

ANNUAL BAROMETER OF THE TRANSITION TO IPv6 IN FRANCE

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Table of contents

1. Accelerating the transition to IPv6: a major issue for competitiveness and innovation	3
2. Different players at different stages in the transition	4
3. Fixed Internet service providers (retail services)	6
4. Mobile operators (retails services).....	9
5. Hosting services and content providers	12
5.1. Hosting Infrastructure	12
5.2. Server applications	13
5.2.1. Web hosting.....	13
5.2.2. Mail hosting	15
6. DNS infrastructure	16
7. Equipment suppliers.....	17
8. Transit providers	17
9. Devices.....	18
10. Where does France stand?.....	19

1. ACCELERATING THE TRANSITION TO IPV6: A MAJOR ISSUE FOR COMPETITIVENESS AND INNOVATION¹

IPv4, which stands for Internet Protocol version 4, has been used since 1983 to allow the Internet to function: each device or machine that is connected to the Internet (computer, phone, server, etc.) has an IPv4 address. The protocol is technically limited to 4.3 billion addresses. However, the Internet's success, coupled with the diversity of uses and the growing number of connected objects has resulted in a **steady decrease in the number of available IPv4 addresses**, with some parts of the world being more heavily affected than others. By the end of June 2018, the top four operators in France (Bouygues Telecom, Free, Orange and SFR) had already **assigned between roughly 88% and 99% of their IPv4 addresses**².

IPv6 specifications were finalized in 1998. They incorporate functions for increasing security by default and optimizing routing. Above all, IPv6 delivers almost an infinite number of IP addresses: **667 million IPv6 for each square millimeter of the earth's surface**.

But the complexity of today's Internet makes it impossible to achieve the transition from IPv4 to IPv6 in one fell swoop, in a single day (i.e. flag-day). It must therefore take place gradually, starting with a period of cohabitation with IPv4. Once every player has migrated to the new protocol, IPv6 will fully replace IPv4 (switch-off phase).

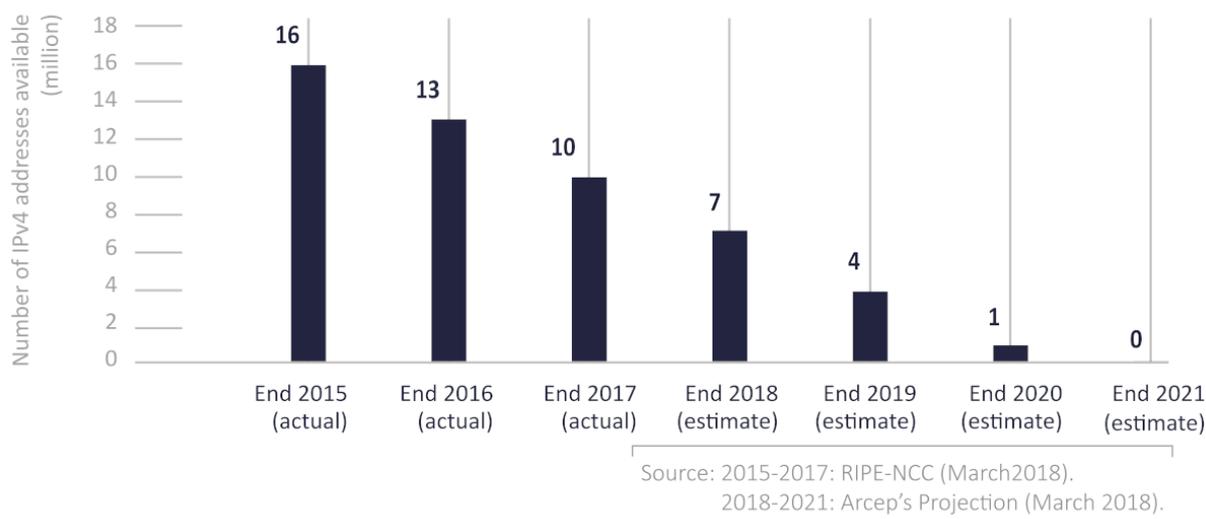
The transition to the IPv6 protocol began in 2003. Despite which, in 2018, **the Internet is still only at the beginning of the cohabitation stage**. The sluggish pace of this transition could, on the one hand, prevent **certain types of Internet service** (controlling smart home systems, online gaming, etc.) **from functioning properly** because of the systems used for sharing IPv4 addresses between several customers to deal with the dearth of IPv4 addresses. On the other hand, it is likely to **create a barrier to entry for newcomers to the market**. IPv4 will continue to be necessary as long as the entire technical chain has not fully switched over to IPv6. Otherwise, a site that is not able to have an IPv4 address could not be accessed by users who subscribe to an ISP that does not provide IPv6 addresses. But the shut-off date for IPv4's availability in Europe is fast approaching. Estimated to be in late 2021, it is already driving a significant increase in the price of IPv4 addresses, which have become the scarce resources of the 21st century Internet. **This high price creates a sizeable barrier to entry for new entrants, and increases the risk of seeing the Internet split in two, with IPv4 on the one side and IPv6 on the other**.

Because of this expected dearth and the risks it entails, **making the transition to this new Internet protocol has become a major key to ensure competitiveness and innovation**.

¹ ARCEP specifies that the observations and works mentioned in this document concern only the Internet and do not apply to the private interconnection between two actors, in particular the interconnection of the networks of two operators for the termination for voice calls in IP mode.

²Data collected from ISPs by Arcep, in accordance with Decision No. 2018-0268

ASSESSMENT AND ESTIMATE OF THE REMAINING STOCK OF IPv4 ADDRESSES



2. DIFFERENT PLAYERS AT DIFFERENT STAGES IN THE TRANSITION

To ensure IPv6 protocol functions from end to end, migration needs to cover all of the links along the Internet value chain simultaneously.

Arcep has employed several indicators in order to evaluate the status of IPv6 deployment in France for the various stakeholders involved in the transition. These indicators are calculated using data collected by Arcep in accordance with Decision No 2018-0268, as well as third-party data³:

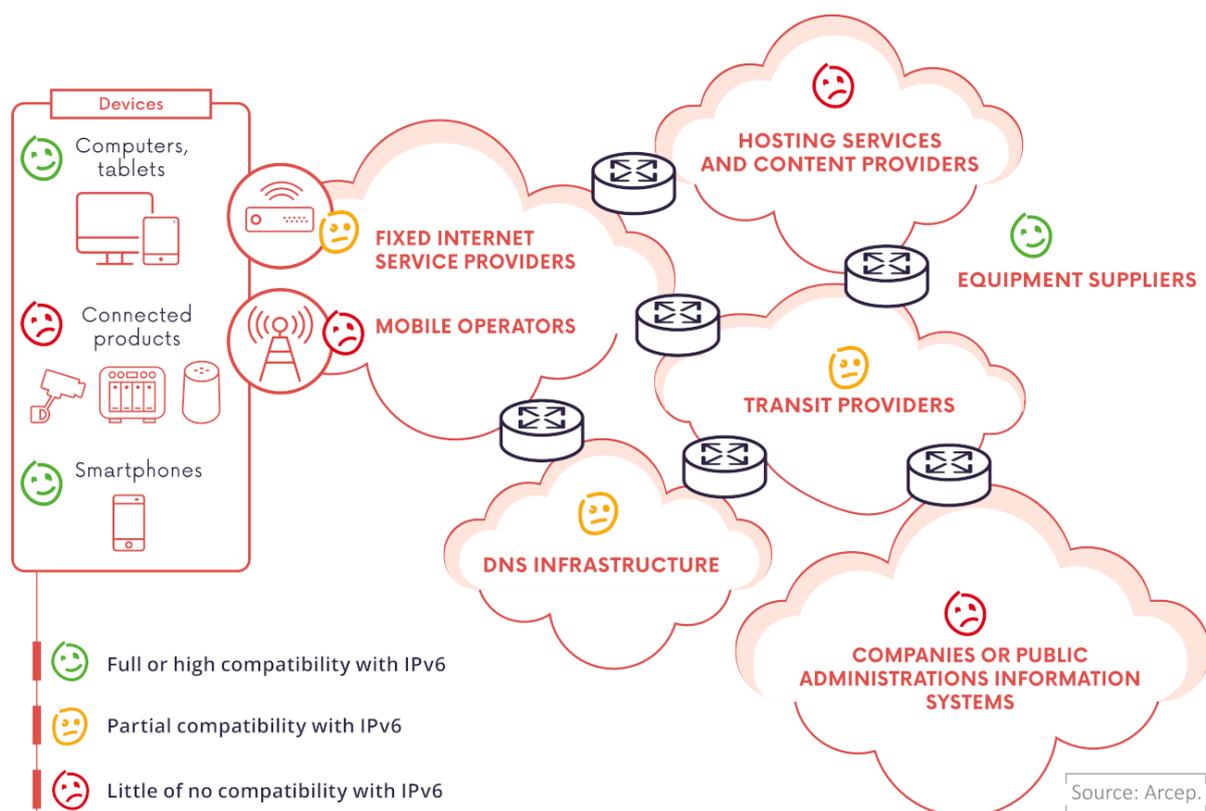
- **Fixed Internet Service Providers (ISPs):**
 - percentage of IPv6-ready (or compatible) customers;
 - IPv6 activation policy for boxes;
 - percentage of IPv6-enabled customers.
- **Mobile operators:**
 - percentage of IPv6-ready customers;
 - percentage of IPv6-enabled customers.
- **Hosting services and content providers:**
 - percentage of IPv6-enabled servers;
 - percentage of new servers that are IPv6-enabled;
 - percentage of the most popular websites in France that are IPv6-enabled;
 - percentage of the most popular web pages in France that are IPv6-enabled (IPv6 content);
 - percentage of .fr, .re, .pm, .yt, .tf and .wf websites that are IPv6-enabled;
 - percentage of .fr, .re, .pm, .yt, .tf and .wf mail services that are IPv6-enabled.

³ Cf. exact source in the sections devoted to each type of player.

- **DNS infrastructure:**
 - percentage of IPv6-enabled DNS servers on the domain names .fr, .re, .pm, .yt, .tf, and .wf.
- **Equipment suppliers:**
 - IPv6-compatible equipment (routers, etc.).
- **Transit providers:**
 - percentage of transit providers managing IPv6;
 - percentage of transit providers managing IPv6, weighted by the number of their clients.
- **Devices:**
 - operating systems' ability to support IPv6.

These additional indicators make it possible to have an overview of the status of IPv6 deployment.

STATUS OF THE TRANSITION TO IPv6 FOR THE DIFFERENT ECOSYSTEM ACTORS



3. FIXED INTERNET SERVICE PROVIDERS (RETAIL SERVICES)

Four conditions need to be met for a fixed line to be able to transmit and receive traffic in IPv6:

- the **fixed network** used must be IPv6-compatible;
- the hardware of the **box** being used must be IPv6-compatible, and its firmware must be capable of managing the protocol. If most of operators' boxes in 2018 are IPv6-compatible, some have not yet upgraded their firmware to be able to handle IPv6.

When both the network and the box are IPv6-compatible, a customer is said to be IPv6-ready (cf. table below).

- The operator needs to **remotely configure the customer's box** for it to be IPv6-enabled (cf. table below). If the customer is IPv6-ready but the operator has not enabled IPv6, the customer can configure his/her own box manually for it to be IPv6-enabled. Nevertheless, because the vast majority of users don't take the initiative to do so, it is the action taken by ISPs that will drive the transition.
- The **device's operating system** must be IPv6-compatible and enabled (cf. section on Devices below).

PERCENTAGE OF IPv6-READY CUSTOMERS ON FIXED NETWORK AND ACTIVATION POLICY FOR ISPs IN FRANCE WITH OVER 10,000 CUSTOMERS THAT OFFER IPv6

		Bouygues Telecom	Free	Orange	SFR	Coriolis Telecom	K-Net	
% of IPv6-ready customers	xDSL	Own network *	2.5%	100%	40%	100%	n/a	n/a
		Backhaul network	0%	0%	n/a	100%	n/a	n/a
	Câble	Own network	n/a	n/a	n/a	0%	n/a	n/a
		Backhaul network	0%	n/a	n/a	n/a	n/a	n/a
	FTTH	Own network	1%	100%	90%	100%	n/a	100%
		Backhaul network	n/a	n/a	n/a	100%	87%	73%
IPv6-enabled by default **	New customers		Yes	Yes	Yes	No	Yes	Yes
	Customers who subscribed after 2015		Yes	Yes	Yes	No	Yes	Yes
	Customers who subscribed before 2015		Yes	No	Yes	No	Yes	No
	Impossibility to disable IPv6		No	No	No	No	Yes	No

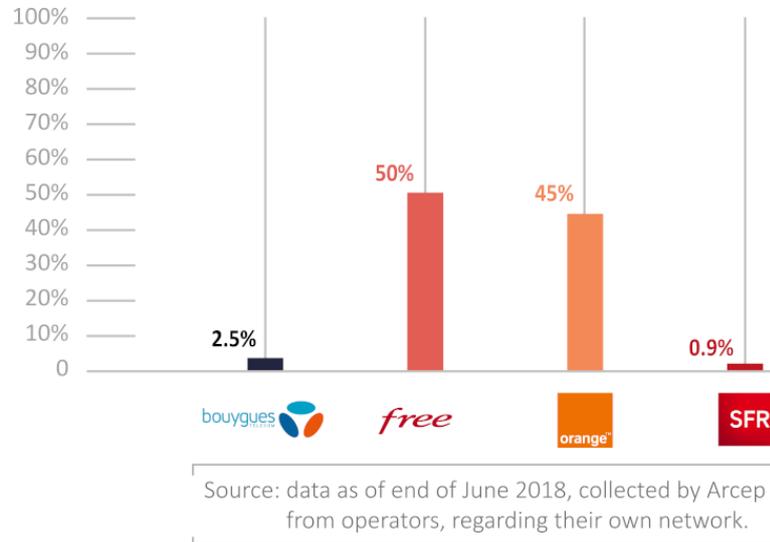
* The respective shares of the own network and the backhaul network vary considerably, depending on the ISP and the technologies used.

** IPv6-enabled, provided that the network and the box are IPv6-compatible.

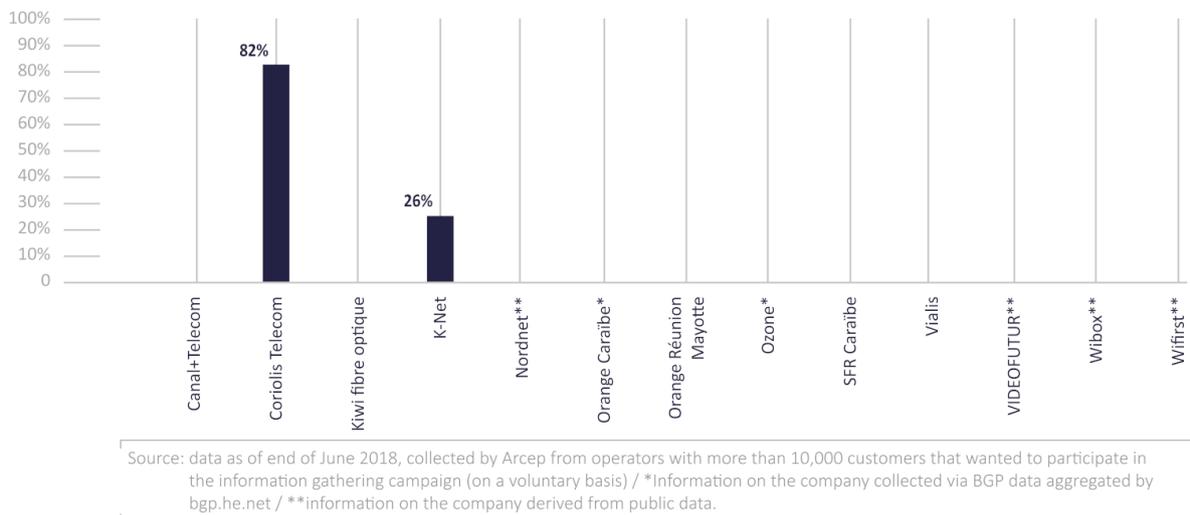
Source: data as of end of June 2018, collected by Arcep from operators.

The disparities between the percentage of customers who are IPv6-ready and the percentage of customers who are actually IPv6-enabled (transmitting and receiving IPv6 traffic) can be explained by the main operators' different IPv6 activation policies.

PERCENTAGE OF IPv6-ENABLED CUSTOMERS ON THE MAIN OPERATORS' FIXED NETWORK IN FRANCE

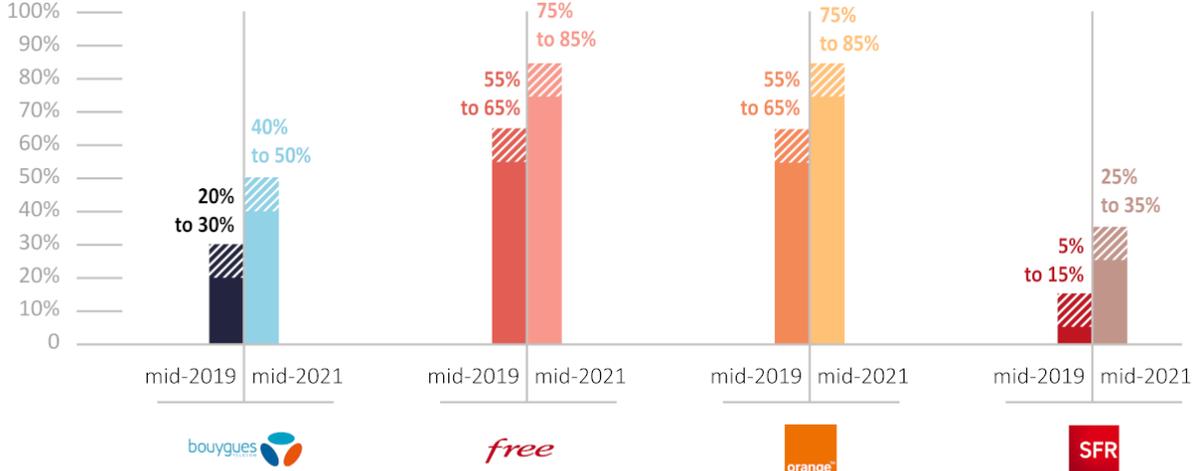


PERCENTAGE OF IPv6-ENABLED CUSTOMERS ON ALTERNATIVE AND OVERSEAS OPERATORS' FIXED NETWORK IN FRANCE



The four main operators have also provided forecasts for the percentage of customers that will be IPv6-enabled one year and three years from now.

PERCENTAGE OF IPv6-ENABLED CUSTOMERS FORECAST ON THE MAIN OPERATORS' FIXED NETWORK IN FRANCE



Source: data collected by Arcep from operators in mid-2018, regarding their own network. Figures subject to change.

Even though predictions indicate that the stock of available IPv4 addresses will wear off by the end of 2021, **some operators still have no plans for the deployments on their fixed networks that will allow them to respond to this dearth in the medium-term** which, as indicated above, would seem problematic.

4. MOBILE OPERATORS (RETAILS SERVICES)

Four conditions need to be met for a mobile line to be able to transmit and receive traffic in IPv6:

- The **mobile network** used must be IPv6-compatible, in other words the Access Point Name (APN) must be capable of managing the IPv6 protocol (cf. table below);
- The operator must **remotely enable the mobile device** before it can use IPv6. With Android, the APN can be configured manually to be made IPv6-compatible. However, because the vast majority of users will not take the initiative of activating IPv6 themselves, it is actions taken by ISPs that will drive the transition. iPhone users cannot enable IPv6 manually.
- The **device's operating system** must be IPv6-compatible (cf. section on Devices below). If this is already the case for almost all recent smartphones, a substantial number of 4G routers are still not IPv6-compatible.

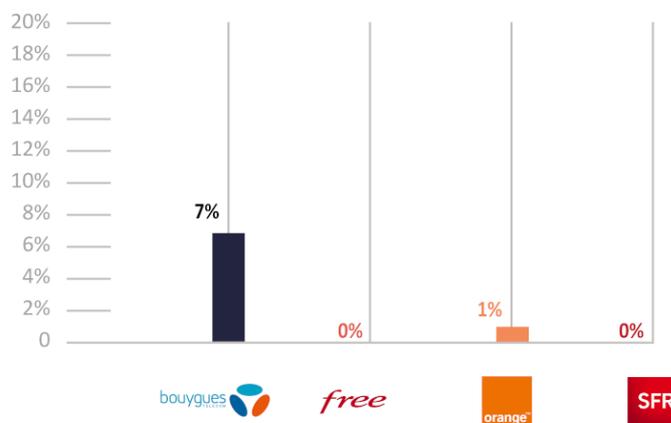
PERCENTAGE OF CUSTOMERS ON IPv6-COMPATIBLE MOBILE NETWORK BY APN FOR THE MAIN OPERATORS IN FRANCE

		Bouygues Telecom	Free	Orange	SFR
Consumer voice + data plans	Smartphone's default APN	100%	0%	50%	0%
	APN for tethering	100%	0%	0%	0%
Consumer data only plans		0%	0%	0%	0%
Consumer fixed 4G plans		0%	n/a	0%	0%

Source: data as of end of June 2018, collected by Arcep from operators.

The disparity between the percentage of customers who are IPv6-ready and the percentage of customers who are actually IPv6-enabled (transmitting and receiving IPv6 traffic) can be explained by the main operators' different IPv6 activation policies.

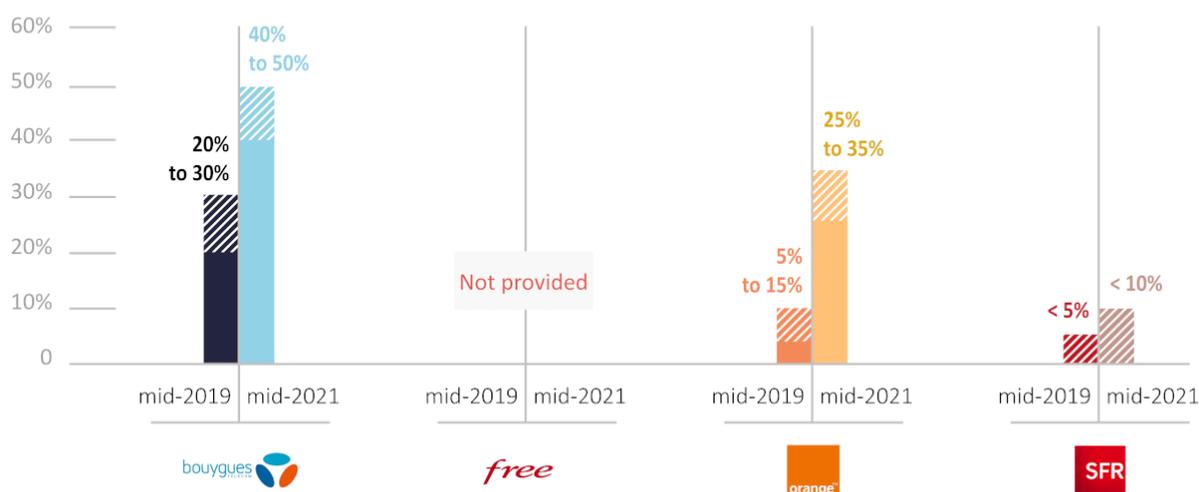
PERCENTAGE OF IPv6-ENABLED CUSTOMERS ON THE MAIN OPERATORS' MOBILE NETWORK IN FRANCE



Source: data as of end of June 2018, collected by Arcep from operators, regarding smartphones' default APN for voice + data plans.

Regarding the different operators' plans for upgrading their mobile network to IPv6 one year and three years from now:

PERCENTAGE OF IPv6-ENABLED CUSTOMERS FORECAST ON THE MAIN OPERATORS' MOBILE NETWORK IN FRANCE



Source: data as of end of June 2018 collected from operators by Arcep, regarding smartphones' default APN for voice + data plans. Figures subject to change.

Even more than on fixed networks; the pace of mobile networks' future IPv6 deployments is very likely to make it impossible to deal with the issue of an overall dearth of IPv4 addresses.

More specifically, with regard to the main telecom operators in France, Arcep is seeing progress but is calling on operators to continue and intensify their efforts:

- If 100% of SFR customers are already compatible on xDSL and FTTH (0% on cable), less than 1% of them are enabled – i.e. able to send and receive IPv6 traffic. Upcoming activations, although higher than the latest announcements from the operator, remain very weak (25-30% in mid-2021). Since a large majority of clients do not enable IPv6 manually, Arcep prompts SFR to perform this default activation like most other operators. As for mobile networks: SFR forecasts less than 10% of customers activated in mid-2021.
- Arcep notes Bouygues Telecom's deployment efforts on mobile networks, but regrets the drop in migration forecasts for fixed networks: 40 to 50% of activated customers are expected by mid-2021, compared to 75 to 85% announced at the end of 2020 in the previous barometer.
- On the fixed networks, the current rates of activated customers of Free and Orange are relatively high (respectively 50% and 45%), but projections on the same indicator in mid-2021 do not allow to complete the transition in the medium term (between 75 and 85% for both ISPs). On mobile networks, the rate of activated customers expected by Orange in mid-2021 is up but remains limited (25-35%); Arcep regrets that Free Mobile has not been able to communicate their forecasts.

5. HOSTING SERVICES AND CONTENT PROVIDERS

Five conditions need to be met for a hosting service to be able to transmit and receive in IPv6:

- The **hosting service network** must be IPv6-compatible;
- The **server's operating system** must be IPv6-compatible and its IPv6 stack enabled. It is the case for all currently used servers' operating systems;
- The hosting service must **preconfigure the server**, to use IPv6 addressing.

Once these three conditions have been met, the hosting service can then enable IPv6 at the server level (cf. see diagram in Part 1).

- The content provider must use **server applications** (web, mail, etc.) that can manage the IPv6 protocol. It is almost already the case by default.
- The content provider must **configure the DNS** by adding an IPv6 record, so that the domain name points towards an IPv6 address.

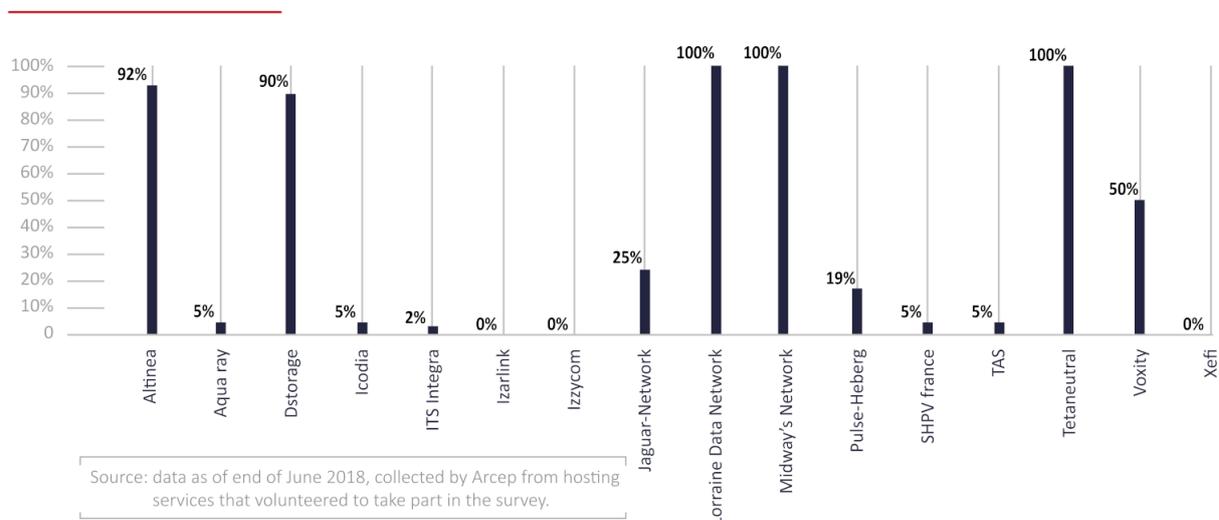
Once all of these conditions are met, the hosted service can be IPv6-enabled (cf. see diagrams in Part 2).

Thus, unlike an ISP that can enable IPv6 remotely, without requiring any action from its customers (i.e. end users), a hosting service's customer (i.e. content provider) must take several steps before IPv6 can be used end-to-end.

5.1. Hosting Infrastructure

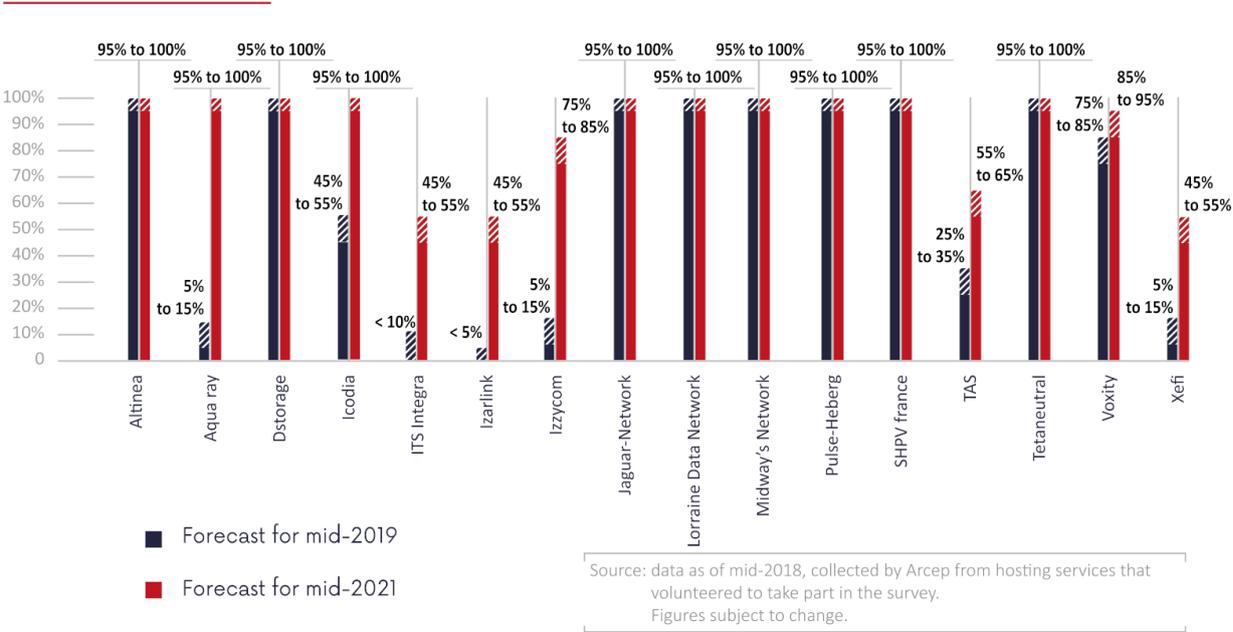
Arcep would like to thank all hosting services that agreed to answer this optional survey. It should therefore be noted that the resulting map is not representative of the ecosystem, as those who chose to take part are probably those that are the furthest along in the transition.

**PERCENTAGE OF IPv6-ENABLED SERVERS,
FOR A SELECTION OF HOSTING SERVICES IN FRANCE**



The forecasts provided below are limited to the percentage of new servers sold as of mid-2019 or mid-2021 and that are IPv6-enabled by default, as a hosting service cannot force a server that has already been commercialized to use IPv6.

PERCENTAGE OF NEW SERVERS THAT ARE IPv6-ENABLED BY DEFAULT FORECAST, FOR A SELECTION OF HOSTING SERVICES IN FRANCE



In the next part of this section, we take a look at two types of applications: web and mail.

5.2. Server applications

5.2.1. Web hosting

Web hosting services continue to constitute **one of the main bottlenecks** in the migration to IPv6: of the most popular websites in France according to Alexa rankings, only 26% are IPv6-enabled⁴. A site is considered IPv6-enabled if its domain name is mapped as being IPv6 (AAAA) in the DNS server record.

Note that the percentage of web pages that are IPv6-enabled (IPv6 content) is significantly higher than that (61%⁵). The reason is that many of the smaller content providers operate websites (generally small number of pages viewed) that are not IPv6-compatible.

⁴ Cisco 6lab as of 28/09/2018 (<http://6lab.cisco.com>); Data on the top 731 websites in France, Alexa rankings: <http://www.alexa.com/topsites/countries>

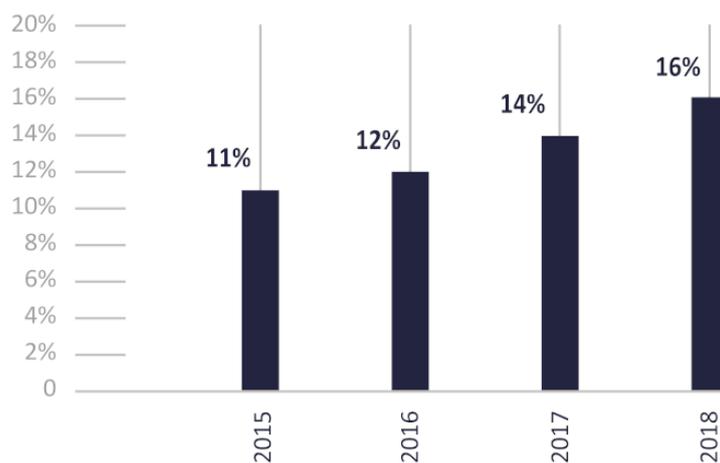
⁵ *ibid*



Source: Cisco 6lab as of 28/09/2018 (6lab.cisco.com). Data on the top 731 websites in France, as ranked by Alexa (www.alexa.com/topsites/countries).

The percentage of IPv6-enabled sites stands at a mere 16% when looking at the 3 million .fr, .re, .pm, .yt, .tf, and .wf⁶ websites. This percentage has been increasing since 2015, but **the pace of this increase appears far from fast enough to enable a complete transition by the end of 2021.**

PERCENTAGES OF IPv6-ENABLED WEBSITES ON .fr, .re, .pm, .yt, .tf, .wf DOMAIN NAMES



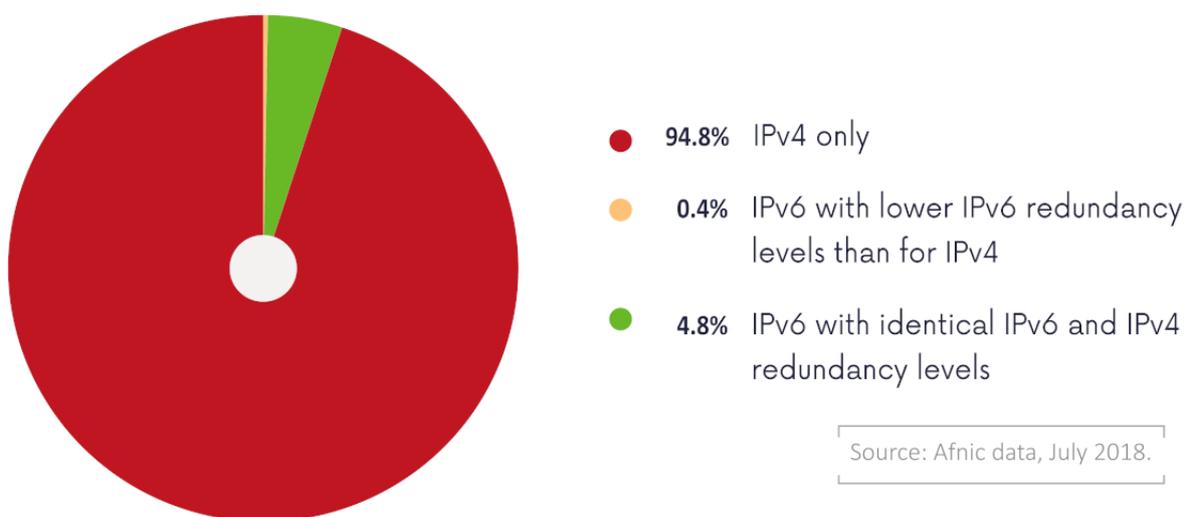
Source: Afnic data, July 2018 .

⁶ Afnic data

5.2.2. Mail hosting

The transition of the main mail hosting services is also proving **very slow**: only 5.2% of mail servers on .fr, .re, .pm, .yt, .tf and .wf domain names are currently IPv6-enabled. It should also be noted that on a number of them, there is an IPv6 redundancy level that is below the one provided for IPv4, which is likely to create resilience issues⁷.

PERCENTAGE OF IPv6-ENABLED MAIL HOSTING ON .fr, .re, .pm, .yt, .tf AND .wf DOMAIN NAMES

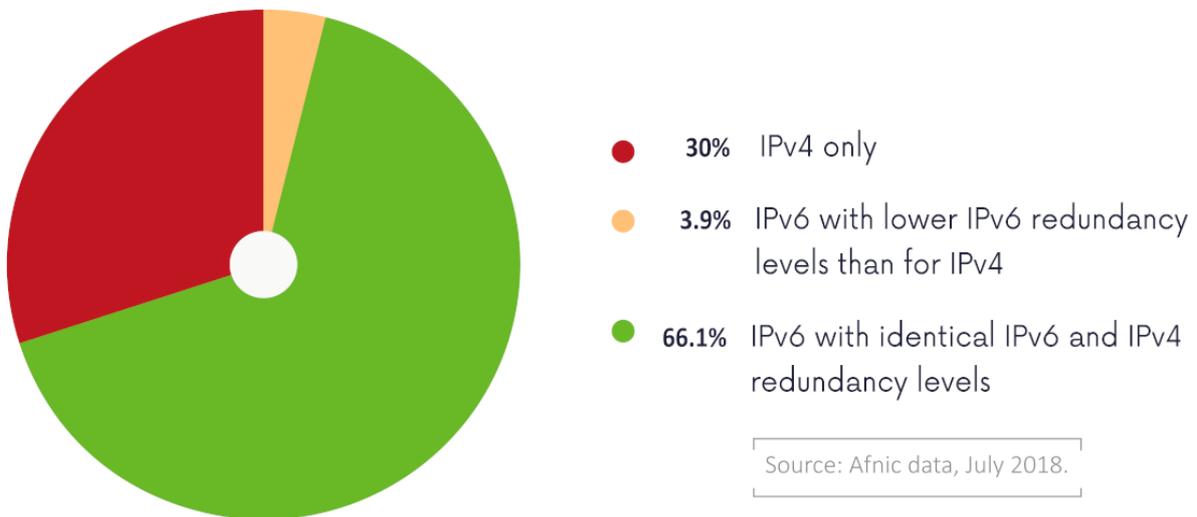


⁷ Afnic data, July 2018.

6. DNS INFRASTRUCTURE

DNS infrastructure makes it possible to translate a domain name, e.g. www.arcep.fr, into an IP address. This is currently **the sector that is the most advanced in the transition to IPv6**, with 70% of authoritative nameservers⁸ supporting IPv6. Around 66%⁹ of them guarantee equivalent resilience to IPv4 (identical redundancy levels). Also noteworthy is that only a small handful of players provide authoritative DNS nameservers hosting¹⁰.

PERCENTAGE OF IPv6 ACCESSIBLE DNS SERVERS ON .fr, .re, .pm, .yt, .tf AND .wf DOMAIN NAMES



⁸ An authoritative DNS nameserver is the primary DNS server for a domain, in other words the one that holds the domain name resolution information, Afnic data, July 2018.

⁹ Afnic data, July 2018.

¹⁰ The French Internet Resilience Observatory, 2014, ANSSI: https://www.ssi.gouv.fr/uploads/2014/10/rapport_observatoire_2014_fr.pdf

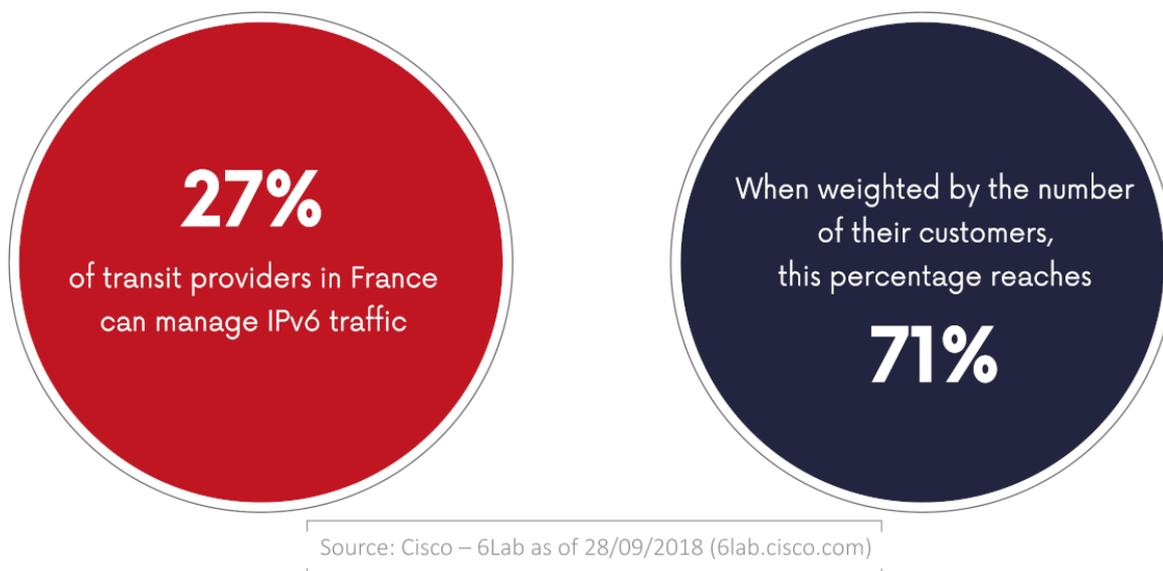
7. EQUIPMENT SUPPLIERS

All of the major equipment suppliers (Cisco, Juniper and Nokia) have indicated that all the network solutions they sell (routers, etc.) are **systematically made IPv6-compatible**¹¹.

This compatibility does not necessarily guarantee that traffic will be routed in IPv6, as this would require each player (ISPs, hosting companies, transit providers etc.) to have configured IPv6 routes at the router level.

8. TRANSIT PROVIDERS

27% of transit providers¹² operating in France (i.e. 65 of 240 transit providers) can manage IPv6 traffic. When weighted by the number of transit providers' customers, this percentage climbs to 71%, as a large portion of small transit providers does not route IPv6 traffic¹³.



¹¹ Arcep 2016 questionnaire

¹² The methodology employed by Cisco's 6lab stipulates that "all AS that appear on an AS path of BGP table (and that are not the origin AS or the destination) are considered Transit AS".

¹³ 6lab Cisco as of 28/09/2018: <http://6lab.cisco.com>

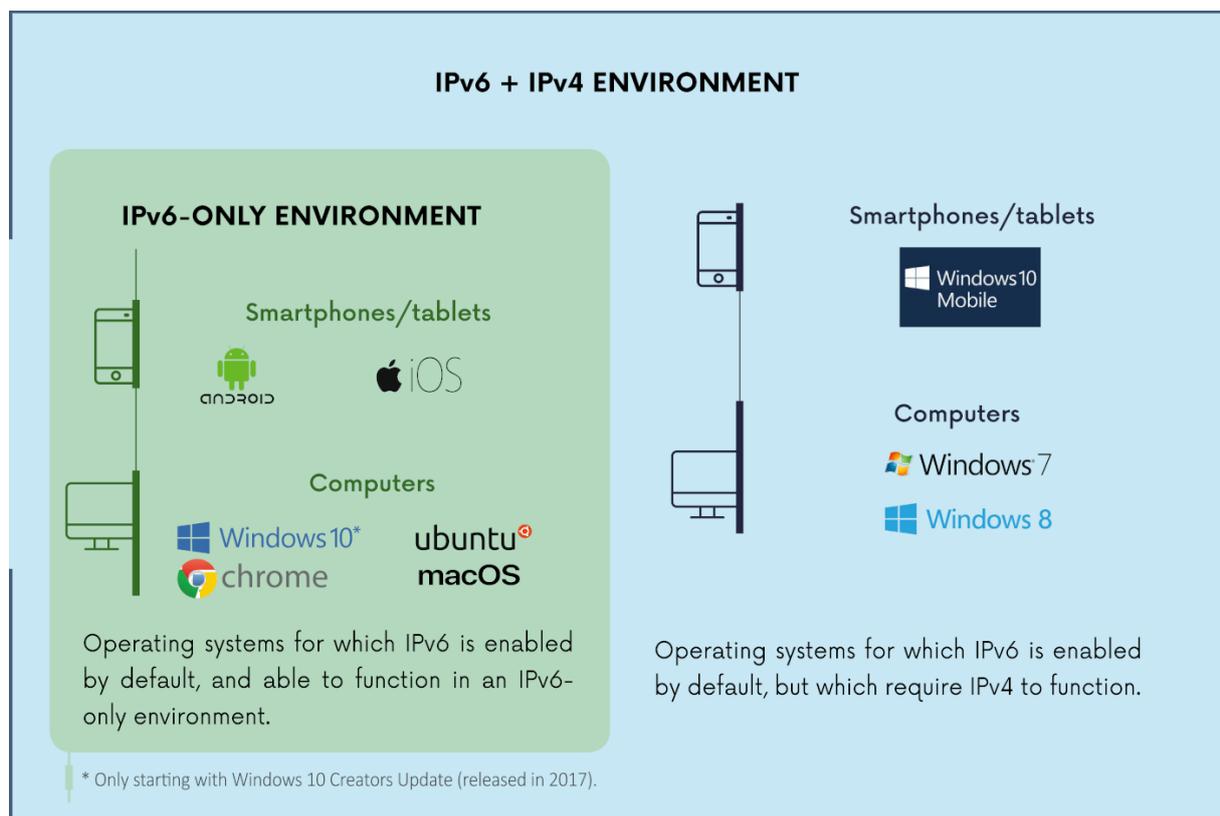
9. DEVICES

For a device to be able to transmit and receive IPv6 traffic, the operating system (OS) must be IPv6-compatible, and IPv6 must be enabled by default.

In the many connected objects (alarm systems, televisions, etc.), **IPv6 is integrated into the OS but has not been enabled by the connected object's manufacturer.**

Only the versions of operating systems that are preinstalled on retail market computers, tablets and smartphones, and still maintained (i.e. for which security updates, etc. are still provided) are examined below.

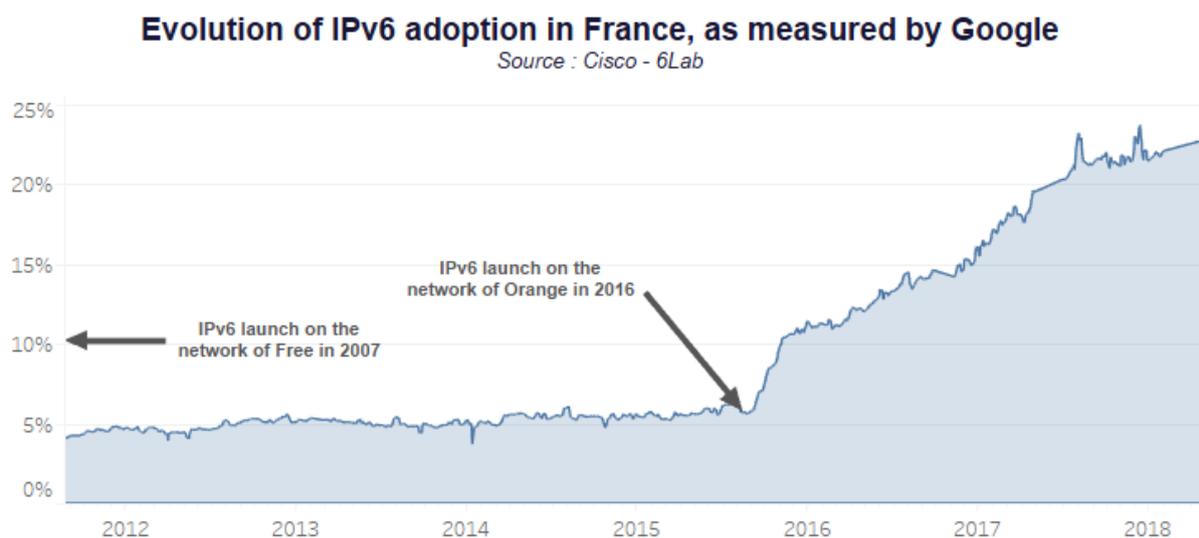
All of these operating systems are compatible with IPv6, which has been enabled by default for several years now (for instance, IPv6 has been enabled by default in Windows since Windows Vista in 2007). However, some OS cannot work properly in IPv6 without an IPv4 address (i.e. when IPv6 is the only protocol available) as they do not include support for the RFC 8106 Neighbor Discovery Protocol RDNSS.



10. WHERE DOES FRANCE STAND?

The *IPv6 adoption rate* represents the percentage of users measured at a hosting service level (service proposing already IPv6). This therefore gives an idea of the status of the transition amongst devices, ISPs and mobile operators, and by other technical intermediaries when the hosting service in question makes use of transit providers.

As measured by Google, this rate currently stands at around 23% in France.



Because Google servers are typically located close to end users, this indicator gives an only partial view of the actual situation (the *percentage of transit providers that have adopted IPv6* has a direct influence on the number of IPv6-initiated Internet connections in France, but is marginally taken into account by this indicator). It is also important to know how many web hosts are actually able to provide IPv6, by measuring the *percentage of web pages that are accessible through IPv6 (or content)*.

The following map provides a comparison of the different countries around the world for the three indicators listed above. **France has an average score for Europe**, being neither at the top of the rankings (as Belgium is) nor at the bottom.

State of the transition to IPv6 in the world as of 08/10/2018

Source: Cisco - 6Lab

