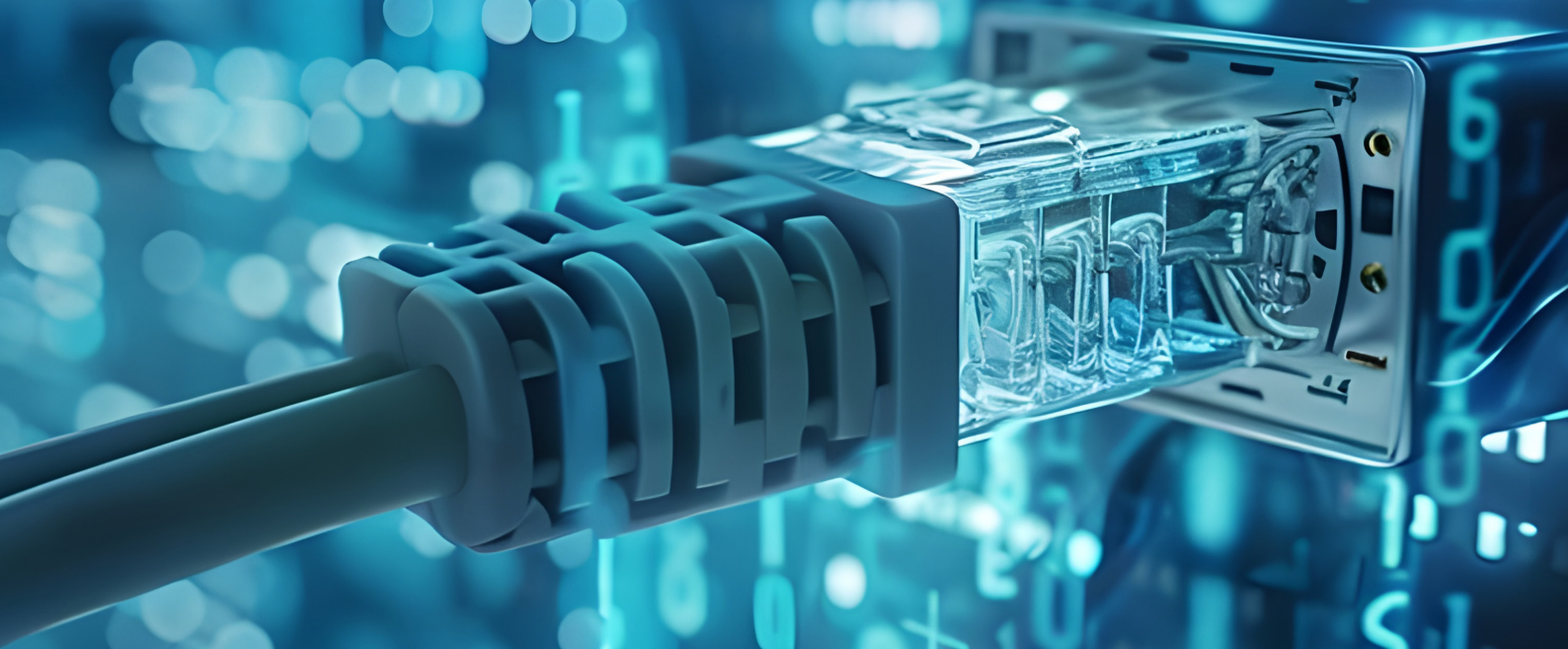# Global IPv6 Development Report 2024

IPv6 Development Analysis and Policy Suggestions

Roland Berger

Executive summary

With the advent of the digital economy era, digitalization, network integration, and intelligent transformation have become the main themes of society development and a new engine driving economic growth. As the foundation of digital economy infrastructure, IP networks face numerous new demands in the new era, including ubiquitous connectivity, interconnection of myriad networks, fusion of virtual and physical realms, and convergence of computing and networking. However, in the face of exponentially growing address requirements driven by emerging services, the dwindling supply of IPv4 addresses has imposed an invisible constraint on the development of the Internet. Consequently, the large-scale deployment of IPv6 and technology innovations based on IPv6 have emerged as the main path for the evolution and upgrading of the Internet.

The intrinsic motivation driving IPv6 development not only stems from the expansion of public IP address space in response to IPv4 exhaustion, but more significantly, from the flexibility, scalability, and programmability that the IPv6 protocol introduces, which collectively open up vast horizons for network technology innovation. The application of IPv6 innovative technologies, referred to as "IPv6 Enhanced," **including Segment Routing (SRv6), Network Slicing, In-situ Flow Information Telemetry (IFIT), Application-Aware Networking (APN6), and advanced multicast technologies like bit index explicit replication (BIERv6),** is set to further unlock the technical potential of IPv6. This will cater to the diverse needs of applications and introduce a next-generation internet that is more efficient, open, intelligent, and secure. By doing so, it lays the groundwork for the upgrading of the internet industry and the global boom of the digital economy.

Undoubtedly, the large-scale deployment and innovative application of IPv6 constitute a crucial cornerstone for national digital economy development, serving as the link connecting end-users (individuals, households, and enterprises), networks, and data centers in the AI era. Over the past decade, nations worldwide have implemented numerous initiatives to facilitate the transition of the internet ecosystem toward IPv6. In reviewing the progress of IPv6 in 2023, particular attention is drawn to the accelerated growth of the Internet of Things (IoT) and the notable

implementation of IPv6 Enhanced technologies integrated into various industry scenarios. The increase in the number of deployments of IPv6 protocol and IPv6 Enhanced technologies are the foundation for realizing the interconnectivity of all things and a precursor to the smart revolution.

Given the mounting urgency for IPv6 deployment and application, the year 2023 witnessed a significant acceleration in the large-scale deployment of global IPv6 networks, alongside the progressive realization of scaled product implementations for IPv6 Enhanced applications. As of today, it is a must to review the advancements made in global IPv6 adoption and its innovative applications during 2023, offering insights and best practices for other countries to increase the effectiveness of their IPv6 initiatives.

Building upon the philosophy and methodology employed in the "Global IPv6 Development Index Report 2022," we have, in response to industry dynamics, timely adjusted the model structure and weight allocation of the Global IPv6 Development Index. Acknowledging that IPv6 development has progressed beyond the planning stage, the model appropriately reduces the weight given to planning indicators within the IPv6 Development Index. Under the innovation indicator, emerging domains such as digital mapping and IPv6-dedicated lines/ private networks have been incorporated into consideration. In the policy recommendations section, this year's report delves deeper into an analysis of the current state of IPv6 development in 10 representative countries across major global regions, proposing tailored policy suggestions.

In a nutshell, IPv6, as the universally acknowledged evolution for the Internet, presents a pivotal opportunity for upgrading network infrastructure, fostering digital industry innovation, and driving socio-economic developments. It serves as a crucial lever for countries to seize the moment in global internet advancement, expedite the deployment of digital infrastructure, forge new competitive edges, and gain the initiative in industrial competition. The future is here, with the IPv6 wave looming on the horizon.

Contents

1

Overview of IPv6 in 2023

Throughout 2023, the urgency for large-scale IPv6 deployment as a replacement for IPv4 escalated, fueled by the depletion of IPv4 addresses and the expanding demands from applications such as 5G, the Internet of Things (IoT), and cloud computing. The pace of IPv6 network deployment notably accelerated, marking a breakthrough with global coverage surpassing 30% for the first time. Leading nations have reached or neared 70% IPv6 coverage, with mobile traffic on IPv6 overtaking IPv4.

It is noted that, with the establishment of foundational IPv6 networks in multiple leading countries, the focus of policies has shifted from initial expansion to the commercialization and large-scale application of IPv6 Enhanced technologies, driving the implementation of IPv6 Enhanced use cases to stimulate new momentum for IPv6 protocol deployment from the demand side.

As the bedrock for the development of the next-generation internet, IPv6 deployment and application are imminent. On one hand, IPv6, as the foundation of digital infrastructure, is a cornerstone for internet evolution and network technological innovation, as well as an indispensable path for the digital and transformative upgrade of economies and societies. On the other hand, the fusion of IPv6 Enhanced innovative technologies like SRv6 with industry applications is hastening practical implementations, providing a crucial lever for the digital and intelligent transformation of myriad industries, thereby accelerating the advent of an era of ubiquitous intelligence and connectivity.

1.1. IPv6 as foundation of digital infrastructure

IPv6, as a vital cornerstone in the construction of digital infrastructure, furnishes a colossal pool of address resources that underpin network technological innovations and industrial upgrades.IPv6 Enhanced,by comprehensively enhancing IP network capabilities across six dimensions – ultra-broadband, extensive connectivity, determinism, low latency, automation, and security – provides a high-quality network foundation capable of supporting the demands of massive interconnectivity, voluminous data, cloudification of production, convergence of cloud and networks, intelligent operations and maintenance, as well as secure and trustworthy services.

In the context of new-generation digital infrastructure underpinned by emerging technologies such as 5G, cloud computing, and the Internet of Things (IoT), the limited network bearing capacity of the traditional IPv4 protocol struggles to accommodate new businesses and requirements. Conversely, the IPv6 protocol, through its multiplexed connection and mobile management mechanisms, effectively bolsters the stability of 5G connections. Its auto-configuration feature significantly enhances the efficiency of IoT connectivity, while its near-infinite address space and streamlined address management enable unbounded scalability for cloud computing. By enabling digital infrastructure, IPv6 paves the way for the digital economy, becoming the indispensable path for unleashing new momentum in the digital economy and facilitating the digital and transformative evolution of economies and societies. ▶ 01

1.2. IPv6 realizes massive inter-connectivity

In the surge of the digital era, IP networks serve as vital hubs connecting everything below and applications above, shouldering the core responsibility of linking the two ends, and thus forming the cornerstone of the era of massive interconnectivity. Compared to IPv4, the most obvious advantage of IPv6 lies in its seemingly inexhaustible supply of public IP addresses, theoretically enabling "an IP address for every grain of sand on Earth." According to market research firm IoT Analytics[1], the number of global IoT connections reached 14.3 billion in 2022 and is expected to grow further to 16 billion in 2023, vastly outnumbering the 4.3 billion public addresses IPv4 can provide.

IPv6's capability to assign a unique IP address to each connected device not only solves the scarcity issue but also facilitates

---

01   Overview of digital infrastructure
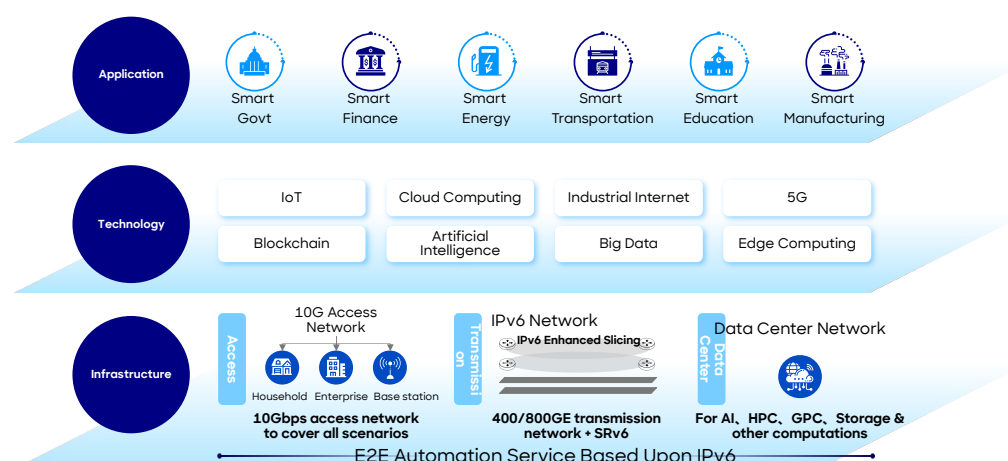
Source: Roland Berger

---

1. State of IoT 2023, IoT Analytics

end-to-end connectivity, enables automated configuration, bolsters security, and enhances mobility, presenting exceptional solutions to these challenges. This makes the concept of a true "Internet of Everything" not just a theoretical possibility but a tangible reality, underpinning the seamless integration and interaction among devices that forms the backbone of our modern digital landscape.

▶ 02

1.3. IPv6 Enhanced enlightens intelligent revolution

Innovative applications of IPv6 technology, referred to as "IPv6 Enhanced", are fueling the convergent and innovative development of new technologies such as 5G, the Internet of Things (IoT), cloud computing, AI, and industrial internet, triggering a new wave of intelligence revolution led by advancements in internet technology. Maturity in technologies like SRv6, network slicing, 400 Gigabit Ethernet (400GE), IFIT, APN6, and BIERv6 empower IPv6 with unique capabilities, facilitating multi-faceted, three-dimensional, and comprehensive upgrades in applications and scenario integrations. These technologies have been piloted to varying degrees across multiple sectors including government, finance, energy, transportation, education, and man-

ufacturing. From the perspective of bandwidth enhancement, as routers evolve from 100 Gigabit Ethernet (100GE) to 400GE, IPv6 Enhanced technologies can more fully exploit their advantages in intelligent scheduling and network slicing.

In June 2024, the World Broadband Association (WBBA) released its report titled "Network Evolution for the 5.5G and 6G Era," outlining the industrial vision for Net5.5G, which is segmented into four key components: an access network comprising gigabit mobile networks, gigabit household broadband, gigabit campus networks, and gigabit enterprise leased lines; an IP backbone network supporting 400 Gigabit Ethernet (400GE), Segment Routing over IPv6 (SRv6), and network slicing; data center networks based on 400GE; and end-to-end network management systems. The report underscores that IPv6 and its advanced iteration, IPv6 Enhanced, will form the foundational protocols for the Net5.5G era, laying the groundwork for the next leap in global connectivity capabilities.

It is projected that by 2026, the potential economic value created by IPv6/IPv6 Enhanced across various industries could reach a total of 7.9 trillion US dollars. Among them, the potential value creation of IPv6 in industry and manufacturing is expected to reach

---

02   Illustration of mass inter-connectivity

Source: Roland Berger

1.9 trillion US dollars, accounting for 5.5% of the total industry output value; the potential value creation of IPv6 in the public services, finance, transportation, education, and energy industries is expected to be approximately 1,100, 1,000, 560, 210 and 190 billion US dollars, accounting for 3.0%-4.6% of the total industry output value respectively . The integration of IPv6 Enhanced with industry-specific appli-cations is reshaping traditionally hard-to-digitize sectors from the supply side, infusing new impetus into the digital and intelligent transformation of myriad industries. An era of ubiquitous intelligence, characterized by seamless human-machine integration, is rapidly approaching, propelled forward by the acceleration of IPv6. ▶ 03

---

03   IPv6 Enhanced vertical industry application scenarios

Smart Government
Provides capabilities such as secure isolation and critical communication support for video conferencing, etc

Smart Finance
Achieves application-oriented network quality assurance, behavior analysis, and bandwidth optimization

Smart Energy
Enhances network security and reliability in applications such as power system monitoring and oil & gas pipeline transmission surveillance

IPv6 Enhanced
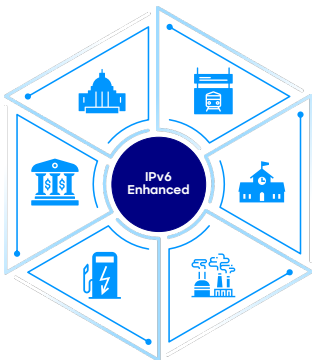
Smart Transportation
Empowers the construction of intelligent highway networks, supporting the digitalization of transportation infrastructure

Smart Education
Facilitates the development of dedicated education networks for high-quality transmission, driving the deployment of educational services on the cloud

Smart Manufacturing
In conjunction with 5G and Artificial Intelligence, creates high-quality Industrial Internet

Source: Roland Berger

2. Global IPv6 Development Report 2022, Roland Berger

Global IPv6 Development Index

2

To gauge the progress of IPv6 deployment across different countries, we have meticulously developed a Global IPv6 Development Index, drawing extensively from the past research conducted by esteemed institutions such as the Latin American and Caribbean Internet Addresses Registry (LACNIC[3]) and the Organization for Economic Co-operation and Development (OECD[4]). This index serves as the foundation for the subsequent analysis of each nation's IPv6 development status presented later in our discourse.

2.1. Index definition and methodology

In today's era, the scope of IPv6 has expanded beyond mere IP addressing, encompassing innovative applications symbolized by technologies like SRv6, which fall under the umbrella of IPv6 Enhanced. **Drawing from the essence of IPv6 and incorporating methodologies referenced from organizations such as LACNIC, OECD and companies like Cisco[5], a comprehensive evaluation of nation's IPv6 development is conducted across three dimensions: IPv6 address penetration, its effectiveness, and the realm of innovative applications.**

The specifics are outlined as follows: ▶ **04**

04 Methodology of IPv6 Development Index
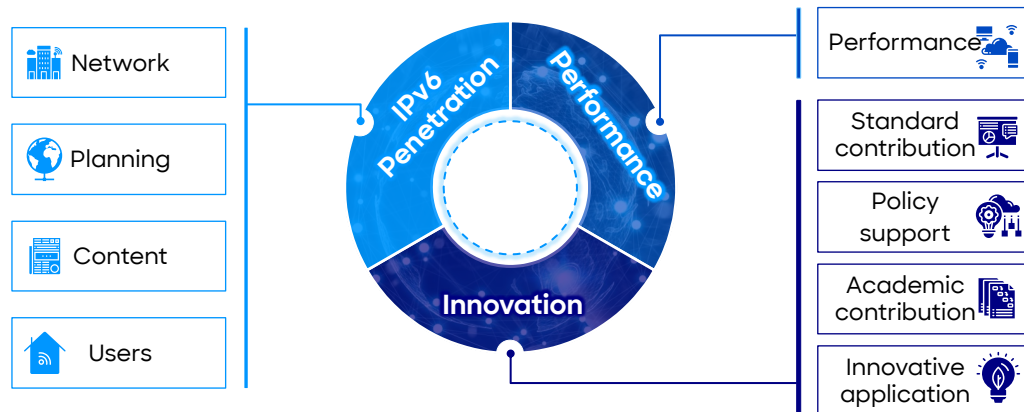
Source: Roland Berger

---

3. IPv6 Deployment for Social and Economic Development
4. Internet Addressing: Measuring Deployment of IPv6, K.Perset, OECD digital economy paper No.172, Apr 2010
5. Internet IPv6 Adoption: Methodology, Measurement and Tools

The calculation method and weight distribution of the Index are explained as followed:

Index Type	Level 1 dimension			Level 2 dimension			
Type	Index	Indication		Index	Description	Source[6]	Weight
IPv6 penetration	Planning	Ratio of allocated v6 prefixes to allocated v4 prefixes; Ratio of allocated IPv6 prefixes from which traffic has been seen to all allocated v6 prefixes		Allocation of IPv6 prefixes	Ratio of allocated v6 prefixes to allocated v4 prefixes	APNIC	3%
				Ratio of advertised v6 prefixes to allocated v6 prefixes	Ratio of advertised v6 prefixes to allocated v6 prefixes	APNIC	3%
	Network	Measure the level of deployment of IPv6 in the network, incl. data centers of telecom operators and cloud service providers		Adoption of IPv6 transit AS	Ratio of dual-stack IPv6 Transit AS to all du-al-stack Transit AS	Cisco	20%
	Content	Measure the level of deployment of IPv6 in websites from content providers		The website's support for IPv6	Weighted ratio of IPv6 enabled to tested top 500 websites	Cisco, APNIC	20%
	Users	Measure the accessibility to the internet through IPv6 for end-us-ers		End-user accessibili-ty to IPv6	Ratio of IPv6 capable us-ers to number of internet users	APNIC	20%
Performance	Performance	Measure the quality of network and effects of IPv6 deployment during end-users' visits to the internet through IPv6		Speed of IPv6 network connection	Average RTT differ-ence between IPv6 and IPv4 on dual stack end devices	APNIC	8%
				Reliability of IPv6 network connection	IPv6 failure rate on du-al-stack end devices	APNIC	8%
Innovation	Standard contribution	Measure the contribution to international standards of IPv6 and IPv6 Enhanced innovation by each country		Standard contribu-tion	# of companies, univer-sities and other institu-tions in working groups of IEEE and IETF	IEEE, IETF	3%
	Policy support	Measure the # of organizations and supportive policies to pro-mote IPv6 and IPv6 Enhanced innovation by each country		Policy support	# of org. established and policies published by the gov. to regulate the development of IPv6 and IPv6 Enhanced	Official websites	3%
	Academic contribution	Measure the academic contribu-tion to IPv6 and IPv6 Enhanced innovation by each country		Academic contribu-tion	# of academic pa-pers on IPv6 and IPv6 Enhanced innovation technology published in top-level publications	WOS	3%
	Innovative application	Measure the level of deployment of IPv6 Enhanced innovation in-novation projects to evaluate the capabilities of future innovation		Innovative application	# of operators and enterprises with IPv6 En-hanced Innovation pilots or commercial use cases	WOS	3%

---

6. This report considers data till Dec, 2023, including APNIC IPv6 (https://stats.labs.apnic.net/ipv6/), APNIC v6pop (https://stats.labs.apnic.net/v6pop), APNIC v6perf (https://stats.labs.apnic.net/v6perf), APNIC roas (https://stats.labs.apnic.net/roas), CISCO 6Lab(https://6lab.cisco.com/stats), IPv6 Group(https://www.itu.int/en/ITU-T/ipv6/regional), ETSI MEMBER(https://portal.etsi.org/TB-SiteMap/IPv6 Enhanced/List-of-IPv6 Enhanced-Members-and-Participants), Web of Science(https://www.webofscience.com/wos/)

We use the weighting method to sum the sub-indicators involved in the three dimensions to calculate the final IPv6 development index of each country. The weight of each sub-indicator refers to the distribution of the indicator to balance different input variables. Finally, the IPv6 development index is calculated by normalizing different sub-indices, and the average value of each sub-indicator is calculated to determine the weight of the actual application.

Compared with the previous report, this report has appropriately reduced the weight of planning indicators in the IPv6 penetration dimension. Considering that the development of IPv6 has gradually passed the stage where planning is the most important and has entered the stage of focusing on actual use, the weight should be adjusted appropriately.

The framework is based on approaches previously adopted by the OECD[7], LACNIC[8] and Cisco[9]. In terms of data sources, we use Asia Pacific Internet Network Information Center (APNIC), Cisco and other authoritative research institutions and organizations such as WOS as raw data input to ensure data reliability.[10]

2.2. IPv6 Development Index result explanation

The IPv6 Development Index, with a numerical range spanning from 0 to 1, offers a quantifiable measure of a country's progress in adopting and implementing IPv6 technology, where a higher score denotes a more advanced stage of IPv6 development. By selecting 92 countries globally and leveraging data from sources including APNIC and other authoritative organizations for the year 2023, a comprehensive assessment of each nation's IPv6 readiness was conducted.

Based on the computed index values, countries were classified into three categories: Front-runners, Adopters, and Starters. The Front-runner group consists of nations whose IPv6 Development Index places them in the top 25% globally, signifying exceptional progress in IPv6 deployment. Conversely, the Starter category includes those in the bottom 25%, indicating early stages of IPv6 development. Nations falling between these two groups are categorized as Adopters, representing those making strides but not yet in the leading ranks.

To ensure cross-country comparability and account for varying starting points and speeds of transition from IPv4 to IPv6, the index specifically measures the deployment of IPv6 relative to IPv4. This approach takes into account the baseline established by IPv4 and emphasizes the additional advancements made through IPv6 implementation, thereby offering a balanced view of a country's progress in upgrading its digital infrastructure to support the expanding needs of the internet ecosystem.

7. Internet Addressing: Measuring Deployment of IPv6, K.Perset, OECD digital economy paper No.172, Apr 2010
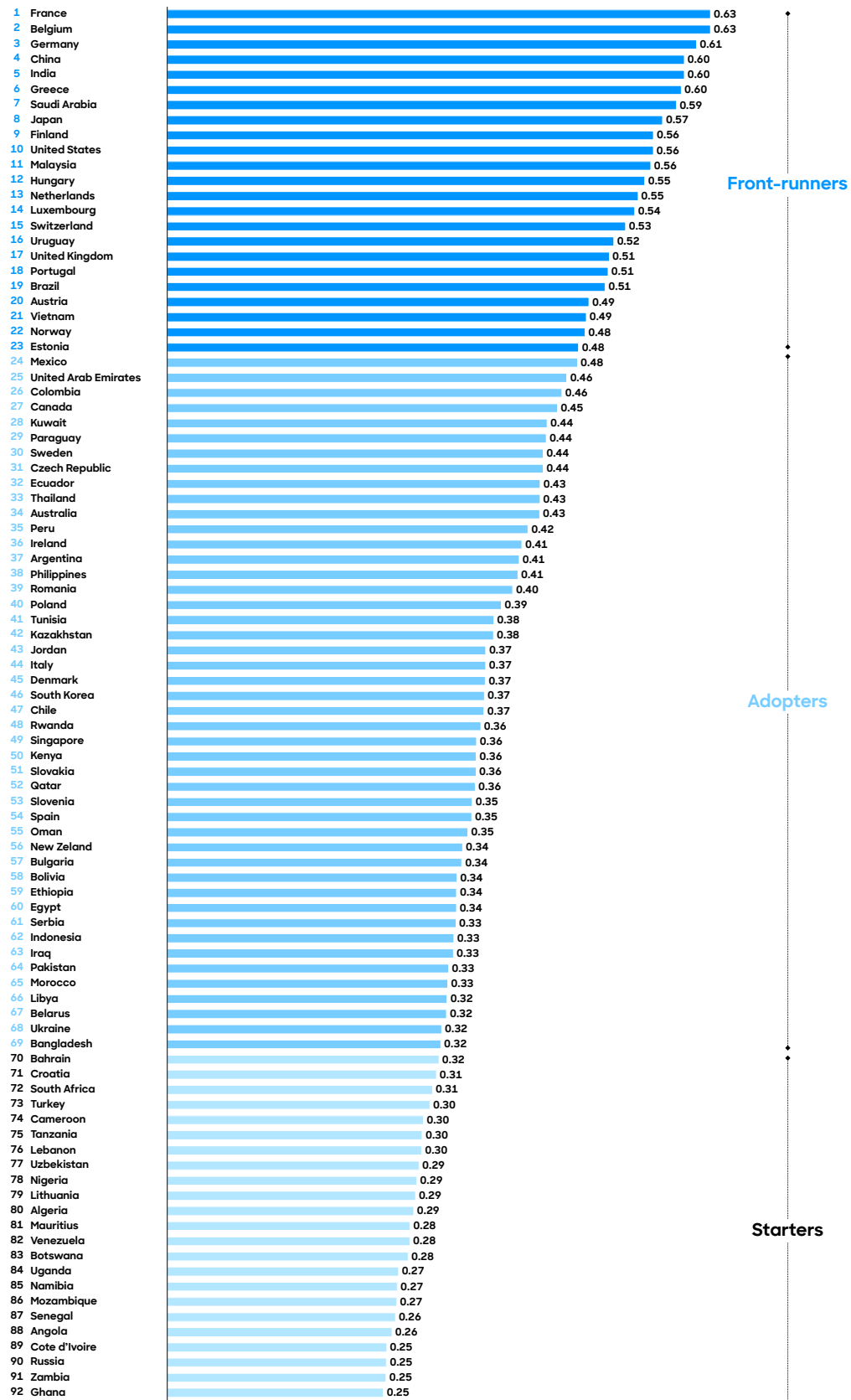8. IPv6 Deployment for Social and Economic Development
9. Internet IPv6 Adoption: Methodology, Measurement and Tools
10. Counrty rankings might deviate from their econmic and development conditions depending on infrastructure legacies

05 **Country ranking of IPv6 Development Index**

#	Country	Value
1	France	0.63
2	Belgium	0.63
3	Germany	0.61
4	China	0.60
5	India	0.60
6	Greece	0.60
7	Saudi Arabia	0.59
8	Japan	0.57
9	Finland	0.56
10	United States	0.56
11	Malaysia	0.56
12	Hungary	0.55
13	Netherlands	0.55
14	Luxembourg	0.54
15	Switzerland	0.53
16	Uruguay	0.52
17	United Kingdom	0.51
18	Portugal	0.51
19	Brazil	0.51
20	Austria	0.49
21	Vietnam	0.49

Front-runners

#	Country	Value
22	Norway	0.48
23	Estonia	0.48
24	Mexico	0.48
25	United Arab Emirates	0.46
26	Colombia	0.46
27	Canada	0.45
28	Kuwait	0.44
29	Paraguay	0.44
30	Sweden	0.44
31	Czech Republic	0.44
32	Ecuador	0.43
33	Thailand	0.43
34	Australia	0.43
35	Peru	0.42
36	Ireland	0.41
37	Argentina	0.41
38	Philippines	0.41
39	Romania	0.40
40	Poland	0.39
41	Tunisia	0.38
42	Kazakhstan	0.38
43	Jordan	0.37
44	Italy	0.37
45	Denmark	0.37
46	South Korea	0.37
47	Chile	0.37
48	Rwanda	0.36
49	Singapore	0.36
50	Kenya	0.36
51	Slovakia	0.36
52	Qatar	0.36
53	Slovenia	0.35
54	Spain	0.35
55	Oman	0.35
56	New Zeland	0.34
57	Bulgaria	0.34
58	Bolivia	0.34
59	Ethiopia	0.34
60	Egypt	0.34
61	Serbia	0.33
62	Indonesia	0.33
63	Iraq	0.33
64	Pakistan	0.33
65	Morocco	0.33
66	Libya	0.32
67	Belarus	0.32
68	Ukraine	0.32
69	Bangladesh	0.32
70	Bahrain	0.32

Adopters

#	Country	Value
71	Croatia	0.31
72	South Africa	0.31
73	Turkey	0.30
74	Cameroon	0.30
75	Tanzania	0.30
76	Lebanon	0.30
77	Uzbekistan	0.29
78	Nigeria	0.29
79	Lithuania	0.29
80	Algeria	0.29
81	Mauritius	0.28
82	Venezuela	0.28
83	Botswana	0.28
84	Uganda	0.27
85	Namibia	0.27
86	Mozambique	0.27
87	Senegal	0.26
88	Angola	0.26
89	Cote d'Ivoire	0.25
90	Russia	0.25
91	Zambia	0.25
92	Ghana	0.25

Starters

Source: Roland Berger

06　Country Ranking of Global IPv6 Development Index

Front-runners

1	France
2	Belgium
3	Germany
4	China
5	India
6	Greece
7	Saudi Arabia
8	Japan
9	Finland
10	United States
11	Malaysia
12	Hungary
13	Netherlands
14	Luxembourg
15	Switzerland
16	Uruguay
17	United Kingdom
18	Portugal
19	Brazil
20	Austria
21	Vietnam
22	Norway
23	Estonia

Adopters

24	Mexico	47	Chile
25	United Arab Emirates	48	Rwanda
26	Colombia	49	Singapore
27	Canada	50	Kenya
28	Kuwait	51	Slovakia
29	Paraguay	52	Qatar
30	Sweden	53	Slovenia
31	Czech Republic	54	Spain
32	Ecuador	55	Oman
33	Thailand	56	New Zeland
34	Australia	57	Bulgaria
35	Peru	58	Bolivia
36	Ireland	59	Ethiopia
37	Argentina	60	Egypt
38	Philippines	61	Serbia
39	Romania	62	Indonesia
40	Poland	63	Iraq
41	Tunisia	64	Pakistan
42	Kazakhstan	65	Morocco
43	Jordan	66	Libya
44	Italy	67	Belarus
45	Denmark	68	Ukraine
46	South Korea	69	Bangladesh

Starters

70	Bahrain
71	Croatia
72	South Africa
73	Turkey
74	Cameroon
75	Tanzania
76	Lebanon
77	Uzbekistan
78	Nigeria
79	Lithuania
80	Algeria
81	Mauritius
82	Venezuela
83	Botswana
84	Uganda
85	Namibia
86	Mozambique
87	Senegal
88	Angola
89	Cote d'Ivoire
90	Russia
91	Zambia
92	Ghana

Source: Roland Berger

2.2.2.　Regional country ranking

Asia Pacific

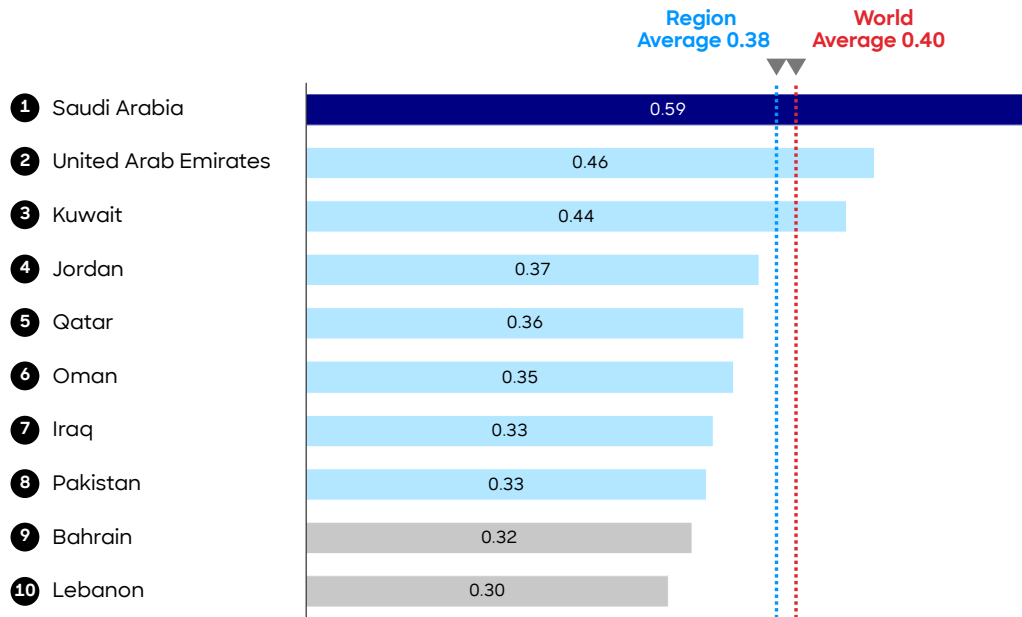## 07　Country ranking of global IPv6 Development Index – Asia Pacific

World Average 0.40　　Region Average 0.45

Rank	Country	Index
1	China	0.60
2	India	0.60
3	Japan	0.57
4	Malaysia	0.56
5	Vietnam	0.49
6	Thailand	0.43
7	Australia	0.43
8	Philippines	0.41
9	South Korea	0.37
10	Singapore	0.36
11	New Zeland	0.34
12	Indonesia	0.33
13	Bangladesh	0.32
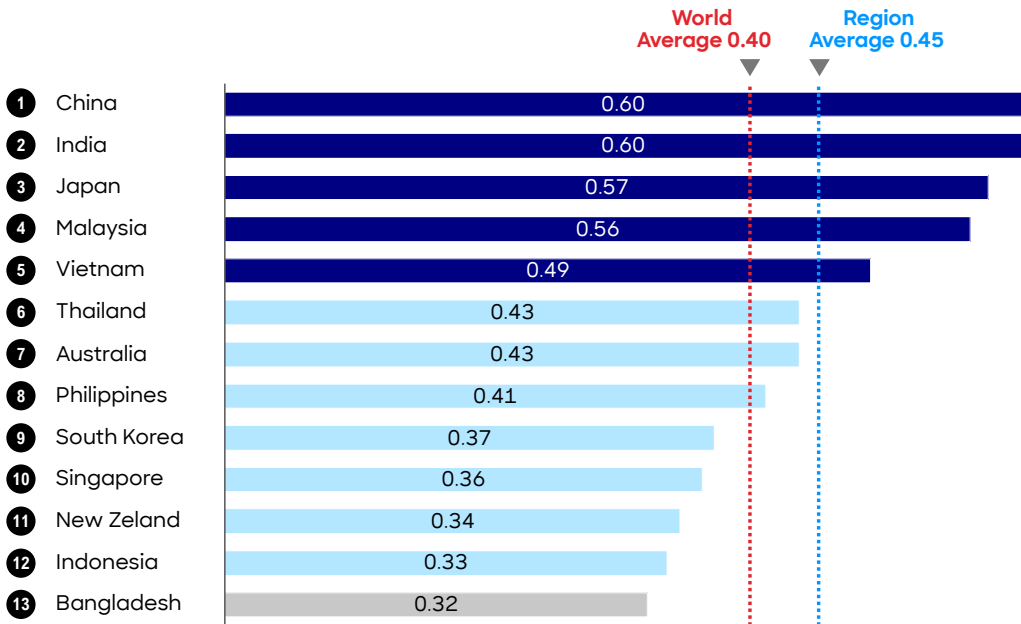
Source: Roland Berger

08 Country ranking of global IPv6 Development Index – Middle East

Region Average 0.38 | World Average 0.40

Rank	Country	Index
1	Saudi Arabia	0.59
2	United Arab Emirates	0.46
3	Kuwait	0.44
4	Jordan	0.37
5	Qatar	0.36
6	Oman	0.35
7	Iraq	0.33
8	Pakistan	0.33
9	Bahrain	0.32
10	Lebanon	0.30

Source: Roland Berger

Northern Africa

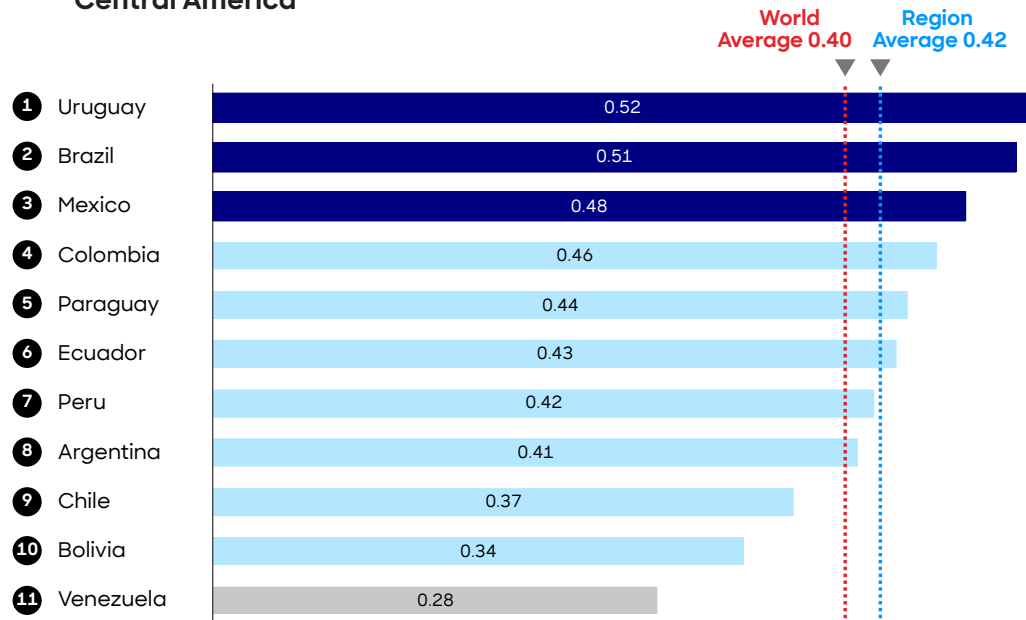## 09 Country ranking of global IPv6 Development Index – Northern Africa

Region Average 0.31 | World Average 0.40

Rank	Country	Index
1	Tunisia	0.38
2	Ethiopia	0.34
3	Egypt	0.34
4	Morocco	0.33
5	Libya	0.32
6	Cameroon	0.30
7	Algeria	0.29
8	Senegal	0.26
9	Cote d'Ivoire	0.25

Source: Roland Berger

10   Country ranking of global IPv6 Development Index – Southern Africa

Region Average 0.29
World Average 0.40

	Country	Index
1	Rwanda	0.36
2	Kenya	0.36
3	South Africa	0.31
4	Tanzania	0.30
5	Nigeria	0.29
6	Mauritius	0.28
7	Botswana	0.28
8	Uganda	0.27
9	Namibia	0.27
10	Mozambique	0.27
11	Angola	0.26
12	Zambia	0.25
13	Ghana	0.25
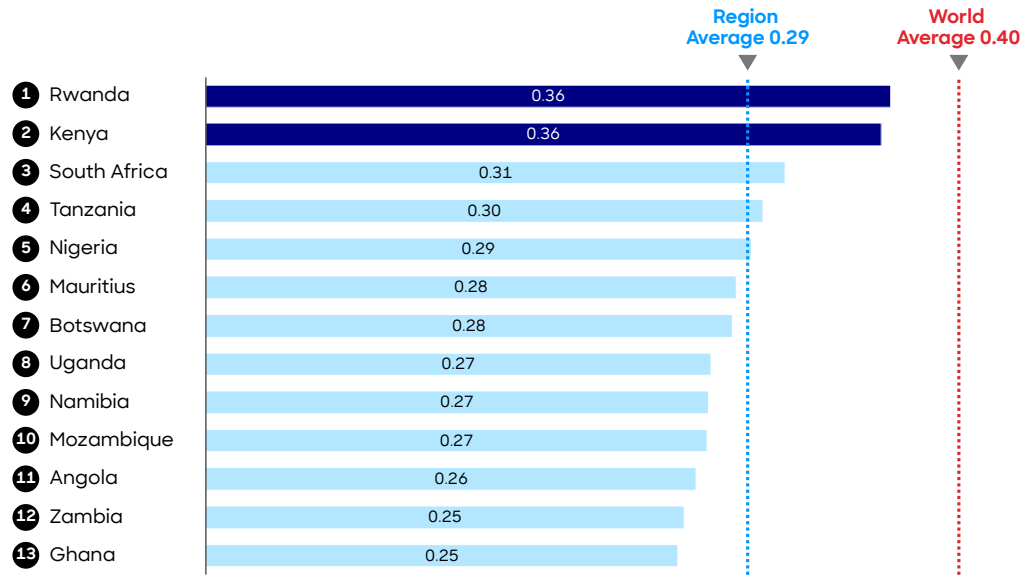
Source: Roland Berger

Southern and Central America

11   Country ranking of global IPv6 Development Index – Southern and Central America
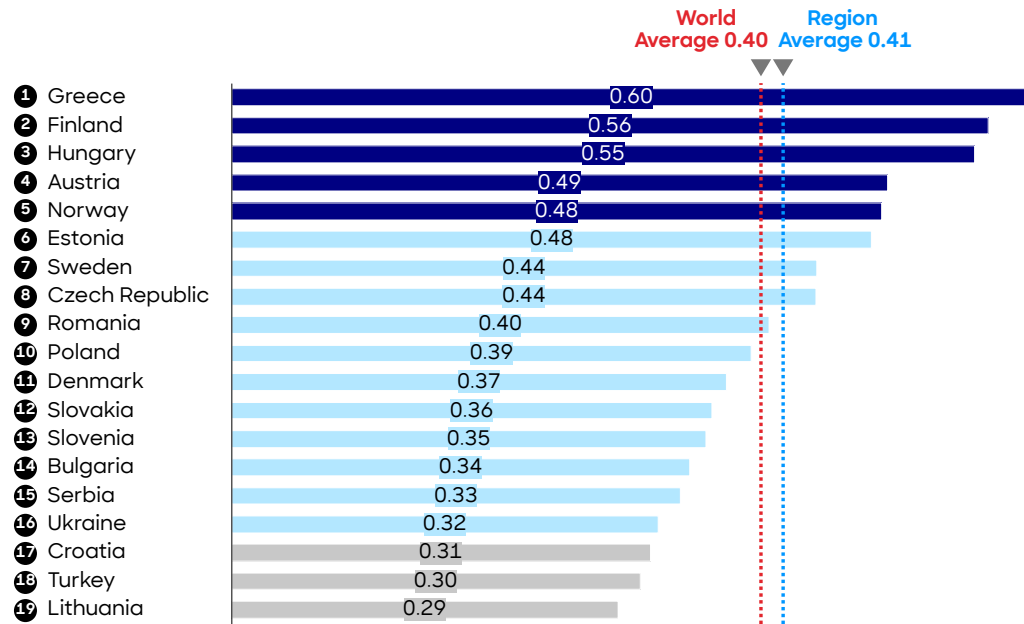

World Average 0.40
Region Average 0.42

	Country	Index
1	Uruguay	0.52
2	Brazil	0.51
3	Mexico	0.48
4	Colombia	0.46
5	Paraguay	0.44
6	Ecuador	0.43
7	Peru	0.42
8	Argentina	0.41
9	Chile	0.37
10	Bolivia	0.34
11	Venezuela	0.28

Source: Roland Berger

12   Country ranking of global IPv6 Development Index – North America

World
Average 0.40

Region
Average 0.51

❶ United States	0.56	
❷ Canada	0.45	

Source: Roland Berger

---
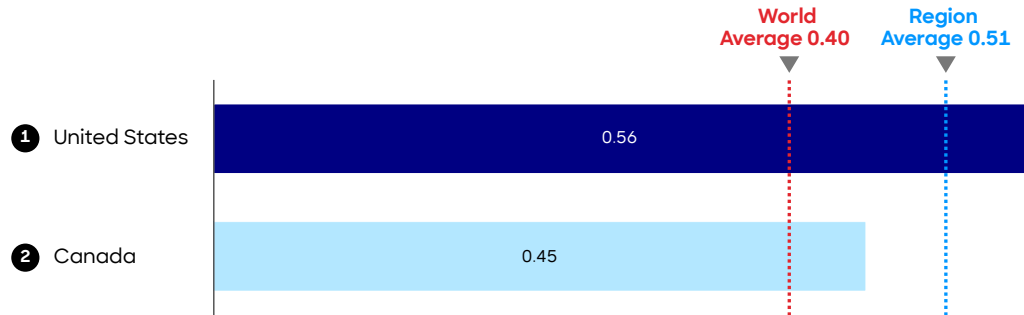
13   Country ranking of global IPv6 Development Index – Northern and eastern Europe

World
Average 0.40

Region
Average 0.41

Rank	Country	Index
❶	Greece	0.60
❷	Finland	0.56
❸	Hungary	0.55
❹	Austria	0.49
❺	Norway	0.48
❻	Estonia	0.48
❼	Sweden	0.44
❽	Czech Republic	0.44
❾	Romania	0.40
❿	Poland	0.39
⓫	Denmark	0.37
⓬	Slovakia	0.36
⓭	Slovenia	0.35
⓮	Bulgaria	0.34
⓯	Serbia	0.33
⓰	Ukraine	0.32
⓱	Croatia	0.31
⓲	Turkey	0.30
⓳	Lithuania	0.29

Source: Roland Berger

14 Country ranking of global IPv6 Development Index – Western Europe

World Average 0.40 ▼

Region Average 0.52 ▼

Rank	Country	Value
1	France	0.63
2	Belgium	0.63
3	Germany	0.61
4	Netherlands	0.55
5	Luxembourg	0.54
6	Switzerland	0.53
7	United Kingdom	0.51
8	Portugal	0.51
9	Ireland	0.41
10	Italy	0.37
11	Spain	0.35
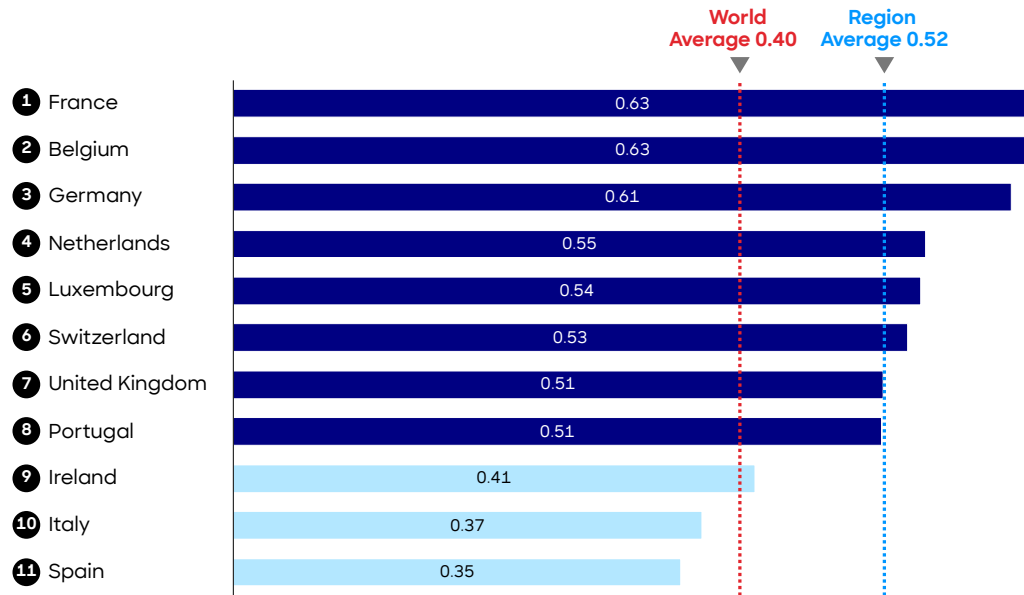
Source: Roland Berger

15 Country ranking of global IPv6 Development Index – Eurasia

Region Average 0.31 ▼

World Average 0.40 ▼

Rank	Country	Value
1	Kazakhstan	0.38
2	Belarus	0.32
3	Uzbekistan	0.29
4	Russia	0.25
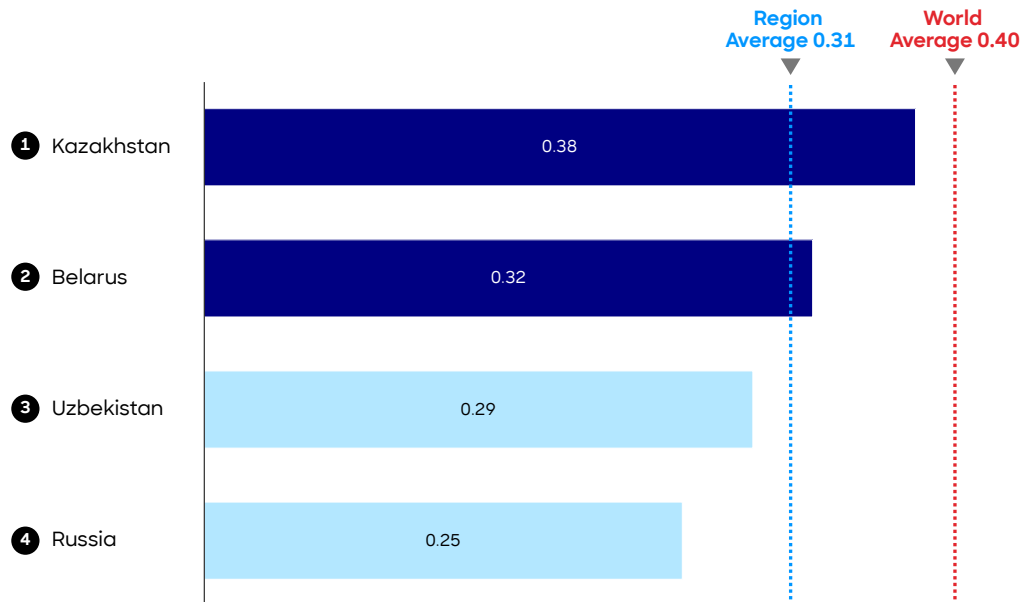
Source: Roland Berger

2.3. Analysis of key drivers behind Index change

Given the intricate web of internal and external factors influencing individual countries' IPv6 Development Index scores, employing a method of grouping and synthesis analysis allows us to distill common trends and identify the pivotal drivers behind the progress within each category. Comparing 2023 to 2022, all three groups—Front-runners, Adopters, and Starters —exhibited notable advancements in their IPv6 Development Indexes, with Front-runners showing the most significant leap, Starters following closely, and Adopters experiencing the smaller increase relatively. Delving deeper into the analysis, the subsequent exploration will concentrate on the underlying factors propelling changes in the sub-indicators that compose the overall IPv6 Development Index for each group. ▶ 16

2.3.1. Planning: Front-runners and Adopters remain steady, while Starters catch up swiftly

▶ **Stage of Development Disparity:** As Front-runners and Adopters move past the planning phase of IPv6 adoption, their focus shifts past applying for and allocating IPv6 prefixes, resulting in their 2023 scores on IPv6 planning indicators being roughly equivalent to those of 2022. Conversely, Starters, somewhat lagging in IPv6 development, are primarily focused on early-stage planning. Their scores on IPv6 planning metrics see a substantial increase in 2023, nearly bridging the gap with Front-runners and Adopters in this area.

2.3.2. Network: Front-runners, Adopters, and Starters all experience substantial growth in tandem

▶ **Joint Supply and Demand Effect:** Net work indicators measure the proportion of network service providers supporting IPv6. From the supply side, IPv6 typically initiates with leading operators before trickling down to SMEs and industry endpoints. Starters at the initial stage of IPv6 adoption witness more overt push from suppliers compared to Front-runners in the late stages of promotion. On the demand side, digitalization levels and needs for 5G, IoT, etc., enhance operators' incentives to deploy IPv6. Front-runners and Adopters, with high digitalization and strong demand for 5G/IoT, exert a more forceful pull on the demand side. The synergistic effect of

16 Average index score by groups

	Overall score	IPv6 penetration				Performance	Innovation
		Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front-runners	0.55	0.39	0.44	0.40	1.02	0.47	0.47
Adopters	0.38	0.38	0.41	0.38	0.35	0.41	0.34
Starters	0.28	0.37	0.36	0.36	0.03	0.29	0.34

Source: Roland Berger

both supply and demand leads to significant growth across all three categories—Front-runners, Adopters, and Starters —in 2023 network indicators, with Front-runners retaining their lead.

2.3.3. Content: Overall indicators show only marginal growth

▶ **Operational Cost Considerations:** When content providers weigh the shift from IPv4 to IPv6, they must consider not only the direct operational costs of IPv6 deployment but also the indirect costs associated with potential disruptions to system stability during migration. Lacking external stimuli, most content providers are hesitant to adopt IPv6 voluntarily. Thus, in 2023, content indicators remain largely stable, exhibiting only minor growth compared to 2022.

▶ **Government Incentives Needed:** To address the lack of direct motivators for content providers, governments need to introduce targeted incentives to encourage IPv6 deployment. This could include specific fiscal subsidies such as tax reductions to alleviate cost pressures for content providers or promoting industry standards that gradually establish IPv6 deployment as an entry requirement, thereby directly facilitating IPv6 penetration in content delivery.

2.3.4. Users: Front-runners show significant growth, followed by Adopters, while Starters see no marked change from last year

▶ **Digitalization Level:** User indicators gauge the capability of end-users to access the network via IPv6. Front-runners and Adopters boast high digitalization levels, with users widely exposed to emerging technologies like 5G and IoT, whereas Starters have lower overall digitalization, limiting the propagation of IPv6 to end-users.

▶ **Concentration of Operators:** Many Starter countries have a low level of concentration in their telecom operator markets, with intense competition making them sensitive to costs. IPv6, requiring additional deployment expenses, takes longer to gain market acceptance. Since end-user routers are mostly provided by operators, IPv6 rollout to end-users progresses at a slower pace.

2.3.5. Effectiveness: Starters show notable improvement, followed by Adopters, while Front-runners' performance slightly dips from last year

▶ **IPv6 Optimization and Maintenance Systems Lag Behind Expansion:** Effectiveness indicators assess the network quality experienced by end-users accessing the network via IPv6, including connection speed and reliability. With some Front-runners witnessing a surge in IPv6 connections, their optimization and maintenance systems face increased pressure, leading to longer connection delays. Compared to their mature IPv4 setups with optimized performance, these Front-runners' IPv6 networks perform less satisfactorily in terms of connection speed. Nonetheless, given their higher digitalization levels, Front-runners still hold a clear advantage in network reliability. Therefore, while the gap between Front-runners and Starters narrows in 2023 effectiveness indicators compared to 2022, it remains significant.

▶ Recommend Increased Government Resource Allocation: To tackle subpar IPv6 network quality, governments need to allocate more resources to IPv6 O&M systems to ensure stable performance. They need also to expedite the migration from IPv4 to IPv6, freeing up investments in IPv4 systems to shorten the transition's painful period.

2.3.6. Innovation: Indicators remain generally stable

▶ **First-Mover Advantage:** Innovation indicators evaluate comprehensive performance in standards, policies, academic research, and innovative application pilots. Front-runner nations hold a first-mover advantage in standard setting and academic research, maintaining a dominant position. While Starter nations make progress in policy indicators, they struggle to significantly close the gap with Front-runners. Thus, innovation indicators in 2023 stay largely consistent with their value from 2022 report.

3

IPv6 development analysis and policy suggestions for benchmarking countries

3.1. Saudi Arabia

IPv6 development analysis

▶ In 2023, Saudi Arabia ranked 6th out of 92 countries in the IPv6 Development Index (classified as a "Front-runner"), marking a significant rise compared to its position in 2022. This notable improvement was chiefly attributed to substantial advancements in sub-indicators such as network infrastructure and effectiveness.

▶ The nation ranks 11th in network deployment, 6th in user readiness, and impressively 2nd in terms of network effectivity, highlighting its leading position globally across these dimensions.

▶ However, Saudi Arabia slipped to the 39th position in content-related IPv6 adoption, experiencing a conspicuous decline in both score and ranking from the previous year. This calls for immediate action to rejuvenate its content adaptation efforts. On a positive note, In April 2024, the Saudi Ministry of Communications and Information Technology announced the launch of

the 10Gbps City initiative, declaring the establishment of an end-to-end high-speed, high-quality network architecture based on IPv6 Enhanced. Saudi telecommunication companies like STC and Zain are proactively deploying advanced technologies, including 400 Gigabit Ethernet (400GE) for enhanced capacity, network slicing for efficient resource allocation, and digital mapping, thereby maintaining a pioneering stance in innovative deployments. ▶ 17

Policy suggestions

▶ **Emphasize Content Deployment and Foster IPv6 Innovation in E-Sports**

- **Targeted Fiscal Subsidies and Policy Support for Deployment:** The government can utilize tailored financial incentives, including tax reductions, to alleviate the cost burden for content providers transitioning to IPv6.

- **Promote Industry Standards in the Content Sector:** Gradually establish IPv6 deployment as a prerequisite for entering the content provider industry, directly

---

17   IPv6 development in Saudi Arabia

	Overall score	IPv6 penetration				Performance	Innovation
		Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front-runners	0.55	0.39	0.44	0.40	1.02	0.47	0.47
Adopters	0.38	0.38	0.41	0.38	0.35	0.41	0.34
Starters	0.28	0.37	0.36	0.36	0.03	0.29	0.34
Saudi Arabia Ranking	0.59 6	0.22 88	0.46 11	0.39 39	1.19 6	0.62 2	0.39 39

Source: Roland Berger

fueling IPv6 integration at the content delivery end. Specifically, for Saudi Arabia's thriving e-sports sector, mandate game service providers to support IPv6 to minimize latency and enhance end-to-end user experiences.

- **Expand Publicity Efforts:** Enhance local enterprises' awareness of IPv6 and encourage domestic content providers to actively engage in IPv6 implementation.

▶ **Deepen Innovation and Elevate International Influence**

- **Integrate IPv6 Innovation into Infrastructure Development:** Include IPv6 and IPv6 Enhanced technology applications in the construction of network infrastructure, advancing their use throughout end-to-end networks. Incorporate IPv6 Enhanced technology requirements into national broadband initiatives and projects like "10Gbps Society."

- **Continuous Investment in R&D:** Augment government investment in IPv6-related research, education, and industry partnerships for technological innovations. Actively lead international technical exchange conferences and cross-border collaborations, encouraging and attracting high-skilled talent for exchanges and research in this field.

- **Strengthen International Influence in IPv6 Domain:** Actively organize and attend global IPv6/IPv6 Enhanced summits, engage in setting international IPv6 agendas, and participate in formulating industry standards related to IPv6 Enhanced applications, thereby enhancing Saudi Arabia's influence and voice in this domain.

3.2. Malaysia

IPv6 development analysis

▶ In 2023, Malaysia held the 11th position out of 92 countries in the IPv6 Development Index, retaining its status as a "Front-runner" from the previous year.

▶ Notably, Malaysia excelled in the user readiness indicator, ranking 2nd globally – a further improvement from its 2022 standing, highlighting its leadership in ensuring users' capability to access the internet via IPv6.

▶ However, despite this strength, Malaysia's rankings in other key areas were considerably lower: It stood at 58th in network deployment, 28th in content adaptation, 50th in effectiveness of IPv6 implementation, and 55th in innovation, all of which are significantly below its overall ranking and indicative of a decline in comparison to 2022's positions. ▶ 18

Policy suggestions

▶ **Focus on Network and Content Deployment to Enhance Penetration**

- **Refine and Strengthen Fiscal Subsidies and Policy Support:** Given the fragmented nature of Malaysia's network operator market, smaller operators often lag behind larger ones in terms of technology and funding, resulting in lower motivation and capability for IPv6 deployment. The government aiming at sustainably, providing financial subsidies and policy, and backing IPv6 implementation, with a particular focus on smaller operators to propel overall IPv6 deployment progress.

- **Facilitate Development of National IPv6 Industry Standards:** On the foundation of promoting large-scale IPv6 deployment, gradually refine IPv6 industry standards and potentially establish IPv6 as an entry criterion for the content provider sector. This would guide content suppliers towards IPv6 adoption, thereby stimulating the transformation drive from the demand side for network operators.

▶ **Control IPv6 Deployment Performance and Optimize Outcomes**

- Incorporate IPv6 Performance Criteria in Policies: Although Malaysia has mandated IPv6 device certification since 2020, there has been inadequate emphasis on performance control. Without clear economic benefits, optimization efforts have been limited. The government ought to build upon the mandatory IPv6 certifi-

---

18   IPv6 development in Malaysia

	Overall score	IPv6 penetration				Performance	Innovation
		Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front-runners	0.55	0.39	0.44	0.40	1.02	0.47	0.47
Adopters	0.38	0.38	0.41	0.38	0.35	0.41	0.34
Starters	0.28	0.37	0.36	0.36	0.03	0.29	0.34
Malaysia Ranking	0.56 — 11	0.37 — 44	0.41 — 58	0.40 — 28	1.30 — 2	0.34 — 50	0.34 — 55

Source: Roland Berger

cation policy by incrementally tightening performance requirements for IPv6, guiding stakeholders toward enhancing its performance optimization.

▶ **Invest Heavily in IPv6 Enhanced Innovation Fields to Drive Commercial Deployment**

- **Promote Commercial Deployment of IPv6 Enhanced Innovative Technology Projects:** Malaysia's technological foresight and international influence do not align with its overall IPv6 development level, and it lacks commercial deployments of IPv6 Enhanced innovation projects. The government ought to facilitate more Malaysian entities to join international associations and project groups in the IPv6 arena, while also promoting the establishment of related industrial clusters to boost domestic demand and consumption levels for digital services.

- **Increase Financial Support for IPv6 and IPv6 Enhanced R&D and Innovation:** Enhance government investment in research, education, and industry institutions engaged in IPv6-related technological innovation. Provide additional policy support to research institutes and enterprises working on these technologies to foster a conducive environment for breakthroughs and advancements.

3.3. Indonesia

IPv6 development analysis

▶ Indonesia's IPv6 Development Index in 2023 ranks 62 out of 92 countries (classified as "Adopters"), marking a significant rise compared to the previous year and, for the first time, moving from the 'Starters' group into the 'Adopters' category.

▶ In terms of planning and impact indicators, Indonesia ranks 50th and 63rd respectively, showing notable improvements over the previous year.

▶ For user engagement and innovation indicators, Indonesia is ranked 51st and 13th, indicating only marginal enhancements from the previous year.

▶ When it comes to network infrastructure and content availability, Indonesia ranks 73rd and 86th, respectively. Although there has been some improvement compared to last year, these areas still lag behind the overall development pace and require additional attention and focus. Indonesian operators have shown forward-thinking in their investments in future network infrastructure, with operators such as XL and IOH already initiating deployments of SRv6 and 400GE. ▶ 19

Policy suggestions

▶ **Policy-Driven Transformation through Supply-Side Push**

- Implement Mandatory Transition Requirements for Leading Network Operators and Content Providers: In Indonesia, major network operators possess relatively ample IPv4 addresses, which, without a surge in digital demand, diminishes their incentive to transition to IPv6. Owing to insufficient self-driven momentum, the government ought to exert pressure on these leading network operators and content providers by instituting stringent policy requirements and evaluation criteria. Complementing this with relevant reward and punishment mechanisms will enforce the adoption and deployment of IPv6 and IPv6 Enhanced.

▶ **Boosting Digital Infrastructure to Stimulate Demand**

- Leveraging Digital Infrastructure to Elevate Overall Digitalization: Constrained by low levels of terminal digitalization, Indonesia faces inadequate demand from end-users, which in turn dampens the motivation for network operators and content providers to shift to IPv6. By intensifying investment in digital infrastructure, the country can escalate the digital

19 IPv6 development in Indonesia

	Overall score	IPv6 penetration				Performance	Innovation
		Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front-runners	0.55	0.39	0.44	0.40	1.02	0.47	0.47
Adopters	0.38	0.38	0.41	0.38	0.35	0.41	0.34
Starters	0.28	0.37	0.36	0.36	0.03	0.29	0.34
Indonesia Ranking	0.33 / 62	0.35 / 50	0.38 / 73	0.31 / 86	0.25 / 51	0.27 / 63	0.46 / 13

Source: Roland Berger

maturity of industries, fostering demand for IPv6-enabled terminals. This, as a result, will incentivize network operators and content providers to meet the rising demand for IPv6 deployment.

3.4. Egypt

IPv6 development analysis

▶ Egypt's IPv6 Development Index in 2023 stands at rank 60 out of 92 countries, classified as "Adopters", reflecting a substantial improvement from its position

▶ In the categories of network infrastructure, content availability, and impact, Egypt ranks impressively high at 21st, 11th, and 6th globally, demonstrating a strong footing in these crucial aspects of IPv6 deployment.

▶ Regarding user engagement and innovation indicators, Egypt is positioned at 66th and 85th respectively, which illustrates better performance than last year but still impacts the total ranking. Addressing these lower rankings should be a priority in future efforts. ▶ 20

Policy suggestions

▶ Policy Guidance for IPv6 Penetration to End Users

- **Enhance Policy Direction at the Terminal Equipment Level:** Egypt's digital economy has rapidly grown in recent years, excelling in IPv6 networking and content aspects. However, due to the relative novelty of its development, IPv6 deployment is yet to fully permeate to end-users. The government ought to introduce targeted policies to facilitate IPv6 adoption among terminal users, including incentivizing or mandating IPv6 certification for terminal devices, thereby accelerating IPv6 penetration at the user level.

▶ **Incorporating IPv6 into National Broadband Strategy**

- **Specify IPv6 Deployment Objectives, Timelines, and Responsibilities within National Broadband Plans:** Clearly outline strategic goals, timelines, and assigned duties for IPv6 implementation within the

---

20 IPv6 development in Egypt

	Overall score	IPv6 penetration				Performance	Innovation
		Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front-runners	0.55	0.39	0.44	0.40	1.02	0.47	0.47
Adopters	0.38	0.38	0.41	0.38	0.35	0.41	0.34
Starters	0.28	0.37	0.36	0.36	0.03	0.29	0.34
Egypt / Ranking	0.34 — 60	0.31 — 75	0.45 — 20	0.43 — 11	0.10 — 66	0.55 — 6	0.17 — 85

Source: Roland Berger

national broadband strategy. This encompasses defining priorities and scopes for IPv6 deployment and promoting the establishment and adherence to relevant technical standards.

▶ **Focus on Innovation Areas with Sustained Investment**

- Ongoing Investment in IPv6 and IPv6 Enhanced R&D: Bolster government investment in research, education, and industry institutions engaged in IPv6-related technological innovation. Foster incubation and innovation within pertinent industries, actively encouraging and attracting highly skilled professionals to engage in exchanges and research within this domain. This persistent commitment to innovation ensures a continuous push toward the forefront of IPv6 technology advancements.

3.5. Algeria

IPv6 development analysis

▶ Algeria's IPv6 Development Index for 2023 ranks 80 out of 92 countries, experiencing a decline in ranking compared to 2022.

▶ Remarkably, Algeria holds the 6th position in terms of planning indicators, highlighting a strong framework and strategy in place for IPv6 adoption, placing it amongst global Front-runners in this aspect.

▶ However, with rankings of 87th in user engagement and 81st in impact indicators, these areas are significantly hindering the overall IPv6 development performance. They should be prioritized for enhancement in subsequent efforts. ▶ **21**

Policy suggestions

▶ **Promote Digital Infrastructure to Stimulate User Demand**

- Leverage Digital Infrastructure to Elevate Terminal Digitalization: Algeria, having started late in digital development, pos-sesses a relatively weak digital foundation with limited network coverage by operators and an overall low level of terminal digitalization. The government ought to ramp up investment in digital infrastructure, vigorously pushing forward the construction of 5G networks, fostering digital industry innovation, and enhancing the digital capabilities of industries. This dual approach aims to boost demand for IPv6-enabled terminals while optimizing the effectiveness of IPv6 network deployments.

- Accelerate Networking of Public Services: The government ought to take the lead by incorporating IPv6 capabilities into procurement plans, government projects, and online services, thereby enhancing the digitalization level of government terminals and serving as a model for others to follow. This initiative will not only modernize public services but also create a conducive environment for wider IPv6 adoption across society.

21   IPv6 development in Algeria

	Overall score	IPv6 penetration				Performance	Innovation
		Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front-runners	0.55	0.39	0.44	0.40	1.02	0.47	0.47
Adopters	0.38	0.38	0.41	0.38	0.35	0.41	0.34
Starters	0.28	0.37	0.36	0.36	0.03	0.29	0.34
Algeria / Ranking	0.29 / 80	0.55 / 6	0.44 / 32	0.39 / 39	0.00 / 87	0.21 / 81	0.29 / 66

Source: Roland Berger

3.6. Nigeria

IPv6 development analysis

▶ Nigeria's IPv6 Development Index in 2023 stands at 78 out of 92 countries, categorized as "Starters", marking a decline in ranking compared to 2022.

▶ Notably, Nigeria excels in content availability and innovation indicators, ranking 13th and 22nd respectively, significantly outperforming other countries in its group. This is thanks to the major national operators such as MTN and Airtel, which have already begun deploying SRv6, network slicing, and 400GE.

▶ Despite slight improvements from the previous year, Nigeria's rankings in network infrastructure and user engagement—87th and 74th respectively—continue to weigh down its overall index performance, highlighting the need for further optimization in these areas. ▶ 22

Policy suggestions

▶ **Policy Guidance for Network Operators to Strengthen Network Deployment**

- **Refine and Enhance Fiscal Subsidies and Policy Support:** Given the low market concentration of network operators in Nigeria and the technological and financial gaps between small and large operators, the motivation and capability for IPv6 deployment are relatively low. The government ought to persistently offer financial subsidies and policy support for IPv6 implementation, with a particular emphasis on smaller operators to facilitate comprehensive development in IPv6 deployment.

▶ **Promote Digital Infrastructure to Stimulate User Demand**

- Utilize Digital Infrastructure to Elevate Terminal Digitalization: Nigeria's digital foundation is relatively weak, and the overall level of terminal digitalization is low, hindering the widespread adoption of digital technologies, including IPv6, due to limited demand. The government ought to increase investment in digital infrastructure, spur innovation in the digital industry, and enhance the digital capabilities of industries. This dual strategy aims to boost demand for IPv6-equipped terminals and simultaneously optimize the effectiveness of IPv6 network rollouts, thereby addressing the existing barriers to broader digital adoption.

---

22   IPv6 development in Nigeria

	Overall score	IPv6 penetration				Performance	Innovation
		Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front-runners	0.55	0.39	0.44	0.40	1.02	0.47	0.47
Adopters	0.38	0.38	0.41	0.38	0.35	0.41	0.34
Starters	0.28	0.37	0.36	0.36	0.03	0.29	0.34
Nigeria / Ranking	0.29 / 78	0.34 / 57	0.29 / 87	0.43 / 13	0.02 / 74	0.27 / 63	0.44 / 22

Source: Roland Berger

3.7. Chile

IPv6 development analysis

▶ Chile's IPv6 Development Index in 2023 is ranked 47 out of 92 countries, maintaining a similar standing as in 2022 within the "Adopters" category.

▶ Chile boasts a 6th place ranking in impact indicators, a testament to its recent advancements in digital infrastructure and the advantage of native IPv6 deployments, positioning it among global Front-runners in the effectiveness of its IPv6 rollout.

▶ While scores for network infrastructure and content availability indicators remained stable compared to the previous year, Chile's relative rankings in these areas slipped to 66th and 69th respectively, due to progress made by other countries. Increased focus and investment are required in these sectors going forward.

▶ Chile ranks 44th in user engagement and 78th in innovation indicators, unchanged from last year. The country shows room for improvement particularly in the realm of innovation, where targeted reinforcements should be considered in the future. ▶ 23

Policy suggestions

▶ **Policy Regulation for Network Deployment and Industry Standard Guidance for Content Penetration**

- **Policy-backed Deployment and Financial Support for Network Operators:** Given Chile's relatively concentrated network operator market, policy-driven IPv6 deployment is more effective. The government ought to continuously offer financial subsidies and policy support for IPv6 implementation, including direct financial incentives and tax benefits for IPv6 deployment, along with technical support and guidance. This approach en-

23   IPv6 development in Chile

	Overall score	IPv6 penetration				Performance	Innovation
		Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front-runners	0.55	0.39	0.44	0.40	1.02	0.47	0.47
Adopters	0.38	0.38	0.41	0.38	0.35	0.41	0.34
Starters	0.28	0.37	0.36	0.36	0.03	0.29	0.34
Chile Ranking	0.37 47	0.33 62	0.39 66	0.36 69	0.33 44	0.55 6	0.22 78

Source: Roland Berger

courages network operators to expand IPv6-Only deployments.

- **Advancement of National IPv6 Industry Standards:** Building on large-scale IPv6 deployment, Chile ought to progressively refine industry standards and potentially establish IPv6 as an entry criterion for content providers, gradually strengthening IPv6 support requirements. The government can lead by example, upgrading government portals and other public service networks to IPv6, guiding private sector transitions.

▶ **Fostering Innovation and Introduction of IPv6 Commercial Deployment**

- **Ongoing Investment in IPv6 and IPv6 Enhanced R&D:** The government ought to escalate investment in research, educa-

tion, and industry institutions engaged in IPv6-related innovation, nurturing industry incubation and attracting high-skilled professionals to advance research and collaboration in this domain.

- **Promotion of IPv6 Enhanced Innovative Technology Commercial Deployments:** Chile lacks commercial projects in IPv6 Enhanced innovation. The government ought to urge operators and businesses to iterate deeply in IPv6 and IPv6 Enhanced, leapfrogging technologically. Support for commercial pilot projects based on IPv6 Enhanced technologies like Segment Routing over IPv6 (SRv6) ought to be encouraged, driving the implementation and realization of IPv6 Enhanced commercial applications.

3.8. Argentina

IPv6 development analysis

▶ Argentina's IPv6 Development Index in 2023 is positioned at 37 out of 92 countries, remaining steady as an "Adopter" compared to its rank in 2022.

▶ The country demonstrates a balanced and improved performance across planning, content, and user engagement indicators, ranking 20th, 34th, and 36th respectively, indicating comprehensive progress from the previous year.

▶ However, Argentina lags in network penetration, occupying the 74th spot, which represents a decline from last year's ranking. Enhancing network infrastructure should be a key area of focus in the following efforts.

▶ With an innovation ranking of 59, unchanged from the previous year and not adequately reflecting the overall development level of Argentina's IPv6 landscape, intensified attention on fostering IPv6-related innovations is imperative moving forward. ▶ **24**

Policy suggestions

▶ **Standardized Policy Driving IPv6 Deployment on the Network Side**

- **Implementation of High-Enforcement Policies to Expedite IPv6 Adoption by Network Operators:** Argentina, with its highly concentrated network operator landscape dominated by three large-scale, wide-reaching providers, can swiftly boost IPv6 penetration through mandatory standard policies. This approach facilitates rapid diffusion of IPv6 within a short timeframe.

▶ **Focusing on Innovation and Facilitating IPv6 Commercial Deployment**

- **Continuous Investment in IPv6 and IPv6 Enhanced R&D:** Argentina ought to amplify government investment in research, education, and industry institutions specializing in IPv6-related technological innovation. This fosters the incubation of new industries and encourages the engagement of high-skilled professionals in research and collaboration within this field.

24   IPv6 development in Argentina

	Overall score	IPv6 penetration				Performance	Innovation
		Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front-runners	0.55	0.39	0.44	0.40	1.02	0.47	0.47
Adopters	0.38	0.38	0.41	0.38	0.35	0.41	0.34
Starters	0.28	0.37	0.36	0.36	0.03	0.29	0.34
Argentina / Ranking	0.41 / 37	0.45 / 20	0.38 / 74	0.40 / 34	0.45 / 36	0.48 / 21	0.32 / 59

Source: Roland Berger

- **Promoting Commercial Deployment of IPv6 Enhanced Innovative Technology Applications:** Acknowledging the dearth of commercial projects in the IPv6 Enhanced innovation sector, the government ought to motivate both network operators and adopting enterprises to delve deeper into IPv6 and IPv6 Enhanced, enabling technological leaps. Endorsing commercial pilot projects leveraging technologies like SRv6, a representative of IPv6 Enhanced, is vital. Such support accelerates the implementation and realization of commercial applications utilizing IPv6 Enhanced.

3.9. Ethiopia

IPv6 development analysis

▶ Ethiopia's IPv6 Development Index in 2023 places the country at rank 59 out of 92 nations, categorizing it as an "Adopter" and marking an improvement from its 2022 ranking.

▶ Ethiopia maintains a leading position in network infrastructure, ranking 9th globally this year, showcasing consistent strength in this domain. It also excels in planning and impact indicators, both ranked at 21st, a clear indication of substantial improvement and entry into the league of leading nations in these aspects.

▶ With an innovation ranking of 49, Ethiopia has made strides compared to the previous year, also entering the 'Adopter' category in this regard. This is due to Ethio Telecom's initiation of deployments involving SRv6, network slicing, and other technologies. Nevertheless, despite significant advancements, the user engagement indicator remains notably low, falling below the average of even 'Starter' countries, pinpointing it as a critical area demanding further enhancement.

▶ In summary, Ethiopia exhibits uneven development across various metrics. While it leads in planning, network infrastructure, and impact, it lags, particularly in content provision and engaging users, indicating that these are the early stages of development. A focused strategy to balance these disparities will be vital for comprehensive progress in IPv6 adoption. ▶ 25

Policy suggestions

▶ **Accelerating Exemplary Project Expansion and Establishing an IPv6-Friendly Ecosystem to Enhance User Penetration**

- **Leading by Example with Showcase Projects:** Select and highlight (e.g., inclusion in national project portfolios with financial backing) exemplary projects that demonstrate successful IPv6 implementation. Publicize these projects and exhibit IPv6's applications and advantages to elevate public understanding and acceptance of IPv6 technology.

- **Building an IPv6-Friendly Ecosystem:** Cultivate applications, services, and content that embrace IPv6, motivating enterprises and innovators to develop IPv6-based solutions to heighten user experience and value.

---

25   IPv6 development in Ethiopia

	Overall score	IPv6 penetration				Performance	Innovation
		Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front-runners	0.55	0.39	0.44	0.40	1.02	0.47	0.47
Adopters	0.38	0.38	0.41	0.38	0.35	0.41	0.34
Starters	0.28	0.37	0.36	0.36	0.03	0.29	0.34
Ethiopia Ranking	0.34 59	0.44 21	0.46 9	0.36 66	0.01 76	0.48 21	0.36 49

Source: Roland Berger

- **Collaborating with Service Providers to Boost User Penetration:** Implement incentive policies such as fee waivers or tax breaks to encourage businesses and service providers to increase IPv6 adoption among their user base.

▶ **Sustained Innovation Efforts Anchored in International Collaboration and Public Service Platform Construction**

- **Promoting International Cooperation and Resource Sharing:** Engage in cooperative exchanges with international organizations, partners, and other nations to share experiences and best practices. Participate in joint international innovation projects, reinforcing deployment in global innovation networks and platforms. Foster cooperation and coordination among service providers to leverage shared resources, knowledge, and experiences for IPv6 innovation, application, and dissemination.

- **Advancing Innovative Public Service Platforms:** Centered around leading enterprises, establish a series of innovation platforms dedicated to technology research, application innovation, solution assessment, and trial validation. These platforms expedite the translation and application of IPv6 innovations across diverse scenarios.

3.10. Kenya

IPv6 development analysis

▶ Kenya's IPv6 Development Index in 2023 is ranked 50 out of 92 countries, classifying it as an "Adopter".

▶ The country has made notable strides in planning and impact indicators, now ranking 25th and 6th respectively. Particularly, the jump of around 20 positions in the effect metric propels Kenya from being an Adopter to a 'Front-runner', highlighting substantial progress in the practical outcomes of its IPv6 implementation.

▶ Conversely, Kenya lags in network infrastructure, content availability, and user engagement, with rankings that place it in the "Starter" tier. Of particular concern is the user engagement indicator, which has seen a decline compared to the previous year, emphasizing the need for focused attention and targeted enhancements in this area. ▶ 26

Policy suggestions

▶ **Iterative Support Measures to Ensure Effective IPv6 Migration Strategy Implementation**

- Following Kenya's release of the "National IPv6 Migration Strategy" in 2022, delays in full IPv6 adoption risk leaving millions of users disconnected and escalating operational costs for internet service providers (ISPs), which could be passed onto consumers. To avoid this, the government must dynamically monitor the strategy's implementation progress, adjusting and updating complementary measures as needed based on real-world developments. This includes launching awareness campaigns targeting both providers and consumers to increase understanding of IPv6's importance, as well as organizing hands-on training sessions on IPv6 migration to equip stakeholders with practical skills.

▶ **Incentivization and Regulation to Accelerate IPv6 Penetration**

- **Financial Support for IPv6 Deployment:** Governments often establish national or sector-specific funds and offer fiscal subsidies to promote broad IPv6 adoption. Kenya's authorities can leverage such resources not only to incentivize industry growth and ISP adoption of IPv6

26   IPv6 development in Kenya

	Overall score	IPv6 penetration				Performance	Innovation
		Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front-runners	0.55	0.39	0.44	0.40	1.02	0.47	0.47
Adopters	0.38	0.38	0.41	0.38	0.35	0.41	0.34
Starters	0.28	0.37	0.36	0.36	0.03	0.29	0.34
Kenya Ranking	0.36 50	0.43 25	0.41 57	0.37 62	0.14 63	0.55 6	0.34 55

Source: Roland Berger

technologies but also to ensure users benefit from IPv6's advantages.

- **Taxation or Restrictions on IPv4 Address Sharing:** While IPv4 address sharing temporarily alleviates address scarcity, it hinders end-to-end connectivity and IPv6 deployment. Implementing taxes or regulatory policies to discourage or limit multiple subscribers from sharing a single IPv4 address can act as a catalyst for elevating IPv6 penetration rates. This push, coupled with supportive measures, creates a more compelling case for transitioning to IPv6, ensuring the longevity and scalability of Kenya's digital infrastructure.

In summary, the level and capacity of a country's digitalization will be among the key factors determining its comprehensive national power in the future, with IPv6/IPV6 ENHANCED serving as a fundamental infrastructure base for building this digital capability. On the access side, IPv6 will help to address the scenarios of an intelligent society characterized by the Internet of Everything and multiplying applications, by providing abundant address resources to ensure the normal operation of diverse terminals and applications. Regarding transmission, IPv6 will leverage technologies such as SRv6 and network slicing to enable virtualization of transmission networks and automated operations, thereby better supporting the evolution of transmission networks from 100GE to 400GE, maintaining the efficiency and smoothness of network channels. In the context of data centers, IPv6 will facilitate the provisioning of ample data "nourishment" for computational power, enabling nodes to access vast amounts of data to fuel computation that generates precise and intelligent results, thereby truly realizing a digital-intelligent society.

Contacts

Bing Li
Partner
bing.li@rolandberger.com

Roland Berger **Liu Xiao** contributed to this report.