CHAPTER 1

Monitoring data interconnection and the relationships between Internet service providers and content providers

THE BOTTOM LINE

- **Inbound traffic to the main ISPs in France** is estimated at **46.5 Tbit/s at the end of 2023,** which marks a 7.6% increase YoY.
- **Close to 53% of inbound traffic** for the top four Internet service providers comes from five companies: **Netflix, Akamai, Facebook, Google, and (Including Twitch's traffic).**
- Across the EU, **BEREC is collecting data on the interconnection market for the first time,** an exercise that is vital to understanding relations between telecoms operators and content providers.

1. DATA NETWORK INTERCONNECTION, AT THE HEART OF ARCEP'S EFFORTS TO SAFEGUARD AN OPEN INTERNET

The internet is a network of networks, in other words networks that are interconnected in a way that enables information to take a multitude of possible paths. Interconnection refers to the technical-economic relationship established between different parties to connect to one another and exchange traffic. It takes the form of a physical link between networks, guarantees their global mesh and enables end users to communicate with one another.

Data network interconnections are at the heart of how the Internet, **"network of networks",** works. Thanks to these links, the internet's many players exchange traffic, thereby creating a global network to which end users connect via their Internet Service Provider (ISP). Meanwhile, ISPs, interconnect with content and application providers (CAP) and other players along the internet value chain, to relay content and ensure good quality of service for their subscribers: the more direct the links, the better the quality of service.

The internet can only run smoothly if these interconnections are sound. Problems in the negotiations between two interconnected parties may, for instance, result in a lesser quality of service or a disruption of the interconnection which, in turn, will make it partially or fully impossible for users to access, use or distribute the services and applications of their choice. Interconnection could also be used for the purpose of anti-competitive discrimination against the source, the recipient, destination or content of the information being relayed.

When an interconnection issue arises, Arcep can exercise the powers assigned to it by the legislature, whether through an *ex ante* regulatory decision, or a dispute settlement decision at the request of one of the parties.

To ensure ongoing monitoring of the market, **Arcep has been collecting data on interconnection and data transport on a biannual basis since 2012**. The aggregated findings of these data collection campaigns are published in the Barometer of data interconnection[1]. Key figures for the 2024 edition of this barometer, pertaining to 2023, are provided in this Chapter.

1 The Barometer of data interconnection is updated annually on the Arcep website

THE MAIN INTERNET PLAYERS INVOLVED IN DATA INTERCONNECTION

A range of major stakeholders interconnect within the internet ecosystem:

- **Content and application providers (CAP):** the owners of the content who rely on multiple intermediaries to relay their content to end users;
- **Web hosting companies:** the owners of the servers that host the content managed by third parties (CAPs or individuals);
- **Transit providers:** international network managers that act as intermediaries between CAPs and ISPs for relaying traffic;
- **Internet Exchange Point (IXP) operators:** third parties operating an exchange point that enables the different players to interconnect directly through that IXP, rather than going through one or several transit providers;
- **Content Delivery Network (CDN) operators:** the technical intermediaries specialised in delivering large volumes of traffic to multiple ISPs, in different geographical areas, using cache servers located near end users, to optimise routing while improving performances and reducing costs;
- **Internet Service Providers (ISPs):** network operators that are responsible for relaying traffic to end users.

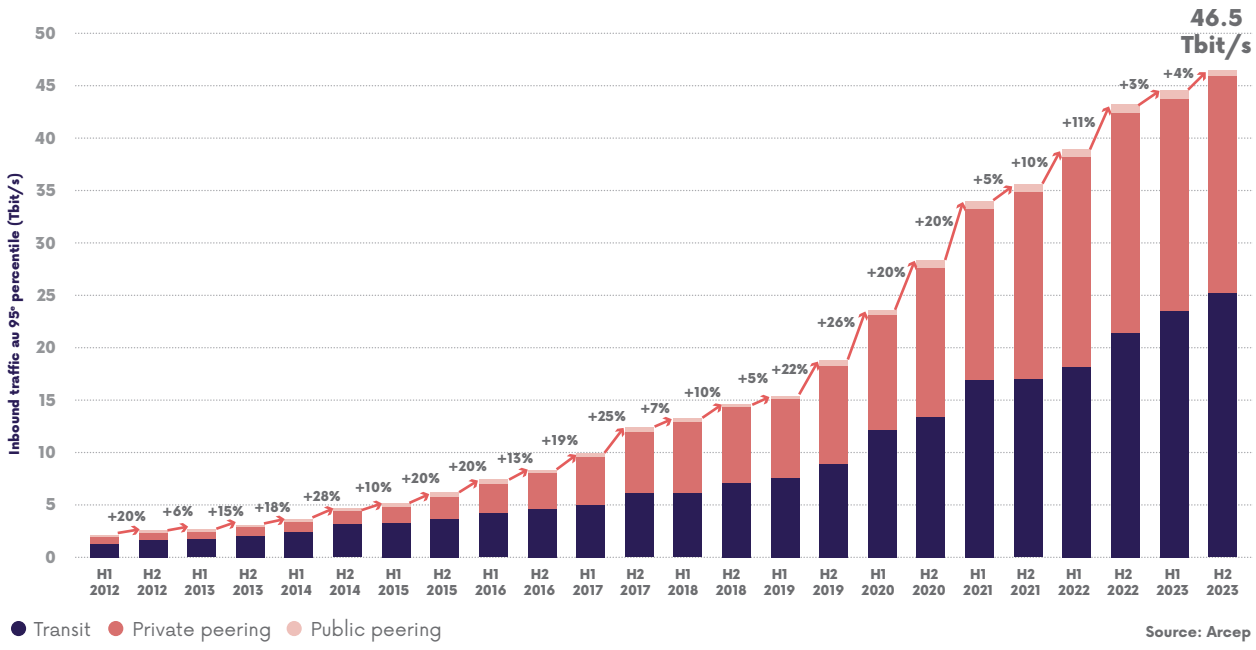
2. STATE OF INTERCONNECTION IN FRANCE IN 2023

Arcep therefore has technical and financial data on interconnection from the first half of 2012 to the second half of 2023. For confidentiality reasons, the published findings[2] are only the aggregated results from the four main electronic communications operators in France.

2.1. Inbound traffic

Inbound traffic to operators' networks continues to increase substantially, reaching a total **46.5 Tbit/s at the end of 2023**. This marks a 7.6% increase in one year. This is nevertheless a smaller increase than the estimated 21% growth observed between the end of 2021 and the end of 2022.

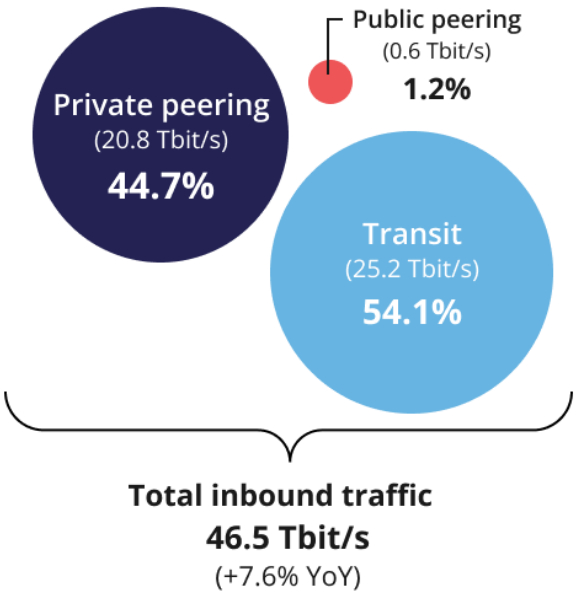
PROGRESSION OF INBOUND TRAFFIC TO THE MAIN ISPS IN FRANCE, FROM H1-2012 TO H2-2023



Source: Arcep

2 Results obtained from operators' responses to information gathering on the technical and financial conditions of data interconnection and routing, whose scope is detailed in Arcep Decision 2017-1492-RDPI.

BREAKDOWN OF INBOUND TRAFFIC AT THE INTERCONNECTION POINT, ON THE NETWORKS OF THE MAIN ISPs* IN FRANCE (END OF 2023)



[k] Bouygues, Free, Orange, SFR.

This deceleration of bandwidth consumption is consistent with the progression of mobile data traffic, which Arcep documented in its Observatory[3]. It can be attributed:

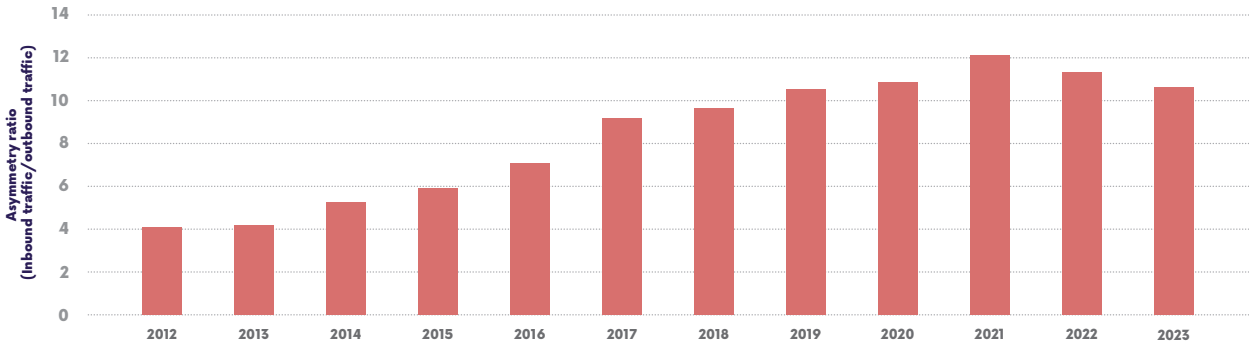
- First, to a change in demand: the 2023 Digital Barometer[4] also underscores the only slight increase in the percentage of people who subscribe to at least one video on demand (VoD) service (56%, +1 point in one year), after several years of steady increase;
- Second, to some content providers' efforts in terms of compression and traffic optimisation.

In the second half of 2023, inbound traffic on operators' networks is split chiefly between transit (around 54%) and private peering (around 45%), with a fraction being handled by public peering, i.e. at Internet Exchange Points or IXPs (around 1.2%). Transit accounts for the majority this year, whereas the division was more balanced in 2022: 48.5% private peering versus 49.5% transit (and 2% public peering).

2.2. Asymmetry between outbound and inbound traffic

The volume of outbound traffic continues to be smaller than the volume of inbound traffic, due to an asymmetry in how the internet is used: end users receive more data than they send. **The asymmetry ratio between inbound and outbound traffic on the main ISPs' networks nevertheless continues to narrow year on year:** in 2023, for 1 Gbit/s of outbound traffic there was 10.6 Gbit/s of inbound traffic, compared to a ratio of 1 to 11.3 in 2022. This change can be the result of the smaller increase in inbound traffic described above (inbound traffic increasing less) and to a possible increase in outbound traffic from the ISP's network.

CHANGE IN THE ASYMMETRY RATIO BETWEEN INBOUND AND OUTBOUND TRAFFIC AT THE INTERCONNECTION LEVEL FOR THE MAIN ISPS IN FRANCE BETWEEN 2012 AND 2023



Source: Arcep

3 See the figures from Arcep's Observatory of electronic communications markets in France.
4 Arcep, Arcom, CGE, ANCT, Digital Market Barometer 2023

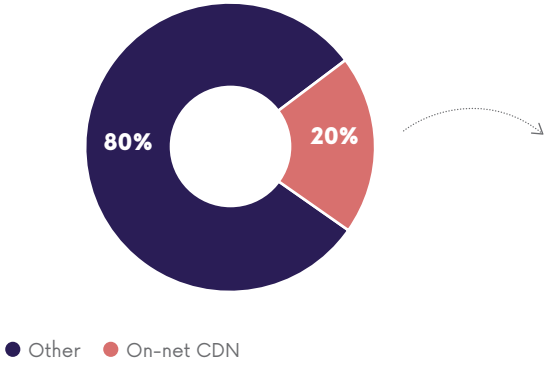
In addition to the above-mentioned analyses about the lesser increase in inbound traffic, several assumptions can be made to explain this outbound traffic dynamic, which was also noted by the firm Sandvine in its latest report[5]. The first would be advances in content distribution methods, which could rely more on outbound traffic using technologies akin to peer-to-peer. A second assumption would be the publication of videos on social media networks: end users may be uploading more videos to the Web, which would up outbound traffic from operators' networks.

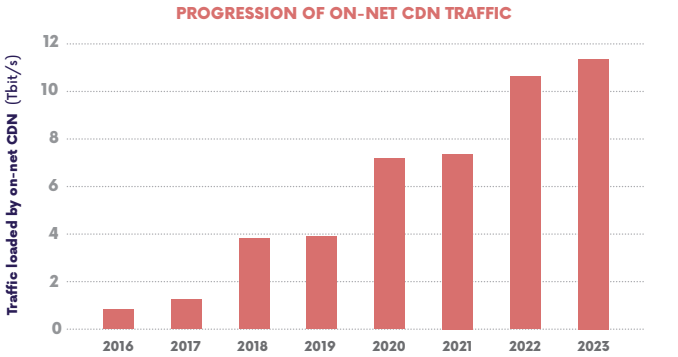
2.3. The different interconnection methods

As internet usage became concentrated around the consumption of content, it became crucial to ensure that said content is relayed seamlessly. This led to the advent of a new interconnection method: on-net content delivery networks, or CDN (see inset), which the Authority has been observing since 2016. To better understand on-net CDN's role in relaying traffic to end users[6], the following graph shows, first, an estimate of their share of traffic in the second half of 2023 and, second, the progression of traffic being loaded onto operators' networks by these content delivery networks.

On-net CDNs continue to grow, with a volume of traffic they loaded onto operators' networks estimated at 11.37 Tbit/s by the end of 2023, versus 10.62 Tbit/s at the end of 2022. Their traffic share is holding steady (20%, as it was last year).

DISTRIBUTION OF TRAFFIC TO THE CUSTOMERS OF THE MAIN ISPS IN FRANCE BY INTERCONNECTION TYPE (END OF 2023)





Source: Arcep

ON-NET CDN, A NOW WELL-ENTRENCHED INTERCONNECTION METHOD

CDN (Content Delivery Networks) are systems that create the ability to **optimise the transmission of content** to end users, thanks to a network of cache servers for storing content temporarily, located close to users where demand exists. This approach helps to reduce latency (content is loaded more rapidly) and to balance the load (requests are distributed between the different cache servers) when demand is high.

A distinction needs to be made between **third-party CDN and on-net CDN.** The former are operated by specialised companies such as Cloudflare, Akamai and Lumen, that have a network of cache servers deployed across the globe. They access ISPs' networks like any other network, via interconnection. On-net (i.e. internal) CDN, are cache servers hosted on the ISP own network (naturally, through an agreement with that ISP): they are therefore located in proximity to end users. This, for instance, is the system used by Netflix and Google[1].

Arcep has been collecting data on on-net CDN since 2016, to be able to factor in this new type of interconnection. Between 2016 and 2023, on-net CDN traffic increased more than tenfold, going from 0.82 Tbit/s to 11.37 Tbit/s.

1 Cf. Arcep, 2024, *Barometer of data interconnection.*

5 Sandvine, 2024, *The Global Internet Phenomena report*.

6 Factoring in the commends made in the inset, "What is the link between French users' digital habits and interconnection traffic?"

WHAT IS THE LINK BETWEEN FRENCH USERS' DIGITAL HABITS AND INTERCONNECTION TRAFFIC?

Traffic measured by ISPs at the interconnection point is influenced by French users' **digital habits,** but is not an exact representation of it.

The **interconnection point** is the location where traffic is exchanged with ISPs' partners. It is not located on the end users' device. The traffic, which is measured upon its arrival into the ISP's network, does not enter solely to meet the needs of end users: a (relatively marginal) percentage of exchanged data can be relayed over an ISP's network to reach another destination, e.g. another ISP.

As an adjunct to the information obtained for the Barometer of data interconnection, Arcep collects and publishes other data that can help provide a more detailed understanding of how the internet is used, and particularly **mobile data consumption,** as part of the Observatory of Electronic Communications Markets in France. The annual Digital Barometer, which is produced in partnership with Arcom, CGE and ANCT, delivers a qualitative snapshot of digital device ownership and usage in France.

2.4. Traffic source

Based on data collected from operators, Arcep can estimate the proportion of traffic originating from certain content providers (FCA) and content delivery or hosting actors, particularly third-party CDNs, when they are identifiable, relative to the total volume observed at interconnection points. The graph on page 17 thus presents an **aggregation of traffic from the main ISPs distributed according to the partners with whom the operators are interconnected.**

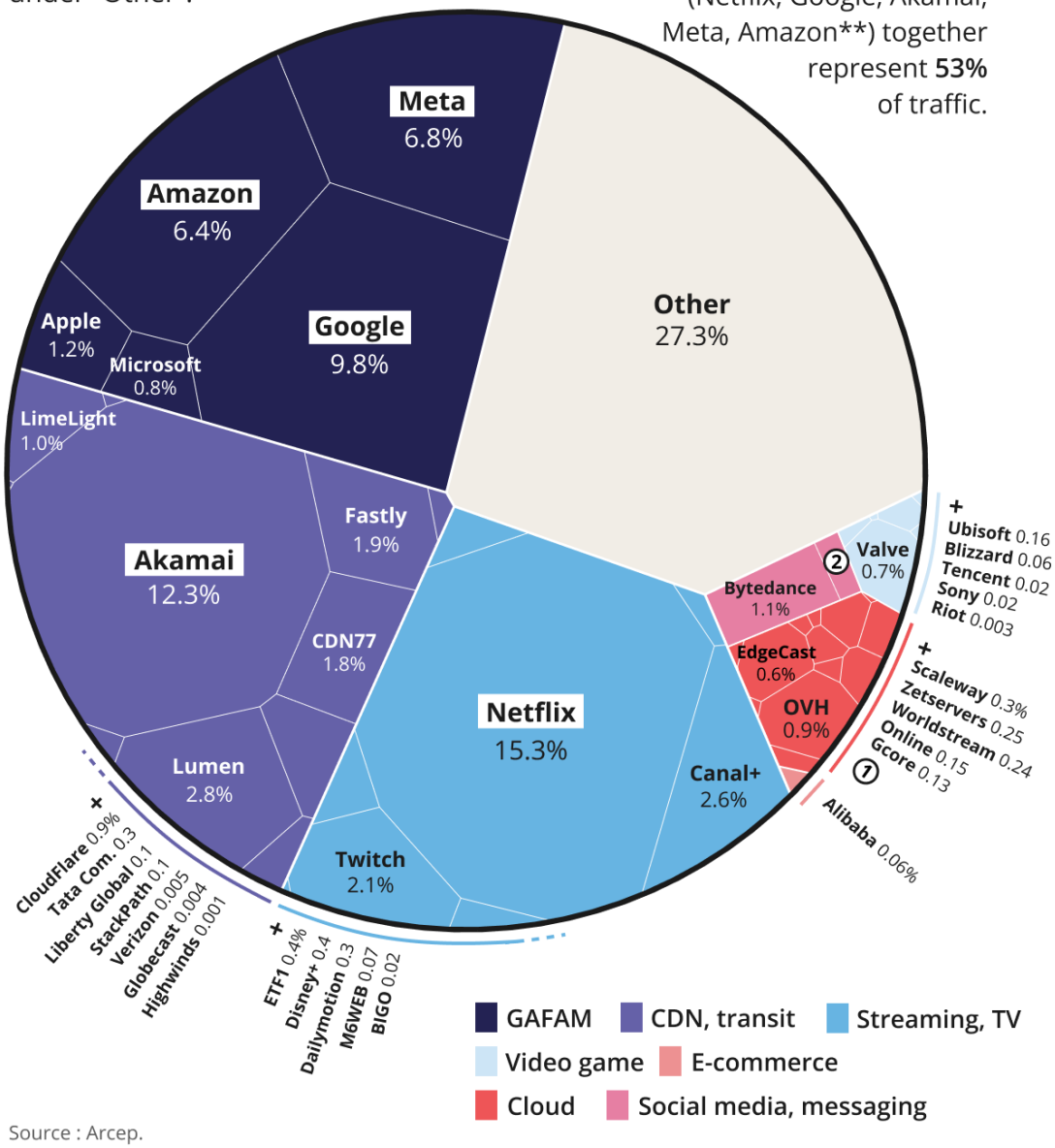
In 2023, Netflix remains the actor with the highest traffic share, estimated at 15.3%. This share has notably decreased from 19.7% at the end of 2022. The percentage generated by Akamai – a CDN specializing in providing cache servers to third parties – has increased by just over 3 points compared to 2022, reaching 12.3% at the end of 2023. The significant growth in Akamai's share could be explained by the increasing demand for video content, which is often hosted on third-party CDNs for traffic optimization reasons. The shares of Google and Meta have respectively declined by 0.8 points and 1.3 points compared to the end of 2022, standing at 9.8% and 6.8% of incoming traffic at the end of 2023. Amazon's share has slightly decreased to 6.4% in 2023 from 7% at the end of 2022. The share of Twitch – owned by Amazon – has dropped from 3% at the end of 2022 to 2.1% at the end of 2023. Beyond these five actors, it is worth noting the increase in the share of Bytedance, the parent company of TikTok, whose volume has doubled since 2021.

While this visualization of traffic from its origin gives an idea of its composition in France, only content actors **directly connected to the interconnection points of internet service providers** are represented. Some service providers, although heavily used by user devices, are not represented because their traffic is routed through intermediaries (CDNs, transit providers, etc.) to the ISPs' interconnection points. For example, audiovisual actors such as TF1, M6, France TV, or platforms like Disney Plus, route some or all of their traffic through CDNs or other technical intermediaries, which explains the low share of traffic attributed to these actors in this graph. Content actors represented in the graph may also route part of their traffic through technical intermediaries and thus be associated with a relatively smaller share of traffic compared to their actual usage at the user terminal level.

BREAKDOWN BY ORIGIN OF TRAFFIC TO CUSTOMERS OF THE MAIN ISPS IN FRANCE (END OF 2023)

Percentage of inbound traffic at the interconnection point from 47 transport or content production companies, as reported by the main ISPs at the end of 2023. The remaining traffic is shown under "Other".

Top 5 companies (Netflix, Google, Akamai, Meta, Amazon**) together represent **53%** of traffic.



Source : Arcep.

* Bouygues, Free, Orange, SFR. ** 53% including Twitch, property of Amazon.

① **M247** 0.07% ; **Dropbox** 0.04 ; **Dstorage** 0.03 ; **LeaseWeb** 0.03 ; **SdV Plurimédia** 0.003 ; **Mediactive** 0.002.

② **Telegram** 0.2%.

3. STATE OF INTERCONNECTION IN EUROPE IN 2023

If Arcep has been collecting data on interconnection since 2012, it remained an exception in the EU up to 2023. Debates over the future of connectivity and network financing revealed the need to monitor the technical-economic relationships between internet players across the EU.

The Authority was able to lend its methodological expertise and experience to the creation of the data collection campaign that BEREC carried out across the EU, when preparing its report on interconnection practices. Through this exercise, BEREC is elaborating a state of the art on European operators' interconnection practices (relationships between the different parties, monitoring of the different types of interconnections), as part of the mandate entrusted to it by EU Regulation 2015/2120. The purpose of this report is to identify new market trends to help complete BEREC's preliminary assessment, which will be published for consultation in June 2024.

The work performed by BEREC could provide additional insights with respect to the European Commission's proposals on IP interconnection, set forth in its recent White Paper[7] on the future of digital infrastructure. It mentions the possibility of giving European regulators additional competencies to monitor the interconnection market.

EUROPEAN WORK ON THE LARGE CONTENT AND APPLICATION PROVIDERS AND THEIR RELATIONSHIPS WITH TELECOM OPERATORS

In addition to IP interconnection, Arcep and BEREC have been actively working on the **various technical and trade relationships between content and application providers (CAPs) and telecom operators,** to fuel and enable informed discussions on the matter across the EU. Arcep is co-chairing BEREC's work on large content and application (CAP) providers' entry into the markets for electronic communications networks and services[1].

The draft report, which was published for a public consultation that ran from 13 March to 26 April 2024, aims to identify the parts of the internet in which large CAPs are investing, and to analyse their strategies for moving up the value chain, their business models and their relationships with traditional ECN/ECS providers in terms of competition, cooperation and interdependence. The draft report thus provides an overview of the impact that large CAPs are having on electronic communications networks and certain services in Europe.

Relationships between large CAPs and electronic communications operators are multifaceted. Two kinds of players can form partnerships to provide joint or complementary services (e.g. operators provide broadband internet access services, and CAP content and applications; set-top boxes deliver both internet access and access to Over-The-Top or voice assistant services). Operators and CAPs can also compete directly, notably when it comes to voice and messaging services, the supply of cloud services, content distribution networks (CDN), submarine cables, etc.

In its report, BEREC analyses these different dynamics through **three case studies:** on CDN, submarine cables and internet relay services that are akin to virtual private networks (VPN). The analysis reveals how large CAPs have deployed their own physical infrastructures (e.g. CDN, data centres etc.) and network infrastructure (e.g. submarine cables), and are now internalising a large portion of the services that they previously contracted from telecoms operators (e.g. international transit).

The reports also details some of the **restrictions** imposed by operating system providers that affect, or could affect, telecoms operators' ability to provide access to the internet or to certain services.

The final version of the report will be published by autumn 2024.

1 BEREC, Draft BEREC Report on the entry of large content and application providers into the markets for electronic communications networks and services, 2024.

7 European Commission, 21 February 2024, White Paper - How to master Europe's digital infrastructure needs?

Lexicon

Afnic (Association française pour le nommage internet en coopération)
France's domain name registry. A non-profit organisation (under France's law of 1901) whose mandate is to manage top-level domain names in France (.fr), Reunion (.re), France's southern and Antarctic territories (.tf), Mayotte (.yt), Saint-Pierre-et-Miquelon (.pm) and Wallis-et-Futuna (.wf).

API (Application Programming Interface)
Application Programming Interface that enables two systems to interoperate and talk to one another without having been initially designed for that purpose. More specifically, a standardised set of classes, methods or functions through which a software programme provides services to other software.

NRA (National Regulatory Authority)
an organism or organisms that a BEREC Member State mandates to regulate electronic communications.

BEREC (Body of European Regulators for Electronic Communications)
independent European body created by the Council of the European Union and the European Parliament, and which assembles the electronic communications regulators from the 27 European Union Member States.

CDN *(Content Delivery Network)*
Internet Content Delivery Network.

On-net CDN
CDN located directly in an ISP's network.

Codec
a device or computer program that encodes or decodes a digital data stream, for transmission or storage purposes.

Cross-traffic
the traffic generated during a QoS and/or QoE test by an application other than the one being used to perform the test, either on the same device or on another device connected to the same box. Cross-traffic decreases the bandwidth available for the test.

Speed
Also referred to as throughput. Quantity of digital data transmitted within a set period of time. Connection speeds or bitrates, are often expressed in bits per second (bit/s) and its multiples: Mbit/s, Gbit/s, Tbit/s, etc. It is useful to draw a distinction between the speed at which data can be:
- received by a piece of terminal equipment connected to the internet, such as when watching a video online or loading a web page. This is referred to as download or downlink speed;
- sent from a computer, phone or any other piece of terminal equipment connected to the internet, such as when sending photos to an online printing site. This is referred to as upload or uplink speed.

DNS (Domain Name System)
mechanism for translating internet domain names into IP addresses.

Dual stack
assigning both an IPv4 address and an IPv6 address to a device on the network.

ISP
Internet Service Provider.

CAP
content (web pages, blogs, videos) and/or application (search engine, VoIP applications) providers.

FttH (Fiber to the Home) network
very high-speed electronic communications network, where fibre is pulled right into the customer's premises.

HTTP (Hypertext Transfer Protocol)
client-server communication protocol developed for the World Wide Web.

HTTPS: HTTP Secured thanks to the use of SSL (secure socket layer) or TLS (transport layer security) protocols.

iOS
mobile operating system developed by Apple for its mobile devices.

IP (Internet Protocol)
communication protocol that enables a single addressing service for any device used on the internet. IPv4 (IP version 4) is the protocol that has been used since 1983. IPv6 (IP version 6) is its successor.

IPv6-enabled
device or connection that actually transmits and receives traffic using IPv6 routing, either thanks to activation by the customer or activation performed by the operator.

IPv6-ready
device or connection that is compatible with IPv6, but on which IPv6 is not necessarily activated by default.

IXP (Internet Exchange Point), or GIX (Global Internet Exchange)
physical infrastructure enabling the ISPs and CAPs connected to it to exchange internet traffic between their networks thanks to public peering agreements.

NAT
Network Address Translation mechanism for remapping one IP address space to another, used in particular to limit the number of public IPv4 addresses being used.

OS (Operating System)
software that runs a peripheral device, such as Windows, Mac OS, Linux, Android or iOS.

Peering
the process of exchanging internet traffic between two peers. A peering link can be either free or paid (for the peer that sends more traffic than the other peer). Peering can be public, when performed at an IXP (Internet Exchange Point), or private when over a PNI (Private Network Interconnect), in other words a direct interconnection between two operators.

Network termination point
the physical location at which a user gains access to public electronic communications networks.

QoS (Quality of Service): in Chapter 1, quality of service on the internet as measured by "technical" indicators such as download or upload speed, latency and jitter. The term QoS is often used to refer to both technical quality and quality of experience (QoE).

RFC (Request For Comments): official memorandum that describes the technical aspects and specifications that apply to the working of the internet or to different computer hardware.

Specialised service: electronic communication service(s) that are distinct from internet access services, and which require specific quality of service levels.

Autonomous Systems: a collection of networks managed by the same administrative entity, having relatively homogeneous routing protocols.

Web tester: tool for measuring QoS and QoE which is accessed through a website.

TLS (Transport Layer Security): used for encrypting internet exchanges and server authentication.

Transit provider: company that provides transit services.

Transit: Bandwidth that one operator sells to a client operator, providing access to the entire internet as part of paid, contractual service.

UDP (User Datagram Protocol): simple, connectionless (i.e. no prior communication required) transmission protocol, which makes it possible to transmit small quantities of data rapidly. The UDP protocol is used on top of IPv4 or IPv6.

VoIP (Voice over IP): Technology for relaying voice calls over IP-compatible networks via the internet.

VPN (Virtual Private Network): Inter-network connection for connecting two local networks using a tunnel protocol.

WAN (Wide Area Network): in this report, WAN refers to the internet network, as opposed to a LAN (local area network).

Wehe: Android and iOS application, developed by Northeastern University in partnership with Arcep, to detect traffic management practices that are in violation of net neutrality rules.

Wi-Fi: wireless communication protocol governed by IEEE 802.11 group standards.

xDSL (Digital Subscriber Line): electronic communications technologies used on copper networks that enable ISPs to provide broadband or superfast broadband internet access. ADSL2+ and VDSL2 are the most commonly used xDSL standards in France for providing consumer access.

Zero-rating: a pricing practice that allows subscribers to use one or more particular online applications without the traffic being counted against their data allowance.

3GPP: The 3rd Generation Partnership Project (3GPP) is a collaboration between standardization and normalization bodies that develops technical specifications for mobile networks.

4G: the fourth generation of mobile telephony standards. It is defined by 3GPP Release 8 standards.

5G: the fifth generation of mobile telephony standards. It is defined by 3GPP Release 15 standards.

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ARCEP, NETWORKS AS A COMMON GOOD

Internet, fixed and mobile telecom, postal and print media distribution networks constitute the “Infrastructures of freedom”. Freedom of expression, freedom to communicate, freedom to access knowledge and to share it, but also freedom of enterprise and innovation, which are key to the country’s ability to compete on the global stage, to grow and provide jobs.

Because it is essential in all open, innovative and democratic societies to be able to enjoy these freedoms fully, national and European institutions work to ensure that these networks develop as a “common good”, regardless of their ownership structure, in other words that they meet high standards in terms of accessibility, universality, performance, neutrality, trustworthiness and fairness.

Democratic institutions therefore concluded that independent state intervention was needed to ensure that no power, be it economic or political, is in a position to control or hinder users’ (consumers, businesses, associations, etc.) ability to communicate with one another.

The electronic communications, postal and print media distribution regulatory Authority (Arcep), a neutral and expert arbitrator with the status of quasi autonomous non-governmental organisation, is the architect and guardian of communication networks in France.

As network architect, Arcep creates the conditions for a plural and decentralised network organisation. It guarantees the market is open to new players and to all forms of innovation, and works to ensure the sector’s competitiveness through pro-investment competition. Arcep provides the framework for the networks’ interoperability so that users perceive them as one, despite their diversity: easy to access and seamless. It coordinates effective interaction between public and private sector stakeholders when local authorities are involved as market players.

As network guardian, Arcep enforces the principles that are essential to guaranteeing users’ ability to communicate. It oversees the provision of universal services and assists public authorities in expanding digital coverage nationwide. It ensures users’ freedom of choice and access to clear and accurate information, and protects against possible net neutrality violations. From a more general perspective, Arcep fights against any type of walled garden that could threaten the freedom to communicate on the networks, and therefore keeps a close watch over the new intermediaries that are the leading Internet platforms.

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