

A1. Technical methodology

This stage of Ofcom's work to measure network performance and the consumer experience of using mobile services is analysing crowdsourced data. The methodology utilizes a panel of UK smartphone users who have installed SDK enabled apps on their Android device¹. The data collection framework and panel are developed and managed by umlaut communications GmbH ('umlaut'), and data was licensed to Ofcom. umlaut also managed the collection and aggregation of the collected data and advised on data analysis.

Data collection

umlaut's data collection framework is designed to collect only anonymous information. Any collected data is stored within the panellist's device sandbox while resting on the device and using encrypted transmission when offloading the information to the back-end systems.

A major objective of this research method was that it should have minimal impact on the consumer's day-to-day smartphone use – particularly with regards to battery consumption and mobile data use. The app uses a maximum of 3MB of data per month for its active connection test, and only sends the data collected over a mobile network if it cannot send it over Wi-Fi. The corresponding average data used depends on users' overall Android smartphone use, but is typically no more than 1MB per day across mobile network and Wi-Fi. The background data collection is also designed to have minimal impact on the user's experience.

The metrics analysed by Ofcom and the technical parameters are:

A1.1 Performance metrics

- Network share
- Reliability of data connections
- Response time

A1.2 Technical parameters

- Location information²
- Device and system parameters

Data collection runs 24/7 and is interrupted only by phases when the device is switched off or in deep doze mode. Most data points are collected whenever the device is in active use, e.g. whenever the user is interacting with apps or making phone calls. In addition, an automated 'lightweight' connection test is attempted four times an hour to test the data service availability.

¹ The operating system used on iPhones (iOS) has restrictions on apps running in the background and being able to access network performance data. Therefore, data collection on iPhone devices is currently not available.

² To ensure the battery is not affected, the SDK relies on the last known location available from the Android OS. This might be a GPS-grade position, whenever another app has used GPS.

A2. Metrics

Network share

Data network share is measured passively. The framework is triggered during panellists' data sessions. Information is collected per second while a data transmission is occurring (sending and/or receiving).

The second-by-second logs contain, among other things, radio and traffic information such as cell ID, radio network technology, signal strength and the transferred data volume. The radio network technology is tagged by the wireless network technology, i.e. 2G, 3G, 4G or Wi-Fi.

The data network share metric establishes the ratio of seconds per network technology across all data sessions, and hence expresses the time share on 2G, 3G, 4G and Wi-Fi while actively transferring data.

Reliability of data connections

The background data collection includes an automated, active test case, also referred to as the 'connection test'. This connection test is a lightweight measurement, testing the availability and accessibility of a data connection to a cloud-based server in the internet. The test is attempted every 15 minutes, regardless of the available wireless network technology at the time of the test.

The test attempts to download a 596 bytes-sized icon via a static URL, hosted on Amazon's CloudFront and Akamai, a global network service for hosting content (also known as content delivery network, or CDN).

Three phases need to be completed for a test to be considered successful:

- the resolution of the URL via DNS³, to obtain the IP address of the server from which the test will attempt the download;
- the TCP⁴ connection setup; and
- the actual download of the content.

Each phase is logged with its respective success or failure. The evaluation of data service availability considers the success or failure on the final phase, i.e. the attempt to download the icon from the destination server.

For the connection test to be executed, a couple of prerequisites need to be fulfilled. In the light of the conservative approach to battery consumption, the execution of the test is not attempted if the device battery level is at 15% or less. Once the battery is recharged to a level above 15%, the test automatically resumes without user interaction. Different versions of operating systems and

³ DNS stands for domain name system. It is a worldwide, distributed directory service and is used in this context to resolve and translate the domain name of the destination URL (xyz.cloudfront.net) to the numerical IP address required for locating and identifying the destination server with the underlying network protocols.

⁴ TCP stands for transmission control protocol. It is one of the main protocols of the Internet protocol suite. The TCP connection phase is mainly characterised by a multi-step handshake process between the client and the server (connection establishment) before entering the data transfer phase.

respective default and/or user-enforced settings also need to be taken into account. This may result in a lower number of tests being executed, or in tests needing to be removed from the analysis.

The measurement data collected include details on the device, the operating system and other relevant system, and environmental parameters, e.g. radio information that allows us to separate cellular from Wi-Fi tests.

As a result, the data service availability metric, established for this report, provides a view on the success or failure to connect to the internet using a 2G, 3G or 4G mobile data network connectivity.

Response time

Response time (referred to technically as latency) is the delay between a consumer making a request to their mobile network for information and the network providing this information to the device.

Latency is measured as part of the connection test (described in detail in the section above). Once a successful resolution of the server IP address is logged (DNS lookup – first phase of the test), a flight of ten ICMP pings (internet control message protocol) is sent towards the same destination server as for the connection test (Amazon's CloudFront or Akamai).

The following ping command is used to send ten pings with 200ms pause in between, and an overall timeout of 30 seconds:

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ping -i 0.2 -c 10 -W 30 [... server ip ...]
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The ping response is parsed for obtaining the round-trip times.

Data use

As with previous metrics, data performance is measured passively. For this metric, we evaluate the actual data amount transferred during panellists' data sessions as part of their everyday phone use.

Traffic information is logged for each second during data sessions while transferring data (uploading or downloading). The amount of data traffic downloaded can be used to examine panellist data use.

Voice call use

The passive data collection includes information on the voice service for calls made or received by a panellist. The framework is triggered on the use of the legacy telephony manager (app); more precisely, when the user attempts to set up a call by pressing the green calling button or when they accept an incoming call. Data are collected every second until the call ends. The voice call types taken into consideration include legacy circuit-switched calls (2G, 3G), cases of circuit-switched fallback (calls initiated while the device was still on 4G and then immediately handed off to 3G or 2G), and VoLTE (calls made over 4G networks).

The second-by-second data logs contain, among other things, radio information such as cell ID, radio network technology and signal strength, as well as information on call duration. This data can be used to examine panellist behaviour in terms of number of calls made and the duration of calls by different access technologies.