END-USER DEVICES

Analysis of their influence on Internet Openness

30 May 2017

End-user Devices and Internet Openness

1   Introduction

At the end of the 1990s, end-user devices, the interfaces by which users connect to the Internet, were almost totally controlled by the operators. These devices were used to make calls and send text messages. Fixed devices were, moreover, the preferred means for accessing the Internet. The widespread adoption of smartphones at the end of the 2000s led to major changes in how these personal devices were used. At the same time, new economic players acquired a crucial status in the area of Internet access.

For government stakeholders, there are a number of ways of considering such end-user devices, that offer significantly revamped functions that are no longer always fully under the control of the operators. Their compliance with the protocols used in networks, or their compatibility with network safety standards, can be studied from a technical point of view. As the operating systems market is structured around a few global players, it may also be useful to look into issues that fall under the jurisdiction of the competition authorities. Given the growing importance of data in the economy in general and the special position of end-user devices in respect of accessing this new resource, the practices of the end-user device manufacturers may also be closely scrutinized by the authorities in charge of privacy and the protection of personal data.

It may also be worthwhile to examine the potential influence of such devices on Internet openness.

On 30 April 2016, European regulation 2015/2120 on the open Internet came into force. It enshrined the right for end-users not only to access a neutral, open and innovative Internet but also to provide content to it. At the same time, it provided a framework for practices liable to be implemented by Internet service providers in the day-to-day management of their networks. Thus, whilst setting forth the objective of an open Internet, the regulation focused on net neutrality.

In the January 2016 report concluding its strategic review, Arcep highlighted that beyond the Internet access networks, explicitly referred to in the regulation, Internet openness was dependent upon a complex technical chain, and that some players, not covered by the regulation, were able to limit effective access to some online services and applications, for both users and Internet stakeholders. For Arcep, such players were thus in a position to reduce the impact of the measures guaranteeing net neutrality. Arcep noted that this was the case not only for the main online platforms (search engines, SEO[1] tools, app stores, etc.), but also for end-user devices and their operating systems.

Noting that the issues relating to such devices are still poorly identified, Arcep believes it is essential to assess to what extent users, irrespective of the device they use, are able to access and contribute to Internet content and applications.

For Arcep, although the principles of an open Internet and net neutrality are indistinguishable in the texts (open Internet regulation, guidelines of the Body of European Regulators for Electronic Communications (BEREC) on this regulation, law n° 2016-1321 dated 7 October 2016 for a Digital Republic), the objective of Internet openness covers a wider field than that of net neutrality. The aim is to ensure that the Internet and its environment are developed as a common good.

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[1] Search Engine Optimization

This document reproduces Arcep's first findings on the devices, in order to allow all stakeholders to state their positions and provide any additional analytical elements. Over the next few months, Arcep will continue its discussions with all parties involved with the aim of producing a more detailed report in early 2018. Arcep's aim, *via* this project, is to be able to inform users on the features of these devices and on how they impact their Internet access. Arcep is also keen to foster a reflection upon any actions that may be required on the devices market to guarantee Internet openness.

2 New device functions and the characteristics of their development models

2.1 The major development stages for devices and uses in so far as concerns Internet access

2.1.1 Fixed terminals, originally the only means of accessing the Internet

At the end of the 1990s, the electronic communications devices environment was completely changed in France, when consumers started to equip themselves with mobile telephones and homes were connected to the Internet for the first time.

The first mobile telephones became available in France in the 1980s and were used inside vehicles *via* the Radiocom 2000 analog network, or the SFR NMT analog network, or for short range urban requirements with Bi-Bop phones developed by France Télécom. It was at the end of the 1990s, with the roll-out of GSM networks (*Global System for Mobile Communication*) allowing mobile voice communications, that the use of mobile telephony became widespread in France. Attracted by a nationwide network, French consumers quickly adopted the technology, such that by the year 2000 almost half the population owned a mobile phone. The arrival of SMS messages (*Short Messaging Service*) also helped popularize mobile phones by offering consumers a new means of communication. Usage subsequently exploded - over a billion text messages were sent in the year 2000, a figure which increased year on year until 2015, before stabilising at around 200 billion[2].

At the same time, the Internet was starting to develop, computers being the first devices that provided access to it; in 2000, over a third of French people owned a home computer and 14% had an Internet connection[3]. The French only really became enthusiastic Internet users at the end of the 2000s, by which time over 7 French people in 10 had a fixed Internet connection[4]. Internet access remained at the time closely linked to computers, despite a few mobile limited-access Internet packages being made available in the early 2000s.

#### 2.1.2 The emergence of new means of accessing the Internet

The 2010s saw a new revolution in telephony, with the success of new mobile phones known as smartphones. These smarter mobile devices offer enhanced functions compared to those available on basic mobile phones; they are equipped with a touch screen, can be used to browse the Internet, watch videos or download content and have a GPS chip. Smartphones started to be widely adopted following the launch of the first iPhone in 2007, and their use soared from 2010 onwards - according

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[2] Source: Arcep

[3] Source: CREDOC, Surveys on "Conditions de vie et les Aspirations"

[4] Source: CREDOC, Surveys on "Conditions de vie et les Aspirations"

to Le Baromètre du Numérique[5] published by Arcep, the French Digital Agency and the CGE[6], 65% of French people owned a smartphone in 2016.
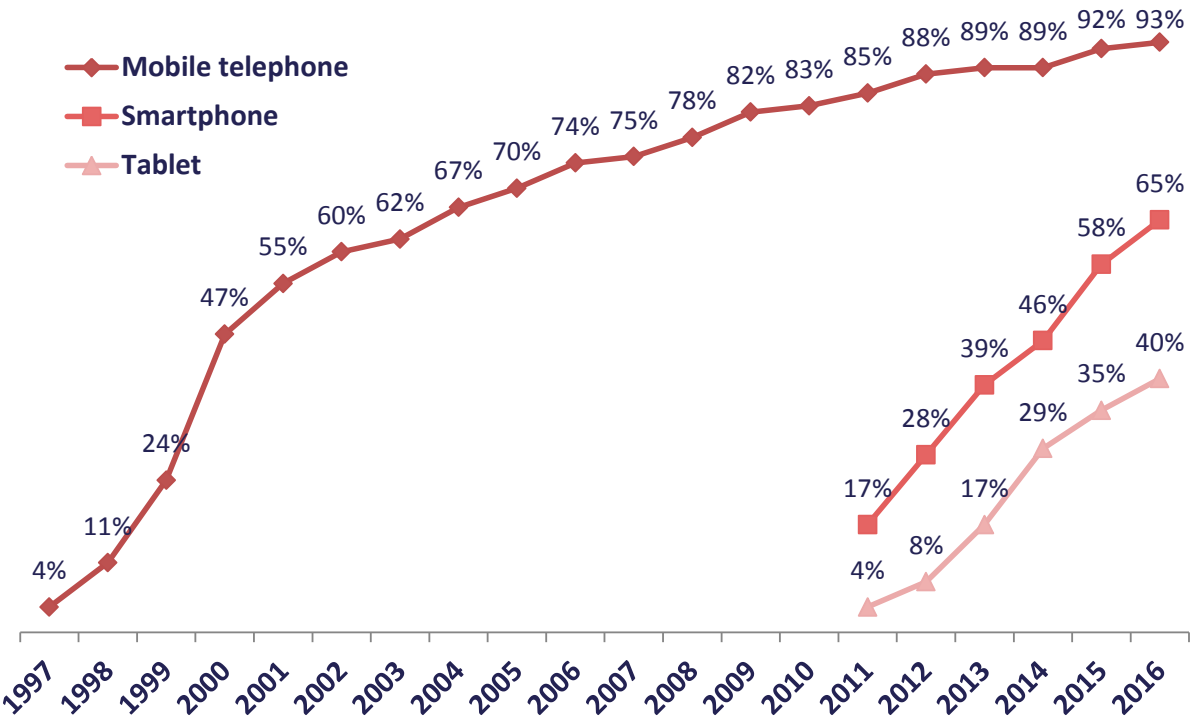
Ownership rate of end-user devices

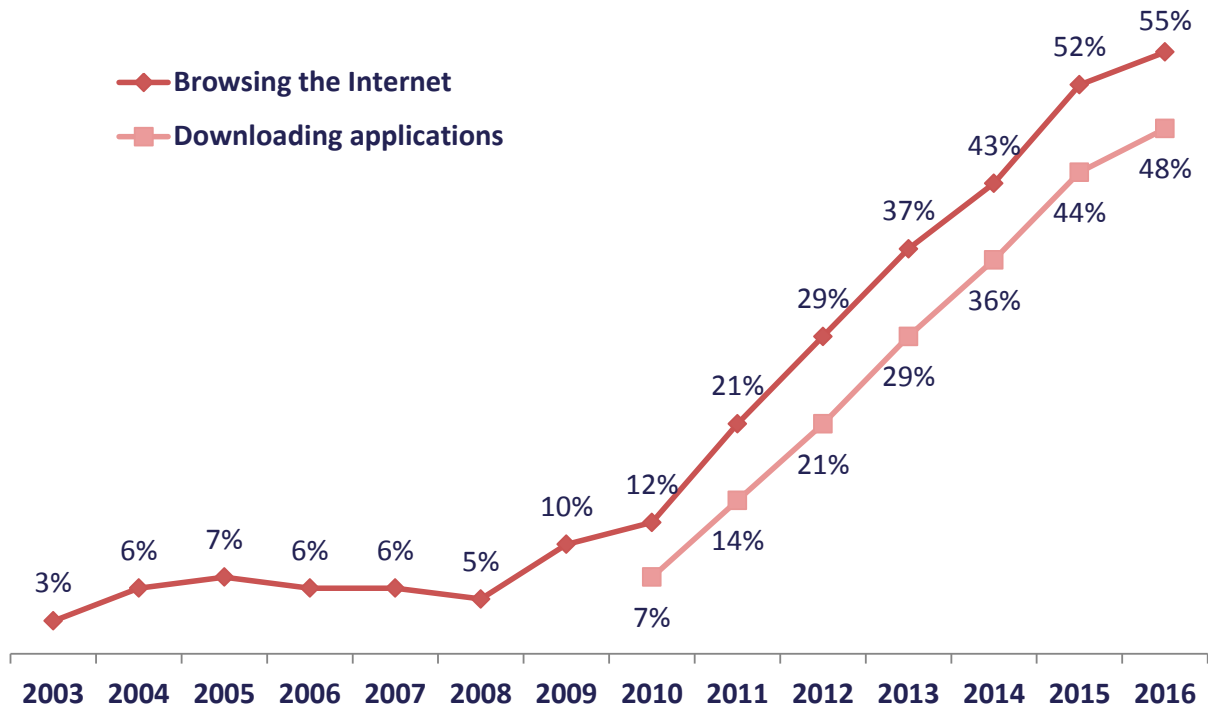Source: CREDOC, Surveys on "Conditions de vie et les Aspirations"

This revolution was accompanied by the adoption of new mobile devices in people's homes. Tablets thus complemented the devices used by French consumers, starting in 2010, when Apple launched the iPad; today, more than 4 consumers in 10 in France own one.

These successes have changed the traditionally fixed means of access to the Internet. Computers now no longer represent the main point of access to the Internet. Whereas at the start of the 2000s, only 3% to 7% of mobile phone owners had mobile access to the Internet, in 2009 such access really took off and reached 55% by 2016. For younger populations, the rate is higher, as over 8 French people in 10 aged under 40 access the Internet *via* their mobile devices[7]. For some users, mobile access has even become the only way they connect to the Internet - in 2016, 3% of French people said their access to the Internet was exclusively mobile.

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[5] Digital Broadcast Use – 2016 Survey

[6] Source: Digital Market Barometer, 2016 edition: http://www.arcep.fr/uploads/tx_gspublication/synthese-barometre-du-numerique-2016-291116.pdf

[7] Source: CREDOC, Surveys on "Conditions de vie et les Aspirations"

Browsing the Internet

Downloading applications

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Browsing	3%	6%	7%	6%	6%	5%	10%	12%	21%	29%	37%	43%	52%	55%
Downloading								7%	14%	21%	29%	36%	44%	48%

Proportion of people using a mobile phone to "browse the Internet" and "download applications"

Source: CREDOC, Surveys on "Conditions de vie et les Aspirations"

Generally speaking, this growing appetite for mobile Internet usage is visible at the global level. A study by the firm Zenith[8] disseminated by the press indicated that in 2016, 68% of the time spent on the Internet worldwide was *via* mobile devices, and that this is expected to rise even further, to reach 79% in 2018.

2012	2013-2015	2016 (f)	2017 (f)	2018 (f)
40%	Information not available	68%	75%	79%
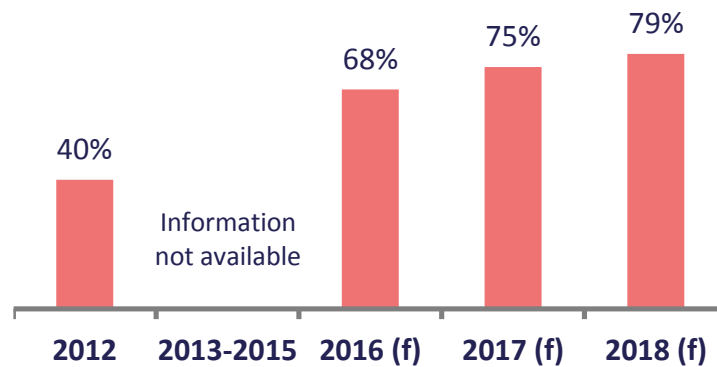
Percentage of time spent on the Internet using a mobile phone, worldwide

Source: Press quoting Zenith

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[8] Study *Mobile Advertising Forecasts*

Similar forecasts exist for France - eMarketer, also referred to in the press, envisages that in 2018, the time spent on the Internet *via* mobile devices will be 2h04 per day, versus 1h41 per day on a computer.

Other means for accessing the Internet have also emerged over the last 10 years. Many electronic devices, whose first use is not Internet browsing, have evolved and now let users access or provide online content. This is the case with games consoles - their Internet connection mainly allows players to download updates for their consoles, to download new video games or to *stream* their game, but some consoles can be used to browse the Internet. This is also true for certain televisions. According to Médiamétrie, in 2016 over half of all homes had a connected television[9].

2.1.3   Mobile applications, the new way of consulting online content

With smartphones, consumers have discovered new uses. Content has become accessible in the form of applications, i.e. free or paid-for downloadable software, adapted to the ergonomy of mobile phones. By making Internet access easier for the end-user and by allowing easy use of the device's other functionalities (3D graphics, motion sensor, access to the camera, etc.) as part of Internet communications, applications offer more functionalities than traditional Internet sites. In the space of ten years, the Internet access model has changed, the use of a browser often being replaced by reliance upon an applications environment, which renders the app store an essential point of access to the Internet. In the USA, according to ComScore[10], 59% of the time spent on the Internet in 2016 involved applications; the proportion is even higher if only that time spent on smartphones or tablets is considered. In France, 48% of mobile phone owners downloaded applications in 2016; this figure is even higher for those aged under 40, over 72% of whom downloaded an application[11]. However, whereas French mobile Internet users had on average 28 applications in January 2016, in practice they only use 5 of them regularly, according to Médiamétrie[12].

2.1.4   The voice assistant, future means for consulting online content

The early 2010s brought a new wave of innovation. Devices started to be equipped with voice assistants, voice-controlled applications offering end-users an alternative to the touch screen to interact with their devices. Spoken requests are now possible, and the device is also capable of providing spoken replies.

This technology concerns fixed and mobile devices. Whereas these assistants are now widely available in the latest generation smartphones, they are still rarely used, in their fixed version. The voice assistants' possible uses, which are currently limited, are expected to be developed in new areas of connectivity, such as connected vehicles.

2.2   The main families of devices currently available to access the Internet

Today, given the intense competition between equipment manufacturers, consumers are faced with a plethora of fixed and mobile devices. By contrast, the choice is much smaller in so far as concerns the operating systems installed on such devices. The market structure for smartphones is not

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[9] Source: Médiamétrie – Médiamat, Global TV – VOD/SVOD Study

[10] Source: ComScore - Media metrix multi-platform & Mobile metrix, U.S., Total audience

[11] Source: CREDOC, Surveys on "Conditions de vie et les Aspirations"

[12] Source: Médiamétrie – Web Observatory Q4 2015 – Base: Internet users aged 15+ mobile users

dissimilar to that for personal computers, where most users have made their choice between a system developed around Microsoft tools and the "integrated" system provided by Apple[13] - the two main mobile operating systems are managed by Apple (iOS) and Google (Android).

Apple has opted for an "integrated" approach for its devices and related services, in order to guarantee maximum fluidity for its customers. Its economic model is based on selling devices and promoting its services. In order to do this, Apple guarantees continuity between its products, all its services being consistent in terms of quality, security, ergonomy, performance and protection of personal data. In practice, this means that Apple has exclusive control of its devices, in respect of both hardware, with the iPhones and iPads, and software with the uniqueness of the iOS operating system and the App Store; Apple controls access to its device for content and service providers by requiring that developers use its development kit (Xcode, available on Macintosh only), apply a strict editorial policy, and has taken the decision to support only a limited number of versions of iOS. Nevertheless, the development languages for applications on the iOS, Objective-C and Swift, are both open source.

With Android, Google has adopted an approach based in the main on open source code, in order to ensure its operating system is compatible with as many devices as possible: smartphones and tablets, but also watches, televisions or connected objects. As Google's economic model is based on online advertising, in particular contextualised advertising, the purpose of making Android available is to increase Internet usage. By making its operating system freely available to device manufacturers Google is, in the short term, trying to make its search engine available on all devices and, in the longer term, to make all its applications and services available, in particular its Play Store app[14]. Device manufacturers and operators can modify the basic Android system by adding overlays or by creating "*forks*", i.e. derivative systems that evolve independently. On the other hand, Google favours making the derivatives of its operating system compatible with as many services as possible and in particular with the applications that it develops by offering device manufacturers the possibility of signing an Anti-Fragmentation Agreement.

■ **Android** ■ **iOS** ■ **Windows** ■ **BlackBerry** ■ **Symbian** ■ **Other**

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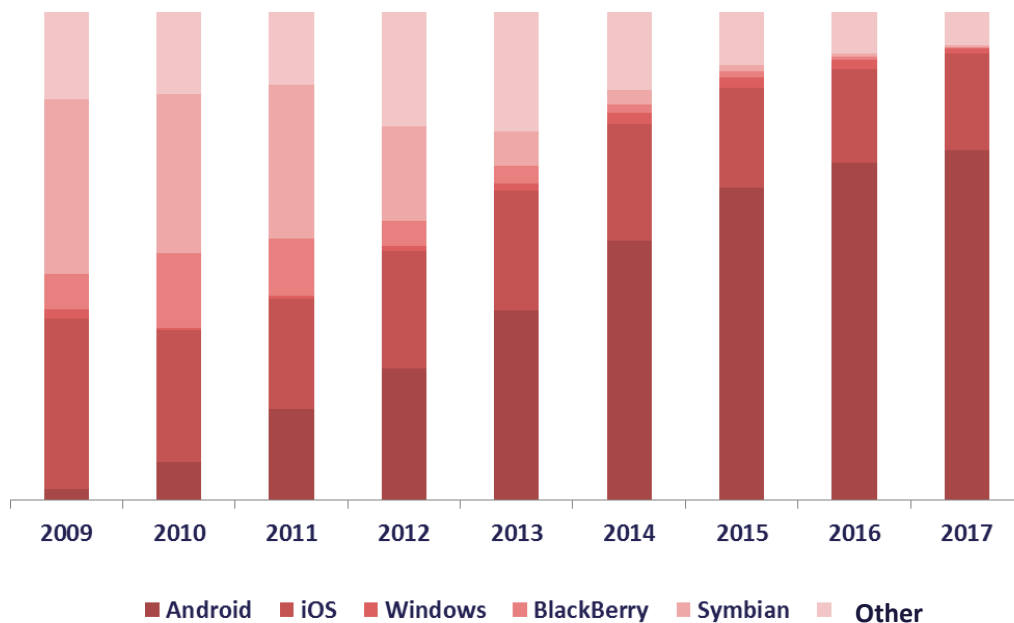
[13] There are, nevertheless, numerous alternative operating systems, in particular those based on a Linux open source core.

[14] It is interesting to note that Amazon, with its personal assistant Alexa, appears to be adopting a similar strategy.

Market share of mobile operating systems worldwide between January 2009 and April 2017

Source: StatCounter

There were more than five mobile operating systems in existence when smartphones were first launched. Android and iOS now largely dominate the market. There are two reasons for this concentration in the operating system market. Firstly, there are effects of scale - a small number of operating systems is an advantage for developers who want to optimise their resources and benefit from high quality. It is important, however, to note that for developers, even with two main operating systems, supporting applications on all the devices requires significant resources - to the updates on all systems is added the fragmentation of open source systems. Secondly, the concentration of the operating systems market is further reinforced by club effects on app stores - from the users' point of view, the number of applications available is a criterion for choosing their device and therefore the operating system. These club effects may explain the failure of late arrivals such as Firefox OS, as they were unable to attract a large enough community of developers and users.

3 Limits of the measures provided for by the regulation on the open Internet

At the time when devices play an essential role in accessing the Internet, offer functionalities that are potentially very different and are in part controlled by a small number of economic stakeholders, they need to be taken into consideration when assessing the smooth functioning of the Internet. It appears nevertheless that the regulation on the open Internet, despite an ambitious objective, neglects this link in the chain that extends from the end-user of the Internet service to the information, content, applications and services.

3.1 The principles of the regulation, the rights that it creates, the players that it regulates

3.1.1 The objective - Internet openness

With regulation 2015/2120 of 25 November 2015 establishing measures relating to an open Internet access, the European legislator appears to have taken a position on the character of common good of the Internet, by highlighting that it has developed "*as an open platform for innovation with low access barriers for end-users, providers of content, applications and services and providers of internet access services*". In addition, the Constitutional Council considered that "*in the current state of the means of communication and given the generalized development of public online communication services and the importance of the latter for participation in democracy and the expression of ideas and opinions,*", the constitutional right of expression and free communication "*implies freedom to access such services"* [15]. This resource, the current value of which is in particular due to the fact that it is easy to share, should not be appropriated by any physical or legal persons.

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[15] Decision n° 2009-580 DC of 10 June 2009, Law furthering the dissemination and protection of creation on the Internet

3.1.2 The creation of rights for end-users - reception and distribution of information

The regulation recognises the rights of end-users.

It should be noted that these rights concern not only the flows that enter the network of the Internet service provider, but also the flows that come from it; indeed, "*irrespective of the end-user's or provider's location or the location, origin or destination of the information, content, application or service*", end-users must be able to:

- on the one hand, "*access information and content*" and "*use […] applications and services*";
- on the other hand, "*distribute information and content*" and "*provide applications and services*".

The regulation provides moreover that the users are entitled to "*use the end-user devices of their choice*".

3.1.3 Measures targeting Internet service providers

Noting "*traffic management practices which block or slow down specific applications or services* [having an effect] *on a significant number of end-users*", the European legislator deemed it necessary to adopt *"common rules at the Union level to ensure the openness of the Internet*".

Whilst setting an ambitious objective for an open Internet, the regulation focuses on Internet service providers, with measures designed to control traffic management practices, measures in favour of transparency, and a ban on restrictions on the use of end-user devices connected to the networks.

However, other players could influence Internet openness.

3.2 A technical chain that includes intermediaries other than access networks

Internet service providers are not the only players likely to influence Internet openness. Indeed, on the technical chain that connects the end-user of the Internet service to the information, content, applications and services, other essential links can be identified; among these links, devices are particularly important.

3.2.1 Hardware links

These are first of all hardware links. Thus, to be connected to end-users, the providers of content and applications generally deliver their data to hosting providers. These hosting providers are interconnected with the different Internet service providers or make use of transit operators so they can reach all Internet users, who are connected to the network *via* one or more fixed or mobile end-user devices.

Hardware links between the end-user and the Internet
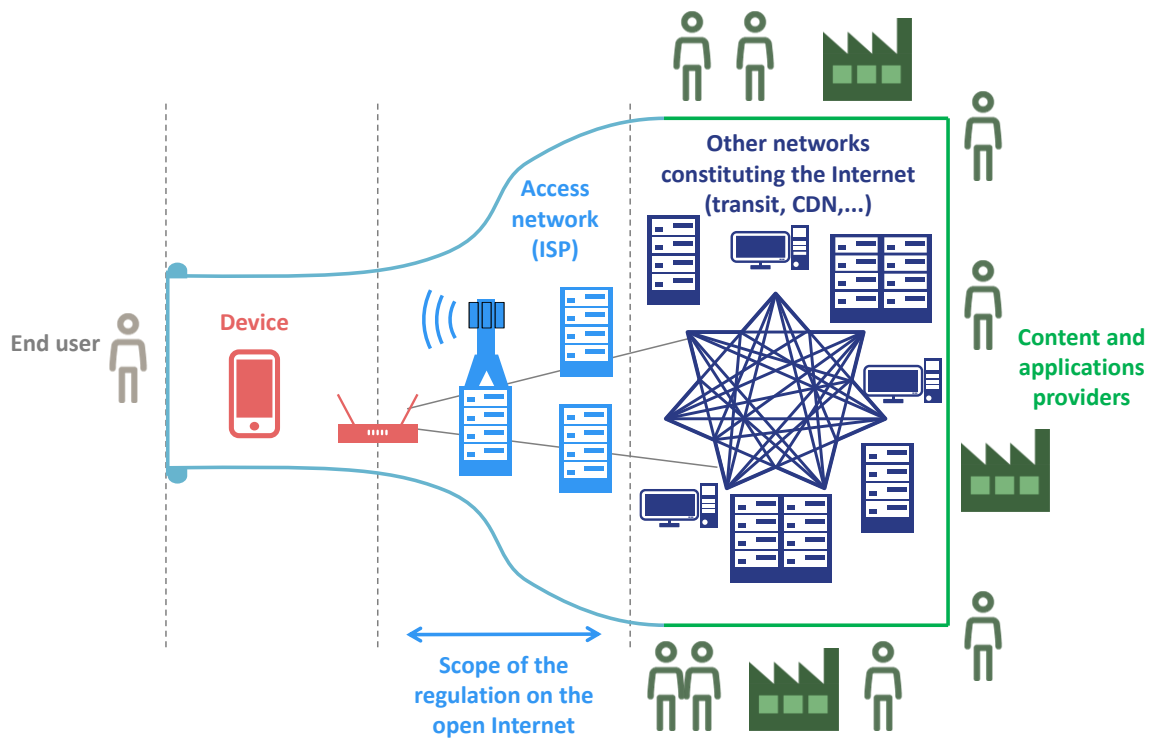
3.2.2   Software links

These links are also software in nature. For example, online platforms, defined by law n° 2016-1321 of 7 October 2016 for a Digital Republic as the activities of " *ranking or SEO, using computer algorithms, content, goods or services provided or uploaded by third parties* ", or " *bringing together several parties to sell an asset, supply a service or exchange or share an asset or service*"[16], occupy a dominant space in respect of exchanging data over the Internet. App stores and the applications themselves meet this definition of online platforms. Similarly, the operating systems of the end-user devices constitute an absolute requirement for any data exchanged over the Internet.

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[16] Article L. 111-7 of the Consumer Code as amended by Article 49 of Law n° 2016-1321.

Software links between the end-user and the content
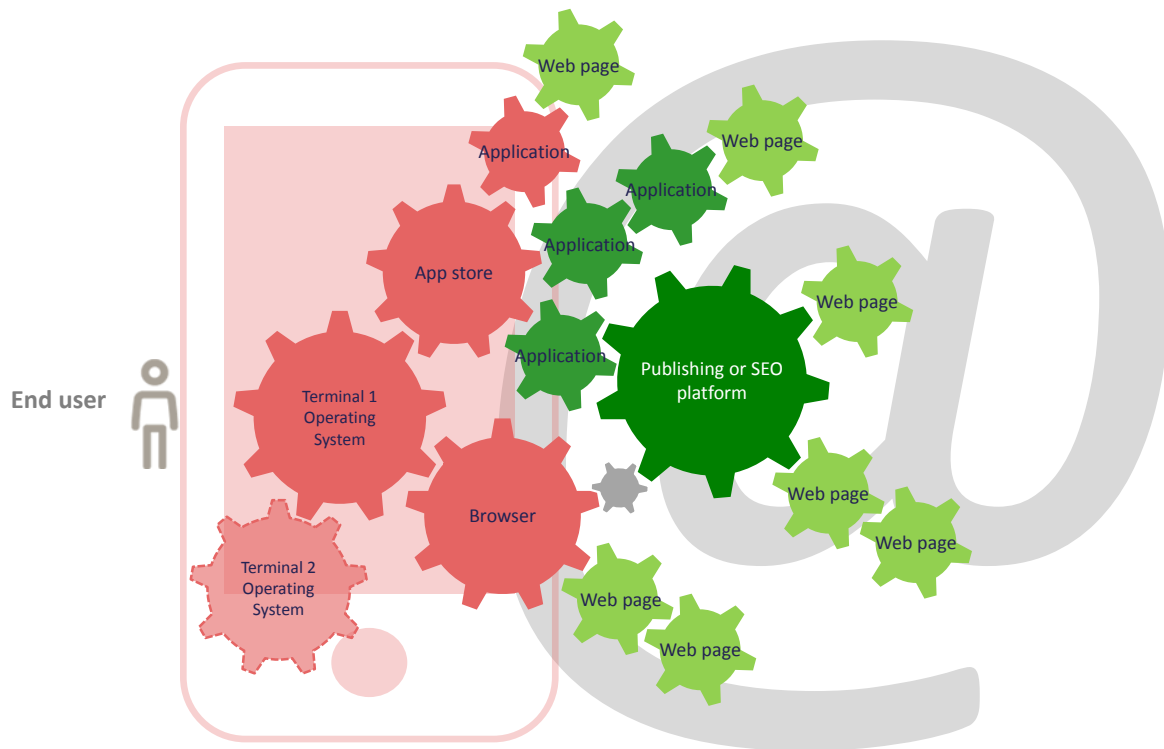
3.2.3 The specific features of the links formed by the devices

Thus, Arcep considers it necessary to look into the limits of Internet openness that could result from factors not covered by the regulation on the open Internet.

Among these factors, in this study Arcep focuses on end-user devices and their operating systems. The end-user is in fact not necessarily in a position to evaluate all the characteristics of these devices - first of all, people that buy end-user devices are often not professionals; then, when an end-user chooses a device, they generally use it exclusively (it is rare for people to have several Internet boxes or mobile devices for the same Internet access), and do not immediately renew it (in 2016, according to the firm Kantar, European users of smartphones changed devices after using them for 22 months on average); finally, the manufacturers of some end-user devices, in particular mobile devices, today have the advantage of a particularly strong competitive position. Moreover, these devices could lead to limits on Internet openness, whether for technical or for commercial reasons. As guarantor of net neutrality, it is therefore Arcep's aim to study end-user devices and their operating systems that present adherences with the networks.

4 Approach used to analyse devices with regard to the objective of an open Internet

In order to evaluate the influence of the devices on the openness of the Internet, it was necessary to define an analytical framework. The aim, first of all, was to define the scope of the study by adopting a wide interpretation of the notion of end-user device, then determine a working method that would allow a far-reaching survey of the cases and a qualitative analysis of them.

4.1 The scope of the analysis

The term "end-user device" is defined in Article L. 32 of the French Postal and Electronic Communications Code as "*any device designed to be connected directly or indirectly to a network termination point with a view to the transmission, processing or reception of information*." Radio and television equipment meets this definition.

This definition invites two comments.

On the one hand, it is important to note that some end-user devices may not be directly connected to the network - there may be a chain of end-user devices. Thus, in the case of a fixed Internet connection, the modem may be followed by a router then a personal computer and a connected television; similarly, in the case of a mobile Internet connection, a smartphone with the "connection sharing" function may be followed by a personal computer; all these devices constitute terminals in the meaning of the French Postal and Electronic Communications Code.

On the other hand, it should be pointed out that the legal definition of the devices is based more on the location of such devices than on their usage, which may vary. The result is that not all devices that correspond to the definition of "end-user device" allow the same uses. Thus, a smartphone does not generally by itself allow content hosting, and its small touch screen does not offer the same ease of use as the keyboard and mouse of a personal computer for developing applications; however, it generally includes functionalities that are not available either from a box, or a personal computer, such as a camera, a motion sensor, a NFC chip[17], etc.

4.1.1 Analysis focused on devices designed to allow users to access the Internet

In connection with this work, devices are considered based on the ability that they offer end-users to access all the information and services available on the Internet and to upload content.

In this context, the main devices analysed are:

- mobile communications devices (smartphones and tablets),
- Internet boxes provided by telecommunications operators,
- TV set-top boxes provided by operators or alternative players (Apple TV, Roku, etc.),
- computers,
- voice terminals,
- video games consoles,
- connected televisions,
- other connected objects offering Internet access (connected watches, readers, etc.).

Conversely, other devices, like the vast majority of connected objects (connected sensors, smart computers, connected furniture, etc.), do not fall within the scope of this study, in so far as they do not offer users Internet access.

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[17] NFC (*Near Field Communication*) is a technology that allows two devices to communicate automatically when they are close to each other.

4.1.2 Analysis of the boxes, independent of their possible qualification as a network element

It is interesting to note that although the approaches of the Internet service providers may be constant in so far as concerns the definition of "network termination point" for mobile access, they are variable in respect of fixed access. Some operators maintain, in fact, that Internet boxes constitute elements of their network; such operators consider that the principle of free choice of the end-user device does not apply, as it could impact the integrity of their network.

The purpose of this study is not to determine the precise location of the "network termination point"; consequently, fuelled by a desire for comprehensiveness and wishing to adopt a functional approach, Arcep decided to include Internet boxes provided by telecommunications operators in the range of devices examined.

4.1.3 Analysis extended to browsers and app stores

The analysis of end-user devices is not limited to the hardware layers, but also relates to any software layers there may be - operating systems, browsers and app stores.

Indeed, within certain devices, the operating system plays a prominent role in Internet openness. Before mobile devices became "smart", they did not offer their users Internet access, only traditional electronic communications services (voice, SMS, wap). It is mainly the development of more powerful operating systems, made possible by the progress achieved in the area of embedded electronics, that has allowed "intelligence" to be added to mobile end-user devices and an increase in the services accessible *via* telephone, thanks to Internet access.

As software foundation of the device, the operating system is an element for which decisive choices relating to compatibility can be made. The operating system is, however, not the only place where the device's smart software resides - other services are generally associated with the operating system, which are also indispensable to enable all the functions of the smart device to be used (browser, app store, e-mail service, search engine, mapping tool…). Among the latter, some services, such as the browser and the app store, may also be the subject of choices relating to compatibility and are particularly prone to impairing Internet access.

4.2 The method employed to identify the limits

4.2.1 Hearing the various types of stakeholders involved

To analyse the influence that devices may have on Internet access, Arcep organised a series of interviews with those directly concerned by the subject - content providers, device manufacturers, operating system developers, operators, consumer representatives. It also met with stakeholders from all areas - representatives of central government, consultants, lawyers or academics.

4.2.2 Automated referencing of cases of access being limited

At the same time as the hearings, Arcep was keen to objectify the survey of cases of Internet access being restricted by devices. It therefore introduced search automation - using a tool[18] that allows

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[18] This tool was developed by François-Guillaume FERNANDEZ-MOURON as part of a task entrusted to the Junior Supélec Stratégie association, the junior-entreprise of Supélec.

requests to be made on online forums of technical experts using keywords relating to types of devices, device manufacturer names, operating system developer names, or types of practices envisaged.

5   Map of the limits identified

The work carried out thus far, which should not be seen as constituting a judgement by Arcep, has made it possible to identify and qualify situations experienced by some players as being limits on Internet access and online content provision as a result of the devices used.

These limits are varied in nature. They may be the result of the characteristics of the device used (fixed or mobile physical equipment); they may be the result of software developments; they may also be explained by the editorial policies of the operating systems and the app stores; they may finally be the result of the economic models of the device suppliers.

Some of these limits are known and accepted by end-users. Other limits are criticised. Others finally seem to pass unnoticed by end-users. Among these limits, some may be contrary to the spirit of an open Internet.

5.1   Limits inherent to the nature of the device

When an end-user acquires a device, they choose it first and foremost based on its intended uses - fixed or mobile, simple or advanced. This choice has direct consequences on the scope of its possibilities in terms of Internet access and the provision of online content.

The limits, that go hand in hand with the choices of the end-user are generally known and accepted. The same does not apply to those limits noted by advanced users who consider they are suffering restrictions despite choosing the environment that is *a priori* the most favourable to unlimited Internet access.

5.1.1   Specific uses of fixed and mobile devices

Choosing a fixed or a mobile device to access the Internet naturally leads to different possibilities, including in the area of information exchange over the Internet.

For example, in addition to mobility *per se*, a smartphone offers the possibility of carrying out financial transactions (contactless payment for example) or sharing data measured by motion sensors more easily than a personal computer, but does not generally allow services to be developed or content to be hosted. The ergonomy of a mobile device, that is not usually designed with this in mind, is generally not suited to such actions. Developers prefer the large screen of a computer and the possibility of using computer accessories such as a keyboard or a mouse.

It is important, however, to note the emergence of *smartphones* able to change themselves into CPUs (Central Processing Units) when they are connected to a screen; once connected, such mobile devices allow multi-window displays that give the end-user access to a personal computer environment. The boundaries between fixed devices and mobile devices could thus become blurred.

5.1.2   Advanced uses restricted by some boxes

In so far as concerns fixed devices, some users have informed Arcep of the difficulties due to the inadequacy of the technical documentation made available by suppliers of some boxes, and more generally, the restrictions on use (concerning for example self-hosting, virtual private networks,

remote desktops, some functionalities of online games, etc.) linked to the router included in some boxes.

5.2 Compatibility issues caused by changes to software

When an end-user acquires a device, they must implicitly choose an operating system which, by its very nature, changes over time. This progressive nature inevitably leads to issues of upward or downward compatibility, that are more or less significant depending on the cases, in respect of access to content. The end-user's initial choice thus has repercussions on the quantity and variety of applications which they may access.

5.2.1 Managing the obsolescence of operating systems

The providers of operating systems may wish to limit the number of versions of the operating system in circulation, for example in order to increase the security level of the platform, limit their costs, or encourage users to switch to their most recent products.

In order to encourage the demise of the oldest versions, the developer of the operating system may, following an update, decide to no longer provide access to APIs (Applications Programming Interfaces)[19] previously made available to applications developers. The result is that an application available on an older version of an operating system may disappear when this version is no longer supported, if its provider is not able to make the investment needed to recode the basic functions. Thus, users who have not downloaded the most recent versions of an operating system may lose access to some of their applications, or be unable to update some applications.

5.2.2 Fragmentation of operating systems

In the same spirit, the increase in the number of derivatives of a single operating system, or fragmentation, may also result in limits to the content available to end-users. Although versioning exists for all operating systems, fragmentation is particularly significant for operating systems that are mainly open source, i.e. whose code is in part available to all developers - users are able to develop and enrich these operating systems, by offering overlays, or even by making major changes by creating forks.

This situation can give rise to two effects. Firstly, the technical ability of some content publishers to offer their products over all devices may be limited. In fact, significant development work may then be needed to ensure that all the devices are compatible with the content. Secondly, the fragmentation of open source operating systems may lead to multiple versions of the same application coexisting, to ensure the compatibility evoked above, which may undermine its showcasing in the app stores. In fact, it appears that the applications that are downloaded the most are often very visible in the app stores, which naturally showcase the most popular products.

5.2.3 Pace of adherence of operating systems to international Internet standards

Generally, Internet access *via* a browser offers the end-user the guarantee of being able to access the maximum amount of information. Nevertheless, the browsers of certain mobile devices may be limited and thus restrict end-user access to some content. For example, access to content requiring

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[19] An API is a programming interface that allows two programs to interact. It allows a program to use the building blocks of another program.

certain HTML5 functionalities, currently used to design most Internet sites rich in multimedia content, is not yet possible on some devices.

The limiting of browsers, in particular when they are old, may in some cases be explained by their non-adherence to the most recent Internet international standards.

It may, nevertheless, also result from the desire of their developers to encourage the use of applications to access Internet content. For some operating system providers, it is in fact more profitable to manage the sale of advertising space or content *via* the app store or the applications.

Such an analysis does not seem to be able to totally explain the case of content being blocked that, in order to operate correctly, requires Flash Player (a proprietary plug-in that enables the animation of Internet pages) – if many mobile browsers do not support this external module, it is because it is not very energy efficient, thus ill-suited to a mobile environment, and is a source of numerous security flaws that cannot be avoided as the developers are unable to adapt its code, which belongs to Adobe.

5.3 Limits linked to the editorial policy of the operating systems and app stores

When they choose their device, end-users are not only making a technical choice. In fact, they are relying on the provider of the operating system and, if they have chosen an "integrated" device, the provider of the app store, to determine, when they make a request, the criteria used to select and store the content that they are being offered. These criteria, that users do not necessarily notice, may influence Internet openness.

5.3.1 Processing sensitive content

Access to some content deemed sensitive may, without this resulting from the sole compliance with the law, be limited by an app store controlled by a player keen to preserve its brand image.

Based on the editorial policy of the app store and its general terms and conditions, it may turn out to be impossible for the end-user, in the case of an integrated system, to access some content - the user is in fact obliged, in this case, to use the only app store available on the device.

Policies in respect of referencing and promoting content on devices Devices are usually sold with a series of pre-installed key applications. In some cases, these applications cannot be deactivated or deleted; in other cases, they can be deactivated but not deleted, as the manufacturer is keen to ensure that users remain able to restore the device's original configuration. This could, for example, be an e-mail service, a cloud space, a video service, a mapping service or a browser. These practices in favour of services linked to the operating system naturally tend to entice end-users away from other services. Nevertheless, the pre-installation of essential applications may meet the expectations of end-users who want to be able to use their devices as soon as they get them.

Policies in respect of referencing and promoting content in app stores Generally, referencing and content showcasing policies in app stores are not very transparent. In fact, the editorial policies of the app stores are not always documented and could be based on criteria contrary to the objective of an open Internet. The potential effects of such policies could be particularly significant if the device's operating system does not allow the installation of an alternative app store.

Apart from the technical justifications set out, such as the security and integrity of the app store, or the protection of personal data, it is possible that some limits are the result in reality of competitive issues - app stores may encourage vertically integrated services by preventing competitor apps from operating correctly, whether music, video or press. Such prevention may not necessarily take the

form of the actual blocking of the applications in question - it could take the form of an extended period of approval for certain applications that are candidates for access to an app store.

5.4 Limits linked to the economic models of device manufacturers and operating systems developers

Choosing a device, means, more generally, entering the universe of an equipment manufacturer and a provider of an operating system, whose economic models may impact the quality of the Internet access. Thus, the equipment manufacturer may wish to promote technological innovations by requiring payment from the content suppliers that wish to use them; similarly, the provider of the operating system may promote the method of access to the Internet that offers it the best prospects for monetisation.

5.4.1 Practices aimed at monetizing the device's associated functionalities

The development of some content requires access to associated functionalities of the device. The conditions of access to these functionalities could be such that, directly or indirectly, access to the content would finally be limited for the end-user.

Such a situation could result from the financial conditions offered to the content providers accessing the associated functionalities of certain devices. Access to some content could be more expensive for users of such devices if the publisher were to choose to pass on in its rates access costs that vary depending on the app stores. This is the case when access to paid-for multimedia content involves using the payment system integrated in the app store, that charges a commission. It is also the case when access to electronic money services, such as contactless payment, involving access to specialised components of the telephone (for example the device's NFC chip), and that this access is dependent upon the use of a paying intermediary financial platform, imposed by the device manufacturer[20].

Such a situation could also result from the conditions for making use of the user payment data generated when users buy content. Access to such data, even if they are not directly related to the service providers' core business, may help to reinforce their strategy of increasing customer loyalty. This is the case when publishers of app stores require content providers to use their dematerialised subscription service.

Taken to the extreme, the conditions imposed on content providers could lead to a drying up of the content offer, as the economic viability of the publishers could be compromised.

5.4.2 Promotion of applications as method of Internet access

Internet access *via* applications presents clear advantages of ergonomy for users of mobile devices. Moreover, mobile Internet users tend to prefer to use applications rather than browsers.

In addition, numerous applications make use of the devices' ancillary functionalities, such as the geolocation tool, camera or accelerometer, which allows them to simply offer services which it may be complicated, or impossible, to access from traditional Internet sites. Some services are, moreover, available only in the form of applications; this is the case, for example, for several applications that allow contact with transport service providers with drivers.

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[20] This is a platform acting as an interface between the banking establishments and the traditional players in payment systems, developed by the manufacturer of the device equipped with a NFC chip.

However, access to the Internet *via* applications is by nature more restrictive than access *via* a browser, as it is highly specialised - applications developers design them in order to provide a specific service. Although such specialisation simplifies the user experience, it results in reduced control of the information which they can access and reduced control of the criteria based on which this information is highlighted.

5.4.3 Development of voice assistants as a method of accessing the Internet

Like applications that channel access to content on the Internet for end-users, the increase in the number of voice assistants at home or in connected vehicles could further restrict Internet access in a growing number of configurations.

In fact, although this equipment has the advantage of allowing access to some Internet content in an extremely fluid manner as it is no longer necessary to be in front of a screen and to use a keyboard (when a user makes a request they only receive one reply, chosen by the assistant's provider), their use is liable to be at the detriment of the end-user's ability to choose. Even in the event that users were to be able to perfectly configure response criteria to their requests, the complexity of the manipulations needed would be such as to limit, in practice, the field of the content explored. This response could be biased by commercial issues, with effects that would increase as and when these assistants become more competent (they are now already capable of buying goods or services for the user directly, with, if appropriate, a commission on the transaction).

This phenomenon will be particularly significant if users have an imperfect understanding of the limits of voice assistants to respond to their open questions. This question is part of the wider field of the transparency of the response algorithms.

6   Conclusion

After the first hearings and research carried out by Arcep, it proved possible to map different types of limits on Internet openness that are not the result of the practices of the Internet service providers but of the characteristics of the end-user devices or decisions of the operating system providers.

It can be seen from this first mapping that not all the limits identified are the result of a deliberate choice by the device manufacturers - the latter are in fact subject to technical constraints over which they do not necessarily have any control. Some of the limits identified, often software, may be circumvented - there are often workaround solutions within the same device. Other software limits identified do not appear to be open to workarounds, in particular on some mobile devices whose already substantial uses are quickly becoming predominant.

It is possible that some limits may not have been noted by Arcep during its initial work and therefore, in so far as concerns digital uses, probable developments need to be anticipated. The limits observed up until now may increase in future, including on fixed devices, with the growing integration of ever more specialised devices and voice-controlled software.

As a result, Arcep is keen to extend the approach initiated of analysing how devices influence Internet openness in order to not only complement its mapping of the limits, but also improve its understanding of the mechanisms involved. Where necessary, Arcep will put forward proposals to ensure greater Internet openness, notably in regard to fluidity of the end-user device markets.

To further its work over the coming months, the Authority invites all stakeholders to share their assessment of this study and to make known their prospective vision on the subject, *via* the following e-mail address: terminaux@arcep.fr.

Appendix: list of people heard

Warning: The content of this report represents the Authority's conclusions after its first surveys and not those of the people heard in connection with the drafting of this report.

Apple	Marie-Laure DARIDAN, Government Affairs Senior manager
	Sylvain SCHNERB, Senior Counsel
Autorité de la Concurrence	Nicolas DEFFIEUX, Deputy General Rapporteur
Bouygues Telecom	Laurent BONNET, Regulatory Division Manager
BEUC	Guillermo Beltrà, Head of Legal and Economic Department
	David Martín, Senior Legal Officer, Digital and Consumer Rights
Canal Plus	François FOURRIER, Head of Product and Partnerships
	Philippe RIVAS, Distribution Technical Manager
	Christophe ROY, Head of European Affairs, Deputy Legal Director
CNIL	Brice BASTIE, Legal Expert for Economic Affairs
	Olivier DESBIEY, Innovation and Foresight Manager
	Vincent TOUBIANA, Technologist
CNNum	Romain DELASSUS, General Rapporteur
	Judith HERZOG, Rapporteur
DGCCRF	Geneviève CAVAZZI, Industrial Products Department (department 5A)
	David HELM, department 6B
	Paul-Emmanuel PIEL, Head of Media, Telecommunications, Goods and Cultural Services Department (department 6B)
	Vincent PONET, department 5A
	Philippe SAUZE, department 6B
DGE	Olivier COROLLEUR, Deputy Director, Sub-division of Electronic and Postal Communications
	Mélanie PRZYROWSKI, Advisor, Sub-division of Electronic and Postal Communications
Facebook	Anton'Maria BATTESTI, Public Affairs Manager France
The FDN Federation	Benjamin BAYART, President

	Oriane PIQUER-LOUIS, Vice-President
FPWA Lawyers	Jean-Baptiste SOUFRON, Partner
Free	Ombeline BARTIN, Director - Institutional Relations Thanh PHAM-DOAN, Director - Regulatory Affairs
Google	Olivier ESPER, Head of Institutional Relations France Benoît TABAKA, Head of Economic Policies linked to Mobile Technology (Europe Middle East Africa)
Heetch	Teddy PELLERIN, Co-founder
Netflix	Colin BORTNER, Director of Global Institutional Relations
Nexedi	Jean-Paul SMETS, CEO
Oracle	Frank JOURNOUD, Senior Director, Cybersecurity and Technology Policy Peter LORD, Senior Director for Technology Policy Charlotte THORNBY, Head of EU Affairs, Senior Director Public Policy and Corporate Affairs EMEA
Orange	Gilles FILARY, Head of Anticipation and Technology Devices Jean MAHE, Head of Audiovisual and Content Regulation Brice MIRANDA, Director of Devices and Services Expertise Stéphane RAULIN, Head of Software, Connected Objects and Partnerships Julien SICART, VP Technology Connected Objects
SFR	Marie-Georges BOULAY, Director Regulatory and Public Affairs, Jean HYBRE
Spotify	Marine ELGRICHI, Head of Public Policy Europe