EXECUTIVE SUMMARY

TeleGeography Global Internet Research Service

Executive Summary

The year 2021 may be remembered as the year that the internet returned to normal—however one may choose to define that. After a tumultuous 2020, in which the COVID-19 pandemic caused internet traffic patterns to shift and volumes to surge, network operators returned to the business of adding bandwidth and engineering their traffic in a more measured manner.

In our *Global Internet Geography Research Service,* we analyze the meaning of our robust internet capacity and traffic data sets. We also discuss factors impacting IP transit pricing, and the role individual backbone operators play. Based on hard survey data gathered from dozens of regional and global network operators around the world, we conclude that COVID-related expansion of internet traffic and bandwidth was largely a one-off phenomenon, and that the trends we had been observing in recent years have reasserted themselves. International internet bandwidth and traffic growth had been gradually slowing in recent years, but they remain brisk. IP transit price declines continue globally, but significant regional differences in prices remain.

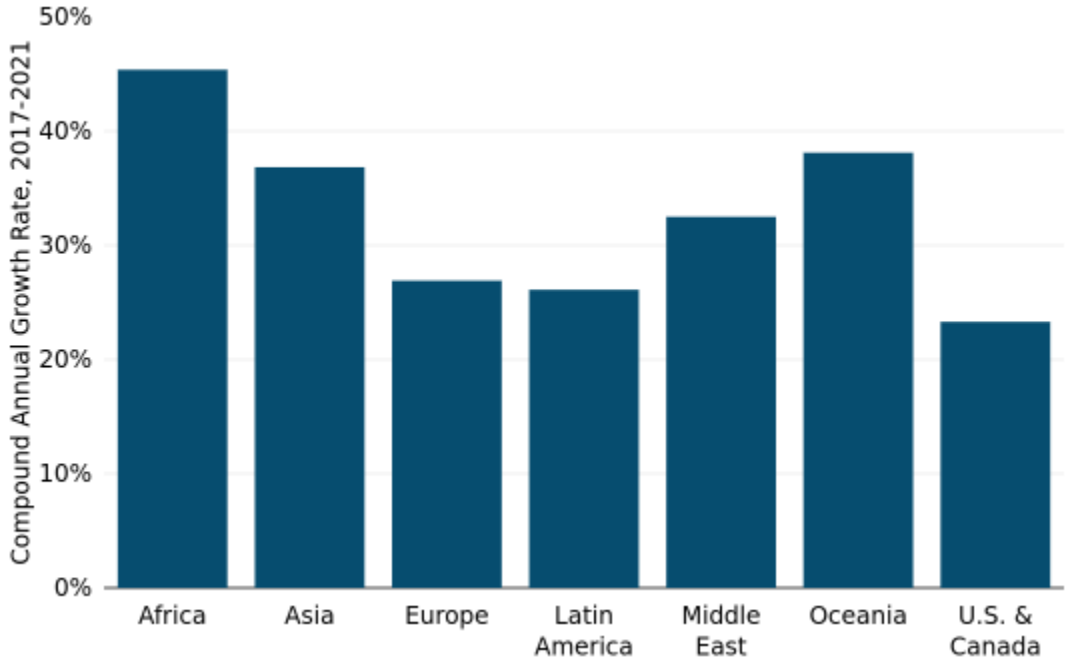
Internet Traffic and Capacity

Global internet bandwidth rose by 29% in 2021, a return to "normal" over the previous year's COVID-driven surge of 34%. Total international bandwidth now stands at 786 Tbps, representing a 4-year CAGR of 29%. The pace of growth *had been* slowing, but we still see a near tripling of bandwidth since 2017.

Strong capacity growth is visible across regions. Africa experienced the most rapid growth of international internet bandwidth, growing at a compound annual rate of 45% between 2017 and 2021. Oceania sits just behind Africa, rising at a 38% compound annual rate during the same period.

FIGURE 1

International Internet Bandwidth Growth by Region



Notes: Data as of mid-year.

Source: TeleGeography

International internet bandwidth growth largely mirrors that of internet capacity. Average and peak international internet traffic increased at a compound annual rate of 29% between 2017 and 2021—matching the 29% compounded annual growth rate in bandwidth over the same period. All of the stay-at-home activity associated with COVID-19 last year resulted in a spike in traffic from 2019-2020. As one may expect, the return to more normal usage patterns has resulted in a substantial drop in average and peak traffic for 2020-2021. Average traffic growth dropped from 48% between 2019-2020 to 23% between 2020-2021, while peak traffic growth dropped from 46% to 26% over the same time period.

FIGURE 2

Global International Internet Traffic (Gbps)

	2017	2018	2019	2020	2021	Change 2017-18	Change 2018-19	Change 2019-20	Change 2020-21	CAGR 2017-21
Internet Bandwidth	286,104	362,031	453,709	608,768	785,635	27%	25%	34%	29%	29%
Average Traffic	74,216	93,650	113,687	167,720	205,799	26%	21%	48%	23%	29%
Peak Traffic	127,485	160,067	191,054	279,877	353,559	26%	19%	46%	26%	29%
Average Utilization	26%	26%	25%	28%	26%	-0%	-3%	10%	-5%	0%
Peak Utilization	45%	44%	42%	46%	45%	-1%	-5%	9%	-2%	0%

Notes: Data reflects traffic over internet bandwidth connected across international borders. Data as of mid-year.

Source: TeleGeography

This return to normalcy can be seen across regions of the world. With the initial rapid traffic growth

due to COVID-19 waning in 2021, many global networks appear to have started to return to more typical rates of utilization. Global average and peak utilization rates declined slightly to 26% and 45% percent, respectively, in 2021.

FIGURE 3

International Internet Traffic by Region (Gbps)

	2017	2018	2019	2020	2021	Change 2017-18	Change 2018-19	Change 2019-20	Change 2020-21	CAGR 2017-21
Africa										
Internet Bandwidth	5,972	8,677	12,420	18,785	26,681	45%	43%	51%	42%	45%
Average Traffic	2,314	3,402	4,689	7,051	9,313	47%	38%	50%	32%	42%
Peak Traffic	3,850	5,519	7,711	11,621	16,309	43%	40%	51%	40%	43%
Average Utilization	39%	39%	38%	38%	35%	1%	-4%	-1%	-7%	-3%
Peak Utilization	64%	64%	62%	62%	61%	-1%	-2%	-0%	-1%	-1%
Asia										
Internet Bandwidth	54,724	76,953	102,932	144,145	191,910	41%	34%	40%	33%	37%
Average Traffic	18,481	26,135	32,612	49,860	66,406	41%	25%	53%	33%	38%
Peak Traffic	28,938	41,632	51,486	77,967	105,408	44%	24%	51%	35%	38%
Average Utilization	34%	34%	32%	35%	35%	1%	-7%	9%	0%	1%
Peak Utilization	53%	54%	50%	54%	55%	2%	-8%	8%	2%	1%
Europe										
Internet Bandwidth	193,931	243,216	297,063	393,128	503,089	25%	22%	32%	28%	27%
Average Traffic	48,554	59,715	72,432	103,687	122,975	23%	21%	43%	19%	26%
Peak Traffic	83,068	101,512	119,930	171,877	207,778	22%	18%	43%	21%	26%
Average Utilization	25%	25%	24%	26%	24%	-2%	-1%	8%	-7%	-1%
Peak Utilization	43%	42%	40%	44%	41%	-3%	-3%	8%	-6%	-1%
Latin America										
Internet Bandwidth	35,841	41,244	53,758	71,032	90,658	15%	30%	32%	28%	26%
Average Traffic	7,228	8,378	10,108	15,968	19,873	16%	21%	58%	24%	29%
Peak Traffic	15,686	18,262	22,044	33,024	43,697	16%	21%	50%	32%	29%
Average Utilization	20%	20%	19%	22%	22%	1%	-7%	20%	-2%	2%
Peak Utilization	44%	44%	41%	46%	48%	1%	-7%	13%	4%	2%
Middle East										
Internet Bandwidth	18,573	25,231	32,393	44,519	57,255	36%	28%	37%	29%	33%
Average Traffic	7,090	9,097	11,373	15,939	20,210	28%	25%	40%	27%	30%
Peak Traffic	10,818	14,029	17,471	24,546	31,610	30%	25%	40%	29%	31%
Average Utilization	38%	36%	35%	36%	35%	-6%	-3%	2%	-1%	-2%
Peak Utilization	58%	56%	54%	55%	55%	-5%	-3%	2%	0%	-1%
Oceania										
Internet Bandwidth	2,919	3,862	5,572	7,886	10,623	32%	44%	42%	35%	38%
Average Traffic	1,086	1,366	1,655	2,515	3,363	26%	21%	52%	34%	33%
Peak Traffic	1,553	2,053	2,658	4,076	5,446	32%	29%	53%	34%	37%
Average Utilization	37%	35%	30%	32%	32%	-5%	-16%	7%	-1%	-4%
Peak Utilization	53%	53%	48%	52%	51%	-0%	-10%	8%	-1%	-1%
U.S. & Canada										
Internet Bandwidth	70,357	82,356	101,665	130,134	162,622	17%	23%	28%	25%	23%
Average Traffic	18,103	21,732	25,386	37,198	43,922	20%	17%	47%	18%	25%
Peak Traffic	33,051	40,023	46,380	66,156	80,732	21%	16%	43%	22%	25%
Average Utilization	26%	26%	25%	29%	27%	3%	-5%	14%	-6%	1%

	2017	2018	2019	2020	2021	Change 2017-18	Change 2018-19	Change 2019-20	Change 2020-21	CAGR 2017-21
Peak Utilization	47%	49%	46%	51%	50%	3%	-6%	11%	-2%	1%

Notes: Data reflect traffic over Internet bandwidth connected across international borders including links within each region. Data as of mid-year.

Source: TeleGeography

Prices

Now that internet backbone operators have adapted their networks to accommodate changes in traffic flows, they've resumed a more measured approach to capacity planning and network upgrades in 2021. Price trends have resumed their downward trajectory and regional characteristics accordingly.

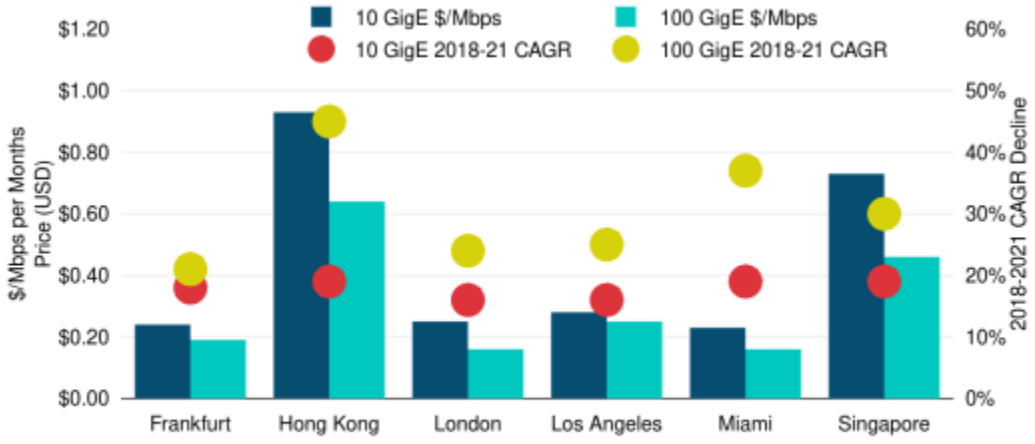
Across a range of markets, 10 GigE prices fell 18% compounded annually from Q2 2018 to Q2 2021. A comparable sample of 100 GigE port prices fell 30% over the same period.

The sharper decline in 100 GigE reflects the advanced maturity of 10 GigE. While 10 GigE remains a relevant increment of IP transit, particularly in more emerging markets, its share of the transaction mix continues to yield to 100 GigE. Most internet backbone operators have 100 GigE deployed, many with multi-100 GigE transactions. Following early speculation that the next increment of port capacity might jump to 1 Tbps, operators are poised to adopt 400 GigE IP transit ports as the next fundamental upgrade from multiple 100 GigE ports.

Customers with the highest traffic commitments receive the best price. IP transit transactions, which are expressed as unit price per Mbps, are lowest for full port allocation. In Q2 2021, the lowest 10 GigE prices on offer were at the brink of $0.09 per Mbps per month. The lowest for 100 GigE were $0.06 per Mbps per month.

FIGURE 4

Weighted Median 10 GigE and 100 GigE IP Transit Prices & Three Year CAGR Decline in Major Global Hub Cities



Notes: Each column represents the weighted median monthly price per Mbps in the listed city. The circle represents the percentage decline of the weighted median price calculated as a three year compound annual growth rate. Prices are in USD and exclude local access and installation fees. 10 Gigabit Ethernet (10 GigE) = 10,000 Mbps and 100 Gigabit Ethernet (100 GigE) = 100,000 Mbps

Source: TeleGeography

Price erosion for 100 GigE ports in the cities above has exceeded that noted for 10 GigE ports significantly, 30% versus 18%, attributed to more carriers offering it and more competition. On average, across the cities noted, the Monthly Recurring Charge (MRC) for a 100 GigE port is just over seven times the MRC for a 10 GigE port.

Provider Connectivity

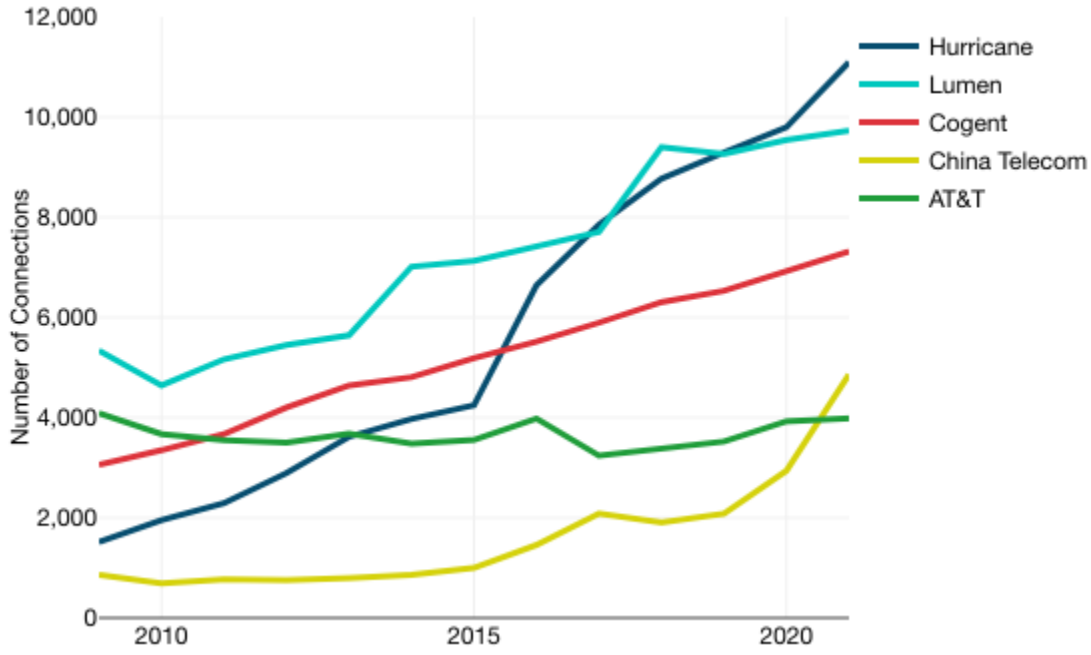
Our rankings of provider connectivity includes analysis based on BGP routing tables, which govern how packets are delivered to their destinations across myriad networks as defined by autonomous system numbers (ASNs). Every network must rely on other networks to reach parts of the internet that it does not itself serve; there is no such thing as a ubiquitous internet backbone provider.

If you want a single, simple number to identify the best-connected provider in the world, you may come away disappointed. There are several ways to measure connectivity, and each highlights different strengths and weaknesses of a provider's presence. One basic metric is to count the number of unique Autonomous Systems (AS) to which a backbone provider connects, while filtering out internal company connections. The results are presented in the table below.

We've seen little change amongst the top providers based on this ranking system. Hurricane Electric and Lumen have swapped the top spot for several years. Hurricane edged out then-Level 3 in 2017 as the best-ranked ISP in terms of overall connections, but the Lumen (at that time CenturyLink) merger with Level 3 moved the combined entity back to the top in 2018. Hurricane Electric maintained its lead in 2021.

FIGURE 5

Number of Connections for Selected Providers



Notes: Data show the number of connections to other ASNs. The line indicating Lumen's number of connections reflect Level 3 (parent ASN 3356) rather than Lumen (formerly parent ASN 209) prior to 2018.

Source: TeleGeography

In addition to examining overall number of connections, we also used our analysis of BGP routing tables to look at the "reach" (a measure of the number of IP addresses an upstream ASN has been given access to from downstream ASNs) and "share" (which compares an upstream provider's reach to all other upstream providers of a downstream ASN.) The results of this analysis paint a different picture. In some cases, an ISP might end up high-ranked in terms of number of connections but low-ranked in terms of share or reach when the number of IP addresses passed from its customers is relatively small.

Finally, to focus on which backbone providers best serve the end-user ISP market and corporations, we compare upstream provider connections to downstream broadband ISPs, calculated the top providers to Fortune 500 companies, and examined connectivity to specific industry sectors such as hosting, medical, and finance.

Outlook

The combined effects of new internet-enabled devices, growing broadband penetration in developing markets, higher broadband access rates, and bandwidth-intensive applications will continue to fuel strong internet traffic growth. While end-user traffic requirements will continue to rise, not all of this demand will translate directly into the need for new long-haul capacity. A variety of factors shape how the global internet will develop in coming years:

- Post-COVID-19 growth trajectory. Initial evidence suggests that the spike in the rate of bandwidth and traffic growth in 2020 from the pandemic was a one-time event and we have largely returned to more traditional rates of growth. Operators we spoke to indicated they no longer see the pandemic leading to upward adjustments to their demand forecasts.

- IP Transit Price Erosion. International transport unit costs underlay IP transit pricing. As new international networks are deployed, operational and construction costs are distributed over more fiber pairs and more active capacity, making each packet less expensive to carry. We already see a major shift from 10 GigE requirements to 100 GigE requirements, and expect that 400 GigE requirements emerge in 2021 and comprise a substantive proportion of the market within three years. The introduction of new international infrastructure also creates opportunities for more regional localization of content and less dependence on distant hubs. As emerging markets grow in scale, they too will benefit from economies of scale, even if only through cheaper transport to internet hubs.

- International versus domestic. While there's little doubt that enhanced end-user access bandwidth and new applications will create large traffic flows, the challenge for operators will be to understand how much of this growth will require the use of international links. In the near-term, the increased reliance on direct connections to content providers and the use of caching will continue to have a localizing effect on traffic patterns and dampen international internet traffic growth.

- Bypassing the public internet. The largest content providers have long operated massive networks, these companies continue to experience more rapid growth than internet backbones and they are expanding into new locations. Many other companies, such as cloud service providers, CDNs, and even some data center operators, are also building their own private backbones that bypass the public internet. As a result, a rising share of international traffic may be carried by these networks.

The content on the preceding pages is a section from TeleGeography's Global Internet Geography

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