

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

| Technology (coverage threshold) | Percentage of premises covered | | | | |
|------------------------------------|--------------------------------|---------|-------|-----|-------------|
| | 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 speeds³¹ 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

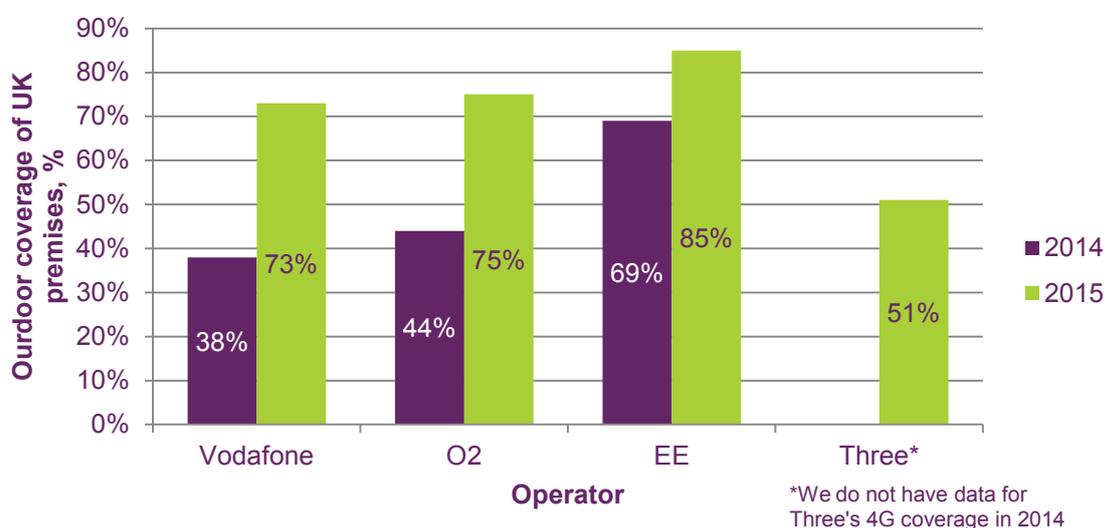
| | O2 | Vodafone | EE | Three |
|--------------------------------|-----|----------|-----|-------|
| Outdoor coverage | | | | |
| Premises | 92% | 92% | 98% | 98% |
| Geographic | 47% | 49% | 75% | 68% |
| Indoor/In-car* coverage | | | | |
| Premises | 86% | 83% | 94% | 93% |
| Motorways | 83% | 83% | 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 areas³². 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 agreement³³ 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 2017³⁴.
- 5.15.2 **Providing better information to consumers:** In August 2015, Ofcom launched interactive online mobile coverage maps³⁵. 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 signals³⁶. 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.

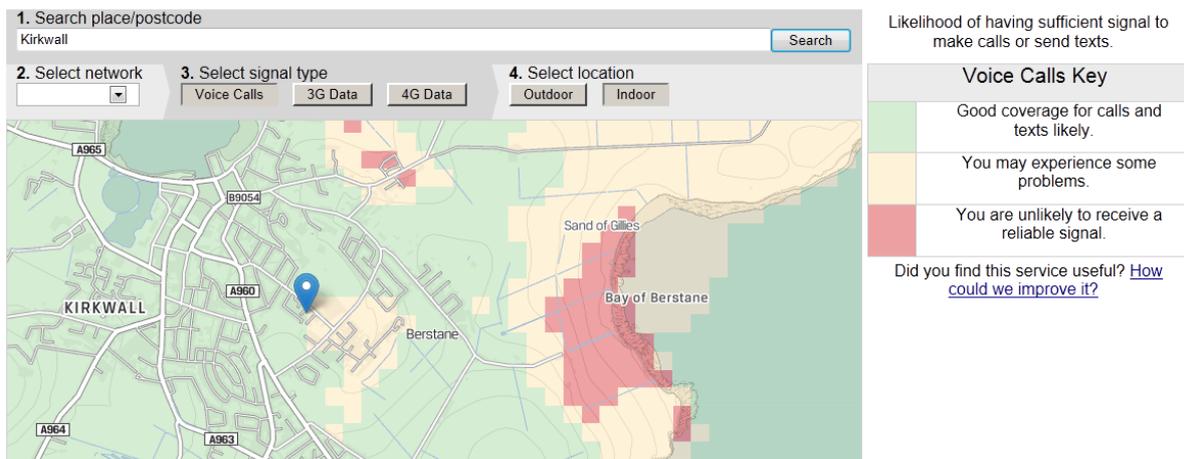
³⁵ <http://www.ofcom.org.uk/mobile-coverage>

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 licensing³⁷. 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 inputs³⁸ asking stakeholders to provide their view on the use of repeaters in licensed spectrum. More recently, we have commissioned a technical study³⁹ 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 2012⁴⁰. 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 SIM⁴² 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.