White Paper

Cisco Global Cloud Index: Forecast and Methodology, 2012–2017

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 7.7 zettabytes by the end of 2017. By 2017, global data center IP traffic will reach 644 exabytes per month (up from 214 exabytes per month in 2012).
- Global data center IP traffic will nearly triple over the next 5 years. Overall, data center IP traffic will grow at a compound annual growth rate (CAGR) of 25 percent from 2012 to 2017.

Data center virtualization and cloud computing transition:

- The ratio of workloads to non-virtualized traditional servers will increase from 1.7 in 2012 to 2.3 by 2017.
- The ratio of workloads to non-virtualized cloud servers will increase from 6.5 in 2012 to 16.7 by 2017.
- By 2017, nearly two-thirds of all workloads will be processed in the cloud.

Global cloud traffic:

- Annual global cloud IP traffic will reach 5.3 zettabytes by the end of 2017. By 2017, global cloud IP traffic will reach 443 exabytes per month (up from 98 exabytes per month in 2012).
- Global cloud IP traffic will increase nearly 4.5-fold over the next 5 years. Overall, cloud IP traffic will grow at a CAGR of 35 percent from 2012 to 2017.
- Global cloud IP traffic will account for more than two-thirds of total data center traffic by 2017.

Regional cloud readiness:

- North America and Western Europe led in broadband access (fixed and mobile) in 2012 and will continue to lead in this category through 2017. However, all regions will show measurable improvement in broadband access to their respective populations throughout the forecast period. Central and Eastern Europe will have the highest growth in fixed and mobile broadband penetration between 2012 and 2017. 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 14.4 Mbps. North America follows with an average fixed download speed of 13.1 Mbps. Central and Eastern Europe and Asia Pacific lead all regions in average fixed upload speeds with 7.4 Mbps and 6.1 Mbps, respectively (see Download and Upload Speed Overview section for details).
- Central and Eastern Europe and Western Europe and lead all regions in average fixed network latency with 56 ms and 57 ms, respectively (refer to Network Latency section for details). North America leads all regions with an average mobile download speed of 11.2 Mbps. Western Europe follows with an average mobile download speed of 9.4 Mbps. Central and Eastern Europe and North America lead all regions in average mobile upload speeds with 5.4 Mbps and 4.7 Mbps, respectively (refer to Download and Upload Speed Overview section for details).
- Western Europe and North America lead all regions in average mobile network latency with 106 ms and 114 ms, respectively (refer to Network Latency section for details).

Top Five Data Center and Cloud Networking Trends

Over the last few years, the telecommunications industry has seen cloud adoption evolve 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 into the cloud. And for consumers, cloud services offer ubiquitous access to content and services, on multiple devices, delivered to almost anywhere network users are located.

The following sections identify five important trends in data center and cloud networking that are driving traffic growth, changing the end-user experience, and placing new requirements and demands on data center and cloud-based infrastructures.

1. Growth of Global Data Center Relevance and Traffic
2. Continued Global Data Center Virtualization
3. Remote Data Services and Storage Access Services Growth
4. Internet of Everything (IoE) and IPv6 Adoption Foster Cloud Traffic Growth
5. Global Cloud Readiness

Trend 1: Growth of Global Data Center Relevance and Traffic

The main qualitative 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.

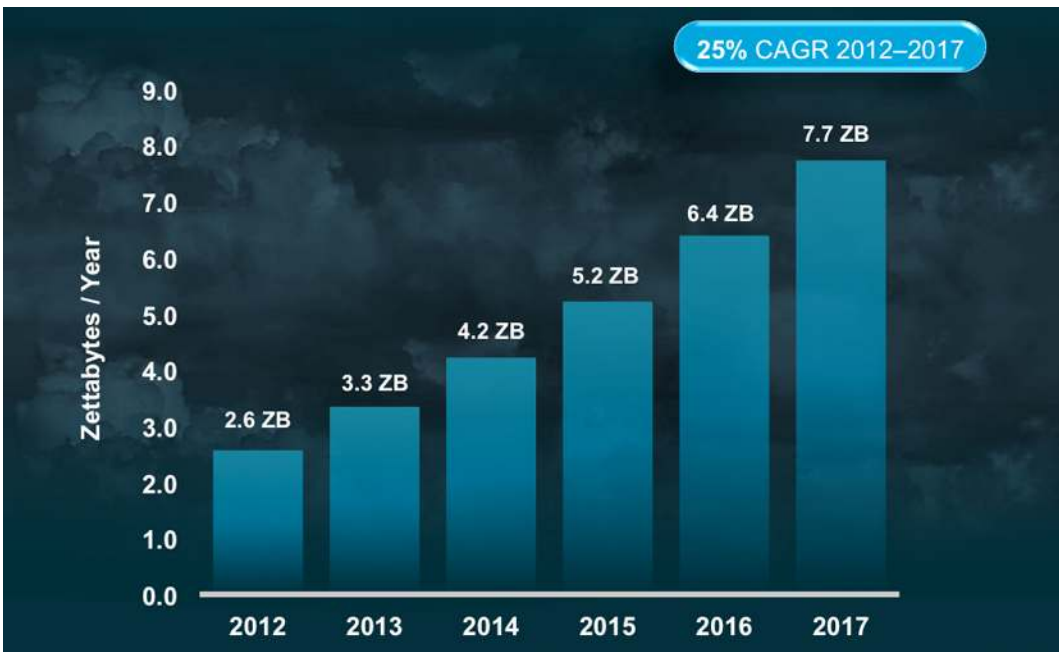
Quantitatively, the impact of cloud computing on data center traffic is clear. It is important to recognize that most Internet traffic has originated or terminated in a data center since 2008. Data center traffic will continue to dominate Internet traffic for the foreseeable future, but the nature of 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 2017 sixty-nine percent, or over 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, cloud versus traditional data center segments, and business versus consumer cloud segments.

Global Data Center IP Traffic: Three-Fold Increase by 2017

Figure 1 summarizes the forecast for data center IP traffic growth from 2012 to 2017.

Figure 1. Global Data Center IP Traffic Growth



While the amount of traffic crossing the Internet and IP WAN networks is projected to reach 1.4 zettabytes per year in 2017[1], the amount of data center traffic is already 2.6 zettabytes per year—and by 2017 will triple to reach 7.7 zettabytes per year. This represents a 25 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.

Table 1 provides details for global data center traffic growth rates.

Table 1. Global Data Center Traffic, 2012–2017

Data Center IP Traffic, 2012–2017							
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**CAGR 2012–2017**
By Type (EB per Year)							
Data center to user	427	560	711	883	1,086	1,317	25%
Data center to data center	167	221	281	352	435	530	26%
Within data center	1,971	2,560	3,223	3,978	4,867	5,879	24%
By Segment (EB per Year)							
Consumer	1,952	2,585	3,301	4,123	5,097	6,211	26%
Business	613	756	914	1,091	1,291	1,515	20%
By Type (EB per Year)							
Cloud data center	1,177	1,755	2,419	3,224	4,178	5,313	35%
Traditional data center	1,389	1,586	1,795	1,989	2,210	2,413	12%
Total (EB per Year)							
Total data center traffic	2,565	3,341	4,215	5,214	6,387	7,726	31%

Source: Cisco Global Cloud Index, 2013

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 non-cloud consumer and business applications

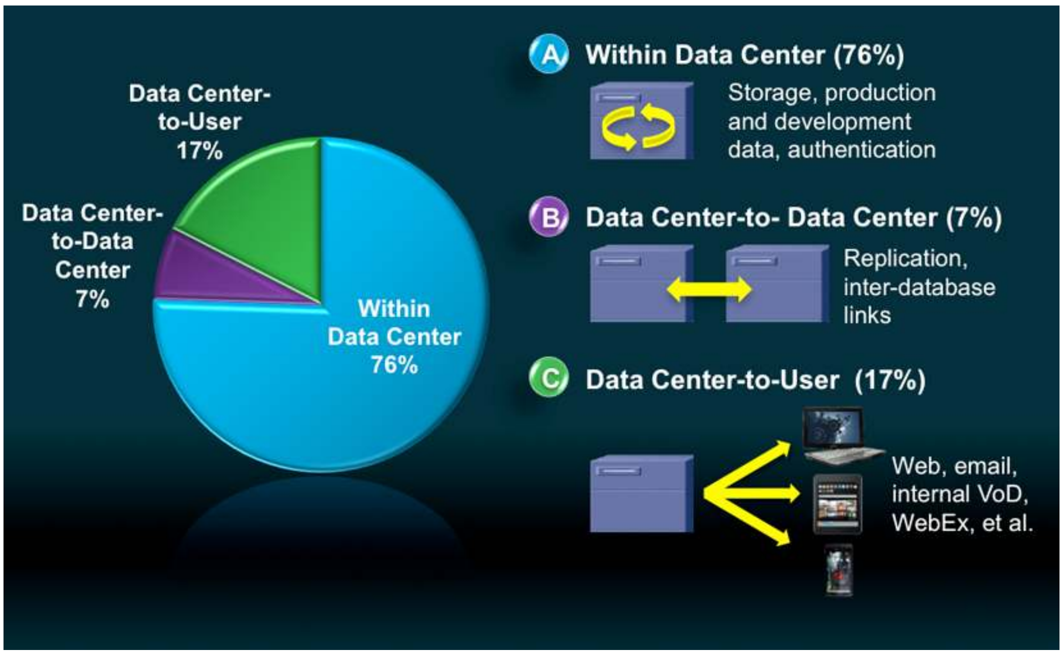
[1] See Cisco Visual Networking Index: Forecast and Methodology, 2012–2017.

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

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 2012 and 2017. 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.

Global Data Center and Cloud IP Traffic Growth

Data center traffic on a global scale will grow at a 25 percent CAGR (Figure 3), but cloud data center traffic will grow at a faster rate (35 percent CAGR) or 4.5-fold growth from 2012 to 2017 (Figure 4).

Figure 3. Total Data Center Traffic Growth

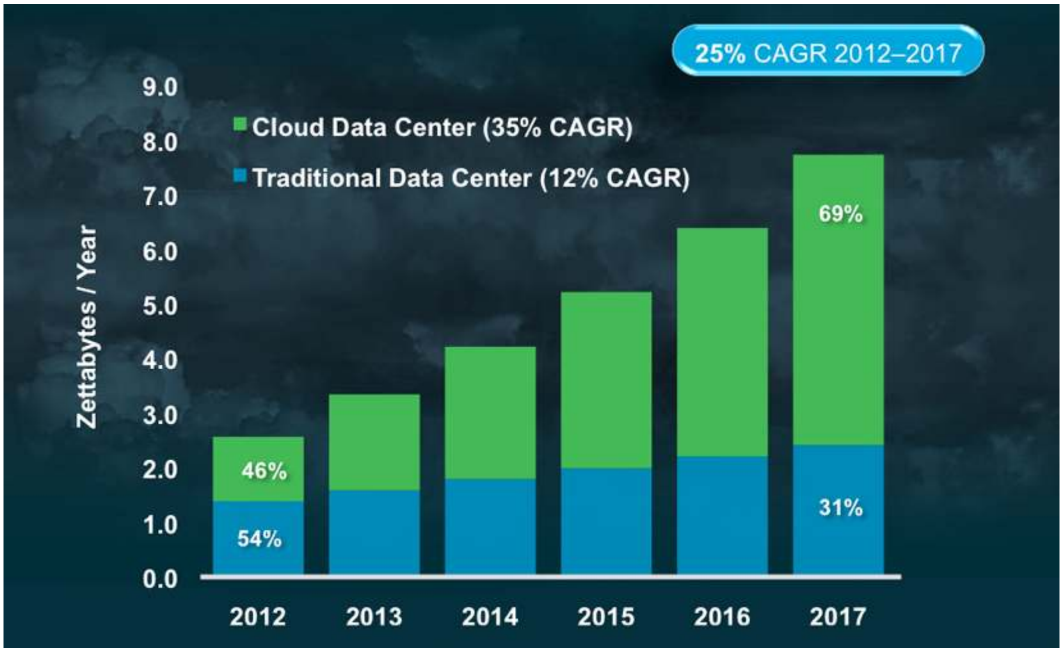


Figure 4. Cloud Data Center Traffic Growth

Global cloud traffic crossed the zettabyte threshold in 2012, and by 2017, over two-thirds of all data center traffic will be based in the cloud. (For regional cloud traffic trends, please see Appendix C.) Cloud traffic will represent 69 percent of total data center traffic by 2017.

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 36 percent, reaching 4.3 ZB annually by 2017. Business cloud traffic grows at a CAGR of 31 percent, increasing to 1.0 ZB annually by 2017. Table 2 provides details for global consumer and business cloud traffic growth rates.

Table 2. Global Cloud Traffic, 2012–2017

Cloud IP Traffic, 2012–2017							
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**CAGR 2012–2017**
By Segment (EB per Year)							
Consumer	918	1,384	1,923	2,581	3,368	4,310	36%
Business	259	371	496	644	810	1,004	31%
Total (EB per Year)							
Total cloud traffic	1,177	1,755	2,419	3,224	4,178	5,313	35%

Source: Cisco Global Cloud Index, 2013

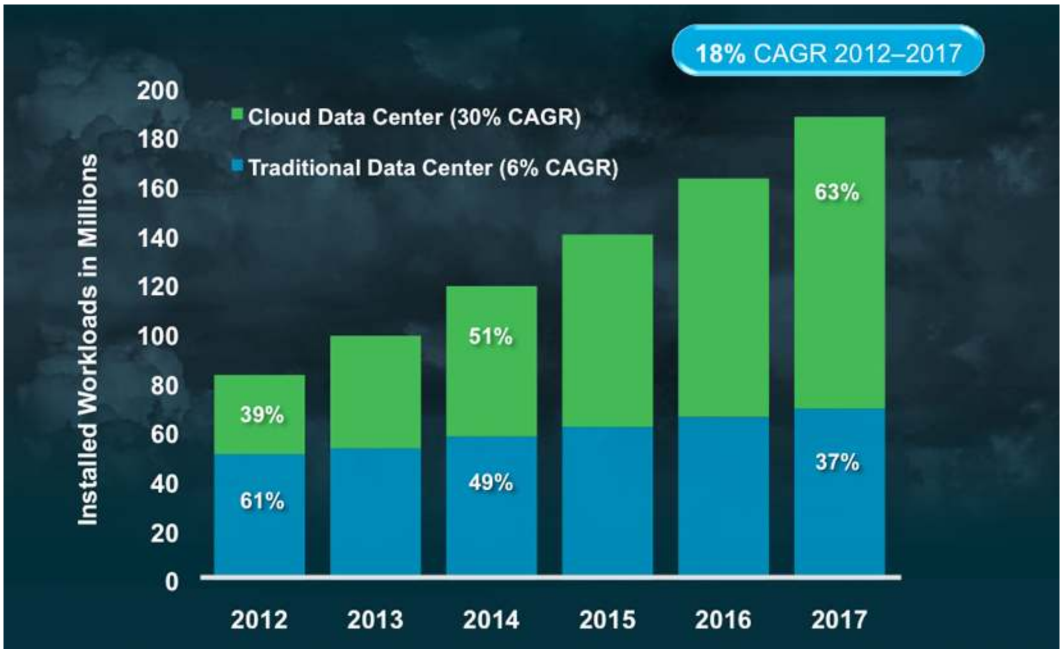
Real-time and time-sensitive applications are contributing to increased cloud adoption in both the business and consumer segments. For business, the necessity to provide fast and flexible access to large data archives is an important objective for IT organizations considering cloud-based solutions. In 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 contributors to cloud traffic growth, while newer services such as personal content lockers are also gaining in popularity.

Trend 2: Continued Global Data Center Virtualization

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 2017, nearly two-thirds of all workloads will be processed in cloud data centers (Figure 5). For regional distributions of workloads, see Appendix D.

Figure 5. Workload Distribution: 2012–2017



Growth of workloads in cloud data centers is expected to be five times the growth in traditional workloads between 2012 and 2017. 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 data centers in different geographic areas). Often an end-user application can be supported by several workloads distributed across servers. This approach can generate multiple streams of traffic within and between data centers, in addition to traffic to and from the end user. Table 3 provides details on the shift of workloads from traditional data centers to cloud data centers.

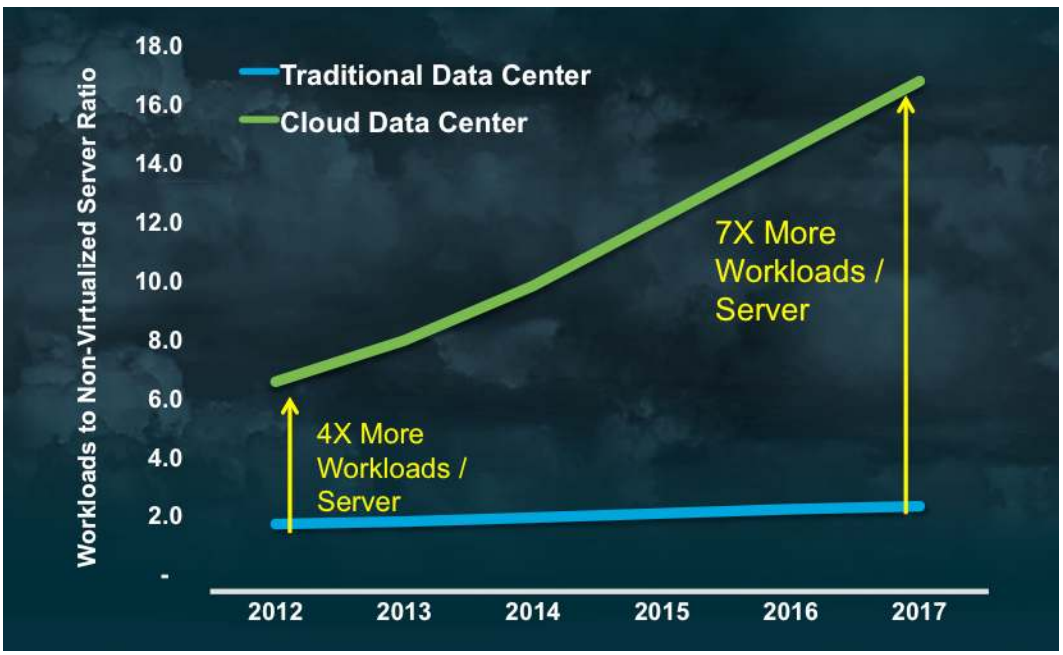
Table 3. Workload Shift from Traditional Data Centers to Cloud Data Centers

Global Data Center Workloads in Millions							
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**CAGR 2012–2017**
Traditional data center workloads	51.2	53.5	58.4	62.3	66.3	69.7	6%
Cloud data center workloads	32.2	45.7	61.1	78.1	96.8	118.5	30%
Total data center workloads	83.4	99.3	119.5	140.4	163.2	188.2	18%
Cloud workloads as a percentage of total data center workloads	39%	46%	51%	56%	59%	63%	NA
Traditional workloads as a percentage of total data center workloads	61%	54%	49%	44%	41%	37%	NA

Source: Cisco Global Cloud Index, 2013

One of the main factors affecting this migration of workloads from traditional data centers to cloud data centers is the greater degree of virtualization (Figure 6) in the cloud space, which allows dynamic deployment of workloads in the cloud to meet the dynamic demand of cloud services. The ratio of workloads to non-virtualized cloud servers will grow from 6.5 in 2012 to nearly 16.7 by 2017. In comparison, the ratio of workloads to non-virtualized traditional data center servers will grow from 1.7 in 2012 to 2.3 in 2017.

Figure 6. Increasing Cloud Virtualization



Trend 3: Remote Data Services and Storage Access Services Growth

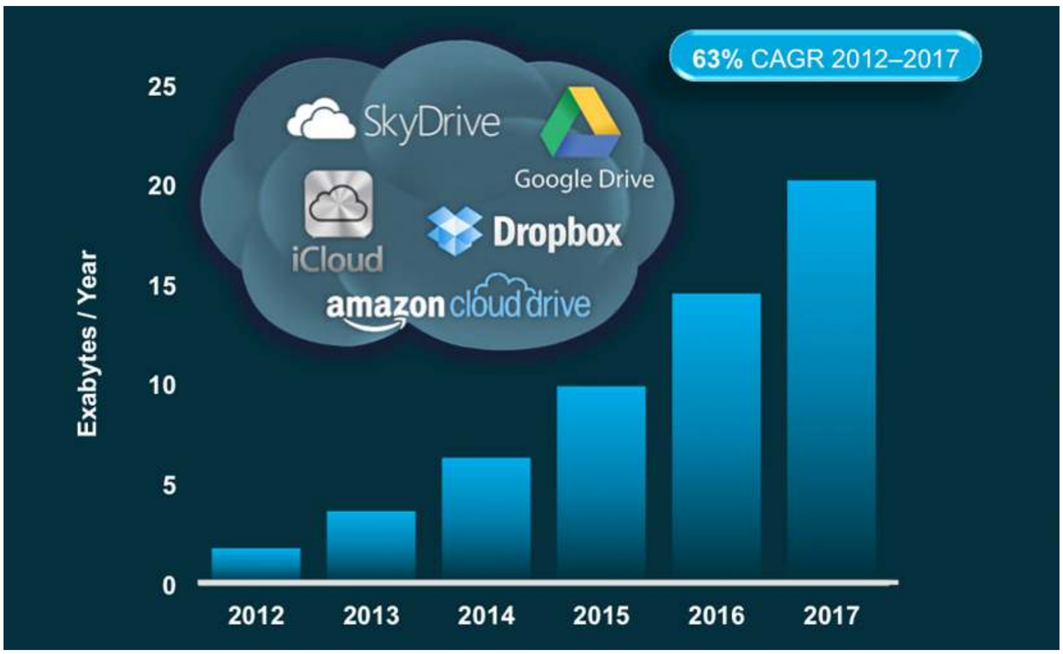
This section reviews the growth of cloud services, such as personal content lockers and enterprise remote data storage and access services.

Personal Content Locker Traffic Growth

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 1.7 EB annually in 2012 to 20 EB in 2017, at a CAGR of 63 percent (Figure 7).

Figure 7. Personal Content Locker Traffic Growth



Enterprise Remote Data Storage and Access Services

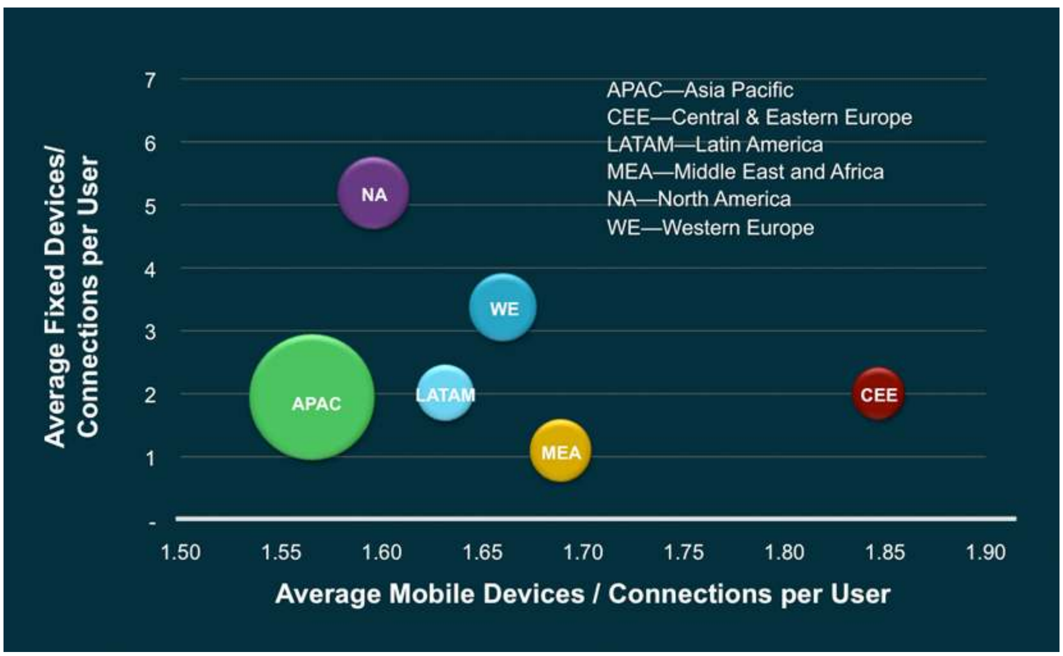
Cloud-based storage and access solutions offer scalable and cost-effective options for managing the volumes of data being generated by enterprises of all sizes. In a recent Gartner global survey of over 500 organizations in multiple verticals, 20 percent of respondents indicated they are using cloud-based storage services for part or all of their storage requirements. While the pay-as-you-go model addresses the needs of small businesses for flexibility and cost management, larger enterprises will be looking for increased emphasis on service reliability and security, as well as value-added services such as file sharing and synchronization.

Trend 4: Internet of Everything (IoE) and IPv6 Adoption Foster Cloud Traffic Growth

The rapid growth in the adoption of multiple devices by end users, consumers and businesses alike, is 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.

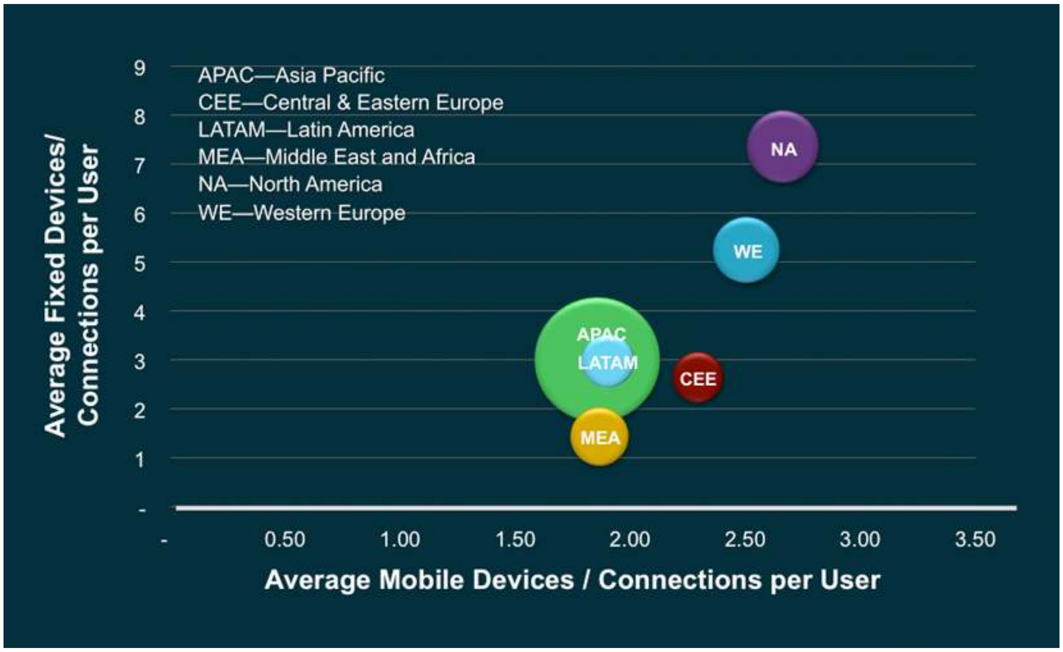
Figures 8, 9, and 10 demonstrate the projected expansion of multiple device usage at a regional level from 2012 to 2017. In 2012, North America led in average fixed devices per user, while Central and Eastern Europe led in average mobile devices per user. By 2017, North America is expected to lead both in average fixed devices per user, as well as average mobile devices per user. All the regions continue to show growth in both mobile and fixed average devices per user. Many mobile devices have dual-mode capabilities. This growth, in turn, creates a demand for cloud services and content that can be accessed across multiple devices and using any mode of access—fixed or mobile.

Figure 8. Multiple Device Proliferation in 2012



The size of the bubbles represents the total number of devices for the region.

Figure 9. Multiple Device Proliferation by 2017



The size of the bubbles represents the total number of devices for the region.

Cloud-based services are also essential to the Internet of Everything, which increases the ability for people, data, and things to communicate with one another over the Internet. According to Machina Research, machine-to-machine (M2M) connections are expected to grow five times faster than smart devices from 2012 to 2022, and 22 times faster than the global population.

Furthermore, Machina Research forecasts that trillions of M2M "events" (a data transmission from a networked M2M node over a WAN connection) will be generated to power the Internet of Everything, totaling over 84 trillion events per year by 2022. As shown in Figure 10, Smart Office events are expected to grow from 3.6 trillion in 2012 to 9.8 trillion by 2022, at a 10 percent CAGR. Smart Home events are expected to grow from 1.5 trillion in 2012 to 47.8 trillion by 2022, at a 42 percent CAGR. Cloud-based services will be instrumental in facilitating and managing the volume and complexity of these events and allowing even greater connectivity growth and functionality.

Figure 10. Internet of Everything Generating Trillions of Network "Events"

Another important component of the Internet of Everything and adoption of cloud services is the growth of IPv6 capability in devices, network connectivity, content enablement, and users. According to Google, the percentage of IPv6 users globally has doubled in the last year, reaching 2 percent of their global user base in September 2013. In comparison, it took more than two years to reach 1 percent of their global users. In addition, recent advancements in IPv6 network deployment signify service providers' focus on IPv6 connectivity on both mobile and fixed networks. This is projected to generate IPv6 traffic growth, potentially reaching 24 percent of global Internet traffic by 2017. (Refer to the Cisco VNI white paper, "The Zettabyte Era," for more detail.) In addition, content providers are continuing to make strides in IPv6, enabling video and other rich media content. Based on industry feedback, the IPv6 cloud looks similar to the IPv4 cloud, with video making up a significant percentage of the downstream traffic profile.

Trend 5: 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 11 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 11. 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 Ookla[2], 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 E.

The cloud readiness characteristics are as follows.

[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 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

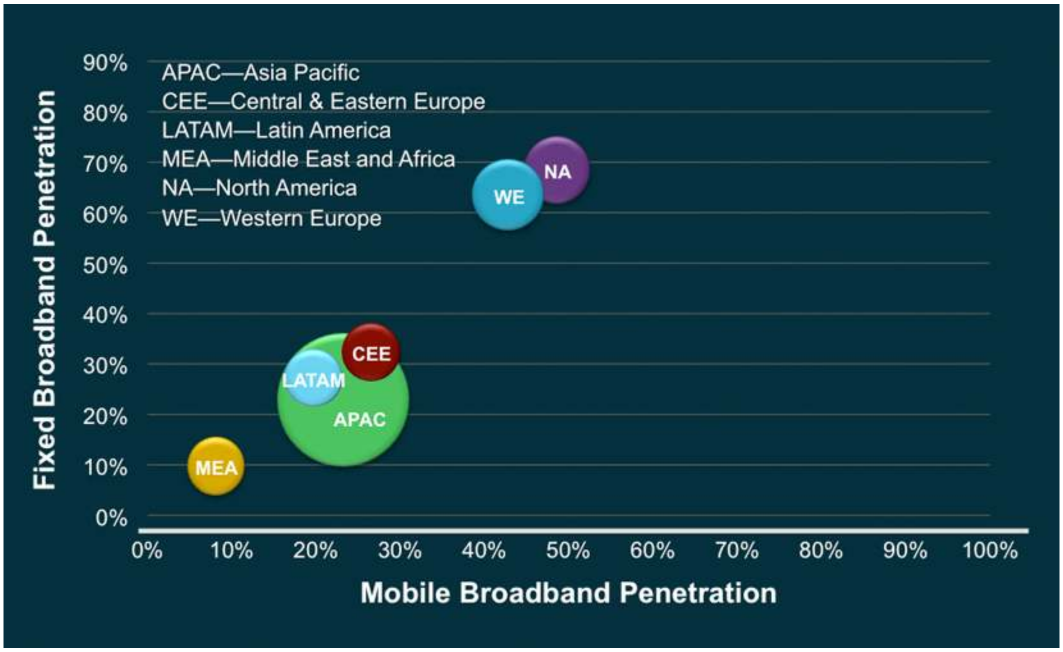
- **Download speed**: With increased adoption of mobile and fixed bandwidth-intensive applications, end-user download speed is an important characteristic. This indicator will continue to be critical for the quality of service delivered to virtual machines, customer relationship management (CRM), and enterprise resource planning (ERP) cloud platforms for businesses, 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.
- **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 12 and 13 summarize broadband penetration by region in 2012 and 2017. North America and Western Europe led in broadband access (fixed and mobile) in 2012 and will continue to lead by 2017. 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.

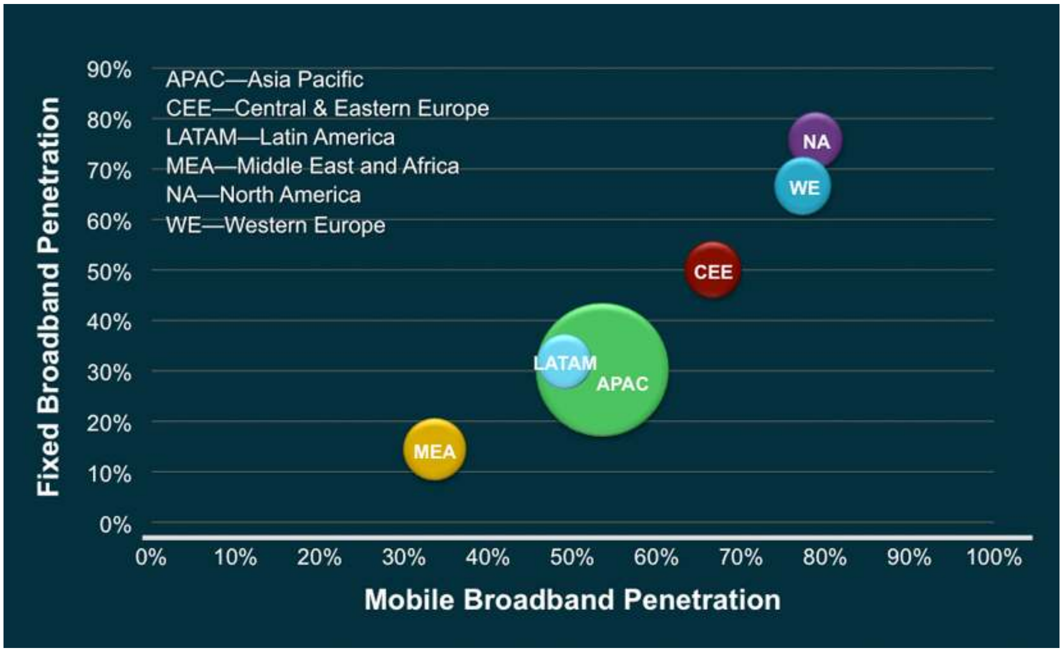
For broadband ubiquity, we use internal projections and a bottom-up approach that includes estimating broadband lines and average users per household, and then validating the country estimates against country-specific telecom-reported data. On the mobile side, the approach focuses on mobile Internet users instead of subscriptions, which prevents duplicative calculations (because some users may have multiple subscriptions). Please refer to Appendix F for further details.

Figure 12. Regional Broadband Ubiquity, 2012



The size of the bubbles represents the total Internet population of the region.

Figure 13. Regional Broadband Ubiquity, 2017



The size of the bubbles represents the total Internet population of the region.

Global Average Download and Upload Speed Overview (2013)

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. To support cloud services and applications, the quality of the broadband connection is critical. While theoretical speeds offered by fixed and mobile operators can seem high, many extraneous factors are involved in the actual network measurements. Speeds and latencies vary within each country and region, based on urban and rural deployment of fixed and mobile broadband technology, proximity to traditional and cloud data centers, and the quality of Customer Premises Equipment (CPE).

Lesser variability in download speeds, upload speeds, and latency will allow consumers to access advanced cloud applications consistently throughout the country. To measure this variability, we have also included the median download speeds and median upload speeds, along with the update to the mean or average download speeds and upload speeds, all measured in kilobits per second (kbps) or megabits per second (Mbps).

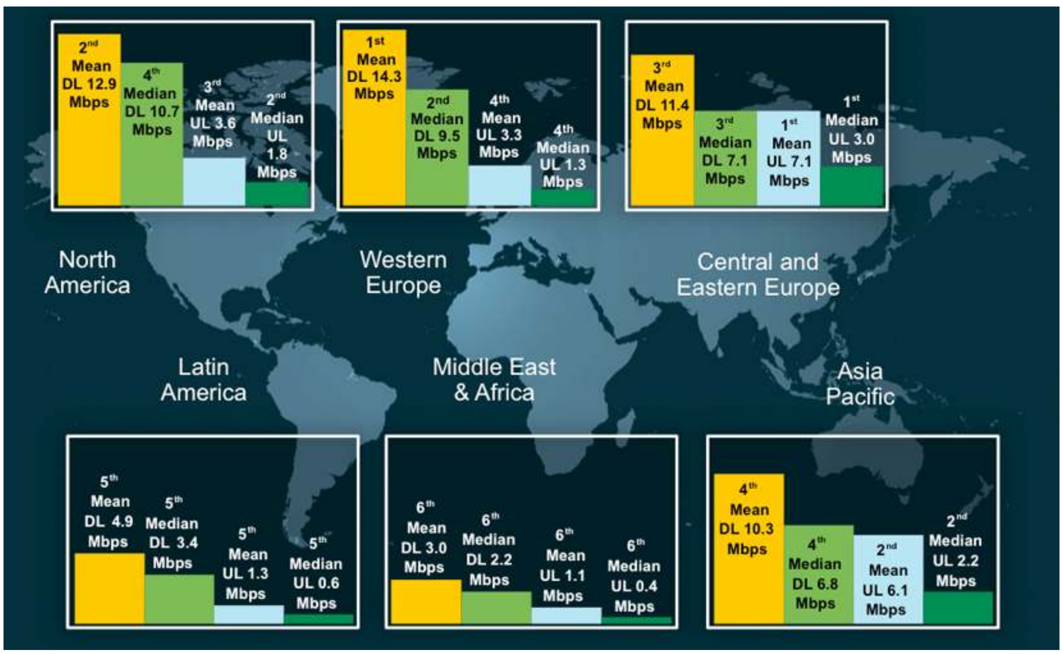
Key Results

- The global average fixed download speed is 11.2 Mbps, and the global median fixed download speed is 7.7 Mbps.
- The global average fixed upload speed is 4.8 Mbps, and the global median upload speed is 1.9 Mbps.
- The global average mobile download speed is 6.9 Mbps, and the global median mobile download speed is 4.3 Mbps.
- The global average mobile upload speed is 3.5 Mbps, and the global median mobile upload speed is 1.2 Mbps.

Consumer Average Fixed Download and Upload Speeds

- For consumer average fixed download speeds, Western Europe leads with 14.3 Mbps and North America follows with 12.9 Mbps.
- For consumer average fixed upload speeds, Central and Eastern Europe leads in with 7.1 Mbps and Asia Pacific follows with 6.1 Mbps (Figure 14). Please refer to Appendix E and the Cisco GCI Supplement for further details.
- Median fixed consumer speeds are lower than the mean fixed consumer speeds, as shown in Figure 14, due to a higher distribution of speeds in the region that are lower than the mean. Besides the required network characteristics for advanced cloud application, for an optimal end-user experience in larger user bases with cloud services, the majority of speeds must also be closer to the mean. This is a key factor.

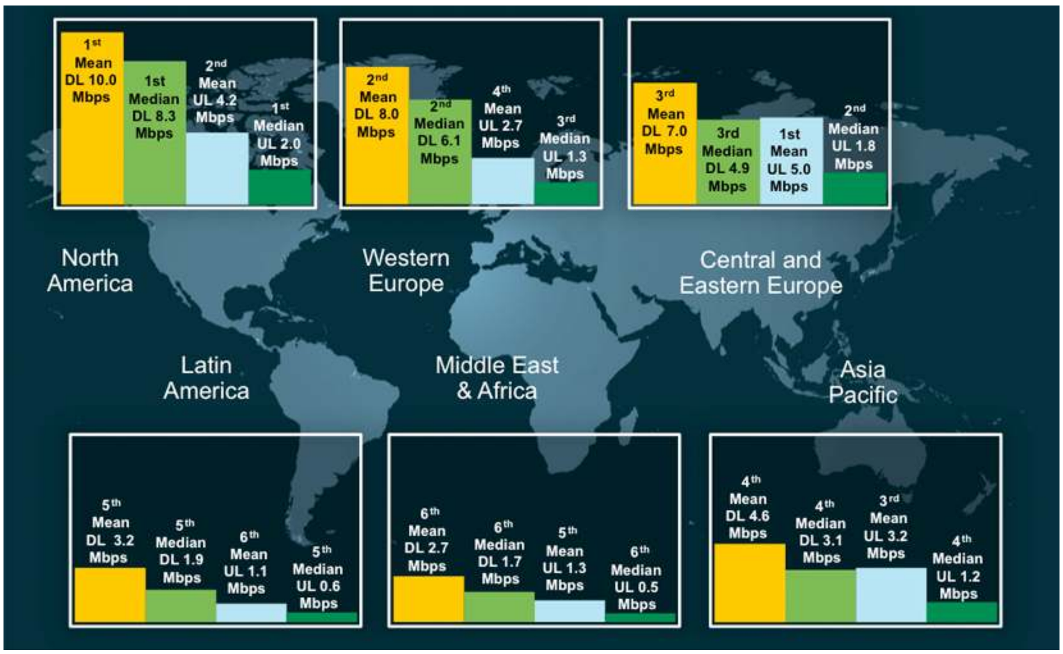
Figure 14. Regional Consumer Average Fixed Speeds, 2013



Consumer Average Mobile Download and Upload Speeds

- For consumer average mobile download speeds, North America leads with 10 Mbps and Western Europe follows with 8.0 Mbps.
- For consumer average mobile upload speeds, North America leads with 8.3 Mbps, and Western Europe follows with 6.1 Mbps (Figure 15). Please refer to Appendix E and the Cisco GCI Supplement for further details.
- Median consumer mobile speeds are lower than mean consumer mobile speeds within all regions, with the distribution of speeds in the regional population tending to be lower than the average.

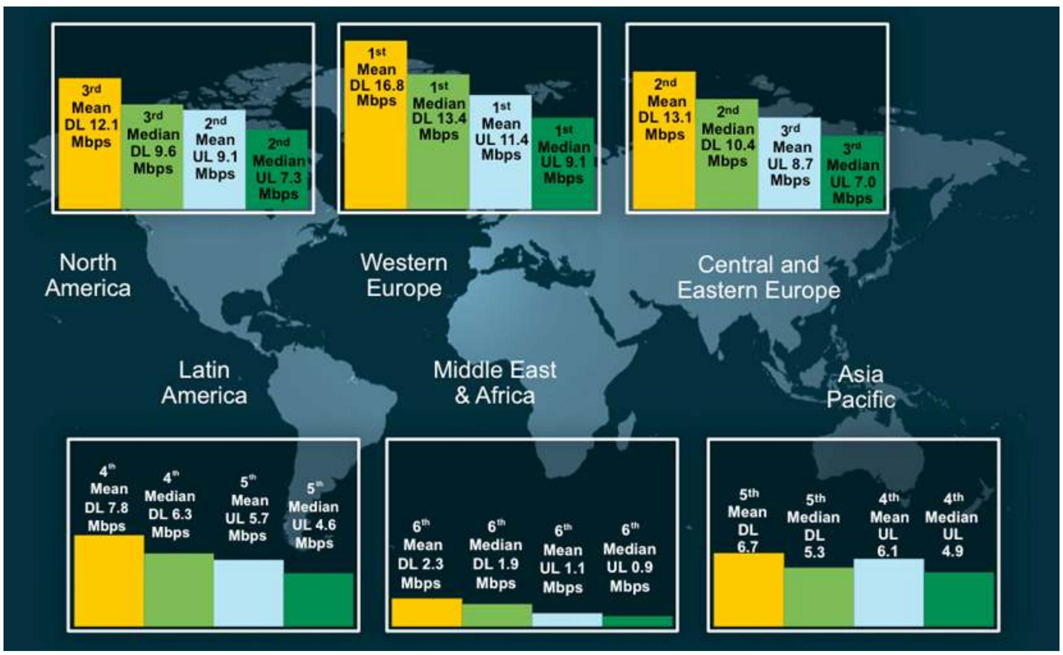
Figure 15. Regional Consumer Average Mobile Speeds, 2013



Business Average Fixed Download and Upload Speeds

- For business average fixed download speeds, Western Europe leads with 16.8 Mbps followed by Central and Eastern Europe with 13.1 Mbps.
- For business average fixed upload speeds, Western Europe leads with 11.4 Mbps followed by North America with 9.1 Mbps (Figure 16). Please refer to Appendix E and the Cisco GCI Supplement for further details.
- Median business fixed speeds are lower than mean business fixed speeds within all regions, with the distribution of speeds in the regional population tending to be lower than the average.

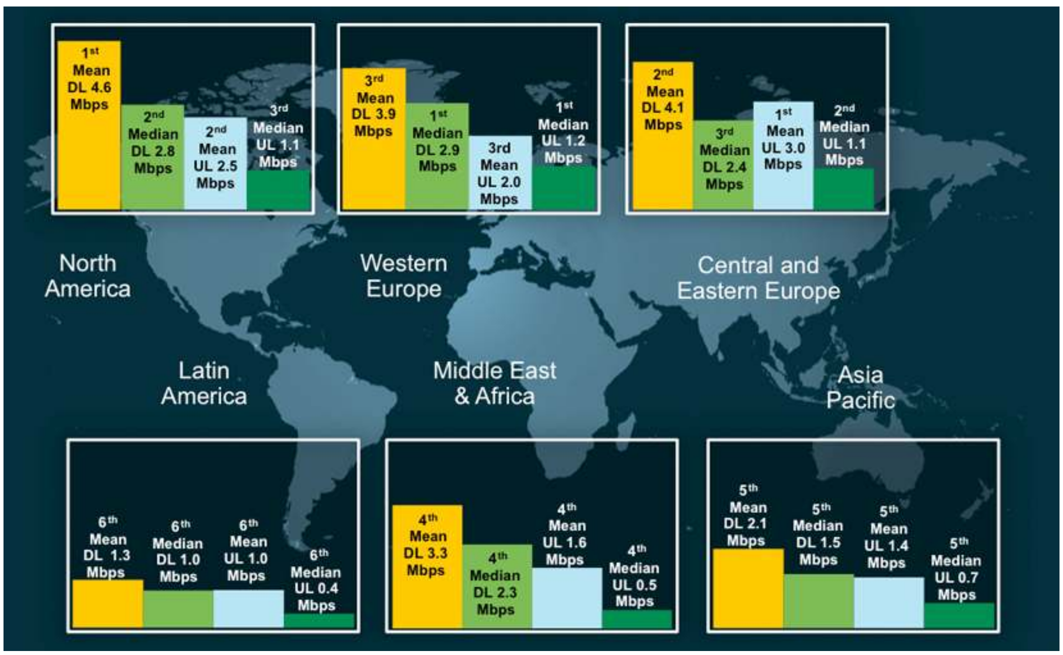
Figure 16. Regional Business Average Fixed Speeds, 2013



Business Mobile Download and Upload Speeds

- For business average mobile download speeds, North America leads with 4.6 Mbps and Central and Eastern Europe follows with 4.1 Mbps.
- For business average mobile upload speeds, Central and Eastern Europe leads with 3.0 Mbps and Asia Pacific follows with 2.5Mbps (Figure 17). Please refer to Appendix E and the Cisco GCI Supplement for further details.
- Median business mobile speeds are lower than mean business mobile speeds within all regions, with the distribution of speeds in the regional population tending to be lower than the average.

Figure 17. Regional Business Average Mobile Speeds, 2013



Network Latency

- Global average fixed latency is 62 ms.
- Central and Eastern Europe leads in average fixed latency with 56 ms and Western Europe closely follows with 57 ms.
- Central and Eastern Europe leads in business average fixed latencies with 68 ms followed by Western Europe with 85 ms.
- Central and Eastern Europe leads in consumer average fixed latencies with 56 ms followed by Western Europe with 57 ms.
- Global average mobile latency is 164 ms.
- Western Europe leads in average mobile latency with 106 ms and North America follows with 114 ms.
- North America leads in business average mobile latency with 225 ms followed by Western Europe with 227 ms.
- Western Europe leads in consumer average mobile latency with 93 ms followed by North America with 97 ms. Please refer to Appendix E and the Cisco GCI Supplement for further details.

Conclusion

In summary, there are several main conclusions from the Cisco Global Cloud Index 2012–2017.

Global data center traffic is firmly in the zettabyte era and will triple from 2012 to reach 7.7 zettabytes annually by 2017. A rapidly growing segment of data center traffic is cloud traffic, which will increase nearly five-fold over the forecast period and represent nearly two-thirds of all data center traffic by 2017.

An important traffic enabler 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 2017, 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.

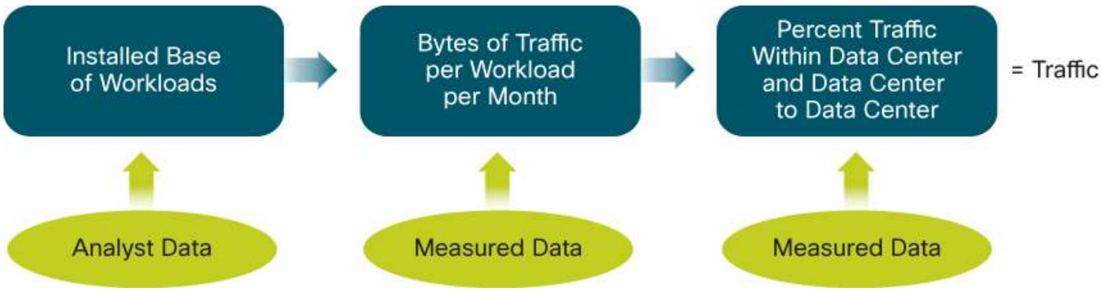
For More Information

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

Appendix A: Data Center Traffic Forecast Methodology

Figure 18 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 18. 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 non-cloud). 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 2013.

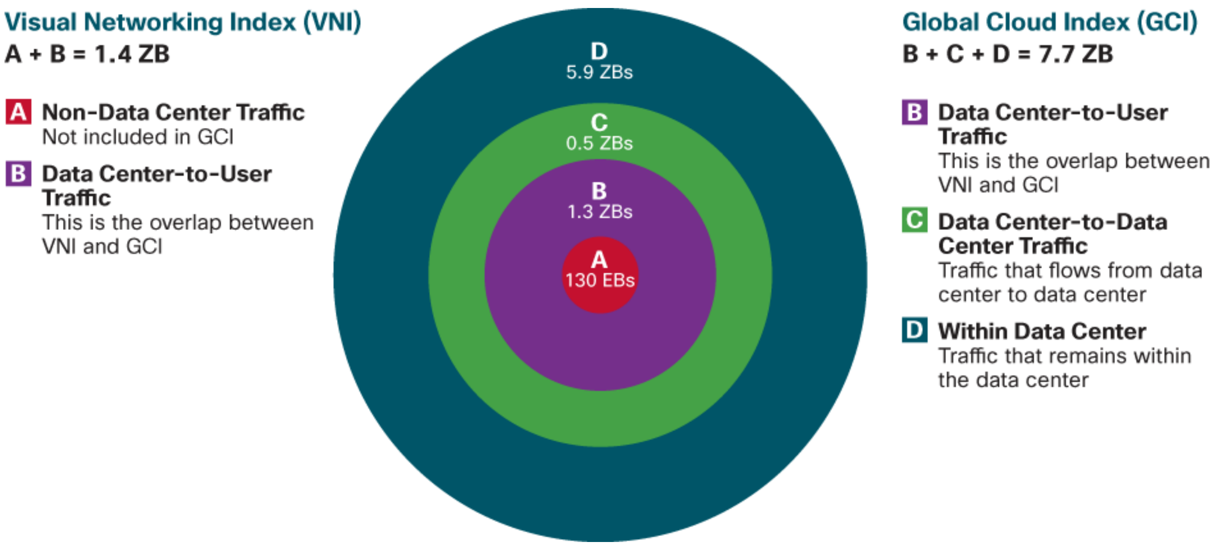
In addition, as noted in the white paper, the methodology for the estimation of cloud data center traffic has changed since the last release of the Cisco Global Cloud Index. The previous methodology included all storage traffic in the non-cloud traffic category. The updated methodology includes storage 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 19).

Figure 19. Cisco VNI and Global Cloud Index



Appendix C: Regional Cloud Traffic Trends

The Cisco Global Cloud Index now includes regional forecast data for cloud traffic growth (Figure 20).

- In 2012, North America generated the most cloud traffic (469 exabytes annually), followed by Asia Pacific (319 exabytes annually) and Western Europe (225 exabytes annually).
- By 2017, North America will continue to generate the most cloud traffic (1.886 zettabytes annually), closely followed by Asia Pacific (1.876 zettabytes annually) and Western Europe (770 exabytes annually).
- From 2012–2017, the Middle East and Africa is expected to have the highest cloud traffic growth rate (57 percent CAGR), followed by Asia Pacific (43 percent CAGR) and Central and Eastern Europe (36 percent CAGR).

Figure 20. Cloud Traffic Growth by Region

Table 4. Cloud Traffic Growth by Region, in Exabytes

Region	2012	2013	2014	2015	2016	2017	CAGR 2012–17
Asia Pacific	319	505	736	1,042	1,415	1,876	43%
Central and Eastern Europe	69	101	140	191	253	325	36%
Latin America	77	117	159	203	249	298	31%
Middle East and Africa	17	31	51	77	112	157	57%
North America	469	691	933	1,211	1,526	1,886	32%
Western Europe	225	311	400	501	623	770	28%

Source: Cisco Analysis, 2013

Appendix D: Workload Distribution by Region

Tables 5, 6, and 7 summarize data center workloads by type and region.

Table 5. Regional Distribution of Total Data Center Workloads, in Millions

Total Data Center Workloads in Millions							
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**CAGR 2012–2017**
Asia Pacific	19.7	24.1	30.3	38.2	47.6	58.6	24%
Central and Eastern Europe	3.9	4.5	5.4	6.4	7.5	8.7	17%
Latin America	4.1	4.8	5.7	6.4	7.2	8.0	14%
Middle East and Africa	1.4	1.8	2.4	3.1	3.9	4.8	27%
North America	36.6	43.5	52.0	59.7	67.3	75.4	16%
Western Europe	17.6	20.6	23.8	26.6	29.7	32.9	13%

Source: Cisco Analysis, 2013

Table 6. Regional Distribution of Cloud Workloads, in Millions

Cloud Data Center Workloads in Million							
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**CAGR 2012–2017**
Asia Pacific	6.8	10.1	14.5	20.4	27.6	36.5	40%
Central and Eastern Europe	1.4	1.9	2.5	3.3	4.2	5.2	31%
Latin America	1.5	2.1	2.8	3.5	4.2	4.9	28%
Middle East and Africa	0.4	0.7	1.1	1.6	2.2	2.9	45%
North America	15.2	21.1	27.7	34.3	40.8	48.2	26%
Western Europe	7.0	9.8	12.5	15.1	17.8	20.8	24%

Source: Cisco Analysis, 2013

Table 7. Regional Distribution of Traditional Data Center Workloads, in Millions

Traditional Data Center Workloads in Millions							
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**CAGR 2012–2017**
Asia Pacific	12.9	13.9	15.8	17.8	20.0	22.1	11%
Central and Eastern Europe	2.6	2.6	2.8	3.0	3.3	3.4	6%
Latin America	2.6	2.7	2.9	2.9	3.0	3.0	3%
Middle East and Africa	1.0	1.1	1.3	1.5	1.7	1.9	13%
North America	21.5	22.4	24.3	25.4	26.5	27.2	5%
Western Europe	10.6	10.8	11.3	11.5	11.9	12.1	3%

Source: Cisco Analysis, 2013

Appendix E: 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	**All**	Asia Pacific	10,356	6,128	62
		Central and Eastern Europe	11,592	7,360	56
		Latin America	4,859	1,270	80
		Middle East and Africa	3,026	1,119	118
		North America	13,106	3,465	59
		Western Europe	14,351	3,166	57
Mobile	**All**	Asia Pacific	5,573	3,792	199
		Central and Eastern Europe	7,967	5,450	117
		Latin America	3,818	1,569	198
		Middle East and Africa	3,294	1,558	237
		North America	11,211	4,725	114
		Western Europe	9,404	3,077	106
Fixed	**Business**	Asia Pacific	6,652	6,125	162
		Central and Eastern Europe	13,057	8,688	68
		Latin America	7,841	5,720	117
		Middle East and Africa	2,334	1,095	322
		North America	12,063	9,138	115
		Western Europe	16,756	11,356	85
	Consumer	Asia Pacific	10,346	6,125	62
		Central and Eastern Europe	11,350	7,135	56
		Latin America	4,858	1,270	80
		Middle East and Africa	3,013	1,116	121
		North America	12,856	3,576	61
		Western Europe	14,332	3,256	57
Mobile	**Business**	Asia Pacific	2,144	1,369	501
		Central and Eastern Europe	4,058	2,966	261
		Latin America	1,308	1,030	636
		Middle East and Africa	3,347	1,645	367
		North America	4,570	2,501	225
		Western Europe	3,860	2,015	227
	Consumer	Asia Pacific	4,580	3,181	176
		Central and Eastern Europe	6,961	4,984	100
		Latin America	3,154	1,071	173
		Middle East and Africa	2,652	1,250	208
		North America	10,013	4,186	97
		Western Europe	8,002	2,702	93

Source: Cisco Analysis, 2013

Appendix F: Broadband Ubiquity

Tables 9 and 10 summarize regional broadband penetration for 2012 and 2017. The methodology for the estimation of broadband and Internet ubiquity has changed since the initial release of the Global Cloud Index in 2012. 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 2012

Region	Fixed Broadband Subscriptions (2012)	Mobile Broadband Users (2012)	Internet Population (2012)
Asia Pacific	890,862,018 (23%)	912,475,300 (23%)	3,919,577,222
Central and Eastern Europe	158,820,656 (32%)	131,123,668 (27%)	492,588,452
Latin America	166,010,218 (27%)	120,790,900 (20%)	612,171,821
Middle East and Africa	128,299,586 (10%)	109,522,532 (8%)	1,335,265,681
North America	248,703,493 (68%)	177,083,900 (49%)	364,019,597
Western Europe	276,580,068 (63%)	186,904,300 (43%)	436,100,276

Source: Cisco Analysis, 2013

Table 10. Regional Broadband Penetration (Percentages Indicate Users with Broadband Access Per Region) in 2017

Region	Fixed Broadband Subscriptions (2017)	Mobile Broadband Users (2017)	Internet Population (2017)
Asia Pacific	1,232,608,187 (30%)	2,198,830,400 (54%)	4,102,053,575
Central and Eastern Europe	249,710,340 (50%)	333,435,897 (67%)	499,710,427
Latin America	205,119,709 (32%)	316,985,600 (49%)	645,585,277
Middle East and Africa	213,415,046 (14%)	501,629,503 (34%)	1,491,094,868
North America	287,389,014 (76%)	299,468,600 (79%)	379,566,614
Western Europe	295,740,474 (67%)	344,297,900 (77%)	444,623,933

Source: Cisco Analysis, 2013

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