TeleGeography

The State of the Network

2020 EDITION

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INTRODUCTION

It's officially 2020 and we have new data to show us how the world is connecting.

With our third *State of the Network* report, we reflect on an industry marked by evolving challenges and a special brand of unpredictability. The global bandwidth market is navigating price erosion and the limits of cable capacity. International call traffic has continued to decline across the voice market, with falling carrier traffic becoming a fact of life. Internet bandwidth and traffic growth has gradually slowed in recent years, but remains brisk.

This is the environment in which we take our annual snapshot.

That's right—as we say every year—this annual reflection is simply a snapshot of the telecom market right now. The challenges, the trends, the regional stories, the shifting profile of cable owners—this is where we start in 2020.

As always, this analysis is created by TeleGeography data. It was collected throughout 2019 and you can find even more of it within our full suite of research apps.

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GLOBAL WHOLESALE BANDWIDTH MARKET

The global bandwidth market is marked by change and uncertainty. New network builders shape changes in traffic flows, operators race to keep revenue margins ahead of constantly eroding prices, and the industry now faces the very limits of cable capacity as we know it. Our *Global Bandwidth Research Service* assesses the state of the global telecom transport network industry and evaluates the factors that shape long-term demand growth and price erosion.

Demand Trends

If demand is the key factor in assessing the health of the global bandwidth market, then the market is thriving. Between 2016 and 2018 international bandwidth used by global networks more than doubled to reach 963 Tbps.

Let's break this demand growth down to a more granular level. If we look at used international bandwidth growth by region, two observations jump out. The first is that demand growth has been strongest on links connected to Asia, which experienced a compound annual growth rate of 53% between 2014 and 2018. The second is that growth in the most developed markets in the world—Europe and North America—wasn't far behind. While mature markets typically grow slower than developing markets, that's not the case here.

The Role of Content

Who's driving all this demand growth for international capacity? Historically, it's been carrier networks, provisioning public internet services. More recently a handful of major content and cloud service providers—namely Google, Facebook, Amazon, and Microsoft—have become the primary sources of demand. In 2018 these companies became the dominant users of international bandwidth, accounting for 55% of all used international capacity.

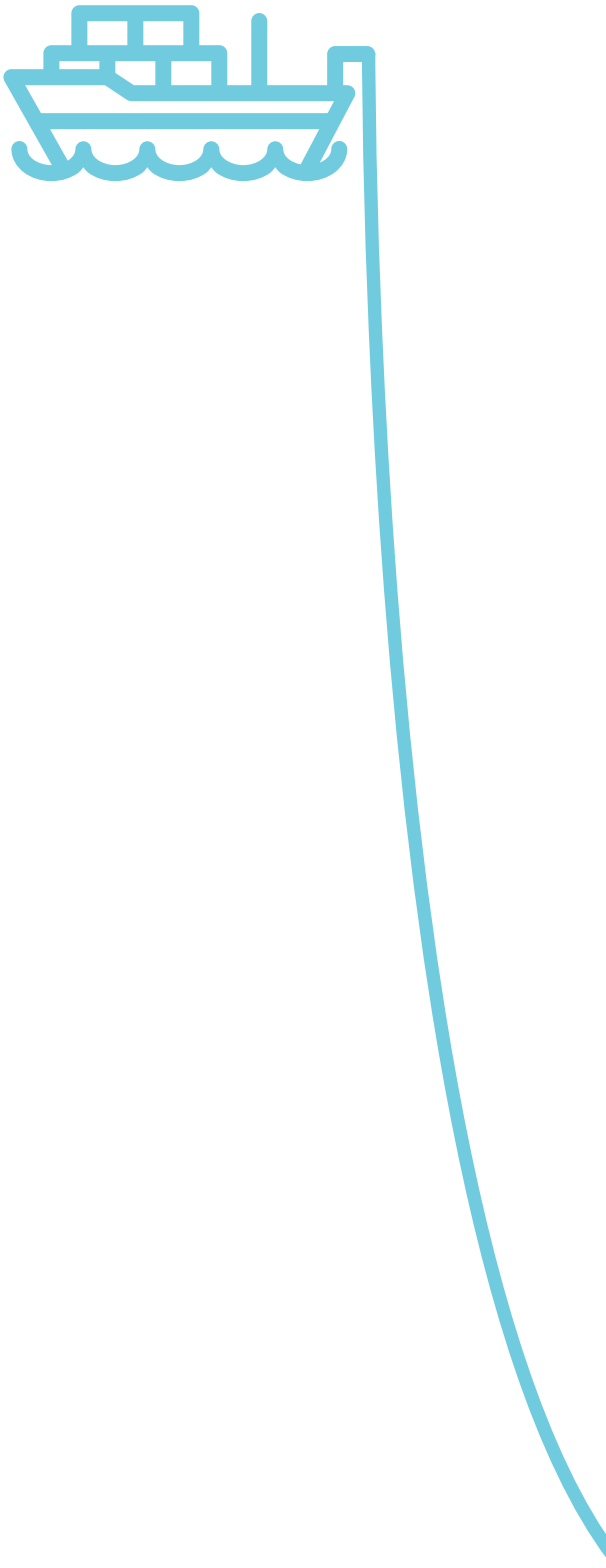
But their capacity requirements vary extensively by route. Content providers concentrate network planning on linking their data centers and major interconnection points. As such, they often take tremendous capacity on core routes, while focusing much less on secondary long-haul routes than traditional carriers. To get a sense of this contrast, note that in 2018, content providers accounted for 85% of used capacity on the trans-Atlantic route but just 5% on the Europe-Middle East & Egypt route.

While the share of content provider capacity on some routes may be much lower than on others, the growth in their demand across all routes has been relentless. Across all world regions, content providers added capacity at a compound annual rate of at least 65% between 2014 and 2018, compared to a rate no higher than 43% for others.

Meeting Demand Requirements

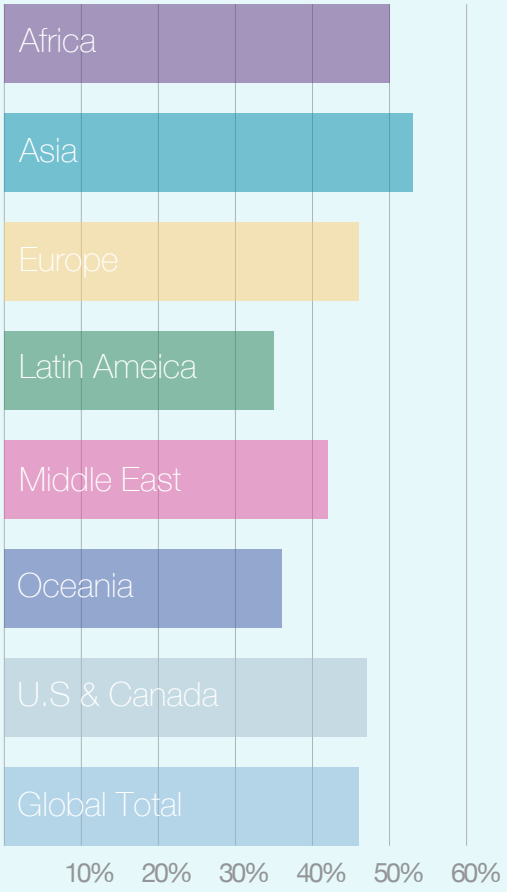
Demand for international bandwidth is more than doubling every two years. To meet this demand, companies are investing in existing networks and in new infrastructure.

The lit capacity on major submarine cable routes continues to soar, keeping pace with demand. Between 2014 and 2018 lit capacity more than tripled on many routes. The pace of growth was the most rapid on Europe-Sub-Saharan African routes, where lit capacity increased over five-fold between 2014 and 2018.



Used International Bandwidth Growth

By Region, 2014-2018



Aside from lighting new capacity, new systems are coming online across all routes. The year 2016 ushered in a period of significant global investment in the sector. Cables with a combined construction cost of $7.9 billion entered service between 2016 and 2018. Based on publicly announced planned cables, an additional $6.9 billion worth of new cables will be launched between 2019 and 2021. Notably, every major subsea route saw new cables deployed between 2016 and 2018, and investment is poised to continue across all routes. The trans-Pacific route leads the way with $2 billion of new cable investment expected from 2019 to 2021.

Pricing

Abundant supply and increasing competition have led to robust price erosion throughout the global bandwidth market. New 100 Gbps equipped submarine cable systems and upgrades to existing networks have further lowered unit costs. And this has driven down both 10 Gbps and 100 Gbps wavelength prices. Across critical global routes, weighted median 10 Gbps and 100 Gbps prices fell an average of 27% and 24% compounded annually since 2015.

Yes, bandwidth price declines are widespread. But significant differences in price still exist depending on your destination. In Q4 2018, 10 Gbps monthly lease prices ranged from just $795 on the Frankfurt-London route to $22,766 between Los Angeles and Sydney. This is largely a reflection of differences in available supply and competition—on both international and domestic segments.

Although differences remain, prices are converging in general. Price declines on high growth and underserved routes are outpacing those in established markets. And new cable systems and technological advancements have narrowed the unit cost of capacity.

With falling prices, the incentive to buy larger versus smaller circuits increases. In Q4 2018, the average multiple of 100 Gbps over 10 Gbps service among key routes was 5, down from 6.4 in 2015. Individual route multiples ranged from 4.2 on the shorter connection between London and New York to 5.8 on the route between Miami and São Paulo. Capacity multiples for 100 Gbps tend to be lower when sellers compete aggressively for 100 Gbps business but not for 10 Gbps. That is, a low 100 Gbps to 10 Gbps multiple can arise both from a relatively low 100 Gbps price or a high 10 Gbps price.

Outlook

What does the future hold for the global bandwidth market? The two most predictable trends are persistent demand growth and price erosion. Beyond that, operators will have to navigate major uncertainties in continuing to move forward in an evolving sector. Here are a few of the key trends, among many, that will affect the long-haul capacity market beyond 2020.

Expanding Frontiers by a Limited Group

Content providers' cable investments have largely focused on trans-Atlantic, trans-Pacific, U.S.-Latin American, and intra-Asian routes. As their demand for capacity continues to grow across all routes, other paths are likely to draw content provider-backed cable construction in the near future. In particular, India-Singapore, India-Europe, and Europe-Africa may attract content provider interest in new systems.

Content provider demand dominates the development of certain routes; will new content providers follow suit? Our assessment is that a very limited group of players will continue to dominate content and cloud network demand. It seems unlikely that many more such networks, even the Chinese content providers, will reach sufficient demand volumes in the near-term to warrant their emergence as full-fledged owners of subsea cables.

Rising Utilization

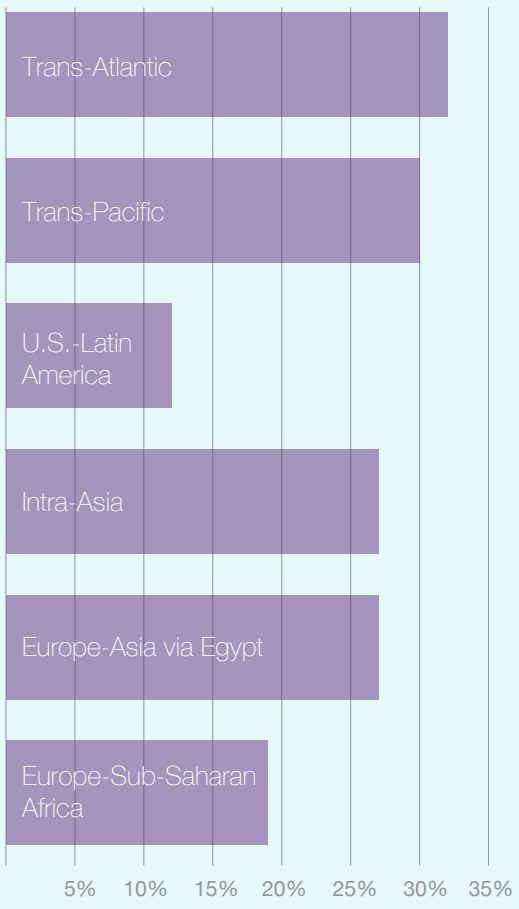
Even with the introduction of many new cables and the ability of older cables to accommodate more capacity, the growth of potential capacity has failed to outpace that of lit capacity. This means that the percentage of capacity that is lit on major routes has begun to rise. The one exception is the U.S.-Latin America route, where the recent launches of the three high-capacity cables has caused lit capacity to decline as a share of total potential capacity.

Looming Cable Retirements

Cables are engineered to have a minimum design life of 25 years, but what really matters is the economic life. The economic life depends on a cable's revenue exceeding the costs. If the costs of operating a cable continually exceed the revenues, an operator may

Percentage of Potential Capacity Lit on Major Routes

2018



Notably, every major subsea route saw new cables deployed between 2016 and 2018, and investment is poised to continue across all routes. The trans-Pacific route leads the way with $2 billion of new cable investment expected from 2019 to 2021.

consider retiring the cable. This could happen well before a cable runs of out capacity. Many older cables laid in the late 1990s and early 2000s may soon become candidates for retirement.

Addressing the Shannon Limit

In moving beyond 100 Gbps wavelengths, the industry faces a major challenge in that it will reach the very edge of the Shannon Limit—the theoretical channel capacity limit given a specified channel bandwidth and signal-to-noise ratio (SNR).

So how is the industry tackling this problem? It's taking a multi-pronged approach.

A few of the major strategies include increasing the number of fiber pairs, introducing multi-core fiber, and continuing to introduce more powerful processors.

One interim technique to add more capacity on transoceanic systems in the short term will be to implement spatial division multiplexing (SDM), which lowers the total output power per fiber pair and uses less power-intensive modulation to enable the addition of extra fiber pairs. Current transoceanic systems generally deploy six to eight fiber pairs, but Dunant, which is slated to launch in 2020, will have 12. Future systems could have even more.

As a long-term growth strategy, adding fiber pairs has limitations. The general consensus in the industry is that once systems reach somewhere between 24 and 32 fiber pairs, mechanical complications will increase to the point where the trend is unsustainable.

Wholesale Market Challenges

The rapid expansion of major content providers' networks has caused a shift in the global wholesale market. Google, Microsoft, Facebook, and Amazon are investing in new submarine cable systems and purchasing fiber pairs. Although this removes large swaths of bandwidth from the managed wholesale bandwidth market, it also drives scale to establish new submarine cable systems and lower overall unit costs.

Many submarine cable business models actually rely on this capital injection, allocating fiber and network shares to the largest consumers to cover initial investment costs, then selling remaining shares of system capacity as managed wholesale bandwidth.

Unit cost savings of large investments are a great investment incentive for operators, but they don't want to be left with too much excess bandwidth. It's often a race to offload wholesale capacity before a new generation of lower-cost supply emerges. Carriers most likely to succeed are those with massive internal demand and less dependence on wholesale market revenues.

Both content and telco network operators are reckoning with massive bandwidth demand growth, driven by new applications and greater penetration into emerging markets. The sheer growth in supply will drive lower unit costs for bandwidth. In the face of unrelenting price erosion, the challenge for wholesale operators is to carve out profitable niches where demand trumps competition.

ALL THINGS INTERNET

Our Global Internet Geography Research Service provides analysis and data on internet capacity and traffic, IP transit pricing, and backbone operators. The trends we've observed in recent years have largely continued. International internet bandwidth and traffic growth has gradually slowed in recent years, but remains brisk. IP transit price declines continue globally, but significant regional differences in prices remain.

Internet Traffic and Capacity

Global internet bandwidth rose last year by "only" 26%—the lowest annual growth rate seen in at least 15 years—and at a compound annual rate of 28% between 2015 and 2019. Total international bandwidth now stands at 466 Tbps. The pace of growth is slowing, but it still represent a near tripling of bandwidth since 2015.

The pace of new international internet capacity deployments varied by region. Africa experienced the most rapid growth of international internet bandwidth, growing at a compound annual rate of 45% between 2015 and 2019. Asia was just behind Africa, rising at a 42% compound annual rate during the same period.

Since we began tracking international internet capacity in 1999, the highest-capacity inter-regional route had always been Europe-United States & Canada. This route has been eclipsed by the Latin America-U.S. & Canada route, which has seen an explosion in bandwidth. Capacity on this route first exceeded that on the Europe route in 2013. Six years later, this route has more than double the capacity of the Europe-U.S. & Canada route. In 2019, operators turned up an additional 9.5 Tbps of bandwidth, a 27% increase from the year before, to reach nearly 43 Tbps of bandwidth.

Why such a dramatic shift?

First, Latin America's international internet bandwidth is almost completely connected to the U.S. & Canada, whereas Asia and Europe have a greater diversity of connectivity. Second, large content providers have deployed massive trans-Atlantic and trans-Pacific links, which appears to have dampened the growth of internet capacity on these routes. By contrast, these content providers have only recently begun sticking their toes in the water in Latin America.

Prices

While IP transit prices vary across the globe, they all decline. Some of the highest rates of price erosion occurred in markets with the greatest competition and the largest amount of international internet traffic exchange—namely, global hubs.

- In Europe, London is a primary destination for regional traffic, as well as internet bandwidth from sub-Saharan Africa and the Middle East. Prices in the British capital dropped at an astonishing rate of 36%.

- The price for a 10 GigE port in Miami fell at a rate of 33%. Miami is a global hub in its own right, host to traffic exchange from Latin America.

- In East Asia, Singapore has emerged as a hub for intra-regional traffic exchange. Even with a 31% rate of price erosion, ports in Singapore remain more expensive than in Western Europe and major U.S. destinations. For example, a 10 GigE port in Singapore is about 3.8 times the price in London.

10 Highest Capacity International Internet Hub Cities

Domestic routes omitted, 2019

Frankfurt, Germany
Bandwidth: 86.2 Tbps

London, U.K.
Bandwidth: 61.8 Tbps

Amsterdam, Netherlands
Bandwidth: 55.6 Tbps

Paris, France
Bandwidth: 54.5 Tbps

Singapore, Singapore
Bandwidth: 37.0 Tbps

Hong Kong, China
Bandwidth: 25.3 Tbps

Miami, U.S.
Bandwidth: 25.1 Tbps

Stockholm, Sweden
Bandwidth: 23.2 Tbps

Marseille, France
Bandwidth: 21.9 Tbps

New York, U.S.
Bandwidth: 21.3 Tbps

- The price for a 10 GigE port in Johannesburg dropped 32%. This largely reflects falling transport prices linking South Africa to Europe, especially on the WACS cable.
- The price for a 10 GigE port in São Paulo fell 27% to reach $2 per Mbps. After the launch of three new cables connecting Brazil to the United States (Seabras-1, Monet, and BRUSA), it's no wonder transport prices dropped.

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.

We've seen little change amongst the top providers based on this ranking system. Hurricane Electric and CenturyLink 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 CenturyLink merger with Level 3 moved the combined entity back to the top in 2018. The two companies are now locked in a virtual tie.

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 with a high ranking in terms of number of connections, but a low one in terms of share or reach when the number of IP addresses passed from its customers is relatively small.

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:

- **IP Transit Price Erosion**. It's not a bold prediction that IP transit prices will continue to fall globally, as they always have. The rate of decline will be greatest in emerging markets. In these markets, high prices have greater potential to fall due to increases in volume and local traffic exchange that improve economy of scale. In established global hubs, prices will also fall, largely a result of escalating volume and declining unit cost.

- **CDNs and Caching**. While the increase in broadband users and access rates will continue to drive traffic growth in access networks, much of this growth may be managed locally within a network and may not lead to proportional increases in traffic on international links. Thus, CDNs and caching will continue to have a localizing effect on traffic patterns and dampen international internet traffic growth.

- **Content Providers**. Beyond the impacts of CDNs and caching, the largest content providers' private networks are having a major impact on the growth of internet capacity requirements. As the content providers extend their networks into new locations, the traditional backbone operators are adjusting the networks in response. In some cases, backbone operators may reduce capacity on some routes or shift capacity to new locations.

While IP transit prices vary across the globe, they all decline. Some of the highest rates of price erosion occurred in markets with the greatest competition and the largest amount of international internet traffic exchange—namely, global hubs.

DATA ON DATA CENTERS

More workplaces worldwide are moving to the cloud. That means that the demand for global interconnection infrastructure is increasingly diffuse.

All that to say: it's an exciting time to examine the colocation market. This chapter uses information from our Data Center Research Service to provide an overview of the data center space.

Metro Capacity

As of 2019, Tokyo is still the world's largest retail colocation market, with 10 million square feet of gross capacity. Arguably a far more dynamic global market, Washington has moved into the second position and is closely followed by London, which is nearly tied with Tokyo as the market with the most retail data center sites.

A number of sizable regional markets have cropped up around the globe in recent years. Madrid, Moscow, and Stockholm in Europe; Atlanta, Boston, and Montreal in North America; and Osaka and Mumbai in Asia have become critical secondary markets with around 1 to 2 million square feet of retail space.

Only a fraction of total data center space is used for customer server equipment. Proportions of fitted colocation space vary by market

and operator and average 56% of gross capacity. In Dallas, only an estimated 46% of gross colocation space is actual colocation server capacity, while 70% of gross space in Tokyo is fitted for colocation clients.

Market Growth

Between 2015 and 2019, the median compound annual growth rate in retail colocation capacity among the 55 markets highlighted in the study was a modest 8%. Major hubs outpacing the median growth rate include Amsterdam and Washington, each with at least 15% compound annual growth.

On the other end of the spectrum, Tokyo, New York, and Los Angeles have experienced slower growth, between 2% and 6% compounded annually.

Vacancy

Among the metros with sufficient reporting samples, Sydney, London, and Dallas have relatively high space availability between 40% and 50%. In each of these metros, a few large sites and numerous smaller sites combine to report relatively high aggregate vacancy levels. On the opposite end of the spectrum, respondents indicate that fitted colocation capacity in Johannesburg and Taipei is largely filled.

Providers

Equinix has soared past the NTT Group in the past three years to reclaim the title of world's largest retail colocation provider. After a 30% surge in capacity growth in 2017 following its asset purchase from Verizon, Equinix grew another 40% over the next two years to surpass 22 million square feet of capacity.

When considering the number of operational sites, NTT edges out Equinix with 220 sites. In comparing both gross capacity and number of sites, Equinix and NTT dwarf all other retail colocation providers in scale.

Digital Realty remains the largest operator in the wholesale data center market, but several other operators have aggressively expanded. CyrusOne has increased its gross capacity by 40% over the past year

Largest Wholesale Providers by Gross Floor Space

2019

1. Digital Realty
23,771,964 sq ft

2. STT GDC
9,612,156 sq ft

3. CyrusOne
7,579,670 sq ft

4. Quality Technology Services (QTS)
6,711,069 sq ft

5. Global Switch
4,789,602 sq ft

6. PointOne
3,160,000 sq ft

7. Iron Mountain
2,658,000 sq ft

8. H5 Data Centers
2,111,000 sq ft

9. Sabey Data Centers
2,093,890 sq ft

10. Keppel Data Centres
1,750,739 sq ft

11. SINNET
1,744,236 sq ft

12. Vantage Data Centers
1,579,500 sq ft

13. SUNeVision
1,480,000 sq ft

14. Stack Infrastructure
1,466,000 sq ft

15. Netrality
1,301,981 sq ft

to reach 7.6 million square feet, and it has at least 10% further growth in the immediate pipeline. The STT Group of companies will soon breach 10 million gross square feet of capacity.

Among the operators tracked in our database, at least 90 data center sites are known to be in the pipeline right now. This construction will be quite evenly spread across global regions, with North America edging out EMEA for the biggest percentage of new deployments.

Data center operators are investing both in edge and core markets for future development. Retail colocation providers are doubling down on new metro area deployments in Washington, Amsterdam, and Singapore, but smaller markets like Helsinki and Mumbai are well-represented too. Planned wholesale construction spans the gamut from the largest markets like Washington and Frankfurt to relatively nascent Brazilian locations.

Proprietary Data Centers

Among the proprietary data center operators tracked in the Data Center Research Service, all are rapidly expanding into new markets. Collectively, Facebook, Microsoft, Google, and Amazon have deployed 15 new data centers globally (many of which come in the form of cloud service availability zones) in the last year alone. Their growth is expected to accelerate over the near term with at least 21 more proprietary sites and cloud region deployments in the immediate pipeline.

Facebook currently operates nine proprietary data center campuses with 9.1 million square feet of operational capacity and room for further growth. That's up more than 80% from their reported operational capacity just one year ago. In the pipeline, the company is planning six further campuses with more than 6 million square feet of capacity in the initial phases alone.

Power

As of 2019, an overwhelming majority of respondents, nearly 80%, indicate that their site density levels exceed 100 watts per square foot (W/sq ft). At the highest levels we track, only about 22% of operators currently provision site density levels exceeding 200 W/sq ft. That proportion isn't dramatically higher than it was even five years ago, when the response rate was about 17%.

Around 65% of operators support only density levels of up to 10 kilowatts per rack (kW/rack). The share of sites offering the highest density levels exceeding 20 kW/rack is nearly 13%.

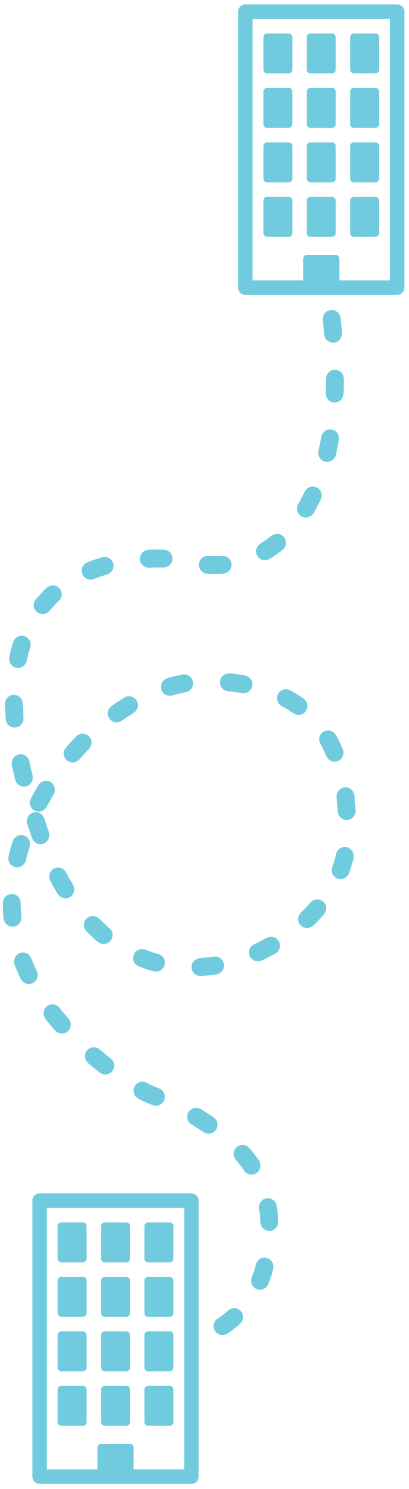
The average site density levels in Washington, Dallas, and Amsterdam all exceed 200 W/sqft. This puts their average density levels into the very highest range that we track. Dallas also has an above-average rack density level of 13 kW/rack. On the other end of the spectrum, Hong Kong has relatively low density provisioning for a major market at around 140 W/sqft and 5 kW/rack.

As of 2019, our survey indicates that most sites don't operate at a very low PUE level. A significant minority of sites (38%) operate below 1.5, but that percentage hasn't shifted over the past two years.

Connectivity

As in the previous year, 2019 respondents indicated that CenturyLink, Verizon, and Zayo are the most prominent carriers in their facilities. These three operators are especially widespread in North America. AT&T and Cogent are also common in North American facilities, while Colt, GTT, and BT are heavily represented in European data centers. Telstra, China Telecom, China Unicom, Tata, and NTT are among the most ubiquitous carriers across Asian sites.

By our estimates, Equinix FR5—the former Ancotel site at Kleyerstraße 90 in Frankfurt—is the most carrier-dense colocation site in the world. Critical facilities run by TELEHOUSE in London and CoreSite in Los Angeles are also among the most connected sites globally.



Individual Pricing Components

As of H2 2019, the European median price per kilowatt for a 4-kilowatt colocation cabinet is about 22% higher than the North American rate. And as of H2 2019, we're also able to include an assessment of Asian colocation rates, due to a growing sample of markets in that region. The current average price per kilowatt there is nearly identical to that of Europe.

Hub metros from Asia continue to top the list of most expensive colocation markets, but six major markets in the analysis—representing three global regions—all have median colocation rates of around $400 per kilowatt or more.

Reported per-kilowatt rates for high-density cabinets (cabinets with 10-kilowatt density) are an average of just 4% lower than those for standard 4-kilowatt cabinets, although relative premiums or discounts vary extensively. Among 27 markets reporting high-density prices, all of the Asian markets indicated the same or higher costs for high-density colocation, while nearly all North American and European markets indicated price discounts per kilowatt for high-density cabinets.

Large-scale retail colocation leases (100 kilowatts) are consistently discounted relative to single 4-kilowatt cabinet leases. Discounted rates are on average 10% lower than per-kilowatt rates for single cabinets.

Average monthly fiber cross-connect fees fell below $300 in North America in H1 2017 and have generally moved between $250 and $265 since then. European rates have always been drastically lower, but are creeping upward, now averaging more than $100 per cross-connect. As a result, the price multiple for a North American fiber cross-connect relative to one in Europe is at its lowest that we've seen on record, at just 2.3. In Asia, cross-connect rates fall directly between the European and North American averages.

Historically, operators in North America have charged more for fiber cross-connects than for Ethernet, whereas European operators typically charged more for Ethernet cross-connects. Now, most European operators have largely swung in the direction of discounting Ethernet cross-connect fees relative to the cost of fiber cross-connects, with the exceptions of those in Frankfurt and Amsterdam.

Cost Expectations

Current expectations are mixed across all metro areas with sufficient data to report. Of note, operators in Tokyo and Singapore are divided as to whether prices will remain flat or rise significantly, while those in Frankfurt and London are torn between stable expectations and bracing for a fall in rates.

Regional trends persist, but they only tell part of the story.

Each market contains operators that report significant variance in base rates and cross-connect prices. So in any of these locations, relative deals can be found. But in order to access the most carrier-dense and highly-sought ecosystems, customers can expect to pay a premium, regardless of the geographical location.

Data center operators are investing both in edge and core markets for future development. Retail colocation providers are doubling down on new metro area deployments in Washington, Amsterdam, and Singapore, but smaller markets like Helsinki and Mumbai are well-represented too.

MISHAPS IN THE VOICE MARKET

The international voice market doesn't bring a lot of joy these days.

2015 marked a turning point in the international voice market—the first time since the Great Depression that international call traffic declined, even if only by one half percent. It's been downhill ever since, as the slump in voice traffic has turned into a fact of life. Carriers' traffic fell a further 9% in 2017 and 4% in 2018, to a total of 465 billion minutes.

The OTT Effect

A new market dynamic—social calling that replaced business communications as the primary driver of ILD usage—fueled a long era of international call traffic growth that began in the 1990s. In 1990, U.S. international call prices averaged over one dollar per minute(!) and business users accounted for 67% of ILD revenue. A wave of market liberalization in the subsequent decade brought new market entrants, causing prices to tumble, and making international calling ever more affordable to consumers. In the early 2000s, the introduction of low-cost prepaid phones made it possible for billions of people in developing countries to obtain their own telephones, and to keep in touch with friends and family abroad easily. Call volumes soared, and by 2015, calls to mobile phones in developing countries accounted

for 65% of global ILD traffic.
The transition to mobile and social calling drove a 20-year boom in voice traffic, but it has also left the industry uniquely vulnerable to the rise of mobile social media. While Skype was the dominant communications application for computers, a veritable menagerie of smartphone-based communications applications, such as WhatsApp, Facebook Messenger, WeChat (Weixin), Viber, Line, KakaoTalk, and Apple's FaceTime, now pose a greater threat. Both WhatsApp and Facebook Messenger topped 1.3 billion monthly active users in 2019, and WeChat is not far behind, with just over an estimated 1 billion active users in September 2019. TeleGeography estimates that just seven communications apps—WhatsApp, Facebook Messenger, WeChat, QQ, Viber, Line, and KakaoTalk—combined for over 5 billion monthly users in September 2019. These estimates exclude apps for which directly comparable data is unavailable, including Apple's FaceTime, Google Hangouts, and Skype (the latter two of which have over 1 billion downloads from Google's App Store).

It's hard to pin precise numbers on the volume of international OTT communications. However, a simple thought experiment helps to illuminate its likely scale. Between 1983 and 2007, international phone traffic grew at a compounded annual growth rate (CAGR) of 15%, and traffic grew an even faster 21% CAGR between 1927 and 1983. It's hard to believe then that the recent decline in traffic means that people have lost interest in communicating with friends and family abroad. Rather, it suggests that they are turning to other means of keeping in touch.

TeleGeography has fairly reliable estimates of Skype's traffic through 2013, when the company carried 214 billion minutes of on-net (Skype-to-Skype) international traffic. Telcos terminated 547 billion minutes of international traffic in 2013, and OTT plus carrier traffic totaled 761 billion minutes. If we assume that total international (carrier plus OTT) traffic has continued to grow at a relatively modest 13% annually since 2013 (with a drop to 9% in 2018 due to texting, video, and email), the combined volume of carrier and OTT international traffic would have expanded to 1.35 trillion minutes in 2018, and to 1.47 trillion minutes in 2019. This calculation suggests that cross-border OTT traffic overtook international carrier traffic in 2016, and would top 1 trillion minutes in 2019, far exceeding the 432 billion minutes of carrier traffic projected by TeleGeography.

International Wholesale Services

Many retail service providers, such as mobile operators, MVNOs, and cable broadband providers, rely heavily on wholesale carriers to transport and terminate their customers' international calls. Wholesale carriers terminated approximately 327 billion minutes of traffic in 2018, down 3% from 2017. While wholesale traffic declined in 2018, over the last 10 years it has seen a compounded annual growth rate of 3%. Consequently, the ratio of international traffic terminated by wholesale carriers increased from 59% in 2008 to 72% in 2018. Traffic to mobile phones in emerging markets has historically spurred expansion of the wholesale market, and that demand continues to drive wholesale's relative growth. In 2018 wholesale carriers terminated 86% of traffic to Sub-Saharan Africa, Central Asia, and South America, but only 54% of traffic to western Europe. Revenues on calls to sub-Saharan Africa grew 26% between 2011 and 2018, $2.4 billion to $3.0 billion. Conversely, revenues on calls to western Europe fell substantially from $1.2 billion to $900 million.

Declining wholesale prices stabilized in 2015 and have inched up ever since. This resulted in a modest increase in wholesale revenues between 2016 and 2017. But 2018's drop in wholesale volumes wiped away that gain. As a result, revenues dropped last year to $13 billion, below the 2014 peak of $14.4 billion.

Wholesale operators make the bulk of their revenues in only a handful of regional markets. Africa, for example, received 9% of the world's wholesale traffic, but accounted for 34% of wholesale revenues ($4.4 billion.) Countries in the Middle East accounted for 6% of world wholesale traffic, but 12% of wholesale revenues ($1.6 billion).

Wholesale revenues are bolstered by a select set of low-traffic routes with stubbornly high prices. For example, the France to Tunisia accounts for just 0.3% of international traffic, but, at $0.37 per minute, it provides 3% of all revenues. Thanks to low termination prices in Mexico, the U.S.-Mexico route serves as a converse example: that massive route represents 7% of all international traffic in the world, but only 0.4% of wholesale carrier revenues.

Who's carrying all this traffic? In 2018, eight carriers in TeleGeography's ranking transported more than 20 billion minutes of traffic, down from eleven in 2015. Among the nine largest carriers in the world, only two terminated more traffic in 2018 than in 2017.

Prices & Revenues

Until 2015, international carrier voice traffic had increased in each of the previous 60 years. In each of the past four years, paid call volumes have slumped, with no end in sight. International carriers had already suffered from revenue stagnation due to slow traffic growth and falling prices. The unprecedented occasion of outright traffic decline, however, marked a new and depressing turning point.

In reviewing developments from the past year, three major trends stand out:

1. **Retail international call revenues peaked in 2012**, and have been on the decline ever since. Retail revenues have decreased from $99 billion in 2012 to $70 billion in 2018.

2. **Retail prices were essentially unchanged in 2018**, at about $0.15 per minute. Unfortunately, we anticipate that traffic loss will overwhelm this recent price stabilization, and that revenues will decline by a forecasted 9% in 2019. Perhaps a puppy isn't enough.

3. **At current run rates, international service revenues will fall to $50 billion by 2024**. If that trend holds true, revenues will have declined by nearly half of the $99 billion total in the 10 years after 2012.

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