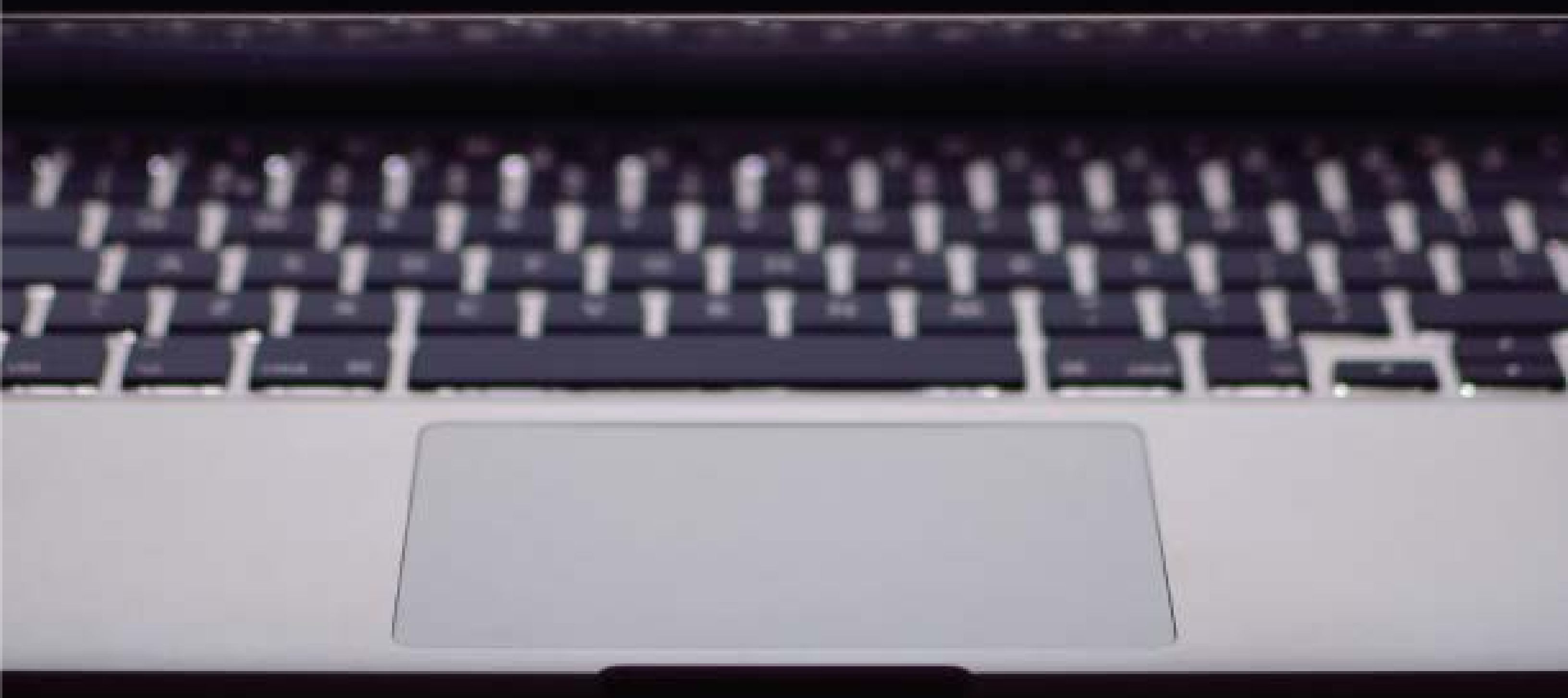
EXECUTIVE SUMMARY

TeleGeography Global Internet Research Service



Executive Summary

The internet continues its return to normal—however one chooses to define this term—in the wake of the COVID-19 pandemic. After a tumultuous 2020, in which the COVID-19 pandemic caused internet traffic patterns to shift and volumes to surge, network operators have 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.

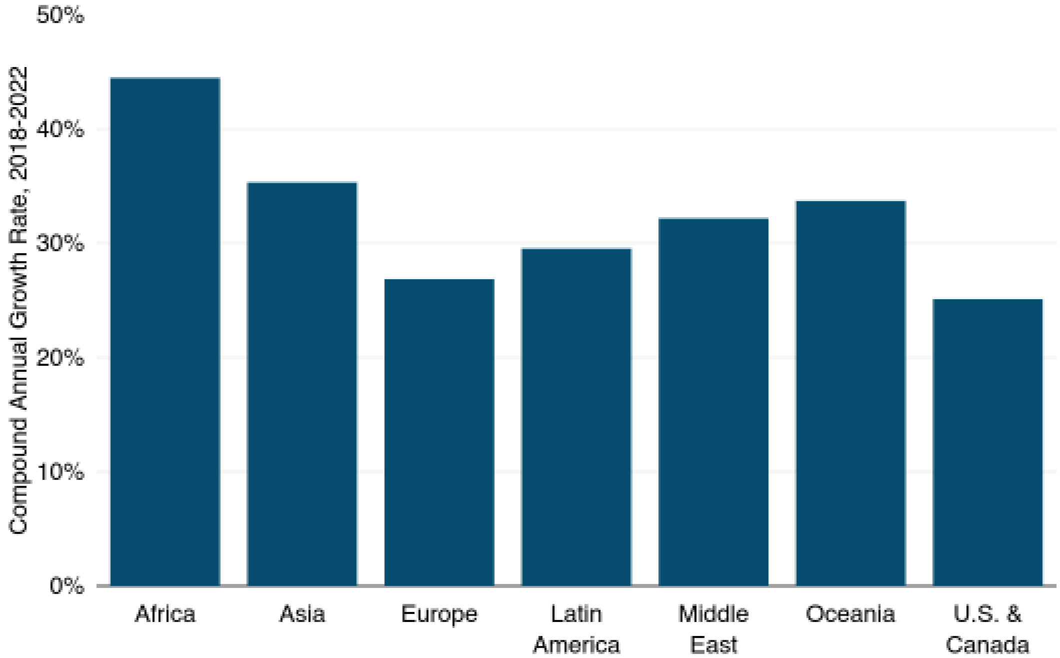
Internet Traffic and Capacity

Global internet bandwidth rose by 28% in 2022, continuing the return to "normal" from the pandemic-generated bump of 2020. Total international bandwidth now stands at 997 Tbps, representing a 4-year CAGR of 29%. COVID bump aside, the pace of growth has been slowing. Still, we do see a near tripling of bandwidth since 2018.

Strong capacity growth is visible across regions. Africa experienced the most rapid growth of international internet bandwidth, growing at a compound annual rate of 44% between 2018 and 2022. Asia sits just behind Africa, rising at a 35% 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 traffic. Both average and peak international internet traffic increased at a compound annual rate of 30% between 2018 and 2022—slightly above the 29% compounded annual growth rate in bandwidth over the same period. All of the stay-at-home activity associated with COVID-19 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 2021-2022. Average traffic growth dropped from 47% between 2019-2020 to 29% between 2021-2022, while peak traffic growth dropped from 46% to 28% over the same time period.

FIGURE 2

Global International Internet Traffic (Gbps)

	2018	2019	2020	2021	2022	Change 2018-19	Change 2019-20	Change 2020-21	Change 2021-22	CAGR 2018-22
Internet Bandwidth	360,418	452,043	605,689	779,007	997,301	25%	34%	29%	28%	29%
Average Traffic	93,149	113,366	166,114	204,469	262,788	22%	47%	23%	29%	30%
Peak Traffic	159,237	190,295	277,286	351,170	449,634	20%	46%	27%	28%	30%
Average Utilization	26%	25%	27%	26%	26%	-3%	9%	-4%	0%	0%
Peak Utilization	44%	42%	46%	45%	45%	-5%	9%	-2%	0%	1%

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 continuing to wane in 2022, many global networks appear to have started to return to more typical rates of utilization. Global average and peak utilization rates were essentially unchanged from the year before at 26% and 45% percent, respectively, in 2022.

FIGURE 3

International Internet Traffic by Region (Gbps)

	2018	2019	2020	2021	2022	Change 2018-19	Change 2019-20	Change 2020-21	Change 2021-22	CAGR 2018-22
Africa										
Internet Bandwidth	8,527	12,227	18,342	26,263	37,161	43%	50%	43%	41%	44%
Average Traffic	3,339	4,610	6,900	9,212	13,665	38%	50%	34%	48%	42%
Peak Traffic	5,412	7,577	11,386	16,123	22,539	40%	50%	42%	40%	43%
Average Utilization	39%	38%	38%	35%	37%	-4%	-0%	-7%	5%	-2%
Peak Utilization	63%	62%	62%	61%	61%	-2%	0%	-1%	-1%	-1%
Asia										
Internet Bandwidth	76,950	102,977	143,758	192,515	258,046	34%	40%	34%	34%	35%
Average Traffic	26,134	32,621	49,169	66,383	89,432	25%	51%	35%	35%	36%
Peak Traffic	41,630	51,536	77,078	105,066	137,709	24%	50%	36%	31%	35%
Average Utilization	34%	32%	34%	34%	35%	-7%	8%	1%	1%	1%
Peak Utilization	54%	50%	54%	55%	53%	-7%	7%	2%	-2%	-0%
Europe										
Internet Bandwidth	241,611	295,424	391,044	497,890	625,593	22%	32%	27%	26%	27%
Average Traffic	59,222	72,112	103,118	122,268	152,841	22%	43%	19%	25%	27%
Peak Traffic	100,690	119,173	170,868	206,915	259,930	18%	43%	21%	26%	27%
Average Utilization	25%	24%	26%	25%	24%	-0%	8%	-7%	-1%	-0%
Peak Utilization	42%	40%	44%	42%	42%	-3%	8%	-5%	-0%	-0%
Latin America										
Internet Bandwidth	41,244	53,758	71,032	90,488	116,090	30%	32%	27%	28%	30%
Average Traffic	8,378	10,108	15,968	19,927	24,538	21%	58%	25%	23%	31%
Peak Traffic	18,262	22,044	33,024	43,725	56,471	21%	50%	32%	29%	33%
Average Utilization	20%	19%	22%	22%	21%	-7%	20%	-2%	-4%	1%
Peak Utilization	44%	41%	46%	48%	49%	-7%	13%	4%	1%	2%
Middle East										
Internet Bandwidth	24,612	31,695	43,582	56,539	75,113	29%	38%	30%	33%	32%
Average Traffic	8,853	11,099	15,550	19,863	25,257	25%	40%	28%	27%	30%
Peak Traffic	13,660	17,085	23,977	31,142	39,891	25%	40%	30%	28%	31%
Average Utilization	36%	35%	36%	35%	34%	-3%	2%	-2%	-4%	-2%
Peak Utilization	56%	54%	55%	55%	53%	-3%	2%	0%	-4%	-1%
Oceania										
Internet Bandwidth	3,862	5,572	7,386	9,373	12,343	44%	33%	27%	32%	34%
Average Traffic	1,366	1,655	2,126	2,721	3,570	21%	28%	28%	31%	27%
Peak Traffic	2,053	2,658	3,407	4,318	5,890	29%	28%	27%	36%	30%
Average Utilization	35%	30%	29%	29%	29%	-16%	-3%	1%	-0%	-5%
Peak Utilization	53%	48%	46%	46%	48%	-10%	-3%	-0%	4%	-3%
U.S. & Canada										
Internet Bandwidth	82,326	101,585	129,274	160,672	201,624	23%	27%	24%	25%	25%
Average Traffic	21,720	25,362	36,542	43,227	54,758	17%	44%	18%	27%	26%
Peak Traffic	40,005	46,343	65,051	79,426	100,812	16%	40%	22%	27%	26%
Average Utilization	26%	25%	28%	27%	27%	-5%	13%	-5%	1%	1%
Peak Utilization	49%	46%	50%	49%	50%	-6%	10%	-2%	1%	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

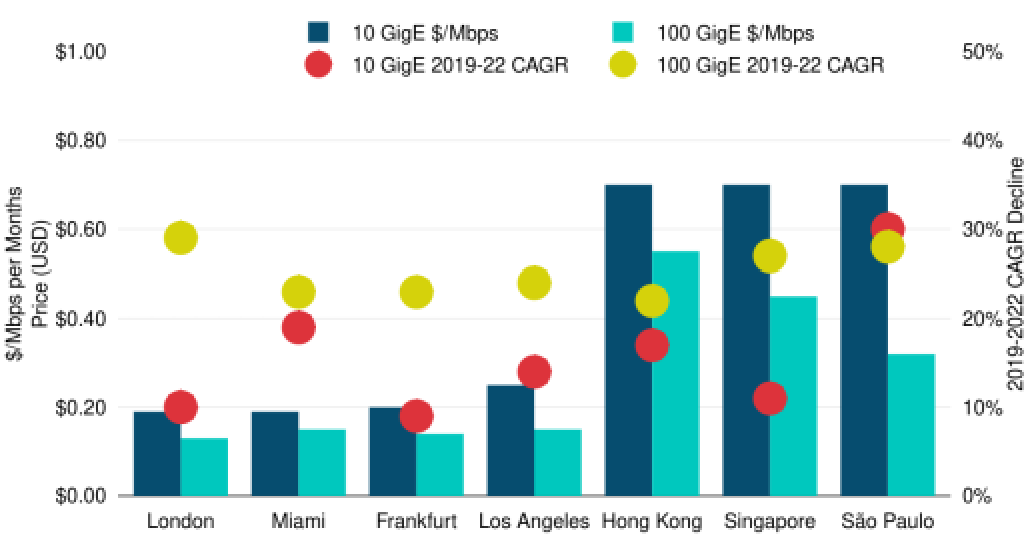
Providers' shift to predominantly 100 Gbps internet backbones continues to reduce the average cost of carrying traffic and enables profitability at lower prices. As a result, price erosion remains the universal norm. It reflects the introduction of competition into new markets and the response of more expensive carriers to lower prices. Trends in the IP transit market generally follow regional trends of the transport market. And while some have suggested that price erosion may slow as a result of recent inflation and supply chain constraints (as it has in the wavelength market), we have not seen this trend make its way into the IP transit market.

Across the cities included in the figure below, 10 GigE prices fell 16% compounded annually from Q2 2019 to Q2 2022. Over the same period 100 GigE port prices fell 25%. In Q2 2022, 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.

The sharper decline in 100 GigE reflects the advanced maturity of 10 GigE, as well as more carriers offering it and more competition. 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. In 2022, providers indicated that a majority of their sales mix in key U.S. and European hubs was now 100 GigE. On average, across the cities noted, the Monthly Recurring Charge (MRC) for a 100 GigE port was 6.7 times the MRC for a 10 GigE port. Operators are poised to adopt 400 GigE IP transit ports as the next fundamental upgrade from multiple 100 GigE ports.

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

Provider Connectivity

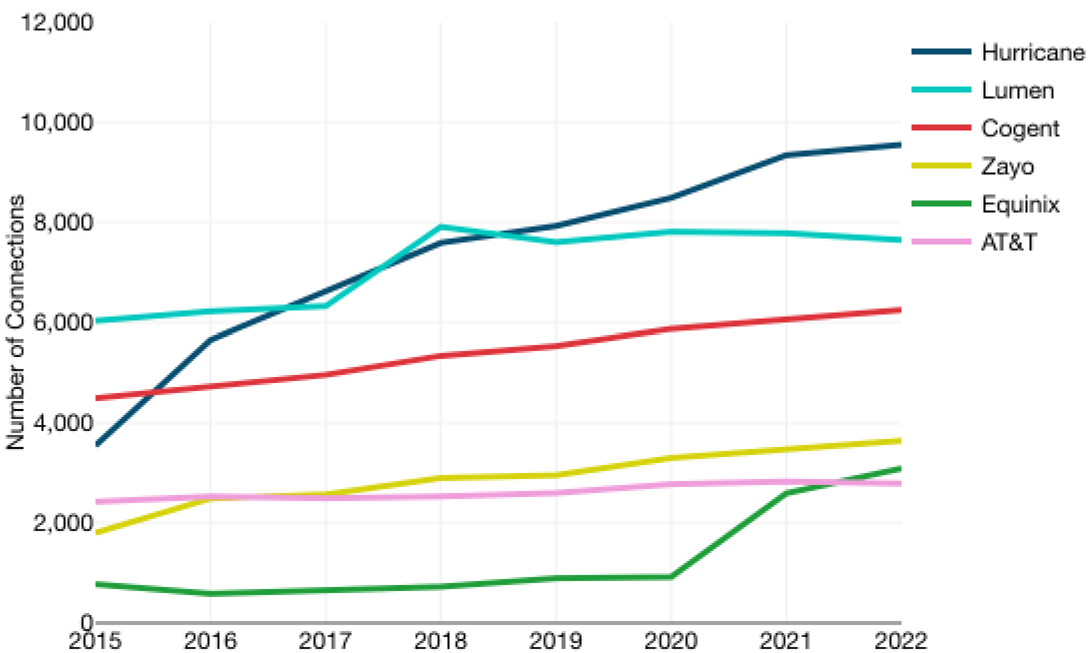
Our rankings of provider connectivity includes analysis based on BGP routing tables, which govern how packets are delivered to their destinations across myriad networks as defined by autonomous system numbers (ASNs). Every network must rely on other networks to reach parts of the internet that it does 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.

Hurricane Electric has experienced consistent gains, and now ranks as the clear number one in terms of connections. Cogent has also experienced steady growth. Some members of the internet old guard, such as AT&T, have begun to slump in the rankings. Data center operator Equinix has now exceeded AT&T's number of observable AS connections, for the first time ever.

FIGURE 5

Number of Connections for Selected Providers



Notes: Data shows 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 will emerge in two to three years as a significant part of the market. 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.

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