TeleGeography

The State of the Network

2019 EDITION

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INTRODUCTION

In 2018 we wanted to take a snapshot of the modern telecom market.

And it was this desire—our attempt to answer the question **what is happening in telecom at this moment in time?**—that led to the creation of this annual *State of the Network* report.

It's one year later and we find ourselves with a new opportunity to reflect on what is happening across all corners of modern communication—from point-to-point backbone telecom pricing and bandwidth supply to international long-distance and the SD-WAN market.

We still believe that no one report or research service can paint a *complete* picture of where telecom is today, nor where it is headed tomorrow. However, if our experience preparing this resource last year has taught us anything, it's that there is much to gain from exploring many different angles of telecommunications at once, considering the ways in which they relate and react to one another.

In 2019 we've again turned to four of our core products to do this: *Global Bandwidth Research Service*, *Global Internet Geography*, *Data Center Research Service*, and the *TeleGeography Report and Database*.

Meet Our Experts

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We combined our latest and greatest findings from each of these distinct products to better understand how international bandwidth, internet, colocation, cloud, wide area network, and voice are evolving and impacting one another.

These chapters provide an overview of the information contained within the four core products sampled, as well as an examination of how these distinct market segments connect to one another.

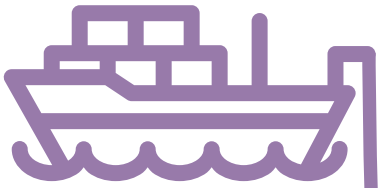
We hope the result paints a picture of how the world is connecting and communicating in 2018-2019.

And we thank you for taking the time to connect with us and enjoy our research. Of the many e-books you could download or posts you could read, you chose ours, and we appreciate that.

If you like what you read and you'd like keep up on new research and our takes on telecom headlines, head over to the TeleGeography blog.

And for more information about the products and methodology used to develop this report, please visit TeleGeography.com.

— The TeleGeography Team



GLOBAL WHOLESALE BANDWIDTH MARKET

The global wholesale bandwidth market is shaped by many factors—some that change the face of the industry and others that contribute a measure of predictability. The industry has forever been marked by the drive to keep innovation and cost competitiveness ahead of inevitable price erosion.

TeleGeography's 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. This chapter will pull from the Global Bandwidth Research Service's latest and greatest analysis to provide an overview of the market.

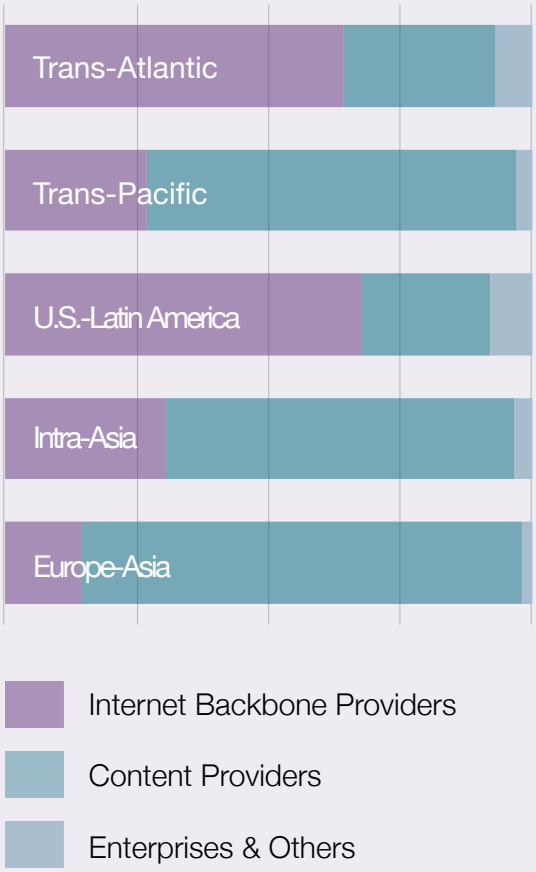
Supply and Demand

Global bandwidth demand continues to grow, spurring terrestrial and submarine cable network operators to undertake extensive network upgrades and deployments.

Globally, demand for international bandwidth increased at a rate of 52 percent in 2017. The amount of capacity deployed on international networks doubled between 2015 and 2017, rising to 684 Tbps.

Share of Used Bandwidth

By Category for Major Routes, 2018



The growth of used international bandwidth is roughly similar between regions. The pace of growth has been strongest on links connected to Asia, which experienced a compound annual growth rate of 52 percent between 2013 and 2017.

Growth rates in other regions were only slightly slower, ranging in a narrow band between 40 percent and 48 percent compound annual growth.

Content Providers

The growth in the amount of capacity deployed by content providers—such as Google, Facebook, and Microsoft—has outstripped that of all other customers of international bandwidth in recent years.

Content providers experience high volumes of demand between their proprietary data centers. The requirements for inter-data center demand vary by company but are generally related to database mirroring, search index synchronization, and cloud computing services and applications. The role of inter-data center bandwidth requirements in bolstering overall transport demand becomes clear when examining content provider capacity on major submarine cable routes. In the Atlantic and Pacific, content providers accounted for over half of total demand in 2017. In contrast, content providers represented only a small share of capacity usage on routes connected to the Middle East and Africa. To date, the large content providers have built U.S.-centric network architectures. Their investments on systems directly connecting Europe to Asia are almost non-existent in comparison.

The concentration of content provider demand along certain routes does not mean these huge bandwidth consumers are not focusing on adding capacity to other regions. A comparison of the international capacity growth experienced by content providers versus all other sources reveals a stark contrast. Across all world regions, content providers added capacity at a compound annual rate of at least 75 percent between 2013 and 2017, compared to a rate no higher than 45 percent for others.

Subsea Cable Investment

Following several years of relatively sparse submarine cable development, 2016 ushered in a period of significant global investment in the sector.

Cables with a combined construction cost of $5.1 billion entered service during 2016 and 2017. Operators could invest an additional $8.8 billion of CAPEX for new cables between 2018 and 2020. The trans-Pacific route leads the way with $2.1 billion of new cable investment expected in 2018 to 2020.

Pricing

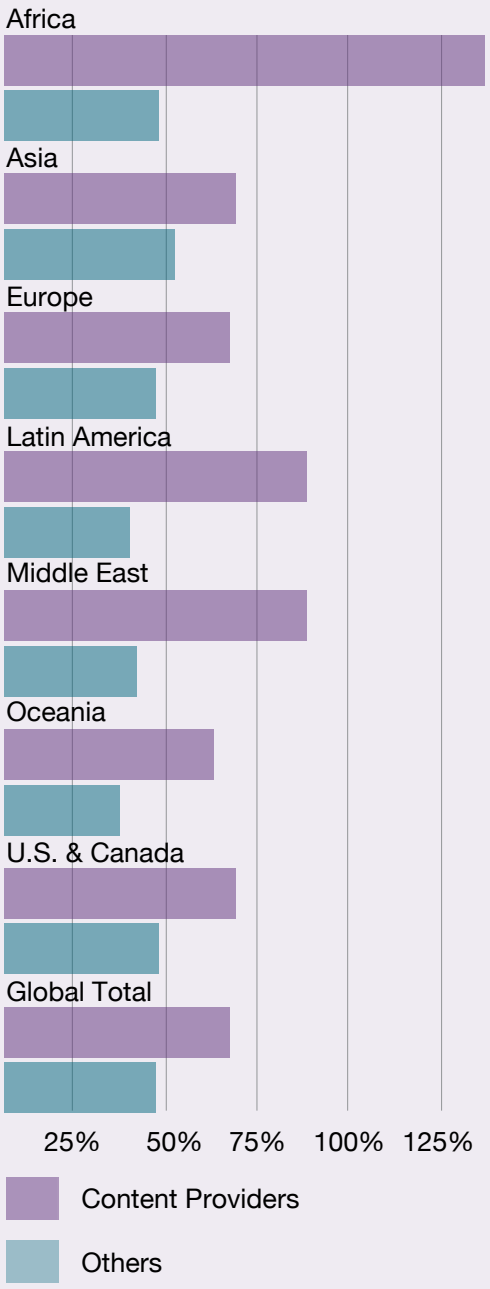
Bandwidth prices remain on the descent, driven downward by competition and an ever-expanding supply that lowers unit cost. Median monthly lease prices across a selection of critical routes declined an average of 26 percent from 2016 to 2017, and 30 percent compounded annually from 2014 to 2017. Among these core routes, Miami-São Paulo 10 Gbps wavelengths exhibited the steepest rate of price erosion at 41 percent compounded annually, dropping from 7.9 times the trans-Atlantic price in 2013 to three times the price in 2017. Compound annual prices on the London-New York and Los Angeles-Tokyo routes fell 19 and 29 percent, respectively, during the period.

Network operators continue to adopt 100 Gbps circuits for wholesale transactions, and the price relationship between 100 Gbps and 10 Gbps has evolved accordingly. In Q4 2017, the average carrier multiple of 100 Gbps over 10 Gbps service among key routes was 5.4, down from 6.4 in 2015. The difference between the median 10 and 100 Gbps price ranged from 4.1 times on the shorter connection between London and New York to 6.0 times on the terrestrial link between Chicago and New York. Capacity multiples for 100 Gbps skew low 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.

Operators could invest an additional $8.8 billion of CAPEX for new cables between 2018 and 2020.

Content Providers Versus Others Bandwidth Growth

By Region, 2014-2018



Outlook

Persistent demand growth and price erosion couple with shifts in sources of demand and changes in network deployment strategies to create challenges for the wholesale telecom market.

Content providers' cable investments have largely focused on trans-Atlantic, trans-Pacific, U.S.-Latin American, and intra-Asian routes thus far. Other routes 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.

And while cloud computing has funneled an increasing amount of international demand to centralized cloud data centers, edge computing is emerging as a method to have some computation and storage remain nearer to end-users.

The rapid expansion of major content providers' networks has caused a major shift in the global wholesale market. Google, Microsoft, and Facebook are investing in new inter-continental submarine cable systems and purchasing increments of 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.

ALL THINGS INTERNET

International internet bandwidth and traffic growth has gradually slowed in recent years, but remains brisk. Meanwhile, IP transit price declines continue globally, but significant regional differences in prices persist in all corners of the globe.

TeleGeography's Global Internet Geography provides analysis and statistics on internet capacity and traffic, IP transit pricing, and backbone operators. This chapter will explore the state of the global internet using our research and analysis from this service.

Internet Traffic and Capacity

International internet capacity growth defied long-term trends in 2018, accelerating for the first time since 2015. This trend was not universal—many routes experienced slower growth in 2018. Global growth was buoyed by the large intra-European routes whose growth accelerated from 22 percent in 2017 to 36 percent in 2018.

Global internet bandwidth reached 393 Tbps in 2018, two-thirds of which was deployed since 2014. Of that capacity, 126 Tbps was inter-regional, while 265 Tbps connected countries within each of the major world regions.

Africa experienced the most rapid growth of international internet bandwidth, growing at a compound annual rate of 45% between 2014 and 2018.

Since TeleGeography began tracking international internet capacity in 1999, the highest-capacity inter-regional route had always been Europe-United States & Canada. This changed in 2013 as capacity on the Latin America-U.S. & Canada route exceeded the Europe-U.S. & Canada route.

In 2018, the Latin America-U.S. & Canada route extended its lead, expanding 28 percent to reach 37 Tbps. This shift may seem surprising, but Latin America's international internet bandwidth is almost completely connected to the U.S. & Canada, whereas Asia and Europe rely far less on the U.S. Also, the considerable deployment of private network capacity by large content providers across the Atlantic and Pacific appears to have dampened the growth of internet capacity on these routes.

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 percent between 2014 and 2018. Asia and the Middle East were just behind Africa, rising at a 41 percent compound annual rate during the same period.

In recent years, a small group of content providers have captured an increasing share of traffic and migrated it to their own international networks. Content networks' capacity has grown faster than internet backbones, and account for their slowing growth. This impact is most acute on the trans-Atlantic and trans-Pacific routes, but also on the U.S.-Latin American route and within Asia and Europe.

Content providers, such as Amazon, Facebook, Google, and Microsoft, have been particularly aggressive in expanding the scale and reach of their networks and increasing their presence at major peering locations.

Prices

IP transit prices continued to decline steadily in 2018, with weighted median 10 GigE prices across a global sample of transit markets in London, New York, São Paulo, and Singapore decreasing an average of 27 percent compounded annually between 2015 and 2018. In the primary internet hubs of London and New York, 10 GigE price declined a bit less than the average at 15 and 21 percent compounded annually from 2015 to 2018, respectively. The higher growth, more expensive 10 GigE markets of São Paulo and Singapore dropped 45 and 30 percent, respectively, compounded annually from 2015 to 2018.

Different rates of price decline have converged prices in more and less mature transit markets. The weighted median in Singapore is now just twice the price of London, compared to 4 times the price in 2015. Similarly, São Paulo's 10 GigE price is now 4 times the price of New York, compared to 13 times in 2015. Outside of these markets, substantial price differences persist. In Q2 2018, the 10 GigE IP transit in Sydney was 13 times the price in Los Angeles, largely due to the underlying cost of transport across the Pacific to access global internet hubs. In remote locations with limited bandwidth utilization and competition, such as sub-Saharan Africa and remote island nations, unit prices extend far higher than global hubs.

Provider Connectivity

TeleGeography's 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.

Mergers and acquisitions have shaped provider rankings over the past several years. CenturyLink's acquisition of Level 3 propelled the combined entity to the top place as ranked by most metrics. CenturyLink/Level 3 supplanted Hurricane Electric as the provider with

10 Highest Capacity International Internet Hub Cities

Domestic routes omitted, 2018

Frankfurt, Germany
Bandwidth: 73.1 Tbps

London, U.K.
Bandwidth: 55.7 Tbps

Amsterdam, Netherlands
Bandwidth: 48.4 Tbps

Paris, France
Bandwidth: 47.8 Tbps

Singapore, Singapore
Bandwidth: 25.8 Tbps

Stockholm, Sweden
Bandwidth: 21.3 Tbps

Miami, U.S.
Bandwidth: 20.0 Tbps

New York, U.S.
Bandwidth: 19.2 Tbps

Marseille, France
Bandwidth: 18.3 Tbps

Hong Kong, China
Bandwidth: 18.2 Tbps

Top Upstream Providers of Finance Sector ASNs

1. CenturyLink
563 Customers
Percent Reach: 23% | Percent Share: 17%

2. Cogent Communications
304 Customers
Percent Reach: 7% | Percent Share: 3%

3. AT&T
296 Customers
Percent Reach: 10% | Percent Share: 6%

4. Verizon
295 Customers
Percent Reach: 16% | Percent Share: 9%

5. Zayo
159 Customers
Percent Reach: 5% | Percent Share: 2%

6. Crown Castle Fiber (Lightower)
124 Customers
Percent Reach: 1% | Percent Share: 1%

7. Orange
121 Customers
Percent Reach: 2% | Percent Share: 1%

8. Comcast
119 Customers
Percent Reach: 2% | Percent Share: 1%

9. Colt
112 Customers
Percent Reach: 7% | Percent Share: 3%

10. Beeline
109 Customers
Percent Reach: 0% | Percent Share: 0%

the most downstream ASN connections. CenturyLink also boasts the most transit customers in the world. GTT's purchase of Interoute significantly moved GTT upwards in the rankings. GTT now serves nearly as many downstream ASNs as AT&T.

In addition to examining overall connectivity, TeleGeography compared 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.

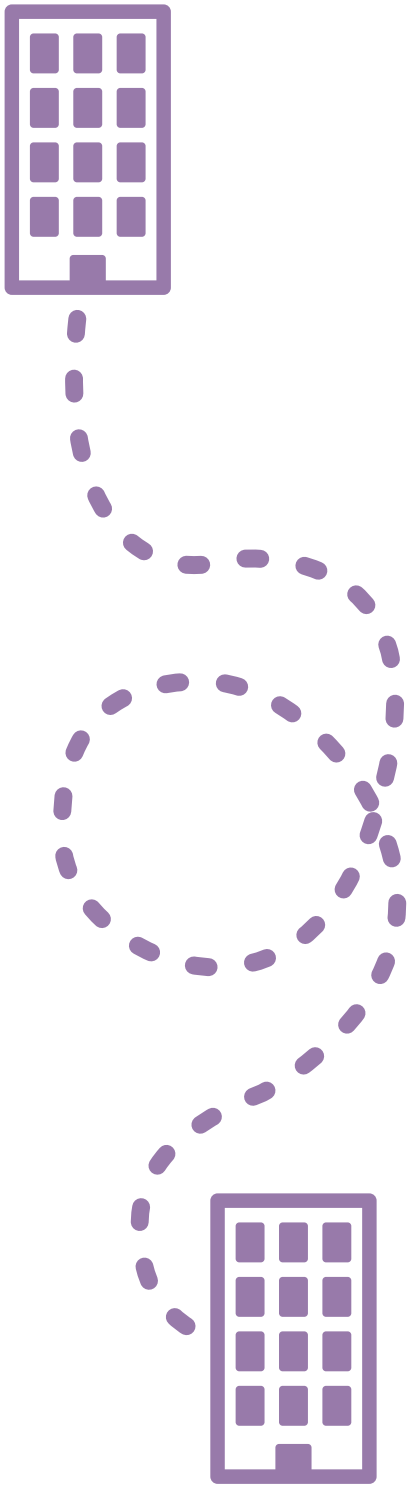
The list of leading providers in the finance sector looks remarkably different from the provider rankings in the ISP/carrier, hosting/cloud, and tech sectors. AT&T and Verizon ranked highly (third and fourth) among all finance sector companies, while Hurricane Electric did not even make the list of top finance sector providers.

The banking industry constitutes a sector with often particular networking requirements. This characteristic appears to have given room for market share to certain upstream providers that might otherwise fly below the radar. For example, the northeastern U.S. regional carrier Crown Castle Fiber (Lightower) ranked as the sixth-best-connected provider to the finance sector, but only 229th in overall internet address share.

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. Aggregate international internet capacity and traffic growth rates are slowing as the global internet matures and more traffic migrates to private networks.



MADE POSSIBLE BY COLOCATION

Colocation is just a collection of buildings, right? It's a bunch of square feet, measured out for network storage. A series of wires and cages—not much of a story there.

Not so. Data centers are points of interconnection; these buildings are key intersections in the modern information highway.

This chapter uses information from our Data Center Research Service to provide an overview on and outlook of the modern data center market.

Metro Capacity

According to TeleGeography's latest colocation capacity survey, Tokyo weighs in as the world's largest colocation data center market, with more than 9 million square feet of gross retail capacity. With more individual retail data center deployments than any other market, London is the second-largest market by gross capacity.

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, Mumbai, and Taipei in Asia have become critical secondary markets with around 1 to 2 million square feet of retail space.

Market Growth

Between 2014 and 2018, the median compound annual growth rate in colocation data center capacity among the 65 markets highlighted in our study has been a modest 7 percent.

Major hubs outpacing the median growth rate include London and Singapore, each with at least 10 percent compound annual growth.

On the other end of the spectrum, Tokyo, New York, and Los Angeles have experienced much slower growth, each at 3 percent compounded annually.

Providers

Equinix remains the world's largest retail colocation data center operator. Following a particularly fast-growing year in 2017, in which the company increased its footprint by 30 percent, Equinix grew a further 12 percent in 2018 to reach 17.9 million square feet of gross data center space.

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

As overwhelmingly large as Equinix and NTT are in the retail space, Digital Realty Trust is equally dominant in the wholesale market, exceeding the second-largest provider's gross capacity by more than 3 times.

Over the next few years, numerous colocation and proprietary data center sites are slated to be deployed across the globe. While construction will be spread across all regions, the heaviest concentration of new builds will be in North America.

Much talk in the industry is focused on bringing network and colocation closer to the network edge in secondary markets, but the largest operators are doubling down on core markets. Retail deployments continue to roll out across the largest markets in the world, including Frankfurt, London, Dallas, Tokyo, and Washington (NoVA).

Proprietary Data Centers

Among the proprietary data center operators tracked by TeleGeography, all are rapidly expanding into new markets. Collectively, Facebook, Microsoft, Google, and Amazon have deployed 24 new data centers globally in the last two years alone.

They are slated to deploy at least 25 more over the next two years.

Power

As of 2018, an overwhelming majority of respondents, nearly 80 percent, indicate that their site density levels exceed 100 watts per square foot (W/sq ft). In the last two years, a growing percentage of respondents (22 percent) indicate that their facilities are running exceptionally high density levels of greater than 200 W/sq ft. In the previous five years, no more than 20 percent of facilities were reported to operate at such high densities.

Since 2016, just under 70 percent 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, however, has increased from 9 percent to 12 percent in the same timeframe.

In a sampling of hub metropolitan markets, Dallas has the highest average site density and the highest average supportable rack density. On the other end of the spectrum, the Asian hubs of Hong Kong and Singapore report the lowest levels of supportable rack density, averaging just 5 and 6 kw per rack respectively.

TeleGeography's 2018 colocation survey indicates a significant shift toward lower PUE operations. The proportion of sites operating below 1.5 has jumped from 37 percent in 2017 to nearly 50 percent.

Among a sampling of metropolitan markets, the moderate climates of San Francisco and London register some of the lowest average PUEs at just 1.4 and 1.5 respectively.

Once you've established yourself as the place to be, the place where networks need to go to interconnect, that momentum continues to build.

Connectivity

In 2018, respondents indicated that CenturyLink (now including the acquired Level 3 network), Verizon, and Zayo are the most prominent carriers in their facilities, with widespread site presence in North America. AT&T and Cogent are also common in North American facilities, while Colt and BT are heavily represented in European data centers.

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 2018, the European median price per kilowatt for colocation is just 4.3 percent higher than that of the median North American price, at $365 per kilowatt vs. $350.

The narrowing in the regional price gap is entirely due to a steady rise in the median North American rate, with almost no change seen over the same timeframe in the median European price.

Median rates for high-density colocation (price per kilowatt for 10 kilowatt cabinets) are almost universally discounted compared to prices per kilowatt for standard 4-kilowatt cabinets, averaging 16 percent lower than the standard rate. While relative scarcity between space and power can result in either discounted rates or premium prices for high-density servers, the general push to discount high-density space incentivizes the consolidation of computing resources.

Large-scale retail colocation leases (100 kilowatts) are consistently discounted relative to single 4-kilowatt cabinet leases. Discounted rates are on average 13 percent lower than per-kilowatt rates for single cabinets.

The gulf between cross-connect rates in Europe and North America has narrowed due to price adjustments and changes in market samples. The median fiber cross-connect rate for the full sample of

North American metro areas has dropped from $300 in H1 2017 to $250 in H2 2017, where it continues to stand through H2 2018. In the full sampling of European metro areas, however, the median rate has fluctuated in recent periods.

Historically, operators in North America have charged more for fiber cross-connects than for Ethernet; European operators typically charged more for Ethernet cross-connects. As of H2 2018, however, European operators have swung in the direction of discounting Ethernet cross-connect fees relative to the cost of fiber cross-connects.

Total Cost of Ownership (TCO)

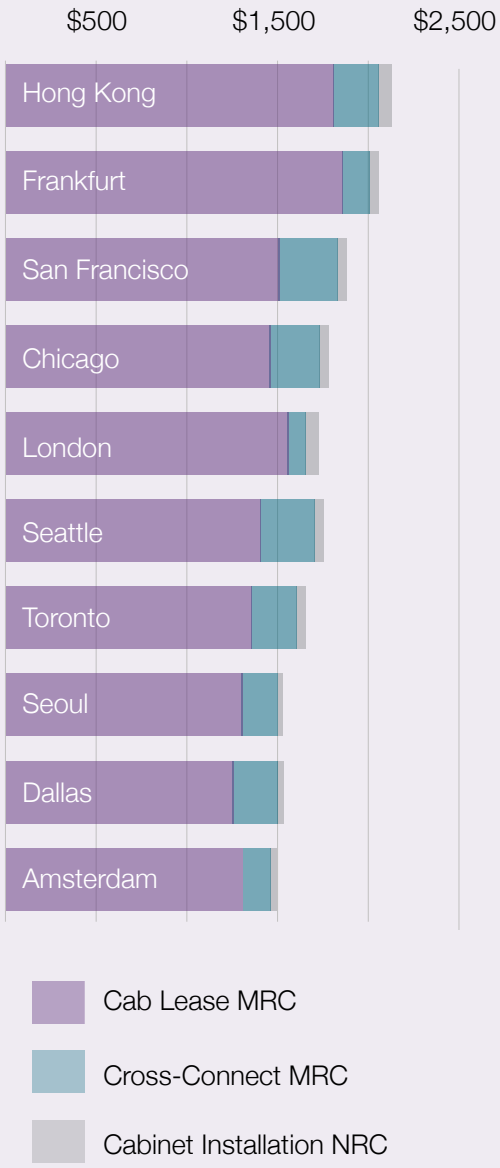
The average TCOs across North American and European markets, when assuming one fiber cross-connect, are almost identical at about $1,675 and $1,655 per month respectively. When five cross-connects are assumed, the total cost for colocation in North America is about 25 percent higher than in Europe, averaging nearly $2,640. In this model, cross-connects account for nearly 50 percent of the TCO in North American markets and just 25 percent of TCO in Europe.

Cost Outlook

Recent periods in the TeleGeography update cycle have been marked by a dramatic narrowing of price differences between Europe and North America. The merging of both colocation prices per kilowatt and cross-connect rates across regions is directly tied to a homogenization of rates in individual metro areas. Individual U.S. markets are not uniformly more expensive than European markets and vice versa. In the midst of increasing uniformity, the greatest constant disparity remains the pricing charged by individual operators. Regardless of location, customers can expect to pay relatively more for access to the most carrier-dense and highly-sought ecosystems.

Total Cost of Ownership

Per Month, One Cross-Connect, H2 2018



VOICE CHANGES

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. However, the slump in voice traffic has turned into a rout, as carriers' traffic fell a further 8.4 percent in 2017 to 484 billion minutes.

This chapter will call on information from TeleGeography's Report and Database to understand trends like this one that persist throughout the voice market.

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 percent 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 residents of 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 percent of global ILD traffic.

The transition to mobile and social calling drove a 20-year boom in voice traffic, but has also left the industry uniquely vulnerable to the rise of mobile social media. While Skype was the dominant communications application for computers, a new generation 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 2018, and WeChat is not far behind, with just over 1 billion active users in September 2018. 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 2018. 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).

While it is difficult to precisely quantify the volume of international OTT communications, 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 percent, and traffic grew an even faster 21 percent CAGR between 1927 and 1983. Consequently, it is hard to believe 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 Skype plus carrier traffic

Carrier vs. OTT

International Traffic, Billions of Minutes

2015
Carrier Traffic: 553.3
OTT Traffic: 418.5

2016
Carrier Traffic: 527.9
OTT Traffic: 570.3

2017
Carrier Traffic: 483.8
OTT Traffic: 757.2

2018
Carrier Traffic: 449.9
OTT Traffic: 952.4

2019
Carrier Traffic: 420.1
OTT Traffic: 1,164.4

2020
Carrier Traffic: 394.5
OTT Traffic: 1,396.0

2021
Carrier Traffic: 373.3
OTT Traffic: 1,650.0

2022
Carrier Traffic: 357.0
OTT Traffic: 1,929.4

2023
Carrier Traffic: 346.3
OTT Traffic: 2,237.3

totaled 761 billion minutes. If we assume that total international (carrier plus OTT) traffic has continued to grow at a relatively modest 13 percent annually since 2013, the combined volume of carrier and OTT international traffic would have expanded to 1.24 trillion minutes in 2017, and to 1.40 trillion minutes in 2018.

This calculation suggests that cross-border OTT traffic overtook international carrier traffic in 2016, and would reach nearly 952 billion minutes in 2018, far exceeding the 450 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 337 billion minutes of traffic in 2017, down 7.5 percent from 2016. While wholesale traffic declined in 2017, wholesale traffic had grown at a compounded annual rate of 5 percent over the previous decade. Consequently, the ratio of international traffic terminated by wholesale carriers increased from 57 percent in 2007 to 70 percent in 2017.

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: wholesale carriers terminated in 2017 85 percent of traffic to Sub-Saharan Africa, Central Asia, and South America, but only 53 percent of traffic to western Europe.

Declining wholesale prices stabilized in 2015 and have ticked up marginally since. The result is that, despite the large absolute decline in wholesale traffic, revenues actually increased from $13.5 to $13.6 billion in 2017. The total is still well below the 2014 peak of $14.4 billion.

The $13.6 billion that wholesale carriers generated in 2017 may appear little different than the global wholesale revenue of $13.4 billion generated in 2011. Under the surface, however, the geo-

graphic sources of this revenue have changed substantially. Revenues on calls to Sub-Saharan Africa grew 30 percent between 2011 and 2017, from $2.4 billion to $3.1 billion. In fact, despite receiving only 10 percent of wholesale traffic, Africa is now the source of 35 percent of wholesale revenues. Conversely, revenues on calls to western Europe fell by 57 percent between 2011 and 2017, from $1.2 billion to $500 million.

Wholesale revenues are bolstered by a select set of low-traffic routes with stubbornly high prices. For example, the France-Tunisia route accounts for just 0.3 percent of international traffic, but, at $0.37 per minute, it provides 2 percent 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 percent of all international traffic in the world, but only 0.5 percent of wholesale carrier revenues.

Scale offers some advantages to carriers, allowing them to spread investments in infrastructure and new technologies across a larger traffic base. Carriers such as Tata, BICS, KPN/iBasis, and Vodafone, have pursued a strategy of volume growth, expanding their wholesale operations, and acquiring or combining their operations with those of other carriers.

However, even scale has its limits. The meager profits to be gleaned from wholesale international voice are prompting a growing number of carriers to eliminate routes and accounts that don't meet their margin targets. Among the 10 largest carriers in the world, only four terminated more traffic in 2017 than in 2016.

The meager profits to be gleaned from wholesale international voice are prompting a growing number of carriers to eliminate routes and accounts that don't meet their margin targets.

Prices & Revenues

Until 2015, international carrier voice traffic had increased in each of the previous 60 years. In the past three years, paid call volumes have slumped, with no end to this decline 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 frightening 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 $73 billion in 2017.

2. Retail prices reversed their decline in 2018. The world weighted average price per minute eked upwards by 0.7 percent. Unfortunately, we anticipate that traffic loss will overwhelm the recent price stabilization, and that revenues will decline by a forecasted 6 percent in 2018.

3. At current run rates, international service revenues will fall to $52 billion by 2022. If that trend holds true, revenues will have declined by nearly half of the $99 billion total in the ten years after 2012.

Research Services

Bandwidth Pricing Database Service
A global database of point-to-point backbone telecom pricing. This database allow users to benchmark TDM services including SDH/SONET and DWDM on key global routes.

Business Broadband Research Service
An extensive database of broadband service providers, plans, and prices.

Cloud and WAN Infrastructure
Profiles international WAN services offered by 153 providers and analyzes trends in VPN, Ethernet, DIA, and IPL availability and pricing, as well as cloud connectivity services.

Data Center Research Service
The number one tool for understanding data centers, network storage, and the nature of interconnection.

Enterprise Pricing Service
A database of international MPLS VPN, Layer 2 EVPN, dedicated internet access, private line, and Ethernet private line price benchmarks for corporate and retail customers.

Global Bandwidth Forecast Service
Detailed forecasts of international bandwidth supply, demand, prices, and revenues, updated quarterly.

Global Bandwidth Research Service
The most complete source of data and analysis for long-haul networks and the undersea cable market.

Global Internet Geography
The most complete source of data and analysis about international internet capacity, traffic, service providers, ASN connectivity, and pricing.

Research Services

GlobalComms Database Service
The most complete source of data about the wireless, broadband, and fixed-line telecom markets, covering over 215 countries and 1,850+ service providers.

GlobalComms Forecast Service
Wireless, broadband, and wireline market metrics and forecasts by country and region.

IP Transit Forecast Service
Detailed historical data and forecasts of IP transit volumes, prices, and revenues for 148 countries.

IP Transit Pricing Service
A database of wholesale internet access price quotes by port speed and committed data rate from more than 60 carriers in over 100 cities around the world.

Local Access Pricing Service
A database of global local access prices, reflecting actual transaction prices paid by carriers for leased private lines and Ethernet circuits.

SD-WAN Research Service
The only product that catalogs and analyzes the SD-WAN market so you can find the right fit.

TeleGeography Report and Database
The most comprehensive source of data on international long-distance carriers, traffic, prices, and revenues.

WAN Cost Benchmark
Provides tailored end-to-end price benchmarks for enterprise wide area networks, based on the client's specified site locations and service requirements.

Research Calendar

Research Service	Q1	Q2	Q3	Q4	M
Bandwidth Pricing Database		✓		✓	
Bandwidth Pricing Report					✓
Business Broadband Research Service	✓	✓	✓	✓	
Cloud and WAN Infrastructure	✓				
Data Center Research Service	✓		✓		
Enterprise Network Pricing Database	✓		✓		
Global Bandwidth Forecast Service	✓	✓	✓	✓	
Global Bandwidth Research Service	✓	✓	✓	✓	
Global Internet Geography			✓		
GlobalComms Database					✓
GlobalComms Forecast Service		✓	✓	✓	
IP Transit Pricing Service		✓		✓	
IP Transit Forecast Service		✓		✓	
Local Access Pricing Service		✓		✓	
SD WAN Research Service				✓	
TeleGeography Report				✓	
TeleGeography Database				✓	
WAN Cost Benchmark	✓	✓	✓	✓	

* Q1, Q2, Q3, Q4, M (Monthly) denotes when a service is updated. ✓ = major update ✓ = update