text and email messages to inform registered users of flooding events. In 2014, the Cabinet Office published a report[72] on the outcome of trials of a potential new general emergency alerting system, based on the mobile phone network. If deployed operationally, the system would send information to all mobile phones within an area affected by an emergency. Similar systems are already in place in Australia, the Netherlands and the US.

72 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/298687/Mobile_Alerting_Trials_Project_Report_FINAL.pdf

Section 8

# Security and resilience

## Overview

8.1 As we increase our dependence on the nation's communications infrastructure, the security and resilience of fixed, mobile and broadcast television networks and services become ever more important. This section summarises the major security and resilience issues that were reported to Ofcom over the past year.

8.2 Important points to note are:

8.2.1 The majority of security incidents reported relate to **voice services**, often affecting consumer access to the 999 emergency services;

8.2.2 The majority of incidents are caused by the **failure of hardware components, the loss of power supply or by software bugs**; and

8.2.3 Incidents with an impact above one million customer-hours are uncommon, and are often the result of a **unique and unexpected threat to security**.

### Our role in security and resilience

Ofcom and providers of communications networks and services are subject to certain requirements[73]. These include requiring operators to appropriately manage security risks, to minimise impacts on consumers and to report any breaches of security or network failures to Ofcom.

We first published guidance on the full range of security requirements in May 2011 and updated that guidance in August 2014.[74] The guidance sets out our expectations for a risk-based approach to the management of security. It highlights appropriate sources of industry best practice and details our incident reporting requirements.

Aside from these specific requirements, digital terrestrial television (DTT) operators have an obligation[75] to meet high standards of reliability and to provide us with an annual report on transmission performance.

[73] In accordance with Article 13a of the Framework Directive[73], sections 105A-D of the Communications Act 2003 place requirements on providers and Ofcom regarding the security and resilience of communications networks and services.
[74] http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/security-resilience/ofcom-guidance.pdf
[75] http://stakeholders.ofcom.org.uk/binaries/broadcast/guidance/techguidance/tv_tech_platform_code.pdf

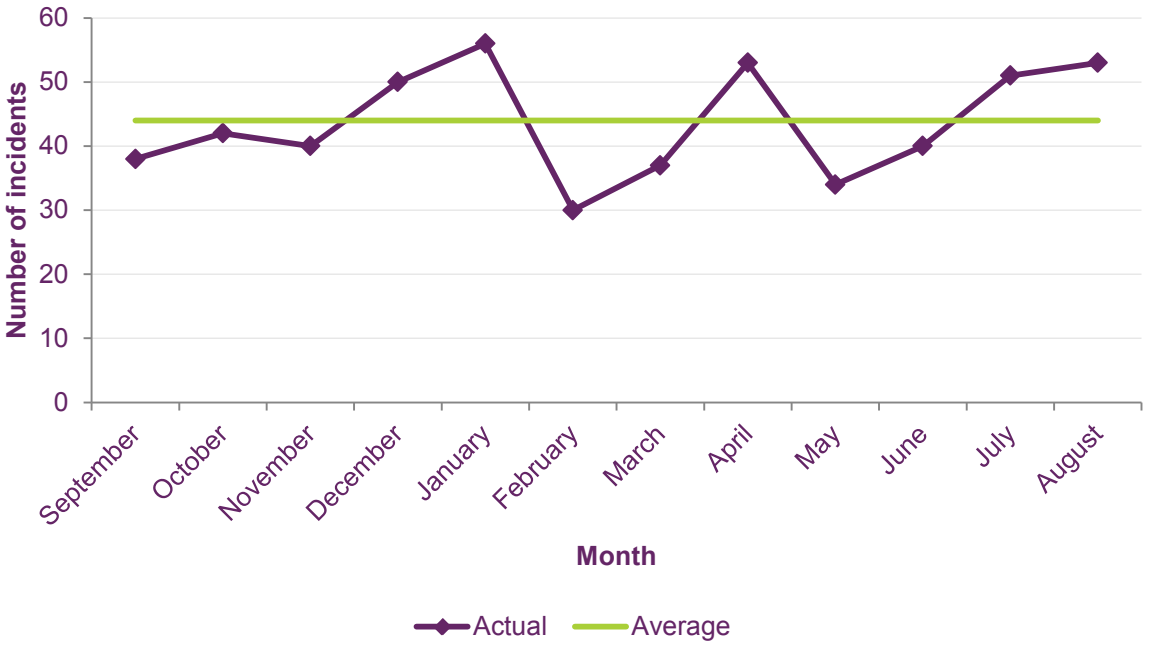
# Resilience of fixed and mobile networks

## The majority of security incidents reported relate to voice services, often affecting consumer access to the 999 emergency services

8.3 In the past year, 524 security incidents were reported to us by fixed and mobile providers. The vast majority of reports were from fixed providers regarding disruption to telephony services (including 999 access) for fewer than 10,000 customers and for less than one day. Incidents with a wider impact, which affect tens of thousands of customers, are less common. Reporting data also show that incidents are more likely to occur in, or near, large population centres.

8.4 Figure 36 summarises the number of incidents reported each month between September 2014 and August 2015. The monthly variation can be as great as 30% of the average and could be the result of seasonal factors such as weather or school holidays. We continue to monitor for trends over time.

**Figure 38: The number of incidents reported between September 2014 and August 2015**




*Source: Ofcom analysis of operator data*

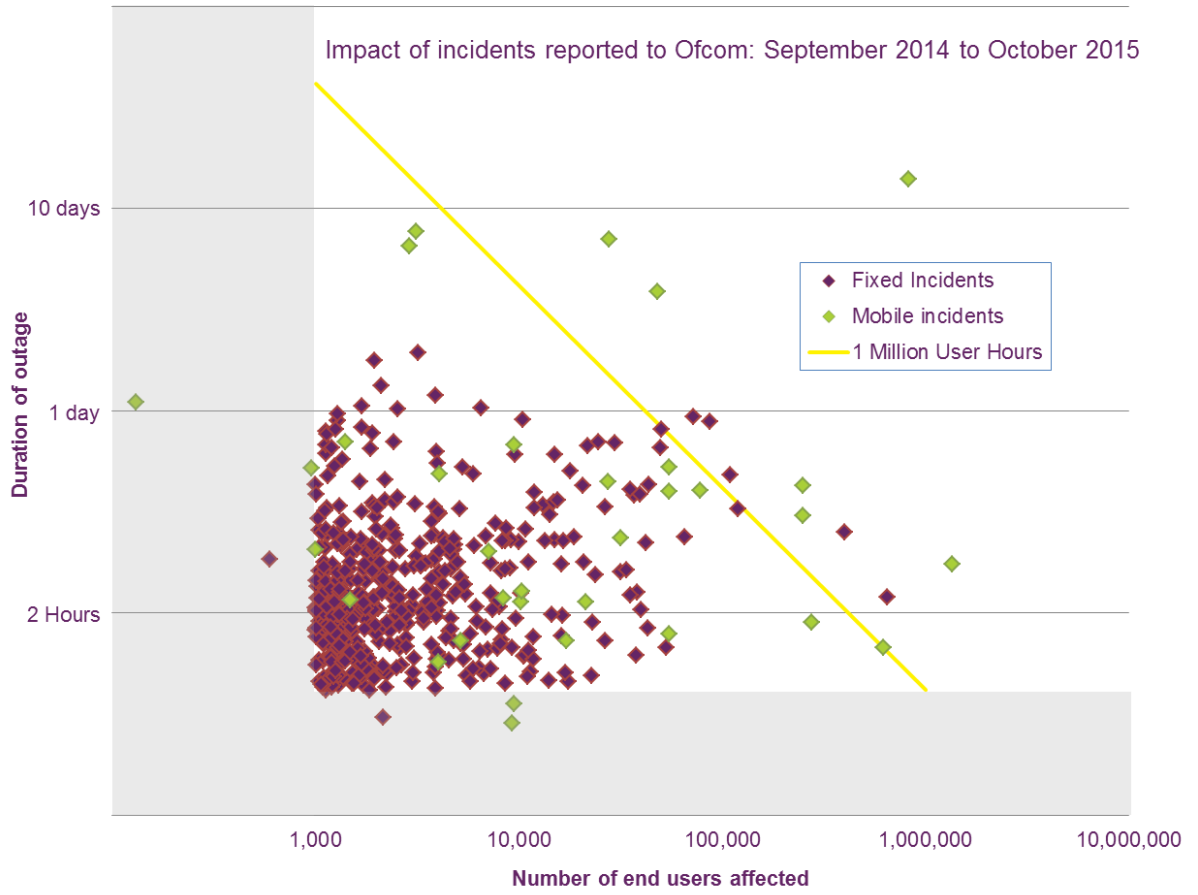
## Scope of Ofcom reporting guidance/ framework

8.5 Ofcom's guidance provides quantitative criteria, or thresholds, against which a provider can gauge the impact of an incident and determine if it should be reported. The most critical is the 'emergency services access' threshold which applies to incidents that affect voice access to the emergency services for 1000 customers, for one hour. There will be incidents that occur but which are not reported to us, since they do not have 'significant impact' as defined in relevant guidance.

8.6 We measure the impact of an incident in 'customer-hours'. This is the product of an incident's duration and the number of consumers affected. While customer-hours is not the only metric by which incidents may be measured, it provides a useful basis

for comparison. Figure 37 shows the customer-hours impact of the 524 incidents reported to Ofcom.

**Figure 39: The impact of incidents reported to Ofcom, between September 2014 and October 2015**



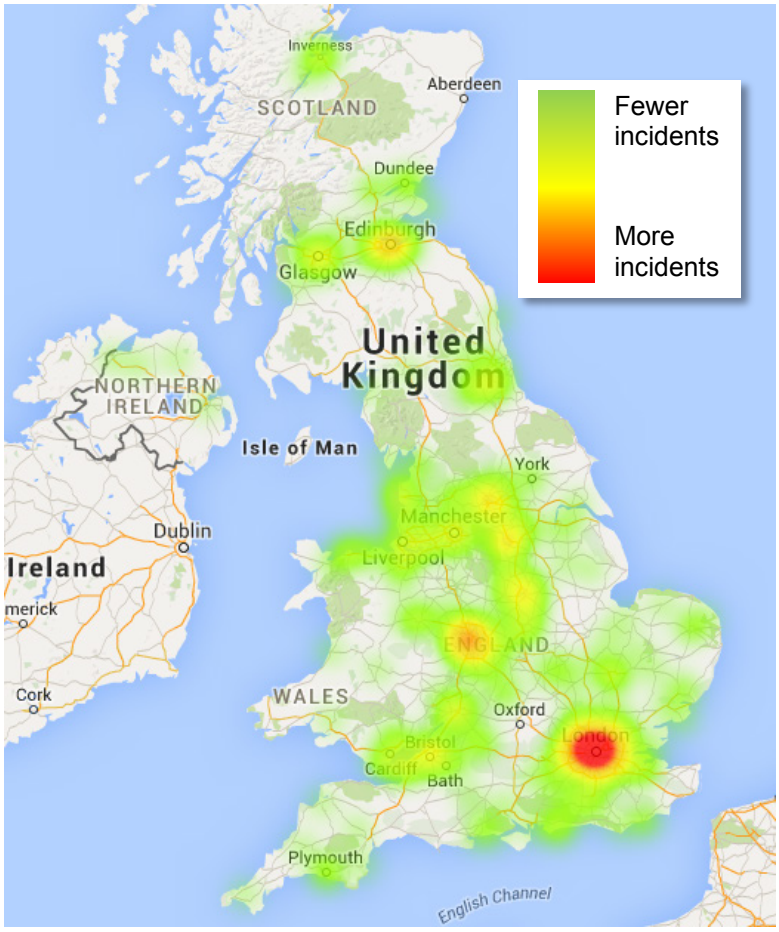

*Source: Ofcom analysis of operator data*

8.7 The majority of incidents have a relatively low customer-hours impact and are reported under the 'emergency services access' threshold.

8.8 Of the 524 reported incidents, 486 affected fixed networks and 38 affected mobile. The difference between these figures is explained by the emergency roaming agreement in place between mobile operators. This means that mobile operators have significant resilience in place for emergency service availability and therefore do not report often under the 'emergency services access' threshold.

8.9 Our revised guidance, published in August 2014, places a particular emphasis on receiving more incident reports from the mobile sector, given the growing importance of mobile services to consumers. The number of mobile incidents reported to Ofcom is more than double that of last year.

**Figure 40: Heat map showing the distribution of incidents throughout the UK**




*Source: Ofcom analysis of operator data*

8.10 Figure 38 shows how the 524 incidents are geographically distributed across the UK, and reveals that there is a correlation between incident frequency and population density. Where population densities are higher, a higher concentration of network equipment, or assets, is required to provide services.

8.11 It is logical to expect that where there are more assets, there is a greater likelihood of incidents. However, our minimum incident threshold of 1,000 end-users affected may result in some rural incidents not being reported.

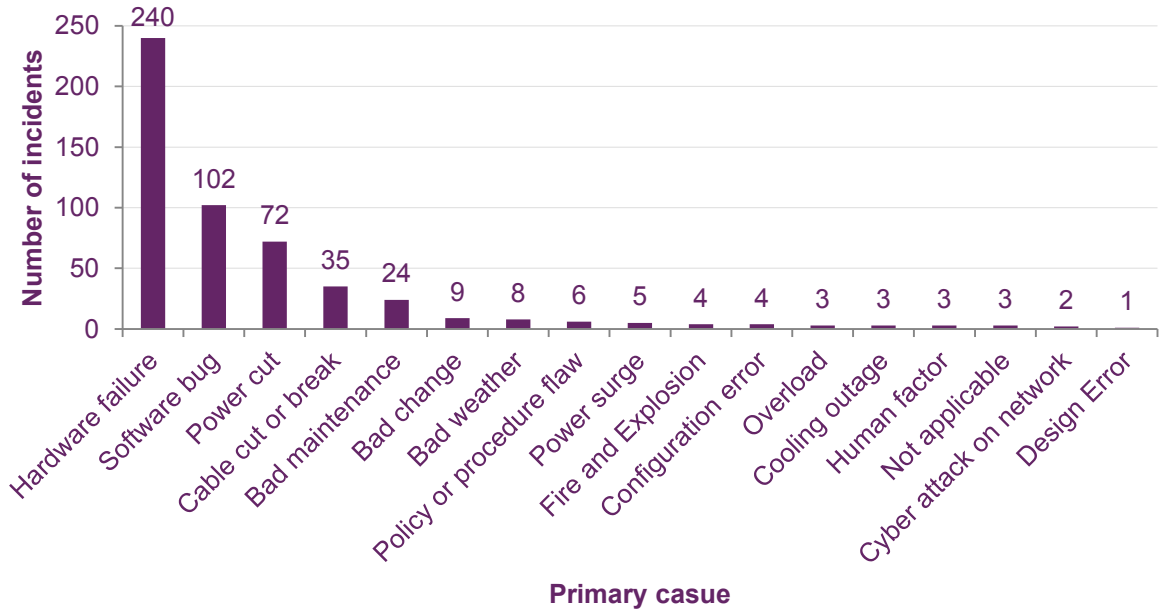
## The majority of incidents are caused by the failure of hardware components, the loss of power supply or by software bugs

8.12 Establishing the root causes of incidents is central to understanding risks to the security and resilience of networks and services. System failure is overwhelmingly the root cause of significant network incidents; for the third year in a row over 95% of reported incidents fall into this category. This includes hardware and software failures, and the failure of systems, processes and procedures.

8.13 The remaining categories are human error, natural phenomena (which includes severe weather) and malicious actions, which were responsible for 3%, 1% and <1% of the reported incidents, respectively.

8.14 Figure 39 shows that incidents were reported against a wide range of primary causes[76]. 'Hardware failure' is the most common primary cause, followed by 'software bug' and 'power cut'. Together these causes account for over 75% of the incidents that are reported to us.

**Figure 41: Primary cause of incidents reported to Ofcom, September 2014 to August 2015**




*Source: Ofcom analysis of operator data*

## Incidents with an impact above one million customer-hours are uncommon, and are often the result of a unique and unexpected threat to security

8.15 The European Union Agency for Network and Information Security (ENISA) is a centre of network and security expertise for the EU. ENISA provides guidance[77] on the reporting of security incidents. This includes the requirement for national regulatory authorities, such as Ofcom, to report annually on incidents with a significant impact; this is defined as those incidents with an impact above one million customer hours.

8.16 In the reporting period of September 2014 to August 2015 there were 12 incidents which met this threshold: seven affected mobile networks and five affected fixed networks. System failure is still the main root cause, at 75%.

[76] We categorise the root and primary cause of reported incidents according to the taxonomy provided in the ENISA Article 13a Technical Guideline on Threats and Assets, https://resilience.enisa.europa.eu/article-13/guideline_on_threats_and_assets

[77] ENISA Technical Guidance on Incident Reporting. https://resilience.enisa.europa.eu/article-13/guideline-for-incidentreporting/Article_13a_ENISA_Technical_Guideline_On_Incident_Reporting_v2_1.pdf

## Cyber security

8.17 Security incidents in the communications sector do not always affect the availability of networks and services. Communications providers can and will be subject to cyber-attack, which is increasingly common across all industries. These attacks are often related to the theft of data or intellectual property, but do not affect the operation of the network or service directly.

8.18 Two recent examples are the widely-reported cyber-attacks on TalkTalk[78] and Vodafone[79]. In both cases hackers attempted to access customers' private information, with varying degrees of success. In such circumstances Ofcom collaborates with the communications provider, the Information Commissioner's Office (ICO) and the appropriate Government departments (particularly DCMS) and agencies, to ensure that the risks to the consumers of communications services are being addressed. The ICO is the primary regulator on data protection issues, so compliance with data protection law, and the investigation and possible sanctioning of data security, such as the data breach of TalkTalk's website, is first and foremost a matter for the ICO80. In parallel, law enforcement agencies have responsibility for investigating any criminal aspects of the cyber-attack that led to the data breach.

8.19 The Centre for the Protection of National Infrastructure (CPNI) protects national security by providing protective security advice. Protective security is "putting in place, or building into design, security measures or protocols such that threats may be deterred, detected, or the consequences of an attack minimised". It provides advice on physical security, personnel security and cyber-security/ information assurance. The CPNI operates a number of 'Information Exchanges' which facilitate the exchange of information, advice and guidance between its members, the providers of different aspects of the national infrastructure, which includes the UK electronic communications infrastructure.

8.20 CESG, the Information Security arm of GCHQ, is the National Technical Authority for Information Assurance within the UK. It builds national capability through the provision of standards and guidance, working with industry to ensure that appropriately assured products, services and people are available, and building up a pool of world-class information assurance and cyber-security professionals on whom organisations can draw. Its role includes working with industry to protect the Critical National Infrastructure of the UK.

8.21 CERT-UK is the UK National Computer Emergency Response Team, formed in March 2014 in response to the National Cyber Security Strategy. It has four main roles:

- national cyber-security incident management;

[78] http://www.talktalkgroup.com/press/press-releases/2015/cyber-attack-update-november-06-2015.aspx
[79] http://mediacentre.vodafone.co.uk/pressrelease/statement-on-unauthorised-account-access/
[80] The ICO enforces two pieces of separate legislation dealing specifically with protecting the confidentiality of data, including personal data, associated with the network or service: the Data Protection Act 1998 (http://www.legislation.gov.uk/ukpga/1998/29/contents) and the Privacy and Electronic Communications Regulations 2003 (http://www.legislation.gov.uk/uksi/2003/2426/regulation/22/made).

- supporting critical national infrastructure companies in their handling of cyber-security incidents, This includes the Cyber Information Sharing Partnership (CISP) which enables companies to share what they know;

- promoting cyber-security situational awareness across industry, academia and the public sector; and

- providing a single international point of contact for co-ordination and collaboration between national CERTs.

8.22 On 17 November 2015, the Chancellor of the Exchequer announced that these structures and bodies would be reformed, with the establishment in 2016 of a new National Cyber Centre, which will report to the Director of GCHQ, and which will take over some or all of the responsibilities of the existing bodies. Consequently, the way in which Ofcom works with other agencies may change in the future to ensure that we continue to collaborate effectively.

8.23 Although cyber security is not referenced in current underpinning legislation, the existing Ofcom guidance on network security and resilience does address the issue specifically, setting the expectation that providers will take appropriate steps to manage the cyber threat and take account of relevant Government advice such as the "10 Steps to cyber security[81]" and the Cyber Essentials Scheme[82]. We have recently written to the largest providers within the sector, reminding them of this guidance and seeking assurance that they are following it.

[81] https://www.gov.uk/government/publications/cyber-risk-management-a-board-level-responsibility/10-steps-summary
[82] https://www.gov.uk/government/publications/cyber-essentials-scheme-overview

Section 9

# The continuing evolution of television

9.1 There have been no significant changes in the coverage of traditional broadcast terrestrial, satellite and cable networks over the past year. However, the ways in which TV is consumed and delivered continues to evolve, in particular TV and video delivery over broadband networks. In this section we set out three key themes:

9.1.1 **Linear TV consumption remains strong:** The way in which we watch TV is continuing to evolve, with more viewing over the internet, but linear broadcast TV remains overwhelmingly most important way of watching TV.

9.1.2 **TV and video delivery is placing increased capacity demands on fixed and mobile broadband networks:** Growth in internet-delivered TV is having major implications for providers of fixed and mobile communications infrastructure. Video carried over fixed and mobile networks is growing rapidly, and networks need to invest in providing more capacity for it.

9.1.3 **More hybrid TV platforms are becoming available:** Traditional broadcast TV platforms are becoming more integrated with the internet. In particular, pay-TV providers are connecting more of their customers to internet-delivered TV, and the free-to-air Freeview platform has launched hybrid Freeview Play services.

## Viewers are able to view TV from a growing range of sources

9.2 Consumers in the UK receive digital television services from a number of providers:

9.2.1 Satellite: TV services over satellite are available through Sky's pay-TV service or through Freesat, which is available for a one-off digital receiver cost.

9.2.2 Cable: Virgin Media makes TV available over its cable network and has set the target[83] to increase the coverage of its cable network. Once implemented this is expected to increase cable TV coverage from 45% to around 65% of UK premises.

9.2.3 Freeview: The digital terrestrial TV (DTT) service provides access to a wide range of free-to-air channels.

9.2.4 IPTV: A number of different providers including Now TV, BT and TalkTalk deliver linear broadband TV services. On-demand content is available to anyone connected to the internet, from a wide variety of providers.

9.3 Last year[84] we set out the coverage levels of these services. Coverage of satellite and cable services is largely unchanged over the past 12 months. There have, however, been some modest changes to coverage for the temporary DTT

[83] http://about.virginmedia.com/press-release/9467/virgin-media-and-liberty-global-announce-largest-investment-in-uks-internet-infrastructure-for-more-than-a-decade
[84] http://stakeholders.ofcom.org.uk/binaries/research/infrastructure/2014/infrastructure-14.pdf

multiplexes that Ofcom has licensed (COM7 and COM8 in the table below) and these are now available to around three-quarters of UK households.

**Figure 42: Coverage levels of DTT services**

| Multiplex | Standards | Bit rates (Mbit/s) | Coverage |
|---|---|---|---|
| PSB1 | MPEG2/DVB-T1 | 24 | 99% |
| PSB2 | MPEG2/DVB-T1 | 24 | 99% |
| PSB3 | MPEG4/DVB-T2 | 40 | 99% |
| COM4 | MPEG2/DVB-T1 | 27 | ~90% |
| COM5 | MPEG2/DVB-T1 | 27 | ~90% |
| COM6 | MPEG2/DVB-T1 | 27 | ~90% |
| COM7 | MPEG4/DVB-T2 | 40 | ~76% |
| COM8 | MPEG4/DVB-T2 | 40 | ~76% |

Source: Ofcom, UK Planning Model

Notes: 1) The coverage figures shown are the percentage of UK households predicted by the UK Planning Model to have coverage. 2) The standards shown refer to the compression and transmission standards used by the different DTT multiplexes. The newer MPEG4 and DVB-T2 standards allow multiplexes to accommodate more channels than the older MPEG2/DVB-T1 standards. The difference in capacity can be seen in the 'bit rates' column.

9.4 In 2014 we reported that although we had licensed two temporary DTT multiplexes, only one of them had launched. During 2015, the roll-out of the second of these temporary multiplexes (COM8 in the table above) has been completed, and new HD services (QVC+1 HD and QVC Beauty HD) have been launched on it, although capacity is still available on this multiplex.

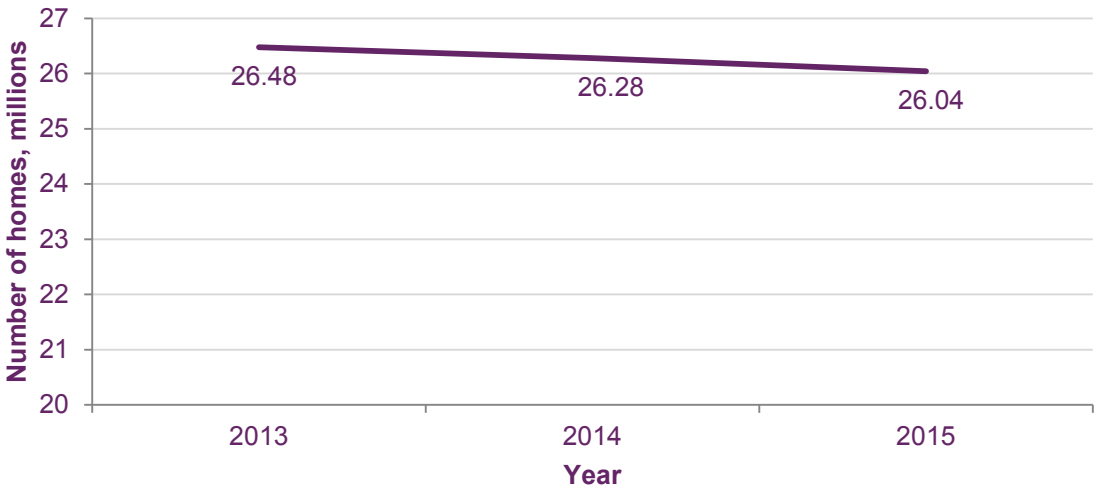
## The way in which consumers watch TV is evolving

9.5 The growing use of new broadcast technologies is changing the way in which consumers watch TV. More content is being viewed over the internet than ever before, but most viewing continues to be to linear broadcast TV. More viewers have sets capable of viewing high-definition (HD) content, although actual viewing of HD has not grown in proportion to the capability to view it.

### The number of TV homes continues to fall

9.6 In last year's *Infrastructure Report* we noted that the number of homes with at least one TV was slowly declining. This trend has continued, as seen in Figure 41 below.

**Figure 43: The number of homes estimated to have at least one TV continues to fall**




*Source: BARB*

9.7 In contrast, the number homes with no conventional TV but with a broadband connection has risen, trebling between 2009 and 2014. It is possible that many of these households are accessing TV using devices such as PCs, tablets and mobile devices. BARB estimates that there are 1.1 million homes with broadband but without a TV set, representing 4.3% of all households.

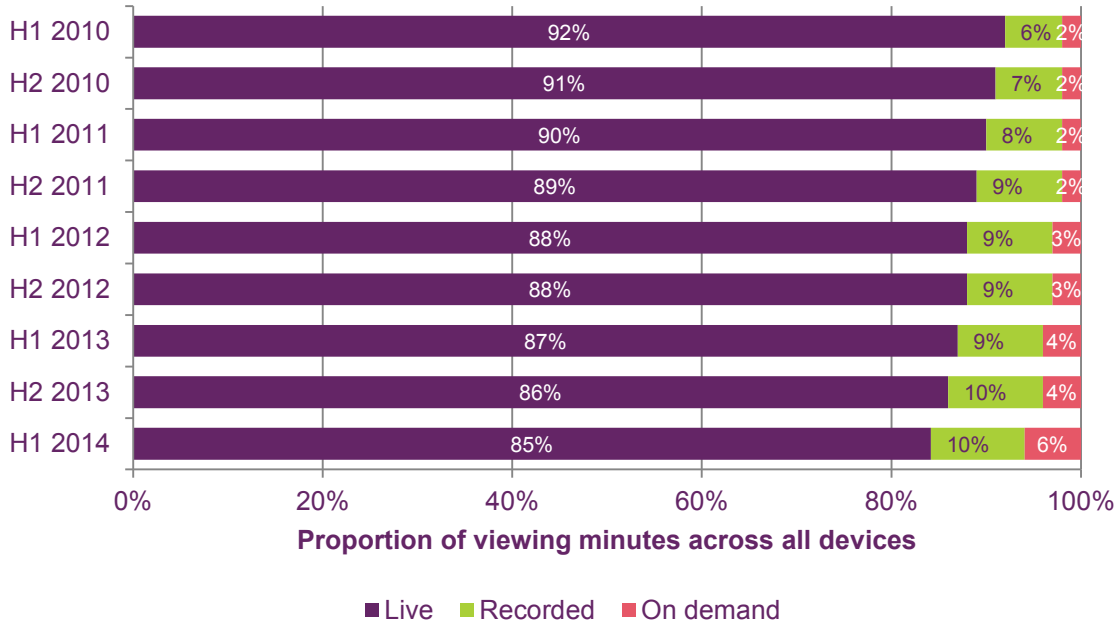
9.8 Younger households are less likely to have a TV set. However, as the total number of these households is growing slowly, and many younger viewers may acquire a TV set as they grow older, it is likely that conventional TV platforms, and their underlying infrastructure, will continue to be important to consumers for many years to come.

## Linear TV viewing is falling, but gradually

9.9 The overwhelming majority of TV viewing (85%) continues to be to linear TV, i.e. watching programmes at the time of broadcast, as opposed to recording them to watch later or viewing them on demand. However, the take-up of on-demand and online viewing is continuing to grow (see Figure 42).

9.10 Time-shift viewing is more popular among younger age groups, and some genres of programme are time-shifted much more than average; for example, over 25% of drama viewing is time-shifted.

**Figure 44: Viewing of recorded and video-on-demand content is increasing**

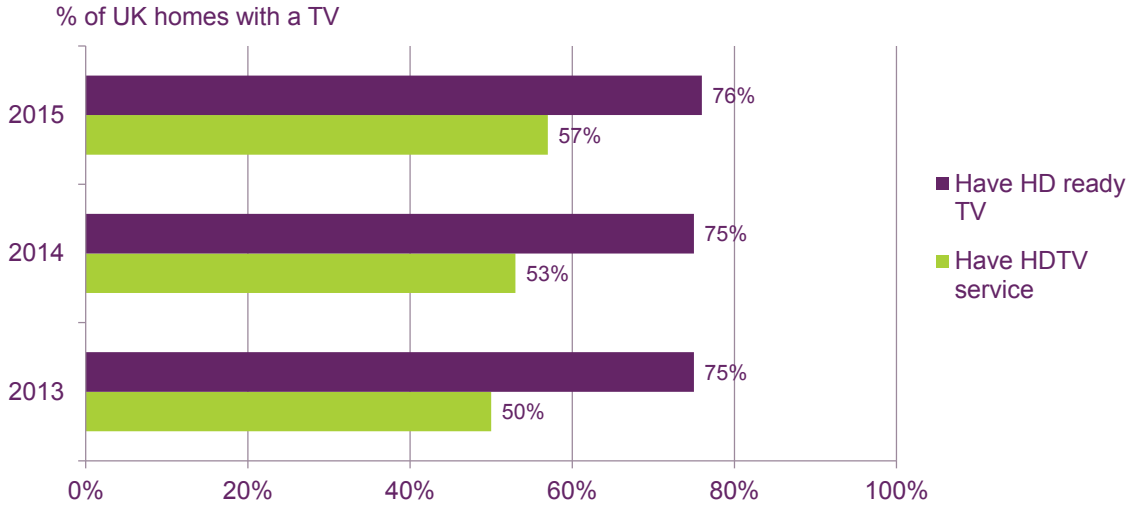



*Source: BARB*

## More consumers are able to receive HD services, but viewing of HD channels fluctuates

9.11 Around 57% of all TV households can access HD services, although this figure is lower (41%) in DTT-only households. The ability to receive HD services in DTT households is likely to grow in future, as more consumers replace their existing SD sets with HD-compatible TV sets. The decision, by Freeview, that from 2017 onwards only HD sets will be able to carry the Freeview brand (see Figure 43) is likely to mean that in the near future all new DTT sets will be capable of receiving HD.

## Figure 45: Take-up of HD services is increasing



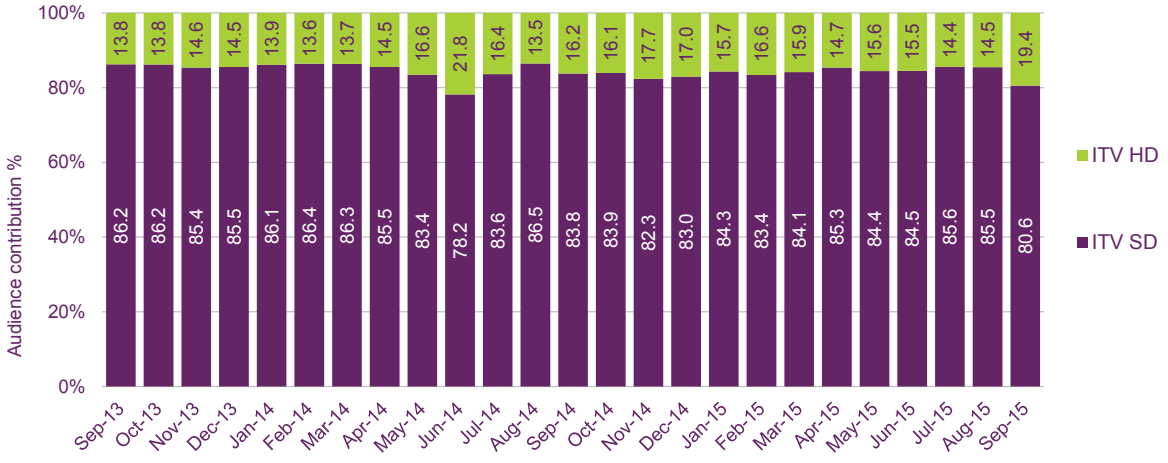

*Source: Ofcom Technology Tracker, Q1 2013-2015*

*Notes: proportion with main TV that is HDTV set or HD ready and proportion who actually watch TV channels and programmes that are broadcast in high definition*

9.12 While the ability to receive HD services has grown, the proportion of viewers watching HD programmes varies. One explanation for this, on some platforms, might be that HD services are more difficult to select than their SD equivalents using a remote control or EPG; for example, on the DTT platform the BBC One SD service can be selected using button 1 on the remote control, while three digits '101' need to be entered to select the HD service. On the DTT platform, regional services are available only on the SD channel.

9.13 We have some evidence that viewers are switching to HD versions of channels for some types of content. The chart below shows viewing of the ITV HD channel as a proportion of total ITV viewing share, in homes that have access to HD. It shows that in these homes, significantly more viewers choose to watch ITV in standard definition rather than ITV HD, most of the time. The data also show, however, that HD viewing (of ITV at least) increases during major sports tournaments such as the football World Cup in 2014 and the rugby World Cup in 2015.

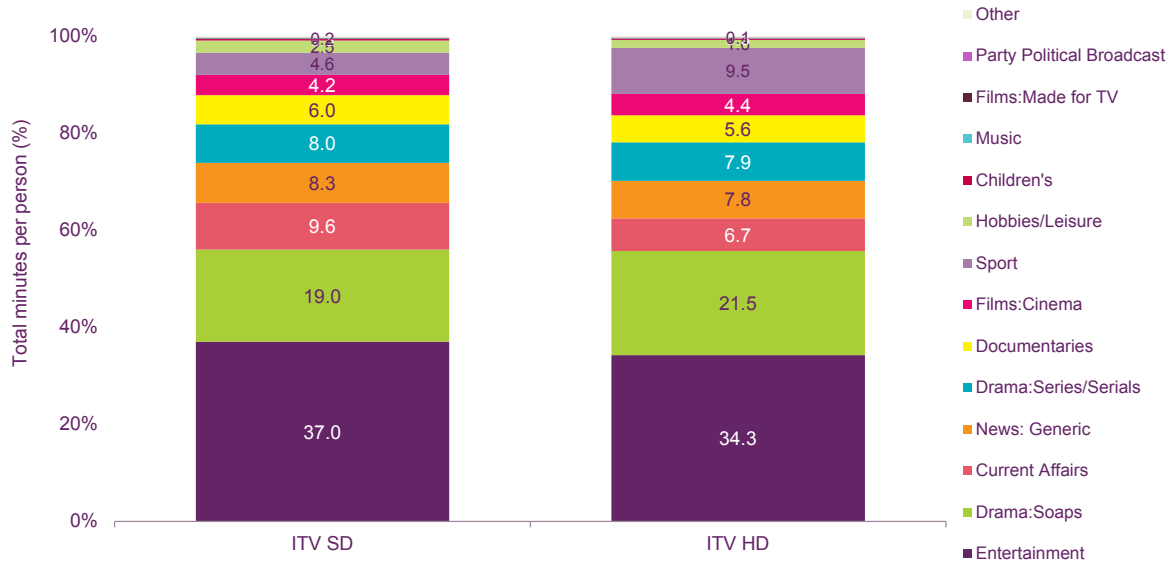
## Figure 46: The proportion of viewers watching HD programming varies




*Source: BARB/Infosys+. Individuals 4+ with HD, ITV (SD+HD), Network*

9.14 In order to further examine how viewers choose to watch HD, we looked at whether there is higher HD viewing of certain types (or genres) or programmes. We found that viewing of ITV HD is proportionately higher for sport, films and soaps, but lower for other genres, as seen in Figure 46.

**Figure 47: Viewers prefer to watch certain genres in HD**




*Source: BARB/Infosys+. Individuals 4+ with HD, Network, (4+ regions), Jan-Sep 2015. Note: proportion of viewing based on total minutes viewed per person to each genre. Based on standard BARB genre definitions*

9.15 The above evidence suggests that consumers value HD channels for certain types of content, and make an active decision when to watch HD and when to watch SD services. While HD viewing is likely to continue to grow as more consumers own HD sets, it may not do so uniformly across all types of programmes.

## A number of trends are driving up IPTV viewing

9.16 As we set out in Section 4, data use over fixed networks is continuing to grow by over 40% a year, driven in particular by video. A combination of distinct trends suggest that the recent strong growth in video use over fixed networks is likely to continue:

9.16.1 **Take-up of connected devices and superfast broadband**. Most consumers have a TV connected to the internet via a smart TV, set-top box, games console or device (such as Chromecast, Apple TV etc.) – sometimes multiple devices. And as we set out in Section 4, the vast majority of UK households now have broadband connections capable of supporting steamed video.

9.16.2 **More use of video on demand**. Our consumer research has found that viewing of video services such as YouTube and Vimeo is continuing to grow, and that many consumers see them as an important source of information, as well as entertainment; 47% of internet users said that they had used YouTube as an information source.

9.16.3 **Growing take-up of linear IPTV services.** Linear internet TV (IPTV) services, such as BT TV and Now TV, are continuing to add customers, competing with existing pay-TV platforms such as Sky and Virgin Media, particularly at the low-cost end of the market.

9.16.4 **Higher use of subscriber video on demand (SVoD).** More households are subscribing to video-on-demand services such as Netflix, Now TV and Amazon Prime (see below). However, subscription video-on-demand services are, on the whole, complementing conventional TV rather than replacing it. Figures from BARB indicate that Netflix subscriptions are above average in pay-TV homes and are below average in homes without TVs, as well as in free-to-air TV homes (Freeview and Freesat).

9.16.5 **More online catch-up viewing.** As more catch-up viewing is done online, the demands for internet bandwidth and capacity are likely to grow further. In part, online catch-up viewing is driven by higher take-up of smart TVs and connected set-top boxes. But on-line catch-up viewing is now increasingly substituting for DVR-recorded programming when viewers want to watch programmes they have missed. BARB reports that in December 2014 Sky On Demand accounted for 11% of all time-shifted viewing on Sky, up from just over 6% in July 2013.

9.16.6 **Improved ease of use.** Over the past decade, touchscreens and intuitive user interfaces have made it easier to use smartphones and tablets, increasing their popularity. IPTV services, on the other hand, have been relatively difficult to use. However, recent improvements, such as more intelligent devices, clearer broadcaster apps and voice-controlled interfaces, are all making it easier for viewers to watch on-demand TV.

9.17 Similarly, as more consumers acquire smartphones and move onto faster 4G mobile services, it is likely that video viewing on mobile phones will carry on increasing strongly, with significant implications for the mobile infrastructure.

## Implications of changing viewer behaviour for broadband infrastructure

9.18 As discussed in Section 4, the vast majority (98%) of broadband connections are, in principle, now capable of providing IPTV in at least standard definition (SD), since they can receive a speed of above 2Mbit/s. However, as also set out in Section 4, the quality of these services is much more likely to be rated as ‘good’ at higher connection speeds.

9.19 A large proportion of data traffic on fixed and mobile networks is made up of video, with providers having to improve network capacity to ensure that consumers receive a high quality experience. The extent to which more capacity will continue to be needed is difficult to forecast with any certainty. For example, while the picture quality of online video is improving, the use of newer, more efficient, compression standards is also helping to lower the bandwidth requirements for online video. In addition, the wider use of multicast technology and content delivery networks is likely to reduce the demand for capacity in some part of the broadband delivery chain.

9.20 Currently, a broadband connection speed of at least 2 to 3Mbit/s is needed to deliver an SD video stream, of 6 to 8Mbit/s to deliver an HD stream, and 20 to 25Mbit/s for an ultra-HD stream (also known as 4K). In practice, higher speeds than these are likely to be needed to provide access to other broadband services in the same household the same time, and to account for other reductions in connection speed caused by congestion in the broadband delivery chain.

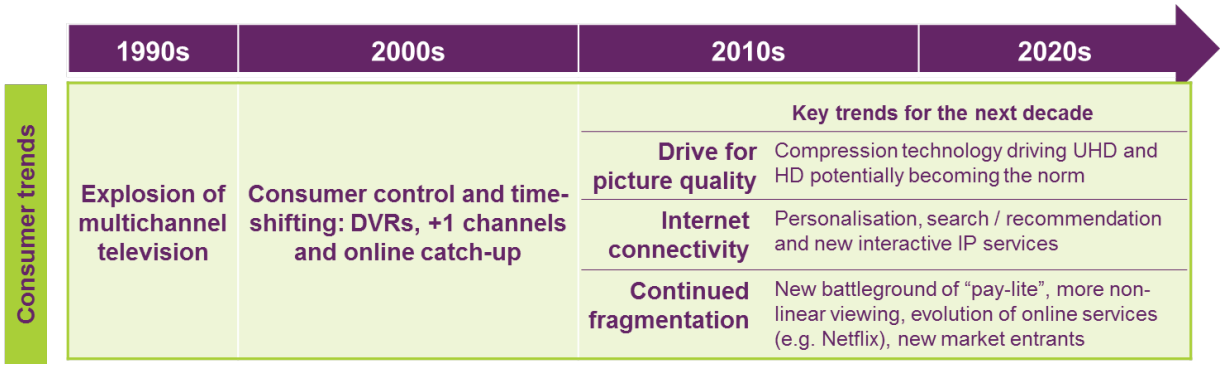
9.21 The new and more efficient HEVC (high efficiency video coding) compression standard is now being used, including for new ultra-HD services from BT, Netflix,

Amazon Prime, and YouTube. If more widely implemented for IPTV, HEVC standards may not only help to provide capacity for higher-resolution broadcast TV, but may also cut the connection speeds needed to deliver IPTV. For example, an HD video stream might, using HEVC, be delivered with a connection speed in the range of 3 to 4Mbit/s; and an ultra-HD stream using less than 10Mbit/s.

## Implications of changing viewer behaviour for broadcast infrastructure

9.22 In Ofcom's *The Future of Free-to-View* discussion document[85], published in 2014, we noted the consumer trends of improved picture quality, more internet connectivity and greater viewer choice (illustrated in Figure 46) and indicated that TV platforms would have to continue evolving in order to meet consumer needs.

**Figure 48: Trends in TV consumption**




9.23 In terms of infrastructure, we noted that TV platforms would have to address these viewer challenges, by:

- providing more channels and services over IP through hybrid/DTT products, such as Freeview Play and YouView ; and
- upgrading broadcast compression and transmission standards.

9.24 TV platforms are making these improvements. For example, Freeview has launched its Freeview Play service, which offers consumers easier-to-use IPTV services. It has also announced that the Freeview label will be available only for HD products from the end of 2016. Sky have also launched their Sky Q platform which similarly integrates broadcast and internet TV services.

9.25 Other TV platforms have, over the past year, continued to connect their subscribers' TV set-top boxes to the internet. Pay-TV platforms have also announced improvements in picture quality, with Sky and BT now offering ultra-HD services. As the evidence of viewing HD indicates (Figure 46), it is likely that the demand for higher picture quality will vary between consumers.

9.26 An improved selection of HD channels on DTT is likely to encourage viewers to adopt Freeview HD. In the short term, new capacity for HD channels has come from the launch of two temporary DTT multiplexes using the 600MHz spectrum band that was

[85] http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/discussion/ftv.pdf

cleared as a result of digital switchover[86]. These temporary multiplexes, available to around 76% of UK viewers, use more efficient technology[87] and their transmissions can be received by households with Freeview HD equipment.

9.27 In turn, these newer technologies allow more channel capacity on the multiplex, thereby providing a range of SD and HD channels that were not previously available over DTT. The new SD and HD channels on the temporary DTT multiplexes, provided they are attractive to viewers, should encourage consumers to adopt Freeview HD sets, recorders and devices.

9.28 The new Freeview Play receiver standard includes support for MPEG 4 and HEVC compression. Although there is no plan to broadcast a broader range of services using HEVC on digital terrestrial TV in the UK, the standard's support for HEVC services will help future-proof the platform and could be used to provide additional DTT capacity in future. The support for MPEG 4 could be particularly important when the existing temporary multiplexes are eventually turned off, to accommodate new mobile broadband services[88].

## Broadcasters will have to continue adapting to changing viewer needs

9.29 Although viewer behaviour is changing, it is important to remember that this change is taking place slowly, with the majority of viewing still to linear broadcast TV. There is also wide variation in people's behaviour. Some continue to watch many hours of linear broadcast TV per week; others, usually younger, do not even have a TV set, and watch everything online. The future capacity demands on traditional TV and broadband infrastructure is likely to depend on the extent to which the on-demand and online viewing habits of a currently small proportion of the population are adopted more widely over time.

[86] In 2012, analogue terrestrial TV services in the UK were switched off and replaced by digital services, which offer better picture quality. Broadcasting digital TV services is also more efficient, which means it is possible to transmit a greater number of channels while using less radio spectrum than was previously required. This released spectrum for new uses, including 4G mobile services.
[87] The use of DVB-T2 transmission technology and the MPEG4 compression standard means that more channels can be broadcast within the same amount of radio spectrum.
[88] In November 2014, we published a statement setting out our decision to make the 700MHz band available for mobile broadband. Our objective is to make the band available for mobile by the start of 2022, and sooner if possible.

## Annex 1

# Methodology

A1.1 Sections 4 and 5 of this report use new data gathered from the largest operators in each sector, as well as information already held by Ofcom. For fixed networks, we used input from the four largest networks and from KCOM for services in Hull. In the case of mobile networks we gathered data from all the network operators.

**Figure 49: List of operators that provided data on network availability**

| Name of provider | Types of networks or service |
|---|---|
| Arqiva | Public Wi-Fi, national DTT and national DAB |
| BT | Fixed networks: voice and broadband, public Wi-Fi |
| EE | Mobile networks: voice and broadband, public Wi-Fi |
| KCOM | Fixed networks: voice and broadband, public Wi-Fi (Hull only) |
| $O_2$ Telefonica | Mobile networks: voice and broadband, public Wi-Fi |
| Sky | Fixed networks: voice and broadband, public Wi-Fi |
| TalkTalk | Fixed networks: voice and broadband |
| Three | Mobile networks: voice and broadband |
| Virgin Media | Fixed networks: voice and broadband, public Wi-Fi |
| Vodafone | Mobile networks: voice and broadband |

A1.2 Much of the data presented in this report is based on the analysis of the new data provided by the operators. In this annex we summarise our approach to this analysis.

## Fixed broadband networks

A1.3 Our data on coverage of fixed broadband services are collected from the three main fixed network operators, BT, KCOM and Virgin Media.

A1.4 For the overall coverage of fixed broadband, reported in Section 4, coverage is reported on a base of residential and small business premises (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 large organisations.

A1.5 Where we report on the availability of superfast broadband for SMEs, we use a base of SME premises only, for SMEs with at least one employee. This section only reports on the coverage of networks provided by BT, KCOM and Virgin Media.

A1.6 We use premises data from OS Addressbase Premium dataset[89] (May 2015 version), OSNI Pointer file[90] (June 2015 version) and ONS NSPL (Nov 2014 and Feb 2015 versions)[91].

A1.7 Where two network operators are present in the same postcode, our source data are unable to indicate the degree of overlap between these networks. We estimate the coverage value for each postcode based on the average of the 'best case' (where there is least overlap) and 'worst case' (where there is most overlap). This is the same methodology as used by the consultancy IHS when compiling data for the European Commission's Digital Agenda Scorecard.

### Take-up, speeds and data use

A1.8 We gathered data from the main fixed broadband internet service providers (BT, KCOM, Sky, TalkTalk and Virgin Media) on both their retail services and the services they provide to other ISPs as a wholesale service.

A1.9 Our analysis of broadband speeds is based on information provided by these ISPs on the sync speed of each active line. This gives a measure the maximum possible connection speed achievable between the ISP's access network and the consumer premises. Line speed measurements are typically a few Mbit/s lower than sync speed measurement, and they typically vary throughout the day depending on the level of congestion in the ISP's network.

A1.10 For cable networks, we have used the headline speed of the broadband package for each line. Due to the nature of the network, cable network providers have greater control of the speeds they can provide to customers on a line. They typically set a sync speed higher than the headline speed to ensure that end-users can experience the advertised speeds.

A1.11 We set certain speed thresholds in some of our analysis, of 2Mbit/s, 10Mbit/s and 30Mbit/s. We include any ADSL/ADSL2+/VDSL modem sync speed below 2.2Mbit/s in our assessment of sub-2Mbit/s broadband, as some data is used in protocol overheads and so is not available to the end-user. We do not apply a margin to 10Mbit/s or 30Mbit/s because these thresholds are derived differently.

A1.12 We use 10Mbit/s because our data suggest that an average sync speed of 10Mbit/s is where data use begins to appear to not be constrained by speed. We use 30Mbit/s because this is our threshold, and the European Commission's threshold for superfast broadband.

A1.13 Along with information about the sync speed of each line, we gathered information about the postcode of that line. This provides the source data for our geographic analysis.

A1.14 Our analysis of data use uses information on the amount of data downloaded and uploaded on each line in June 2015. We also collected data on the total data use between the hours of 6pm and midnight, to assess data use at 'peak times'. Our

[89] https://www.ordnancesurvey.co.uk/business-and-government/products/addressbase.html
[90] http://www.nidirect.gov.uk/index/information-and-services/property-and-housing/your-neighbourhood-roads-and-streets/ordnance-survey-of-northern-ireland/product-range/digital-products/pointer.htm
[91] http://www.ons.gov.uk/ons/guide-method/geography/products/postcode-directories/-nspp-/index.html

analysis considers all lines where the amount of data downloaded in June was greater than zero.

A1.15 The analysis of overall traffic mix and encrypted traffic is calculated from the individual traffic mix provided by each ISP, weighted by the total data downloaded by customers of that network.

## Mobile

### Coverage

A1.16 Our data on the coverage of mobile networks were collected from the four mobile network operators, EE, O2, Three and Vodafone as 100m x 100m pixels referenced against the OSGB[92] grid system, for their coverage in May 2015 for 2G ,3G and 4G networks. Premises coverage is calculated from a base of 28.6 million postal delivery points, taken from the OS Addressbase Premium dataset[93] (May 2015 version), OSNI Pointer file (June 2015 version)[94] and ONS NSPL (Nov 2014 and Feb 2015 versions)[95]. Roads data is taken from Ordnance Survey Meridian and LPS OSNI datasets. We set the following signal strength thresholds when estimating coverage.

| | Metric | Outdoor | Indoor and in-car |
|---|---|---|---|
| **2G** | RxLev | -81dBm | -71dBm |
| **3G** | RSCP CPiCH | -100dBm | -90dBm |
| **4G** | RSRP | -115dBm | -105dBm |
| **Voice(2G+3G)** | RxLev/ RSCP CPiCH | -81 dBm &-100dBm | -71 dBm &-90dBm |
| **Data(3G+4G)** | RSCP CPiCH /RSRP | -100dBm&-115dBm | -90 dBm &-105dBm |

*Source: Ofcom*

### Data use

A1.17 We also gathered data on the amount of data uploaded and downloaded on each mobile cell in these networks.

A1.18 The analysis of overall traffic mix and encrypted traffic is calculated from the individual traffic mix provided by the four network operators, weighted by the total amount of data downloaded by customers of that network.

[92] Ordnance Survey of Great Britain (OSGB) Coordinate System
[93] https://www.ordnancesurvey.co.uk/business-and-government/products/addressbase.html
[94] http://www.nidirect.gov.uk/index/information-and-services/property-and-housing/your-neighbourhood-roads-and-streets/ordnance-survey-of-northern-ireland/product-range/digital-products/pointer.htm
[95] http://www.ons.gov.uk/ons/guide-method/geography/products/postcode-directories/-nspp-/index.html

## Femtocells and public Wi-Fi

### Femtocells

A1.19 The mobile network operators that have more than 1000 femtocells on their networks provided information on the postcodes where these femtocells are located.

### Public Wi-Fi

A1.20 Our data on public Wi-Fi was gathered from the main providers of this service (Arqiva, BT, KCOM, O2, Sky and Virgin Media). These public Wi-Fi providers reported on the total data downloaded and uploaded at each of their public Wi-Fi access points, and the postcodes of these access points.

A1.21 Where they were able to do so, operators also provided information on the proportion of data downloaded and uploaded on 2.4GHz and 5GHz Wi-Fi.

### Internet

A1.22 We collected data from fixed internet service providers and mobile network operators about the nature of their internet interconnection (peering, transit or CDN), the capacity of that connection, the total volume of data through that interconnection in June 2015 and the physical location of that interconnection.

A1.23 From this, we calculated the proportion of traffic by each type of interconnection for each CP and weighted this by the total data used by their customers, to estimate the overall mix of internet interconnection traffic.

## Urban and rural classifications

A1.24 In previous reports, Ofcom has used a third-party data source (Locale) to classify postcodes as being urban or rural. This year, that data source was not available, so we have used the rural/urban classifications developed by DEFRA, NISRA and The Scottish Registry Office to produce urban/rural splits.

A1.25 Analysis shows that at an urban/rural split level, the two datasets correspond 95% of the time where postcodes can be matched. However, each dataset cannot match 2.5% of all postcodes, and the unallocated postcodes differ between datasets. Therefore, the urban/rural classification of between 5% and 10% of postcodes varies between datasets, and the urban/rural figures in this report are not directly comparable to those in previous reports.

## Annex 2

# 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

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

**CDN** Content Delivery Network – Networks of servers based in many geographic locations designed to improve the speed and quality of content delivery by routing requests to the closest server.

**CGNAT** Carrier Grade Network Address Translation - a technique that makes it possible to use fewer public IPv4 addresses to support more subscribers.

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

**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).

**ENISA** European Network and Information Security Agency – a European Union agency responsible for cyber security.

**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.

**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.

**IPv4** The fourth and most widely used version of the Internet Protocol. It defines IP addresses in a 32-bit format, which looks like 111.111.111.111

**IPv6** The successor to IPv4. It uses 128-bit addresses, increasing the number of possible addresses.

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

**LINX** London Internet Exchange. A not-for-profit membership organisation that provides peering services to Internet Service Providers.

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

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

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

**Peer to Peer (P2P)** A distributed application that uses end users' computers as nodes to deliver service applications.

**RIPE NCC** Europe and the Middle East, Réseaux IP Européens Network Coordination Centre - The Regional Internet Registry with responsibility Europe, the Middle East and parts of Central Asia. It oversees the allocation and registration of IP addresses in these areas.

**RIR** Regional Internet Registry. Provide blocks of IP addresses to telecommunications companies and Internet Service Providers within an allocated region.

**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** The next generation of faster broadband services, which delivers headline download speeds of greater than 30 Mbit/s.

**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.

**VOD** Video-on-demand. A service or technology that enables TV viewers to watch programmes or films whenever they choose to, not restricted by a linear schedule (also see 'push' VOD and 'pull' VOD.

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

**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.

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