

Cisco Global Cloud Index: Forecast and Methodology, 2011–2016



What You Will Learn

The Cisco® Global Cloud Index is an ongoing effort to forecast the growth of global data center and cloud-based IP traffic. The forecast includes trends associated with data center virtualization and cloud computing. This document presents the details of the study and the methodology behind it.

Forecast Overview

Global data center traffic:

- Annual global data center IP traffic will reach 6.6 zettabytes by the end of 2016. By 2016, global data center IP traffic will reach 554 exabytes per month (up from 146 exabytes per month in 2011).
- Global data center IP traffic will nearly quadruple over the next 5 years. Overall, data center IP traffic will grow at a compound annual growth rate (CAGR) of 31 percent from 2011 to 2016.

Data center virtualization and cloud computing transition:

- The number of workloads per installed traditional server will increase from 1.5 in 2011 to 2.0 by 2016.
- The number of workloads per installed cloud server will increase from 4.2 in 2011 to 8.5 by 2016.
- By 2016, nearly two-thirds of all workloads will be processed in the cloud.

Global cloud traffic:

- Annual global cloud IP traffic will reach 4.3 zettabytes by the end of 2016. By 2016, global cloud IP traffic will reach 355 exabytes per month (up from 57 exabytes per month in 2011).
- Global cloud IP traffic will increase six-fold over the next 5 years. Overall, cloud IP traffic will grow at a CAGR of 44 percent from 2011 to 2016.
- Global cloud IP traffic will account for nearly two-thirds of total data center traffic by 2016.

Regional cloud readiness:

- North America and Western Europe led in broadband access (fixed and mobile) in 2011 and will continue to lead in this category through 2016. However, all regions will show measurable improvement in broadband access to their respective populations throughout the forecast period. Asia Pacific leads in the number of subscribers throughout the forecast period due to the region's large population (see [Broadband Ubiquity](#) section for details).
- Western Europe leads all regions with an average fixed download speed of 11.7 Mbps. North America follows with an average fixed download speed of 10.3 Mbps. Asia Pacific and Central and Eastern Europe lead all regions in average fixed upload speeds of 6.7 Mbps and 5.9 Mbps, respectively (see [Download and Upload Speed Overview](#) section for details).
- Western Europe and Central and Eastern Europe lead all regions in average fixed network latency with 58 ms and 59 ms, respectively (see [Network Latency](#) section for details).

Evolution of Data Center Traffic

In just the past year since the first Cisco Global Cloud Index was released, the industry has seen cloud adoption evolving from an emerging technology to an established networking solution that is gaining widespread acceptance and deployment. Enterprise and government organizations are moving from test environments to placing more of their mission-critical workloads in the cloud. And for consumers, cloud services offer ubiquitous access to content and services, on multiple devices, almost anywhere network users are located.

Qualitatively, the main drivers for cloud adoption include faster delivery of services and data, increased application performance, as well as improved operational efficiencies. While security and integration with existing IT environments continue to represent concerns for some potential cloud-based applications, a growing range of consumer and business cloud services are currently available. Today's cloud services address varying customer requirements (for example, privacy, mobility, and multiple device access) and support near-term opportunities as well as long-term strategic priorities for network operators, both public and private.

Quantitatively, the impact of cloud computing on data center traffic is clear. It is important to recognize that most Internet traffic has originated or terminated in a data center since 2008. Data center traffic will continue to dominate Internet traffic for the foreseeable future, but the nature of data center traffic is undergoing a fundamental transformation brought about by cloud applications, services, and infrastructure. The importance and relevance of the global cloud evolution is highlighted by one of the top-line projections from this updated forecast—by 2016 nearly two-thirds of data center traffic will be cloud traffic.

The following sections summarize not only the volume and growth of traffic entering and exiting the data center, but also the traffic carried between different functional units within the data center.

Global Data Center IP Traffic: Nearly Four-fold Increase by 2016

Figure 1 summarizes the forecast for data center IP traffic growth from 2011 to 2016.

Figure 1. Global Data Center IP Traffic Growth



The Internet is forecast to reach the zettabyte era in 2016, but the data center has already entered the zettabyte era. While the amount of traffic crossing the Internet and IP WAN networks is projected to reach 1.3 zettabytes per year in 2016¹, the amount of data center traffic is already 1.8 zettabytes per year, and by 2016 will nearly quadruple to reach 6.6 zettabytes per year. This represents a 31 percent CAGR. The higher volume of data center traffic is due to the inclusion of traffic inside the data center (typically, definitions of Internet and WAN stop at the boundary of the data center).

The global data center traffic forecast, a major component of the Cisco Global Cloud Index, covers network data centers worldwide operated by service providers as well as private enterprises. Please see [Appendix A](#) for more details on the methodology of the data center and cloud traffic forecasts, and [Appendix B](#) for the positioning of the Global Cloud Index Forecast relative to the Cisco VNI Global IP Traffic Forecast.

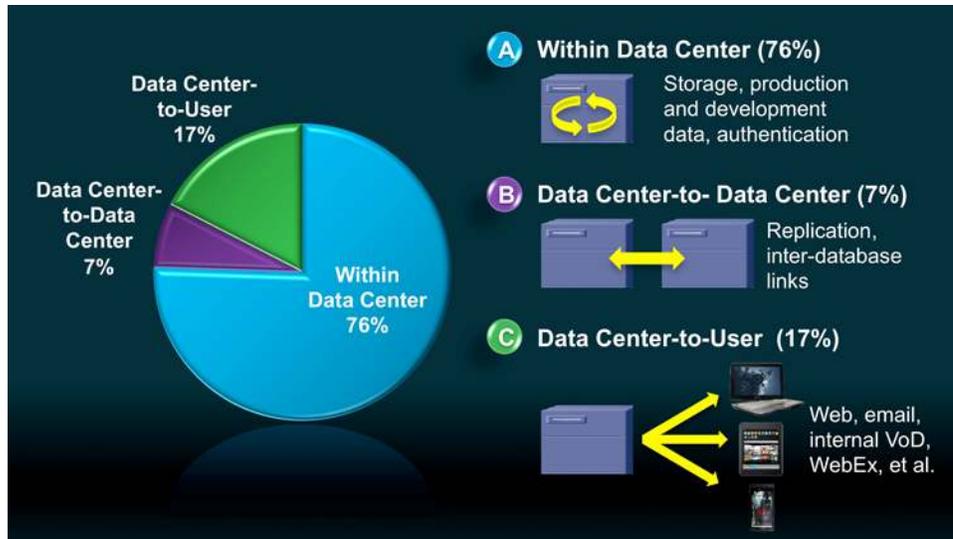
Data Center Traffic Destinations: Most Traffic Remains Within the Data Center

Consumer and business traffic flowing through data centers can be broadly categorized into three main areas (Figure 2):

- Traffic that remains within the data center
- Traffic that flows from data center to data center
- Traffic that flows from the data center to end users through the Internet or IP WAN

¹ See [Cisco Visual Networking Index: Forecast and Methodology, 2011–2016](#).

Figure 2. Global Data Center Traffic by Destination



The portion of traffic residing within the data center will remain the majority throughout the forecast period, accounting for 76 percent of data center traffic in both 2011 and 2016. Factors contributing to traffic remaining in the data center include functional separation of application servers, storage, and databases, which generates replication, backup, and read/write traffic traversing the data center. Furthermore, parallel processing divides tasks and sends them to multiple servers, contributing to internal data center traffic.

The ratio of traffic exiting the data center to traffic remaining within the data center could be expected to increase over time, because video files are bandwidth-heavy and do not require database or processing traffic commensurate with their file size. However, the increasing use of applications such as desktop virtualization is likely to offset this trend. In addition, the virtualization of storage and other data center capabilities increases traffic within the data center because functions may no longer be local to a rack or server. Table 1 provides details for global data center traffic growth rates.

Table 1. Global Data Center Traffic, 2011–2016

Data Center IP Traffic, 2011–2016							
	2011	2012	2013	2014	2015	2016	CAGR 2011–2016
By Type (EB per Year)							
Data center to user	299	438	561	714	912	1,160	31%
Data center to data center	118	173	222	284	365	468	32%
Within data center	1,338	1,940	2,468	3,126	3,969	5,021	30%
By Segment (EB per Year)							
Consumer	1,404	2,107	2,700	3,439	4,418	5,672	32%
Business	351	444	551	685	828	977	23%
By Type (EB per Year)							
Cloud data center	683	1,181	1,694	2,324	3,166	4,255	44%
Traditional data center	1,072	1,370	1,557	1,800	2,080	2,394	17%
Total (EB per Year)							
Total data center traffic	1,755	2,551	3,251	4,124	5,246	6,649	31%

Source: Cisco Global Cloud Index, 2012

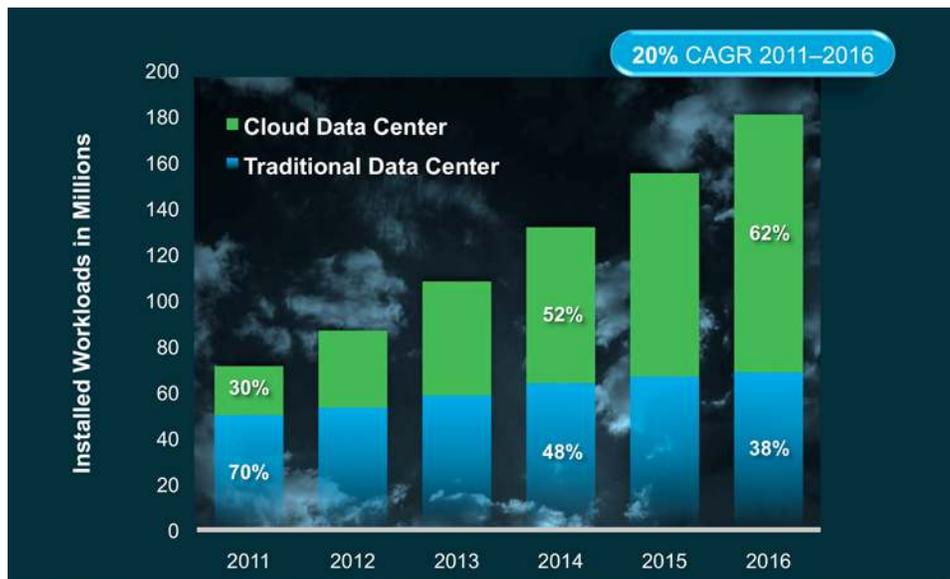
Definitions:

- **Data center to user:** Traffic that flows from the data center to end users through the Internet or IP WAN
- **Data center to data center:** Traffic that flows from data center to data center
- **Within data center:** Traffic that remains within the data center
- **Consumer:** Traffic originating with or destined for consumer end users
- **Business:** Traffic originating with or destined for business end users
- **Cloud data center:** Traffic associated with cloud consumer and business applications
- **Traditional data center:** Traffic associated with noncloud consumer and business applications

Data Center Workloads: Nearly Two-Thirds Will Be Cloud-Based by 2016

A workload can be defined as the amount of processing a server undertakes to run an application and support a number of users interacting with the application. The Cisco Global Cloud Index forecasts the continued transition of workloads from traditional data centers to cloud data centers. By 2016, nearly two-thirds of all workloads will be processed in cloud data centers (Figure 3). For regional distributions of workloads, see [Appendix E](#).

Figure 3. Workload Distribution: 2011–2016



Growth of workloads in cloud data centers will be five and a half times that of the growth in traditional workloads between 2011 and 2016. Traditionally, one server carried one workload. However, with increasing server computing capacity and virtualization, multiple workloads per physical server are common in cloud architectures. Cloud economics, including server cost, resiliency, scalability, and product lifespan, are promoting migration of workloads across servers, both inside the data center and across data centers (even centers in different geographic areas).

Often an end-user application can be supported by several workloads distributed across servers. This can generate multiple streams of traffic within and between data centers, in addition to traffic to and from the end user. The average workload per cloud server will grow from a little over four in 2011 to eight and a half by 2016. In comparison, the average workload per traditional data center server will grow from one and a half in 2011 to two in 2016. Table 2 provides details on workloads shifting from traditional data centers to cloud data centers.

Table 2. Workload Shift from Traditional Data Center to Cloud Data Center

Global Data Center Workloads in Millions							
	2011	2012	2013	2014	2015	2016	CAGR 2011–2016
Traditional data center workloads	49.8	53.1	58.3	63.7	66.7	68.5	7%
Cloud data center workloads	21.3	33.5	49.7	67.9	88.4	112.1	39%
Total data center workloads	71.1	86.6	108.0	131.6	155.1	180.6	20%
Cloud workloads as a percentage of total data center workloads	30%	39%	46%	52%	57%	62%	NA
Traditional workloads as a percentage of total data center workloads	70%	61%	54%	48%	43%	38%	NA

Source: Cisco Global Cloud Index, 2012

Global Data Center and Cloud IP Traffic Growth

Data center traffic on a global scale grows at 31 percent CAGR (Figure 4), but cloud data center traffic grows at a faster rate of 44 percent CAGR, or six-fold growth between 2011 and 2016 (Figure 5).

Figure 4. Total Data Center Traffic Growth

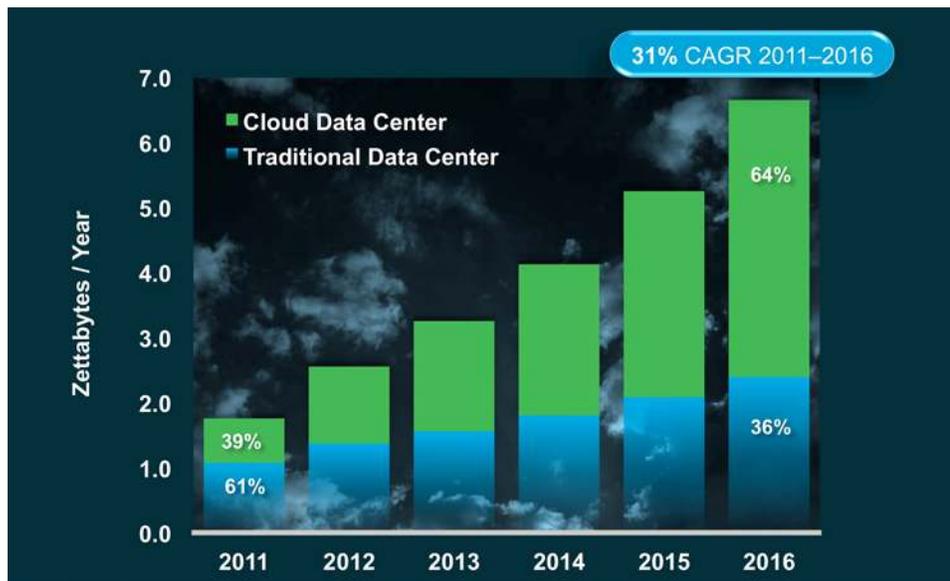
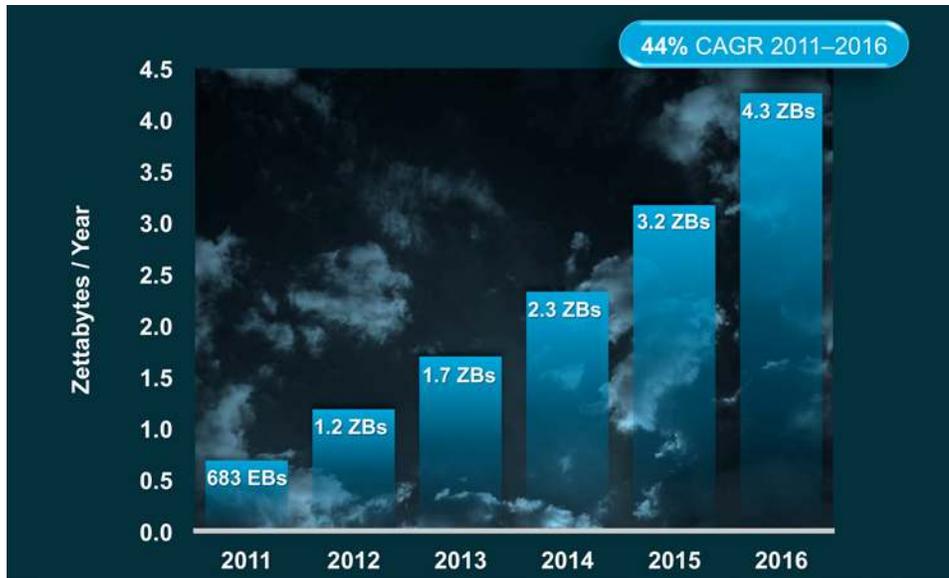


Figure 5. Cloud Data Center Traffic Growth



Cloud traffic will cross the zettabyte threshold in 2012, and by 2016, nearly two-thirds of all data center traffic will be based in the cloud. It is important to note that the methodology for the estimation of cloud data center traffic has changed since the initial release of the Cisco Global Cloud Index in 2011. The previous methodology positioned all storage traffic in the noncloud traffic category. The updated methodology now distinguishes storage traffic associated with cloud workloads and positions it within the cloud traffic category.

For example, storage traffic associated with cloud application development would be counted as cloud traffic in the updated methodology, but would have been excluded in the previous methodology. Because storage accounts for approximately 40 percent of data center traffic, the change in methodology substantially raises the overall cloud percentage of data center traffic. Using the updated methodology, cloud traffic will represent 64 percent of total data center traffic by 2016. Using the previous methodology, cloud traffic would have represented only 36 percent of total data center traffic by 2016.

Significant promoters of cloud traffic growth are the rapid adoption of and migration to cloud architectures, along with the ability of cloud data centers to handle significantly higher traffic loads. Cloud data centers support increased virtualization, standardization, and automation. These factors lead to increased performance, as well as higher capacity and throughput.

Global Business and Consumer Cloud Growth

For the purposes of this study, the Cisco Global Cloud Index characterizes traffic based on services delivered to the end user. Business data centers are typically dedicated to organizational needs and handle traffic for business needs that may adhere to stronger security guidelines. Consumer data centers typically cater to a wider audience and handle traffic for the mass consumer base.

Within the cloud data center traffic forecast, consumer traffic leads with a CAGR of 46 percent, reaching 3.6 ZB annually by 2016. Business cloud traffic grows at a CAGR of 37 percent, increasing to 596 PB annually by 2016. Table 3 provides details for global consumer and business cloud traffic growth rates.

Table 3. Global Cloud Traffic, 2011–2016

Cloud IP Traffic, 2011–2016							
	2011	2012	2013	2014	2015	2016	CAGR 2011–2016
By Segment (EB per Year)							
Consumer	559	992	1,426	1,960	2,692	3,659	46%
Business	124	189	268	364	474	596	37%
Total (EB per Year)							
Total cloud traffic	683	1,181	1,694	2,324	3,166	4,255	44%

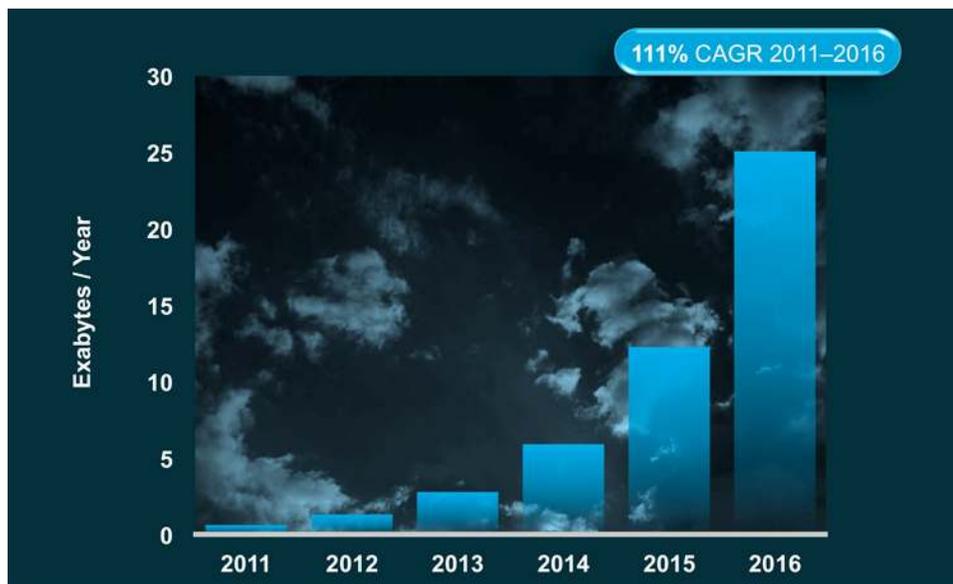
Source: Cisco Global Cloud Index, 2012

Crucial applications are contributing to increased cloud adoption in both the business and consumer segments. For business, the necessity to provide fast and flexible access to large data archives is an important objective for IT organizations considering cloud-based solutions. In addition, enabling advanced analytics to tap into the wealth of information contained in largely unstructured data archives can create a valuable competitive business advantage. And enhanced collaboration services delivered through the cloud can increase employee productivity and customer satisfaction.

In the consumer space, applications such as video and audio streaming are strong factors in cloud traffic growth, while newer services such as personal content lockers are also gaining in popularity. In personal content lockers, users can store and share music, photos, and videos through an easy-to-use interface at relatively low or no cost. Furthermore, the proliferation of tablets, smartphones, and other mobile devices allow access to personal content lockers in a manner convenient to the user.

Cisco GCI forecasts that personal cloud traffic will increase from .6 EB annually in 2011 to 25 EB in 2016, at a CAGR of 111 percent (Figure 6).

Figure 6. Personal Content Locker Traffic Growth

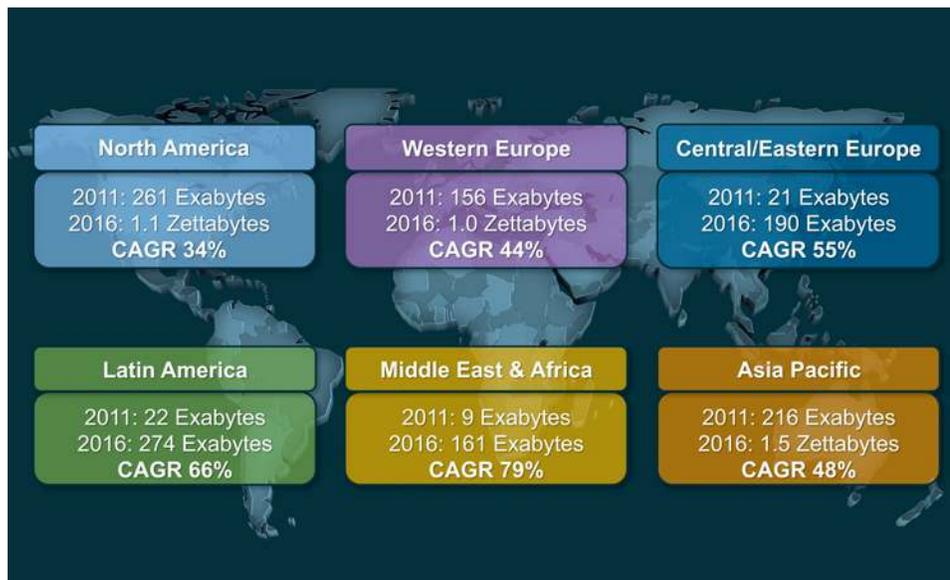


Cloud Traffic Growth by Region

The Cisco Global Cloud Index now includes regional forecast data for cloud traffic growth (Figure 7).

- In 2011, North America generated the most cloud traffic (261 exabytes annually); followed by Asia Pacific (216 exabytes annually); and Western Europe (156 exabytes annually).
- By 2016, Asia Pacific will generate the most cloud traffic (1.5 zettabytes annually); followed by North America (1.1 zettabytes annually); and Western Europe (1 zettabyte annually).
- From 2011–2016, the Middle East and Africa is expected to have the highest cloud traffic growth rate (79 percent CAGR); followed by Latin America (66 percent CAGR); and Central and Eastern Europe (55 percent CAGR). These regions are starting from a smaller cloud traffic base than other regions. Please refer to [Appendix F](#) for further details.

Figure 7. Cloud Traffic Growth by Region



Global Cloud Readiness

The cloud readiness segment of this study offers a regional view of the requirements for broadband and mobile networks to deliver next-generation cloud services. The enhancements and reliability of these networks will support the increased adoption of business consumer cloud computing solutions that deliver basic as well as advanced application services. For example, consumers expect to be able to communicate with friends as well as stream music and videos any time, any place. Business users require continuous access to business communications and mobile solutions for videoconferencing and mission-critical customer and operational management systems.

Download and upload speeds as well as latencies are essential measures to assess network capabilities for cloud readiness. Figure 8 provides the sample business and consumer cloud service categories and the corresponding network requirements used for this study. Note that the concurrent use of applications can further influence the user experience and cloud accessibility.

Figure 8. Sample Business and Consumer Cloud Service Categories



Regional network performance statistics were ranked by their ability to support these three cloud service categories. Over 90 million records from Ookla², the [Cisco GIST](#) application, and the International Telecommunication Union (ITU) were analyzed from nearly 150 countries around the world, covering a span of two years of data. The regional averages of these measures are included below and in [Appendix G](#).

The cloud readiness characteristics are as follows.

Network Access:

- **Broadband ubiquity:** This indicator measures fixed and mobile broadband penetration while considering population demographics to understand the pervasiveness and expected connectivity in various regions.

Network Performance:

- **Download speed:** With increased adoption of mobile and fixed bandwidth-intensive applications, end-user download speed is an important characteristic. This indicator will continue to be critical for the quality of service delivered to virtual machines, customer relationship management (CRM), and enterprise resource planning (ERP) cloud platforms for businesses, and video download and content retrieval cloud services for consumers.
- **Upload speed:** With the increased adoption of virtual machines, tablets, and videoconferencing in enterprises as well as by consumers on both fixed and mobile networks, upload speeds are especially critical for delivery of content to the cloud. The importance of upload speeds will continue to increase over time, promoted by the dominance of cloud computing and data center virtualization, the need to transmit many millions of software updates and patches, the distribution of large files in virtual file systems, and the demand for consumer cloud game services and backup storage.

² Measured by [Speedtest.net](#), small binary files are downloaded and uploaded between the web server and the client to estimate the connection speed in kilobits per second (kbps).

- **Network latency:** Delays experienced with voice over IP (VoIP), viewing and uploading videos, online banking on mobile broadband, or viewing hospital records in a healthcare setting, are due to high latencies (usually reported in milliseconds). Reducing delay in delivering packets to and from the cloud is crucial to delivering today's advanced services (and ensuring a high-quality end-user experience).

Broadband Ubiquity

Figures 9 and 10 summarize broadband penetration by region in 2011 and 2016. North America and Western Europe led in broadband access (fixed and mobile) in 2011 and will continue to lead by 2016. However, all regions will show measurable improvement in broadband access to their respective populations throughout the forecast period. Asia Pacific leads in the number of subscribers throughout the forecast period due to the region's large population.

The methodology for estimating of broadband ubiquity has changed since the initial release of the Cisco Global Cloud Index in 2011. This year, internal projections were used based on a bottom-up approach that includes estimating broadband lines and average users per household, and then validating the country estimates against country-specific telecom-reported data. On the mobile side, the approach focuses on mobile Internet users instead of subscriptions, which prevents duplicative calculations (because some users may have multiple subscriptions). Please refer to [Appendix H](#) for further details.

Figure 9. Regional Broadband Ubiquity, 2011

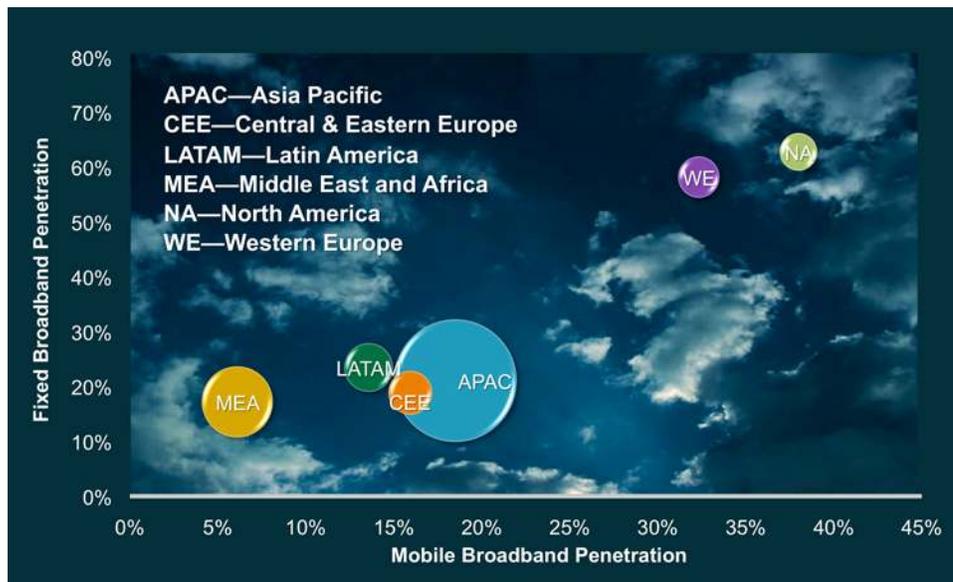
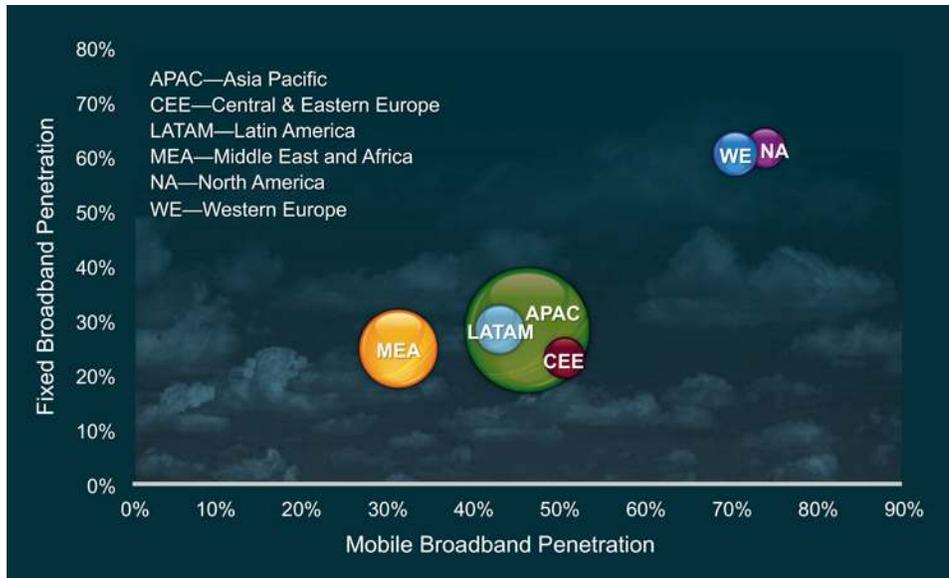


Figure 10. Regional Broadband Ubiquity, 2016



Global Average Download and Upload Speed Overview (2012)

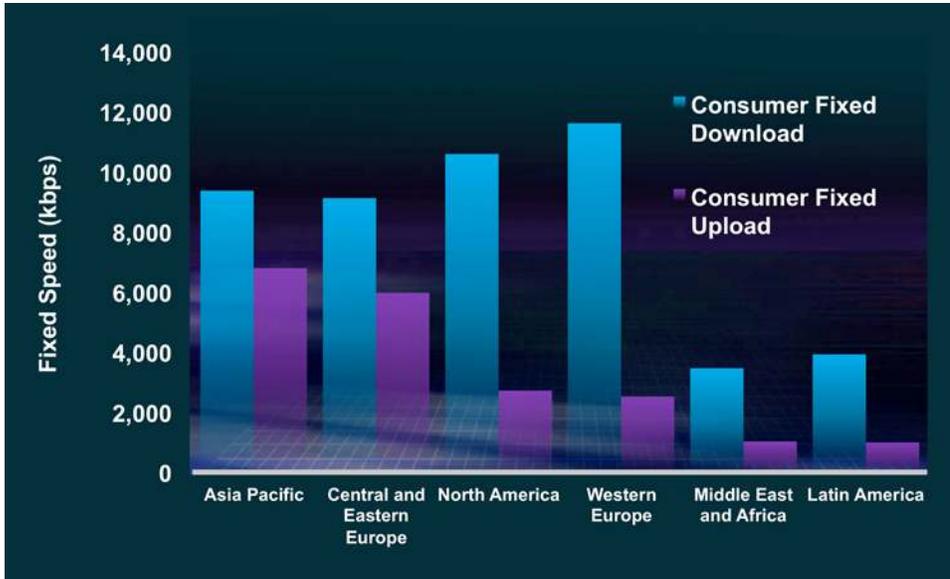
Download and upload speeds as well as latencies are key measures to assess network capabilities for cloud readiness. The [Cisco GCI Supplement](#) provides additional country-level detail for download speeds, upload speeds, and latencies.

- The global average fixed download speed is 9.4 Mbps.
- The global average fixed upload speed is 4.5 Mbps.
- The global average mobile download speed is 2.2 Mbps.
- The global average mobile upload speed is .97 Mbps.

Consumer Average Fixed Download and Upload Speeds

- For consumer average fixed download speeds, Western Europe leads with 11.6 Mbps and North America follows with 10.6 Mbps.
- For consumer average fixed upload speeds, Asia Pacific leads in with 6.8 Mbps and Central and Eastern Europe follows with 5.9 Mbps (Figure 11). Please refer to [Appendix G](#) and the [Cisco GCI Supplement](#) for further details.

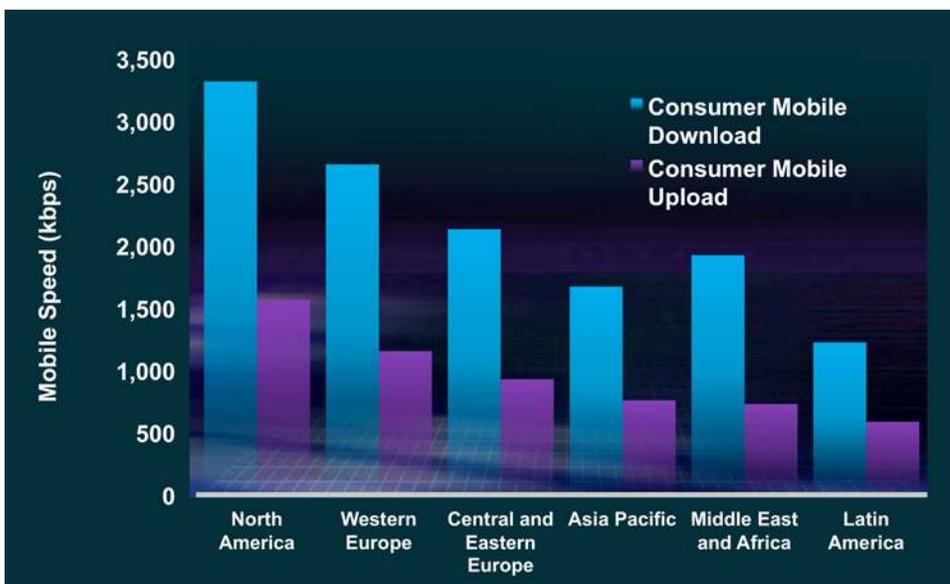
Figure 11. Regional Consumer Average Fixed Speeds, 2012



Consumer Average Mobile Download and Upload Speeds

- For consumer average mobile download speeds, North America leads with 3.3 Mbps and Western Europe follows with 2.7 Mbps.
- For consumer average mobile upload speeds, North America leads with 1.6 Mbps, and Western Europe follows with 1.2 Mbps (Figure 12). Please refer to [Appendix G](#) and the [Cisco GCI Supplement](#) for further details.

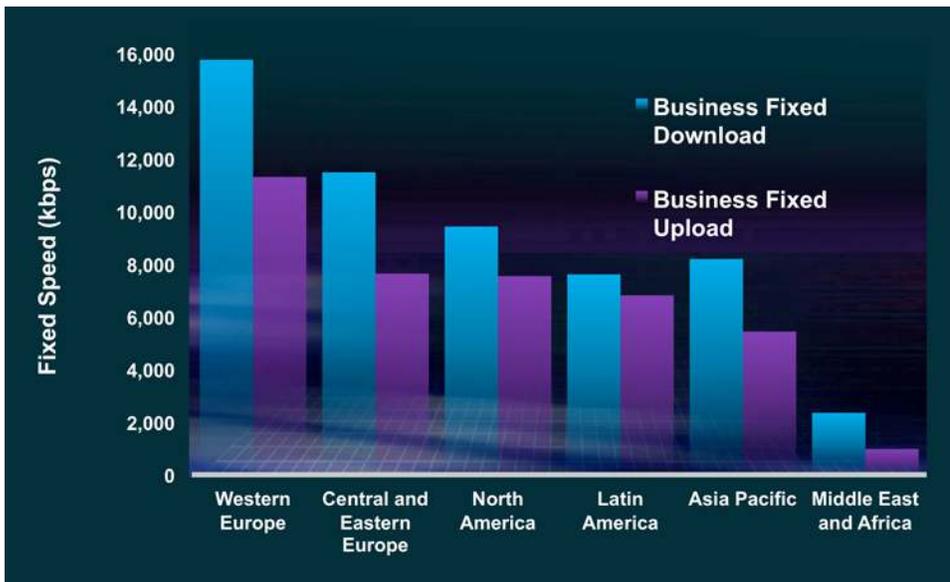
Figure 12. Regional Consumer Average Mobile Speeds, 2012



Business Average Fixed Download and Upload Speeds

- For business average fixed download speeds, Western Europe leads with 15.8 Mbps and Central and Eastern Europe is next with 11.5 Mbps.
- For business average fixed upload speeds, Western Europe leads with 11.3 Mbps and Central and Eastern Europe is next with 7.6 Mbps (Figure 13). Please refer to [Appendix G](#) and the [Cisco GCI Supplement](#) for further details.

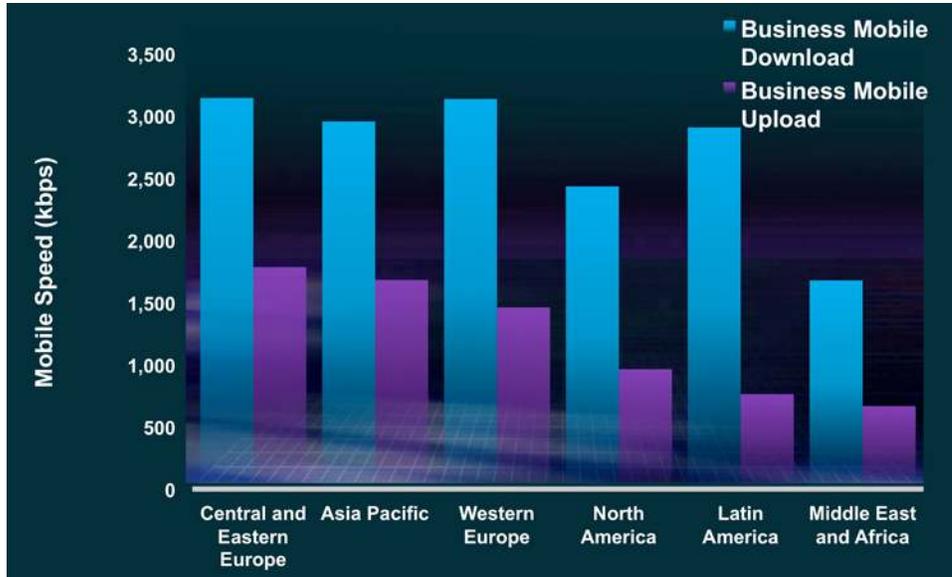
Figure 13. Regional Business Average Fixed Speeds, 2012



Business Mobile Download and Upload Speeds

- For business average mobile download speeds, Central and Eastern Europe leads with 3.14 Mbps and Western Europe follows with 3.13 Mbps.
- For business average mobile upload speeds, Central and Eastern Europe leads with 1.7 Mbps and Asia Pacific follows with 1.6 Mbps (Figure 14). Please refer to [Appendix G](#) and the [Cisco GCI Supplement](#) for further details.

Figure 14. Regional Business Average Mobile Speeds, 2012



Network Latency

- Global average fixed latency is 70 ms.
- Western Europe leads in average fixed latency with 58 ms and Central and Eastern Europe closely follows with 59 ms.
- Central and Eastern Europe leads in business average fixed latencies with 73 ms and North America is next with 93 ms.
- Western Europe leads in consumer average fixed latencies with 58 ms and Central and Eastern Europe is next with 59 ms.
- Global average mobile latency is 229 ms.
- Western Europe leads in average mobile latency with 142 ms and Central and Eastern Europe follows with 180 ms.
- Latin America leads in business average mobile latency with 231 ms and North America is next with 248 ms.
- Western Europe leads in consumer average mobile latency with 142 ms and North America is next with 179 ms. Please refer to [Appendix G](#) and the [Cisco GCI Supplement](#) for further details.

Conclusion

In summary, there are several main conclusions from the Cisco Global Cloud Index 2011–2016.

Global data center traffic is firmly in the zettabyte era and will nearly quadruple from 2011 to reach 6.6 zettabytes annually by 2016. A rapidly growing segment of data center traffic is cloud traffic, which will increase six-fold over the forecast period and represent nearly two-thirds of all data center traffic by 2016.

An important traffic promoter in the rapid expansion of cloud computing is increasing data center virtualization, which provides services that are flexible, fast to deploy, and efficient. Additional trends influencing the growth of cloud computing include the widespread adoption of multiple devices combined with increasing user expectations to access applications and content anytime, from anywhere, over any network. To address these rising user demands, cloud-based data centers can support more virtual machines and workloads per physical server than traditional data centers. By 2016, nearly two-thirds of all workloads will be processed in the cloud.

This study also considers the importance of broadband ubiquity and its relationship to cloud readiness. Based on the regional average download and upload speeds and latencies for business and consumer traffic on mobile and fixed connections, all regions can support at least a basic level of cloud services. The focus now turns to continuing to improve network capabilities to support the advanced cloud applications that organizations and end-users expect and rely upon.

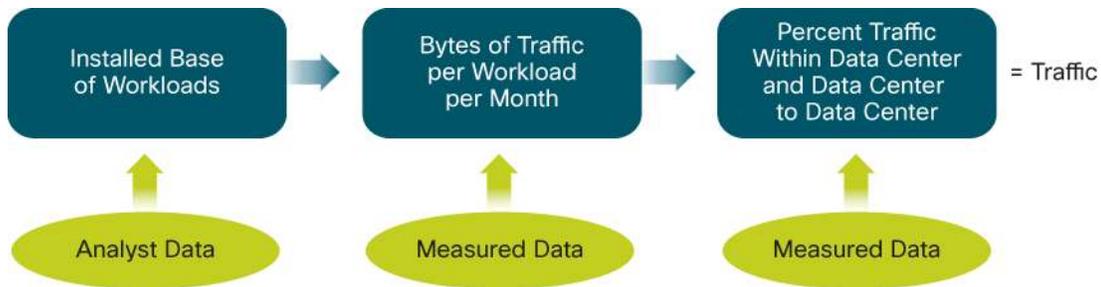
For More Information

For more information, please see www.cisco.com/go/cloudindex.

Appendix A: Data Center Traffic Forecast Methodology

Figure 15 outlines the methodology used to forecast data center and cloud traffic. The methodology begins with the installed base of workloads categorized by workload type and implementation and then applies the volume of bytes per workload per month to obtain the traffic for current and future years.

Figure 15. Data Center Traffic Forecast Methodology



Analyst Data

Data from several analyst firms and international agencies (including Gartner, IDC, Informa, Ovum, ITU, United Nations) was used as inputs to the Global Cloud Index analysis. For example, analyst data was considered to calculate an installed base of workloads by workload type and implementation (cloud or noncloud). The analyst input consisted of server shipments with specified workload types and implementations. Cisco then estimated the installed base of servers and the number of workloads per server to obtain an installed base of workloads.

Measured Data

Network data was collected from 10 enterprise and Internet centers. The architectures of the data centers analyzed vary, with some having a three-tiered and others a two-tiered architecture. For three-tiered data centers, data was collected from four points: the link from the access routers to the aggregation routers, the link from the aggregation switches or routers to the site or regional backbone router, the WAN gateway, and the Internet gateway. For two-tiered data centers, data was collected from three points: the link from the access routers to the aggregation routers, the WAN gateway, and the Internet gateway.

For enterprise data centers, any traffic measured northbound of the aggregation also carries non-data-center traffic to and from the local business campus. For this reason, to obtain ratios of the volume of traffic carried at each tier, it was necessary to measure the traffic by conversations between hosts rather than traffic between interfaces, so that the non-data-center conversations could be eliminated. The hosts at either end of the conversation were identified and categorized by location and type. To be considered data center traffic, at least one of the conversation pairs had to be identified as appearing in the link between the data center aggregation switch or router and the access switch or router. A volume of 40 terabytes of traffic for each month was analyzed. Included in this study were the 12 months ending September 2012.

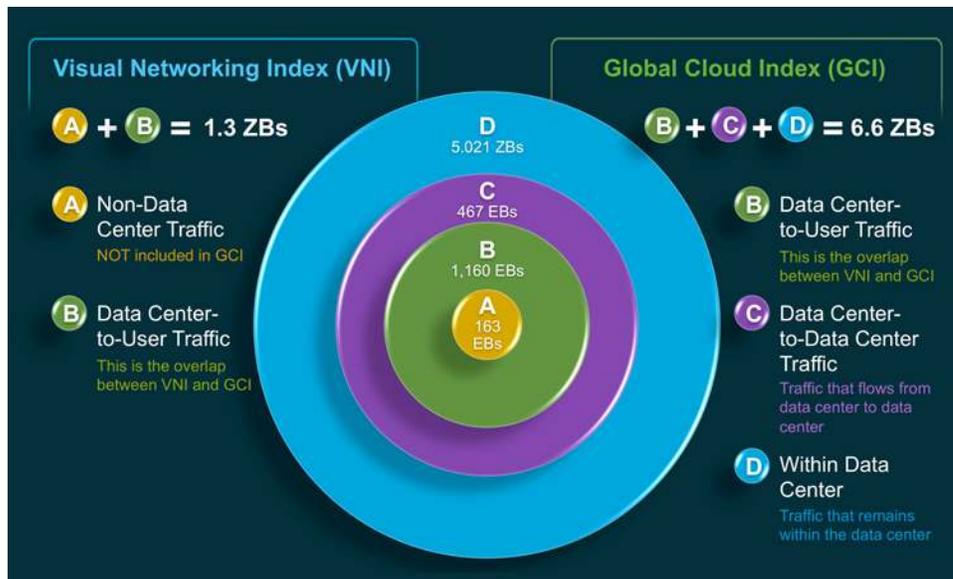
In addition, as noted in the white paper, the methodology for the estimation of cloud data center traffic has changed since the last release of the Cisco Global Cloud Index. The previous methodology included all storage traffic in the noncloud traffic category. The updated methodology includes storage traffic associated with cloud workloads in the cloud traffic category. For example, storage traffic associated with cloud application development would be counted as cloud traffic in the updated methodology, but would have been excluded in the previous methodology.

Appendix B: Global Cloud Index and Visual Networking Index

The Cisco Global Cloud Index and Cisco Visual Networking Index are distinct forecasts that have an area of overlap. The Cisco VNI forecasts the amount of traffic crossing the Internet and IP WAN networks, while the Cisco GCI forecasts traffic within the data center, from data center to data center, and from data center to user. The Cisco VNI forecast consists of data-center-to-user traffic, along with non-data-center traffic not included in the Cisco GCI (various types of peer-to-peer traffic).

The Cisco GCI includes data-center-to-user traffic (this is the overlap with the Cisco VNI) data-center-to-data-center traffic, and traffic within the data center. The Cisco VNI forecasts the amount of traffic crossing the Internet and IP WAN networks (Figure 16).

Figure 16. Cisco VNI and Global Cloud Index



Appendix C: Multiple Device Proliferation

The rapid growth in the adoption of multiple devices by end users, consumers and businesses alike, has been noted in this white paper as a major factor in the transition to cloud-based services that can provide ubiquitous access to content and applications through any device at any location.

Figures 17 and 18 demonstrate at a regional level the expansion of multiple device usage from 2011 to 2016. In 2011, North America led in average fixed devices per user, while Central and Eastern Europe led in average mobile devices per user. In 2016, North America is expected to lead in average fixed devices per user, while Western Europe takes a slight lead in mobile devices per user. Latin America and Central and Eastern Europe increase in both mobile and fixed average devices per user, while Middle East and Africa's increases are primarily in mobile devices.

Figure 17. Multiple Device Proliferation in 2011

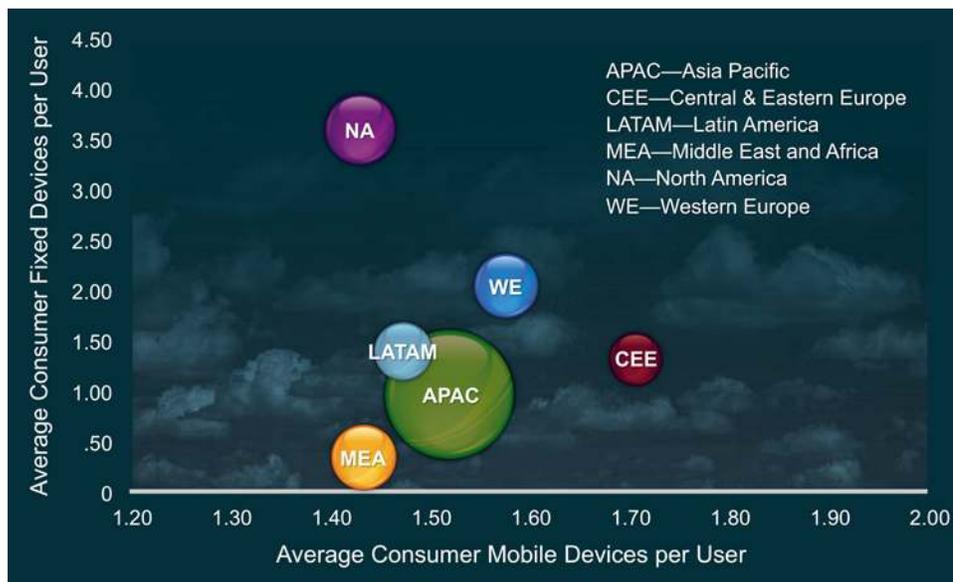
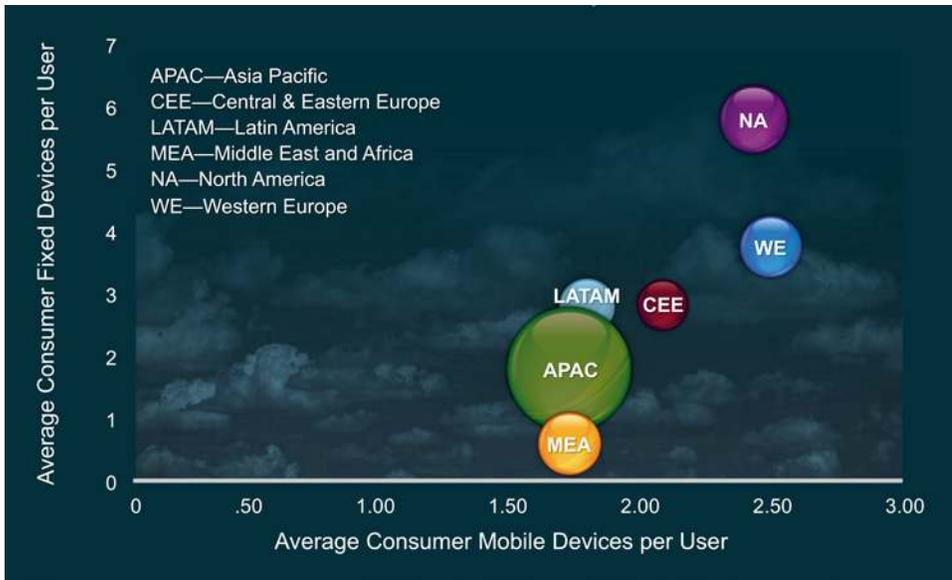


Figure 18. Multiple Device Proliferation in 2016



Appendix D: IPv6 and Cloud Traffic

As indicated by the Cisco Global Cloud Index, 2011–2016, strong cloud traffic growth is expected over the next few years. This growth is largely due to businesses, public sector organizations, and consumers who are increasingly connecting to business-critical applications, communications services, and interactive multimedia content through the cloud, using multiple devices.

Each network-connected device or node (including smartphones, tablets, PCs, TVs, and M2M) will require an IP address, but IPv4 address space is rapidly depleting. IPv6, however, is well-positioned to deliver the scalability and operational efficiencies that will deliver an environment where every “thing” could be part of the cloud.

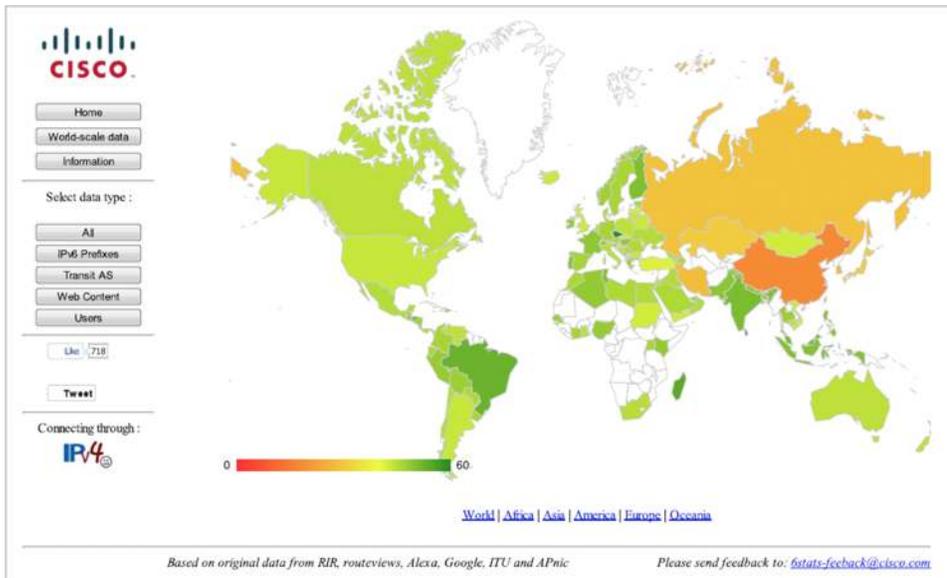
The IPv6 cloud transformation is already underway, with providers enabling IPv6 for their service offerings, including:

- Cisco WebEx[®] offering the first Collaboration Cloud service over IPv6 before year end, and the first to U.S. federal customers
- Cloud infrastructure providers such as Rackspace, Amazon, and OVH enabling IPv6 by default
- StratoGen managed hosting of 4 million domain names over IPv6
- Cloud services running over IPv6, such as Google Gmail or GDoc for enterprises and the public sector
- Content delivery network providers Akamai and Limelight deploying IPv6 throughout their infrastructures, and offering IPv6 caching and transition services to their enterprise customers

In addition, progress is being made in the IPv6 enablement of web content likely to traverse the cloud, including such popular sites as Facebook, YouTube, and Netflix. The Cisco IPv6 Lab tracks the top 500 websites in more than 120 countries, providing insights into the growing trend of web content available over IPv6 (Figure 19).

For example, in the Czech Republic, 59.4 percent of web pages are available over IPv6, and 52.9 percent are available in Brazil. Comparatively, France has 49 percent; while the United States has 43.8 percent. Some countries have much more room to grow in terms of IPv6 website availability, such as Russia (28.8 percent) or China (17.8 percent). Obviously these percentages of pages available to users with IPv6 connectivity are delivered from a relatively small number of websites that rank high as most visited. In other words, a small number of websites among the top visited sites account for the majority of the content visited over IPv6.

Figure 19. Global Websites Available over IPv6



Source: Cisco IPv6Lab, <http://6lab.cisco.com/stats>

Another perspective to consider is the capability of devices to connect to an IPv6 network when it becomes enabled. As forecast in the [Cisco VNI 2011–2016 Update](#), 40.3 percent of fixed and mobile devices will be IPv6-capable by 2016, increasing from 1.03 billion devices in 2011 to 7.6 billion in 2016, at a 49 percent CAGR.

With this convergence of cloud adoption and IPv6 enablement, the question is not if IPv6 cloud transformation will occur, but rather how quickly, and whether service providers and enterprises will be prepared to take advantage of the opportunities ahead.

“In a world of IPv4 scarcity, and as users will be connected using either IPv6 or shared IPv4, it is in both the interest of cloud providers and users to use end-to-end IPv6 connectivity to access their data and applications, without incurring the risk of impacting the performance, security, and user experience created by the IPv4 address sharing mechanism. It requires enterprise and cloud providers alike to enable IPv6 access to their applications whether they reside in the cloud or in their own data center.” – Alain Fiocco, Senior Director, Cisco IPv6 High Impact Project

Appendix E: Workload Distribution by Region

Tables 4, 5, and 6 summarize data center workloads by type and region.

Table 4. Regional Distribution of Total Data Center Workloads, in Millions

Region	2011	2012	2013	2014	2015	2016	CAGR 2011–16
Asia Pacific	23.0	28.1	36.0	45.8	55.7	66.7	24%
Central and Eastern Europe	2.2	2.7	3.6	4.9	6.4	8.0	29%
Latin America	2.3	3.0	4.4	6.4	8.7	11.4	38%
Middle East and Africa	1.0	1.3	2.0	3.0	4.6	6.8	48%
North America	26.4	31.5	36.5	40.0	43.4	47.1	12%
Western Europe	16.3	20.1	25.6	31.5	36.3	40.7	20%

Source: Cisco Analysis, 2012

Table 5. Regional Distribution of Cloud Workloads, in Millions

Region	2011	2012	2013	2014	2015	2016	CAGR 2011–16
Asia Pacific	6.7	10.6	16.2	23.2	31.2	40.6	43%
Central and Eastern Europe	0.7	1.0	1.7	2.5	3.7	5.0	50%
Latin America	0.7	1.1	2.0	3.3	5.0	7.2	60%
Middle East and Africa	0.3	0.5	0.9	1.5	2.6	4.2	73%
North America	8.1	12.5	17.1	21.0	25.1	29.7	30%
Western Europe	4.9	7.8	11.7	16.2	20.7	25.4	39%

Source: Cisco Analysis, 2012

Table 6. Regional Distribution of Traditional Data Center Workloads, in Millions

Region	2011	2012	2013	2014	2015	2016	CAGR 2011–16
Asia Pacific	16.3	17.4	19.8	22.6	24.5	26.0	10%
Central and Eastern Europe	1.6	1.7	2.0	2.4	2.7	3.0	14%
Latin America	1.6	1.8	2.3	3.0	3.6	4.2	21%
Middle East and Africa	0.7	0.8	1.1	1.5	2.0	2.6	30%
North America	18.3	19.0	19.3	19.0	18.2	17.4	-1%
Western Europe	11.4	12.4	13.8	15.3	15.6	15.3	6%

Source: Cisco Analysis, 2012

Appendix F: Cloud Traffic Growth by Region

Table 7 summarizes cloud traffic growth by region.

Table 7. Cloud Traffic Growth by Region, in Exabytes

Region	2011	2012	2013	2014	2015	2016	CAGR 2011–16
Asia Pacific	216	375	554	793	1,116	1,541	48%
Central and Eastern Europe	21	36	57	87	131	190	55%
Latin America	21	40	69	114	181	273	66%
Middle East and Africa	8	17	30	53	94	161	79%
North America	261	439	584	720	901	1,126	34%
Western Europe	156	274	400	557	743	964	44%

Source: Cisco Analysis, 2012

Appendix G: Regional Cloud Readiness Summary

Table 8 summarizes cloud readiness by region, considering download and upload speeds, and latency. Please refer to the [Cisco GCI Supplement](#) for more detail.

Table 8. Regional Cloud Readiness

Network	Segment	Region	Average Download Speeds (kbps)	Average Upload Speeds (kbps)	Average Latency (ms)
Fixed	Business	Asia Pacific	8,190	5,433	215
		Central and Eastern Europe	11,477	7,635	73
		Latin America	7,606	6,809	117
		Middle East and Africa	2,349	976	442
		North America	9,420	7,538	93
		Western Europe	15,755	11,305	94
		Business average		10,056	7,505
	Consumer	Asia Pacific	9,367	6,790	76
		Central and Eastern Europe	9,119	5,967	59
		Latin America	3,919	989	92
		Middle East and Africa	3,457	1,021	120
		North America	10,588	2,714	62
		Western Europe	11,610	2,515	58
		Consumer average		9,469	4,490
Fixed Average		9,438	4,514	70	
Mobile	Business	Asia Pacific	2,955	1,680	347
		Central and Eastern Europe	3,143	1,784	309
		Latin America	2,907	763	231
		Middle East and Africa	1,677	666	388
		North America	2,432	963	248
		Western Europe	3,136	1,461	264
		Business average		2,919	1,443
	Consumer	Asia Pacific	1,670	757	449
		Central and Eastern Europe	2,130	927	197
		Latin America	1,222	585	247
		Middle East and Africa	1,922	727	323
		North America	3,315	1,563	179
		Western Europe	2,651	1,152	142
		Consumer average		2,209	967
Mobile Average		2,218	964	229	

Source: Cisco Analysis, 2012

Appendix H: Broadband Ubiquity

Tables 9 and 10 summarize regional broadband penetration for 2011 and 2016. The methodology for the estimation of broadband and Internet ubiquity has changed since the initial release of the Global Cloud Index in 2011. This year, internal projections were used based on a bottom-up approach that includes estimating broadband lines and average users per household, and then validating the country estimates against country-specific telecom-reported data. On the mobile side, the approach focuses on mobile Internet users instead of subscriptions, which prevents duplicative calculations (as some users may have multiple subscriptions).

Table 9. Regional Broadband Penetration (Percentages Indicate Users with Broadband Access Per Region) in 2011

Region	Fixed Broadband Subscriptions (2011)	Mobile Broadband Users (2011)	Population (2011)
Asia Pacific	815,516,524 (21%)	627,271,466 (16%)	3,880,762,984
Central and Eastern Europe	92,426,466 (19%)	67,546,558 (14%)	491,195,658
Latin America	141,743,264 (23%)	79,083,243 (13%)	605,241,915
Middle East and Africa	223,884,843 (17%)	74,891,178 (6%)	1,305,228,573
North America	226,280,637 (63%)	106,975,042 (30%)	360,824,514
Western Europe	252,360,141 (58%)	111,968,203 (26%)	434,200,925

Source: Cisco Analysis, 2012

Table 10. Regional Broadband Penetration (Percentages Indicate Users with Broadband Access Per Region) in 2016

Region	Fixed Broadband Subscriptions (2016)	Mobile Broadband Users (2016)	Population (2016)
Asia Pacific	1,130,347,660 (28%)	1,689,910,551 (42%)	4,066,889,702
Central and Eastern Europe	113,441,563 (23%)	210,862,009 (42%)	498,003,945
Latin America	178,876,168 (28%)	251,529,890 (39%)	639,071,873
Middle East and Africa	350,433,532 (24%)	426,103,680 (29%)	1,458,984,051
North America	232,197,863 (62%)	216,644,001 (58%)	376,433,836
Western Europe	269,376,918 (61%)	247,291,265 (56%)	442,819,648

Source: Cisco Analysis, 2012

Appendix I: Regional Download and Upload Peak Speeds

Download and upload peak speeds measured are shown in Table 11.

Table 11. Regional Download and Upload Peak Speeds

Network	Segment	Region	Peak Download Speeds (kbps)	Peak Upload Speeds (kbps)		
Fixed	Business	Asia Pacific	100,418	85,023		
		Central and Eastern Europe	931,107	663,801		
		Latin America	43,318	59,257		
		Middle East and Africa	145,720	97,122		
		North America	61,237	479,006		
		Western Europe	218,480	243,480		
	Consumer	Asia Pacific	34,118	130,832		
		Central and Eastern Europe	44,141	315,950		
		Latin America	15,280	166,218		
		Middle East and Africa	15,798	136,316		
		North America	36,096	246,634		
		Western Europe	49,618	406,175		
		Mobile	Business	Asia Pacific	16,634	21,166
				Central and Eastern Europe	21,835	19,736
Latin America	32,889			33,216		
Middle East and Africa	16,992			18,085		
North America	10,894			36,252		
Western Europe	15,485			16,068		
Consumer	Asia Pacific		5,273	19,152		
	Central and Eastern Europe		7,563	13,414		
	Latin America		3,969	13,600		
	Middle East and Africa		5,577	9,240		
	North America		18,172	42,198		
	Western Europe		8,479	16,357		

Source: Cisco Analysis, 2012



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