

REPORT ON IP INTERCONNECTION IN THE INTERNET IN SPAIN - 2024

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REPORT ON IP INTERCONNECTION IN THE INTERNET IN SPAIN – 2024

(INF/DTSA/171/25)

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Madrid, 23 July 2025

In accordance with the function established in article 6 of Law 3/2013, of 4 June, creating the CNMC, the Regulatory Oversight Chamber issues the following report:

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1. INTRODUCTION AND PURPOSE OF THE REPORT

IP interconnection in the Internet analysed in this report refers to the technical-economic relationship established between the different players that make up the Internet in order to connect their networks and exchange traffic for the provision of services. Through this interconnection, the global mesh of interconnected networks that forms the Internet is configured, enabling connected end-users to communicate with each other.

The purpose of this report is to describe the status, practices and services used by the various active players active in the Internet in Spain to interconnect their IP networks.

2. BACKGROUND

2.1. Main players involved

IP interconnection on the Internet has undergone major changes linked to the development of new services and applications and the resulting increase in network traffic. This growth has also led to the emergence of new players that have had an impact on the very structure of the Internet, as well as on the way they interconnect and interact with each other.

At present, the following roles can be distinguished:

1. Content and application providers (usually referred to as CAPs): provide content to end users.
2. Data centres: facilities that house servers that store content managed by third parties, whether CAPs or end-users, and networking equipment that enables the implementation of interconnections.
3. Content Delivery Networks (CDNs): A CDN is a collection of servers optimised for content distribution, located in different locations, that replicate and distribute digital content over the IP networks to which they connect in order to serve end-user requests from a nearby location. These servers are located in both public and private Internet data centres, as well as integrated into operators' networks, known as on-net CDNs.
4. Internet Exchange Points (IXPs): facilities, located in a data centre, with the necessary network infrastructure that allows the players present to interconnect directly and exchange traffic.
5. Internet Service Providers (ISPs): network operators that provide Internet access services to end users.

6. Transit operators: operate and manage backbone networks (national or international) that enable interconnection and traffic transmission between players and networks located across different geographical areas.

The different players have also evolved in the roles and types of functions performed. Thus, large CAPs have deployed their own infrastructures and CDNs to distribute their content; transit operators have leveraged their infrastructures to deploy their own CDNs and store third-party content; CDN managers have begun deploying infrastructures to connect their servers; while ISPs have also become content creators through their own platforms and operate CDNs. The Body of European Regulators for Electronic Communications (BEREC) has published several reports on the evolving roles of the different players in the Internet ecosystem and their relationships¹.

2.2. Other Studies

IP interconnection in the Internet domain has traditionally operated as an unregulated market without any intervention². However, IP interconnection has been regularly analysed by BEREC in successive reports in 2012³, in 2017⁴, and most recently in 2024⁵.

The first BEREC report in 2012 concluded that the evolution of interconnection had managed to adapt to various changes, whether in technology, in the relative market power of some players, in business models or in traffic demand, all without the need for regulatory intervention. The 2017 report confirmed that the trends and developments observed were continuing to take place and that the market remained highly competitive, as shown by the continuing downward trend in

¹ BoR (22) 167, BEREC Report on the Internet Ecosystem, 8 December 2022. (<https://www.berec.europa.eu/en/document-categories/berec/reports/berec-report-on-the-internet-ecosystem>), and BoR (24) 139, BEREC Report on the entry of large CAPs into the markets for ECN and services, 3 October 2024. (<https://www.berec.europa.eu/en/all-documents/berec/reports/berec-report-on-the-entry-of-large-content-and-application-providers-into-the-markets-for-electronic-communications-networks-and-services>)

² Not to be confused with the interconnection of two operators' networks for the provision of publicly available telephone service and the termination of voice calls.

³ BoR (12) 130, An assessment of IP interconnection in the context of Net Neutrality, December 2012. [https://www.berec.europa.eu/sites/default/files/files/document_register_store/2012/12/BoR_\(12\)_130_IP_IC_Assessment_NN_Report_publication2.pdf](https://www.berec.europa.eu/sites/default/files/files/document_register_store/2012/12/BoR_(12)_130_IP_IC_Assessment_NN_Report_publication2.pdf)

⁴ BoR (17) 184, BEREC Report on IP-Interconnection practices in the Context of Net Neutrality, October 2017. [https://www.berec.europa.eu/sites/default/files/files/document_register_store/2017/10/BoR_\(17\)_184_BEREC_IP-IC_report_clean.pdf](https://www.berec.europa.eu/sites/default/files/files/document_register_store/2017/10/BoR_(17)_184_BEREC_IP-IC_report_clean.pdf)

⁵ BoR (24) 177, BEREC Report on the IP Interconnection ecosystem, 5 December 2024. <https://www.berec.europa.eu/en/all-documents/berec/reports/berec-report-on-the-ip-interconnection-ecosystem>

prices for transit and CDN services. However, it also found that this market was under strong pressure from different players and services. In the latest report published in 2024 there continues to be a downward trend in prices and costs for IP interconnection services due to technological developments and the competitive situation in the IP interconnection market. The report also describes other developments and practices observed.

Within the EU, regulatory authorities such as ARCEP⁶ have been regularly monitoring the state of IP interconnection in France since 2012⁷. ARCEP periodically collects data on the technical and economic characteristics governing interconnection in France in order to understand this market and to have sufficient data to be able to act if conflicts arise between the different players in this market. It also publishes an annual report⁸.

Other regulatory authorities have also published reports on the IP interconnection market, such as the one approved in 2021 by ACM for the Netherlands⁹ and the one in February 2022 for the German regulator BNetzA¹⁰.

2.3. Request for information

In order to understand the state and evolution of the IP interconnection market in the Internet domain in Spain and to be able to act, if necessary, in the relations between the various players involved in conflicts and disputes, as well as to have data and information that allow reasoned and justified assessments to be made in the different regulatory debates in which IP interconnection is involved, this Commission will carry out an annual data collection among the players participating in this market and related to the provision of Internet access services and the supply of content to Spanish users.

For this purpose, in exercise of the powers recognised in article 9 of Law 11/2022, of 28 June, the General Telecommunications Act (LGTel), in August 2024, an information request was sent to a group of companies involved in IP interconnection to perform measurements during the month of September and to submit the data on the interconnections implemented by 31 October 2024. This request was sent to the main operators offering Internet access services in

⁶ French national regulatory authority.

⁷ Decision No. 2012-0366 of the French Regulatory Authority for Electronic Communications and Postal Services (ARCEP), dated 29 March 2012, regarding the establishment of a data collection on the technical and pricing conditions of interconnection and data routing.

⁸ "The State of the Internet in France", available at https://en.arcep.fr/uploads/tx_gspublication/ARCEP-RA2025-TOME_3-UK-Norme_A.pdf

⁹ <https://www.acm.nl/en/publications/ip-interconnection-market-study-2021>

¹⁰ <https://www.bundesnetzagentur.de/EN/Areas/Telecommunications/Peering/start.html>

Spain¹¹, as well as to the main players operating on the Internet in Spain: content providers, content delivery network (CDN) providers and transit service providers.

3. AUTHORITY AND POWERS

The CNMC's authority to issue this report derives from the provisions of article 6 of Law 3/2013, of 4 June, establishing the Spanish National Markets and Competition Commission (LCNMC)¹², under which it is tasked with supervising and controlling the proper functioning of electronic communications markets. The CNMC's power are developed by the LGTel - in particular see Article 100, and in particular points (e), (j) and (v)¹³.

This legal authority is established for the purpose of understanding electronic communications markets and promoting effective and sustainable competition in those markets, duly taking into account the variety of competitive conditions and consumers in different geographical areas, and ensuring that there is no distortion or restriction of competition in the operation of electronic communications networks or in the provision of electronic communications services, as well as the achievement of other objectives set out in article 3 of the LGTel.

By virtue of the provisions of articles 20.1 and 21.2 of the LCNMC and articles 8.1 and 14.1.b) of the Organic Statute of the CNMC, approved by Royal Decree 657/2013, of 30 August, the Regulatory Oversight Chamber of the CNMC is authorised to issue this report.

4. CONCEPTS LINKED TO IP INTERCONNECTION

4.1. Networks and routing protocols

Network interconnection allows end-users located on one network to exchange data/traffic with users on the other network. Networks are made up of a set of interconnected nodes called routers, which are responsible for routing traffic through the network until it reaches the destination device identified by its IP address.

The routing of traffic from its source to its destination through the entire network is the result of the set of individual routing decisions made by each router as it

¹¹ Those with a turnover exceeding €1m in 2023 according to data in the CNMC's sector economic report.

¹² <https://www.boe.es/eli/es/l/2013/06/04/3/con>

¹³ (e) to impose network interconnection obligations on operators controlling access to end-users, to the extent necessary to ensure end-to-end connectivity; (j) to resolve disputes in electronic communications markets; and (v) to assess and monitor market configuration and competition issues in relation to open internet access.

receives traffic and relays it to one of the neighbouring nodes to which it is connected. In order to make these decisions, routers have routing tables. Each router builds its table from the information received from the other routers about the location of the IP addresses. This is done by means of routing protocols.

The routers in two interconnected networks must exchange this information in order to determine the location of the IP addresses within each network., The routing protocol used in the interconnection of IP networks on the Internet to exchange information between the networks is BGP (Border Gateway Protocol) and the exchanged information is progressively propagated and incorporated by all routers into their routing tables.

4.2. Autonomous Systems

In the context of Internet and IP interconnection, an Autonomous System (AS) corresponds to a network or group of networks, consisting of the aforementioned *routers*, with its own independent routing policy. Typically, each AS - or sometimes several ASes - is managed and administered by a single organisation, such as an ISP, a technology company, but it can also be a university, an administration or a large company (bank, electricity sector, etc.). Therefore, when the nomenclature AS is used in this report, it can also be equated to an organisation, such as an operator, CAP, CDN, etc.

Each AS is uniquely identified within the Internet by an Autonomous System Number (ASN)¹⁴ assigned by the IANA¹⁵ or the various regional registries. The ASNs assigned to different organisations can be found on the IANA or Regional Internet Registry for Europe (RIPE).

The interconnection of ASes forms the Internet as a network of interconnected networks.

4.3. IP Interconnection Services: Transit and Peering

4.3.1. Transit

Most ASes cover a limited geographical area. Consequently, in order to be able to reach all the other ASes that are part of the Internet, most ASes will have to interconnect with another AS that has a broader scope and deliver traffic to it so that this second AS transmits it over its network and also through its own interconnections, thus providing global connectivity to the first AS. This second

¹⁴ Initially 16 bits allowing up to 65536 AS, now increased to 32 bits.

¹⁵ The Internet Assigned Numbers Authority is the organisation responsible, among other functions, for the global coordination of Internet numbering resources, IP addresses and ASNs, initially assigning them to the Regional Internet Registries (RIRs).

AS (provider) acting as an intermediary offers a **transit service** to the first AS (customer). In the analysis section 5 it is denoted **1:E**.

In general, the transit provider transmits the traffic of the customer AS from/to any origin/destination regardless of its location, thereby providing global connectivity and allowing the customer-operator to access the entire Internet ecosystem. However, there may also be a transit service whereby the provider forwards the operator-customer's traffic to/from a destination/origin only if it is located in a certain geographical area, thereby offering connectivity and reach limited to a reduced set of AS, service known as partial transit.

When a customer AS contracts several transit providers it is referred to as “multi-homed” as opposed to “single-homed” when it contracts only one transit operator.

Because the predominant nature of Internet end-users is content consumption, traffic on transit interconnections is generally heavily unbalanced, with traffic primarily flowing from the transit provider to the customer AS, except in cases where the customer AS is specifically a content provider, where the reverse happens.

4.3.2. Peering

In addition to transit services, two ASes can directly interconnect and exchange traffic directed to/from only their own networks, including all customer ASes to which they provide transit¹⁶. This type of interconnection is known as **peering**¹⁷. In the analysis section it is denoted as **1:1**.

4.3.3. Interconnection implementations

The interconnection of the different ASes can be implemented in different ways:

- Dedicated direct links: establishing a direct physical connection between the equipment of both ASes, whether all the equipments are located in the premises of one of the ASes or in their respective premises and connected through direct links. A very common case nowadays is that multiple ASes locate their equipment in the same data centre. Thus, the existence of data centres in which multiple ASes with their equipment are present allows direct connections to different ASes to be made in a single location, thus simplifying and reducing the cost of implementation.

¹⁶ In a peering interconnection, no traffic is exchanged from/to third-party ASes with which a peering relationship also exists, as this would imply that these third-party ASes would transit traffic through the network to the other ASes interconnected via peering.

¹⁷ Derived from the English term *peers*, meaning between equals or at the same level.

- **Shared infrastructure:** Neutral Points or Internet Exchange Points (IXPs) are facilities that share internal network structures intended for interconnection and traffic exchange between the ASes present. In this case the different ASes are connected to a shared network that facilitates connectivity between their respective equipment. Thus, interconnection with multiple different AS can be achieved through a single physical connection to this shared network.

When the interconnection between two *peering* ASes is established through dedicated physical connections between their respective equipment, it is referred to as **private peering**. When the peering interconnection between two ASes is carried out via the shared network of an IXP, it is referred to as **public peering**.

Similarly, in the case of public *peering*, i.e. when the shared network at an IXP is used to interconnect with other ASes, a distinction can be made between bilateral or multilateral relationships. In the first case, although the same shared Ethernet network is used, bilateral relationships are established with each AS for the exchange of routing information using the BGP protocol. In the second case, in addition to using the shared Ethernet network, the ASes receive the routing information of all attached ASes via a device called a *Route Server* which is responsible for redistributing it, resulting in multilateral peering.

4.3.4. Economic conditions related to transit and peering

The provision of a transit service involves a payment from the customer to the provider for the supply of connectivity and traffic transmission. The transit service is usually billed according to the capacity in Mbit/s¹⁸, normally calculated as a 95th percentile¹⁹ of the values measured in the month. There are different billing methods, for example: (i) a flat rate based on the maximum contracted capacity; (ii) an amount depending on the actual capacity used (metered traffic); or (iii) a combination of both a fixed charge for the contracted capacity and a separate additional charge for metered traffic exceeding the contracted capacity.

If an AS has access to all other ASes on the Internet through contracted transit services, direct *peering* interconnection between two ASes is justified if both ASes obtain savings on the transit costs necessary to exchange traffic between them.

¹⁸ In order to interconnect and receive the transit service, a connection must be established between the customer's network and the transit provider's network. Such a connection shall be based on a physical interface with a given capacity. However, the maximum contracted transit service capacity may be lower, and sometimes a minimum committed value may also be established which it will be billed, whether or it is used or not.

¹⁹ Maximum capacity or actual traffic is defined using the 95th percentile, meaning that the top 5% of measured traffic values are discarded.

Since *peering* between two ASes involves equipment/network costs for both ASes to establish a direct connection, this will be economically justified if these costs for both ASes are lower than the savings of reducing the contracted transit capacity (by establishing a direct connection, traffic is no longer exchanged between the two ASes via this paid service). This is more likely if (i) the cost of implementing the *peering* connection is very low, and (ii) the traffic exchanged between the two ASes is significant, thereby significantly reducing the required transit capacity and associated costs.

In addition to the costs of establishing the connection, setting up direct *peering* with other ASes also increases management and operational complexity due to the higher number of interconnections and links. Therefore, certain ASes make the establishment of *peering* conditional on the traffic exchanged between the two parties being significant and exceeding certain thresholds.

Typically, each AS sets out in a reference document the conditions that must be met for it to accept a *peering* relationship, known as a *peering policy*, which is usually publicly available.

Because it is the mutual benefit for both interconnected parties that justifies the establishment of a *peering* relationship, such interconnections are often agreed without payment for the traffic exchanged. In the analysis section the case in which no payment is made for interconnection is denoted with **1:1 free**.

However, the existence of a mutual benefit, as a condition for the setup of a *peering* interconnection to make sense, does not imply that the benefit is equal for both parties (e.g. because the reduction in transit costs may differ, or because the costs of establishing a direct interconnection are also different, or for other reasons). The less-benefited AS could try to negotiate to seek some additional compensation from the more-benefited AS, resulting in a payment from the latter.

With changes in Internet usage and services, the reasons for establishing *peering* between two ASes are not only related to lower transit costs, but may also involve other technical or technological reasons, quality of service and control of the traffic conditions. This makes it more likely that there will be differences in the benefits of both parties when establishing this *peering* and the less advantaged AS may try to obtain some form of payment. The existence of payments in a *peering* interconnection is known as “*paid peering*”. In the analysis section, it is denoted as **1:1 paid**.

4.4. Internet interconnection structure

As indicated above, due to the specific geographic scope/coverage of each AS and the use of transit services, not all ASes are directly interconnected with all

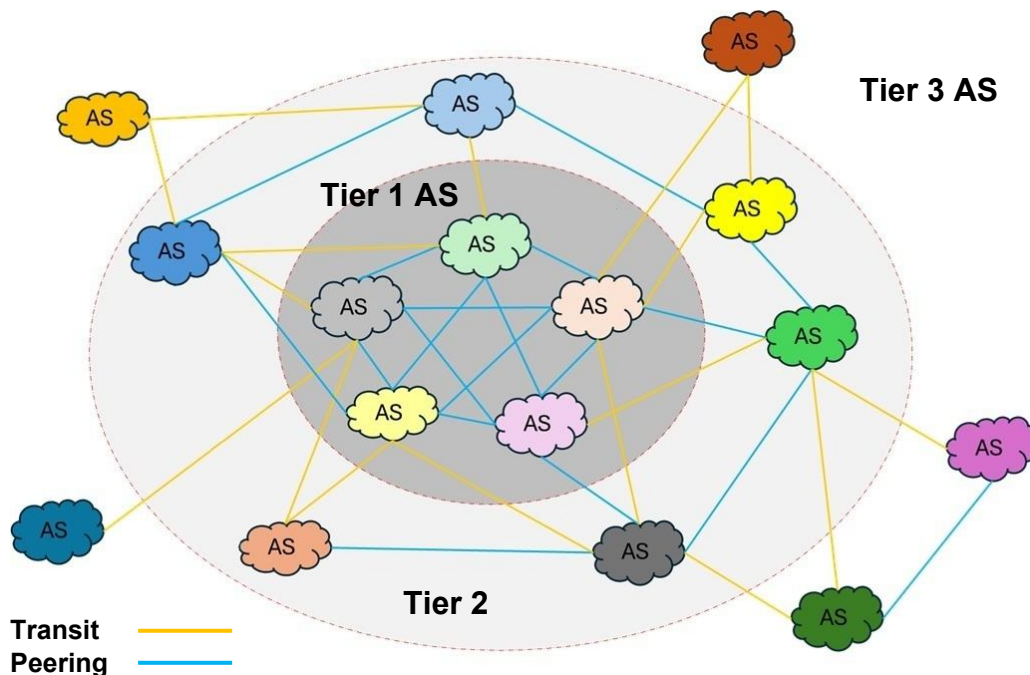
the other ASes that make up the Internet. Consequently, interconnection on the Internet adopts a hierarchical architecture. Depending on the scope and type of interconnections, ASes are categorised as Tier 1, Tier 2, Tier 3.

An AS consisting of a large international network with global reach is considered Tier 1 when it reaches and exchanges traffic with all other ASes that make up the Internet exclusively using *peering*. In other words, Tier 1 ASes can send/receive traffic to all IP addresses on the Internet without using transit services²⁰. Tier 1 ASes *peer* with each other, meaning they have interconnections across several continents.

Tier 2 ASes are considered to be those that require some degree of transit services in addition to *peering* in order to have connectivity to the entire Internet. This category of AS includes major national and international operators.

Tier 3 are those smaller ASes that base their connectivity with the rest of the ASes and the Internet almost exclusively on contracting transit services.

Figure 1. Tier 1, Tier 2 and Tier 3 structure on the Internet



Source: CNMC

²⁰ The classification of a provider as Tier 1 is conditioned by how it is viewed by other market players and especially the willingness of other Tier 1s to agree to peer with that supplier. For this reason, some providers that are sometimes classified as Tier 1 and sometimes as “almost” Tier 1, because they get far-reaching peering agreements, but still require some transit service to reach some other important ASes.

5. ANALYSIS OF IP INTERCONNECTION IN SPAIN

The following is an analysis of the data on IP interconnection on the Internet in Spain based on the information provided by the different agents in response to the CNMC's request. Various data were requested in relation to (i) direct bilateral interconnections with other players; (ii) connections at Internet Exchange Points (IXPs) intended for multilateral interconnections with multiple players via Route Servers; and (iii) CDNs deployed by third parties within an operator's networks (On-net CDNs).

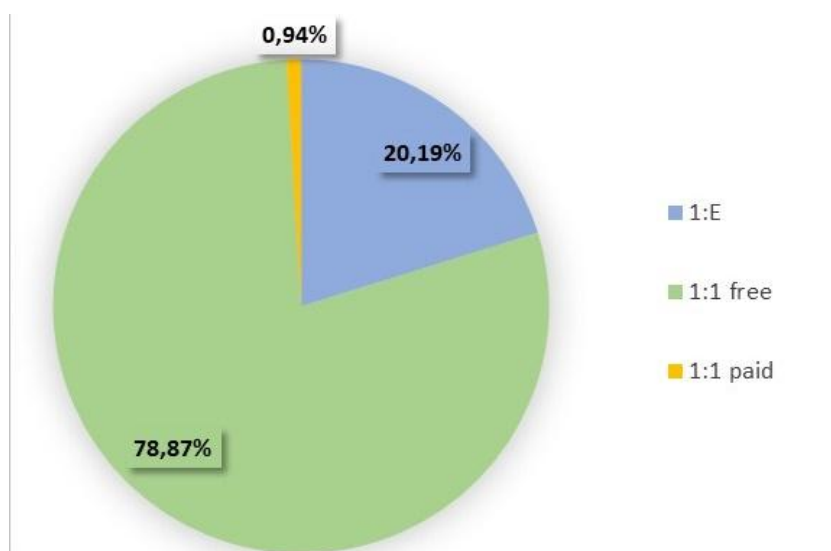
Data were received from around 40 operators, including Internet access service providers and transit operators (including Tier 1), and from a dozen major content providers and CDNs.

5.1. Use of transit and peering services by ISPs

The following analysis is based on data sent to CNMC by operators providing Internet access services that represent 99% of the fixed Internet access connections and Internet connections of mobile telephony users.

The service with the highest number of interconnections established by these ISPs is free *peering* (1:1 free), followed by transit peering (1:E) and, at a much lower level, paid *peering* (1:1 paid).

Diagram 1. Percentage of transit, free peering and paid peering by number of interconnections²¹



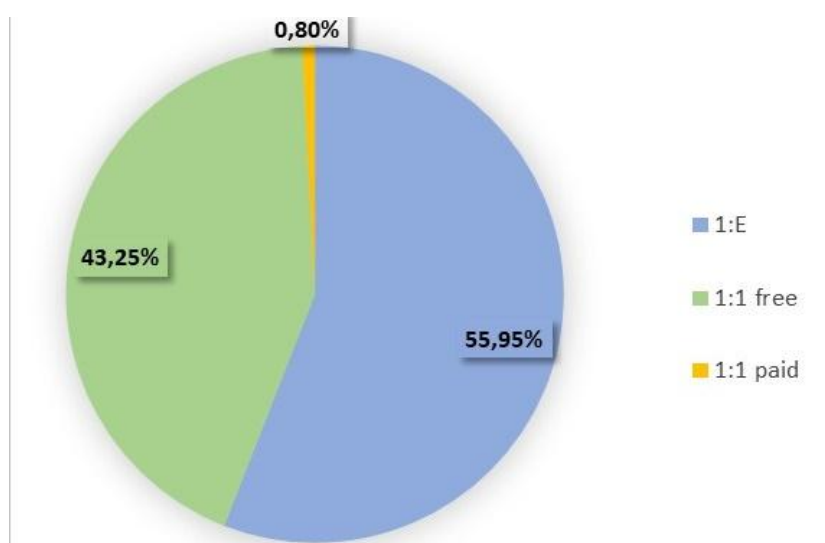
Source: CNMC

²¹ Presence at an exchange point is counted as a single interconnection even though it may include relationships with multiple ASes through a shared infrastructure.

Transit services account for a smaller number of IP interconnections, which is consistent with the fact that each operator contracts the transit service from a limited number of providers. In contrast, establishing multiple *peering* interconnections with other players reduces the need to contract transit traffic.

However, when considering the total traffic exchanged by ISPs (in both directions), rather than the number of interconnections, the share of traffic exchanged by ISPs over transit interconnections is much higher than that exchanged over *peering* interconnections, even though the number of interconnections is lower.

Diagram 2. Percentage of transit, free peering and paid peering by exchanged traffic



Source: CNMC

The relevance of the transit service from the perspective of the volume of traffic exchanged is due, among other reasons, to the fact that some of the major ISPs base their interconnection largely on the transit service provided by the company in their corporate group dedicated to offering this service (e.g. Telxius in the Telefónica group).

As a result, these ISPs directly minimise their *peering* interconnections with other players. It is this interconnection service provider that manages and implements a large part of the interconnections on behalf of the group.

This circumstance is also relevant when observing the low weight of interconnections based on *paid peering*. As already noted in previous analyses by other NRAs or BEREC, this type of service, would be more common if the

analysis focused on interconnections of subsidiaries or group companies dedicated to providing interconnection and offer transit services²².

5.2. Analysis of ISP interconnection locations

One of the aspects requested by the CNMC from Internet access service providers has been the location of interconnection points to analyse dependence inside and outside Spanish territory. Based on the data provided on the main interconnection points in ISPs' bilateral relations with third-party agents, it can be seen that practically all interconnections take place in data centres located in Spanish territory²³. Stakeholders have reported connections in 40 data centres in Spain.

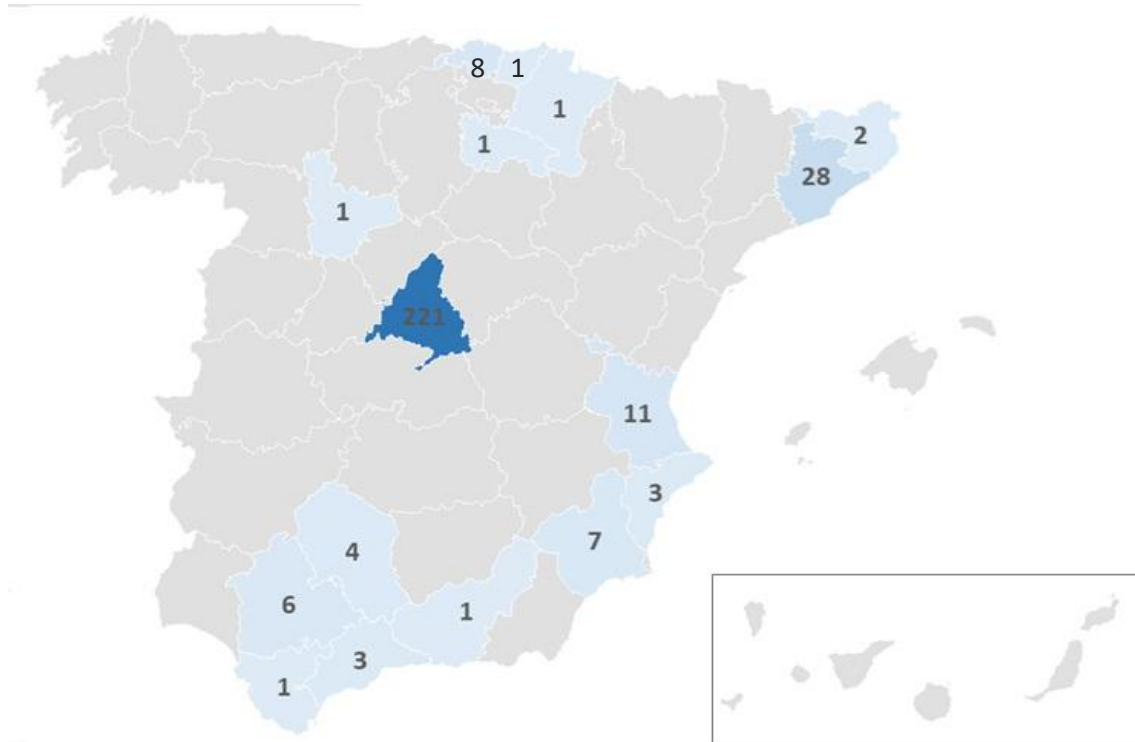
Among other reasons, this happens because, in addition to the ISPs offering Internet access services, as can be seen from the data provided, the main Internet players, including Tier 1 transit operators, CDN service providers and content and application providers, are present and open to interconnection at the different IXPs and data centres located in Spanish territory.

For the ISPs in Spanish territory that were required to provide information by the CNMC, the number of interconnection points they have in place are mostly concentrated in the province of Madrid and, to a much lesser extent, in Barcelona and other provinces such as Valencia and Bilbao.

²² In the most recent BEREC report, the percentage of *paid peering* was highest among those ISPs that combined a Tier 1 transit provider in their group (Figure 9, from BEREC "Report on the IP Interconnection ecosystem" BoR (24) 177)

²³ Although practically all of the interconnections reported are located in Spanish territory, this does not rule out the possibility of interconnections between certain agents that lead to traffic between them being routed through third parties or interconnections outside Spain. This is called "*tromboning*", where traffic originating and terminating in one country is routed through interconnections in other countries.

Diagram 3. Location of ISP interconnection points



Source: CNMC

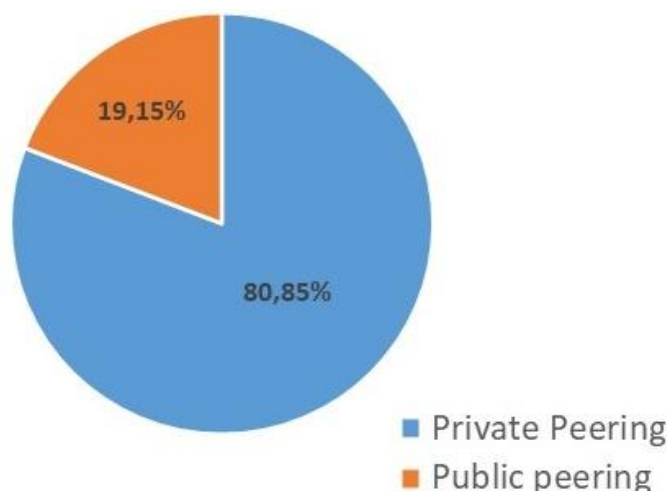
5.2.1. Public and private peering

The majority (81%) of the *peering* interconnections of the analysed ISPs are located in third-party data centres or on the premises of one of the parties. In other words, they are considered private *peering* interconnections.

Public peering, implemented at neutral internet exchange points (IXP), either through bilateral relationships or through multilateral relationships via an RS (Router Server)²⁴, represents 19% of the total peering traffic in Spain.

²⁴ See point 4.3 of the report.

Diagram 4. Percentage of traffic through private peering vs. public peering



Source: CNMC

5.3. Prices of transit services contracted by ISPs

The large differences in size of the various operators that have provided data in terms of the number of fixed and mobile Internet access connections are also reflected in the contracted transit capacities. Thus, interconnections and traffic range from a few Gbit/s up to tens of Tbit/s. In addition, as previously noted, in the case of some large ISPs, the main transit service provider is another subsidiary of the same group or unit within the parent company, some of which are Tier 1 transit operators.

As a result, the reported prices of transit services cover a wide range with significant differences between the minimum and maximum values, which are separated by an order of magnitude.

The average prices submitted are in line with the prices in the figure published on Telegeography's website²⁵ applicable in major European *hubs* such as London or Frankfurt which are around \$0.15 and \$0.17 per month per Mbps for 10 Gbit/s links, and even in some cases close to the most competitive 100 Gbit/s prices of \$0.05 per month per Mbps.

5.4. Traffic

For reasons of consistency and to allow future assessment of their evolution, the traffic associated with the different interconnection services is analysed separately (i) for the four Internet access operators with the largest market share

²⁵ <https://blog.telegeography.com/ip-transit-price-erosion-significant-regional-differences-remain>

(Digi, MasOrange, Telefónica and Vodafone)²⁶ and for the rest of the Internet access service providers that have responded to the CNMC's request.

It should be noted that although all traffic values for all operators refer to the same period (September 2024), the way traffic is measured may differ between operators²⁷, meaning that the data submitted may not be entirely homogeneous.

5.4.1. Operators with the largest market share

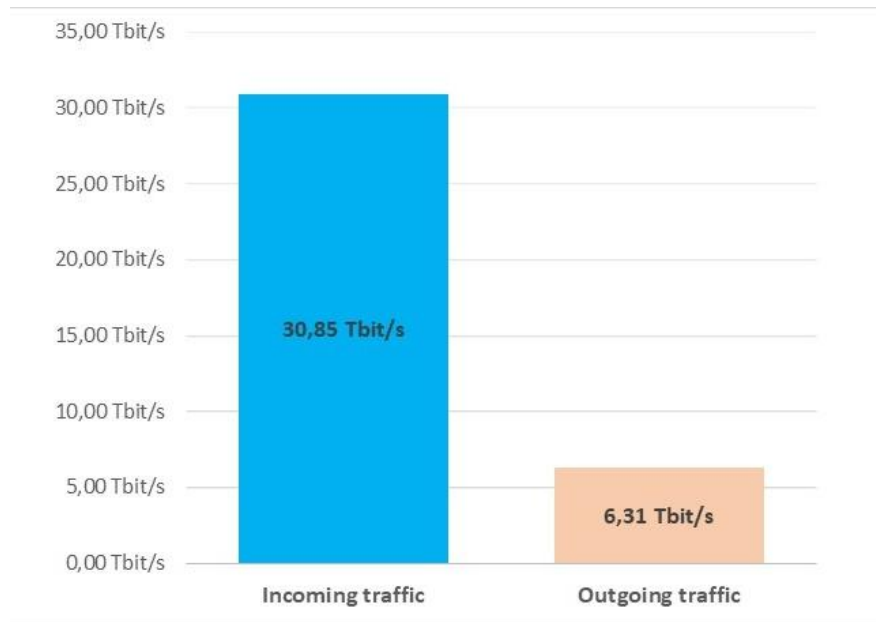
For the four operators with the largest market share (Digi, MasOrange, Telefonica and Vodafone), the total incoming traffic (from the rest of the Internet ASes to each ISP's network) in September 2024 reached 30.86 Tbit/s. Outgoing traffic (from each ISP's network to the rest of the Internet) reached 6.31 Tbit/s.

The 30.86 Tbit/s transmitted incoming is well below the total installed interconnection capacity which is slightly below 100 Tbit/s (a value which, being symmetrical interfaces, is available in both directions of communication). However, this does not prevent some individual interconnections (around 4%) from reaching occupancies above 80% of the total available capacity according to the traffic data measured in September 2024 and submitted by the operators.

²⁶ In 2024, these four operators accounted at retail level for almost 95% of fixed broadband connections and more than 95% of mobile broadband connections. For confidentiality reasons, the data are presented in aggregate form for the four operators.

²⁷ Traffic values reported by operators are traffic measurements based on the 95th percentile, or higher in some cases. Different traffic sampling intervals are also used, ranging from every 1 minute, to every 5 minutes (the most common) to every 15 minutes or even longer.

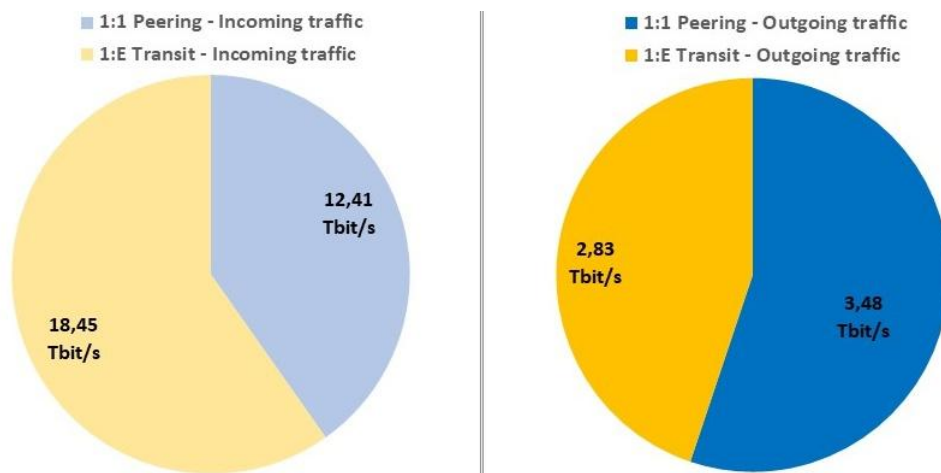
Diagram 5. Aggregated incoming and outgoing traffic from the four main ISPs²⁸.



Source: CNMC

A breakdown of incoming and outgoing traffic between the two types of interconnection service, *peering* and transit, gives the following values:

Diagram 6. Breakdown of incoming and outgoing traffic between peering and transit services for the four main ISPs.



Source: CNMC

As already noted in the section 5.1 on *Use of transit and peering services by ISPs*, the significance of the transit service in terms of the volume of traffic carried – particularly with regard to incoming traffic (18.45 Tbit/s) – is due, among other

²⁸ Includes all reported traffic, both in direct bilateral relationships and in IXPs through shared infrastructures.

reasons, to the fact that some of the main ISPs rely to a great extent on the transit service provided by another company in the group, which offers interconnection services to various subsidiaries (accounting for more than 85% of those 18.45 Tbit/s). This reliance reduces the number of direct interconnections or *peering* arrangements with other AS.

Comparing the incoming traffic to the network for each specific service (18.45 Tbit/s in transit and 12.41 Tbit/s for *peering*), both values are also much lower than the total installed capacities of each type of service which are around 60 and 40 Tbit/s respectively.

5.4.1.1. Traffic asymmetry among the four operators with the highest market shares

As might be expected given that the Internet is a network mainly dedicated to content consumption, the data provided indicate that the values of incoming traffic to ISP networks are much higher than outgoing traffic, i.e. there is an asymmetry between incoming and outgoing traffic to ISP networks, with incoming traffic to operators' networks predominating.

The asymmetry between the total combined incoming and outgoing traffic of the four operators is approximately a ratio of 5 to 1. Analysing the two interconnection services separately, it can be seen that transit traffic across all four operators has a higher asymmetry, with a ratio of 6.5 to 1, while for the *peering* service, the asymmetry decreases to approximately 3.5 to 1.

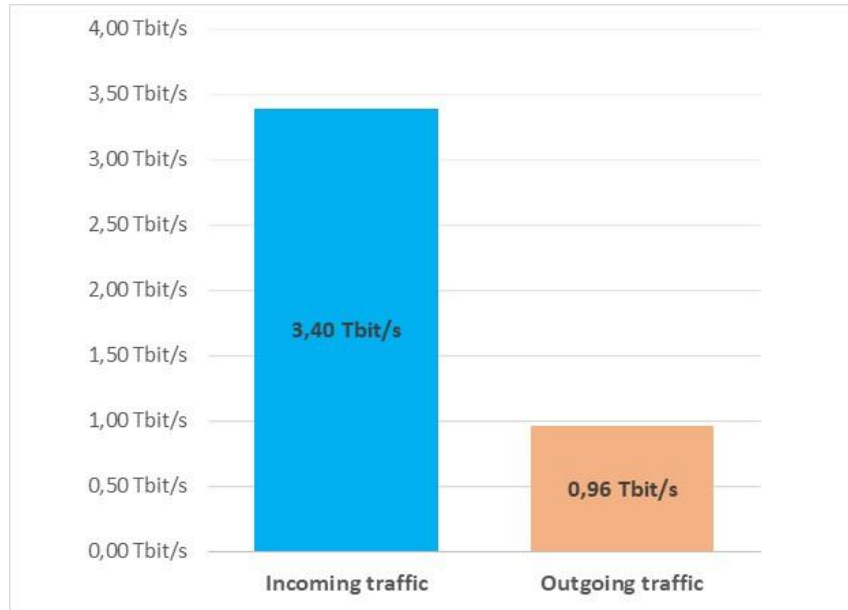
5.4.2. Other operators

The traffic values associated with the other operators are considerably smaller, taking into account that the top four account for almost 95% of fixed and mobile broadband connections.

According to the data submitted by the other operators requested to do so, incoming traffic to their networks in September 2024, when the measurements were taken, reached 3.40 Tbit/s. Outgoing traffic (from each ISP's network to the rest of the Internet) was 958 Gbit/s.

These traffic values are also well below the total interconnection capacity installed for both types of service, which exceeds 11 Tbit/s. However, this does not prevent that there may be some individual interconnections (around 2%) which, according to data submitted about average traffic data in September 2024, have had occupancies above 80%.

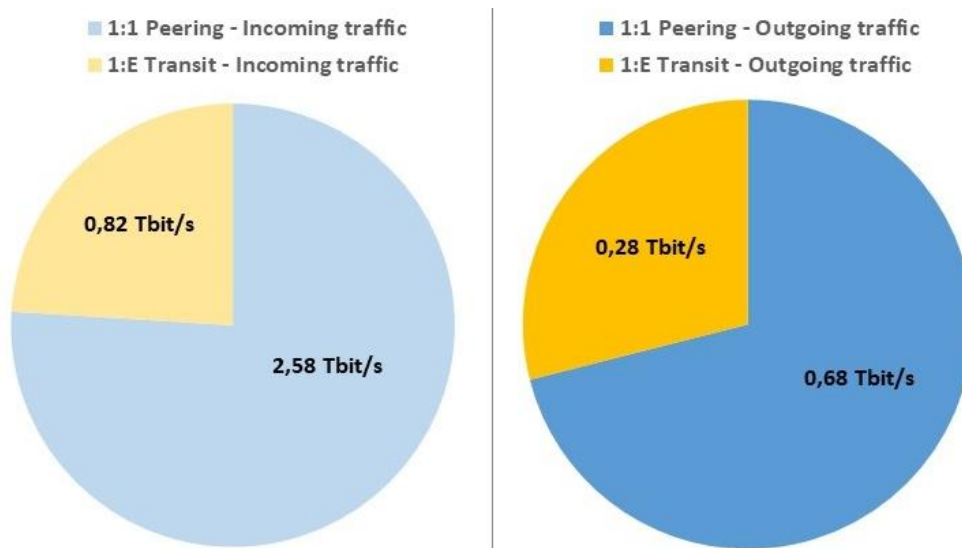
Diagram 7. Aggregated incoming and outgoing traffic for the rest of the ISPs analysed²⁹.



Source: CNMC

In the breakdown shown in the figure below, it can be seen that incoming traffic associated with *peering* services is significantly more important than incoming traffic associated with transit services. In contrast, in the previous analysis of the four main operators, traffic carried via the transit service was higher than through *peering* interconnections.

Diagram 8. Breakdown of incoming and outgoing traffic between peering and transit services for other operators.



²⁹ Includes all reported traffic, both in bilateral relationships and in IXPs.

Source: CNMC

The greater importance of transit among the operators with the largest market share, among other reasons, is related to the fact, as noted earlier, that these operators, albeit to varying degrees, rely heavily on the transit service provided by the parent company or a subsidiary of the group dedicated to interconnection.

In contrast, smaller operators, but large enough to afford access to and be present at interconnection points and data centres, establish *peering* interconnections with the large content providers and CDN operators from which they receive a large part of their traffic.

It is also observed that the incoming network traffic for each specific service, 0.82 Tbit/s in transit and 2.58 Tbit/s for *peering*, are both much lower than the total installed capacities of each type of service which are around 2.63 and 8.69 Tbit/s respectively.

5.4.2.1. Traffic asymmetry for the remaining operators

According to the traffic measured by these operators in September 2024, the overall traffic asymmetry for these operators as a whole³⁰ is approximately 3.5 to 1 between incoming and outgoing traffic on their networks (significantly less than the asymmetry obtained for the four main operators as a whole, which was 5 to 1).

Analysing the asymmetry of traffic associated specifically with the transit and *peering* services, it can be seen that there is a ratio of approximately 3 to 1 between incoming and outgoing traffic via transit across all operators and 3.8 to 1 for *peering*. In other words, for these operators as a whole, the asymmetry associated with *peering* is greater than that associated with transit.

This behaviour differs from that obtained by the four operators with the highest traffic share, where the asymmetry associated with transit traffic across all of them combined was higher than that associated with that for *peering*. This is again due to the fact that *peering* traffic, for the rest of the operators as a whole, was higher than that associated with transit service.

5.5. On-net CDN

Virtually all of the analysed ISPs deployed CDNs within their own networks (on-net CDNs). Only two small ISPs do not have such internal networks. When the number of end-users is small, the cost savings from implementing a CDN – by

³⁰ The figures refer to the sum of the traffic of all operators analysed; the asymmetry obtained for each operator would differ.

reducing the traffic transmitted over the backbone network and interconnection points and bringing the content closer to end-users – are more limited and do not outweigh the installation costs.

The internal CDNs deployed on operators' networks generally belong to the major CAPs or CDN providers, although large ISPs offering audiovisual services also have their own CDNs to bring their content to users.

The economic terms applied for such third-party in-house CDNs are broadly similar: there are no payments between the parties and the CDN owner bears the cost of the equipment, while the ISPs provide the space to install them and cover the operational costs, including energy.

From the data provided, it is possible to compare the capacities associated with on-net CDNs with the total capacities associated with the different interconnection services, transit and *peering*. It is also possible to calculate the ratio between (i) incoming traffic to CDN servers to fill them with content and (ii) outgoing traffic from these servers to the end-users to deliver the requested content. This makes it possible to assess the impact of installed CDNs and whether they lead to a significant reduction of traffic flowing over the Internet, interconnection points and, to some extent, depending on the location and number of locations of the on-net CDN, over the backbone network of the ISPs.

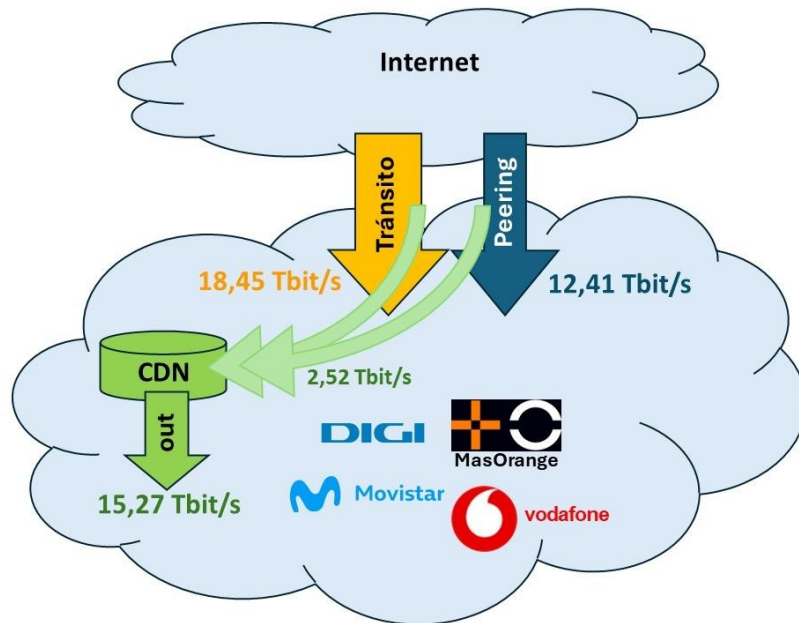
5.5.1. ISPs with the largest market share

For the four largest ISPs, comparing the capacities associated with the on-net CDNs with the total capacities associated with the different interconnection services, transit and *peering*, we obtain the following values.

Excluding the traffic associated with the CDNs belonging to the ISPs themselves (used exclusively for their own audiovisual services), the maximum capacity from the CDNs to the end-users, for delivering requested content, is 15.27 Tbit/s. This value is of the same order of magnitude as the incoming traffic to the network of these four operators through each of the interconnection services, as detailed in the previous point 5.4 (18.45 Tbit/s for transit and 12.41 Tbit/s for *peering*). In addition, the capacity to fill these on-net CDNs with content reaches 2.52 Tbit/s, and forms part of the traffic associated with transit or *peering* services³¹.

³¹ It should not be assumed that these 2.52 Tbit/s are all part of the maximum incoming capacity of 18.45 and 12.41 Tbit/s associated with transit and *peering* services, since CDN content filling can be managed to occur at times of lower interconnection usage.

Diagram 9. Capacities associated with CDNs and interconnection services for top four ISPs



Source: CNMC

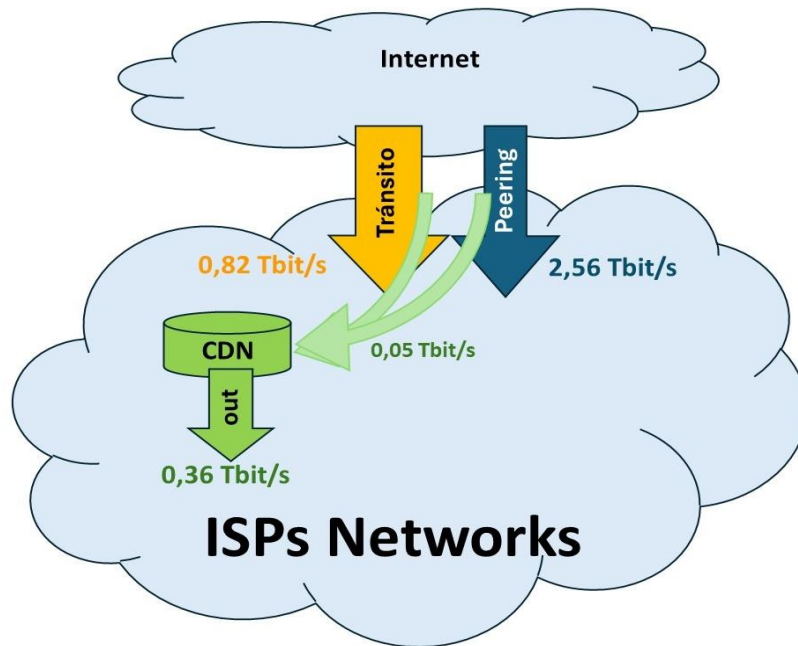
Likewise, if the ratio is analysed for the four main ISPs between the traffic delivered to end-users by all installed CDNs (excluding those used for their own services) and the incoming traffic to those CDNs, it is found to be approximately 6 to 1. Therefore, the installed CDNs represent a significant reduction in traffic flowing over the Internet, interconnection points and, to some extent, depending on the location and number of locations of the on-net CDN, over the backbone network of the ISPs.

5.5.2. Other ISPs

For the other ISPs that provided data, the maximum capacity from CDNs to end-users, to deliver the requested content, is 360 Gbit/s. This figure is approximately half the incoming traffic to these ISPs' networks through the transit service (820 Gbit/s) and an order of magnitude below the incoming traffic through the *peering* service (2.56 Tbit/s) indicated in the previous point 5.4. In addition the capacity to fill these on-net CDNs with content is 53 Gbit/s, and forms part of the traffic associated with transit or *peering*³² services.

³² It should not be assumed that these 53 Gbit/s are all part of the maximum incoming capacity of 820 Gbit/s and 2.56 Tbit/s associated with transit and peering services, since CDN content filling can be managed to occur at times of lower interconnection usage.

Diagram 10. Capacities associated with CDNs and interconnection services for the rest of ISPs



Source: CNMC

If the same analysis is carried out for the other ISPs, the ratio between the traffic served to end-users by all installed CDNs (excluding those used for their own services) and the incoming traffic to these CDNs shows a slightly higher figure, closer to 7 to 1.

In any event, this relationship between the outgoing traffic from CDNs to deliver the requested content to end-users and the incoming traffic needed to fill them with content varies between each operator and, within each operator, between each CDN. This ratio could be expected to increase with the number of the operator's end-users and/or subscribers of a given service and also the popularity of the content, since the probability that the same content stored in the CDN will be viewed and delivered many more times is much higher, thus increasing the ratio between the two traffic flows.

6. CONCLUSION

The following conclusions can be drawn from the responses received and the data analysed:

- The transit interconnections of all analysed ISPs carry a higher proportion of total traffic (56%) than non-paid *peering* (43%). In any case it should be noted that the relevance of the transit service is also due to the fact that

some of the major ISPs base a large part of their interconnection on the transit service provided by a group company dedicated to providing transit services.

- The incoming traffic from the Internet to the network of the four main Spanish ISPs in terms of fixed and mobile broadband market share was estimated during September 2024 at 30.86 Tbit/s, which can be broken down into 18.45 Tbit/s in transit and 12.41 Tbit/s in *peering*.
- Practically all the interconnections reported take place in data centres located within the Spanish territory, and mostly in the province of Madrid.
- The main Tier 1 transit operators, CDN providers and content and application providers (CAPs) have a presence in various data centres and IXPs in Spain. This allows medium-sized ISPs to have direct access to a wide range of transit providers, as well as to establish *peering* interconnections with major Internet players if they are also present in one of the major data centres or IXPs.
- Average reported prices for transit services are in line with published prices for the main European *hubs*.
- All large ISPs and almost all of the ISPs analysed in Spain have CDNs deployed. For the top four ISPs, internal CDNs belonging to third parties (not including those for proprietary services) generate traffic in Gbit/s to end-users of an order of magnitude equivalent to the traffic they receive through transit or *peering* services. The traffic in Gbit/s needed to fill CDNs with content is 6-7 times less than the traffic delivered to users. This implies a significant reduction in the interconnection capacity required and may also be so in the backbone part of the ISP's network.

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