White Paper

Cisco Global Cloud Index: Forecast and Methodology, 2013–2018

What You Will Learn

The Cisco® Global Cloud Index (GCI) 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 8.6 zettabytes (715 exabytes [EB] per month) by the end of 2018, up from 3.1 zettabytes (ZB) per year (255 EB per month) in 2013.
- Global data center IP traffic will nearly triple (2.8-fold) over the next 5 years. Overall, data center IP traffic will grow at a compound annual growth rate (CAGR) of 23 percent from 2013 to 2018.

Data Center Virtualization and Cloud Computing Growth

- By 2018, more than three quarters (78 percent) of workloads will be processed by cloud data centers; 22 percent will be processed by traditional data centers.
- Overall data center workloads will nearly double (1.9-fold) from 2013 to 2018; however, cloud workloads will nearly triple (2.9-fold) over the same period.
- The workload density (that is, workloads per physical server) for cloud data centers was 5.2 in 2013 and will grow to 7.5 by 2018. Comparatively, for traditional data centers, workload density was 2.2 in 2013 and will grow to 2.5 by 2018.

Public vs. Private Cloud

- By 2018, 31 percent of the cloud workloads will be in public cloud data centers, up from 22 percent in 2013. (CAGR of 33 percent from 2013 to 2018).
- By 2018, 69 percent of the cloud workloads will be in private cloud data centers, down from 78 percent in 2013. (CAGR of 21 percent from 2013 to 2018).

Global Cloud Traffic

- Annual global cloud IP traffic will reach 6.5 ZB (541 EB per month) by the end of 2018, up from 1.6 ZB per year (137 EB per month) in 2013.
- Global cloud IP traffic will nearly quadruple (3.9-fold) over the next 5 years. Overall, cloud IP traffic will grow at a CAGR of 32 percent from 2013 to 2018.
- Global cloud IP traffic will account for more than three-fourths (76 percent) of total data center traffic by 2018.

Cloud Service Delivery Models

- By 2018, 59 percent of the total cloud workloads will be Software-as-a-Service (SaaS) workloads, up from 41 percent in 2013.
- By 2018, 28 percent of the total cloud workloads will be Infrastructure-as-a-Service (IaaS) workloads, down from 44 percent in 2013.
- By 2018, 13 percent of the total cloud workloads will be Platform-as-a-Service (PaaS) workloads, down from 15 percent in 2013.

Internet of Everything (IoE) Potential Impact on Cloud

- Globally, the data created by IoE devices will reach 403 ZB per year (33.6 ZB per month) by 2018, up from 113.4 ZB per year (9.4 ZB per month) in 2013.
- Globally, the data created by IoE devices will be 277 times higher than the amount of data being transmitted to data centers from end-user devices and 47 times higher than total data center traffic by 2018.

Consumer Cloud Storage

- By 2018, 53 percent (2 billion) of the consumer Internet population will use personal cloud storage, up from 38 percent (922 million users) in 2013.
- Globally, consumer cloud storage traffic per user will be 811 megabytes per month by 2018, compared to 186 megabytes per month in 2013.

Multiple-Device Ownership

- North America, followed by Western Europe, had the highest average number of fixed devices per user, while Middle East and Africa, followed by Latin America, had the highest average number of mobile devices per user.

IPv6 Adoption Fosters Cloud Growth

- Globally 24 percent of Internet users will be IPv6-capable by 2018.
- Globally, by 2018, nearly 50 percent of all fixed and mobile devices and connections will be IPv6-capable.
- Increased cloud provider deployments have had a positive impact on IPv6 content and its availability. From October 2013 to October 2014, there has been nearly a 33-percent increase in the number of websites that are IPv6-capable.

Regional Cloud Readiness

Internet Ubiquity

- North America and Western Europe led in Internet access penetration (fixed and mobile) in 2013 and will continue to lead in this category through 2018. However, all regions will show measurable improvement in broadband access to their respective populations throughout the forecast period.

Network Speeds and Latency

- Western Europe leads all regions with an average fixed download speed of 20 Mbps. Asia Pacific follows with an average fixed download speed of 18.8 Mbps. Central and Eastern Europe and Asia Pacific lead all regions in average fixed upload speeds with nearly 12.2 Mbps.
- Asia Pacific leads all regions in average fixed network latency with 40 ms, followed by Western Europe with 46 ms.
- North America leads all regions with an average mobile download speed of 10.1 Mbps. Western Europe follows with an average mobile download speed of 9.5 Mbps. Central and Eastern Europe and North America lead all regions in average mobile upload speeds with 4.9 Mbps and 4.3 Mbps respectively.
- North America and Western Europe lead all regions in average mobile network latency with 101 ms and 113 ms, respectively.

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. 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 accelerating 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
    - Data Center Traffic by Destination
    - Data Center and Cloud IP Traffic Growth
    - Business vs. Consumer Cloud Traffic
2. Continued Global Data Center Virtualization
    - Public vs. Private Cloud Workloads
3. Cloud Service Delivery Models (IaaS, PaaS, and SaaS)
4. Potential Cloud Catalysts—Internet of Everything
    - Consumer Cloud Storage Analysis
    - Multiple-Device Ownership Accelerates Cloud
    - IPv6 Adoption Fosters Cloud Growth
5. Global Cloud Readiness
    - Internet Ubiquity
    - Network Speeds and Latency Analysis

Trend 1: Growth of Global Data Center Relevance and Traffic

The main qualitative motivators for cloud adoption include faster delivery of services and data, increased application performance, and improved operational efficiencies. Although 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. Most Internet traffic has originated or terminated in a data center since 2008, when peer-to-peer traffic (which does not originate from a data center but instead is transmitted directly from device to device) ceased to dominate the Internet application mix. 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 2018 seventy-six percent, or more than three-quarters 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 2018

Figure 1 summarizes the forecast for data center IP traffic growth from 2013 to 2018.

Figure 1. Global Data Center IP Traffic Growth

Source: Cisco Global Cloud Index, 2013–2018

Although the amount of global traffic crossing the Internet and IP WAN networks is projected to reach 1.6 ZB per year by 2018[1], the amount of annual global data center traffic in 2013 is already estimated to be 3.1 ZB—and by 2018, will triple to reach 8.6 ZB per year. This increase represents a 23-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 GCI report, covers network data centers worldwide operated by service providers as well as private enterprises. Please refer to Appendix A for more details about the methodology of the data center and cloud traffic forecasts, and Appendix B for the positioning of the GCI 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, 2013–2018

Data Center IP Traffic, 2013–2018							
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**CAGR 2013–2018**
By Type (EB per Year)							
Data center to user	513	643	797	979	1,196	1,457	23%
Data center to data center	202	266	346	447	572	729	29%
Within data center	2,350	2,920	3,587	4,373	5,303	6,389	22%
By Segment (EB per Year)							
Consumer	1,789	2,328	2,966	3,724	4,629	5,726	26%
Business	1,275	1,501	1,764	2,075	2,443	2,849	17%
By Type (EB per Year)							
Cloud data center	1,647	2,277	3,050	3,994	5,131	6,496	32%
Traditional data center	1,417	1,551	1,680	1,805	1,941	2,079	8%
Total (EB per Year)							
Total data center traffic	3,065	3,829	4,730	5,798	7,072	8,574	23%

Source: Cisco Global Cloud Index, 2014

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

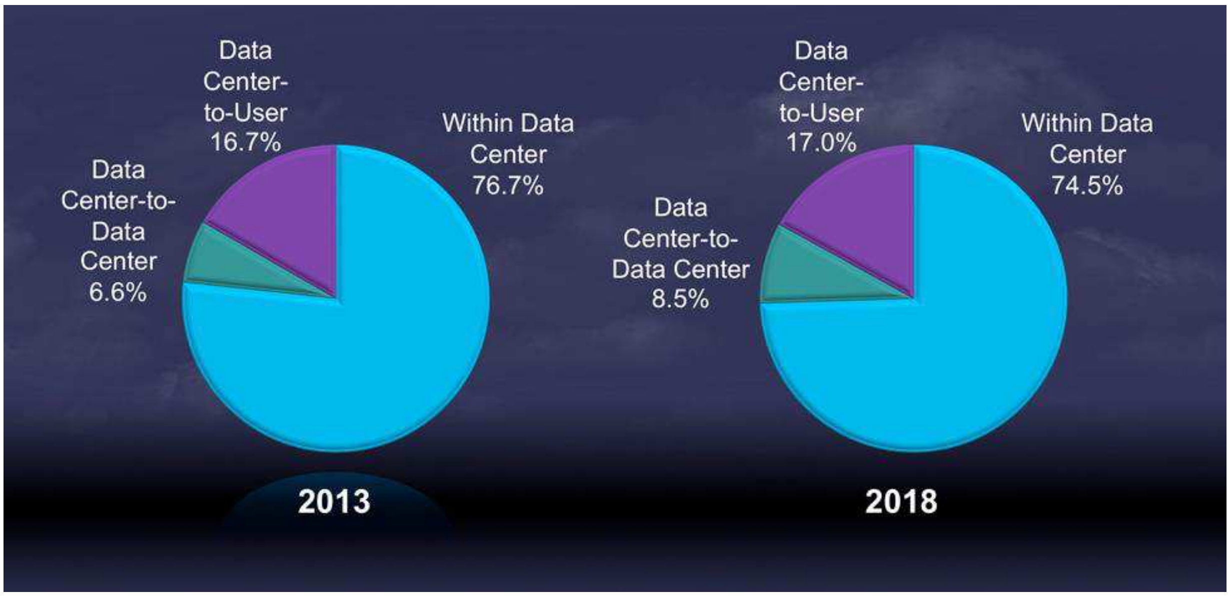
[1] Refer to: Cisco Visual Networking Index: Forecast and Methodology, 2013–2018.

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**: For example, moving data from a development environment to a production environment within a data center, or writing data to a storage array
- **Traffic that flows from data center to data center**: For example, moving data between clouds, or copying content to multiple data centers as part of a content distribution network
- **Traffic that flows from the data center to end users through the Internet or IP WAN**: For example, streaming video to a mobile device or PC

Figure 2. Global Data Center Traffic by Destination



Source: Cisco Global Cloud Index, 2013–2018

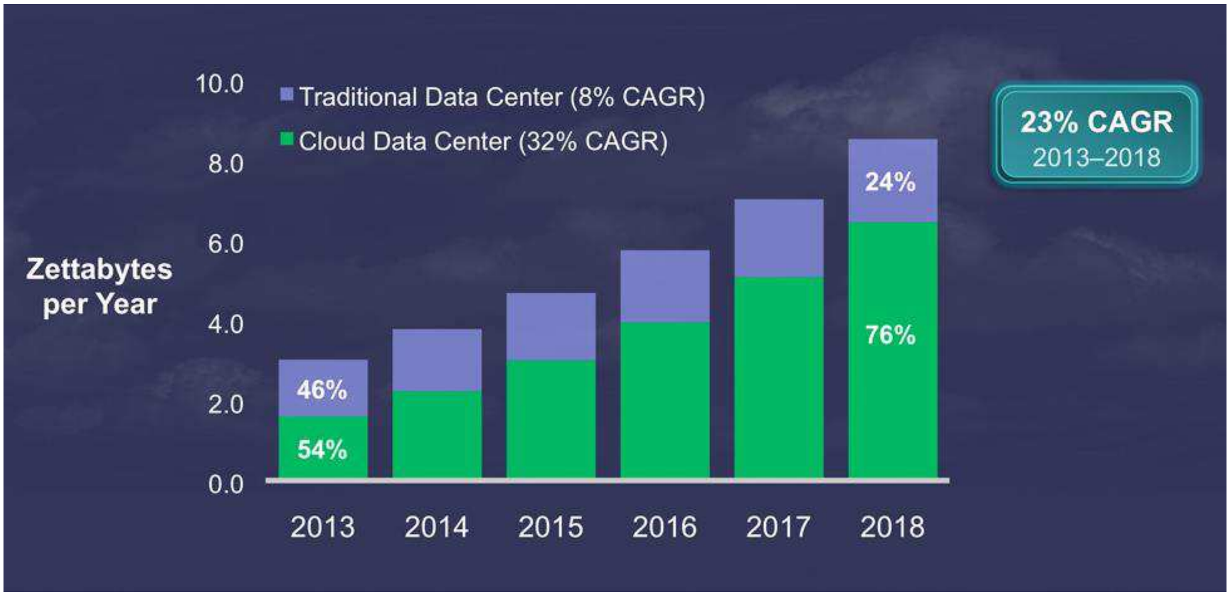
The portion of traffic residing within the data center will decline slightly over the forecast period, accounting for nearly 77 percent of data center traffic in 2013 and about 75 percent by 2018. Despite the decline, the majority of traffic remains within the data center because of factors such as the functional separation of application servers, storage, and databases, which generates replication, backup, and read and write traffic traversing the data center. Furthermore, parallel processing divides tasks and sends them to multiple servers, contributing to internal data center traffic.

Traffic between data centers is growing faster than either traffic to end-users or traffic within the data center, and by 2018, traffic between data centers will account for almost 9 percent of total data center traffic, up from nearly 7 percent at the end of 2013. The high growth of this segment is due to the increasing prevalence of content distribution networks, the proliferation of cloud services and the need to shuttle data between clouds, and the growing volume of data that needs to be replicated across data centers.

Global Data Center and Cloud IP Traffic Growth

Data center traffic on a global scale will grow at a 23-percent CAGR (Figure 3), but cloud data center traffic will grow at a faster rate (32 percent CAGR) or 3.9-fold growth from 2013 to 2018 (Figure 4).

Figure 3. Total Data Center Traffic Growth



Source: Cisco Global Cloud Index, 2013–2018

Figure 4. Cloud Data Center Traffic Growth

Source: Cisco Global Cloud Index, 2013–2018

Global cloud traffic crossed the zettabyte threshold in 2013, and by 2018, more than three-quarters of all data center traffic will be based in the cloud (for regional cloud traffic trends, please refer to Appendix C). Cloud traffic will represent 76 percent of total data center traffic by 2018.

Significant promoters of cloud traffic growth include the rapid adoption of and migration to cloud architectures and 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 better performance as well as higher capacity and throughput.

Global Business and Consumer Cloud Growth

For the purposes of this study, the Cisco GCI characterizes traffic based on services delivered to two types of end users—business and consumer. 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 34 percent, reaching 4.3 ZB annually by 2018. Business cloud traffic grows at a CAGR of 27 percent, increasing to 2.2 ZB annually by 2018. Table 2 provides details for global consumer and business cloud traffic growth rates.

Table 2. Global Cloud Traffic, 2013–2018

Cloud IP Traffic, 2013–2018							
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**CAGR 2013–2018**
By Segment (EB per Year)							
Consumer	979	1,398	1,914	2,555	3,331	4,288	34%
Business	669	880	1,136	1,438	1,800	2,208	27%
Total (EB per Year)							
Total cloud traffic	1,647	2,277	3,050	3,994	5,131	6,496	32%

Source: Cisco Global Cloud Index, 2014

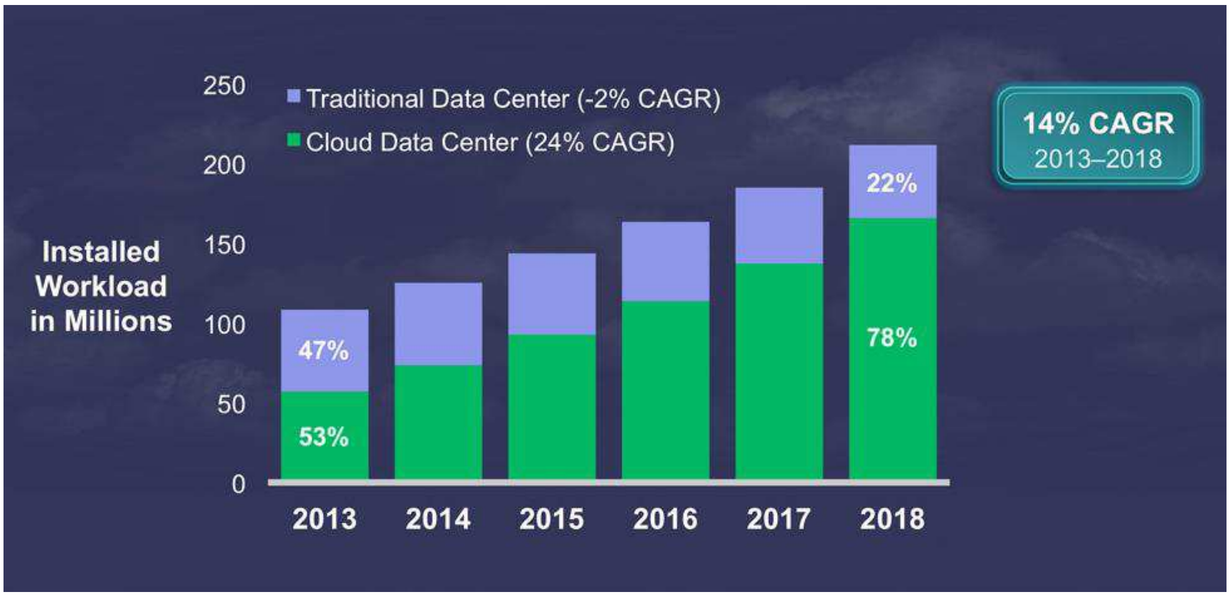
Real-time and time-sensitive applications are contributing to increased cloud adoption in both the business and consumer segments. For business, the necessity to provide fast and flexible access to large data archives is an important objective for IT organizations considering cloud-based solutions. In 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 server workload is defined as a virtual or physical set of computer resources that are assigned to run a specific application or provide computing services for one to many users. A workload is a general measurement used to describe many different applications, from a small lightweight SaaS application to a large computational private cloud database application. The Cisco Global Cloud Index forecasts the continued transition of workloads from traditional data centers to cloud data centers. By 2018, more than three-fourths (78 percent) of all workloads will be processed in cloud data centers (Figure 5). For regional distributions of workloads, refer to Appendix D.

Figure 5. Workload Distribution: 2013–2018



Source: Cisco Global Cloud Index, 2013–2018

Cloud workloads are expected to nearly triple (grow 2.9-fold) from 2013 to 2018, whereas traditional data center workloads are expected to see a global decline, for the first time, at a negative 2-percent CAGR from 2013 to 2018. 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, along with enhancements in cloud security, 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 about 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							
	2013	2014	2015	2016	2017	2018	CAGR 2013–2018
Traditional data center workloads	51.4	51.7	51.0	49.8	47.7	45.9	-2%
Cloud data center workloads	56.9	73.5	92.6	113.6	137.1	165.7	24%
Total data center workloads	108.3	125.2	143.6	163.4	184.8	211.5	14%
Cloud workloads as a percentage of total data center workloads	53%	59%	64%	70%	74%	78%	NA
Traditional workloads as a percentage of total data center workloads	47%	41%	36%	30%	26%	22%	NA

Source: Cisco Global Cloud Index, 2014

One of the main factors prompting the 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. This greater degree of virtualization in cloud data centers can be expressed as workload density. Workload density measures average number of workloads per physical server. The workload density for cloud servers will grow from 5.2 in 2013 to nearly 7.5 by 2018. In comparison, the workload density in traditional data center servers will grow from 2.2 in 2013 to 2.5 by 2018.

Figure 6. Increasing Cloud Virtualization

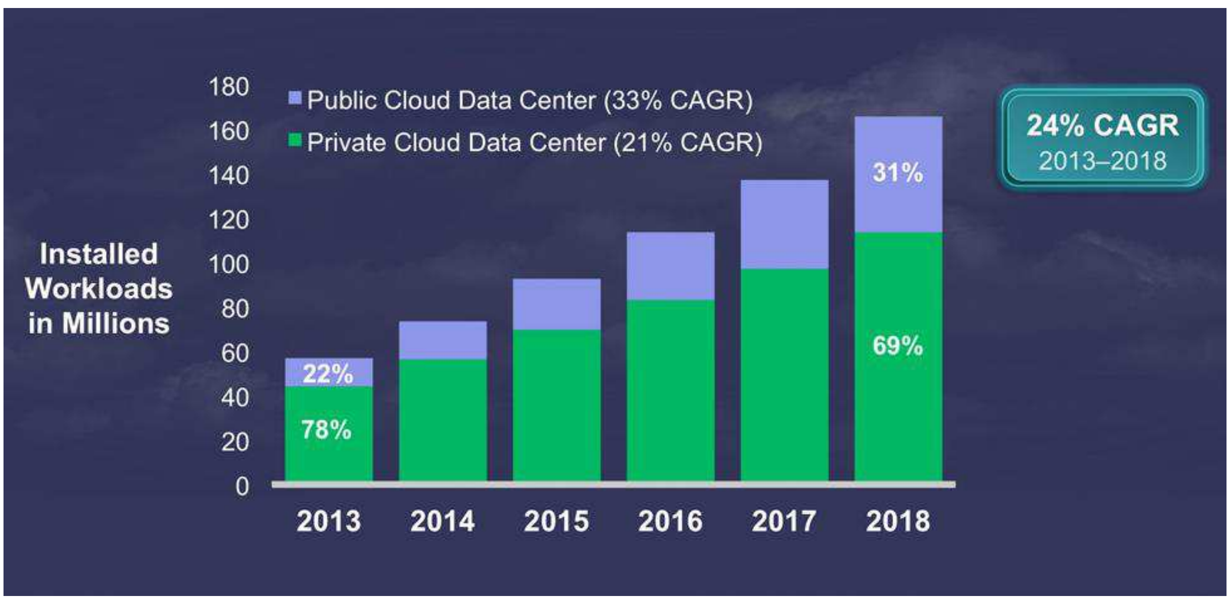
Source: Cisco Global Cloud Index, 2013–2018

Public vs. Private Cloud[2]

This year we have looked into the growth of public cloud vs. private cloud through workload analysis. Public cloud, as indicated by the workloads growth, is growing faster than the private cloud. As the business sensitivity to costs associated with dedicated IT resources grows along with demand for agility, we can see a greater adoption of public cloud by the businesses, especially with strengthening of public cloud security. Although many mission-critical workloads might continue to be retained in the traditional data centers or private cloud, the public cloud adoption is increasing along with the gain in trust in public cloud. Some enterprises might adopt a hybrid approach to cloud. In a hybrid cloud environment, some of the cloud computing resources are managed in-house by an enterprise and some are provided by an external provider. Cloud bursting is an example of hybrid cloud where daily computing requirements are handled by a private cloud, but for sudden spurts of demand the additional traffic demand (bursting) is handled by a public cloud.

While the overall cloud workloads are going to grow at a CAGR of 24 percent from 2013 to 2018 (Figure 7), the public cloud workloads are going to grow at 33-percent CAGR from 2013 to 2018 and private cloud workloads will grow at a slower pace of 21-percent CAGR from 2013 to 2018.

Figure 7. Public vs. Private Cloud Growth

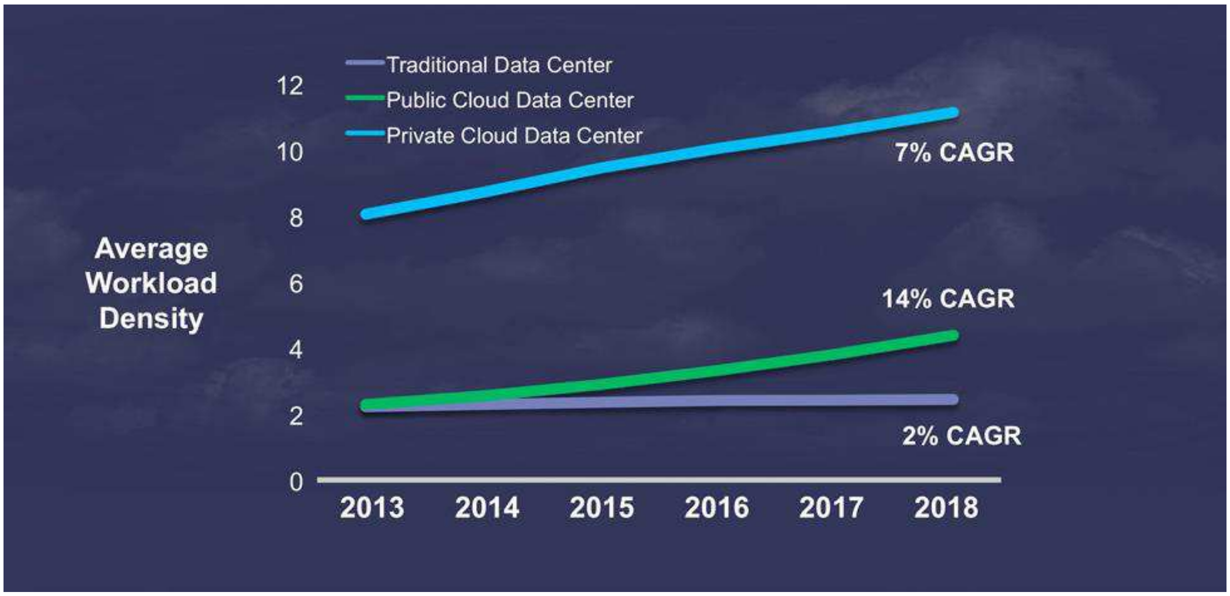


Source: Cisco Global Cloud Index, 2013–2018

[2] For definition of public and private cloud, please refer to Appendix E.

This growth of workloads in the public cloud space is also reflected in the growth of virtualization, as shown in Figure 8. While the workload density in private-cloud data centers will continue to outpace that in public cloud data center, the gap continues to narrow over the forecast period. In 2013, the average workloads per physical server in private data centers were 3.5 times more than those in public cloud, but by 2018 this difference will decrease to 2.5 times. Public cloud virtualization, as depicted by workload density, will grow at 14-percent CAGR compared to private clouds, which will grow at 7-percent CAGR from 2013 to 2018.

Figure 8. Public Cloud Virtualization Gaining Momentum



Source: Cisco Global Cloud Index, 2013–2018

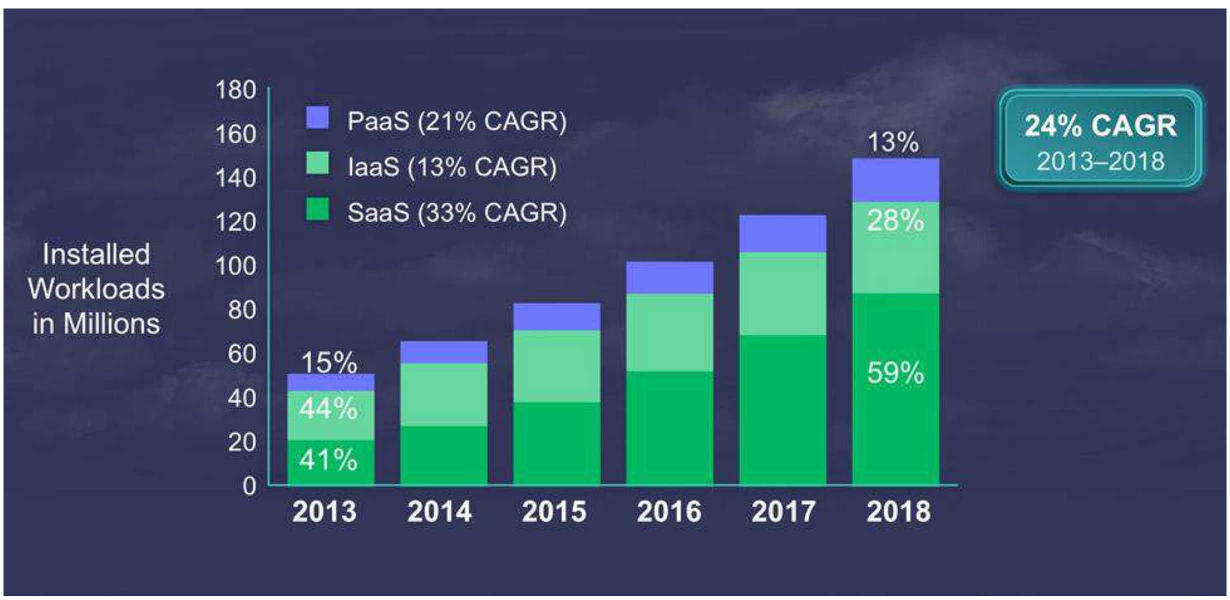
Trend 3: Cloud Service Trends

This section reviews the growth of the three different cloud service categories: IaaS, PaaS, and SaaS[3]. Although numerous other service categories have emerged over time, they can be aligned within the IaaS, PaaS, and SaaS categorization. For example, business process-as-a-service (BPaaS) is considered part of SaaS. For simplicity we can think of these three service models as different layers of cloud with infrastructure at the bottom, with the platform next and finally software at the top.

GCI categorizes a cloud workload as IaaS, PaaS, or SaaS based upon how the user ultimately uses the service, regardless of other cloud services types that may be involved in the final delivery of the service. As an example, if a cloud service is a SaaS type but it also depends on some aspects of other cloud services such as PaaS or IaaS, such a workload is counted as SaaS only. As another example, if a PaaS workload operates on top of an IaaS service, such a workload is counted as PaaS only.

At the aggregate cloud level, we find that initially IaaS has the majority workload share, but soon SaaS workloads will take the majority share, and by 2018 will have 59-percent share of all cloud workloads, growing at 33-percent CAGR from 2013 to 2018 (Figure 9). PaaS will have the second-fastest growth, although it will lose the share of total cloud workloads from 15 percent in 2013 to 13 percent by 2018.

Figure 9. SaaS Most Highly Deployed Global Cloud Service by 2018

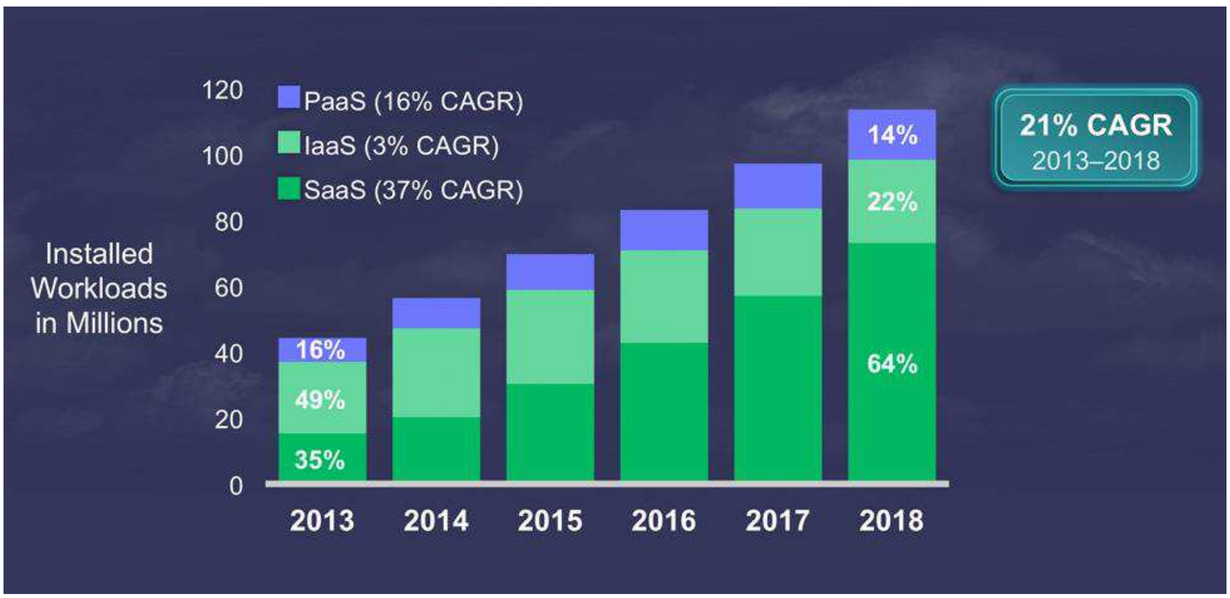


Source: Cisco Global Cloud Index, 2013–2018

[3] For definition of IaaS, PaaS, and SaaS, please refer to Appendix E.

In order to understand the reasons behind this trend, we have to analyze the public and private cloud segments a bit more deeply. In the private cloud, initial deployments were predominantly IaaS and PaaS. Test and development types of cloud services were the first to be used in the enterprise; cloud was a radical change in deploying IT services, and this use was a safe and practical initial use of private cloud for enterprises. It was limited, and it did not pose a risk of disrupting the workings of IT resources in the enterprise. As trust in adoption of SaaS or mission-critical applications builds over time with technology enablement in processing power, storage advancements, memory advancements, and networking advancements, we foresee the adoption of SaaS type applications to accelerate over the forecast period (Figure 10).

Figure 10. SaaS Gains Momentum in Private Cloud

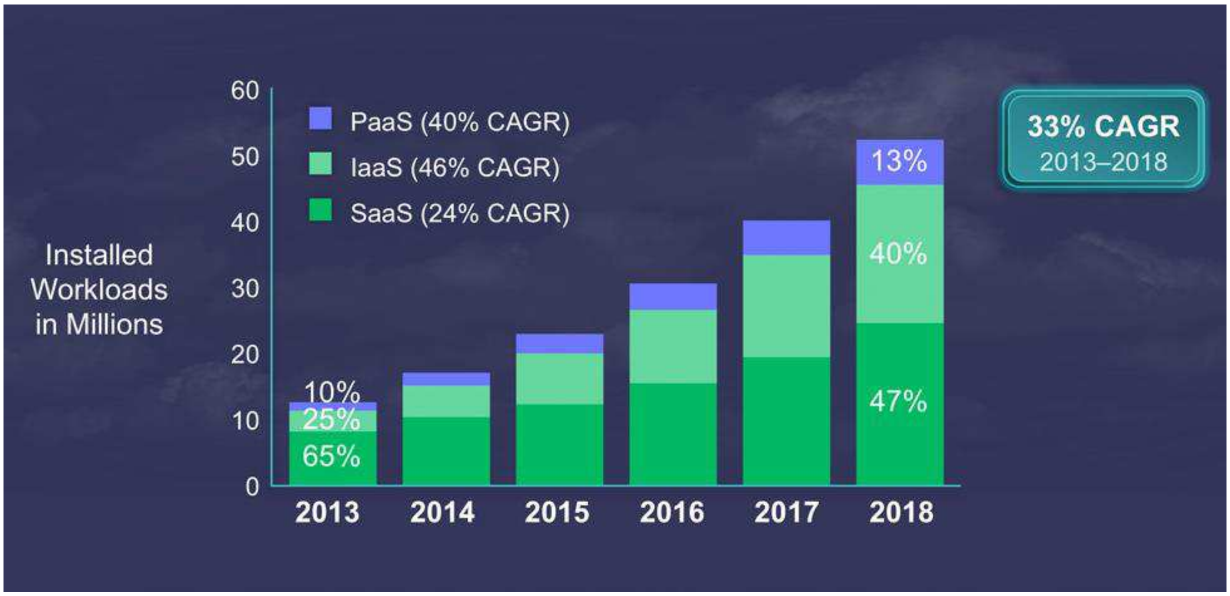


Source: Cisco Global Cloud Index, 2013–2018

In the public cloud segment the first cloud services to be deployed were SaaS. SaaS services offered in the public cloud were often a low-risk and easy-to-adopt proposition, with some clear financial and flexibility benefits to users. The first users of SaaS were the consumer segment, followed by some small and medium-sized businesses. As public SaaS solutions become more sophisticated and robust, larger enterprises are adopting these services as well, beginning with less-critical services. Enterprises, especially large ones, will be carefully weighing the benefits (scalability, consistency, cost optimization etc.) of adopting public cloud services against the risks (security, data integrity, business continuity etc.) of adopting such services.

As shown in Figure 11, IaaS and PaaS are in the initial stages of deployment in the public cloud. Spend on public IaaS and PaaS is still small compared with spend on enterprise data center equipment, data center facilities, and associated operating expenses. These cloud services will gain momentum over the forecast period as more competitive offers come to the market and continue to build enterprise trust for outsourcing these more technical and fundamental services.

Figure 11. IaaS and PaaS Gain Public Cloud Share of Workloads



Source: Cisco Global Cloud Index, 2013–2018

Trend 4: Potential Cloud Catalysts—Internet of Everything

This section reviews the potential impact of IoE on the growth of cloud services. Cloud-based services are essential for most IoE applications, which increases the ability for people, data, and things to communicate with one another over the Internet.

The IoE is generating large volumes of data, and currently only a small portion of that data reaches the data center. Although data center traffic is anticipated to reach 8.6 ZB in 2018, the total volume of data generated by IoE in 2018 will be more than 400 ZB, or nearly 50 times higher than the sum total of data center traffic. For example:

- A Boeing 787 generates 40 terabytes (TB) per hour of flight, half a TB of which is ultimately transmitted to a data center for analysis and storage.
- A large retail store collects approximately 10 gigabytes (GB) of data per hour, and 1 GB of that is transmitted to a data center.
- An automated manufacturing facility generates approximately 1 TB of data per hour, and 5 GB of that is transmitted to a data center.
- A mining operation such as that of Rio Tinto can generate up to 2.4 TB per minute.

As data center capacity improves, more of the data generated locally by the IoE may be transmitted to a data center, and the remaining data may still be available for analysis through data virtualization, which enables analysis of distributed data sources.

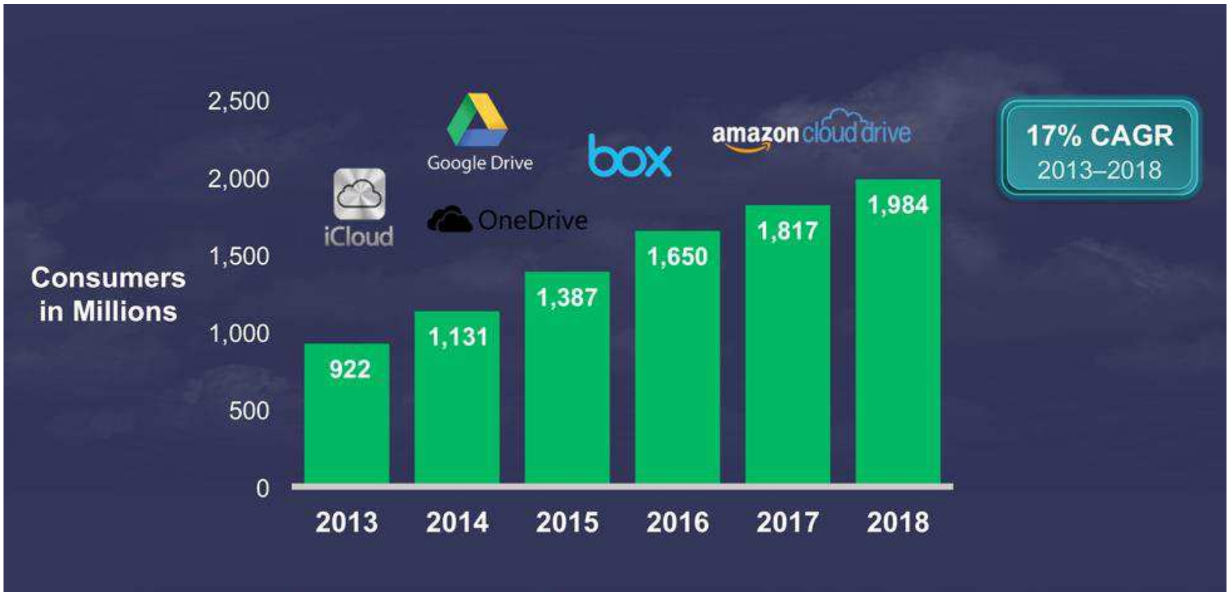
The rapid growth in the adoption of multiple devices by end users, consumers, and businesses alike is a major factor in the transition to cloud-based services that can provide ubiquitous access to content and applications through any device at any location.

Consumer Cloud Storage Growth

Along with the growth in consumer Internet population and multidevice ownership devices, we are seeing a significant growth in the use of cloud services such as consumer cloud storage, also called personal content lockers. 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 allows access to personal content lockers in a manner convenient to the user.

Cisco GCI estimates that by 2018, 53 percent (2 billion) of the consumer Internet population will use personal cloud storage, up from 38 percent (922 million users) in 2013 (Figure 12).

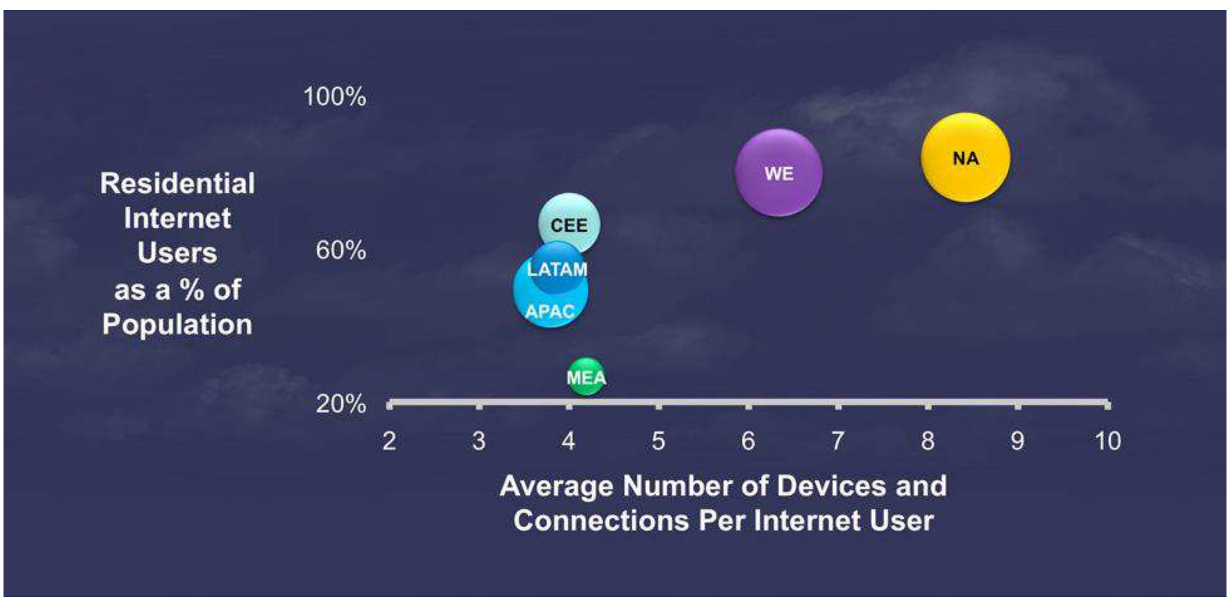
Figure 12. Personal Cloud Storage—Growth in Users



Source: Cisco Global Cloud Index, 2013–2018; Juniper Research

Figure 13 demonstrates the projected expansion of consumer cloud storage in relation to multiple device usage and growing Internet access at a regional level in 2018. The high adoption of consumer cloud storage services in North America and Western Europe as depicted by the size of the bubble for those regions clearly shows a high correlation with the regional consumer Internet penetration as well as average of devices per consumer. For details for other regions, please refer to Appendix F.

Figure 13. Personal Cloud Storage Accelerated by Growth in Internet Access and Multidevice Ownership



The size of the bubbles represents the adoption of consumer cloud storage as a % of residential Internet population.
Source: Cisco Global Cloud Index, 2013–2018

Cisco GCI forecasts that global consumer cloud storage traffic will grow from 2 EB annually in 2013 to 19.3 EB by 2018 at a CAGR of 57 percent (Figure14). This growth translates to per-user traffic of 811 megabytes (MB) per month by 2018, compared to 186 MB per month in 2013.

Figure 14. Consumer Cloud Storage Traffic Growth

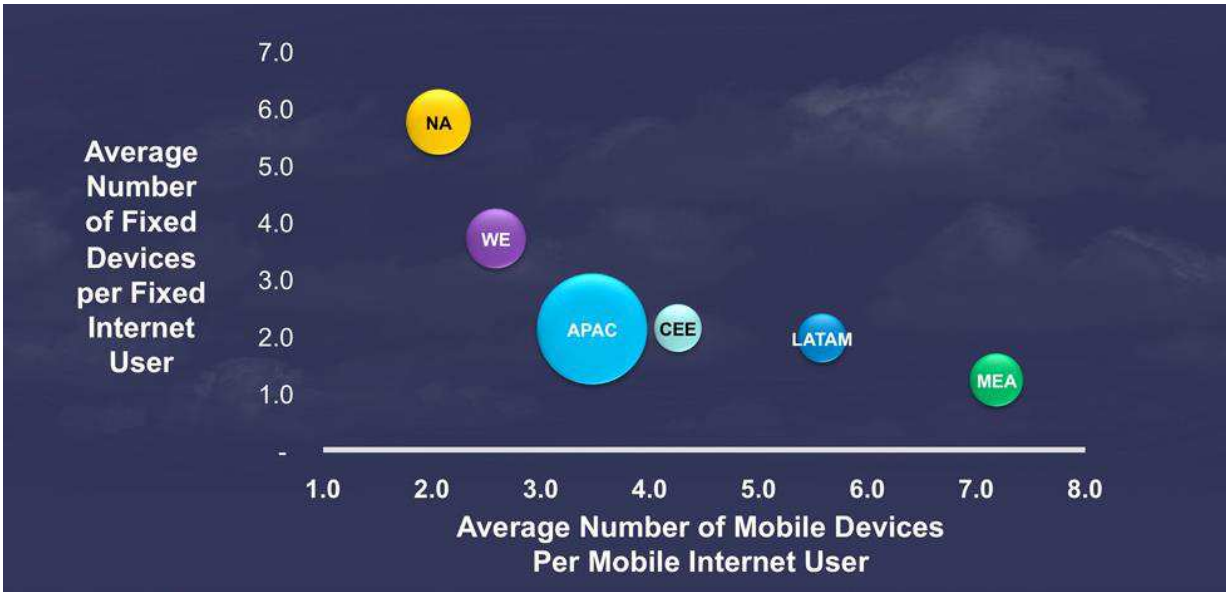
Source: Cisco Global Cloud Index, 2013–2018; Juniper Research

Multiple-Device Ownership Accelerates Cloud

The rapid growth in the adoption of multiple devices by consumers along with the growing Internet access 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. Many devices have dual-mode capabilities. This growth, in turn, creates a demand for cloud services and content that can be accessed across multiple devices using any mode of access—fixed or mobile.

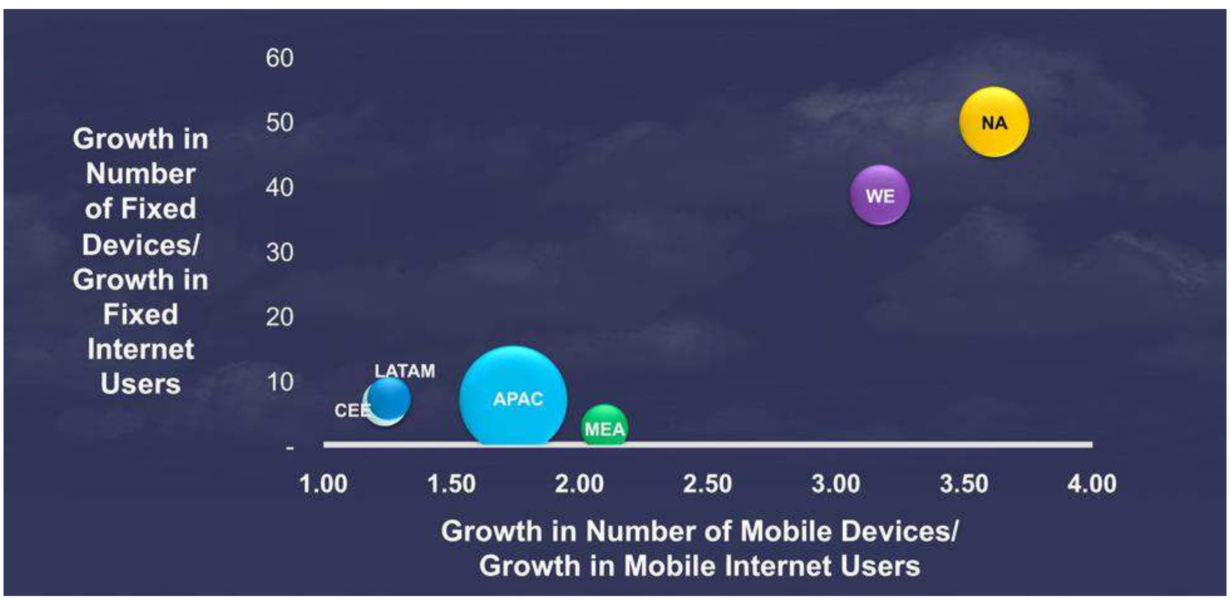
Figures 15, 16, and 17 demonstrate the projected expansion of multiple-device usage at a regional level from 2013 to 2018. In 2013, North America, followed by Western Europe and Central and Eastern Europe, led in average fixed devices per user, Middle East and Africa, followed by Latin America and Central and Eastern Europe, had the highest average mobile devices per user. As shown in Figure 16, all the regions showed growth in both mobile and fixed average devices per user during the period 2013 to 2018. However, higher growth on an average will occur in the fixed-devices category relative to mobile devices. In the mobile segment many new Internet users will have device average lower than that in 2013 except for the two regions—North America and Western Europe—a situation that will result in lower average mobile device count for the rest of the regions by 2018.

Figure 15. Multiple Device Proliferation in 2013



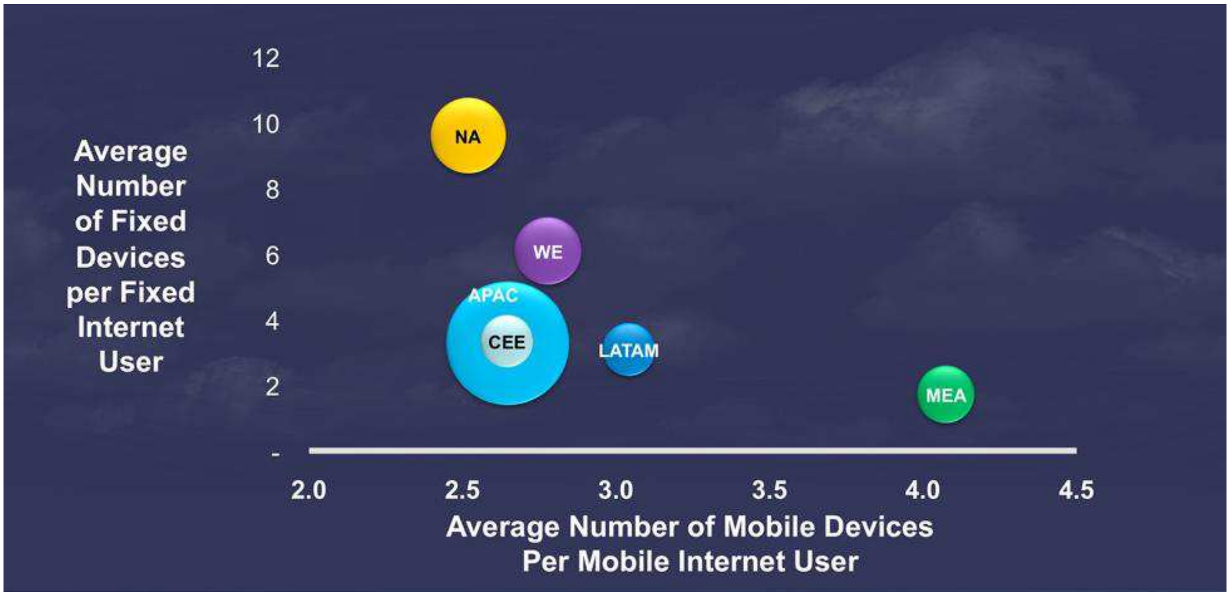
The size of the bubbles represents the total number of devices for the region.
Source: Cisco Global Cloud Index, 2013–2018

Figure 16. Multiple-Device Proliferation—Growth from 2013 to 2018



The size of the bubbles represents the total number of incremental devices for the region from 2013 to 2018.
Source: Cisco Global Cloud Index, 2013–2018

Figure 17. Multiple-Device Proliferation by 2018



The size of the bubbles represents the total number of devices for the region.
Source: Cisco Global Cloud Index, 2013–2018

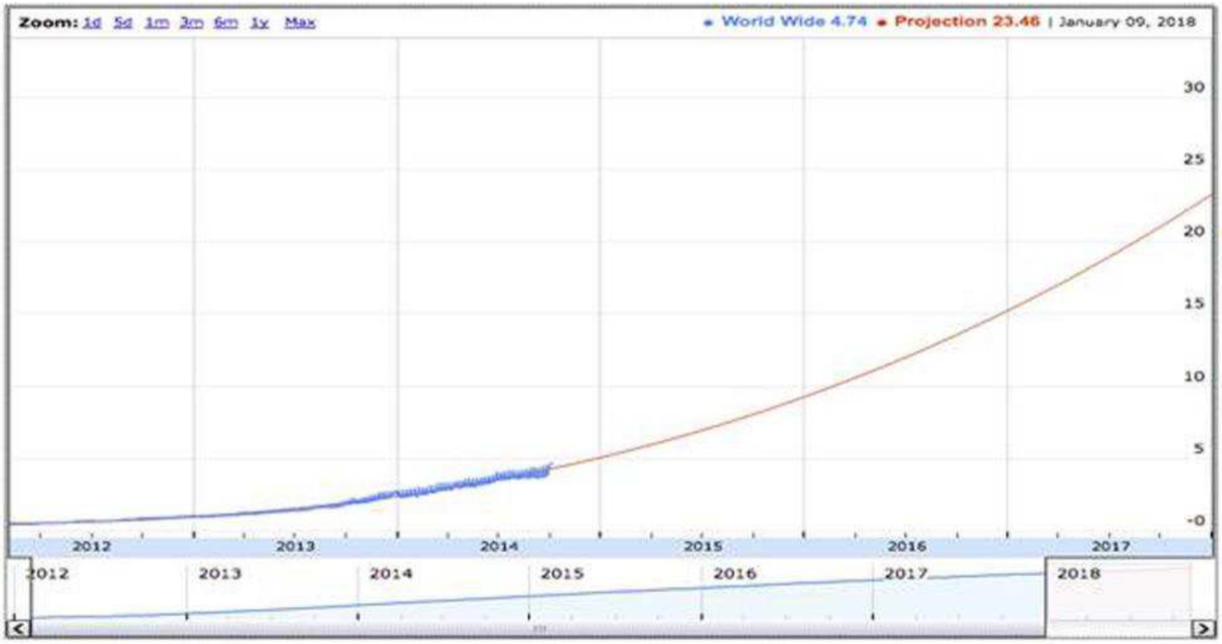
IPv6 Adoption Fosters Cloud Growth

Another important component of the Internet of Everything and adoption of cloud services is the growth of IPv6 capability among users, devices, network connectivity, and content enablement.

According to Google, the percentage of IPv6 global users on Sept 27, 2014, was 4.54 percent, up from 1.82 percent on Sept 27, 2013, showing an increase of nearly 150 percent in the last year alone.

In several countries, the proportion of Internet users enjoying IPv6 connectivity has grown to double digits over the last 18 months, with Belgium at 29 percent, Germany ~12 percent, Switzerland ~11 percent, and United States ~10 percent (Source: Google and APNIC). Based on 6lab.cisco.com projections, globally 24 percent of users will be IPv6-capable by January 2018, and this number will reach 50 to 60 percent in most advanced countries (Figure 18).

Figure 18. IPv6 User Projections

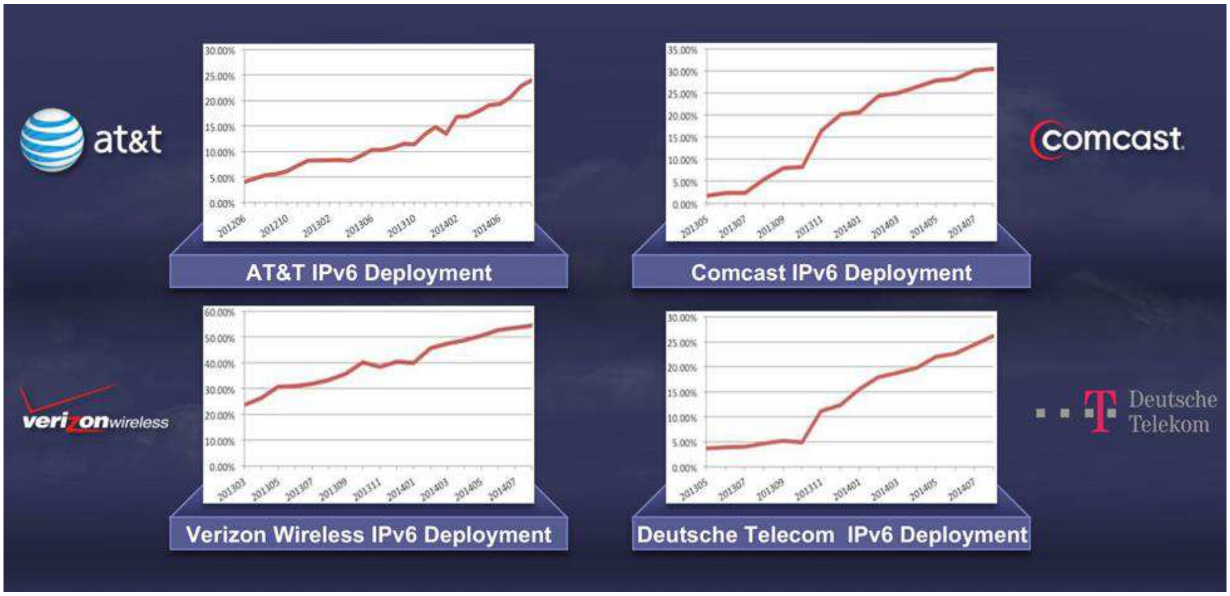


Source: Forecast simulation tool at 6lab.cisco.com

From a device perspective, there will be 10 billion IPv6-capable fixed and mobile devices in 2018, up from 2 billion in 2013, a CAGR of 37 percent and in terms of percentages, 47 percent of all fixed and mobile networked devices will be IPv6-capable in 2018, up from 16 percent in 2013. That means that by 2018, ~50 percent of all fixed and mobile devices and connections will be IPv6-capable. (Refer to the Cisco VNI white paper, "The Zettabyte Era," for more details.)

Specific country initiatives and cloud provider deployments have positively affected local IPv6 content reachability. In addition, recent advancements in IPv6 network deployment signify service providers' focus on IPv6 connectivity on both mobile and fixed networks. According to the World IPv6 Launch Organization, in September 2014 IPv6 deployment within Time Warner Cable was ~10 percent, Japan's KDDI ~11 percent, AT&T ~24 percent, Deutsche Telecom 26 percent, Comcast ~30 percent, T-Mobile 40 percent, and Verizon Wireless 56 percent (Figure 19).

Figure 19. IPv6 User Projections



Source: World IPv6 Launch Organization

Content providers are also moving to increase the IPv6 enablement of their sites and services. Cisco's IPv6 Lab reports that nearly 5,880 websites (on Oct. 1, 2014) of the 27,736 websites tracked are IPv6-capable, up from 4,430 websites (on Oct. 1, 2013). Cisco's IPv6 Lab tests 27,736 websites every day, from the top 500 websites for each of the 120 countries listed by Alexa (redundancy is not tested by Cisco IPv6 Lab). But more important than the sheer number of websites, the proportion of webpage clicks, or in other words web activity accessible over IPv6 for users who enjoy IPv6 connectivity, is much more than 50 percent in many countries. This increase is due to the greater proportion of content on top websites (that is, Google, Facebook, YouTube, Yahoo, etc.) that have enabled IPv6 access worldwide.

Facebook was 75% IPv6 capable internally in March 2014 as announced in the IPv6 World Congress with the goal of being 100% IPv6-only internally in the next 2-3 years. LinkedIn also launched IPv6 in September 2014 for both its web and mobile sites and email and messaging service. 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 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 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 at any time, any place. Business users require reliable access to business communications along with mobile solutions for videoconferencing and mission-critical customer and operational management systems.

The study also explores the ability of each global region (Asia Pacific, Central and Eastern Europe, Latin America, Middle East and Africa, North America, and Western Europe) to support a sample set of basic, intermediate, and advanced business and consumer cloud applications. Each region's cloud readiness is assessed with relation to the sample services based on download and upload fixed and mobile network speeds as well as associated network latencies (segmented by business and consumer connections). Download and upload speeds as well as latencies are essential measures to assess network capabilities for cloud readiness. Figure 20 provides the business and consumer cloud service categories and the corresponding network requirements used for this study. Figures 21, 22, and 23 describe the requirements and define a sample set of applications from each of the readiness categories. Note that the concurrent use of applications can further influence the user experience and cloud accessibility.

Figure 20. Sample Business and Consumer Cloud Service Categories

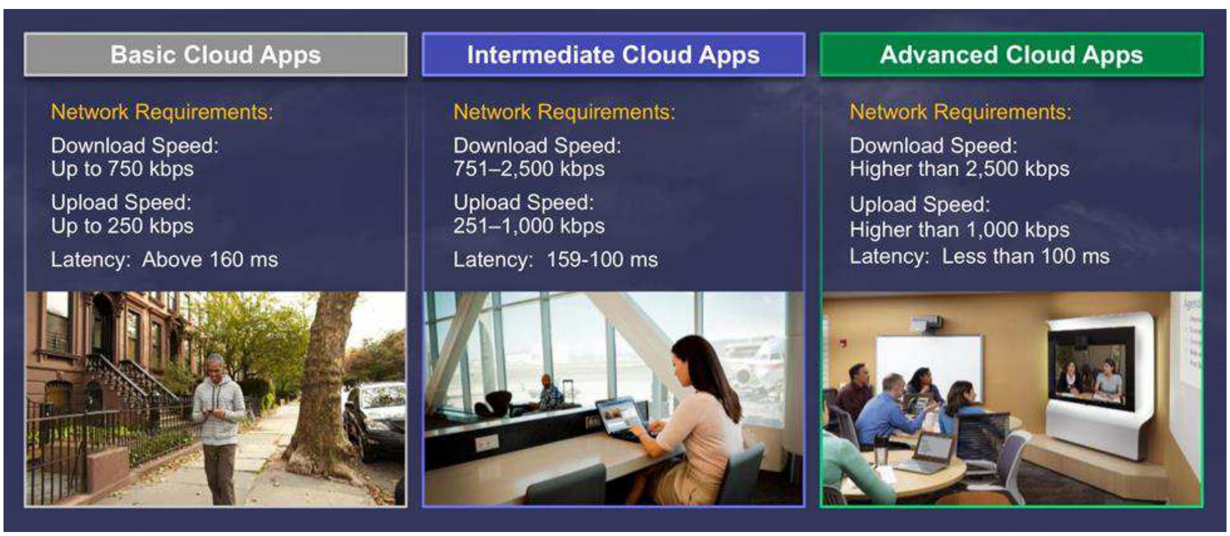


Figure 21. Sample Basic Applications

Apps	Definitions	Download	Upload	Latency
Stream Basic Video/ Music	Deliver sound and video without the need to download files of different audio or video formats utilizing computer servers connected to the Internet to access information.	High	Low	Medium
Text Communications (Email/IM)	A cross-platform messaging application which allows the exchange of messages without having to pay for SMS, using an internet data plan	Low	Low	Medium
VOIP (Internet Telephony)	A broad range of services transmitting voice over the Internet.	Low	Low	Medium
Web Browsing	Accelerate web experiences and searching through cloud computing using technology to shift the workload to the cloud servers.	Low	Low	Medium
Web Conferencing	A Cloud application used to interact with other participants and have that "live and in person" feeling attendees which offers services such as collaborative Web browsing, and application sharing.	Medium	Medium	Medium
Cloud-based Learning Management System	This app provides the user with the flexibility of being able to access and collaborate with others in a centralized environment and with information being housed in a virtual storage environment, it allows work to be completed outside the boundaries of the formal learning or work institutions	High	Medium	Medium

Figure 22. Sample Intermediate Applications

Apps	Definitions	Download	Upload	Latency
ERP/CRM	ERP and CRM systems allows businesses to manage their business and business relationships and the data and information associated with them.	Medium	Low	Medium
HD Video Streaming	Deliver High Def video without the need to download files of High Def video formats utilizing computer servers connected to the Internet to access information.	High	Low	Low
SD Video Conferencing	Two-way interactive standard Def video communication delivered using Internet technologies that allow people at different locations to come together for a meeting.	Medium	Medium	Medium
Web Electronic Health Records	EHRs are designed to contain and share information from all providers involved in a patient's care in a structured format allowing patient information to be easily retrieved and transferred in ways that can aid patient care.	Medium	High	Low
VOLTE	Standardized system for transferring traffic for voice over LTE	Low	Low	Low
Personal Content Locker	Asynchronous storage enables applications that use compound files to efficiently render their content when accessed by means of existing Internet protocols with a single request to a server triggering the download of nested objects contained within a Web page, eliminating the need to separately request each object.	High	High	Low

Figure 23. Sample Advanced Applications

Apps	Definitions	Download	Upload	Latency
Telemedicine	Telemedicine is the use of medical information exchanged from one site to another via electronic communications to improve a patient's clinical health status and includes using two-way video, email, smart phones, wireless tools and other forms of telecommunications technology	Medium	Medium	Low
HD Video Conferencing	Two-way interactive Hi Def video communication delivered using Internet technologies that allow people at different locations to come together for a meeting	High	High	Low
Ultra HD Video Streaming	Delivering Ultra High Def video without the need to download files of different video formats utilizing computer servers connected to the Internet to access information.	High	High	Low
Virtual Office	Mobile or remote work-environment equipped with telecommunication links but without a fixed office space using a combination of off-site live communication and address services that allow businesses to reduce traditional office costs while still maintaining business professionalism.	Medium	Medium	Low
High Frequency Stock Trading	Apps which support the rapid turnover of positions through the use of sophisticated trading algorithms, which process hundreds of trades in fractions of a second on the basis of changing market conditions	Low	Low	Low
Connected Vehicles Safety Applications	The development and deployment of a fully connected transportation system that makes the most of multi-modal, transformational applications requiring a combination of well-defined technologies, interfaces, and processes that, combined, ensure safe, stable, interoperable, reliable system operations that minimize risk and maximize opportunities.	Low	Low	Low

Regional network performance statistics were ranked by their ability to support these three cloud service categories. More than 150 million records from Ookla[4], the Cisco GIST application, Ovum, Informa, telecoms and media, Point Topic, United Nations (UN), and the International Telecommunication Union (ITU) were analyzed from nearly 150 countries around the world, covering a 2-year range of data. The regional averages of these measures are included as follows and in Appendix G.

The cloud readiness characteristics follow.

Network Access

- **Internet ubiquity**: This indicator measures fixed and mobile Internet 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.

[4] 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).

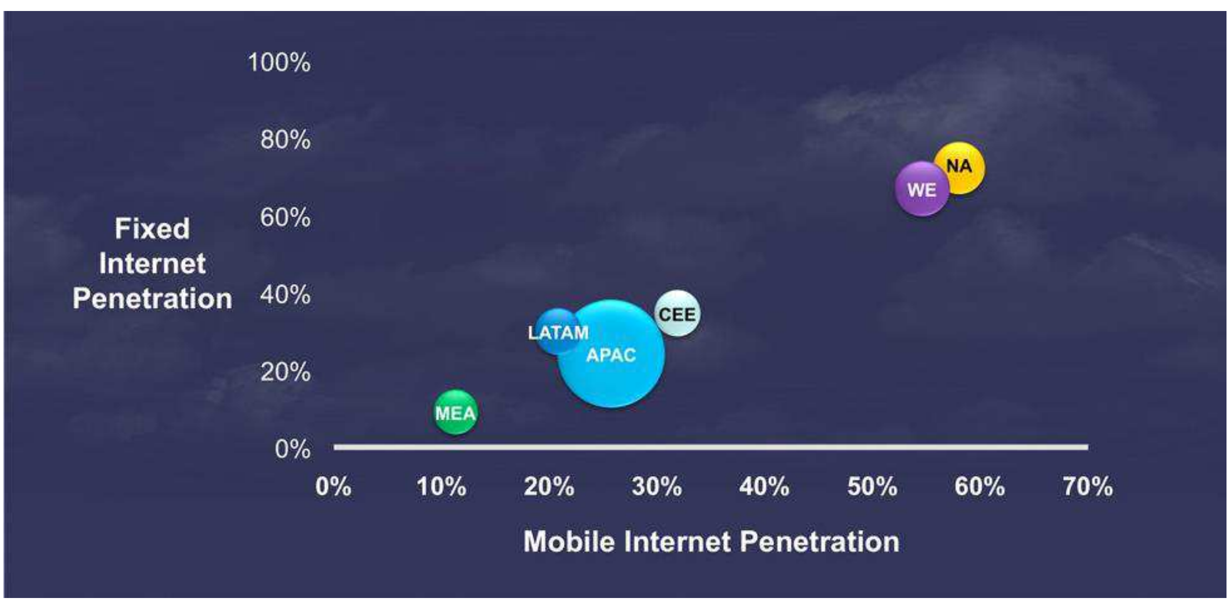
- **Upload speed**: With the increased adoption of virtual machines, tablets, and videoconferencing in enterprises as well as by consumers on both fixed and mobile networks, upload speeds are especially critical for delivery of content to the cloud. The importance of upload speeds will continue to increase 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).

Internet Ubiquity

Figures 24 and 25 summarize Internet penetration as a percentage of regional population in 2013 and 2018. North America and Western Europe led in Internet access (fixed and mobile) in 2013 and will continue to lead by 2018. 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 because of the region's large population.

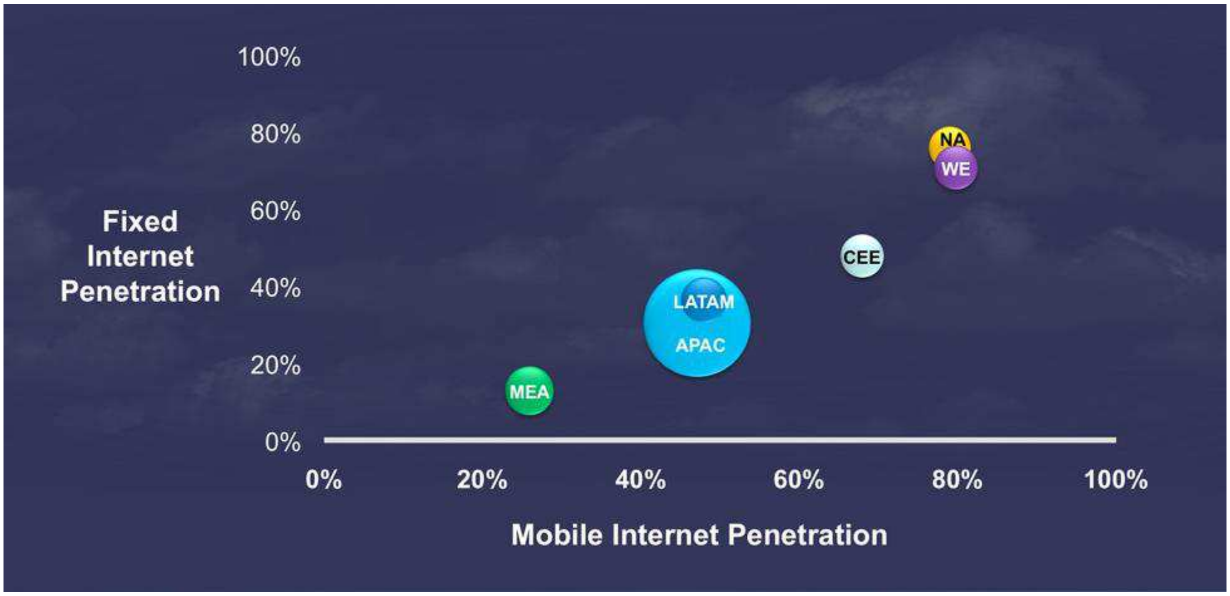
For Internet access ubiquity, we use internal projections and a bottom-up approach that includes estimating broadband lines and average users per household, and then validating the country estimates against country-specific telecom-reported data. On the mobile side, the approach focuses on mobile Internet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

Figure 24. Regional Broadband Ubiquity, 2013



The size of the bubbles represents the total Internet population of the region.
Source: Cisco Global Cloud Index, 2013–2018

Figure 25. Regional Internet Ubiquity, 2018



The size of the bubbles represents the total Internet population of the region.
Source: Cisco Global Cloud Index, 2013–2018

Global Average Download and Upload Speed Overview (2014)

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 details for download speeds, upload speeds, and latencies. To support cloud services and applications, the quality of the broadband connection is critical. Although theoretical speeds offered by fixed and mobile operators can seem adequate, 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).

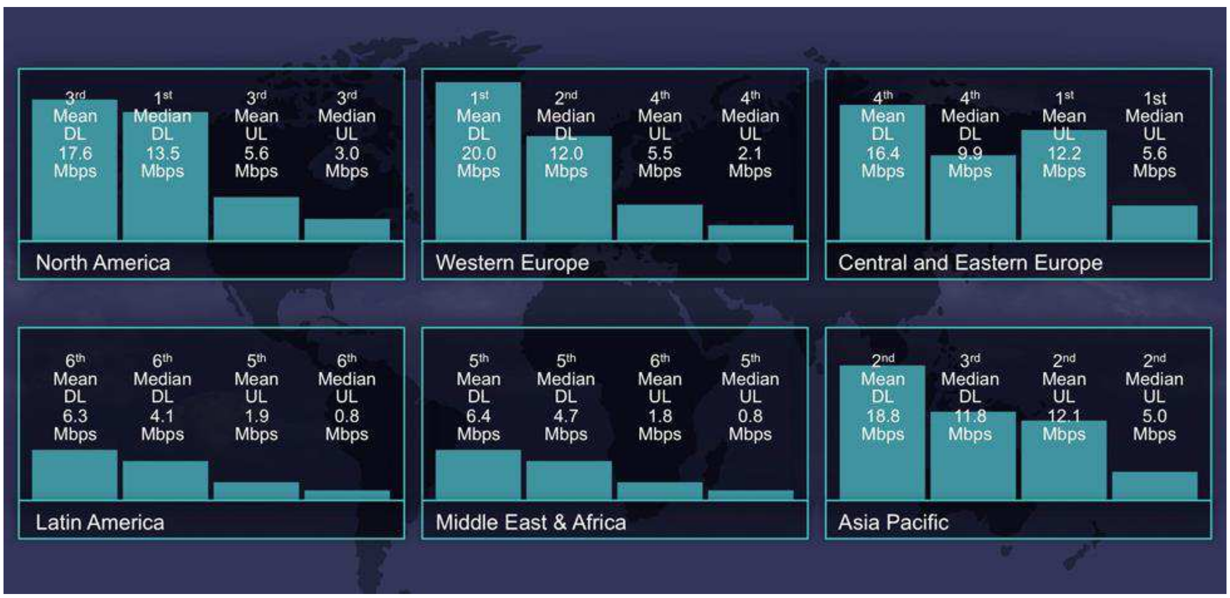
Key Results

- The global average fixed download speed is 17.3 Mbps, and the global median fixed download speed is 11.1 Mbps.
- The global average fixed upload speed is 8.8 Mbps, and the global median upload speed is 3.8 Mbps.
- The global average mobile download speed is 6.3 Mbps, and the global median mobile download speed is 4.8 Mbps.
- The global average mobile upload speed is 2.6 Mbps, and the global median mobile upload speed is 1.3 Mbps.

Regional Fixed Download and Upload Speeds

- **Average fixed download speeds**: Western Europe leads with 20.0 Mbps, and Asia Pacific follows with 18.8 Mbps.
- **Average fixed upload speeds**: Central and Eastern Europe leads with 12.2 Mbps, and Asia Pacific follows with 12.1 Mbps (Figure 26). Please refer to Appendix G and the Cisco GCI Supplement for further details.
- **Median fixed download and upload speeds**: Median speeds are lower than the average/mean speeds, as shown in Figure 26, because of 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 factor is a key factor. To understand speed distribution patterns in detail for a select list of countries, please refer to the Cisco GCI Supplement.

Figure 26. Regional Average Fixed Speeds, 2014



Source: Cisco Global Cloud Index, 2013–2018

Regional Average Mobile Download and Upload Speeds

- **Average mobile download speeds**: North America leads with 10.1 Mbps, and Western Europe follows with 9.5 Mbps.
- **Average mobile upload speeds**: Central and Eastern Europe leads with 4.9 Mbps, and North America follows with 4.3 Mbps (Figure 27). Please refer to Appendix G and the Cisco GCI Supplement for further details.
- **Median mobile download and upload speeds**: median speeds are lower than mean mobile speeds within all regions, with the distribution of speeds in the regional population tending to be lower than the average.

Figure 27. Regional Average Mobile Speeds, 2014

Source: Cisco Global Cloud Index, 2013–2018

Network Latency

- Global average fixed latency is 47 ms.
- Asia Pacific leads in average fixed latency with 40 ms, and Western Europe closely follows with 46 ms.
- Global average mobile latency is 198 ms.
- North America leads in average mobile latency with 101 ms, and Western Europe follows with 113 ms.

Please refer to Appendix G and the Cisco GCI Supplement for further details.

Conclusion

In summary, we can draw several main conclusions from the updated Cisco GCI 2013–2018 report.

Global data center traffic is firmly in the zettabyte era and will triple from 2013 to reach 8.6 zettabytes annually by 2018. A rapidly growing segment of data center traffic is cloud traffic, which will nearly quadruple over the forecast period and represent more than three-fourths of all data center traffic by 2018.

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. By 2018, more than three-fourths of all workloads will be processed in the cloud. 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 services such as consumer cloud storage are gaining momentum. By 2018, more than 50 percent of the consumer Internet population will be using personal cloud storage.

Within the cloud segment private cloud will have significantly more workloads than the public cloud, however, public cloud will grow faster than the private cloud over the forecast period. As the business sensitivity to costs associated with dedicated IT resources grows along with demand for agility, we can see a greater adoption of public cloud by the businesses, especially with strengthening of public cloud security. Many enterprises will adopt a hybrid approach to cloud as they transition some workloads from internally managed private clouds to externally managed public clouds. All three types of cloud service delivery models—IaaS, PaaS and SaaS—will continue to grow as more and more businesses realize the benefits of moving to a cloud environment.

This study also considers the importance of Internet 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.

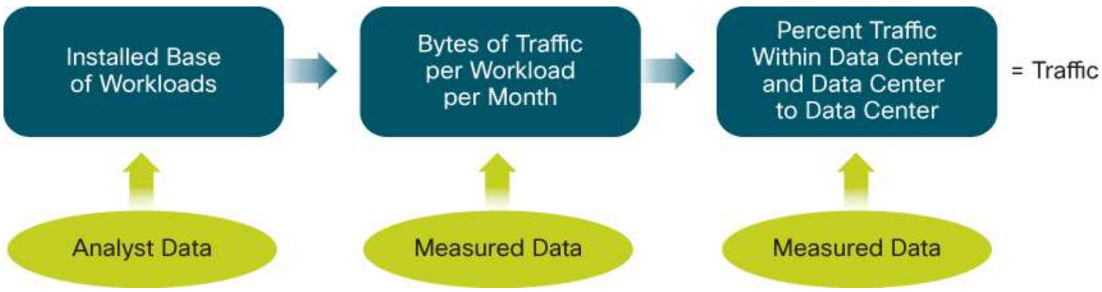
For More Information

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

Appendix A: Data Center Traffic Forecast Methodology

Figure 28 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 28. Data Center Traffic Forecast Methodology



Analyst Data

Data from several analyst firms and international agencies (including Gartner, IDC, Juniper Research, Informa, Ovum, Synergy, ITU, and the 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.

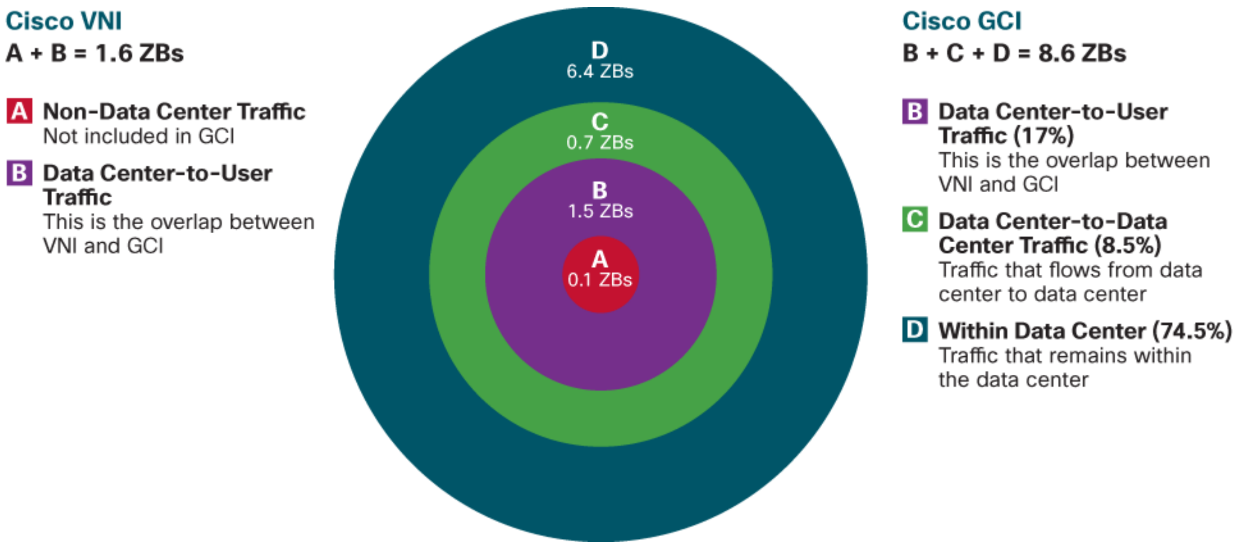
In addition, as noted in this paper, the methodology for the estimation of cloud data center traffic has changed since the last release of the Cisco Global Cloud Index. The previous methodology included all storage traffic in the noncloud traffic category. The updated methodology includes storage traffic 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 (VNI) are distinct forecasts that have an area of overlap. The Cisco VNI forecasts the amount of traffic crossing the Internet and IP WAN networks, whereas 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 area 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 29).

Figure 29. Cisco VNI and Global Cloud Index



Source: Cisco Global Cloud Index, 2013–2018

Appendix C: Regional Cloud Traffic Trends

The Cisco Global Cloud Index now includes regional forecast data for cloud traffic growth (Table 4).

- In 2013, North America generated the most cloud traffic (643 exabytes annually), followed by Asia Pacific (489 EB annually) and Western Europe (311 EB annually).
- By 2018, Asia Pacific will generate the most cloud traffic (2.3 zettabytes annually), closely followed by North America (2.1 ZB annually) and Western Europe (988 EB annually).
- From 2013 to 2018, the Middle East and Africa is expected to have the highest cloud traffic growth rate (54-percent CAGR), followed by Central and Eastern Europe (39-percent CAGR) and Asia Pacific (37-percent CAGR).

Table 4. Cloud Traffic Growth by Region, in Exabytes

Region	2013	2014	2015	2016	2017	2018	CAGR 2013–18
Asia Pacific	489	716	1,010	1,368	1,802	2,331	37%
Central and Eastern Europe	85	120	170	238	331	442	39%
Latin America	89	130	180	240	312	394	35%
Middle East and Africa	31	53	86	132	193	262	54%
North America	643	857	1,102	1,384	1,701	2,077	26%
Western Europe	311	401	502	631	791	988	26%

Source: Cisco Analysis, 2014

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	2013	2014	2015	2016	2017	2018	CAGR 2013–2018
Asia Pacific	16.3	20.9	28.4	37.9	48.0	61.2	30%
Central and Eastern Europe	2.3	2.7	3.1	3.6	4.3	5.1	17%
Latin America	2.6	3.2	3.9	4.7	5.7	6.9	21%
Middle East and Africa	1.8	2.3	2.9	3.5	4.3	5.2	24%
North America	56.1	62.8	68.7	73.9	80.3	88.0	9%
Western Europe	29.2	33.3	36.5	39.7	42.2	45.1	9%

Source: Cisco Analysis, 2014

Table 6. Regional Distribution of Cloud Workloads, in Millions

Cloud Data Center Workloads in Million	2013	2014	2015	2016	2017	2018	CAGR 2013–2018
Asia Pacific	7.5	11.1	17.3	25.5	34.9	47.5	45%
Central and Eastern Europe	1.0	1.4	1.8	2.3	3.0	3.8	31%
Latin America	1.2	1.7	2.3	3.1	4.1	5.2	34%
Middle East and Africa	0.8	1.2	1.7	2.3	3.1	4.0	39%
North America	30.5	37.8	45.2	52.0	60.1	69.3	18%
Western Europe	16.0	20.3	24.3	28.3	32.0	35.8	18%

Source: Cisco Analysis, 2014

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

Traditional Data Center Workloads in Millions	2013	2014	2015	2016	2017	2018	CAGR 2013–2018
Asia Pacific	8.8	9.7	11.1	12.4	13.1	13.7	9%
Central and Eastern Europe	1.3	1.3	1.3	1.3	1.3	1.3	0%
Latin America	1.4	1.5	1.6	1.6	1.7	1.7	3%
Middle East and Africa	1.0	1.1	1.1	1.2	1.2	1.2	5%
North America	25.6	25.0	23.6	21.9	20.2	18.7	-6%
Western Europe	13.2	13.1	12.2	11.4	10.3	9.2	-7%

Source: Cisco Analysis, 2014

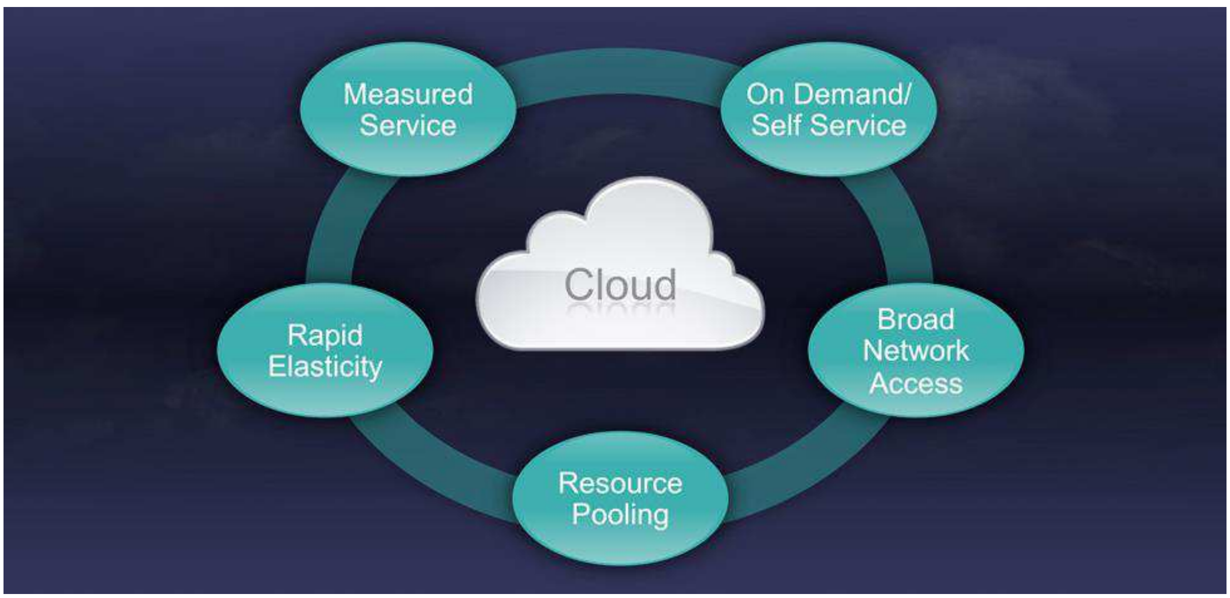
Appendix E: Cloud Definitions

Cloud Definition

The Cisco GCI aligns with the industry-standard cloud computing definition from the National Institute of Technology (NIST). The NIST definition lists five essential characteristics of cloud computing (Figure 30):

- On-demand self-service
- Broad network access
- Resource pooling
- Rapid elasticity or expansion
- Measured service

Figure 30. Essential Characteristics of Cloud

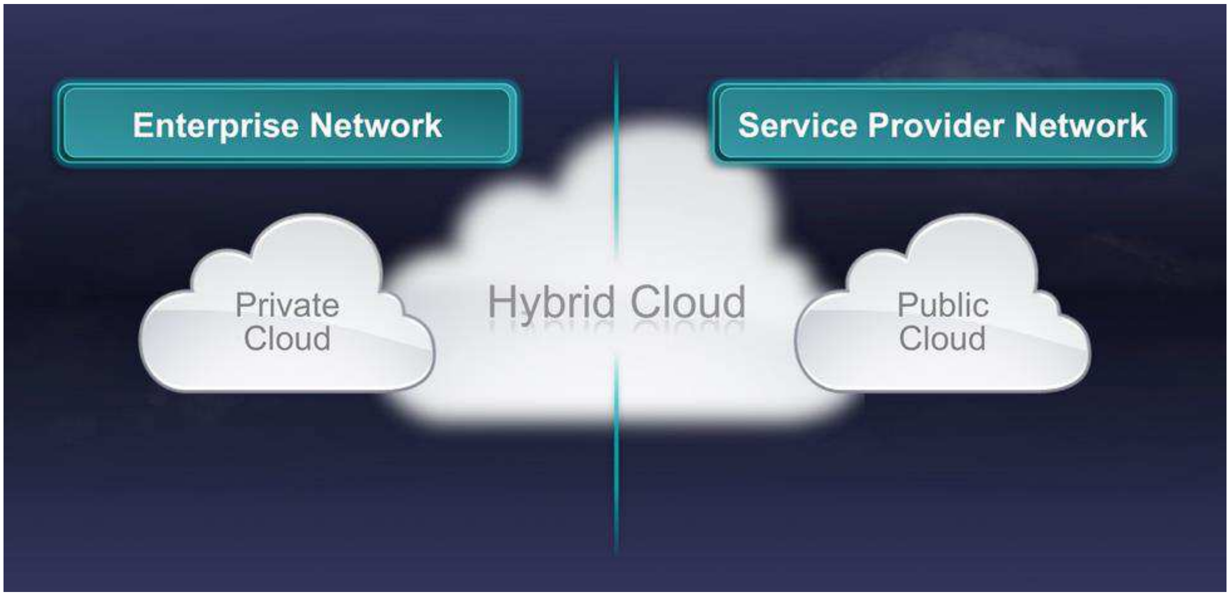


Cloud Deployment Models

Cloud deployment models include private, public, and hybrid clouds (or a combination of these). These distinct forms of cloud computing enable a variety of software, platform, and infrastructure services. Cloud data centers can be operated by service providers as well as private enterprises.

However, there is a slight variation from the NIST definition on how we classify private and public clouds. A cloud service could be public or private, depending on the demarcation line—the physical or virtual demarcation—between the public telecommunications network (WAN) and the private network of an organization (LAN) (Figure 31).

Figure 31. Cloud Deployment Models



If the cloud assets lie on the service provider side of the demarc line, then it would be considered a public cloud service. Virtual private cloud (VPC) falls in this category. Also the multitenant consumer cloud services would fall in this category.

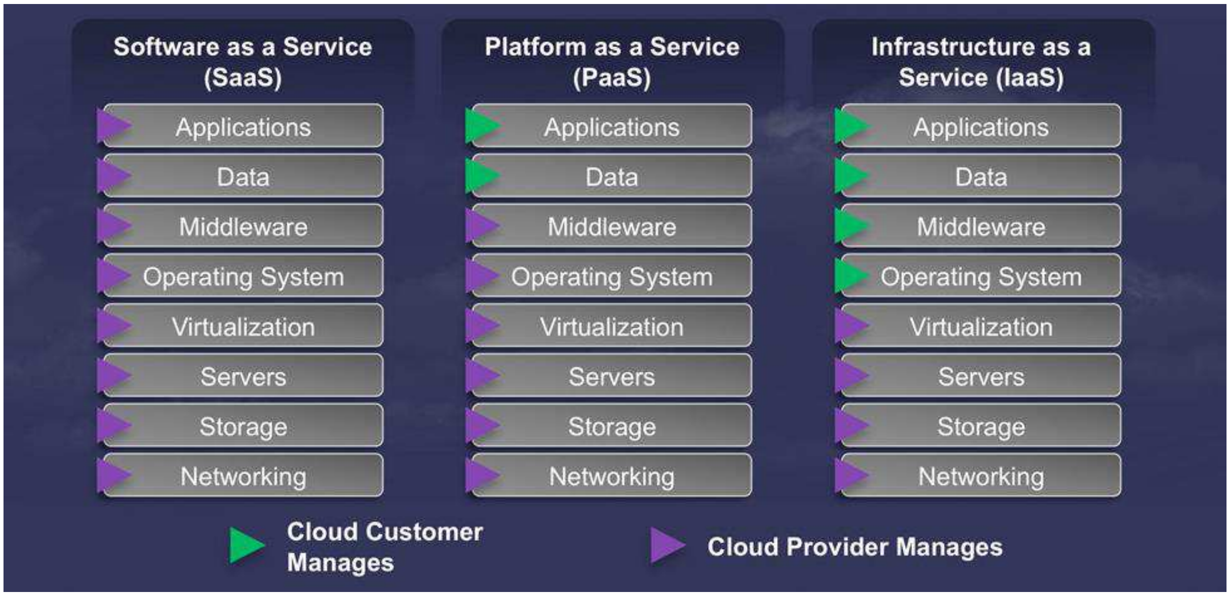
If the cloud assets lie on the organization side of the demarcation line, then it would be considered a private cloud service. In general, a dedicated cloud owned and managed by an organization's IT would be considered a private cloud.

Hybrid cloud, as the name suggests, is a combination of public and private clouds. In a hybrid cloud environment some of the cloud computing resources are managed in-house by an enterprise and some are managed by an external provider. We define private and public as distinct categories; we do not separately break out the hybrid cloud because it is simply a superset of the private and public clouds in varying degrees.

Cloud Service Models (IaaS, PaaS, and SaaS)

The Cisco GCI forecast for cloud workload splits across the three main cloud services models—Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS), and Infrastructure-as-a-Service (IaaS) (Figure 32). They are defined in line with NIST's definitions.

Figure 32. Cloud Service Models—IaaS, PaaS, and SaaS



SaaS

The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through either a thin-client interface, such as a web browser (for example, web-based email) or a program interface. The consumer neither manages nor controls the underlying cloud infrastructure, including networks, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.

PaaS

The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider. The consumer neither manages nor controls the underlying cloud infrastructure, including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment.

IaaS

The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer neither manages nor controls the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (for example, host firewalls).

Appendix F: Regional Consumer Cloud Storage

Table 8 provides regional details for 2018 regarding consumer Internet users (adoption percent), average number of consumer devices per Internet user, and the number of consumer cloud storage users (percent of consumer Internet users).

Table 8. Regional Consumer Cloud Storage Users by 2018

Region	Consumer Internet Users in Millions (% of Population)	Average Number of Devices per Consumer Internet User	Consumer Cloud Storage Users in Millions (% of Internet Users)
Asia Pacific	2,015 (49%)	3.80	1,174 (58%)
Central and Eastern Europe	322 (66%)	4.00	125 (39%)
Latin America	355 (55%)	3.87	109 (31%)
Middle East and Africa	410 (27%)	4.19	57 (14%)
North America	309 (84%)	8.42	252 (81%)
Western Europe	337 (80%)	6.34	267 (79%)

Source: Cisco Analysis, 2014

Appendix G: Regional Cloud Readiness Summary

Table 9 summarizes cloud readiness by region, considering download and upload speeds, and latency. Please refer to the Cisco GCI Supplement for more details.

Table 9. Regional Cloud Readiness

Network	Segment	Region	Average Download Speeds (kbps)	Average Upload Speeds (kbps)	Average Latency (ms)
Fixed	All	Asia Pacific	18,858	12,172	40
		Central and Eastern Europe	16,446	12,227	47
		Latin America	6,355	1,909	69
		Middle East and Africa	6,452	1,849	87
		North America	17,640	5,606	49
		Western Europe	20,034	5,476	46
Mobile	All	Asia Pacific	7,096	2,644	182
		Central and Eastern Europe	7,058	4,890	147
		Latin America	3,811	1,400	220
		Middle East and Africa	2,518	1,036	328
		North America	10,101	4,303	101
		Western Europe	9,481	3,433	113

Source: Cisco Analysis, 2014

Appendix H: Internet Ubiquity

Tables 10 and 11 summarize regional Internet access penetration for 2013 and 2018. For fixed Internet access, 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, preventing duplicative calculations (because some users may have multiple subscriptions).

Table 10. Regional Internet Penetration (Percentages Indicate Users with Internet Access Per Region) in 2013

Region	Fixed Internet Users in Millions (2013)	Mobile Internet Users in Millions (2013)	Internet Population in Millions (2013)
Asia Pacific	947 (24%)	1,009 (26%)	1,239
Central and Eastern Europe	167 (35%)	154 (32%)	224
Latin America	184 (30%)	128 (21%)	235
Middle East and Africa	125 (9%)	155 (11%)	213
North America	256 (72%)	206 (58%)	287
Western Europe	279 (67%)	228 (55%)	323

Source: Cisco Analysis, 2014

Table 11. Regional Internet Penetration (Percentages Indicate Users with Internet Access Per Region) in 2018

Region	Fixed Internet Users in Millions (2018)	Mobile Internet Users in Millions(2018)	Internet Population in Millions (2018)
Asia Pacific	1,244 (30%)	1,929 (47%)	2,109
Central and Eastern Europe	232 (48%)	330 (68%)	339
Latin America	235 (36%)	311 (48%)	371
Middle East and Africa	197 (13%)	400 (26%)	431
North America	280 (76%)	292 (79%)	317
Western Europe	299 (71%)	338 (80%)	346

Source: Cisco Analysis, 2014

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