HexaBuild

IPv6 Adoption Report 2020

The IPv6 Internet *is* the Corporate Network

1) Executive Summary

Introduction

2020 has been one of the most disruptive years in recent human history. In particular, the Covid-19 pandemic has forced all organizations to re-think how they do business and work with their partners and customers. As a result of social distancing requirements and subsequent limits to safe common areas for doing business, the Internet itself has emerged as *the* critical network for all business transactions.

Since the importance of the Internet in enabling business to function and succeed cannot be overstated, such a development represents a tectonic shift in what was already the disruptively rapid growth and evolution of this fundamental technology. Meanwhile, the Internet itself—now more than ever before—relies on IPv6 to scale and perform. Yet most organizations have, at best, merely an ad-hoc approach to this critical protocol. They are unprepared to effectively adopt and manage IPv6 in both their on-premises and cloud networks.

Not only does the increasing performance and scale of the IPv6 Internet—and the opportunity to use this emerging global IT network to cost-effectively solve business problems—remain unrealized, the security and late adoption risks grow by the day.

Organizations that continue to neglect the IPv6 protocol—and the new and updated technology practices it requires—will find themselves increasingly isolated. This isolation will result in steeper costs over time. Some of these costs are direct; e.g., the increasing CAPEX and OPEX required to maintain costly and brittle transition technologies which are needed to connect isolated IPv4 networks to a growing IPv6 Internet.

But they will also manifest as opportunity costs from failing to realize the performance, operational, and architectural benefits that the unlimited scale of IPv6 provides. As more organizations adopt IPv6 to enable IT innovation and transformation, another digital divide threatens to emerge—one between those who have embraced IPv6 and those who have chosen to remain reliant on the legacy protocol. As a result, organizations that have moved to adopt IPv6 as a protocol and practice have already accrued a real competitive advantage over those that continue to delay, believing perhaps that IPv6 is still merely *optional* or something not needed at all.

Meanwhile, the Internet continues with two significant trends that will challenge IT strategies and budgets for years to come:

1. The Internet has become the corporate network
2. The Internet requires continued IPv6 adoption to scale

Organizations may prove to have little control over the first trend. But a decisive response to the second trend—one that deliberately and securely adopts IPv6 and develops a practice to support it—ensures that organizations will be ready to seamlessly and cost-effectively leverage the new corporate network now and in the future.

What Is in This Report?

The report covers global trends in IPv6, details about adoption rates at current Telco's, wireless providers, web and content providers as well as similar data for enterprise networks. The report also provides insight into the consistent performance advantage IPv6 offers over IPv4. The report is an aggregate of data available from diverse sources, including websites that specifically collect and track information about IPv6 adoption, performance, and trends. This information is collected and compiled in this report to make it easier for technology executives and decision makers to review it.

HexaBuild will continue to publish additional reports and white papers that cover specific use cases, the status of IPv6 skills and IPv6 education, and unique business challenges that can be cost-effectively solved with IPv6. These publications will be available at https://hexabuild.io/

What's New in the Report?

HexaBuild first published this IPv6 Report in the summer of 2018 at the 6-year anniversary of World IPv6 Launch. We then updated it for 2019 highlighting the rise of India. Since then there has been a continued increase in the amount of IPv6 traffic on the Internet. The graphs presented here are updated to show the yearly progress.

This year we continue to see that IPv6, on average, is faster than IPv4 on the Internet. This report includes data that supports this conclusion.

Finally, we have chosen to spotlight notable change. For this report and it is the rise of the Internet as the new primary corporate network.

Report Spotlight - The Internet *is* the Corporate Network

For the 2020 report we wanted to highlight some significant or important changes that have occurred as a transition since the last report. The clear difference is the Covid-19 pandemic. Companies have been forced to quickly move out of their offices and deploy a large, distributed team solution with their employees overwhelmingly working from home. The Internet is now your corporate network and that network is dual-stack.

The US, western Europe, China, India, and developing countries need to invest in IPv6 to continue their innovation and growth. Those that fail to do so will suffer financial and technical innovation losses and lose their competitive position in the global marketplace. Fortune 1000 will particularly be impacted as these changes happen more rapidly than they can accommodate in their global strategies. Their distributed workforce continues to use and leverage IPv6 in their daily lives but with no formal strategy or technology adoption plan it becomes impossible to understand the impact that IPv6 will have on their business operations. In addition, it is functionally impossible to administer that many home networks and configurations to comply with corporate standards. In the past, remote employees were a small use case for companies, today all employees are part of a distributed workforce and companies are not prepared to deal with this from a technical level.

Who Should Read It and Why?

This report will prove most useful for technology executives, IT architects, and key business decision makers in helping them to determine the impact and potential technology gaps their organizations have not addressed around understanding and adopting IPv6. Because networking protocols are most often perceived as merely a core technology function, their larger impact to a business and its operations is often overlooked. The goal of this report is to successfully convey to its readers this impact; e.g., the business opportunities, cost of adoption, the lack of adoption, the security landscape and the capabilities and availability of talent able to execute and deploy IPv6 in the industry.

The report starts with Global IPv6 Trends, then breaks these down into data specific to Telco, Wireless, Web and Content Provider, and finally Enterprise. The performance advantage IPv6 offers over IPv4 is also discussed. You can use this information to help build appropriate business cases for IPv6 adoption as well as to understand and help better explain what is happening in the industry overall in relation to IPv6.

This report is a point-in-time snapshot of the state of IPv6 adoption and – based on ongoing trends in global IPv6 adoption – may be updated periodically at the discretion of the HexaBuild team (though not strictly annually or semi-annually).

Our goal for the report is to provide a useful barometer in helping others understand what is happening with the adoption of IPv6 as well as the potential impacts of that adoption to businesses and organizations.

What (and Who) Is HexaBuild?

HexaBuild is a professional services IT company with IPv6 industry veterans who have a deep understanding of the IPv6 ecosystem, technology, and community. HexaBuild was founded with the explicit goals of advancing Cloud, IoT and Security with IPv6. In other words, we want to enable companies to adopt IPv6 successfully and securely in their networks. We do this through training and education, professional services, and consulting.

2) Global IPv6 Trends

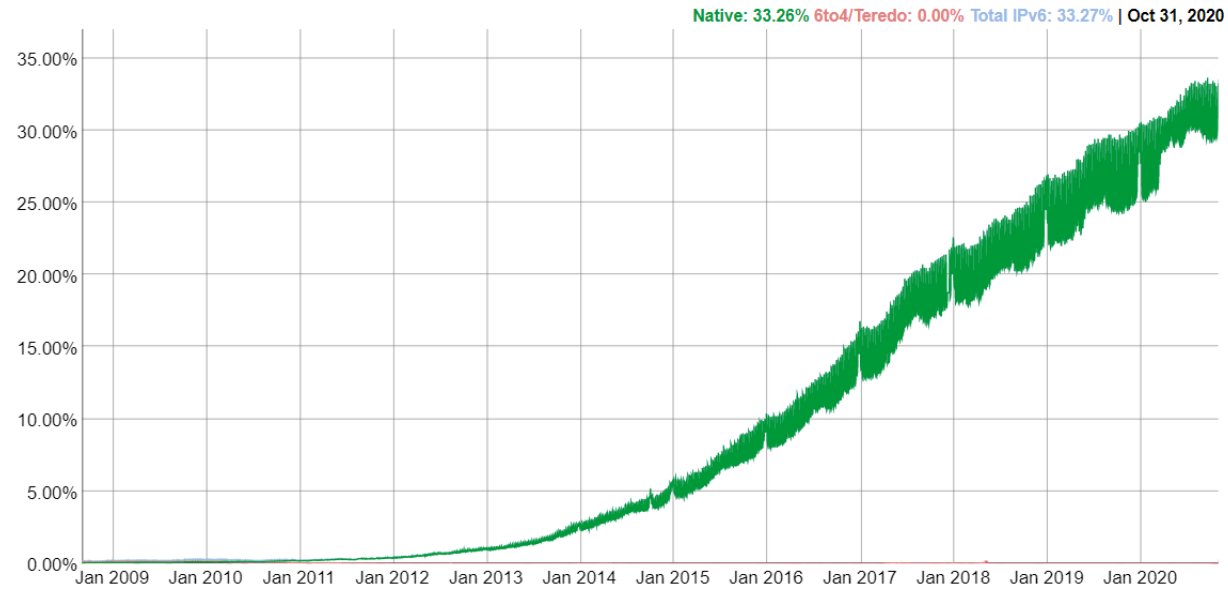
It is not newsworthy to state that the Internet as a whole has grown dramatically in the past 30 years and that it will continue grow in the years to come. The Internet is now foundational to our society and culture, our methods of commerce, the ways we learn, and almost all aspects of the human experience. What is perhaps less well-known is that, in the midst of this phenomenal and critical growth, the fundamental method of communication the Internet relies on is in a transition from the legacy Internet Protocol version 4 (IPv4) to the modern IP version 6 (IPv6).

Cisco's Annual Internet Report, 2018-2023 (AIR) provides statistics on the historical rise in mobile devices and data traffic volumes. The Cisco AIR also predicts what the number of mobile devices and the volume of Internet traffic will be in 2021. The World Internet Users and 2020 Population Stats show that Internet penetration rate is now over 63%. Based on the deluge of Internet-connected devices we have depleted the original supply of Internet Protocol version 4 addresses. IPv4 address exhaustion occurred years ago and now service providers are unable to obtain public IPv4 addresses for their growing subscriber populations from the Regional Internet Registries (RIRs). Therefore, ISPs and Public Cloud Providers are purchasing IPv4 addresses on the open address transfer market and/or they are forced to implement Carrier-Grade-NAT (CGN) or Large-Scale-NAT (LSN) systems. However, this is a stop-gap solution with high CAPEX and OPEX. All ISPs and Public Cloud Providers are deploying IPv6 and working on IPv4-as-a-Service (v4aaS) offerings to sustain their businesses.

Virtually all mobile and end-user devices that connect to networks and the Internet now support IPv4 and IPv6 connectivity. When these devices are connected to service provider networks that support both IP versions, the device has a choice of which protocol to use. So long as the content provider or Internet application is also connected by both protocols, then the result is often an IPv6 connection. In fact, there are entire mobile networks such as T-Mobile in the United States, and Reliance Jio in India, that are IPv6-only. These networks leverage transition technologies to allow these IPv6-only networks to communicate with the legacy IPv4-only network. There is a kind of "tipping-point effect" when you add IPv6 to a network and when mobile devices are given a choice of protocol to use: for every connection that uses IPv6, there was one less connection that used IPv4 transport.

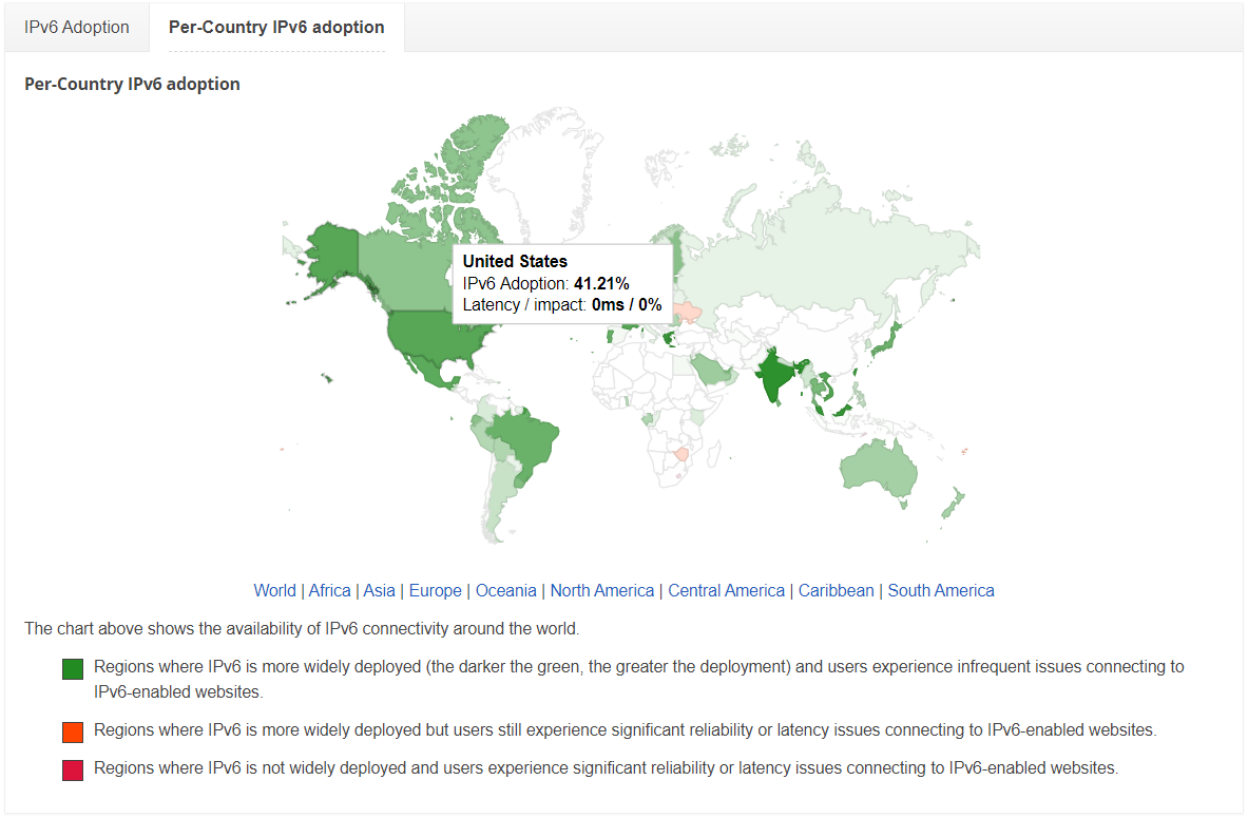
As a result of more and more Internet providers offering IPv6, more mobile devices supporting IPv6, and more content providers making content available over IPv6, there has been a tremendous rise in global Internet IPv6 volumes in recent years.

To get a visual perspective of the huge growth in IPv6 usage, let's look at the "Google IPv6 Statistics" graph below.



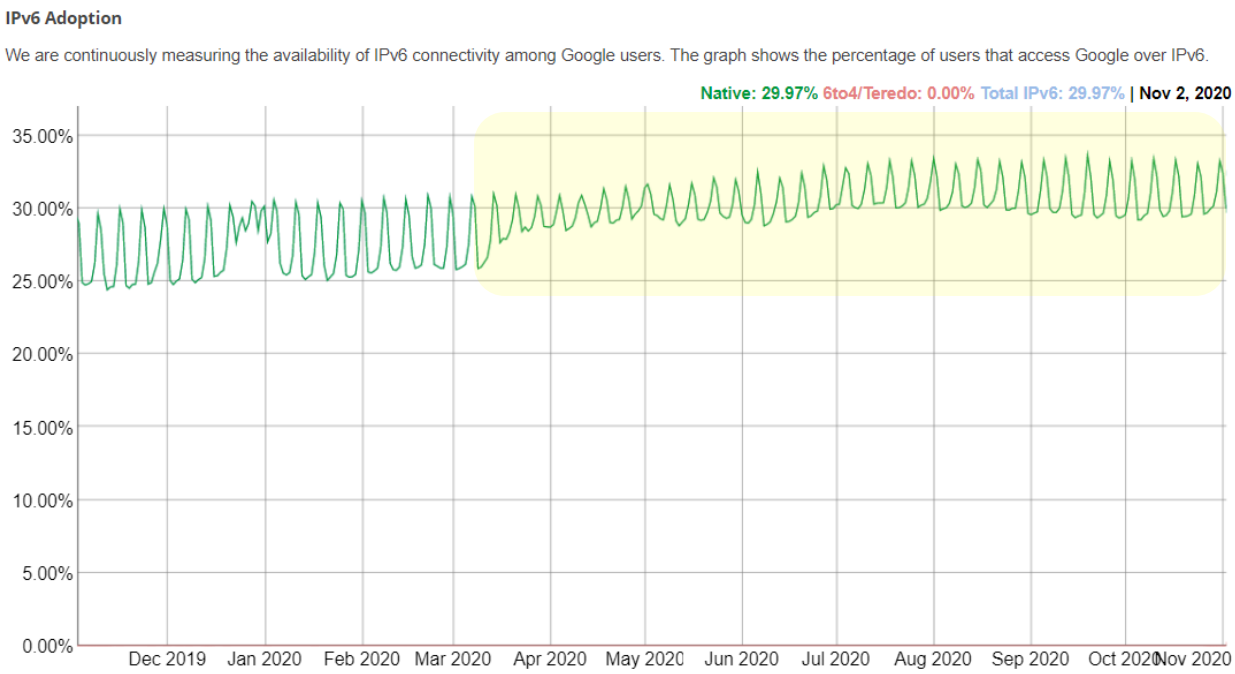
This graph shows the overall rise in IPv6 traffic volumes over the last decade (with nearly 10x growth happening in just the last 5 years). These measurements are derived from the perspective of Google's worldwide infrastructure. Google's search service and their auxiliary applications receive among the largest volume of connections from all over the globe. As a result, they are uniquely well-positioned to provide accurate and meaningful measurements of Internet traffic.

The previous Google graph essentially displays an aggregate of the entire world's IPv6 usage with Google. However, if we look at the Google IPv6 per-country IPv6 adoption page, we can see that some countries have more IPv6 usage with Google than others.

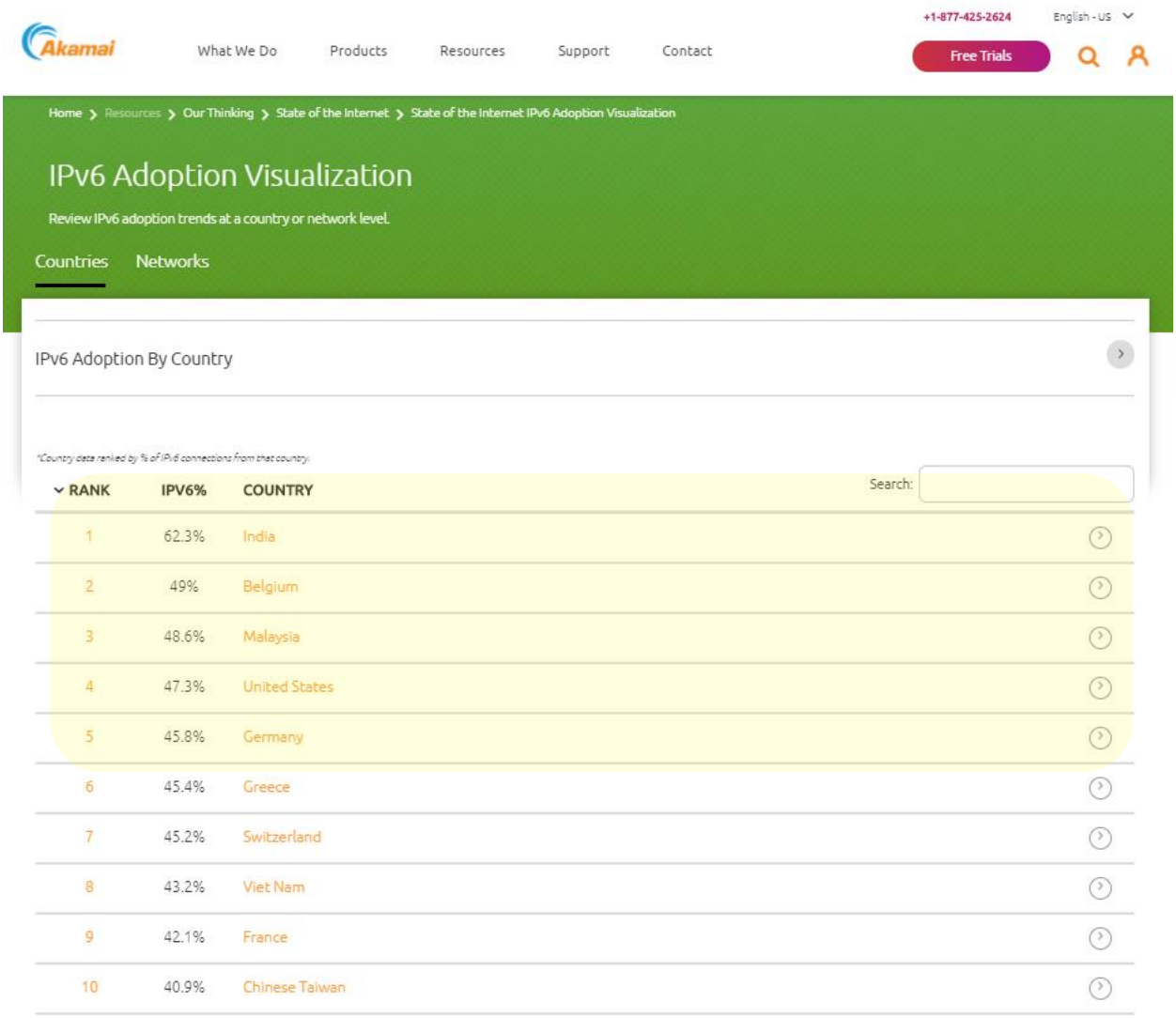


Of particular interest in the graph from Google depicted below is the data from the timeframe beginning in late March of this year and continuing through to the time of this report (November 2020). It is the compression of the height of the peak to valley of the daily usage pattern, highlighted in the graph in yellow. We believe this compression is due to many employees working, and students doing school, from home. This is entirely due to the pandemic requiring many to work from home using their broadband connections, which are likely dual-stacked and therefore supporting IPv6.

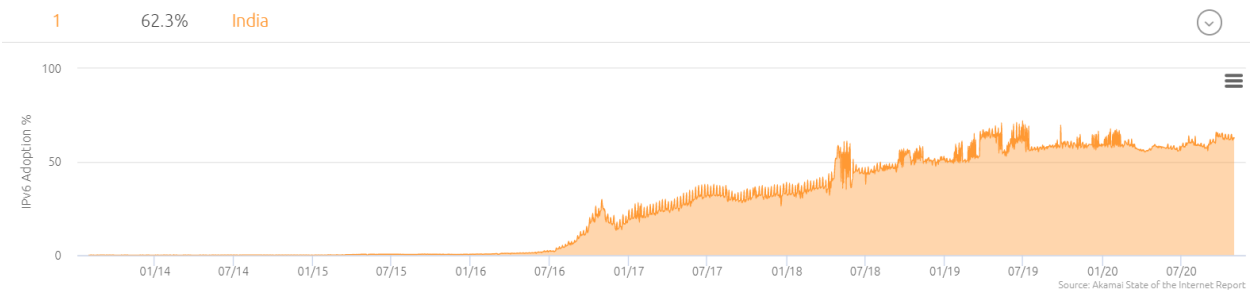
Prior to this period, the difference in the peaks and valleys was due to employees switching from work (no IPv6) to home (dual-stack). During the pandemic, with more people on IPv6 capable networks, the height of the peak to valley has decreased. In other words, more people are consistently on IPv6 day and night. This trend will continue until the pandemic concludes and workers return to office locations that lack IPv6. It highlights how many companies do not have any IPv6. The lack of IPv6 means these companies are likely not addressing their employee, partner, and general Internet needs appropriately. When this peak-to-valley of daily usage starts to get narrower without the pandemic, it will be an indicator of broader enterprise IPv6 adoption (as more and more people will have IPv6 at work, not just at home) .



Another company that can provide a holistic view of the Internet is Akamai. From their global Content Delivery Network (CDN) service and their thousands of interconnected networks and quarter-million Internet servers, they can observe "the whole Internet" and measure Internet traffic with great accuracy and specificity. Akamai shares their IPv6 Statistics through their State of the Internet Report, conference presentations, and their IPv6 Adoption Visualization site. This site can show the countries or the networks with the highest percentage of IPv6 usage (shown below, respectively).



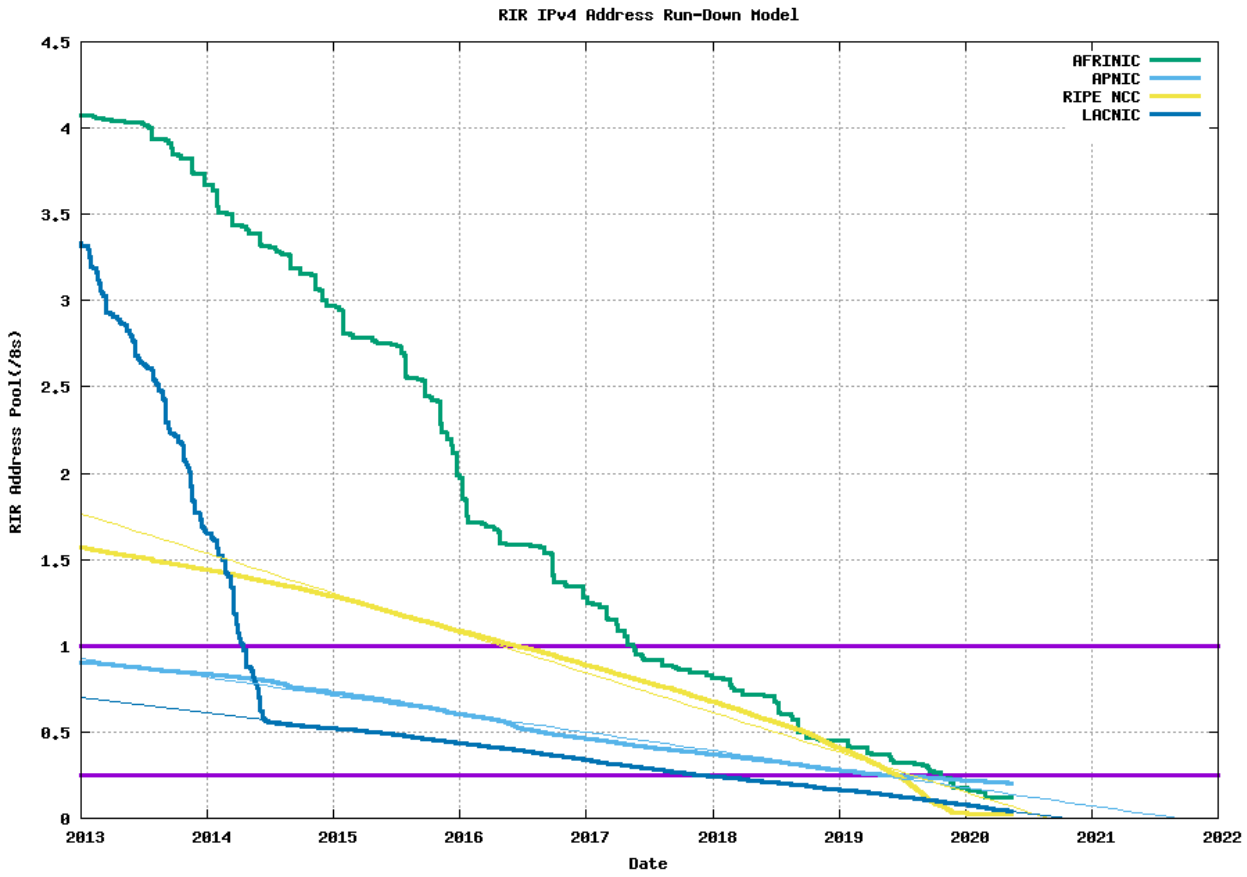
By clicking on a network or country on the Akamai IPv6 Adoption Visualization site, the IPv6 traffic growth is displayed. For instance, Akamai's statistics show that U.S. IPv6 traffic volume is nearly 47% (compared to Google's listed 41%) – almost half of all the Internet traffic in the U.S. However, the Akamai graph for India (ranked #1 worldwide) displays the even more dramatic 3-year rise of their IPv6 traffic growth to 62%! (Note: The India IPv6 percentage can vary daily from 58% up to 68%.)



These graphs prove that some countries are taking a much more aggressive approach to Internet-enabled innovation. Countries who want to obtain a competitive advantage in an interconnected global economy will want to leverage the most widely used and best performing (discussed below) Internet connectivity (i.e., IPv6) to accelerate their national economies. As an example of how quickly this can happen, look at the Philippines' who effectively had 0% IPv6 up until June of 2019. They are now ranked 48th with 12.8%, which has all happened in 2020. It is still possible to have rapid adopt impact on a global scale with IPv6.

Address Resources: IPv4 and IPv6

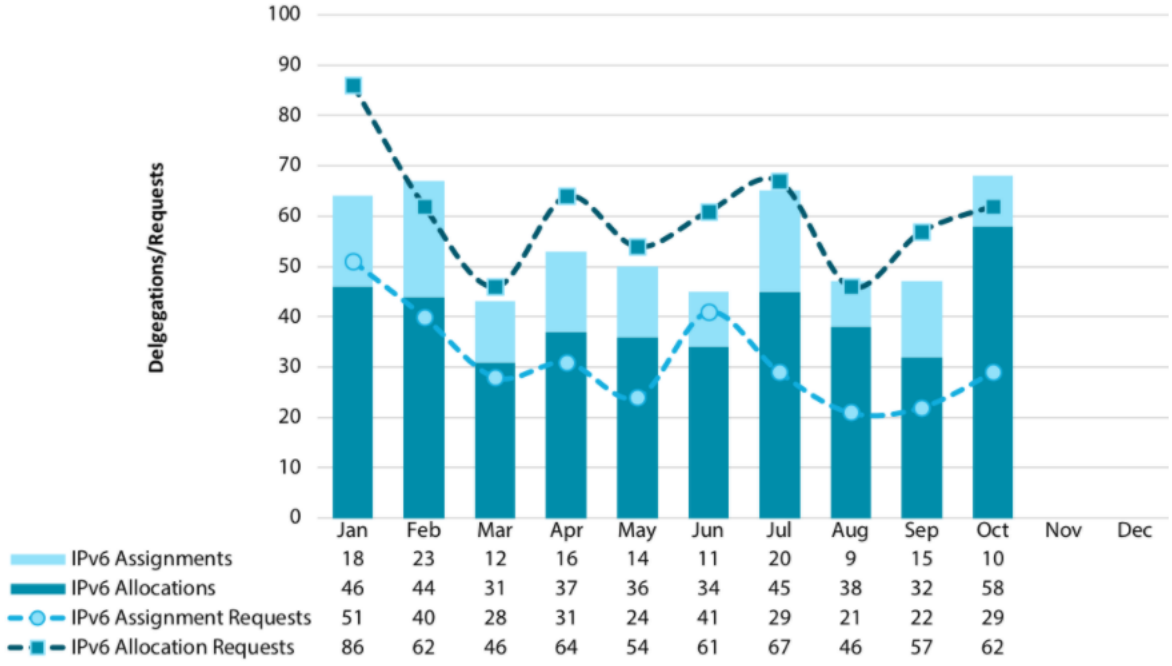
The continued growth of the Internet is dependent on the cost-effective availability of unique publicly-routable addresses. In the past IPv4 has provided these addresses. But beginning in 2011 and continuing up until today, the five Regional Internet Registries (RIRs) that provide these addresses to ISPs and enterprises have all formally announced the exhaustion of their supplies of IPv4 address resources. This exhaustion of IPv4 has been the primary driver of IPv6 adoption. While the following graph published by https://ipv4.potaroo.net/ may look like a screenshot of your worst game ever playing the 1980 classic Atari game "Missile Command", it actually shows the exhaustion of IPv4 addresses by the five global RIRs. As such, it demonstrates that any plans to grow the planet's Internet-connected population with IPv4 are doomed to fail.



In the meantime, a grey market allowing for the sale and transfer of IPv4 resources has arisen. Prices vary depending on the quantity required, but for the /20 to /24 range they are between USD $23 to $29.50 per IPv4 address. This is an increase of about $3 to $5.50 per address in one year. Organizations like cloud providers still need IPv4 addresses to expand their business. In 2019 Amazon reportedly purchased 4 million IPv4 addresses from AMPRNet. A 2020 TechRadar article estimated that Amazon has invested nearly $2.5 billion in IPv4 addresses.

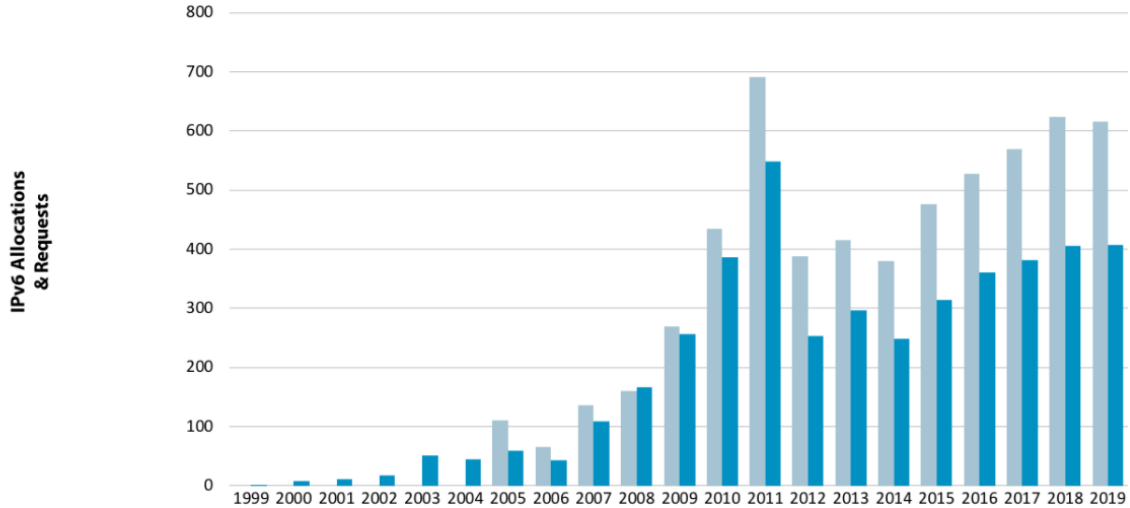
Meanwhile, the steady rate of IPv6 assignments by the RIRs indicate that many ISPs and some enterprises are either continuing existing, or planning new, IPv6 deployments. For example, data from the North American RIR ARIN show an average of 60.5 allocation requests in the 2020. Note that roughly two-thirds of those are first-time IPv6 allocation requests.

2020 IPv6 Address Space Requests / Delegations



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
IPv6 Assignments	18	23	12	16	14	11	20	9	15	10		
IPv6 Allocations	46	44	31	37	36	34	45	38	32	58		
IPv6 Assignment Requests	51	40	28	31	24	41	29	21	22	29		
IPv6 Allocation Requests	86	62	46	64	54	61	67	46	57	62		

1999 - 2019 IPv6 Address Allocations and Requests



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
IPv6 Allocation Requests	0	0	0	0	0	0	110	66	136	161	269	434	691	388	415	380	477	528	570	623	616
Initial IPv6 Allocations	2	8	11	17	51	45	59	44	109	167	257	387	548	254	297	248	314	360	382	406	407

Data on the number of requests for IPv6 allocations prior to 2005 is not available.

Between 1999 and 2010 was the period when early adopters, ISPs, and research organizations were initially obtaining their global IPv6 address allocations. During a 2011 high-point, many federal organizations were receiving their allocations in

preparations to meet the U.S. federal government 2010 mandate to "upgrade public/external facing servers and services (e.g. web, email, DNS, ISP services, etc.) to operationally use native IPv6 by the end of FY 2012." That year also saw increased interest in IPv6 related to World IPv6 Launch. In the intervening years, more and more enterprise organizations have come to the realization that they need to obtain IPv6 addressing to proceed with their deployments. Further, the U.S. federal government in 2020 has issued a new mandate that requires at least 80% of IP-enabled assets on federal networks are operating in IPv6-only environments by the end of FY 2025.

Now we will turn our attention to the specific markets and companies that are making great progress in deploying IPv6 and offering dual-protocol connectivity to their subscribers and users.

3) Telco, Wireless, Web & Content Provider

Service providers have the greatest need for public IPv4 and IPv6 addresses because they need to utilize those addresses to connect their ever-increasing number of Internet subscribers. Subscribers need public addresses to be able to directly reach systems and content on the Internet. The explosive growth of Internet-connected mobile devices has placed even more pressure on an already limited and even exhausted supply of addresses. Therefore, service providers have had to prioritize their IPv6 adoption projects given the virtually unlimited number of addresses IPv6 provides (most often for no more expense than a few thousand US dollars per year).

However, some ISPs have moved much faster than others. Those service providers who reacted more quickly to the transition to IPv6 often were able to avoid having to deploy costly Carrier-Grade-NAT (CGN) or Large-Scale-NAT (LSN) resources to perform a second level of NAT within their networks. Those ISPs that acted quickly were also better able to preserve the perception of their status as Tier-1 providers. By comparison, those ISPs who were slow to adopt IPv6 ended up in a situation where they might have historically been considered a Tier-1 provider, but were perceived to be Tier-2 providers when it came to their IPv6 Internet peering and connectivity.

This section of this document will review some of the providers who have been the most aggressive in deploying IPv6. But first, the reader might be interested to learn some of the additional sources for the IPv6 adoption statistics used in the report.

Where we gathered these statistics?

There are a variety of sources for IPv6 adoption statistics (we've already mentioned a couple of them; e.g., Google and Akamai). The increasing popularity of IPv6 has inspired many organizations to measure the progress of overall IPv6 adoption.

On January 12, 2011, many of the largest content providers coordinated an event called World IPv6 Day. This was a 24-hour event where large content providers enabled IPv6 for their primary domain and resulting website URL (e.g., www.google.com or www.facebook.com) in an effort to measure feasibility of more broadly enabling IPv6 on the Internet. After World IPv6 Day proved a success, the Internet Society (ISOC) coordinated an event on June 6, 2012, called World IPv6 Launch, which organized a "flag day" whereby many organizations pledged to permanently IPv6-enable their websites and their subscribers at the same time. After the success of this launch event, ISOC continued to maintain the measurement site deployed for it and, to this day, it is a key source of IPv6 adoption measurements. For example, try typing in the name of an ISP into the search field to see the volume of their IPv6 traffic. Many of the graphs in this HexaBuild report come from this excellent source of IPv6 data.

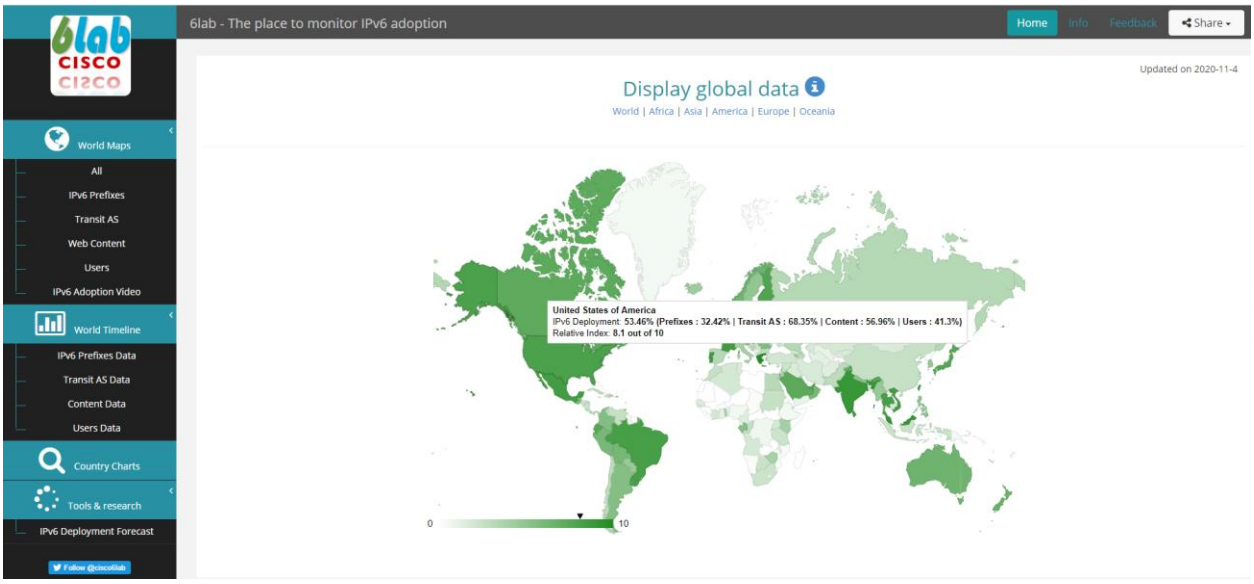
Hurricane Electric (HE), a global Internet backbone and ISP, has published its IPv6 Progress Report for many years now. Part of this report shows that virtually all of the top-level DNS domain names, root name servers, and TLD servers now support IPv6. It also shows a list of the top websites using IPv6 as well as the number of Internet-routed Autonomous Systems Numbers (ASNs) advertising IPv6 prefixes .

The IPv6 CIDR report is another authoritative source of information on IPv6 prefixes advertised to the global Internet by Internet backbone ASNs.

The global Internet relies heavily on the root name servers. The Internet Assigned Number Authority (IANA) maintains the naming and numbering of these servers and this page shows that the they are all now using IPv6.

Besides IPv6-enabled DNS servers, there are additional infrastructure support services that the Internet relies on. Among these are public Certificate Authorities (CAs). This article explains that the topic public commercial CA services and free CA services such as Let's Encrypt now support IPv6 connectivity.

Cisco remains the dominant network device manufacturer. Their Cisco 6Labs site provides global IPv6 adoption statistics. This useful site allows users to drill down into IPv6 usage statistics based on geography, users, advertised IPv6 prefixes, web content, and other parameters. In comparison to other measurement sites mentioned in this report, the Cisco 6labs site shows that U.S. IPv6 deployment is over 53.5%. Explore this map and you will find many countries shaded dark green that have over 50% IPv6 deployment.



Another useful source of IPv6 statistics is the IPv6 Deployment Aggregated Status site, created and maintained by Eric Vyncke, a Cisco Distinguished Engineer in Belgium. His site shows the top IPv6-enabled countries by web, e-mail, DNS and user percentage by population providing yet another view of global IPv6 usage. There are differences in metrics from each of the sources listed and there is a useful article from RIPE NCC that covers why this occurs and provides good context around looking at the data.

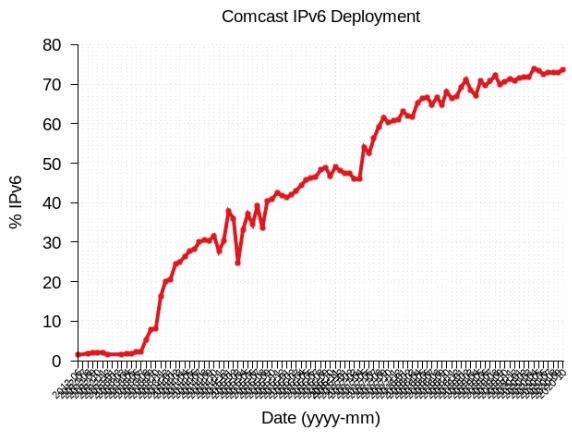
Cable MSOs

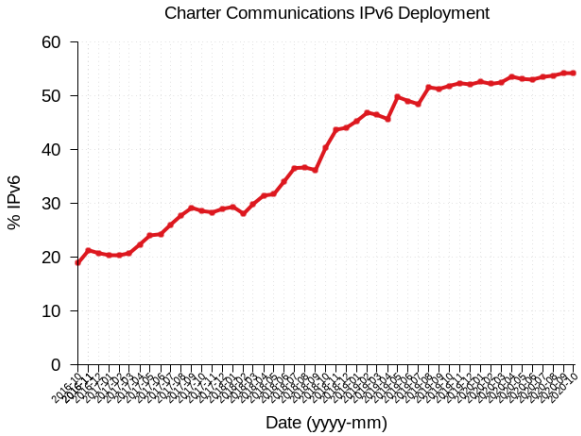
When it comes to business and residential broadband Internet access, many Multi System Operators (MSOs) have expanded their networks to include dual-protocol connectivity to their subscribers.

In North America, one of the largest MSOs is Comcast with over 30 million subscribers. Comcast has been working on their IPv6 deployment since before 2000. Their early field-trials have matured to widespread production IPv6 connectivity. Comcast put substantial effort into upgrading their core backbone, upgrading their Cable Modem Termination Systems (CMTSs), and helping customers upgrade to DOCSIS 3.0 and 3.1 modems and other newer CPE devices that support IPv6. As a result, their IPv6 traffic volumes have increased with more than 74% of their subscribers using IPv6.

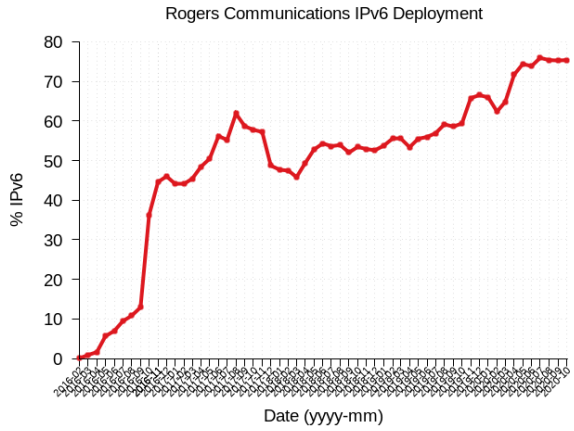
Charter/Spectrum Communications, recently acquired Time Warner Cable and Bright House Networks, and now has over 25 million subscribers across 41 U.S. states and 54% of their subscribers using IPv6. The following graph shows their

steady progress in increasing the number of subscribers that use their IPv6 Internet services.





In Canada, Rogers Communications is the largest cable MSO with nearly 11 million subscribers and 73.38% of their subscribers using IPv6. This graph shows that, in just a few months in 2016, they were able to dramatically shift more customer traffic to IPv6 by enabling it for more subscribers. Canada overall has increased user traffic to approximately 30%, mainly due to cable and mobile operator efforts.



Given these examples, its highly likely that whatever existing broadband Internet service provider you may use already offers IPv6 services to your home or business. This means that a remote, distributed workforce working from home will likely have dual-stack (IPv4 and IPv6) available and will use IPv6 because of their devices' default behavior. This transition to using IPv6 is happening at subscribers' homes, therefore the Enterprise must do something to acknowledge this and adopt IPv6.

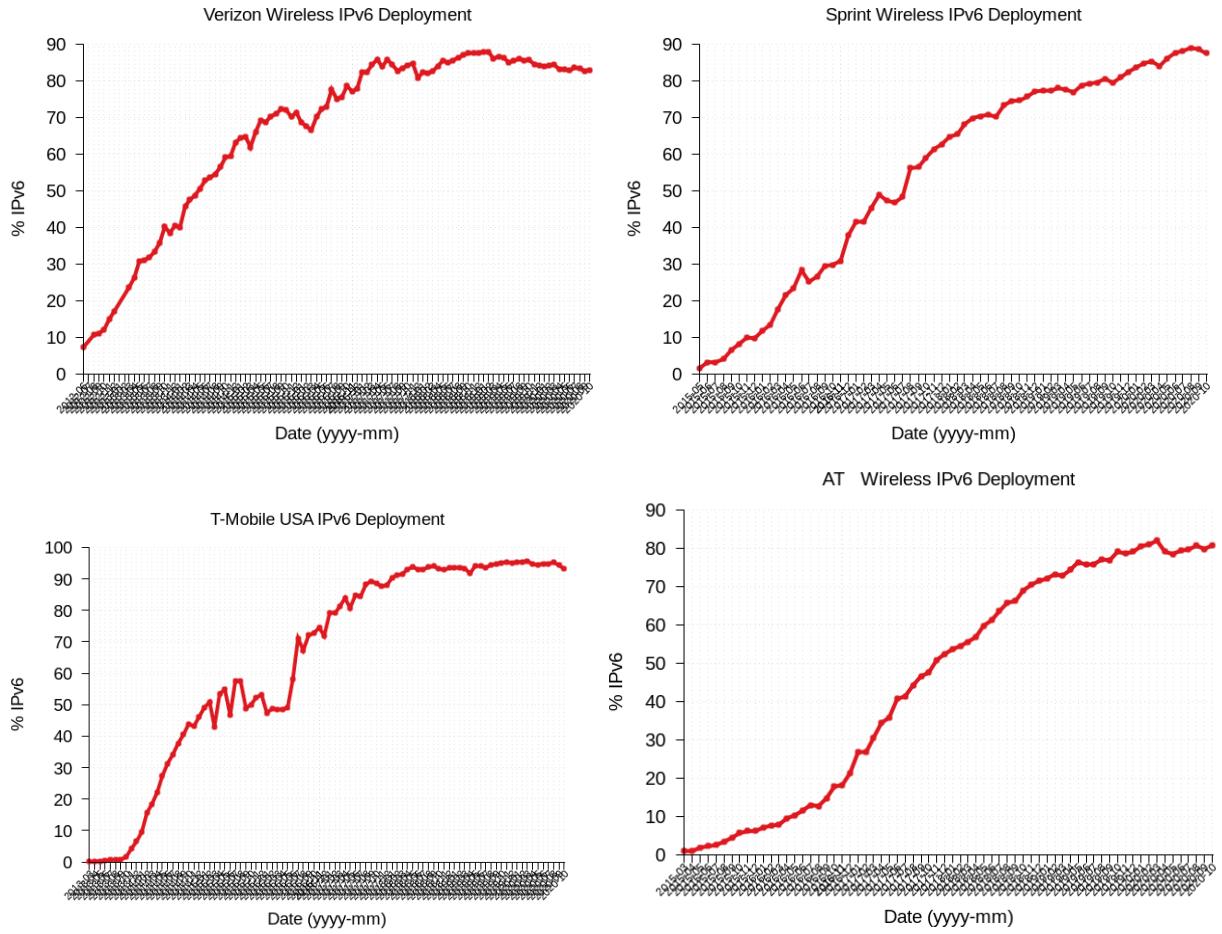
Mobile Providers

Mobile providers have been focused on incorporating IPv6 into their networks since at least 2009, the year when the 3rd Generation Partnership Project (3GPP) standards organization first started to mandate that wireless service providers enable IPv6 on their 4G wireless infrastructure. One of the advantages that mobile providers have over Cable MSOs in driving IPv6 adoption is that they have more influence and control over the software and hardware used by their mobile subscribers. In addition, more rapid turnover of mobile devices results in faster deployment of IPv6-enabled handsets. As a result, IPv6 support in Apple iOS and Android and the handsets running them has paved the way for maximal IPv6 user and traffic percentages.

With nearly 150 million subscribers, Verizon Wireless is the largest mobile operator in the U.S. Verizon has been actively working on both its backbone and 4G network IPv6 deployment for more than a decade. The graph below shows the steady progress that Verizon has made over the past seven years to reach a remarkably high percentage of IPv6-enabled subscribers.

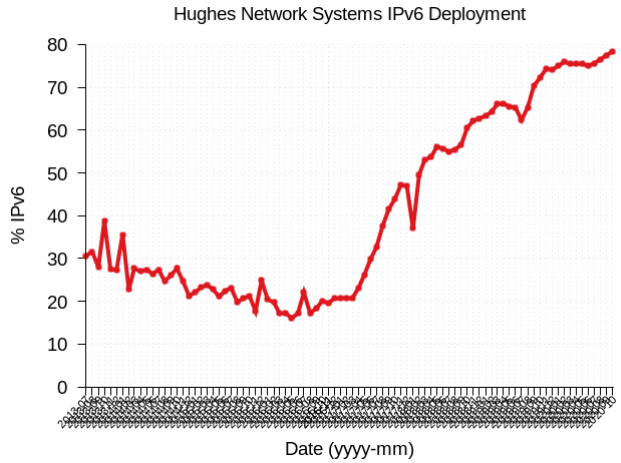
T-Mobile/Sprint is one of the world's largest mobile providers with approximately 98 million subscribers in the US and globally 230 million subscribers. T-Mobile was one of the first mobile providers to wholeheartedly embrace IPv6 with early trials using NAT64/DNS64. T-Mobile's remarkable progress with IPv6 has led to its IPv6-only deployment being the largest in the world. Stephan Langerholm is one of the architects of this effort and gave a presentation at the North American IPv6 Summit in April 2017 covering their IPv6 status and future IPv6 plans. The graph below shows just how close T-Mobile is to attaining 100% IPv6 adoption.

AT&T Wireless has also made slow and steady progress in adopting IPv6. The left graph below demonstrates their early progress, made when they first committed to expanding IPv6 connectivity to subscribers. As with other providers, greater IPv6 adoption can be difficult to obtain due mostly to those subscribers with legacy IPv4-only devices (both CPE as well as handsets in the case of mobile providers).



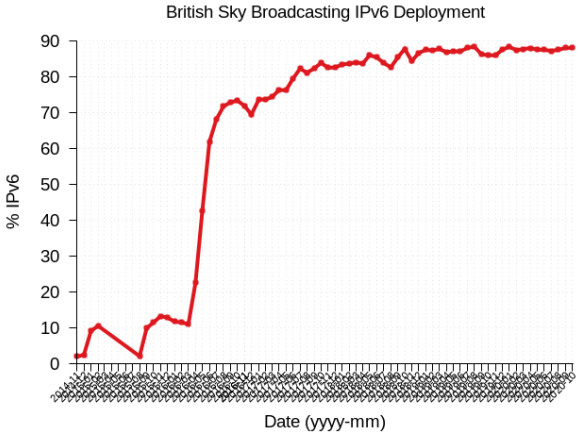
From these graphs, it's safe to conclude that the mobile device you have on you as you read this report already uses IPv6 (and you may not have even realized it!). Again, a remote and distributed work force in the US using mobile devices is preferring IPv6 and in some cases (like T-Mobile) are on an IPv6 only network.

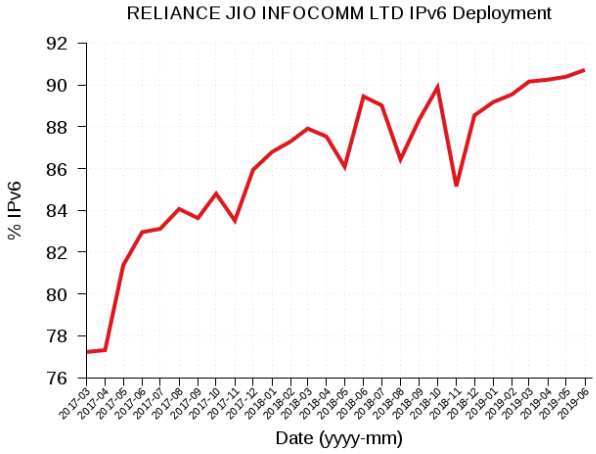
The graph below shows the dramatic rise (less than a year) in the IPv6 traffic volume of the satellite-based ISP, Hughes Network Systems. In a 30-month period their IPv6 traffic percentage grew from 20% to nearly 70%. It proves that when an organization commits to expanding its IPv6 subscriber base, rapid growth is possible.



International Providers

Few IPv6 adoption graphs reflect as dramatic an increase in IPv6 traffic volume as the one experienced by British Sky Broadcasting in early 2016. BSkyB enabled IPv6 end-to-end (from subscribers across the network to the Internet) in just five short months, rocketing from 10% to 70% IPv6 adoption. In a similar example, Reliance Jio, in India, went up to over 90% in just a few years.



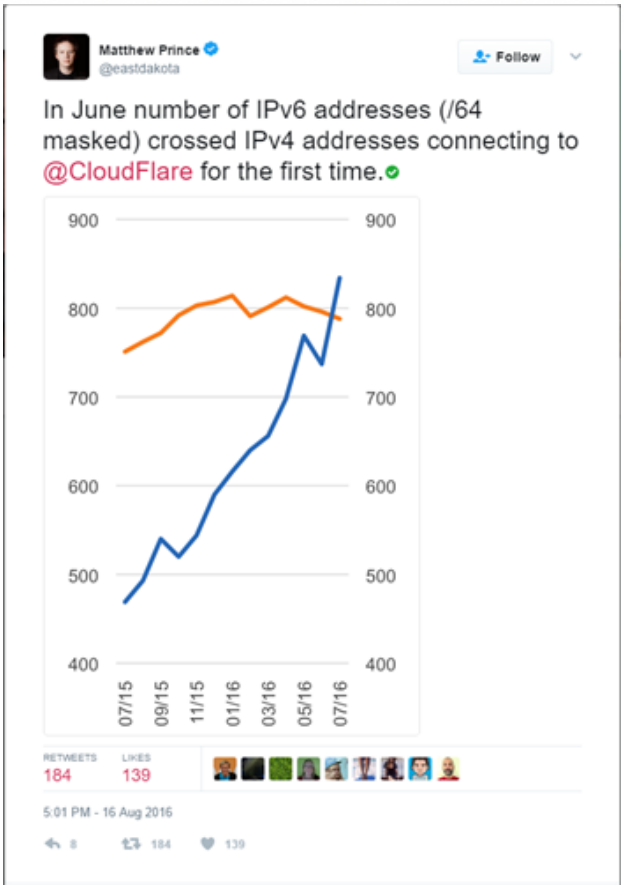


Content Providers

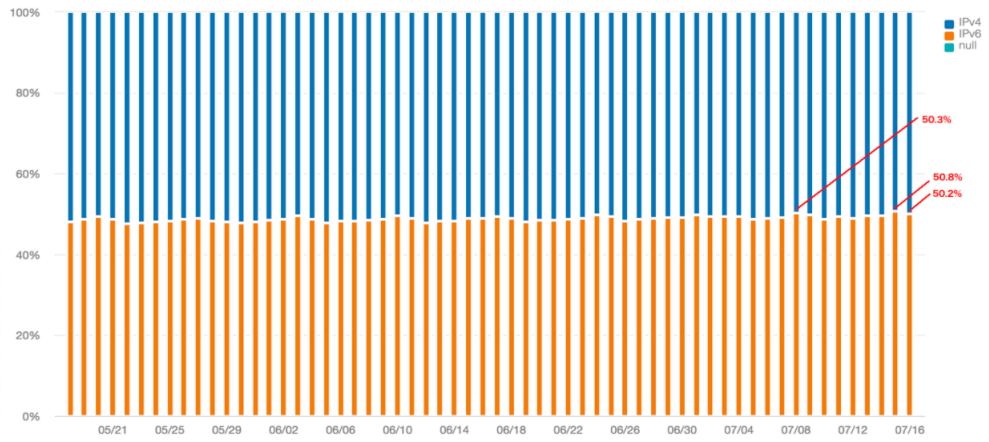
Having a mesh of well-connected IPv6 Internet backbone providers and millions of IPv6-connected subscribers would be pointless if there wasn't a cornucopia of IPv6-enabled web servers.

Today, virtually all the Content Delivery Networks (CDNs) are using IPv6. The success of these companies relies mainly on making sure their client's web content is reachable by the largest percentage of Internet users. As the statistics in the last section demonstrate, many of these users are coming from mobile devices or home

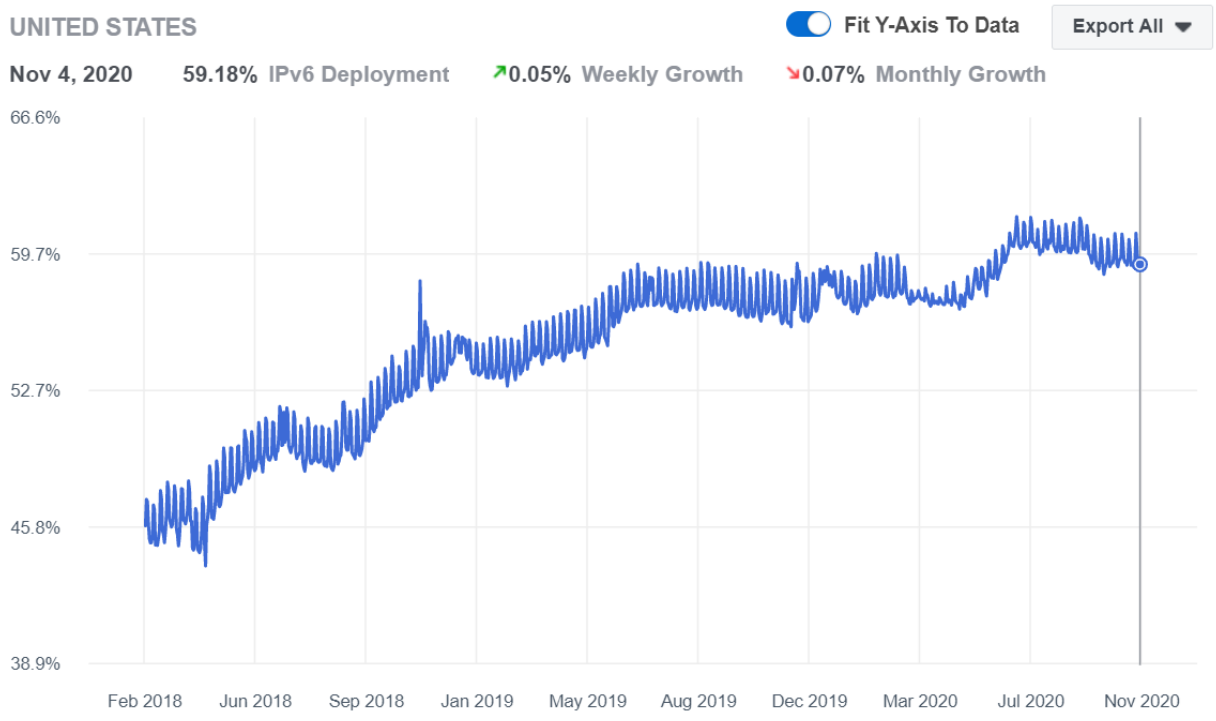
networks that have IPv6 connectivity. Companies often rely on their CDN provider as a way of establishing IPv6 reachability to their web site if they haven't themselves IPv6-enabled their site. As a result, CDNs must support IPv6 on their caching platforms to comprehensively support their customers. Some CDNs, like CloudFlare, have made "IPv6-enabled" the default setting on their services. The following 4-year old graph demonstrates the results of such a configuration: When IPv6 is enabled automatically, IPv6 traffic volumes can be greater than IPv4. As a result of this IPv6-enabled-by-default setting, over 98% of their customer's sites use IPv6.

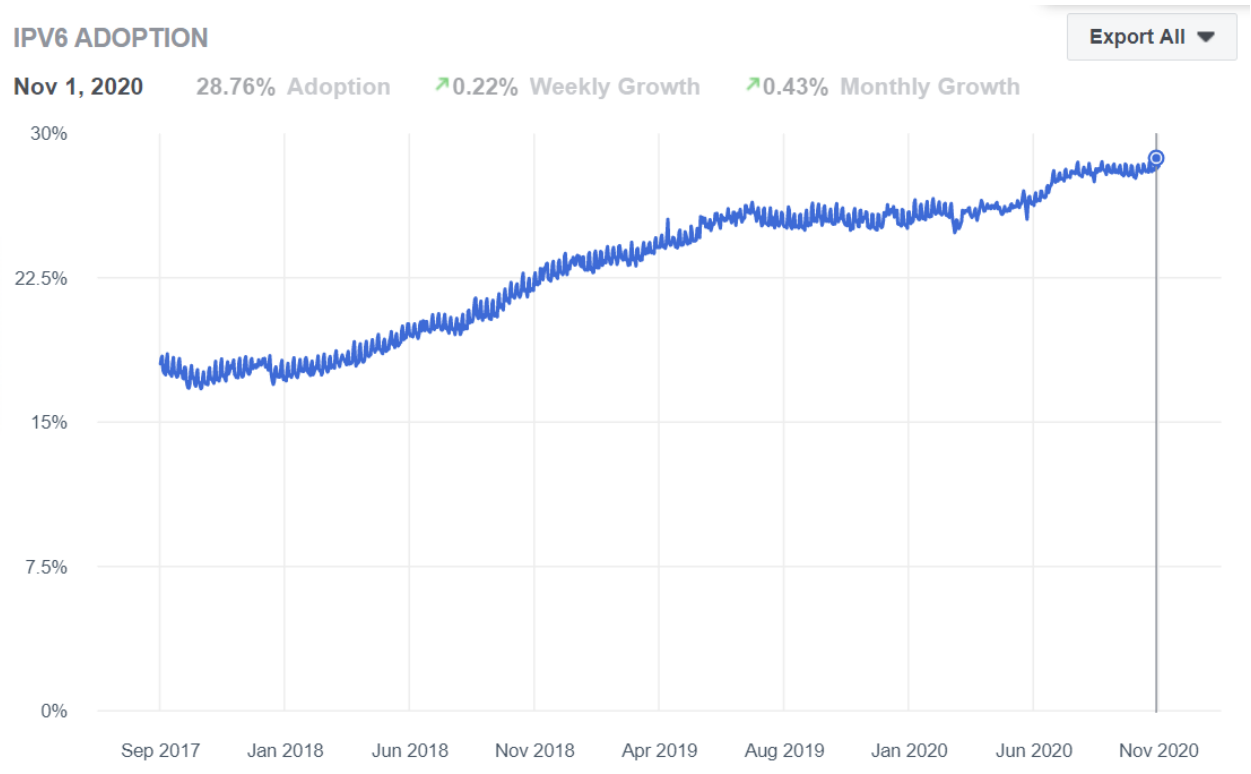


Other large content companies have taken the initiative to IPv6-enable their sites resulting in tremendous growth in the percentage of their IPv6 traffic. One great example of this is LinkedIn. The LinkedIn network engineering team has established a tradition of enabling IPv6 internally as well as encouraging others to use IPv6. As a result, LinkedIn engineering announced in the summer of 2017 (over 3 years ago) that they had passed a historic milestone: For the first time ever, the amount of IPv6 traffic on their network surpassed that of IPv4.



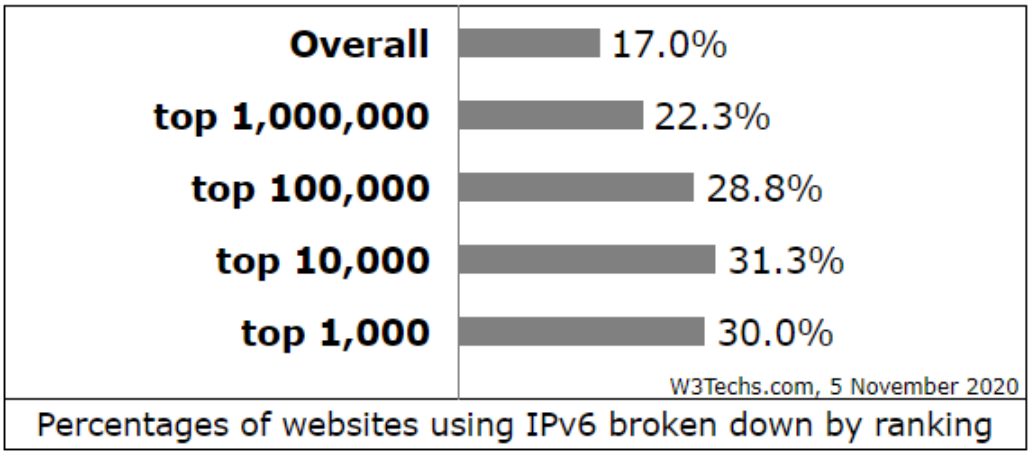
Facebook is arguably the largest content provider in the world. They have also been [very public about their preference for IPv6](#) communications – both internally and to end-users. Paul Saab has led the IPv6 deployment efforts at Facebook and mentioned (nearly 3 years ago) that more than 50% of the traffic across their U.S. network is over IPv6. As shown below, these statistics can be viewed on the [Facebook IPv6](#) measurements site, with the current trend showing 59% traffic to Facebook for the US, and 28% globally.





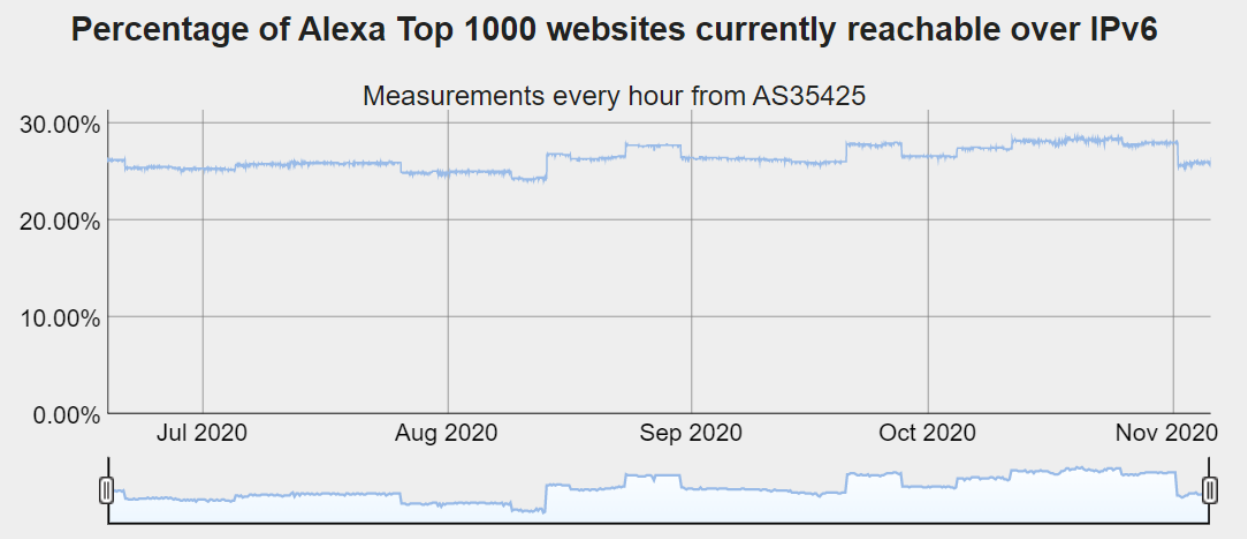
Finally, Google has fully supported IPv6 on their search site and on their numerous other services since World IPv6 Launch. As mentioned earlier, they measure a high percentage of IPv6 connections to their content.

In the above-mentioned Hurricane Electric Global IPv6 Deployment Progress Report, their automated measurements show that about 20% of the top websites are currently reachable over IPv6. Meanwhile, the W3Techs site reveals that IPv6 is used more frequently by the top 1000 web sites and that from 2019 to 2020 the overall IPv6 website numbers have increased almost 3%.



Percentages of websites using IPv6 broken down by ranking

Finally, referring back to the World IPv6 Launch Measurements site we see that data observed from the perspective of AS35425 (Bytemark Limited) shows approximately 28% of the Alexa Top 1000 sites use IPv6.



4) IPv6 Can Be Faster Than IPv4

With IPv6's plentiful supply of global addresses, there is no need for the address sharing functionality of Network Address Translation (NAT). With IPv4, NAT is required because of address scarcity. NAT results in header checksum recalculation for IPv4 packets, which adds latency to returning packets. Congestion and connection competition can also occur for IPv4 sessions passing through NATs. IPv6 does not have these constraints and its simplified header structure allows IPv6 packets to rapidly pass through networks directly.

For many years we have suspected that IPv6 could have performance advantages. Now there is strong evidence that for Internet traffic, on average, IPv6 is faster than IPv4. Asia-Pacific Network Information Centre (APNIC) has a site that shows the Average Round-Trip-Time (RTT) Difference between IPv6 and IPv4. While these measurements change daily, we can see that the RTT difference proves IPv6 is faster on most continents and in most regions. (A negative number indicates that IPv6's RTT is lower than IPv4's RTT.)

Code	Region	Avg RTT Diff (V6-V4)	Samples	Avg V6 Fail Rate	V6 Fails	V6 Samples	Dual Stack	Dual Stack (300ms)	V6 Use Rate
QQ	Melanesia, Oceania	133.64 ms	68	6.73%	7	104	29.41%	94.12%	0.12%
XS	Eastern Asia, Asia	72.27 ms	3,129,991	1.74%	75,034	4,312,207	62.20%	91.91%	23.07%
XP	South America, Americas	10.84 ms	3,510,201	3.49%	154,753	4,429,498	43.24%	98.68%	23.16%
XU	South-Eastern Asia, Asia	6.74 ms	3,270,019	2.97%	129,810	4,372,195	55.80%	96.31%	19.31%
XK	Southern Africa, Africa	4.43 ms	1,107	6.62%	75	1,133	72.09%	81.93%	0.28%
XW	Eastern Europe, Europe	-1.76 ms	1,125,170	2.42%	36,144	1,495,274	64.17%	98.73%	9.68%
QP	Australia and New Zealand, Oceania	-2.13 ms	129,580	1.58%	2,477	157,205	62.10%	95.74%	27.86%
XL	Western Africa, Africa	-3.06 ms	8,737	7.50%	913	12,171	77.01%	76.43%	0.31%
XN	Caribbean, Americas	-5.24 ms	83,264	4.05%	3,929	97,061	78.71%	99.27%	6.47%
QN	Southern Europe, Europe	-5.31 ms	844,624	5.89%	68,593	1,164,873	65.02%	99.45%	8.64%
XV	Western Asia, Asia	-6.43 ms	414,004	7.21%	49,568	687,877	75.31%	97.01%	6.18%
QO	Western Europe, Europe	-8.09 ms	2,165,799	5.72%	167,293	2,923,637	72.90%	99.20%	44.02%
XQ	Northern America, Americas	-8.57 ms	5,072,361	3.60%	207,733	5,766,678	77.24%	98.51%	48.10%
QM	Northern Europe, Europe	-9.09 ms	804,755	5.67%	59,108	1,043,199	84.26%	98.96%	28.08%
XT	Southern Asia, Asia	-11.36 ms	12,115,806	1.34%	297,718	22,205,847	70.59%	93.09%	56.27%
XJ	Northern Africa, Africa	-12.35 ms	100,156	0.56%	774	138,407	71.10%	97.80%	2.22%
XO	Central America, Americas	-14.40 ms	946,323	5.71%	67,380	1,179,985	80.77%	99.29%	30.10%
XH	Eastern Africa, Africa	-24.10 ms	50,136	2.50%	1,962	78,637	64.58%	98.03%	1.72%
XI	Middle Africa, Africa	-34.30 ms	7,711	8.79%	1,061	12,073	79.39%	99.25%	1.04%
QS	Polynesia, Oceania	-46.96 ms	5	0.00%	0	5	80.00%	100.00%	0.05%
XR	Central Asia, Asia	-47.92 ms	106	0.00%	0	106	94.34%	96.23%	0.01%

Facebook, LinkedIn, and others have also measured IPv6 performance advantages and interpret them as a benefit to their businesses.

In the first case of such a benefit, if an organization has public (i.e., Internet-reachable) content, provides a mobile app, or uses public-cloud infrastructure, their web apps will perform better when using IPv6. Therefore, organizations seeking to provide content and applications to the broadest Internet population should do so using IPv6 for a better end-user experience.

In the second case, enterprises and organizations that provide Internet access to employees should strive to provide them the best Internet performance using IPv6 and IPv4. End-user-experience will improve when providing dual-protocol Internet access, similar to what those users experience on their mobile devices or with their broadband Internet access at home.

5) Enterprise Networks

With many other entities on the Internet already deploying IPv6, enterprises are often the last organizations to connect using both IP versions. Many enterprises are fiercely competitive but often fail to recognize how their entire business relies upon robust network connectivity as well as the competitive advantage to be gained by adopting IPv6. As a result, many enterprises will fall into the late majority or laggards section of the adoption lifecycle.

There is danger for organizations that are either too early or too late to adopt a technology. Most enterprises do not want to be testing alpha-version product features for a vendor.

Because IPv6 is now so prevalent on the Internet, ignoring it is no longer a viable strategy. Many enterprises have failed to perform any type of planning for IPv6. As Alan Lakein is often quoted as saying, “failing to plan is planning to fail.” Enterprise IT teams have too often avoided learning about IPv6 when IPv6 is enabled by default on all their operating systems. This results in enterprises’ unknowingly deploying IPv6-enabled end-nodes but failing to configure end-to-end IPv6 network connectivity.

Most large enterprises are experiencing exhaustion of private/RFC 1918 IPv4 address space. Enterprise IT teams are aware the difficulty and expense of deploying double-NAT configurations or having to implement CGN/LSN systems like some ISPs have chosen to do. They also have come to realize that if operating an international business at scale is a requirement of the enterprise, they will need a plentiful supply of IP addresses. As enterprises expand into cloud infrastructure, adopt SD-WAN using direct Internet access, and expand their data centers with use of software containers, they also need more addresses support these initiatives.

Enterprises are also starting to realize that there are performance benefits to their end-users when using IPv6 to access the Internet. They may not configure IPv6 in their data centers, but they want to provide their employees dual-protocol Internet access, just like employees’ experience on their mobile devices using 4G services and at home with broadband Internet access. This goes for employees in the headquarters locations as well as the branch offices. When the branch offices are moving to direct Internet access and Software-Defined Wide Area Network (SD-WAN) solutions, they can establish IPv6 Internet access for their remote sites.

For universities, the need to provide dual-protocol Internet access for their students, faculty, staff, and administration is more widely recognized. Universities also recognize that to obtain some NSF grants, they may need to have IPv6 implemented. For all of these reasons, enterprises are realizing that they have a compelling need to IPv6-enable their wired and wireless access networks.

6) Conclusion

The theme of this HexaBuild IPv6 Report is evident in the many similar graphs of increasing IPv6 traffic volumes – largely a result of more organizations deploying IPv6 on their networks. While IPv6 usage has been accelerating, this will also have an affect on IPv4 usage. Over the next few years, IPv4 traffic volumes will level off and reach their peak before they start to decline in subsequent years.

IPv6's performance improvements will continue to increase as IPv4 address scarcity perpetuates the need for multiple-layers of NAT and more complex routing configurations to deal with Cloud, SD-WAN, mobile and a distributed workforce. All businesses and organizations will want to deploy IPv6 to take advantage of its better performance.

We hope we've convinced you that IPv6 is not a temporary solution or a technology to be ignored. As the included measurements and analysis abundantly demonstrate, IPv6 is essential to the evolution and growth of the Internet itself. As a result, it's just as essential for the evolution and growth of your network.

What You Should Do Next?

Many enterprises have had success with IPv6 adoption using a phased approach:

1. Planning/Training
2. Enablement of IPv6 for Web Content
3. Deployment and Management of IPv6 in the corporate networks

These phases are general enough to encompass many manageable tasks that IT management and teams can assign and accomplish with relative ease (especially given the late-adopter advantage enterprises enjoy where regular tech-refresh cycles over the last decade have integrated ever more robust IPv6 support into the IT infrastructure). This is the same general strategy that the U.S. government enterprise organizations have been mandated to follow.

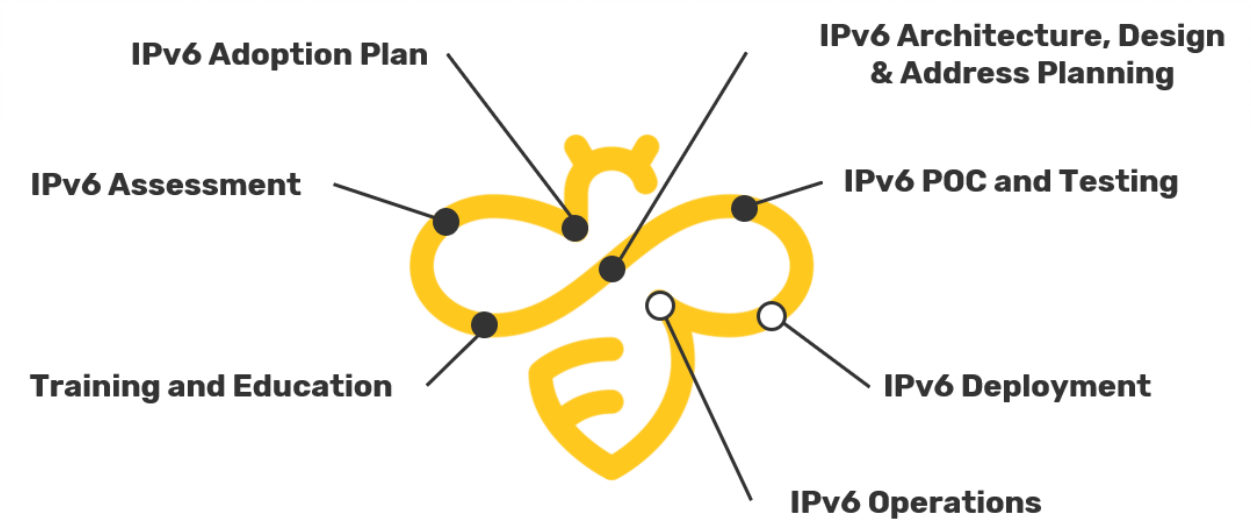
The planning and training phase is arguably the most critical of these phases and provides the foundation from which the successful, cost-effective IPv6 adoption will proceed. And just like anything, having management buy-in to the process is essential. If an organization's management needs convincing of the inevitability of IPv6, in addition to this report, you could also provide them the IT Exec's Guide to IPv6 Adoption.

Enabling IPv6 on the corporate website has never been easier with many CDNs and hosting companies offering accessibility over IPv6 as an option or even by default. Those organizations that choose to neglect this step are at a potential competitive disadvantage with other businesses in their vertical whose websites are reachable directly over IPv6 by the over 75 million users of IPv6 in the US alone.

Deliberate Internal adoption of IPv6 in the enterprise is often delayed or avoided due to assumptions regarding the complexity and risk associated with connecting the desktop or mobile to the IPv6 Internet. But as this report made clear, IPv6 is enabled and preferred by default on all recent devices connected to the corporate

network. In this sense, IPv6 has already been widely deployed by enterprise networks – if not effectively managed.

It is possible to mitigate your risks and have a comprehensive plan allowing your organization to adopt IPv6 with a higher likelihood of success. We help Fortune 1000, State, and Federal organizations do that with our standardized methodology shown below.



At any of these phases, it is critically important to engage IPv6 experts with deployment experience and a mature services portfolio that includes at a minimum IPv6 training, IPv6 readiness assessment, IPv6 address planning, IPv6 security, and IPv6 network architecture (including cloud and IoT integration). IPv6 experts will help prevent having to re-do any IPv6 configurations and start right from the onset with all the best practices garnered from their experience helping other organizations. (Please visit https://hexabuild.io for a complete, detailed list of services and solutions).

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