# STATISTICS AND TRENDS: IPV6 DEPLOYMENT IN LATIN AMERICA AND THE CARIBBEAN 2016-2020

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# Statistics and Trends: IPv6 Deployment in Latin America and the Caribbean 2016-2020

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# Summary

IPv6 deployment and adoption have advanced gradually in the region, accompanying the process of IPv4 exhaustion and the resulting transition to IPv6 and coexistence of the two protocols. Regional statistics show a sustained growth of IPv6 in 2020 compared to 2016, with differences between South America, Central America, and the Caribbean. The first two subregions show a gradual increase in IPv6 adoption, while the latter exhibits low levels of IPv6 adoption and no clear growth trend. IPv6 adoption rate in South America is 25%; in Central America, 30%, and in the Caribbean, 7%. Based on the number of users, regional IPv6 adoption stood at 3% in 2016, compared to a global average of 8%. In 2020, these percentages had increased to 21% at the regional level and to 29% globally. This represents an 18% increase from one study to the other.

Measurements show that, while Latin America and the Caribbean have good interconnection levels and much progress has been made, the average adoption rate of the LAC region is lower than the global average and that of other regions. This and other data are analyzed in this study titled “Statistics and Trends: IPv6 Deployment in Latin America and the Caribbean 2016-2020.” The information provides an understanding of the progress made in terms of IPv6 deployment and adoption and the opportunities ahead. The paper is divided into three sections: “Introduction: Conceptual Aspects of the IPv4 and IPv6 Protocols,” “IPv6 Deployment Statistics and Trends,” and “Considerations for IPv6 Adoption.”

The first section addresses the IPv4 exhaustion process and the work carried out from 2013 to date. This process includes distinct phases, actions, and mechanisms led by LACNIC to guarantee the transition from IPv4 to IPv6. The section also covers conceptual aspects of IPv4 and IPv6, their characteristics and the differences between both versions of the IP protocol, as well as the comparative advantages of IPv6. The second section provides statistics and trends in IPv6 deployment and adoption across the region. To do so, it presents the number of IPv6 users, global and regional adoption rates, adoption by country and subregion, as well as the evolution between 2016 and 2020.

Once IPv6 infrastructure has been deployed, IPv6 adoption depends on multiple factors that have to do with specific elements, such as user devices, their ability to use the IPv6 protocol, their characteristics, IPv6 compatibility of the equipment, as well as the content that is transmitted. The third section incorporates these considerations and presents the main concerns of Internet Service Providers (ISPs) regarding device compatibility and the capacity, along with their potential impact on IPv6 adoption.

Finally, the study briefly addresses emerging technologies such as the Internet of Things (IoT), 5G technology, and cloud computing, as well as the characteristics of the IPv6 protocol and its potential impact on these technologies.

# Introduction: Conceptual Aspects of the IPv4 and IPv6 Protocols

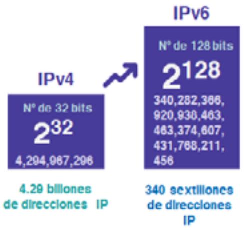
Internet Protocol (IP) addresses are unique numeric identifiers assigned to each computer or device that connects to the Internet which are used to transport packets across multiple networks from their source to their destination.

On the one hand, the IPv4 protocol developed in the 1980s allows defining more than 4.3 billion IP addresses (IPv4 uses a 32-bit address space). However, only 3.7 billion can be used by regular Internet access devices and equipment, as the rest is reserved for special protocols. Of the two, IPv4 is used the most at the global level.

On the other hand, the IPv6 protocol is the improved version of IPv4 and supports a much larger number of IP addresses. It is important to note that IPv6 is not technically an upgrade to IPv4. To a substantial extent, the two protocols are incompatible, which is why IPv4 and IPv6 are considered independent networks with two independent protocol stacks. When it comes to capacity, IPv6 uses a 128-bit address space, which theoretically allows 3.40 x 10^38 IP addresses. These addresses are represented as eight groups of four 16-bit hexadecimal digits (0000 to FFFF), separated by colons.

### Figure 1. Number of IP addresses per protocol

*The information of the different figures is presented in the study's original language*



Regional and global IPv6 deployment has been gradual, allowing its efficient coexistence with IPv4. The latter is expected to be gradually displaced by IPv6 as market demand for IP addresses continues to grow along with the infrastructure necessary for its development. The main benefits of the IPv6 protocol include: (i) IPv6 provides a significantly greater number of IP addresses; (ii) IPv6 allows connecting a greater number of devices; (iii) increased security (IPsec is a mandatory part of IPv6 protocol implementations and no longer optional as it is in IPv4); (iv) IPv6 does not require NAT (Network Address Translation)[1], and (v) IPv6 provides better multicast routing. For all the above, the IPv6 protocol is considered the best option to pave the way for the deployment of new technologies and applications such as IoT, 5G, and smart cities, as well as for innovation in the technological infrastructure at the organization level.

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[1] NAT: Network address translation (NAT) allows computer networks to use a range of special (private) IP addresses and connect to the Internet using a single (public) IP address. Carrier-grade NAT (CGN or CGNAT) is an IPv4 network design tool thanks to which end sites, in particular residential networks, are configured with private network addresses that are translated to public IPv4 addresses by middlebox translator devices installed on the provider's network between the user and the Internet.

The main characteristics and differences between IPv4 and IPv6 protocol are listed below.

**Table 1. Differences between IPv4 and IPv6**

| Characteristic | IPv4 | IPv6 |
|---|---|---|
| Address length | 32 bits | 128 bits |
| Address configuration | Supports manual and DHCP configuration | Supports automatic configuration |
| Address representation | Decimal numbers | Hexadecimal numbers |
| Security protocol | Optional | Mandatory |
| QoS | Without identification | With identification |
| Header length | 20 bytes | 40 bytes |
| Host DNS records | A records | AAAA Records |

# IPv4 Address Exhaustion

The LACNIC community decided to divide IPv4 exhaustion into different phases based on the organization of the actions and mechanisms used to manage the address space, available resources, and the transition from IPv4 to IPv6[2]:

- **Phase 0:** Phase 0 began in October 2013. During this phase, IPv4 resources were assigned until reaching the last available /9.
- **Phase 1:** Phase 1 began on 19 May 2014. During this phase, IPv4 and resources were assigned until reaching the /10 reserved for the gradual exhaustion phase.
- **Phase 2:** Phase 2 began on 10 June 2014. During this phase, IPv4 resources were assigned until the /10 reserved for Phase 2 was exhausted. During this phase, only blocks from a /24 to a /22 were assigned. This mechanism was used until reaching the /10 reserved for gradual exhaustion.
- **Phase 3 (current phase):** This reserve represents LACNIC's last available IPv4 space. It is made up of IPv4 blocks assigned by the IANA (Internet Assigned Numbers Authority) post IPv4 exhaustion, along with recovered and returned blocks. LACNIC's pool of IPv4 addresses ran out on 19 August 2020. Currently, LACNIC has only recovered and returned resources and a pool reserved for critical infrastructure. The number of recovered or returned address blocks varies. Since March 2020, resources go through a six-month quarantine period and are then gradually released. During this phase, assignment size is limited from a /22 to a /24. Each new member may only receive an initial assignment from this space.

**Status of the IPv4 address block reserved for Phase 3 (updated 4 November 2021)[3]**

- **Total number of IPv4 addresses for this phase: 6,003,200**
- **Addresses assigned during this phase: 5,603,840**
- **Pre-approved for their assignment: 8,960**
- **Revoked or returned, quarantined: 256,512**
- **Available in this block: 2,816**
- **Reserved for critical infrastructure: 131,072**
- **Assigned to critical infrastructure: 5,120**
- **Available for critical infrastructure: 125,952**

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[2] LACNIC (2021, October). Phases of IPv4 Exhaustion: https://www.lacnic.net/1001/1/lacnic/fases-de-agotamiento-de-ipv4.

[3] Information last updated before sending this paper for publication. The latest data on the status of this IPv4 address block can be found on the Phases of IPv4 Exhaustion webpage: https://www.lacnic.net/1001/1/lacnic/fases-de-agotamiento-de-ipv4

IPv4 run out makes it impossible for the number of users to grow sustainably and suggests that the deployment of IPv6 in the region's networks should be accelerated. Although many operators still have IPv4 addresses and reservations, deploying the latest protocol (IPv6) will soon be a necessity. Given that there are no more available IPv4 blocks, operators who need more IP addresses and who have not transitioned their networks to the new IPv6 protocol are being forced to procure IPv4 addresses from the secondary market at a higher cost.

# Transition Mechanisms

IPv6 deployment requires thorough processes and mechanisms to minimize the possibility of network disruption and guarantee the coexistence of both protocols. To achieve this, different mechanisms are used to transition from IPv4 to IPv6. These transition mechanisms are classified based on the technique they use:

1. **Dual Stack:** IPv4 and IPv6 coexist on the same device and networks. This is the simplest, most recommended, and most popular mechanism. Dual-stack hosts participate in IPv6 and IPv4 networks simultaneously and applications can select which protocol they will use. The drawback to this mechanism is that IPv4-only devices cannot communicate with IPv6-only devices, so it requires maintaining two routing tables, two sets of firewall rules, and two network management configurations.

2. **Tunneling:** Encapsulation (transport protocol) of IPv6 packets in IPv4 packets and vice versa. Tunneling mechanisms connect IPv4 or IPv6 "islands," making it possible to bridge incompatible networks. They are recommended for site-to-site applications. However, tunneled protocols have related security issues, their performance is low, and they increase the complexity of network administration and troubleshooting.

3. **Translation:** Translation mechanisms are used to enable communication between IPv6-only and IPv4-only devices, allowing IPv4-only hosts to communicate with IPv6-only hosts and vice versa. These mechanisms do not require modifying the IPv4 or IPv6 end nodes, only the edge routers. However, they use a more complex network topology, they performance is not as good (depending on the hardware), they are complex to troubleshoot, and incompatible at the application level.

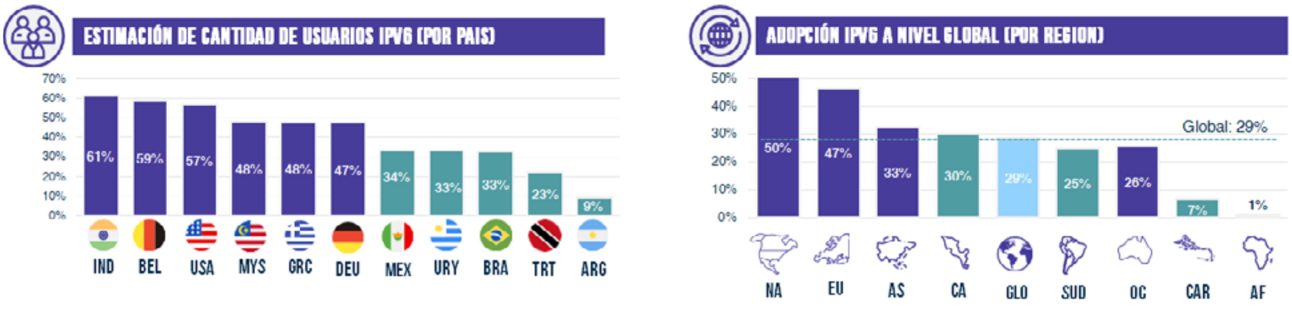
The coexistence of the two protocols results in increased operational complexity and higher costs due to the need to manage and administer two different systems, as well as the related investments depending on the selected transition mechanism.

# IPv6 Deployment Statistics and Trends

While global IPv6 adoption has grown year after year, adoption levels vary across the different regions. The original research on which this study is based used different forms of measurement to survey IPv6 evolution and adoption[4] [5].

The charts below show the results of the analyses that were conducted[6].

Figure 2. Estimated number of IPv6 users by country and IPv6 adoption by region (March 2021)



ESTIMACIÓN DE CANTIDAD DE USUARIOS IPV6 (POR PAIS)

Fuente: SmC+ en base a datos de CISCO Labs Mar/21

ADOPCIÓN IPV6 A NIVEL GLOBAL (POR REGION)

Fuente: SmC+ en base a datos de APNIC Labs Mar/21

The list of countries with the greatest number of IPv6 users is led by India with an estimated 61%, followed by Belgium (59%), the United States (57%), and Malaysia (48%). As for the countries in the LAC region, Mexico tops the list with 34%, followed by Uruguay and Brazil (33%), Trinidad and Tobago (23%), and Argentina (9%).

According to data obtained from APNIC Labs,[7] in March 2021, the global average IPv6 adoption rate stood at 29%. The adoption rate in South America was 25%, which is slightly below the world average; in Central America, adoption rate was 30%, and in the Caribbean, 7%. The Central American penetration rate is higher than the world average, which is strongly influenced by Mexico's high adoption rates. However, when compared to developed markets such as North America and Europe, IPv6 adoption in Latin America and the Caribbean (LAC) is still low.

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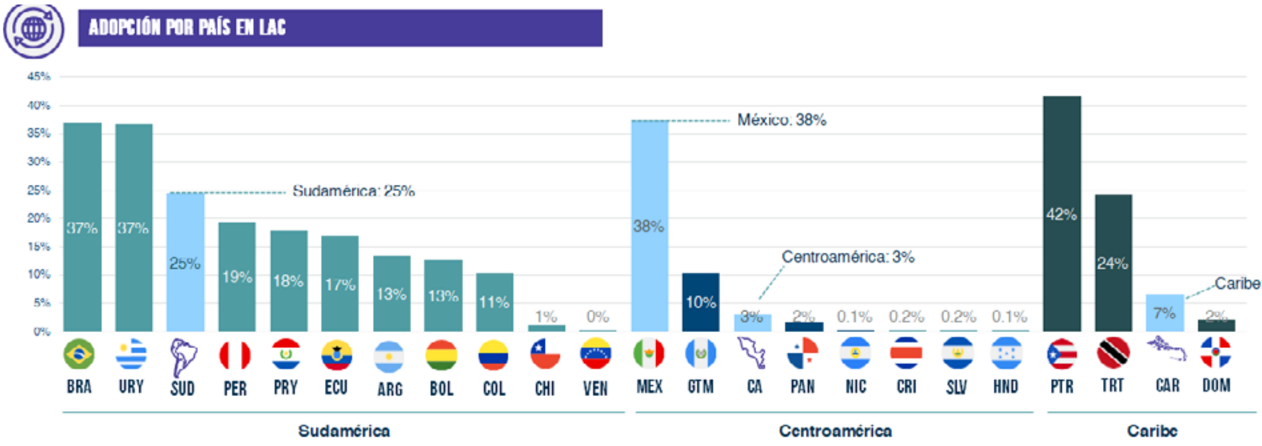
[4] These include Cisco's 6lab project, which provides different indicators, including the estimated percentage of IPv6 users, the percentage of web pages available over IPv6, and the percentage of routable IPv6 prefixes. For more information, visit https://6lab.cisco.com/stats/.

[5] Additional IPv6 adoption criteria can also be obtained from Cisco's IPv6 lab https://6lab.cisco.com/stats/index.php?option=prefixes, including the percentage of web pages available over IPv6 and the ratio of routable IPv6 prefixes. However, because these do not represent the ratio of traffic or users using IPv6, their relevance is limited. Data corresponding to March 2021 shows that, in most of the countries in the region, more than 60% of webpages were available over IPv6. In the case of the ratio of routable IPv6 prefixes, there is greater disparity between the countries in the LAC region, but there are also differences with respect to traffic-based statistics.

[6] The data presented in this section were surveyed in March 2021. The latest IPv6 adoption data are available from APNIC Labs, IPv6 Adoption Measurement https://stats.labs.apnic.net/ipv6/.

[7] For more information on APNIC Labs, visit https: //labs.apnic.net/.

### Figure 3. IPv6 Adoption in LAC by Country



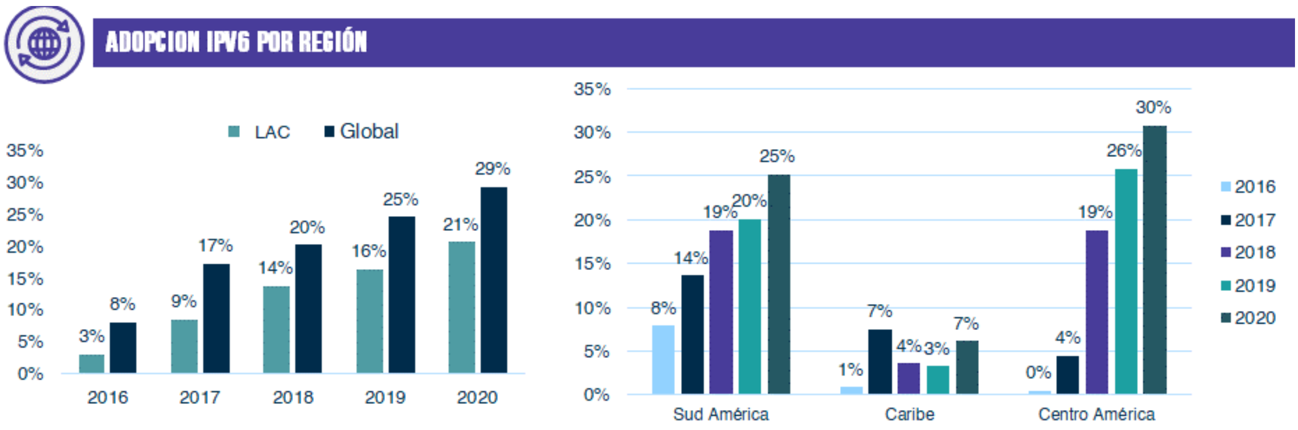
Fuente: SmC+ en base a datos de APNIC Labs Mar/21

Major differences become evident when one considers IPv6 adoption at the regional level disaggregated by country. First, when considering South America, Central America, and the Caribbean; second, when surveying adoption rates by country. In South America, the average IPv6 adoption rate is 25%. Brazil and Uruguay have the highest adoption rates (37%), followed by Peru, Paraguay, and Ecuador (19%, 18%, and 17%, respectively). Argentina, Bolivia, and Colombia have intermediate adoption rates (first two, 13%; the latter, 11%. Finally, the data we surveyed shows that Chile and Venezuela have the lowest levels of IPv6 adoption (1% and 0%, respectively).

In Central America, the average IPv6 penetration rate is 3% and the differences among the various countries are greater than in South America. Mexico (38%) and Guatemala (10%) are at the top of the list. Panama has a penetration rate of 2% and is followed by Nicaragua and Honduras (0.1%), Costa Rica, and El Salvador (0.2%). In the Caribbean, the average IPv6 adoption rate stands at 7% and national figures vary from Puerto Rico (42%)[8], to Trinidad and Tobago (24%), to the Dominican Republic (2%).

### Figure 4. Evolution of IPv6 adoption in LAC (2016-2020)

### Regional and global IPv6 adoption (average adoption rates) and annual evolution of regional and subregional IPv6 adoption (2016-2020)



Fuente: SmC+ en base a datos de APNIC Labs Mar/21

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[8] For measuring the trends in the Caribbean subregion, the study considered countries that are not part of the coverage area of LACNIC.

The first chart compares IPv6 adoption rates in Latin America and the Caribbean (LAC) with average global adoption rates. This chart considers annual global and regional average rates for the 2016-2020 period. Clearly, IPv6 adoption levels increased over these four years, growing from 3% to 9%, to 14%, to 16%, and finally to 21%. A comparison of regional vs global data clearly shows greater IPv6 adoption at world level, with differences ranging from 5 to 9 percentage points. The smallest difference occurs in 2016; the largest, in 2019. The year 2020 is worth noting for several reasons: 1) if one considers only the region, there is a 4% increase from 2019 to 2020; however, in previous years even more significant increases occurred; and 2) if one considers the difference between regional and global adoption rates, no significant differences are detected with respect to previous years.

Despite the above, additional data obtained after the original study show that LACNIC experienced a strong demand for IPv6 assignments during the pandemic[9] and, as a result, almost 49% of assignments are visible on the IPv6 routing table. The same can be said about ASN (Autonomous System Number) traffic, which by the end of June 2020 had grown by 84%[10]. Telecommuting, distance learning, and other activities increased Internet use during the health crisis and led Internet service providers to request a large number of assignments. In this sense, one hypothesis is that the health crisis and its impact on the use of online applications and services generated the perception that IPv4 exhaustion would occur much sooner than originally anticipated and, consequently, increased the motivation for IPv6 deployment.

The second chart compares the different subregions and shows that IPv6 adoption levels have grown gradually in South and Central America over the past five years. In the Caribbean, however, adoption levels remain under 10% and no growth trend is detected.

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[9] LACNIC (29 June 2020). Pandemic Triggers IPv6 Use in the Region. *LACNIC Newsletter:* https://prensa.lacnic.net/news/ipv6/la-pandemia-disparo-el-uso-de-ipv6-en-la-region

[10] LACNIC (10 June 2020). IPv6 Day Webinar [video]. YouTube. https://www.youtube.com/watch?v=90O2gRIJ63o

# Considerations for IPv6 Adoption

Once the necessary infrastructure is deployed, IPv6 adoption depends on factors such as the availability of devices, their ability to use the IPv6 protocol, their specific characteristics, the equipment's IPv6 compatibility, and the content that is transmitted. The most relevant considerations regarding these factors are listed below. Among other circumstances, IPv6 adoption depends on the ability of end-user devices to use this protocol, as well as on the content that is transmitted.

Today, there are a variety of devices that need to be connected to the Internet to function. Examples include of such devices include:

- Mobile devices (e.g., cell phones or tablets) are usually IPv6-compatible, although exceptions may be found among very low-end terminals or devices using outdated versions of Android. Although protocol selection is automatic, in many cases this must be configured manually. Modern smart TVs are IPv6-compatible, yet this feature is factory disabled to avoid configuration issues and customer complaints.

- Most smart appliances (microwave ovens, refrigerators, video surveillance cameras, etc.) are IPv6-compatible to leverage the security offered by the new protocol.

- Smart watches, which have been IPv6-compatible since their inception.

Some IPv4-only customer-premises equipment (CPE) is still in operation. Today, ISPs are demanding IPv6-compatible CPE. This demand is increasing as technology advances. When adopting the IPv6 protocol, ISPs must keep in mind two key aspects in their analysis of the compatibility and capability of their devices: (i) licenses (some devices require an update of their firmware or operating system license to access the functionalities of the new protocol, something that can significantly increase their cost); and (ii) capability (some platforms and devices are not IPv6-capable, not even after an performing an update).

Another factor that affects IPv6 adoption is content availability. Currently, most major content providers (Google, Facebook, Netflix) have deployed IPv6 on their networks and offer content over both protocols. However, to achieve the best possible performance while supporting the coexistence of IPv4 and IPv6, algorithms are used that automatically select which protocol to use. The case of Happy Eyeballs is worth noting, an algorithm published by the IETF which can make dual-stack applications more responsive to users by attempting to connect using both IPv4 and IPv6 at the same time (preferring IPv6). Depending on the quality of each IPv6 deployment, devices may prefer one stack or the other.

Finally, emerging technologies such as the Internet of Things (IoT), 5G technology, and cloud computing are also affecting IPv6 adoption. The term IoT refers to physical device systems that receive and transfer data over wireless networks without human intervention. To operate, each IoT device requires an assigned IP address. While it is true that not all IoT devices will need a public IP address, IPv4 would not have the capacity to support the number of IoT devices expected in LAC in the next few years. On the contrary, IPv6 allows 340 trillion trillion trillion unique IP addresses, which should be sufficient even if the number of IoT devices meets or exceeds current projections.

5G technology and its true potential are not yet being fully realized. Because this technology uses 128-bit addresses, the IPv6 protocol will contribute to the deployment of small cells capable of working simply and efficiently, without the need for address translation. The new protocol may also improve user experience (transmission rates, latency, mobility), system performance, energy efficiency, and device signaling and services (location, security, reliability, transparency of their connectivity). As for cloud computing, it is expected that IPv6 will allow better performance. The absence of NAT in the IPv6 Internet allows cloud operators to be more effective in controlling abuse, which results in improved user security.

# Final Thoughts

The purpose of this study was to present the evolution of IPv6 deployment and adoption in our region along with the main trends we were able to survey, specifically regarding the adoption of IPv6 infrastructure and the various factors affecting this process. The study also explores the evolution of IPv4 exhaustion, the transition to IPv6, and the coexistence of the two protocols.

On the one hand, between 2016 and 2020, regional IPv6 adoption increased 18%. Despite this, asymmetries exist at the subregional level—South America (25%), Central America (30%), and the Caribbean (7%). Even though the region is well-placed and has made much progress, its IPv6 adoption rates continue to be lower than the global average and that of other regions. Additionally, adoption rates in each subregion vary significantly.

On the other hand, the trends we detected show that IPv6 adoption is affected by different factors, including the availability of devices, their ability to use the IPv6 protocol, their specific characteristics, the compatibility of the devices with the IPv6 protocol, and the content that is transmitted.

To conclude, the study briefly presents some aspects of the potential role of emerging technologies such as the Internet of Things (IoT), 5G technology, and cloud computing in the future deployment of IPv6.

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*LACNIC (10 June 2020). IPv6 Day Webinar [video]. YouTube. https://www.youtube.com/watch?v=90O2gRIJ63o*

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