White Paper

The Zettabyte Era: Trends and Analysis

June 10, 2014

This document is part of the Cisco® Visual Networking Index (VNI), an ongoing initiative to track and forecast the impact of visual networking applications. The document presents some of the main findings of Cisco's global IP traffic forecast and explores the implications of IP traffic growth for service providers. For a more detailed look at the forecast and the methodology behind it, visit Cisco VNI: Forecast and Methodology, 2013–2018.

Executive Summary

Annual global IP traffic will pass the zettabyte (1000 exabytes) threshold by the end of 2016, and will reach 1.6 zettabytes per year by 2018. In 2016, global IP traffic will reach 1.1 zettabytes per year or 91.3 exabytes (one billion gigabytes) per month, and by 2018, global IP traffic will reach 1.6 zettabytes per year or 131.9 exabytes per month.

Global IP traffic has increased fivefold over the past 5 years, and will increase threefold over the next 5 years. Overall, IP traffic will grow at a compound annual growth rate (CAGR) of 21 percent from 2013 to 2018.

Busy-hour Internet traffic is growing more rapidly than average Internet traffic. Busy-hour (or the busiest 60-minute period in a day) Internet traffic increased 32 percent in 2013, compared with 25 percent growth in average traffic. Busy-hour Internet traffic will increase by a factor of 3.4 between 2013 and 2018, while average Internet traffic will increase 2.8-fold. Busy-hour Internet traffic will reach 1.0 petabits per second (Pbps) in 2018, while average Internet traffic will reach 311 terabits per second.

Metro traffic will surpass long-haul traffic in 2015, and will account for 62 percent of total IP traffic by 2018. Metro traffic will grow nearly twice as fast as long-haul traffic from 2013 to 2018. The higher growth in metro networks is due in part to the increasingly significant role of content delivery networks, which bypass long-haul links and deliver traffic to metro and regional backbones.

Content delivery networks will carry more than half of Internet traffic by 2018. Fifty-five percent of all Internet traffic will cross content delivery networks by 2018 globally, up from 36 percent in 2013.

Over half of all IP traffic will originate with non-PC devices by 2018. In 2013, only 33 percent of total IP traffic originated with non-PC devices, but by 2018 the non-PC share of total IP traffic will grow to 57 percent. PC-originated traffic will grow at a CAGR of 10 percent, while TVs, tablets, smartphones, and machine-to-machine (M2M) modules will have traffic growth rates of 35 percent, 74 percent, 64 percent, and 84 percent, respectively.

Traffic from wireless and mobile devices will exceed traffic from wired devices by 2016. By 2016, wired devices will account for 46 percent of IP traffic, while Wi-Fi and mobile devices will account for 54 percent of IP traffic. In 2013, wired devices accounted for the majority of IP traffic at 56 percent.

Global Internet traffic in 2018 will be equivalent to 64 times the volume of the entire global Internet in 2005. Globally, Internet traffic will reach 14 gigabytes (GB) per capita by 2018, up from 5 GB per capita in 2013.

The number of devices connected to IP networks will be nearly twice as high as the global population by 2018. There will be nearly three networked devices per capita by 2018, up from nearly two networked devices per capita in 2013. Accelerated in part by the increase in devices and the capabilities of those devices, IP traffic per capita will reach 17 GB per capita by 2018, up from 7 GB per capita in 2013.

Broadband speeds will nearly triple by 2018. By 2018, global fixed broadband speeds will reach 42 Mbps, up from 16 Mbps in 2013.

Global Internet Video Highlights

It would take an individual more than 5 million years to watch the amount of video that will cross global IP networks each month in 2018. Every second, nearly a million minutes of video content will cross the network by 2018.

Globally, IP video traffic will be 79 percent of all IP traffic (both business and consumer) by 2018, up from 66 percent in 2013. This percentage does not include the amount of video exchanged through peer-to-peer (P2P) file sharing. The sum of all forms of video (TV, video on demand [VoD], Internet, and P2P) will continue to be in the range of 80 to 90 percent of global consumer traffic by 2018.

Internet video to TV grew 35 percent in 2013. It will continue to grow at a rapid pace, increasing fourfold by 2018. Internet video to TV will be 14 percent of consumer Internet video traffic in 2018, up from 11 percent in 2013.

Consumer VoD traffic will double by 2018. The amount of VoD traffic in 2018 will be equivalent to 6 billion DVDs per month.

Content delivery network traffic will deliver over half of all Internet video traffic by 2018. By 2018, 67 percent of all Internet video traffic will cross content delivery networks, up from 53 percent in 2013.

Global Mobile Highlights

Globally, mobile data traffic will increase 11-fold between 2013 and 2018. Mobile data traffic will grow at a CAGR of 61 percent between 2013 and 2018, reaching 15.9 exabytes per month by 2018.

Global mobile data traffic will grow three times faster than fixed IP traffic from 2013 to 2018. Global mobile data traffic was 3 percent of total IP traffic in 2013, and will be 12 percent of total IP traffic by 2018.

Regional Highlights

IP traffic is growing fastest in the Middle East and Africa, followed by Asia Pacific. Traffic in the Middle East and Africa will grow at a CAGR of 38 percent between 2013 and 2018.

Summary of regional growth rates:

- IP traffic in North America will reach 40.5 exabytes per month by 2018 at a CAGR of 20 percent.
- IP traffic in Western Europe will reach 19.3 exabytes per month by 2018 at a CAGR of 18 percent.
- IP traffic in Asia Pacific will reach 47.3 exabytes per month by 2018 at a CAGR of 21 percent.
- IP traffic in Latin America will reach 8.9 exabytes per month by 2018 at a CAGR of 21 percent.
- IP traffic in Central and Eastern Europe will reach 10.2 exabytes per month by 2018 at a CAGR of 23 percent.
- IP traffic in the Middle East and Africa will reach 5.3 exabytes per month by 2018 at a CAGR of 38 percent.

Note: Several interactive tools are available to allow you to create custom highlights and forecast charts by region, by country, by application, and by end-user segment (refer to the Cisco VNI Forecast Highlights tool and the Cisco VNI Forecast Widget tool).

Global Business Highlights

Business IP traffic will grow at a CAGR of 18 percent from 2013 to 2018. Increased adoption of advanced video communications in the enterprise segment will cause business IP traffic to grow by a factor of two between 2013 and 2018.

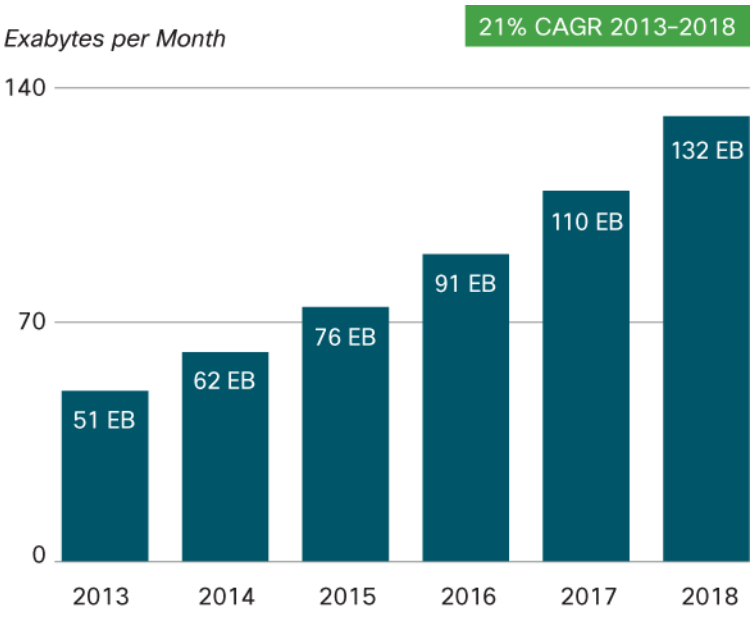
Business Internet traffic will grow at a faster pace than IP WAN. IP WAN will grow at a CAGR of 10 percent, compared with a CAGR of 18 percent for fixed business Internet and 55 percent for mobile business Internet.

Business IP traffic will grow fastest in the Middle East and Africa. Business IP traffic in the Middle East and Africa will grow at a CAGR of 23 percent, a faster pace than the global average of 18 percent. In volume, Asia Pacific will have the largest amount of business IP traffic in 2018 at 8.5 exabytes per month. North America will be the second at 6.2 exabytes per month.

Forecast Overview

The current Visual Networking Index forecast projects global IP traffic to nearly triple from 2013 to 2018. See Appendix A for a detailed summary. Overall IP traffic is expected to grow to 132 exabytes per month by 2018, up from 51 exabytes per month in 2013, a CAGR of 21 percent (Figure 1).

Figure 1. Cisco VNI Forecasts 132 Exabytes per Month of IP Traffic by 2018



Source: Cisco VNI, 2014

For more details about Cisco's forecasting methodology, refer to the paper entitled "Cisco VNI: Forecast and Methodology, 2013–2018."

To appreciate the magnitude of IP traffic volumes, it helps to put the numbers in more familiar terms:

- By 2018, the gigabyte equivalent of all movies ever made will cross the global Internet every 3 minutes.
- Globally, IP traffic will reach 400 terabits per second (Tbps) in 2018, the equivalent of 148 million people streaming Internet HD video simultaneously, all day, every day.
- Global IP traffic in 2018 will be equivalent to 395 billion DVDs per year, 33 billion DVDs per month, or 45 million DVDs per hour.

Total Internet traffic has experienced dramatic growth the past two decades. More than twenty years ago, in 1992, global Internet networks carried approximately 100 GB of traffic per day. Ten years later, in 2002, global Internet traffic amounted to 100 gigabytes per second (GBps). In 2012, global Internet traffic reached 12,000 GBps. Table 1 provides a view of the historical benchmarks for total Internet traffic.

Table 1. The Cisco VNI Forecast Within Historical Context

Year	Global Internet Traffic
1992	100 GB per Day
1997	100 GB per Hour
2002	100 GBps
2007	2000 GBps
2013	28,875 GBps
2018	50,000 GBps

Source: Cisco VNI, 2014

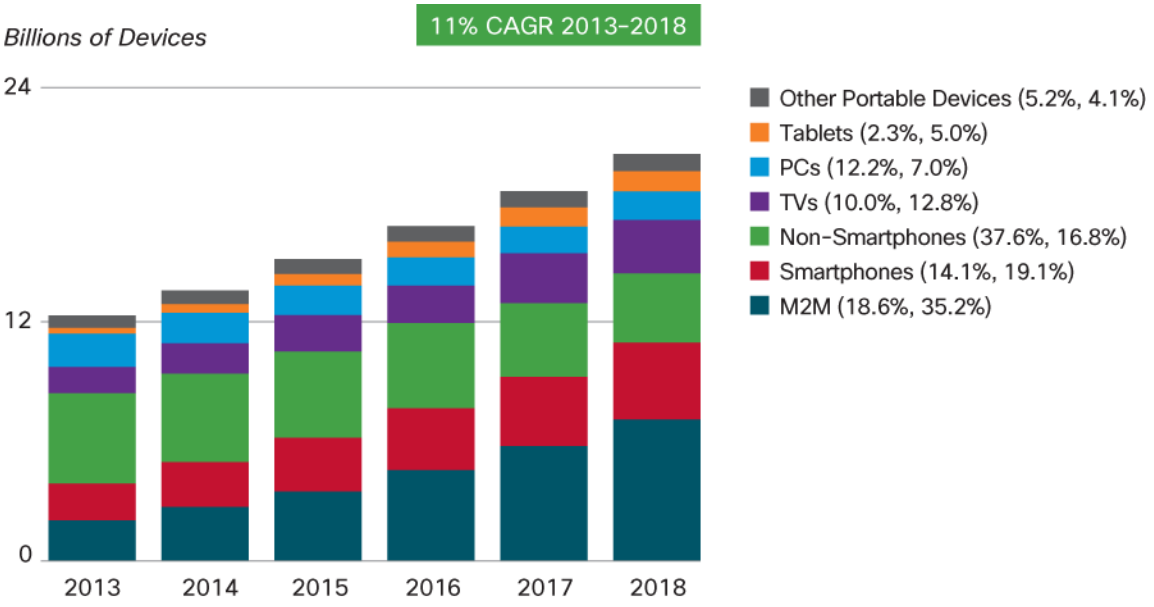
Per capita IP and Internet traffic growth has followed a similarly steep growth curve over the past decade. Globally, IP traffic will reach 17 GB per capita by 2018, up from 7 GB per capita in 2013, and Internet traffic will reach 14 GB per capita by 2018, up from 5 GB per capita in 2013. Not long ago, in 2008, per capita Internet traffic was 1 GB per month. In 2000, per capita Internet traffic was 10 megabytes (MB) per month.

The sections that follow explore the trends contributing to the continued growth of global IP traffic.

Trend 1: Device Transitions Alter Network Demand or Use

Globally, devices and connections (10.7 percent CAGR) are growing faster than both the population (1.1 percent CAGR) and Internet users (9.2 percent CAGR). See Figure 2. This trend is accelerating the increase in the average number of devices and connections per household and per Internet user. Each year, various new devices in different form factors with increased capabilities and intelligence are introduced and adopted in the market. A growing number of M2M applications, such as smart meters, video surveillance, healthcare monitoring, transportation, and package or asset tracking, also are causing connection growth.

Figure 2. Global Devices and Connections Growth



Source: Cisco VNI, 2014
The percentages in parentheses next to the legend denote the device share for the years 2013 and 2018, respectively.

Tablets are the fastest-growing device category with 29 percent CAGR (3.6-fold growth) over the forecast period, followed by machine-to-machine (M2M) connections with 26 percent CAGR (threefold growth). Device categories such as non-smartphones are actually going to start seeing a decline over the forecast period, increasingly being replaced by smartphones, which will more than double at 18 percent CAGR over the forecast period. Connected TVs, which includes flat-panel TVs, set-top boxes, digital media adapters, Blu-ray disc players, and gaming consoles) will double to 2.6 billion by 2018. PCs will also decline by 1 percent CAGR over the forecast period. This decline is more pronounced in Western Europe and North America. More tablets than laptops will be in use by the end of 2018.

Consumer share of the total devices, including the fixed and the mobile, is going to be about 80 percent, with business claiming the remaining 20 percent. Consumer share is going to grow slightly faster, at an 11 percent CAGR relative to the business segment, which is going to grow at a 9 percent CAGR. For more details about devices and connections growth by residential, consumer mobile, and business segments, refer to the Cisco VNI Service Adoption Forecast, 2013–2018.

Globally, the average number of devices and connections per capita is going to grow from 1.7 in 2013 to 2.7 by 2018 (Table 2).

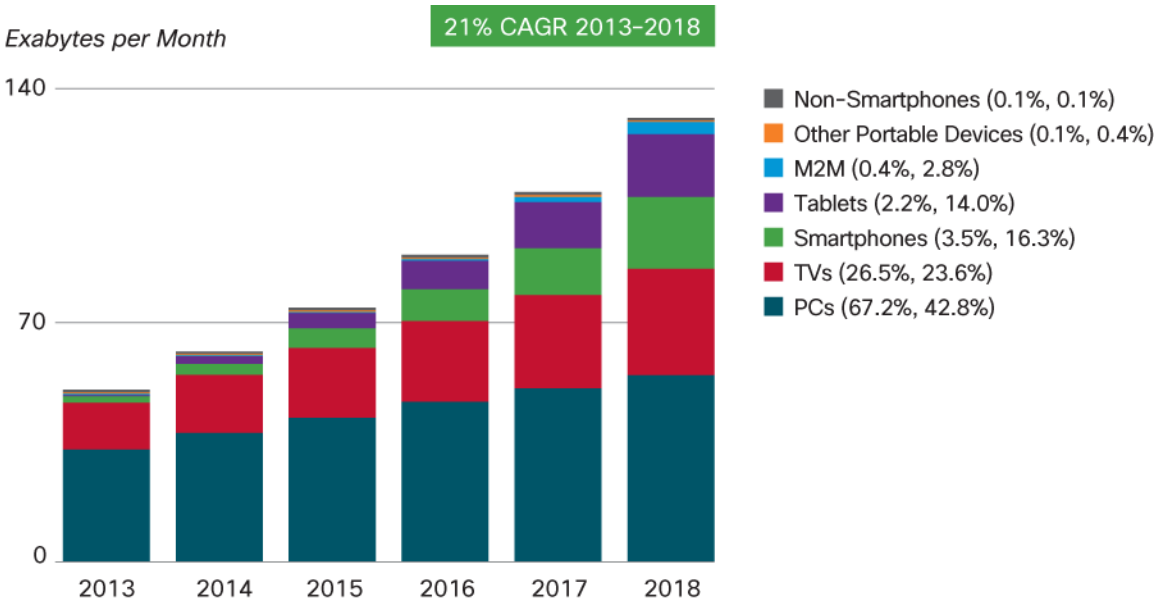
Table 2. Average Number of Devices and Connections per Capita

	2013	2018	CAGR
Asia Pacific	1.41	2.24	9.7%
Central and Eastern Europe	2.10	3.39	10.1%
Latin America	1.75	2.58	8.1%
Middle East and Africa	0.92	1.28	6.7%
North America	5.34	9.26	11.7%
Western Europe	3.89	6.52	10.9%
Global	1.73	2.73	9.5%

Source: Cisco VNI, 2014

The changing mix of devices and connections and growth in multidevice ownership affects traffic and can be seen in the changing device contribution to total IP traffic. At the end of 2013, 33 percent of IP traffic and 15 percent of consumer Internet traffic originated from non-PC devices. By 2018, 57 percent of IP traffic and 52 percent of consumer Internet traffic will originate from non-PC devices (Figure 3).

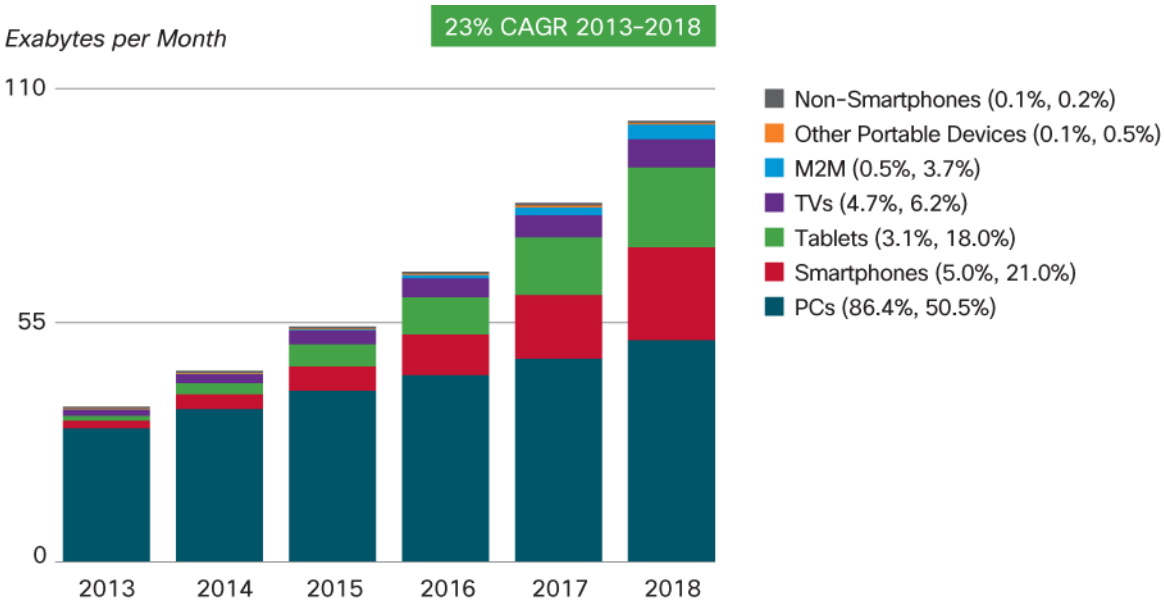
Figure 3. Global IP Traffic by Devices



Source: Cisco VNI, 2014
The percentages in parentheses next to the legend denote the device traffic shares for the years 2013 and 2018, respectively.

As in the case of mobile networks, video devices can have a multiplier effect on traffic. An Internet-enabled HD television that draws 50 minutes of content per day from the Internet would generate as much Internet traffic as an entire household today. With the growth of video viewing on tablets, traffic from tablets is growing as a percentage of total internet traffic. Tablets will account for 18 percent of total global internet traffic by 2018, up from 3 percent in 2013 (Figure 4).

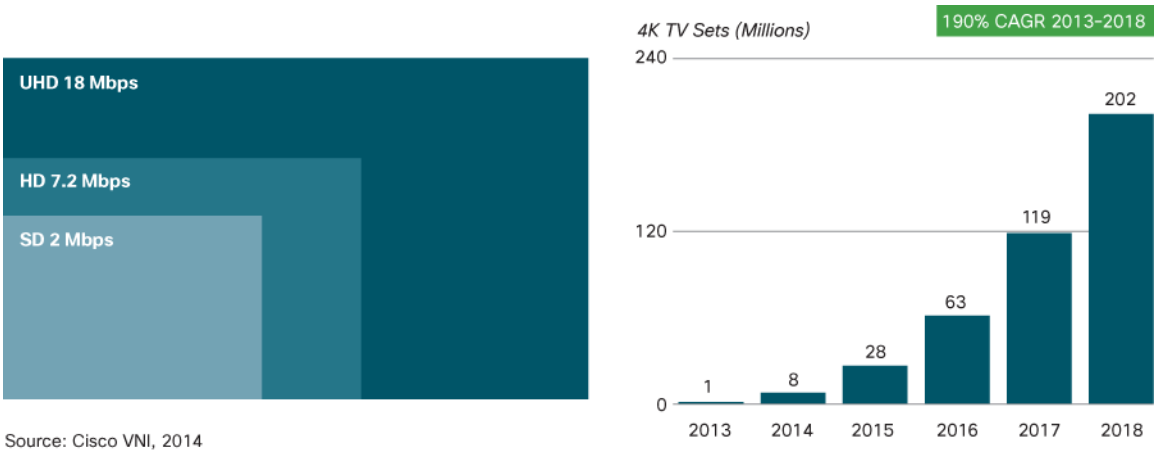
Figure 4. Global Internet Traffic by Device Type



Source: Cisco VNI, 2014
The percentages in parentheses next to the legend denote the device traffic shares for the years 2013 and 2018, respectively.

The video impact of the devices on the traffic is more pronounced due to the introduction of ultra-high-definition (UHD) or 4K video streaming. This is because the bit rate for 4K video at about 18 Mbps is more than double the HD video bit rate and nine times more than standard-definition (SD) video bit rate. We estimate that by 2018, 21 percent of the installed flat-panel TV sets will be UHD, up from 0.4 percent in 2013 (Figure 5).

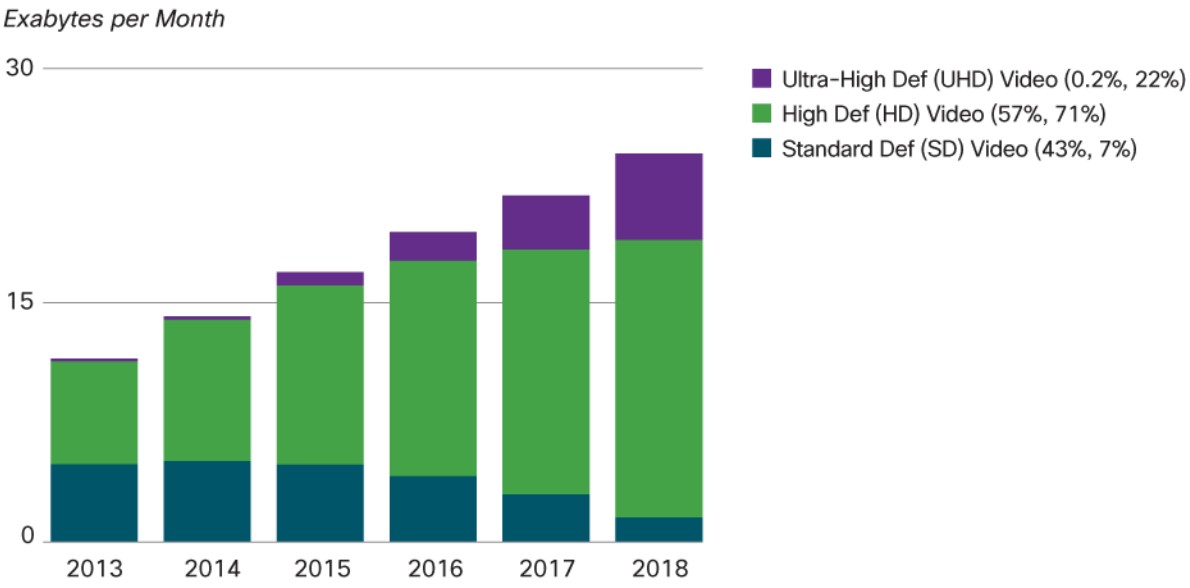
Figure 5. Increasing Video Definition: By 2018, More than 20 Percent of Connected Flat-Panel TV Sets Will Be 4K



Source: Cisco VNI, 2014

Ultra-HD (or 4K) IP VOD Will Account for 22% of global VOD Traffic in 2018, per Figure 6.

Figure 6. 4K Video Traffic

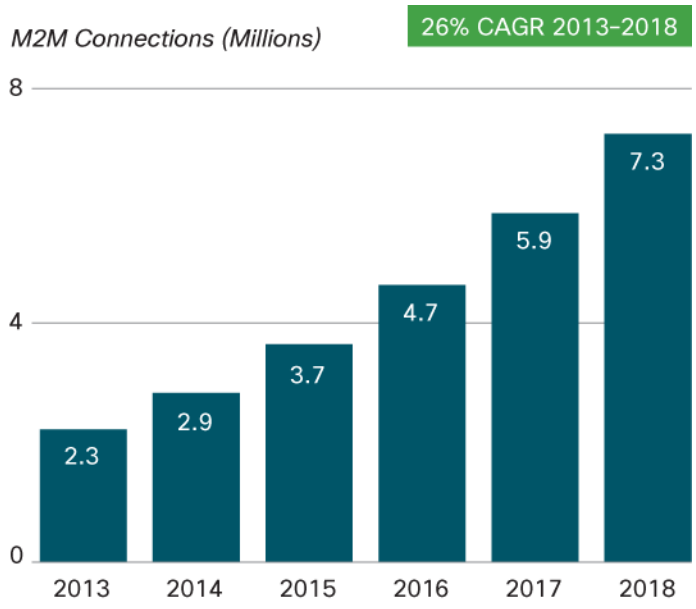


Source: Cisco VNI, 2014
The percentages next to the legend denote the traffic share for the years 2013 and 2018 respectively.

Trend 2: M2M Growth Drives the Reality of Internet of Everything

The Internet of Everything (IoE) phenomenon, or the next wave of the Internet in which people, processes, data, and things connect to the Internet and each other, is showing tangible growth. Globally, M2M connections will grow threefold from 2.3 billion in 2013 to 7.3 billion by 2018 (Figure 7). There will be nearly one M2M connection for each member of the global population by 2018.

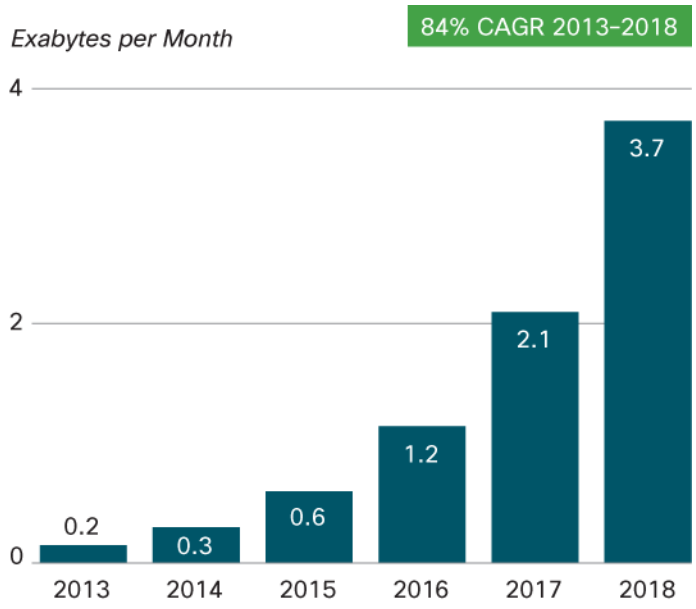
Figure 7. M2M Growth



Source: Cisco VNI, 2014

Applications such as video surveillance, smart meters, smart cars, asset and package tracking, chipped pets and livestock, digital health monitors, and a host of other next-generation M2M services are driving this growth.

Figure 8. M2M Traffic Growth



Source: Cisco VNI, 2014

While the number of connections is growing threefold, global M2M IP traffic will grow 11-fold over this same period, from 179 petabytes in 2013 (0.4 percent of global IP traffic) to 3.7 exabytes by 2018 (2.8 percent of global IP traffic). See Figure 8. The higher traffic growth than connections growth is due to more video applications being deployed on M2M connections as well as the use of applications, such as telemedicine and smart car navigation, that require higher bandwidth and lower latency.

Trend 3: Fixed Broadband Speeds Will Nearly Triple by 2018

Fixed Speeds

Broadband speed is a crucial enabler of IP traffic. Broadband speed improvements result in increased consumption and use of high-bandwidth content and applications. The global average broadband speed continues to grow and will nearly triple from 2013 to 2018, from 16.1 Mbps to 42.2 Mbps. Table 3 shows the projected broadband speeds from 2013 to 2018. Several factors influence the fixed broadband speed forecast, including the deployment and adoption of fiber to the home (FTTH), high-speed DSL, and cable broadband adoption, as well as overall broadband penetration. Among the countries covered by this study, Japan, South Korea, and Sweden lead in terms of broadband speed largely because of their wide deployment of FTTH.

Table 3. Fixed Broadband Speeds, Mbps, 2013–2018

Region	2013	2014	2015	2016	2017	2018	CAGR
Global	11.3	16.1	20.3	25.6	31.1	36.7	42.2
Asia Pacific	10.4	18.0	23.2	29.7	36.4	42.5	48.1
Latin America	5.4	6.4	7.8	9.6	11.6	13.9	16.4
North America	12.9	17.6	21.8	27.0	32.3	37.7	43.2
Western Europe	13.0	19.3	23.8	29.3	35.4	42.1	48.9
Central and Eastern Europe	12.3	17.5	22.2	28.3	34.6	40.0	45.3
Middle East and Africa	2.5	5.7	7.1	8.8	10.8	12.8	14.9

Source: Cisco VNI, 2014

Consider how long it takes to download a HD movie at these speeds: at 5 Mbps, it takes 41 minutes to download the movie; at 10 Mbps, it takes 20 minutes; but at 100 Mbps, it takes only 2 minutes. High-bandwidth speeds will be an essential support for consumer cloud storage, making the download of large multimedia files as fast as a transfer from a hard drive. Table 4 shows the percentage of broadband connections that will be faster than 5 Mbps, 10 Mbps, and 100 Mbps by region.

Table 4. Broadband Speed Greater than 10 Mbps, 2013–2018

Region	Greater than 10 Mbps		Greater than 50 Mbps		Greater than 100 Mbps	
	2013	2018	2013	2018	2013	2018
Global	45%	55%	12%	22%	2%	3%
Asia Pacific	43%	53%	13%	23%	2%	4%
Latin America	24%	34%	3%	5%	1%	2%
North America	57%	62%	12%	20%	2%	4%
Western Europe	50%	52%	14%	24%	4%	6%
Central and Eastern Europe	47%	73%	12%	25%	1%	3%
Middle East and Africa	18%	23%	2%	4%	0.3%	1%

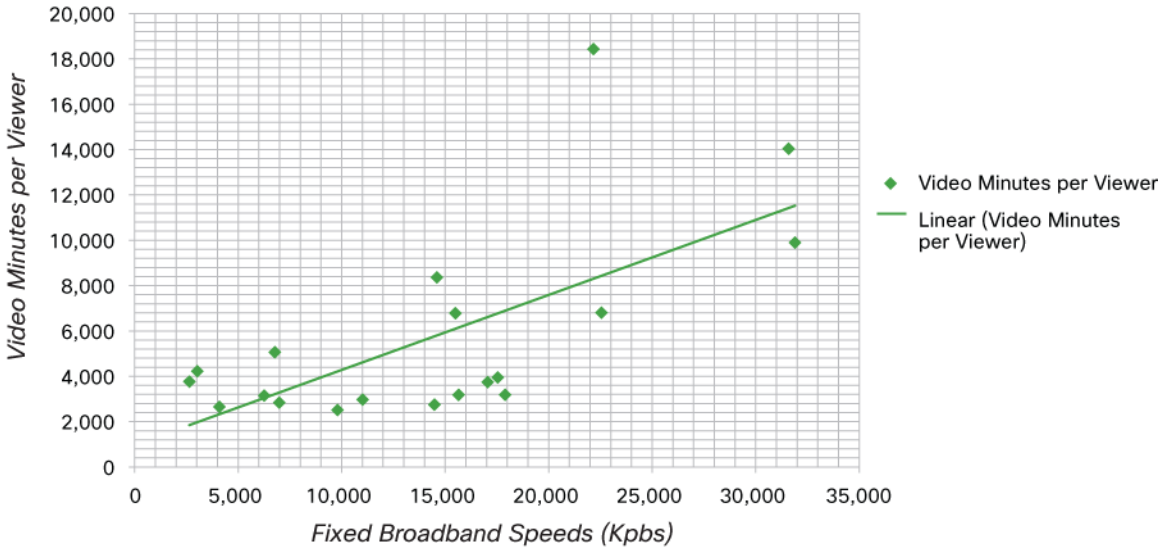
Source: Cisco VNI, 2014

Mobile Speeds

Globally, the average mobile network connection speed in 2013 was 1.4 Mbps. The average speed will nearly double, and will exceed 2.5 Mbps by 2018. Smartphone speeds, generally third-generation (3G) and higher, are currently almost three times higher than the overall average. Smartphone speeds will nearly double by 2018, reaching 7.0 Mbps.

There is a strong correlation between experienced speeds and number of video minutes viewed per viewer (Figure 9). As speeds increase in each country covered in the study, the number of video minutes per viewer also increases.

Figure 9. Increase in Experienced Speeds (Kbps) Increases Internet Video Viewership (Minutes)



Source: Cisco VNI, 2014

Anecdotal evidence supports the idea that overall usage increases when speed increases, although there is often a delay between the increase in speed and the increased usage, which can range from a few months to several years. The reverse can also be true with the burstiness associated with the adoption of tablets and smartphones, where there is a delay in experiencing the speeds that the devices are capable of supporting. The Cisco VNI Forecast relates application bit rates to the average speeds in each country. Many of the trends in the resulting traffic forecast can be seen in the speed forecast, such as the high growth rates for developing countries and regions relative to more developed areas (Table 5).

Table 5. Projected Average Mobile Network Connection Speeds (in Kbps) by Region and Country

	2013	2014	2015	2016	2017	2018	CAGR 2013–2018
Global							
Global speed: All handsets	1,387	1,676	1,908	2,147	2,396	2,509	13%
Global speed: Smartphones	3,983	4,864	5,504	6,132	6,756	7,044	12%
Global speed: Tablets	4,591	5,584	6,298	6,483	8,018	8,998	14%
By Region							
Asia Pacific	1,327	1,492	1,617	1,728	1,863	1,992	8%
Latin America	684	734	793	856	924	999	8%
North America	1,728	2,010	2,304	2,620	2,988	4,549	21%
Western Europe	1,585	1,735	1,946	2,183	2,452	3,003	14%
Central and Eastern Europe	1,351	1,446	1,711	1,945	2,128	2,269	11%
Middle East and Africa	529	605	675	753	832	900	11%

Source: Cisco VNI Mobile, 2014

Current and historical speeds are based on data from the Cisco Global Internet Speed Test (GiST) application and Ookla's Speedtest. Forward projections for mobile data speeds are based on third-party forecasts for the relative proportions of 2G, 3G, 3.5G, and 4G among mobile connections through 2018. For more information about Cisco GIST, visit http://gistdata.ciscovni.com/.

A crucial factor promoting the increase in mobile speeds over the forecast period is the increasing proportion of fourth-generation (4G) mobile connections. The impact of 4G connections on traffic is significant, because 4G connections, which include mobile WiMAX and Long-Term Evolution (LTE), generate a disproportionate amount of mobile data traffic.

Wi-Fi Speeds from Mobile Devices

Globally, Wi-Fi connection speeds originated from dual-mode mobile devices will more than double by 2018. The average Wi-Fi network connection speed (9.9 Mbps in 2013) will exceed 21 Mbps in 2018. North America will experience the highest Wi-Fi speeds of 22.6 Mbps by 2018, and Central and Eastern Europe will have the highest growth by 2018 with Wi-Fi speeds increasing 17 percent over the forecast period (Table 6).

Wi-Fi speeds inherently depend on the quality of the broadband connection to the premises. Also dependent on the speeds is the Wi-Fi standard in the customer-premises-equipment (CPE) device. The latest standard, 802.11ac, is considered a true wired complement and can enable higher-definition video streaming and services that require higher data rates. Also a key factor in the usage of the Wi-Fi technology is the number and availability of hotspots. Globally, there will be nearly 53 million hotspots by 2018, up from 22 million hotspots in 2013, a fourfold increase. The Asia Pacific region will have the highest number of hotspots by 2018.

Table 6. Projected Average Wi-Fi Network Connection Speeds (in Mbps) by Region and Country

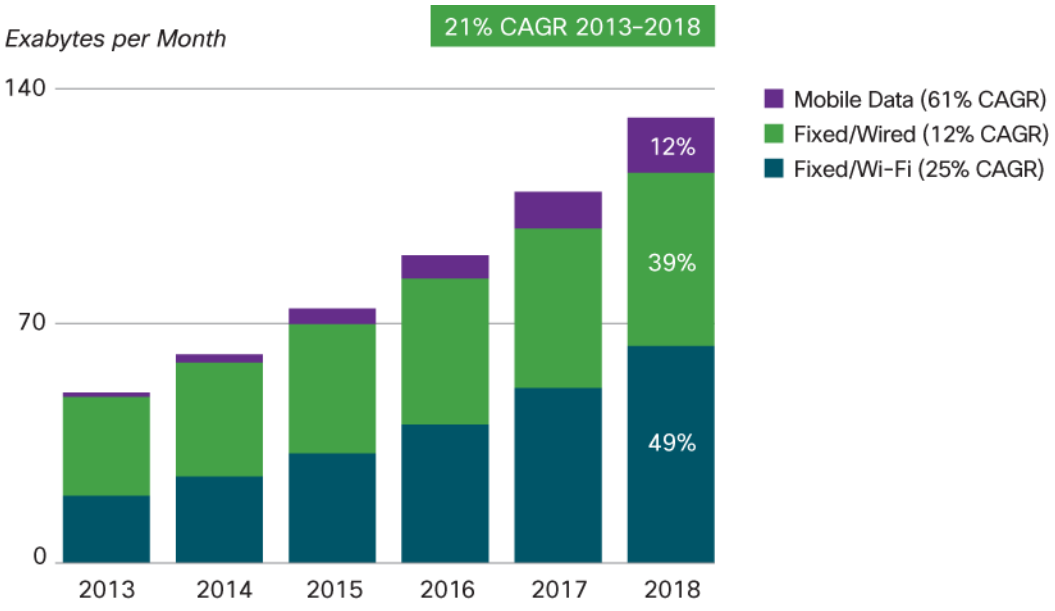
Region	2013	2014	2015	2016	2017	2018	CAGR
Global	9.9	12.6	14.9	17.3	19.3	21.4	16%
Asia Pacific	10.3	13.3	15.8	18.2	20.1	21.9	16%
Latin America	4.7	5.8	6.6	7.5	8.4	9.6	15%
North America	11.6	14.3	16.5	18.5	20.6	22.6	14%
Western Europe	10.6	13.0	14.9	16.9	19.1	21.4	15%
Central and Eastern Europe	9.2	11.7	14.1	16.3	18.5	20.6	17%
Middle East and Africa	4.0	4.9	5.7	6.6	7.4	8.4	16%

Source: Cisco VNI, 2014

Trend 4: Wi-Fi Dominates Access Technology

The rapid growth of mobile data traffic has been widely recognized and reported. The trend toward mobility carries over into the realm of fixed networks as well, in that an increasing portion of traffic will originate from portable or mobile devices. Figure 10 shows the growth of Wi-Fi and mobile traffic in relation to traffic from wired devices. By 2018, wired networks will account for 39 percent of IP traffic, while Wi-Fi and mobile networks will account for 61 percent of IP traffic. In 2013, wired networks accounted for the majority of IP traffic at 56 percent, Wi-Fi accounted for 41 percent, and mobile or cellular networks accounted for 3 percent of total global IP traffic.

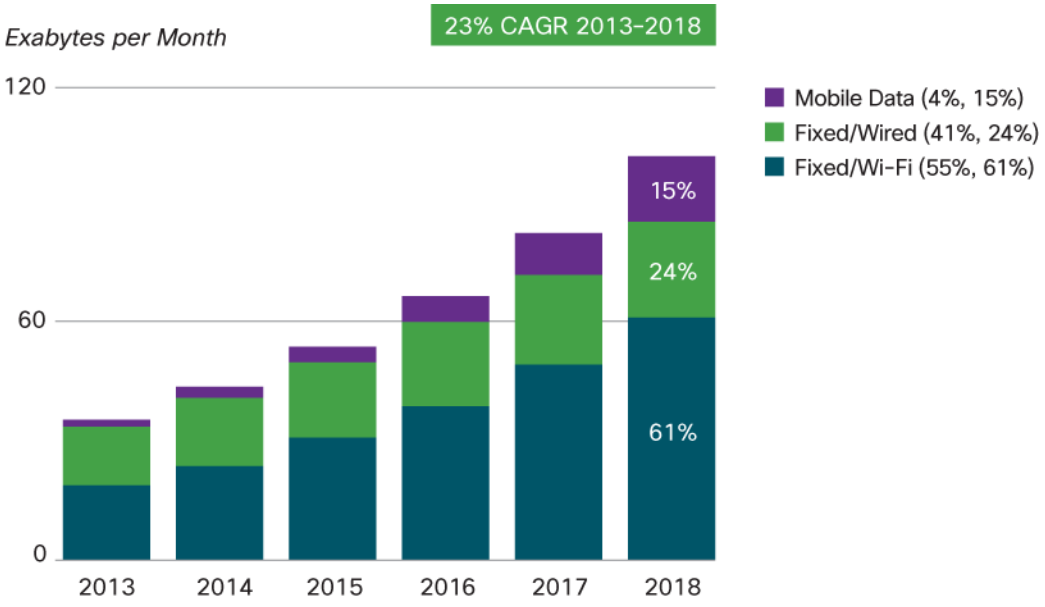
Figure 10. Global IP Traffic, Wired and Wireless



Source: Cisco VNI, 2014

Narrowing the focus to Internet traffic and excluding managed IP traffic yields a more pronounced trend. By 2018, wired devices will account for 24 percent of Internet traffic, while Wi-Fi and mobile devices will account for 76 percent of Internet traffic (Figure 11). In 2013, wired devices accounted for a little less than half of Internet traffic at 41 percent.

Figure 11. Global Internet Traffic, Wired and Wireless

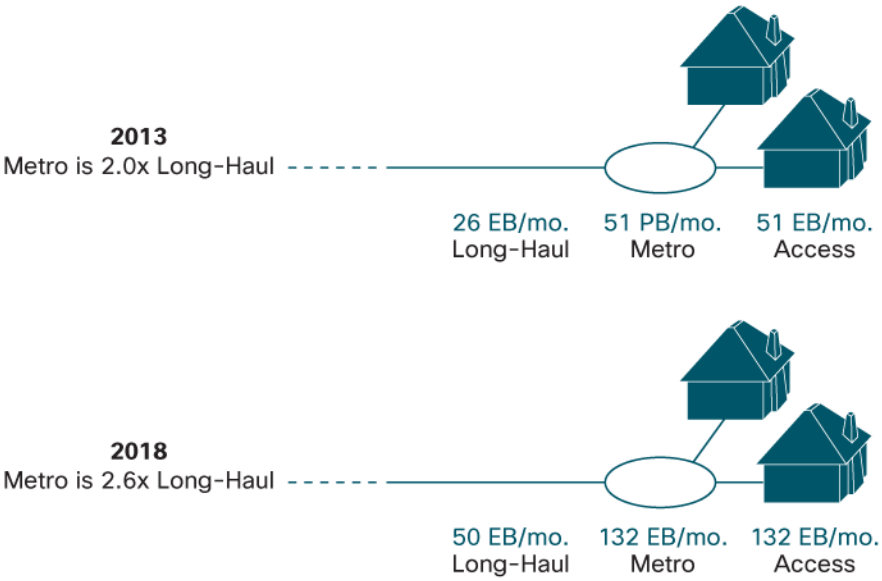


Source: Cisco VNI, 2014
The percentages in parentheses next to the legend refer to traffic share in 2013 and 2018, respectively.

Trend 5: Metro Traffic Will Grow Faster than Long-Haul Traffic

Metro-only traffic (traffic that traverses only the metro and bypasses long-haul traffic links) surpasses long-haul traffic in 2013, and will account for 62 percent of total IP traffic by 2018. Metro-only traffic will grow nearly twice as fast as long-haul traffic from 2013 to 2018. Long-haul traffic is also deposited onto metro networks so that total metro traffic already exceeds long-haul traffic. In 2013, total metro traffic was 2.0 times higher than long-haul traffic, and by 2018, metro traffic will be 2.6 times higher than long-haul (Figure 12).

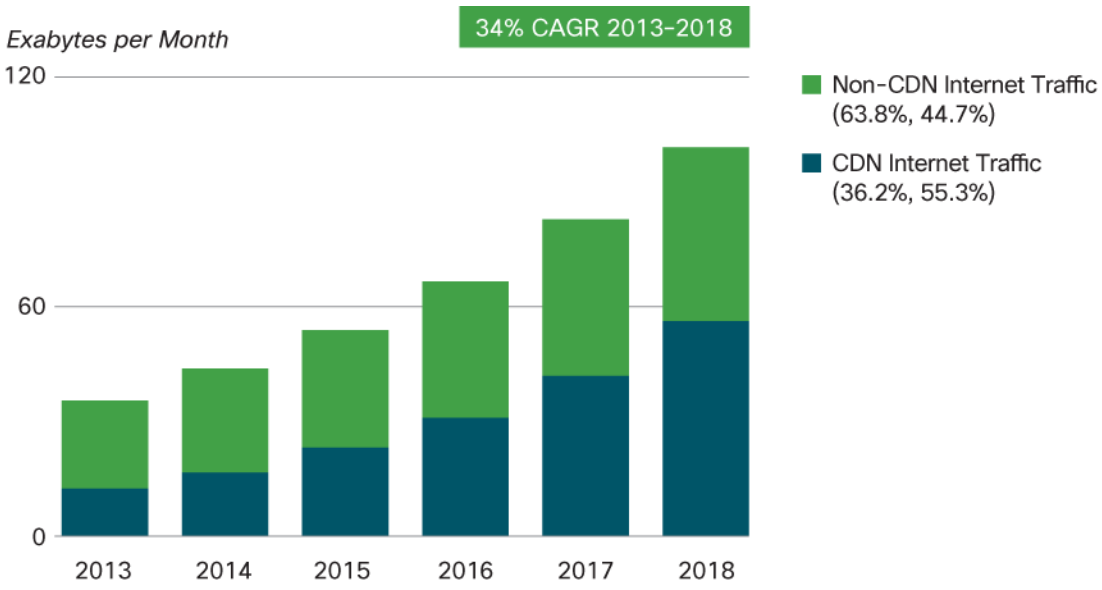
Figure 12. Metro Compared with Long-Haul Traffic Topology, 2013 and 2018



Source: Cisco VNI, 2014

The faster growth of metro traffic compared with long-haul is due in part to content delivery networks, which will carry 55 percent of total Internet traffic by 2018 (Figure 13). While network performance is usually attributed to the speeds and latencies offered by the service provider, the delivery algorithms used by content delivery networks have an equal if not more significant bearing on video quality.

Figure 13. Content Delivery Network Internet Traffic, 2013 and 2018

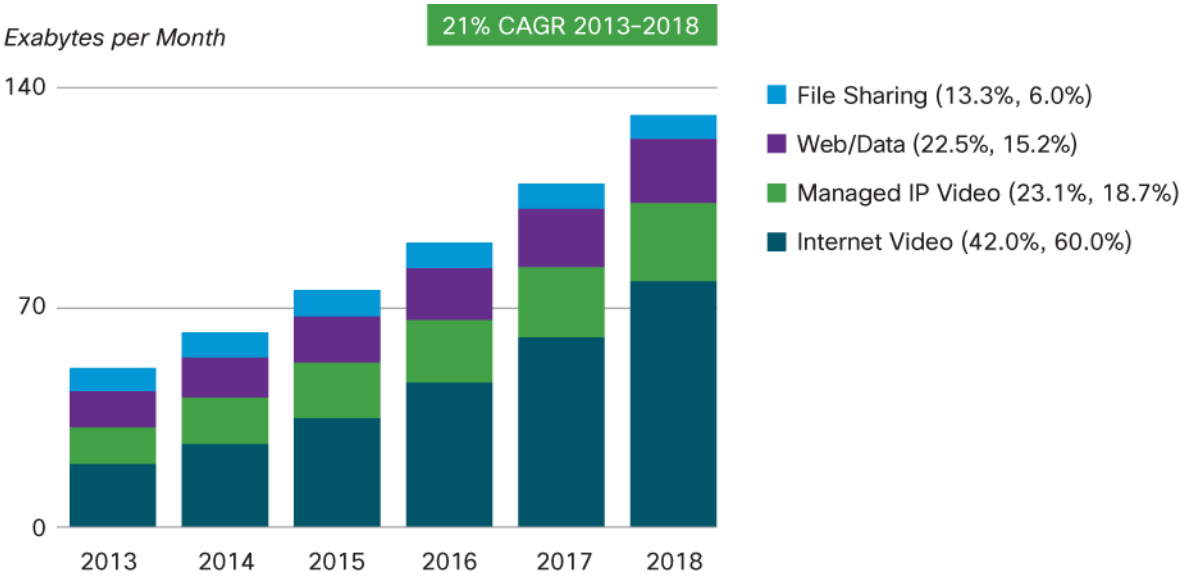


Source: Cisco VNI, 2014
The percentages within parenthesis next to the legend denote the relative traffic shares in 2013 and 2018.

Trend 6: IP Video Will Accelerate IP Traffic Growth Through 2018

The sum of all forms of IP video, which includes Internet video, IP VoD, video files exchanged through file sharing, video-streamed gaming, and videoconferencing, will continue to be in the range of 80 to 90 percent of total IP traffic. Globally, IP video traffic will account for 79 percent of traffic by 2018 (Figure 14).

Figure 14. Global IP Traffic by Application Category



Source: Cisco VNI, 2014
The percentages within parentheses next to the legend denote the relative traffic shares in 2013 and 2018, respectively.

The implications of video growth would be difficult to overstate. With video growth, Internet traffic is evolving from a relatively steady stream of traffic (characteristic of P2P[1]) to a more dynamic traffic pattern.

Impact of Video on Traffic Symmetry

With the exception of short-form video and video calling, most forms of Internet video do not have a large upstream component.

As a result, traffic is not becoming more symmetric as many expected when user-generated content first became popular. The emergence of subscribers as content producers is an extremely important social, economic, and cultural phenomenon, but subscribers still consume far more video than they produce. Upstream traffic has been flat as a percentage for several years, according to data from the participants in the Cisco VNI Usage program.

[1] Peer-to-peer (P2P), by definition, is highly symmetric traffic, with between 40 and 60 percent of P2P traffic consisting of upstream traffic. For every high-definition movie downloaded, approximately the same amount of traffic is uploaded to a peer. Now, with increased video traffic, most video streams that cross the network have a highly asymmetric profile, consisting mostly of downstream traffic, except in areas where P2P TV is prevalent (in China, for example).

It appears likely that residential Internet traffic will remain asymmetric for the next few years. However, numerous scenarios could result in a move toward increased symmetry; for example:

- Content providers and distributors could adopt P2P as a distribution mechanism. There has been a strong case for P2P as a low-cost content delivery system for many years, yet most content providers and distributors have opted for direct distribution, with the exception of applications such as PPStream and PPLive in China, which offer live video streaming through P2P, and have had great success. If content providers in other regions follow suit, traffic could rapidly become highly symmetric.
- High-end video communications could accelerate, requiring symmetric bandwidth. PC-to-PC video calling is gaining momentum, and the nascent mobile video calling market appears to have promise. If high-end video calling becomes popular, traffic could move toward greater symmetry.

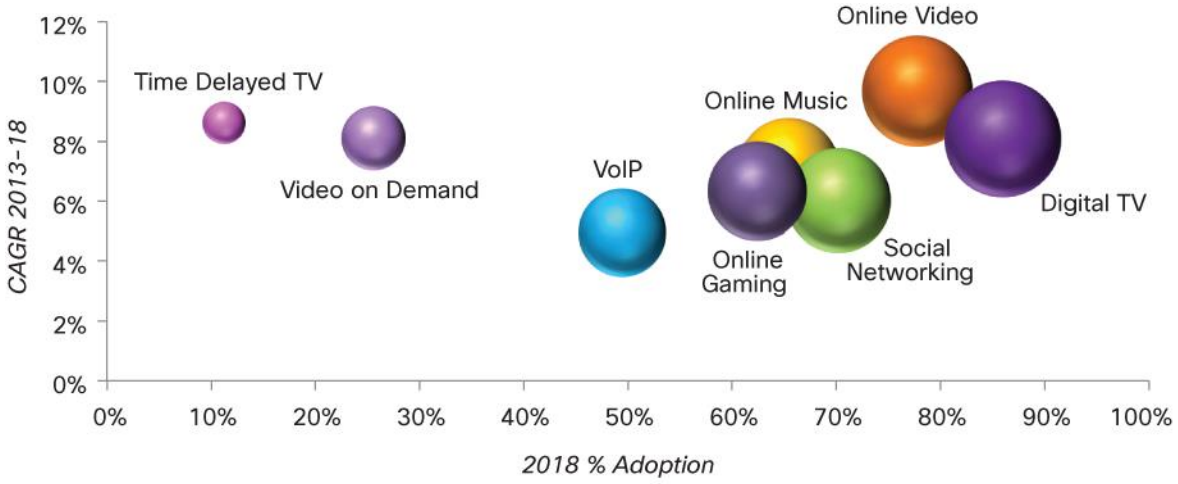
Generally, if service providers provide ample upstream bandwidth, applications that use upstream capacity will begin to appear.

Trend 7: Residential, Business, and Consumer Mobile Service Adoption

Residential Services: Video Continues to Grow

Between 2012 and 2013, the highest growth happened on the Internet side in online video with 16 percent year-over-year growth. On the TV side, VoD grew 17 percent and digital TV and personal video recorder (PVR) services grew at 15 percent. See Figure 15.

Figure 15. Residential Services Adoption and Growth



Source: Cisco VNI Service Adoption Forecast, 2013–2018
Note: By 2018, the global residential fixed Internet population will be 2.5 billion; the number of global TV households will be 1.8 billion.

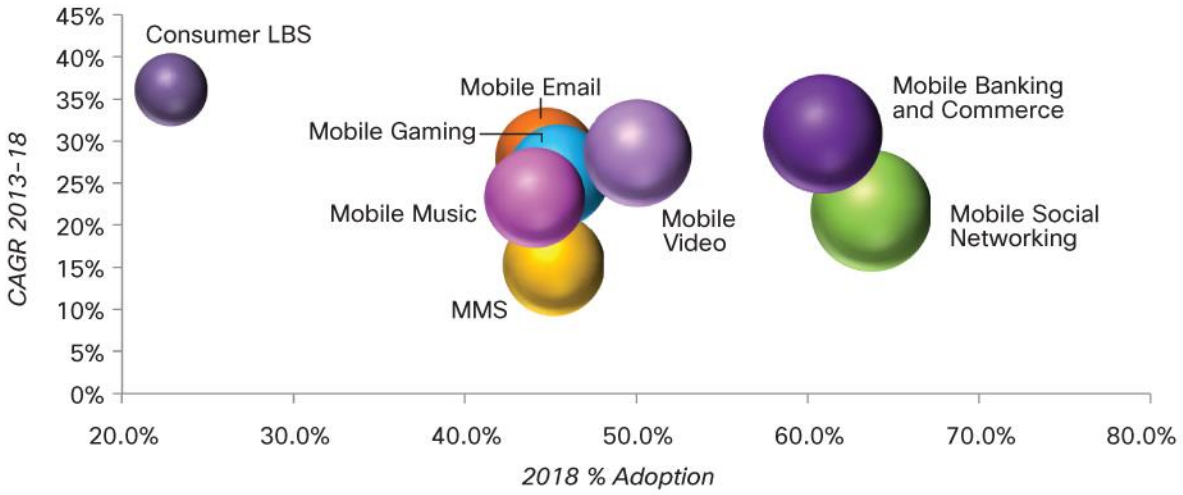
By 2018, digital TV and online video will be the two most highly penetrated services, 86 percent and 78 percent respectively. The fastest growth will come from online video (10 percent CAGR). Online music and video are both driven by cloud-based personal storage and sharing sites, in addition to both copyrighted and user-generated content use.

Among the digital TV services, time-delayed or digital video recorder (DVR)/PVR service will grow the fastest at 9 percent CAGR.

Consumer Mobile Services

Between 2012 and 2013, all the services in this segment grew more than 20 percent year over year. The highest growth was in consumer location-based services (LBS) with year-over-year growth of 81 percent, although from a very small base of 130 million users in 2012 to 236 million in 2013. Other significant year-over-year growth was in mobile banking and commerce (61 percent) followed by mobile video (59 percent). Middle East and Africa had the largest growth at 112 percent, more than doubling the online video users from 14 million to 30 million. See Figure 16.

Figure 16. Consumer Mobile Services Adoption and Growth



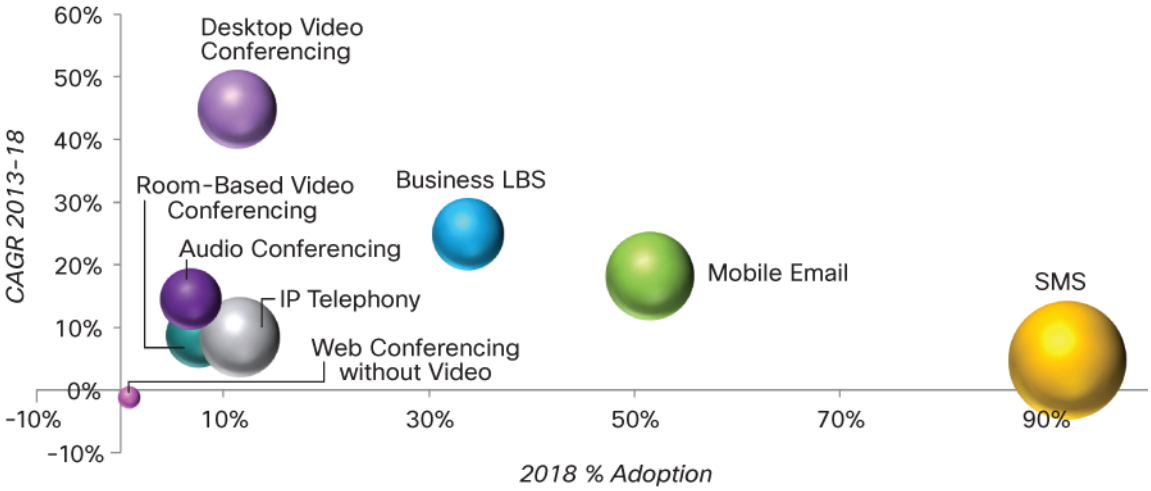
Source: Cisco VNI Service Adoption Forecast, 2013–2018
Note: By 2018, the global consumer mobile population will be 4.8 billion.

From 2013 to 2018, seven out of eight consumer mobile services will grow at more than 20 percent CAGR, and two will grow at more than 30 percent CAGR. The fastest growth will be in consumer LBS (36 percent) followed by mobile commerce (31 percent). Regions that are really driving mobile commerce growth are Latin America, Asia Pacific, and Middle East and Africa, which have been historically underserved (or not reached) by traditional brick-and-mortar financial institutions.

Business Services

Between 2012 and 2013, the highest year-over-year growth was in business LBS with a 47 percent increase, from 44 million users in 2012 to 65 million in 2013. Other significant year-over-year growth was in desktop videoconferencing (44 percent). See Figure 17.

Figure 17. Business Services Adoption and Growth



Source: Cisco VNI Service Adoption Forecast, 2013–2018
Note: By 2018, the global business Internet population will be 2.1 billion; the number of business mobile users will be 582 million.

Business LBS includes services used by corporate subscribers in which the subscription is generally paid by the employer. As such, it includes but is not limited to services such as salesforce and field-force automation, fleet management, etc.

This year's study suggests lower growth in room-based videoconferencing users. Single-codec videoconferencing systems grew, but with the exception of Latin America, all regions experienced a decline in executive conferencing systems and multicodec systems. Multicodec systems are typically fully managed and as such are expensive to keep and operate. As unit sales drop, so does the network of units to connect to, and therefore, usage may be limited. Low-use systems are decommissioned over time due to the high fixed cost of managing these systems.

From 2013 to 2018, the fastest-growing business service is expected to be desktop or personal videoconferencing. The growth of personal videoconferencing, specifically unified communications-based videoconferencing, has recently accelerated due to the higher quality and lower price of new services and products, and also due to the availability of desktop videoconferencing offers, which can stand alone or be integrated. Also, the growth of mobile clients is going to support videoconferencing growth. Conversely, the use of web conferencing without video will show a decline of 1 percent CAGR over the forecast period.

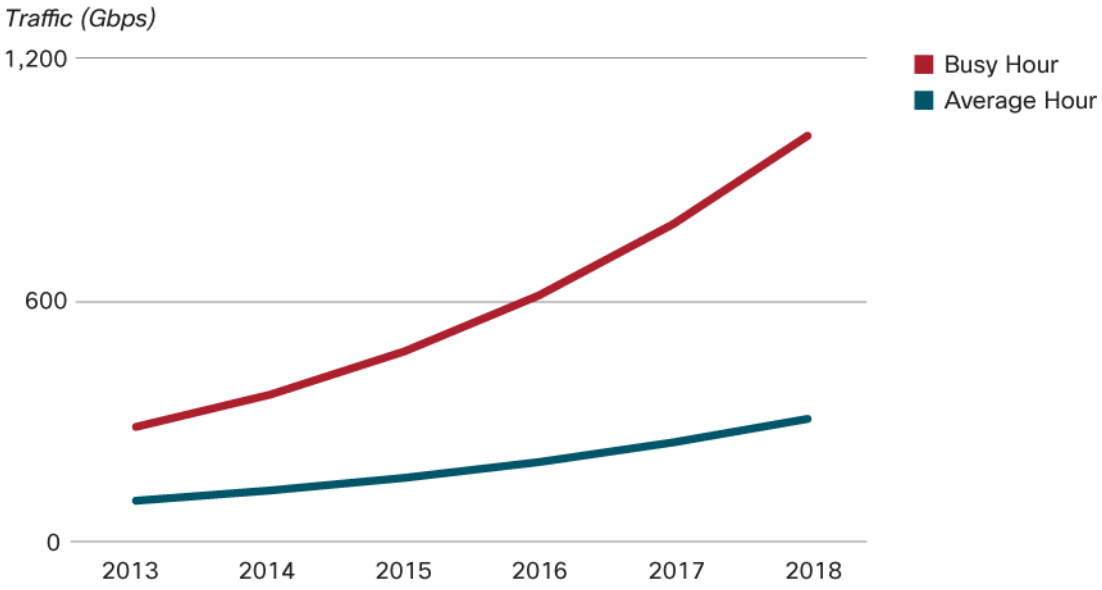
For details on all aspects of the service adoption study, use the Cisco VNI SA highlights tool.

Trend 8: Busy-Hour Traffic Will Grow Faster than Average Traffic

While average Internet traffic has settled into a steady growth pattern, busy-hour (or the busiest 60-minute period of the day) traffic continues to grow more rapidly than average traffic. Service providers plan network capacity according to peak growth, rather than average. In 2013, busy-hour Internet traffic grew 32 percent, while average traffic grew at 25 percent. The difference between busy-hour and average Internet growth was particularly pronounced in Saudi Arabia, where busy-hour growth was 65 percent in 2013 (compared with average-hour growth of 58 percent), and in India, where busy-hour growth was 66 percent in 2013 (compared with average-hour growth of 54 percent). Between 2013 and 2018, global busy-hour Internet use will grow at a CAGR of 28 percent, compared with 23 percent for average Internet traffic (Figure 18).

Video is the underlying reason for accelerated busy-hour traffic growth. Unlike other forms of traffic that are spread evenly throughout the day (such as web browsing and file sharing), video tends to have a “prime time.” Because of video consumption patterns, the Internet now has a much busier busy hour. Because video has a higher peak-to-average ratio than data or file sharing, and because video is gaining traffic share, peak Internet traffic will grow faster than average traffic. The growing gap between peak and average traffic is amplified further by the changing composition of Internet video. Real-time video such as live video, ambient video, and video calling has a peak-to-average ratio that is higher than on-demand video.

Figure 18. Busy-Hour Compared with Average Internet Traffic Growth



Source: Cisco VNI, 2014

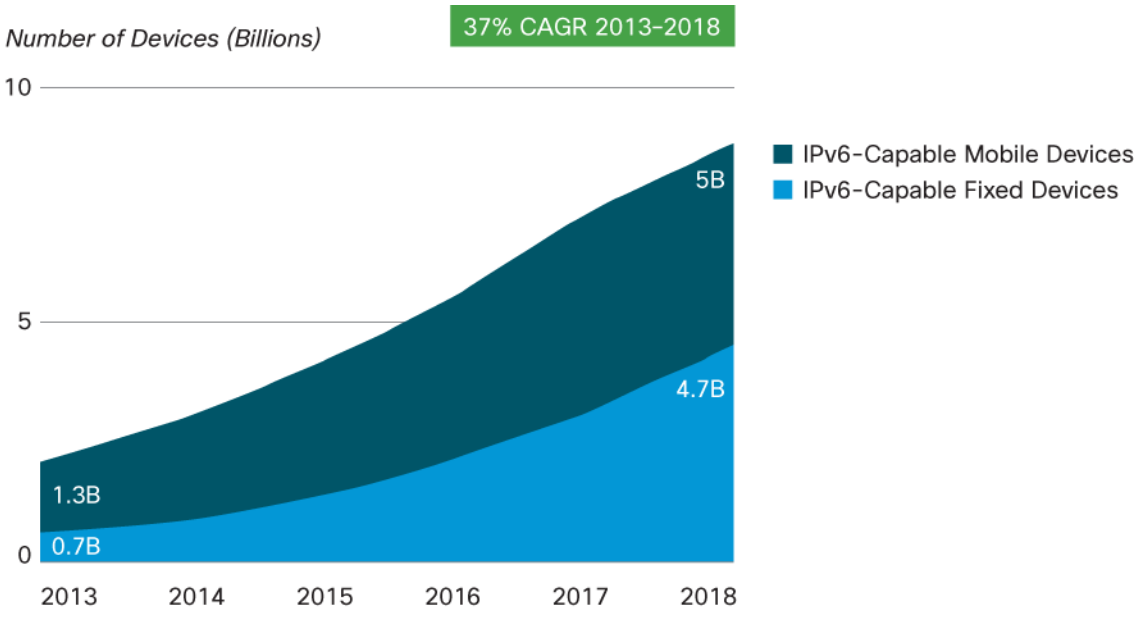
Trend 9: IPv6 Devices and Connections

The transition from an IPV4 environment to an IPV6 environment is making great progress in IPv6 device capability, content enablement, and operators implementing IPv6 in their networks. These developments are particularly important because Asia and Europe have already exhausted their IPv4 allotment, and North America, Africa, and Latin America expect to allocate their remaining IPv4 addresses between 2015 and 2017.

Building upon the VNI IPv6-capable devices analysis initiated in 2012, the forecast estimates that globally, there will be 10 billion IPv6-capable fixed and mobile devices by 2018, up from 2 billion in 2013, a CAGR of 37 percent. 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. See Figure 19. What that means is that by 2018, about 50 percent of all fixed and mobile devices and connections will be IPv6 capable.

This estimate is based on the capability of the device and the network connection to support IPv6, and is not a projection of active IPv6 connections. Mobile-device IPv6 capability is assessed based on OS support of IPv6 as well as by estimating the type of mobile network infrastructure the device is capable of connecting to (3.5G or higher.) Fixed-device IPv6 capability is assessed on device support of IPv6 as well as an estimation of residential CPE or business router capability to support IPv6, depending on the device end-user segment.

Figure 19. IPv6-Capable Devices and Connections Forecast 2013–2018



Source: Cisco VNI Global IPv6 Forecast, 2013–2018

Leading IPv6-capable device segments include:

- Globally, 80 percent of smartphones and tablets will be IPv6-capable by 2018, up from 43 percent in 2013.
- Globally, there will be 3.9 billion IPv6-capable smartphones and tablets by 2018, up from 882 million in 2013.
- 94 percent of laptops will be IPv6-capable by 2018, reaching 797 million.
- 34 percent of M2M connections will be IPv6-capable by 2018, reaching 2.4 billion.

According to the World IPv6 Launch Organization in April 2014, fixed and mobile network operators worldwide are deploying IPv6 and starting to report notable IPv6 traffic generation, ranging up to 49 percent of network traffic with Verizon Wireless at 48.71 percent, France's Free Telecom at 37.52 percent, Romania's RCS and RDS at 24.86 percent, AT&T at 17.88 percent and KDDI at 11.41 percent.

Trend 10: Tiered Pricing: Comparing Mobile and Fixed Data Caps

Speeds influence application use and user behavior and user behaviors are what operators want to manage, optimize and monetize; which looks into the behavior of the top usage subscribers and the institution of usage based tiered pricing.

On the mobile networks, based on the usage of over 33,000 lines from a few Tier 1 mobile operators from 2010 to 2013, we found that the Top 1% usage of monthly traffic is down to 10% of overall usage compared to 52% in 2010; showing the effects of tiered pricing. With mobile penetration reaching a saturation point in many countries across all regions, the trend has been moving towards tiered plans as a way to monetize data and effectively manage/throttle the top users of traffic. On the fixed networks, data caps continue to increase to match subscribers growing appetite for video. In the US, Tier 1 carriers are considering 500 GB as a possible monthly limit by the 2018 timeframe from a variety of offerings today. A large provider in Japan has a 30 GB per day upload cap per

day. In several countries around the world, Netflix has a sizeable of the internet video minutes and traffic. Wild card traffic generators such as Twitch.TV, a live streaming service where video gamers watch each other play has established itself on many fixed networks across the globe.

Data caps impact a larger percentage of mobile users than fixed. With Tier 1 carriers, approximately 4 percent of mobile users consume more than 2 GB per month (a common mobile data cap); while only 2 percent of fixed users consume more than 250 GB per month (a common fixed data cap).

Other Trends to Watch

Cisco's approach to forecasting IP traffic is conservative, and certain emerging trends have the potential to increase the traffic outlook significantly. The most rapid upswings in traffic occur when consumer media consumption migrates from offline to online or from broadcast to unicast:

- **Applications that might migrate from offline to online (cloud)**: The crucial application to watch in this category is gaming. Gaming on demand and streaming gaming platforms have been in development for several years, with many newly released in 2013 or 2014. With traditional gaming, graphical processing is done locally on the gamer's computer or console. With cloud gaming, game graphics are produced on a remote server and transmitted over the network to the gamer. Currently, online gaming traffic represents only 0.04 percent of the total information content associated with online and offline game play[2]. If cloud gaming takes hold, gaming could quickly become one of the largest Internet traffic categories.
- **Behavior that might migrate from broadcast to unicast**: Live TV is currently distributed by means of a broadcast network, which is highly efficient in that it carries one stream to many viewers. Live TV over the Internet would carry a separate stream for each viewer. AT&T in the past estimated that a shift from multicast or broadcast to over-the-top unicast "would multiply the IP backbone traffic by more than an order of magnitude".[3]
- **New consumer behavior**: The adoption of UHD TV would fall into the category of new consumer behavior. UHD is already growing tangible in terms of supporting devices and content Video providers are preparing to broadcast and stream UHD. Higher resolution and network requirements to stream UHD will create traffic multiplier effects. This nascent traffic type can cause surprises that have network design implications.

For More Information

For more information about Cisco's IP traffic forecast, refer to "Cisco VNI: Forecast and Methodology, 2013–2018" and visit the other resources and updates at www.cisco.com/go/vni. Several interactive tools allow you to create custom highlights and forecast charts by region, by country, by application, and by end-user segment. Refer to the Cisco VNI Highlights tool and the Cisco VNI Forecast Widget tool. Inquiries can be directed to traffic-inquiries@cisco.com.

[2] Total game play (online and offline) in the United States represents an estimated 166 exabytes per month, according to the University of California, San Diego, study, "How Much Information?"
[3] Alexandre Gerber and Robert Doverspike, "Traffic Types and Growth in Backbone Networks."

Appendix A: Cisco Global IP Traffic Forecast

Table 7 shows the summary of Cisco's global IP traffic forecast. For more information and additional tables, refer to "Cisco VNI: Forecast and Methodology, 2013–2018."

Table 7. Table A-1 Global IP Traffic, 2013–2018

IP Traffic, 2011–2016							
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**CAGR 2013–2018**
By Type (Petabytes [PB] per Month)							
Fixed Internet	34,952	42,119	50,504	60,540	72,557	86,409	20%
Managed IP	14,736	17,774	20,898	23,738	26,361	29,305	15%
Mobile data	1,480	2,582	4,337	6,981	10,788	15,838	61%
By Segment (PB per Month)							
Consumer	40,905	50,375	61,439	74,361	89,689	107,958	21%
Business	10,263	12,100	14,300	16,899	20,016	23,595	18%
By Geography (PB per Month)							
Asia Pacific	17,950	22,119	26,869	32,383	39,086	47,273	21%
North America	16,607	20,293	24,599	29,377	34,552	40,545	20%
Western Europe	8,396	9,739	11,336	13,443	16,051	19,257	18%
Central and Eastern Europe	3,654	4,416	5,443	6,666	8,332	10,223	23%
Latin America	3,488	4,361	5,318	6,363	7,576	8,931	21%
Middle East and Africa	1,074	1,546	2,174	3,027	4,108	5,324	38%
Total (PB per Month)							
Total IP traffic	51,168	62,476	75,739	91,260	109,705	131,553	21%

Source: Cisco VNI, 2014

Definitions

- **Consumer**: Includes fixed IP traffic generated by households, university populations, and Internet cafés
- **Business**: Includes fixed IP WAN or Internet traffic, excluding backup traffic, generated by businesses and governments
- **Mobile**: Includes Internet traffic that travels over 2G, 3G, or 4G mobile access technology
- **Internet**: Denotes all IP traffic that crosses an Internet backbone
- **Non-Internet IP**: Includes corporate IP WAN traffic, IP transport of TV and VoD, and mobile "walled-garden" traffic

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