White paper
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The Zettabyte Era: Trends and Analysis

June 2017

This document is part of the Cisco Visual Networking Index™ (Cisco VNI™), an ongoing initiative to track and forecast the effects 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, 2016–2021.

Contents

Executive summary

Annual global IP traffic will reach 3.3 ZB per year by 2021, or 278 Exabytes (EB) per month. In 2016, the annual run rate for global IP traffic was 1.2 ZB per year, or 96 EB per month.

Global IP traffic will increase nearly threefold over the next 5 years. Overall, IP traffic will grow at a Compound Annual Growth Rate (CAGR) of 24 percent from 2016 to 2021. Monthly IP traffic will reach 35 GB per capita by 2021, up from 13 GB per capita in 2016.

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 51 percent in 2016, compared with 32 percent growth in average traffic. Busy hour Internet traffic will increase by a factor of 4.6 between 2016 and 2021, and average Internet traffic will increase by a factor of 3.2.

Smartphone traffic will exceed PC traffic. In 2016, PCs accounted for 46 percent of total IP traffic, but by 2021 PCs will account for only 25 percent of traffic. Smartphones will account for 33 percent of total IP traffic in 2021, up from 13 percent in 2016. PC-originated traffic will grow at a CAGR of 10 percent, and TVs, tablets, smartphones, and Machine-to-Machine (M2M) modules will have traffic growth rates of 21 percent, 29 percent, 49 percent, and 49 percent, respectively.

Traffic from wireless and mobile devices will account for more than 63 percent of total IP traffic by 2021. By 2021, wired devices will account for 37 percent of IP traffic, and Wi-Fi and mobile devices will account for 63 percent of IP traffic. In 2016, wired devices accounted for the majority of IP traffic, at 51 percent.

Content Delivery Networks (CDNs) will carry 71 percent of Internet traffic by 2021. Seventy-one percent of all Internet traffic will cross CDNs by 2021 globally, up from 52 percent in 2016.

Thirty-five percent of end-user Internet traffic will be delivered within a metro network by 2021, up from 22 percent in 2016.

The number of devices connected to IP networks will be more than three times the global population by 2021. There will be 3.5 networked devices per capita by 2021, up from 2.3 networked devices per capita in 2016. There will be 27.1 billion networked devices in 2021, up from 17.1 billion in 2016.

Broadband speeds will nearly double by 2021. By 2021, global fixed broadband speeds will reach 53 Mbps, up from 27.5 Mbps in 2016.

Global internet video and gaming highlights

It would take more than 5 million years to watch the amount of video that will cross global IP networks each month in 2021. Every second, a million minutes of video content will cross the network by 2021.

Globally, IP video traffic will be 82 percent of all IP traffic (both business and consumer) by 2021, up from 73 percent in 2016. Global IP video traffic will grow threefold from 2016 to 2021, a CAGR of 26 percent. Internet video traffic will grow fourfold from 2016 to 2021, a CAGR of 31 percent.

Live Internet video will account for 13 percent of Internet video traffic by 2021. Live video will grow 15-fold from 2016 to 2021.

Internet video surveillance traffic increased 71 percent in 2016, from 516 petabytes per month at the end of 2015 to 883 petabytes per month in 2016. Internet video surveillance traffic will increase sevenfold between 2016 and 2021. Globally, 3.4 percent of all Internet video traffic will be due to video surveillance in 2021, up from 1.8 percent in 2016.

Virtual Reality (VR) and Augmented Reality (AR) traffic will increase 20-fold between 2016 and 2021 globally, a CAGR of 82 percent.

Internet video to TV grew 50 percent in 2016. This traffic will continue to grow at a rapid pace, increasing 3.6-fold by 2021. Internet video to TV will be 26 percent of fixed consumer Internet video traffic in 2021.

Consumer Video-on-Demand (VoD) traffic will nearly double by 2021. The amount of VoD traffic in 2021 will be equivalent to 7.2 billion DVDs per month.

Internet gaming traffic will grow nearly tenfold from 2016 to 2021, a CAGR of 57 percent. Globally, Internet gaming traffic will be 4 percent of consumer Internet traffic in 2021, up from 1 percent in 2016.

Global mobile highlights

Globally, mobile data traffic will increase sevenfold between 2016 and 2021. Mobile data traffic will grow at a CAGR of 46 percent between 2016 and 2021, reaching 48.3 exabytes per month by 2021.

Global mobile data traffic will grow twice as fast as fixed IP traffic from 2016 to 2021. Fixed IP traffic will grow at a CAGR of 21 percent between 2016 and 2021, while mobile traffic grows at a CAGR of 46 percent. Global mobile data traffic was 7 percent of total IP traffic in 2016, and will be 17 percent of total IP traffic by 2021.

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 42 percent between 2016 and 2021.

Summary of regional growth rates:

- IP traffic in North America will reach 85 EB per month by 2021, growing at a CAGR of 20 percent.
- IP traffic in Western Europe will reach 37 EB per month by 2021, growing at a CAGR of 22 percent.
- IP traffic in Asia Pacific will reach 108 EB per month by 2021, growing at a CAGR of 26 percent.
- IP traffic in Latin America will reach 16 EB per month by 2021, growing at a CAGR of 21 percent.
- IP traffic in Central and Eastern Europe will reach 17 EB per month by 2021, growing at a CAGR of 22 percent.
- IP traffic in the Middle East and Africa will reach 16 EB per month by 2021, growing at a CAGR of 42 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 21 percent from 2016 to 2021. Increased adoption of advanced video communications in the enterprise segment will cause business IP traffic to grow by a factor of nearly 3 between 2016 and 2021.

Business Internet traffic will grow at a faster pace than IP WAN. IP WAN traffic will grow at a CAGR of 10 percent, compared with a CAGR of 20 percent for fixed business Internet and 41 percent for mobile business Internet traffic.

SD-WAN will account for 25 percent of IP WAN traffic by 2021, up from 6 percent in 2016. SD-WAN traffic will grow 6-fold from 2016 to 2021 at a CAGR of 44 percent, compared to a 5 percent CAGR for traditional WAN traffic.

Business IP traffic will grow fastest in North America. Business IP traffic in North America will grow at a CAGR of 23 percent, a faster pace than the global average of 21 percent. In volume, Asia Pacific will have the largest amount of business IP traffic by 2021, at 17 EB per month. North America will be second, at 14 EB per month.

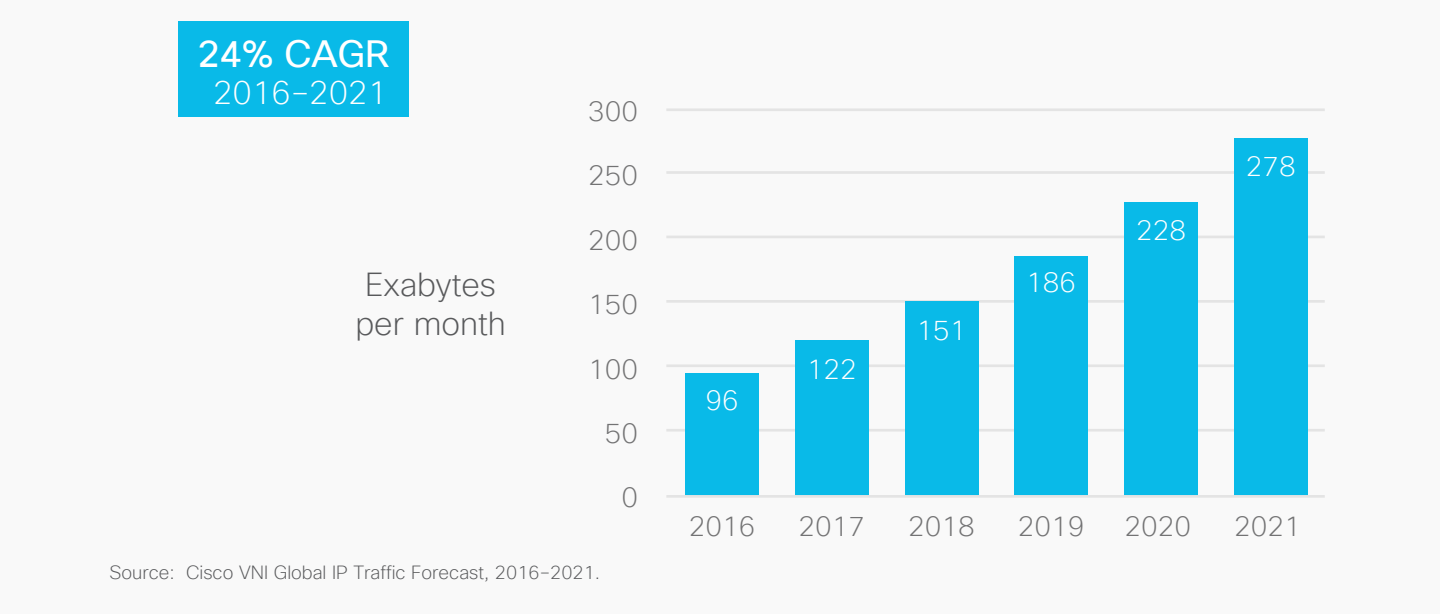
Forecast overview

The current Cisco Visual Networking Index (VNI) forecast projects global IP traffic to nearly triple from 2016 to 2021. The appendix offers a detailed summary.

Overall IP traffic is expected to grow to 278 EB per month by 2021, up from 96 EB per month in 2016, a CAGR of 24 percent (Figure 1). This growth represents a slight increase in expectations over last year's forecast, which projected a CAGR of 22 percent from 2015 to 2020, driven by an increase in expectations for fixed traffic.

Of note in the recent forecast is the growing number of countries whose fixed traffic growth rivals that of their mobile traffic growth. Japan is the outlier, with a fixed growth of 53 percent in 2016 and a mobile growth of 34 percent over the same time period. Australia, Canada, the UK, and the United States all have fixed growth that is only slightly lower than their mobile growth. The majority of countries still have significantly higher growth rates for mobile than for fixed.

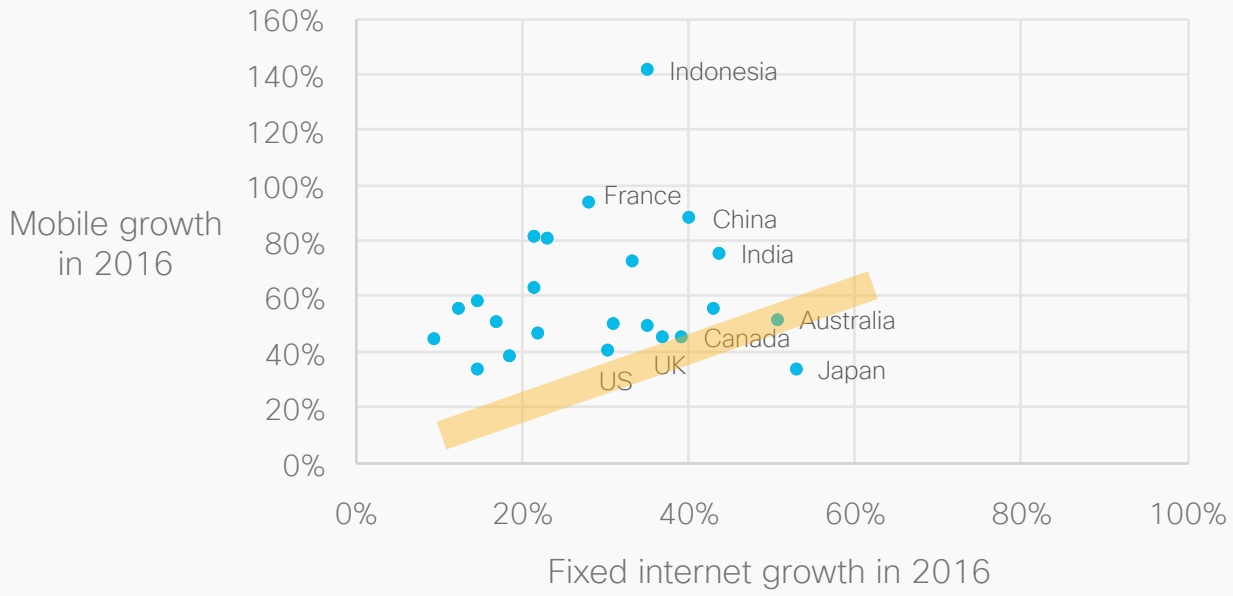
Figure 1. Cisco VNI forecasts 278 EB per month of IP traffic by 2021



Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

For more details about Cisco's forecasting methodology, refer to the paper "Cisco VNI: Forecast and Methodology, 2016–2021."

Figure 2. Fixed and mobile internet traffic growth rates, 2016



Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

Total Internet traffic has experienced dramatic growth in the past two decades. More than 20 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 2016, global Internet traffic reached more than 20,000 GBps. Table 1 provides a view of the historical benchmarks for total Internet traffic.

Table 1. The Cisco VNI forecast: historical internet context

Year	Global Internet Traffic
1992	100 GB per day
1997	100 GB per hour
2002	100 GB per second
2007	2,000 GB per second
2016	26,600 GB per second
2021	105,800 GB per second

Source: Cisco VNI, 2017.

Per capita IP and Internet traffic growth has followed a similarly steep growth curve over the past decade. Globally, monthly IP traffic will reach 35 GB per capita by 2021, up from 13 GB per capita in 2016, and Internet traffic will reach 30 GB per capita by 2021, up from 10 GB per capita in 2016. Ten years ago, in 2007, per capita Internet traffic was well under 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: Continued shifts in mix of devices and connections

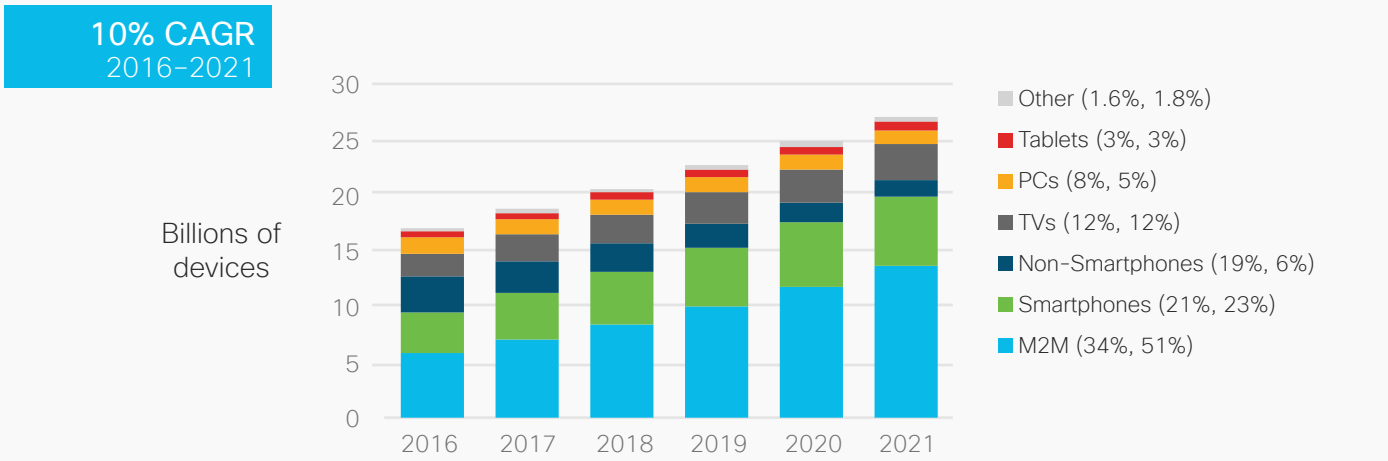
Figure 3 shows that globally, devices and connections (10 percent CAGR) are growing faster than both the population (1.1 percent CAGR) and Internet users (7 percent CAGR). This trend is accelerating the increase in the average number of devices and connections per household and per Internet user. Each 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, are contributing in a major way to the growth of devices and connections. By 2021, M2M connections will be 51 percent of the total devices and connections.

M2M connections will be the fastest-growing category, growing nearly 2.4-fold during the forecast period, at 19 percent CAGR, to 13.7 billion connections by 2021.

Smartphones will grow the second fastest, at 11 percent CAGR (increasing by a factor of 1.7). Connected TVs (which include flat-panel TVs, set-top boxes, digital media adapters [DMAs], Blu-ray disc players, and gaming consoles) will grow next fastest at 9 percent CAGR, to 3.2 billion by 2021. PCs will continue to decline (a 2.5 percent decline) over the forecast period. However, there will more PCs than tablets throughout the forecast period and by the end of 2021 (1.3 billion PCs vs. 750 million tablets).

By 2021 the consumer share of the total devices, including both fixed and mobile devices, will be 71 percent, with business claiming the remaining 29 percent. Consumer share will grow at a slightly slower rate, at 8.7 percent CAGR relative to the business segment, which will grow at 12.2 percent CAGR.

Figure 3. Global devices and connections growth



Figures (n) refer to 2016, 2021 device share.
Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

Globally, the average number of devices and connections per capita will grow from 2.3 in 2016 to 3.5 by 2021 (Table 2).

Among the countries that will have the highest average of per capita devices and connections by 2021 are the United States (13.2), South Korea (12), and Japan (11.4).

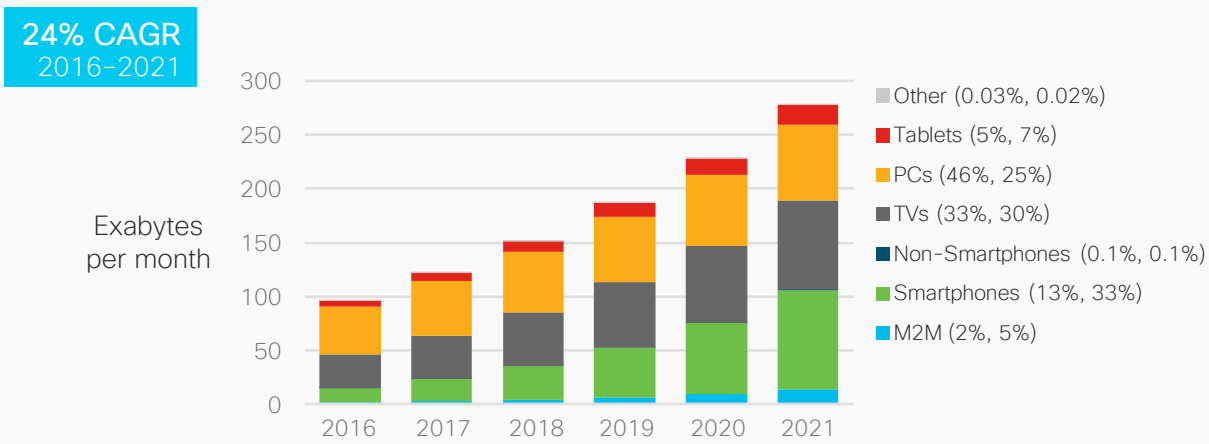
The changing mix of devices and connections and growth in multidevice ownership affects traffic and can be seen in the changing device contribution to total IP traffic. At the end of 2016, 54 percent of IP traffic and 48 percent of consumer Internet traffic originated from non-PC devices. By 2021, 75 percent of IP traffic and 76 percent of consumer Internet traffic will originate from non-PC devices (Figure 4).

Table 2. Average number of devices and connections per capita

	2016	2021	CAGR
Asia Pacific	1.9	2.9	8.3%
Central and Eastern Europe	2.5	3.8	9.1%
Latin America	2.1	2.9	7.0%
Middle East and Africa	1.1	1.4	5.4%
North America	7.7	12.9	11.0%
Western Europe	5.3	8.9	10.9%
Global	2.3	3.5	8.5%

Source: Cisco VNI, 2017.

Figure 4. Global IP traffic by devices

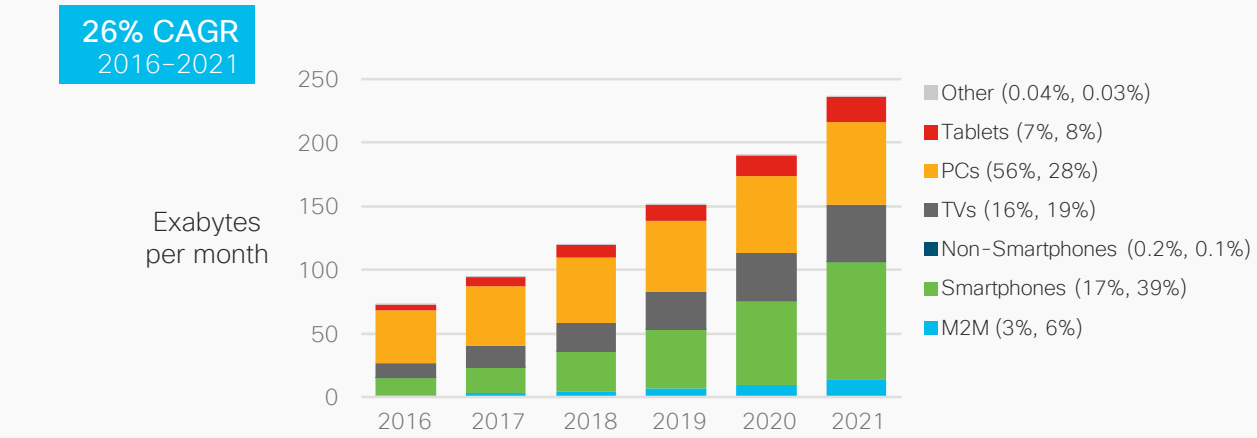


Figures (n) refer to 2016, 2021 device share.
Source: Cisco VNI Global IP Traffic Forecast, 2016–2021

As in the case of mobile networks, video devices can have a multiplier effect on traffic. An Internet-enabled HD television that draws 90 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 smartphones and tablets, traffic from these devices is growing as a percentage of total Internet traffic. Share of PCs to total global Internet traffic will decline to 28 percent by 2021, down from 56 percent in 2016. Smartphones will account for 39 percent of total global Internet traffic by 2021, up from 17 percent in 2016 (Figure 5).

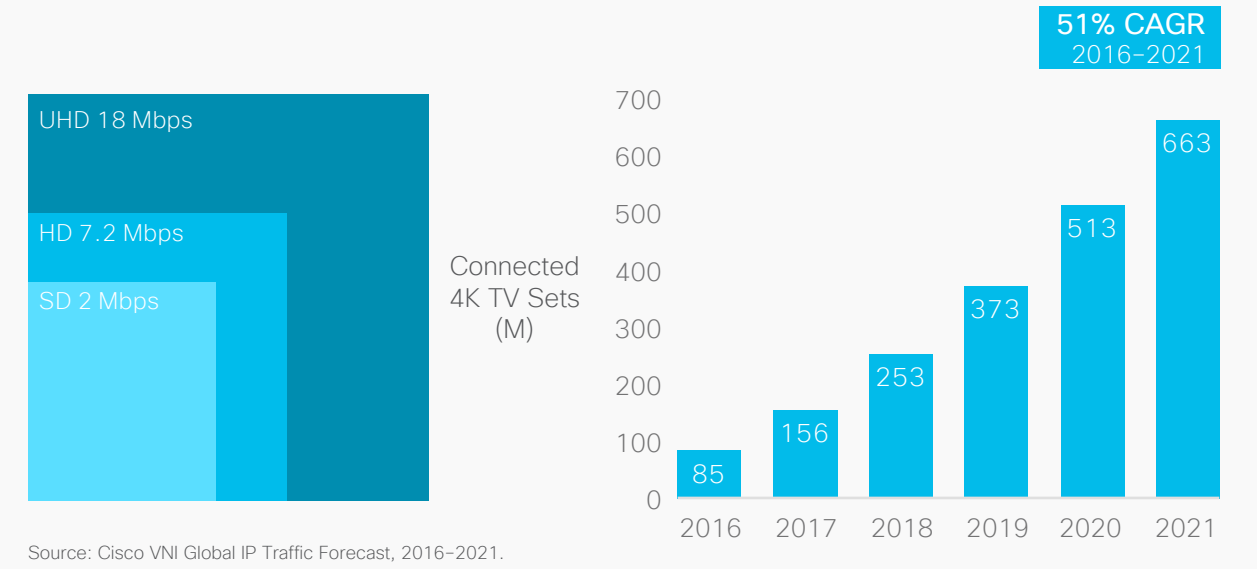
The video effect of the devices on the traffic is more pronounced because of the introduction of Ultra-High-Definition (UHD), or 4K, video streaming. This technology has such an effect because the bit rate for 4K video at about 18 Mbps is more than double the HD video bit rate and nine times more than Standard-Definition (SD) video bit rate. We estimate that by 2021, more than half (56 percent) of the installed flat-panel TV sets will be UHD, up from 15 percent in 2016 (Figure 6).

Figure 5. Global internet traffic by device type



Figures (n) refer to 2016, 2021 device share.
Source: Cisco VNI Global IP Traffic Forecast, 2016-2021.

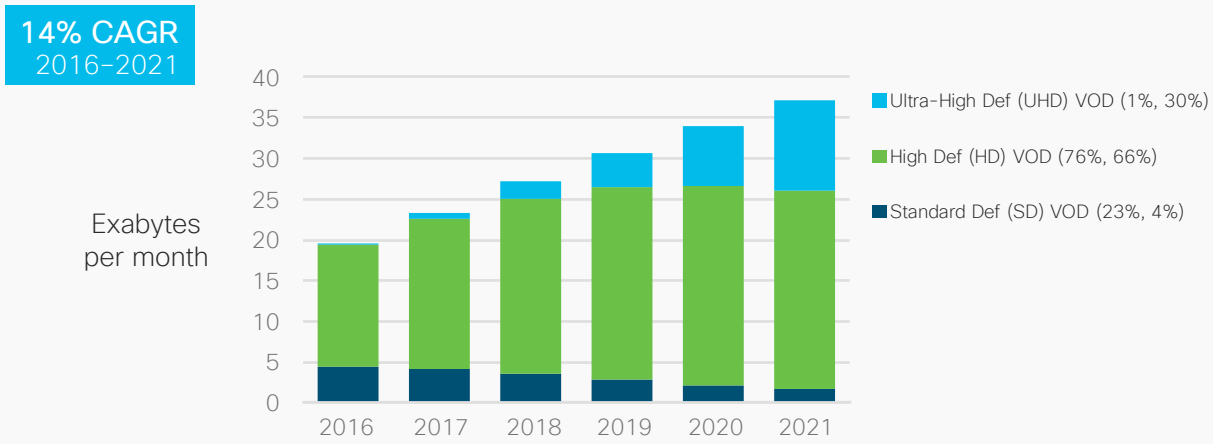
Figure 6. Increasing video definition: By 2021, 56 percent of connected Flat-Panel TV sets will be 4K



Source: Cisco VNI Global IP Traffic Forecast, 2016-2021.

UHD (or 4K) IP VoD will account for 30 percent of global VoD traffic in 2021 (Figure 7). UHD as a percentage of Internet video traffic is slightly lower, at 19 percent by 2021.

Figure 7. Global 4K VoD traffic



Figures (n) refer to 2016, 2021 traffic shares.
Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

Trend 2: IPv6 adoption enables internet of everything connectivity

The transition from an IPv4 environment to an IPv6 environment is making excellent progress, with increases in IPv6 device capabilities, content enablement, and operators implementing IPv6 in their networks. These developments are particularly important because Asia, Europe, North America, and Latin America have already exhausted their IPv4 allotments, and Africa is expected to exhaust its allotment by 2018.

Table 3 shows the projected exhaustion dates as of May 2017, according to the Regional Internet Registries (RIR).

Table 3. IPv4 address exhaustion dates

Regional Internet Registries	Exhaustion Date
Asia Pacific Network Information Centre (APNIC)	April 19, 2011 (actual)
Réseaux IP Européens Network Coordination Centre (RIPE NCC)	September 14, 2012 (actual)
Latin America and Caribbean Network Information Centre (LACNIC)	June 10, 2014 (actual)
American Registry for Internet Numbers (ARIN)	September 24, 2015 (actual)
African Network Information Center (AFRINIC)	June 11, 2018 (projected)

Building on the Cisco VNI IPv6-capable devices analysis, the forecast estimates that globally there will be nearly 16.5 billion IPv6-capable fixed and mobile devices by 2021, up from nearly 5 billion in 2016, a CAGR of 27 percent. In terms of percentages, 61 percent of all fixed and mobile networked devices will be IPv6-capable by 2021, up from 30 percent in 2016 (Figure 8).

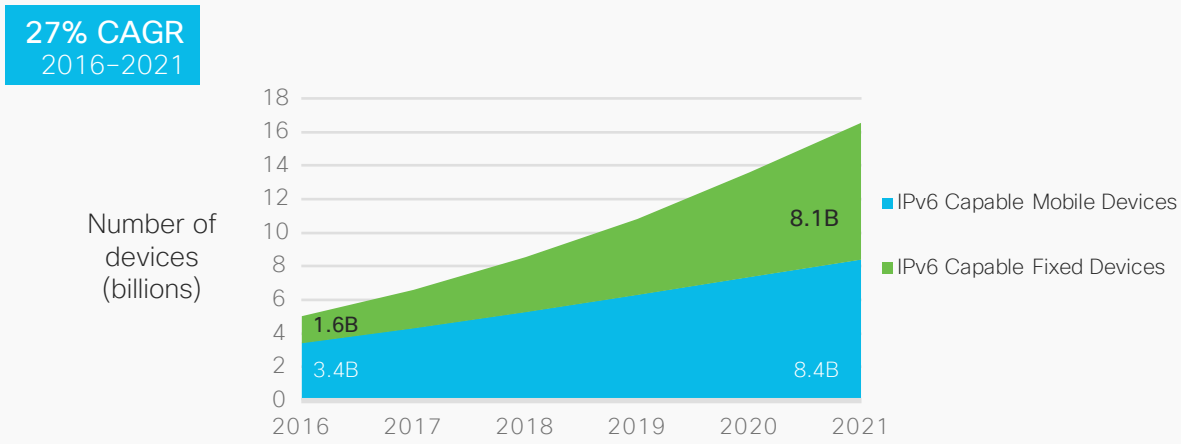
This estimate is based on the capability of the device and the network connection to support IPv6, and is not a projection of active IPv6 connections. Mobile-device IPv6 capability is assessed based on OS support of IPv6 and estimations of the types of mobile network infrastructure to which the device can connect (3.5-generation [3.5G] or later). Fixed-device IPv6 capability is assessed based on device support of IPv6 and an estimation of the capability of the residential customer premises equipment (CPE) or business routers to support IPv6, depending on the device end-user segment.

Globally, 93 percent of smartphones and tablets will be IPv6-capable by 2021, up from 68 percent in 2016. Globally, there will be 6.1 billion IPv6-capable smartphones and tablets by 2021, up from 2.6 billion in 2016.

According to the World IPv6 Launch Organization in May 2017, fixed and mobile network operators worldwide are deploying IPv6 and starting to report notable IPv6 traffic generation. Romania's RCS & RDS reported nearly 16 percent, France's Free Telecom reported 22 percent, KDDI reported nearly 35 percent, Comcast reported 54 percent, AT&T reported 66 percent, Reliance Jio Infocomm reported 81 percent, and Verizon Wireless reported 83 percent deployment. According to Google, in May 2017 the percentage of users who access Google through IPv6 is about 11 percent.

Amid these industry developments, the Cisco VNI forecast is undertaking an effort to estimate the potential IPv6 network traffic that could be generated if a percentage of IPv6-capable devices become actively connected to an IPv6 network, given the estimated global average for monthly traffic per device type.

Figure 8. Global IPv6-capable devices and connections forecast, 2016–2021



Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

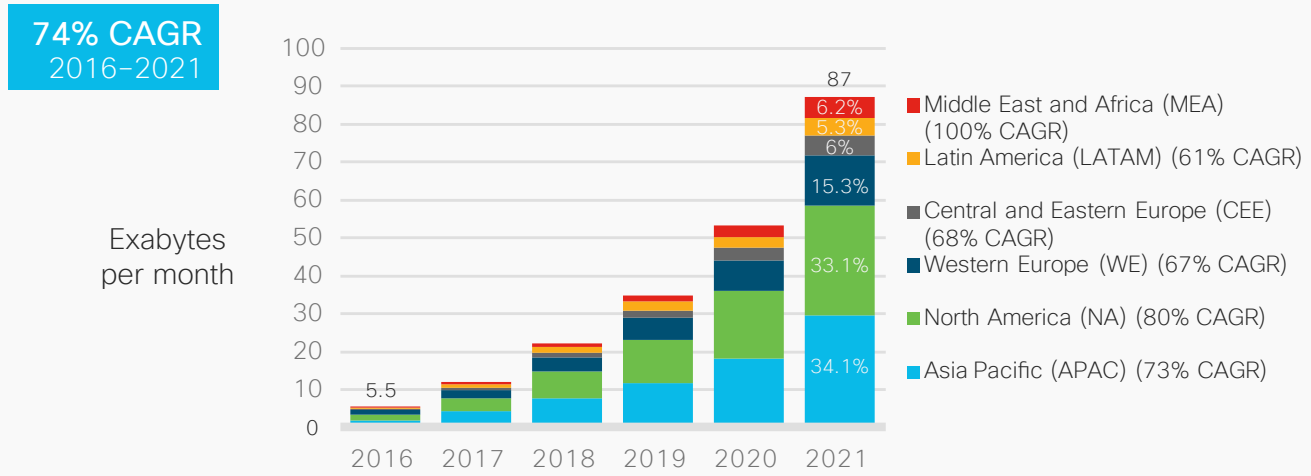
Looking to 2021, if 60 percent of IPv6-capable devices are actively connected to an IPv6 network, the forecast estimates that globally IPv6 traffic would amount to 87 EB per month, or 37 percent of total Internet traffic (Figure 9).

This initial estimation of potential IPv6 traffic is based on the assumptions that IPv6 device capability, IPv6 content enablement, and IPv6 network deployment will keep pace with current trends, and may even accelerate during the forecast period. Considering the interdependence of these variables, forecast assumptions could be subject to refinement as our analysis continues.

Content providers are also moving to increase the IPv6 enablement of their sites and services. According to Cisco® IPv6 labs, by 2021 the content available over IPv6 will be about 48 percent. There can be, however, variation depending on the popularity of websites across regions and countries. In addition, specific country initiatives and content-provider deployments have positively affected local IPv6 content reachability.

Overall, the likelihood that a significant portion of Internet traffic will be generated over IPv6 networks holds considerable opportunity for network operators, content providers, and end users seeking to gain the scalability and performance benefits of IPv6 and enable the Internet of Everything (IoE).

Figure 9. Projected global fixed and mobile IPv6 traffic forecast, 2016–2021



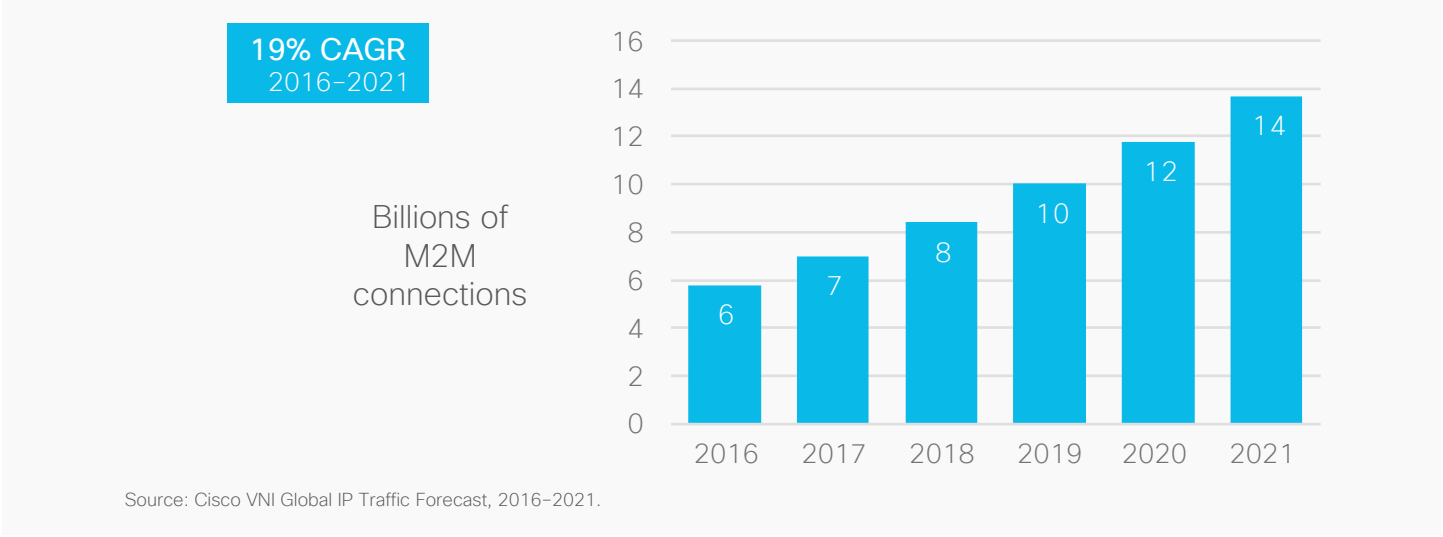
Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

Trend 3: M2M applications across many industries accelerate IoE growth

The Internet of Everything (IoE) phenomenon, in which people, processes, data, and things connect to the Internet and each other, is showing tangible growth. Globally, M2M connections will grow 2.4-fold, from 5.8 billion in 2016 to 13.7 billion by 2021 (Figure 10). There will be 1.75 M2M connections for each member of the global population by 2021.

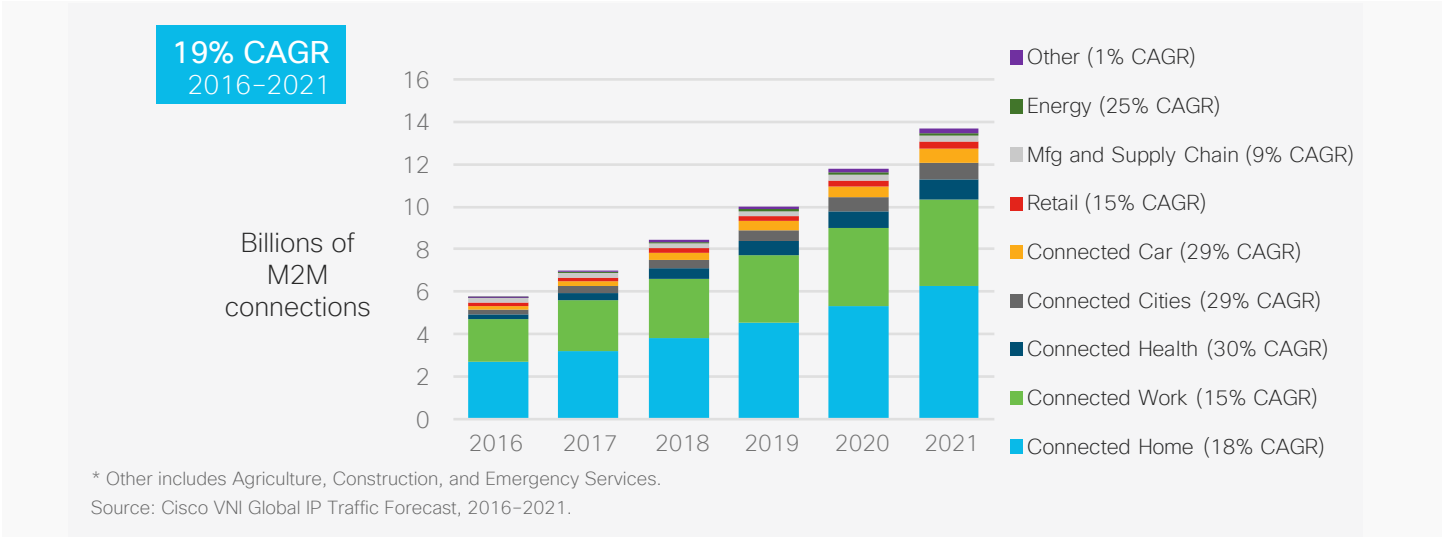
Connected home applications, such as home automation, home security and video surveillance, connected white goods, and tracking applications, will represent 46 percent, or nearly half, of the total M2M connections by 2021, showing the pervasiveness of M2M in our lives (Figure 11). Connected healthcare, with applications such as health monitors, medicine dispensers, first-responder connectivity, and telemedicine, will be the fastest-growing industry segment, at 30 percent CAGR. Connected car and connected cities applications will have the second-fastest growth, at 29 percent CAGR each.

Figure 10. Global M2M connection growth



Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

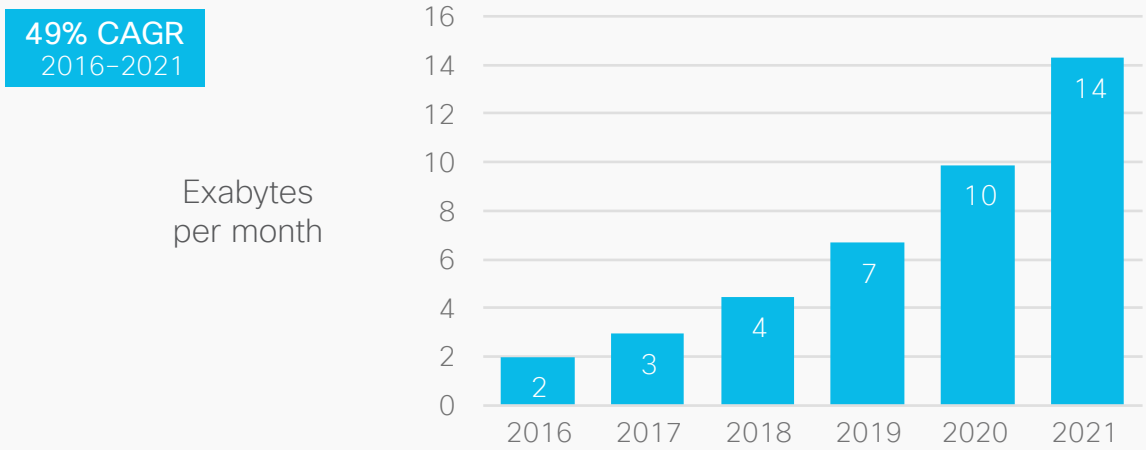
Figure 11. Global M2M connection growth by industries



* Other includes Agriculture, Construction, and Emergency Services.
Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

Although the number of connections is growing nearly 2.5-fold, global M2M IP traffic will grow more than sevenfold over this same period, from 2 EB per month in 2016 (2 percent of global IP traffic) to more than 14 EB by 2021 (5 percent of global IP traffic; refer to Figure 12). The amount of traffic is growing faster than the number of connections because of the increase of deployment of video applications on M2M connections and the increased use of applications, such as telemedicine and smart car navigation systems, which require greater bandwidth and lower latency.

Figure 12. Global M2M traffic growth: Exabytes per month

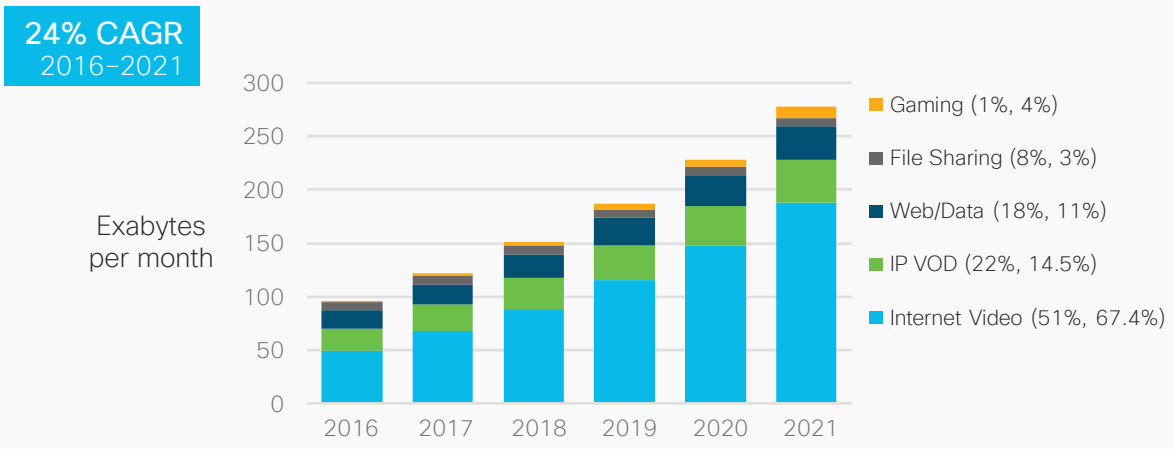


Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

Trend 4: Applications traffic growth

The sum of all forms of IP video, which includes Internet video, IP VoD, video files exchanged through file sharing, video-streamed gaming, and video conferencing, will continue to be in the range of 80 to 90 percent of total IP traffic. Globally, IP video traffic will account for 82 percent of traffic by 2021 (Figure 13).

Figure 13. Global IP traffic by application category



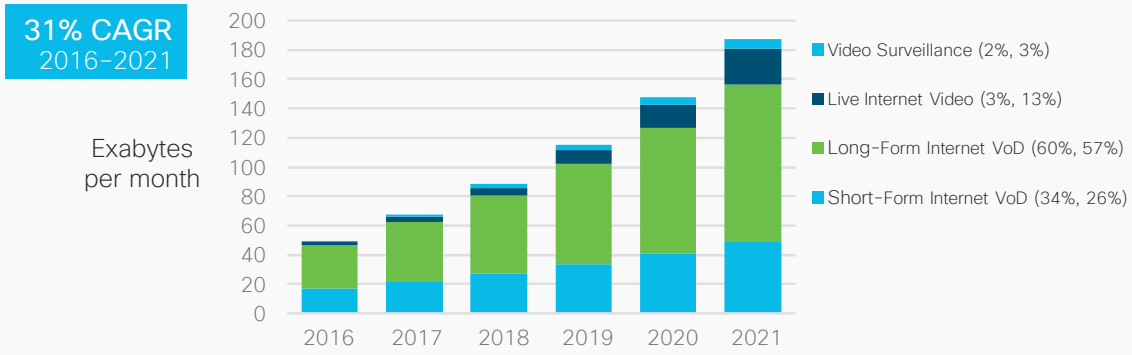
Figures (n) refer to 2016, 2021 traffic shares.
Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

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

In the past two years, service providers have observed a pronounced increase in traffic associated with gaming downloads. Newer consoles such as the Xbox One and PlayStation 4 have sufficient onboard storage to enable gamers to download new games rather than buy them on disc. These graphically intense games are large files, and gaming downloads will reach 4 percent of all Internet video traffic by 2021. Furthermore, these downloads tend to occur during peak usage periods, with gaming downloads reaching up to 8 percent of busy hour traffic. We expect the growth of gaming traffic to continue, and gaming is one of the forms of traffic that will limit the likelihood that video traffic will exceed the projected 82 percent in 2021.

There are shifts within Internet video traffic itself as well. In particular, live Internet video has the potential to drive large amounts of traffic as it replaces traditional broadcast viewing hours. Live video already accounts for 3 percent of Internet video traffic and will grow 15-fold to reach 13 percent by 2021. Also of note is the growth of video surveillance traffic (dropcams). This traffic is of a very different nature than live or on-demand streaming and represents a steady stream of upstream video camera traffic, uploaded continuously from homes and small businesses to the cloud.

Figure 14. Global internet video by subsegment



Figures (n) refer to 2016, 2021 traffic shares.
Source: Cisco VNI Global IP Traffic Forecast, 2016-2021.

Effects 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, a situation that 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 slightly declining as a percentage for several years.

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 (CDS) 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.

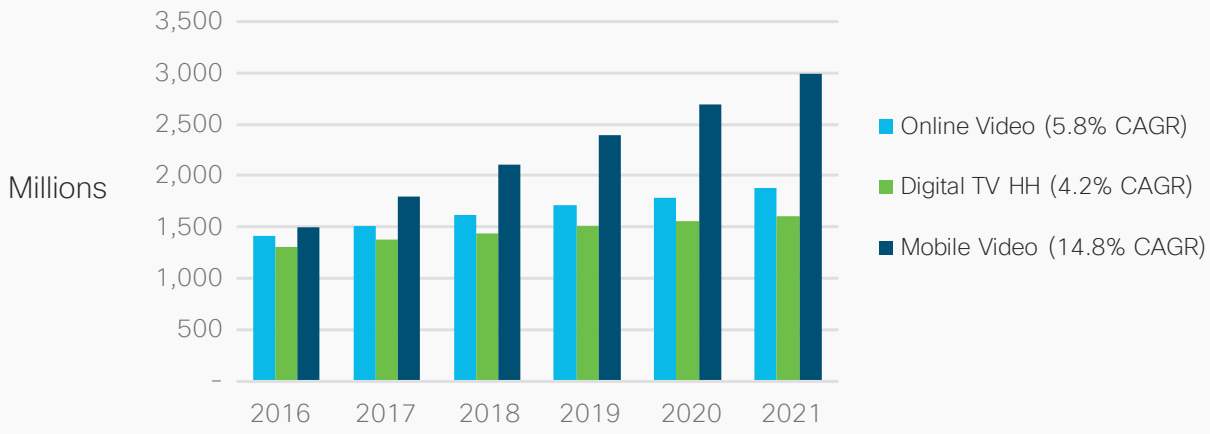
Generally, if service providers provide ample upstream bandwidth, applications that use upstream capacity will begin to appear.

Trend 5: "Cord-Cutting" analysis

In the context of the Cisco VNI Forecast, "cord cutting" refers to the trend in which traditional and subscription television viewing is increasingly being supplanted by other means of video viewing, such as online and mobile video, which are available to viewers through fixed and mobile Internet connections.

We are seeing a trend in which the growth in digital television service that denotes television viewing across all digital platforms (cable, IPTV, satellite, etc.) is growing much more slowly relative to mobile video (Figure 15). This trend is more pronounced in regions such as North America and Western Europe, where the penetration of digital TV is already high. The only region with double-digit growth in digital television is Middle East and Africa, with 11 percent CAGR. Online video, which we found was growing at par with digital TV until last year, is now growing faster than digital television. Also, in emerging regions mobile video growth rates are even higher, because these regions are skipping overfixed connectivity.

Figure 15. Mobile video growing fastest; online video and digital TV grow similarly

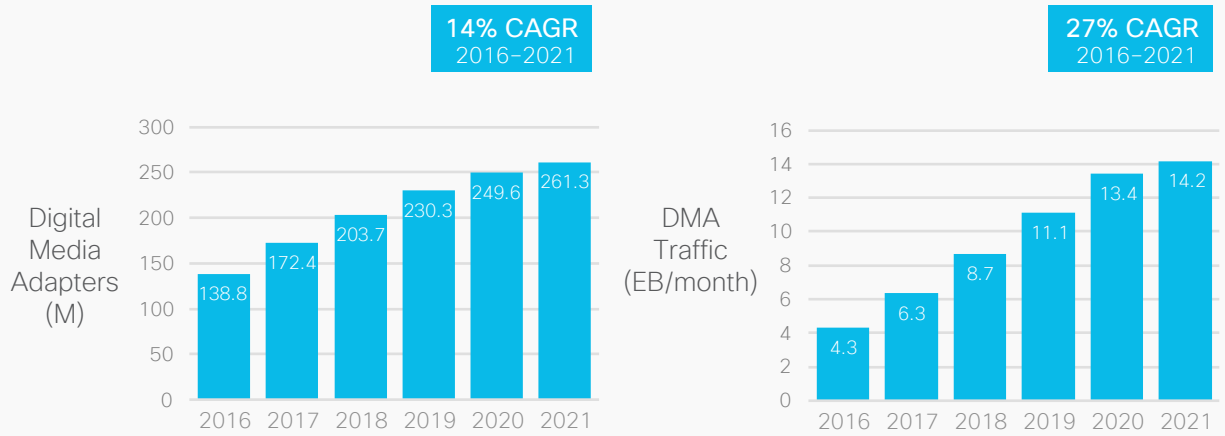


Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

Also, if we look at Internet devices such as Digital Media Adapters (DMAs), we find that although they represent only 16 percent of all Internet connected Set-Top Boxes (STBs)—including, service provider STBs, gaming consoles, and directly connected Internet TV sets—by 2021 they will represent 34 percent of global Internet STB traffic. This trend again shows that there is increasingly less reliance on STBs managed by service providers for Internet access in general and for video specifically (Figure 16).

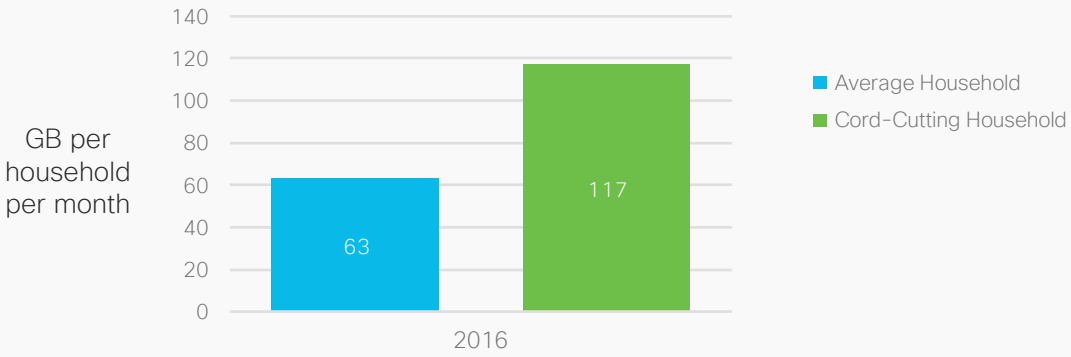
From a traffic perspective, we expect that on average a household that is still on linear TV will generate much less traffic than a household that has "cut the cord" and is relying on Internet video (Figure 17). A cord-cutting household will generate 117 GB per month in 2017, compared to 63 GB per month for an average household. This difference occurs because linear television generates much less traffic (one stream of video shared across numerous linear-TV households) than Internet video, which is unicast to each Internet video device.

Figure 16. Growth in global digital media adapters



* DMAs include devices such as Roku, Apple TV, Chromecast, etc.
Source: Cisco VNI Global IP Traffic Forecast, 2016-2021.

Figure 17. Global cord cutting generates double the traffic



Source: Cisco VNI Global IP Traffic Forecast, 2016-2021.

Trend 6: Security analysis

Users expect their online experience to be always available and always secure—and for their personal and business assets to be safe. Annual security reports for 2017 from industry giants in the security space highlight the need for increased focus on cybercrimes, data breaches and espionage, and mitigation strategies (Figure 18).

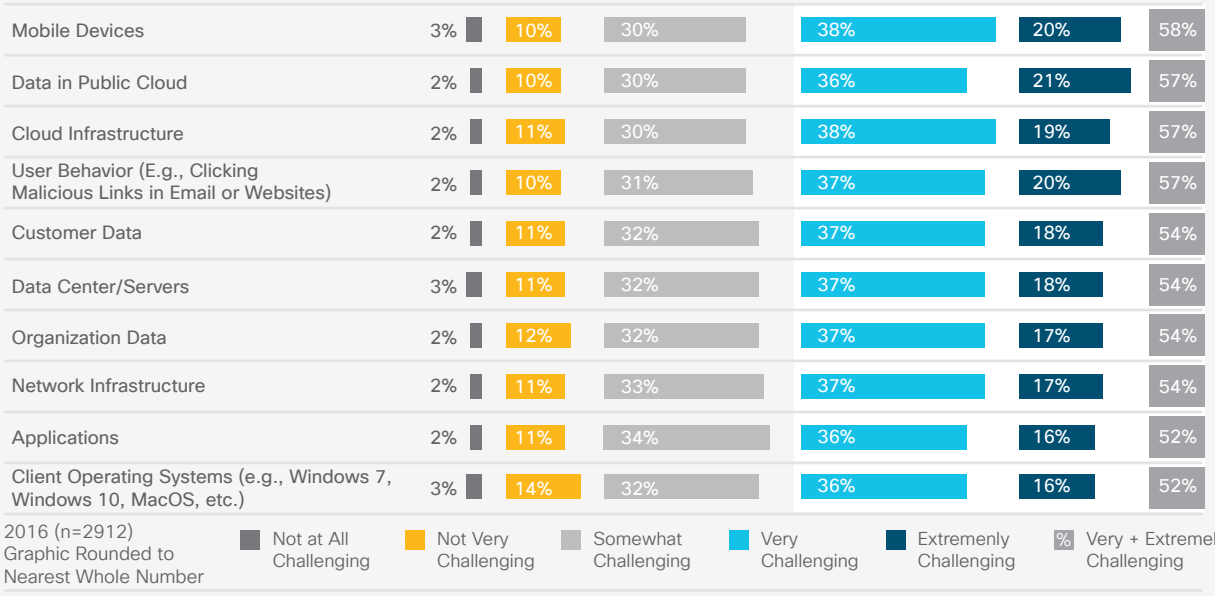
The Cisco 2017 Annual Security Report found that nearly a quarter of the organizations that have suffered an attack lost business opportunities. Four in 10 said those losses are substantial. One in five organizations lost customers because of an attack, and nearly 30 percent lost revenue.

The last several years have been easily the most eventful period from a security threat perspective, with many serious data breaches that have been discussed widely in the media, the "WannaCry" ransomware being the latest, in May 2017. Ransomware is one of the biggest problems faced in cybersecurity. It's a form of malware that encrypts documents on a PC or even across a network. Victims can often only regain access to their files and PCs by paying a ransom to the criminals behind it. "WannaCry" affected around 200,000 computers in more than 150 countries.

There were a total of 1,093 breaches with a total of nearly 36.6 million records exposed in 2016. The number of records exposed per data breach averaged 33,488 in 2016, according to 2016 Identity Theft Resource Center, with the highest number of records exposed in healthcare. Average cost of data breach per capita over 3 years has increased, according to a joint study by IBM and Ponemon Institute. Average per capita cost of a breach globally was $158 in 2016 compared to an average of $154 average last year. The United States and Germany have the highest per capita costs, at $221 and $213. India and Brazil had the lowest costs, at $61 and $100.

More secure Internet servers leads to a large footprint of security and authentication, better serving end users with secure transactions and communication. The percentage of secure Internet servers that conduct encrypted transactions over the Internet using Secure Sockets Layer (SSL) compared to the total number of web-facing servers depicts the nature of the secure footprint. Central and Eastern Europe led percentage of secure Internet servers to the total web-facing servers, with 46 percent, followed by Western Europe, with 40 percent. North America and Western Europe have the highest number of secure Internet servers.

Figure 18. Security professionals' biggest sources of concern related to cyberattacks



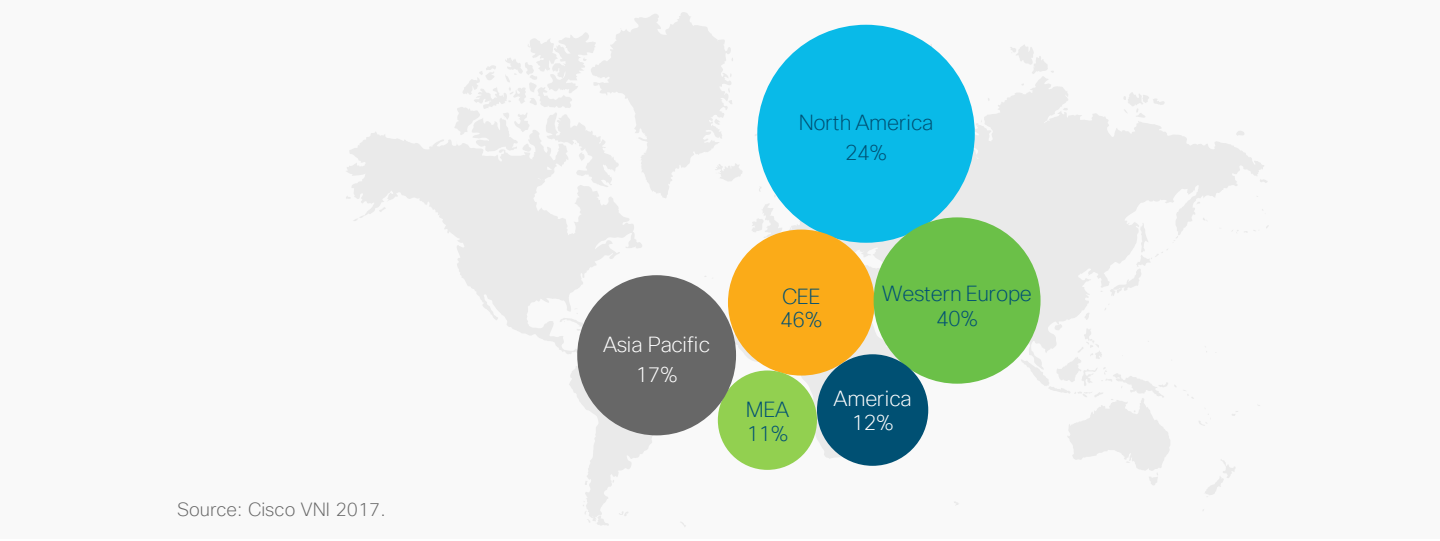
Source: Cisco 2017 Security Capabilities Benchmark Study.

There are many methods to breaching 62 percent of breaches featured hacking, according to the Verizon 2017 data breach investigations report. More than half of the breaches included malware, and 81 percent of hacking-related breaches used either stolen and/or weak passwords.

A Distributed-Denial-of-Service (DDoS) attack occurs when multiple systems flood the bandwidth or resources of a targeted system, usually one or more web servers. Such an attack is often the result of multiple compromised systems flooding the targeted system with traffic. Peak DDoS attack sizes (Gbps) have increasing trajectory, with peak attacks reaching 400, 500, and 800 Gbps, respectively, in 2014, 2015, and 2016, according to Arbor Networks 12th Annual Infrastructure Security report. Average DDoS attack size is increasing steadily and approaching 1.2 Gpbs, enough to take most organizations completely offline. DDoS attacks are increasing at roughly the same rate as traffic. DDoS attacks can represent up to 18 percent of a country's total Internet traffic while they are occurring. In 2016 the top motivation behind DDoS attacks was criminals demonstrating attack capabilities, with gaming and criminal extortion attempts in second and third place, respectively.

The events from 2016 and the first quarter of 2017 once again demonstrated that the attackers are increasing their computing resources to perform DDoS attacks. Amplification attackers, who have tools for carrying out a DDoS attack, exploit vulnerabilities in the network and compute resources. With the growth of the IoE and spread of vulnerable devices and traditional PCs, the abundance of configuration drawbacks with applications can be targeted. Security vendors continue to make sure these attacks are financially unviable for the cybercriminals. Globally the number of DDoS attacks greater than 1 Gbps grew 172 percent in 2016 and will increase 2.5-fold to 3.1 million by 2021 (Figure 20).

Figure 19. Enabling authentication and secure internet: Percentage of secure internet servers to all web-facing servers

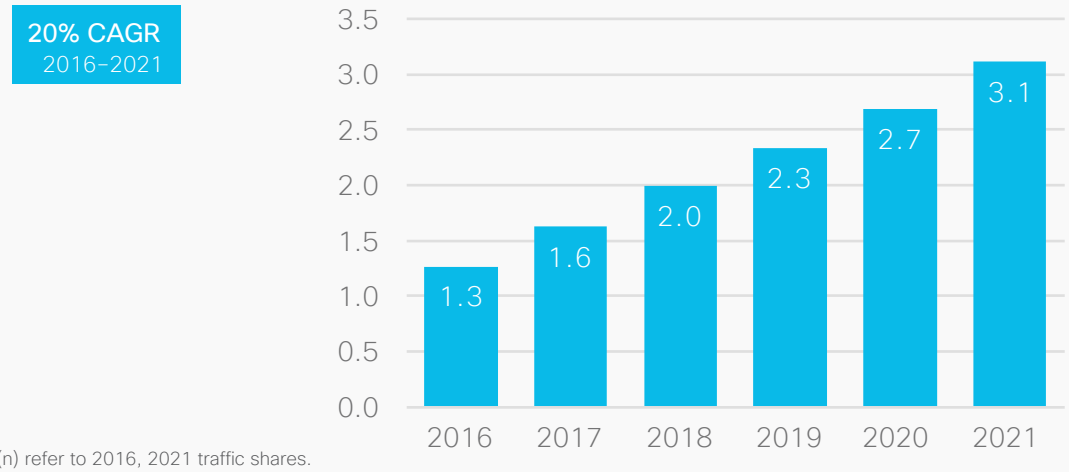


Source: Cisco VNI 2017.

With the Mirai Botnet attack in 2016, compromises and hacking took mainstage with exposing vulnerabilities in IoT in relation to home monitoring and devices. However, the concern is beyond the home as well. For example, many areas of the connected car are a security concern. Volkswagen states that an average car will have 150 sensors by 2020. In modern connected cars, each tire pressure monitoring sensor (TPMS) receives a dedicated address like a computer MAC address.

Vulnerabilities in smartphone apps can also be used to introduce malware. Vehicle-to-vehicle (V2V) communication and vehicle-to-everything (V2X) communication are being enabled with smart cities and next-generation mobile and Wi-Fi standards. Key fob scanning, taking control over air bag systems, and anticollision systems are all possibilities. Security will remain a key part of the IoT deployment and proliferation.

Figure 20. Global DDoS attacks forecast, 2016-2021



Figures (n) refer to 2016, 2021 traffic shares.
Source: Cisco VNI Global IP Traffic Forecast, 2016-2021.

Trend 7: Effects of accelerating speeds on traffic growth

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 double from 2016 to 2021, from 27.5 Mbps to 53.0 Mbps. Table 4 shows the projected broadband speeds from 2016 to 2021. 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 within the Cisco VNI countries in terms of broadband speed largely because of their wide deployment of FTTH.

Table 4. Fixed broadband speeds (in Mbps), 2016-2021

Region	2016	2017	2018	2019	2020	2021	CAGR (2016-2021)
Global	27.5	39.0	42.3	47.9	50.4	53.0	14%
Asia Pacific	33.9	46.2	49.8	56.4	59.4	63.7	13%
Latin America	9.3	11.7	13.6	15.0	17.6	20.5	17%
North America	32.9	43.2	51.0	57.5	65.0	74.2	18%
Western Europe	30.2	37.9	40.7	46.9	49.3	53.6	12%
Central and Eastern Europe	29.2	32.8	36.0	39.0	41.6	45.5	9%
Middle East and Africa	29.3	39.0	46.0	51.6	59.2	67.4	18%

Source: Cisco VNI, 2017.

Consider how long it takes to download an HD movie at these speeds: at 10 Mbps, it takes 20 minutes; at 25 Mbps, it takes 9 minutes; but at 100 Mbps, it takes only 2 minutes. High-bandwidth speeds will be essential to support consumer cloud storage, making the download of large multimedia files as fast as a transfer from a hard drive. Table 5 shows the percentage of broadband connections that will be faster than 10 Mbps, 25 Mbps, and 50 Mbps by region.

Table 5. Broadband speed greater than 10 Mbps, 2016–2021

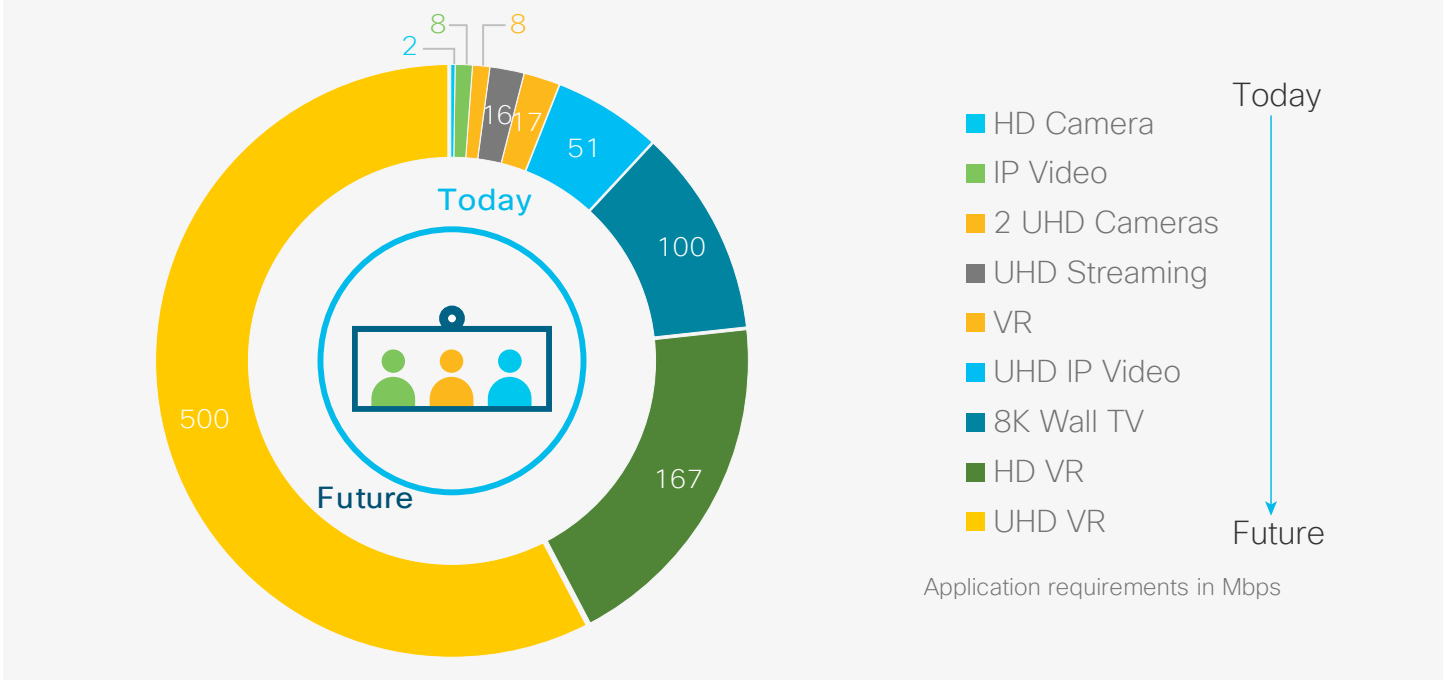
Region	Greater Than 10 Mbps					
	2016	2017	2018	2019	2020	2021
Global	48%	53%	63%	69%	74%	77%
Asia Pacific	46%	53%	69%	77%	81%	84%
Latin America	27%	27%	31%	35%	38%	40%
North America	58%	64%	74%	78%	81%	86%
Western Europe	51%	54%	61%	66%	70%	74%
Central and Eastern Europe	53%	58%	63%	66%	71%	75%
Middle East and Africa	16%	17%	17%	19%	20%	21%
Region	**Greater Than 25 Mbps**					
	2016	2017	2018	2019	2020	2021
Global	48%	53%	63%	69%	74%	77%
Asia Pacific	46%	53%	69%	77%	81%	84%
Latin America	27%	27%	31%	35%	38%	40%
North America	58%	64%	74%	78%	81%	86%
Western Europe	51%	54%	61%	66%	70%	74%
Central and Eastern Europe	53%	58%	63%	66%	71%	75%
Middle East and Africa	16%	17%	17%	19%	20%	21%

Region	Greater Than 50 Mbps					
	2016	2017	2018	2019	2020	2021
Global	21%	29%	33%	38%	43%	48%
Asia Pacific	25%	36%	42%	48%	54%	59%
Latin America	5%	6%	7%	7%	8%	9%
North America	27%	34%	38%	42%	45%	51%
Western Europe	18%	25%	28%	33%	38%	44%
Central and Eastern Europe	23%	24%	26%	29%	33%	36%
Middle East and Africa	3%	2%	3%	3%	4%	5%

Source: Cisco VNI, 2017.

A few countries also have users that currently experience greater than 125 Mbps, paving the path for the future demands of video. Video continues to be of enormous demand in today's home, but there will be significant bandwidth demands with the video application requirements of the future, even beyond the forecast period of 2021. In Figure 21, a scenario with video applications of the future is explored; today's bandwidth needs are a sliver of the future needs.

Figure 21. Significant demand for video in the home of the future



Mobile speeds

Globally, the average mobile network connection speed in 2016 was 6.8 Mbps. The average speed will more than double and will be 20.4 Mbps by 2021. Smartphone speeds, generally third-generation (3G) and later, will be on par with average speeds by 2021.

Anecdotal evidence supports the idea that overall use increases when speed increases, although there is often a delay between the increase in speed and the increased use, 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 can support. 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 6).

Table 6. Projected average mobile network connection speeds (in Mbps) by region and country

	2016	2017	2018	2019	2020	2021	CAGR (2016–2021)
Global							
Global speed: All handsets	6.8	8.7	11.1	14.3	17.7	20.4	24%
Global speed: Smartphones	12.1	13.5	14.9	16.2	18.1	20.3	11%
Global speed: Tablets	19.1	22.6	24.5	26.2	27.2	27.8	8%
By Region							
Asia Pacific	9.8	10.6	12.9	16.0	18.8	20.4	16%
Latin America	3.8	4.9	6.4	7.9	10.0	12.4	27%
North America	13.7	16.3	17.6	19.8	22.8	25.2	13%
Western Europe	11.4	16.0	18.6	21.6	25.7	28.5	20%
Central and Eastern Europe	6.3	10.1	12.3	13.6	16.2	18.4	24%
Middle East and Africa	3.8	4.4	5.3	6.8	8.5	10.8	23%

Source: Cisco VNI Mobile, 2017.

Current and historical speeds are based on data from 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 2021.

A crucial factor promoting the increase in mobile speeds over the forecast period is the increasing proportion of fourth-generation (4G) mobile connections. The effect 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 nearly double by 2021. The average Wi-Fi network connection speed (18.2 Mbps in 2016) will exceed 37.1 Mbps in 2021. North America will experience the highest Wi-Fi speeds, 52.3 Mbps, by 2021 (Table 7).

Wi-Fi speeds inherently depend on the quality of the broadband connection to the premises. The speed also depends on the Wi-Fi standard in the CPE device. The latest standard, IEEE 802.11ac and 802.11 ad, are considered to be a true wired complement and can enable higher definition video streaming and services that require higher data rates. Also an important factor in the use of Wi-Fi technology is the number and availability of hotspots.

Table 7. Projected average Wi-Fi network connection speeds (in Mbps) by region and country

Region	2016	2017	2018	2019	2020	2021	CAGR (2016–2021)
Global	18.2	24.4	29.7	33.1	35.2	37.1	15%
Asia Pacific	19.5	26.7	34.1	36.3	38.4	40.7	16%
Latin America	7.7	9.0	9.5	11.4	12.9	13.9	13%
North America	27.4	37.1	42.4	46.1	48.4	52.3	14%
Western Europe	20.3	25.0	27.8	29.9	31.9	35.1	12%
Central and Eastern Europe	16.7	19.5	22.0	25.0	29.1	31.6	14%
Middle East and Africa	4.9	6.2	7.0	7.8	8.6	9.0	13%

Source: Cisco VNI, 2017.

Trend 8: Mobility (Wi-Fi) continues to gain momentum

Globally, there will be nearly 541.6 million public Wi-Fi hotspots by 2021, up from 94 million hotspots in 2016, a sixfold increase. Western Europe had the highest number of hotspots, with 44 percent of the world's Wi-Fi hotspots in 2016. By 2021, Asia Pacific will have the highest percentage of 45 percent. Public Wi-Fi along with community hotspots are included in the forecast. Community hotspots or homespots have emerged as a potentially significant element of the public Wi-Fi landscape. In this model, subscribers allow part of the capacity of their residential gateway to be open to casual use. The homespot may be provided by a broadband or other provider directly or through a partner.

Asia Pacific will lead in adoption of homespots. By 2021, China will lead in total number of homespots, followed by the United States and Japan.

Hotels, cafes, and restaurants will have the highest number of hotspots by 2021 globally, and the fastest growth is in healthcare facilities (hospitals), where hotspots will triple over the forecast period. The primary objective of Wi-Fi in hospitals is to improve the delivery of healthcare services and staff productivity, with a secondary benefit being Internet access for patients, their families, and their guests.

Integral to these verticals and looking into the future are the game-changing IoT devices and connections. According to Maravedis/Rethink research and the WBA Alliance, more than two-thirds (67 percent) of mobile operators and 78 percent of cable companies expect to use Wi-Fi to support IoT services by 2020.

Critical enablers of Hotspot 2.0 adoption are higher speed Wi-Fi gateways and the adoption of the IEEE 802.11ac and 802.11n standards. Globally, the prevalence of IEEE 802.11ac, the latest Wi-Fi standard, will gain momentum from 2016 through 2021. In 2016, 59.5 percent of all home Wi-Fi routers shipped globally were 802.11ac-enabled. By 2021, 98.1 percent of all home Wi-Fi routers will be equipped with 802.11ac. IEEE 802.11n, which was ratified in 2007, provides a range of speeds that allow users to view medium-resolution video streaming because of the higher throughput.

The latest standard, IEEE 802.11ac, with very high theoretical speeds, is considered a true wired complement and can enable higher definition video streaming and services with use cases that require higher data rates (Figure 22).

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 23 shows the growth in Wi-Fi and mobile traffic in relation to traffic from wired devices. By 2021, wired networks will account for 37 percent of IP traffic, and Wi-Fi and mobile networks will account for 63 percent of IP traffic. In 2016, wired networks accounted for the majority of IP traffic, at 51 percent; Wi-Fi accounted for 41 percent; and mobile or cellular networks accounted for 7.5 percent of total global IP traffic.

Figure 22. Future of Wired and Wireless Technologies

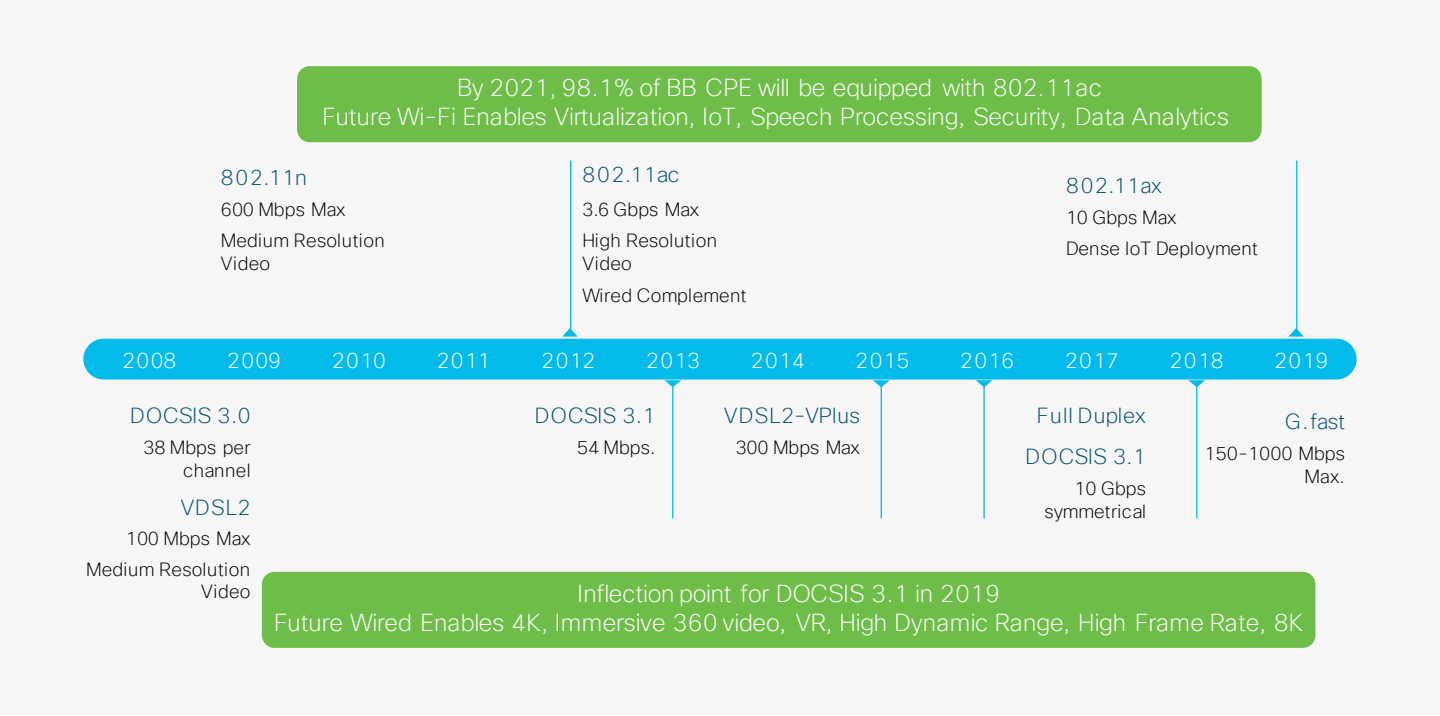
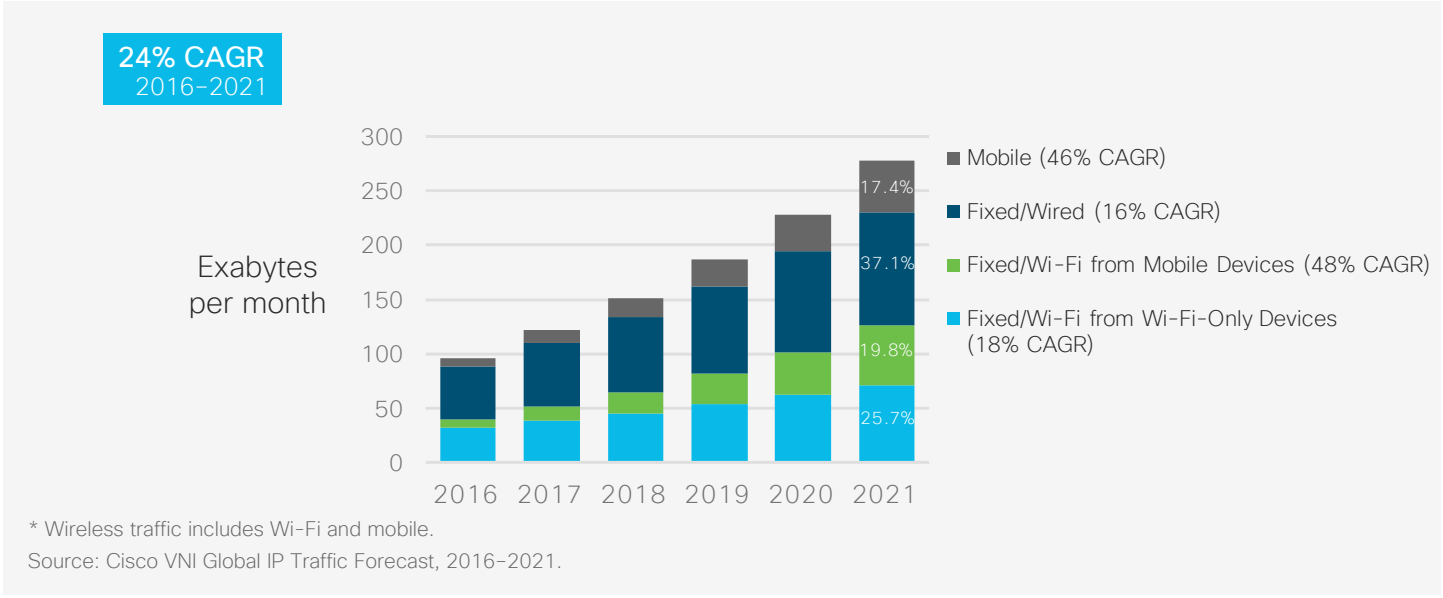


Figure 23. Global IP traffic, wired and wireless*

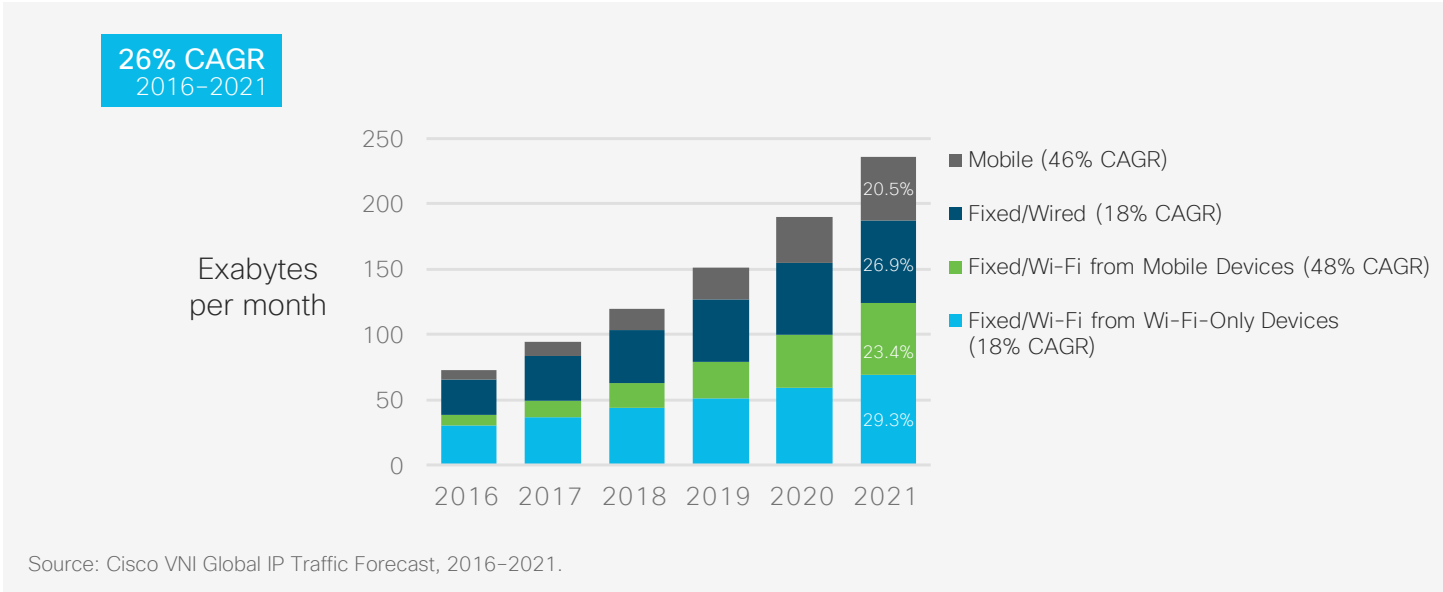


* Wireless traffic includes Wi-Fi and mobile.

Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

Narrowing the focus to Internet traffic and excluding managed IP traffic yields a more pronounced trend. By 2021, wired devices will account for 27 percent of Internet traffic, and Wi-Fi and mobile devices will account for 73 percent of Internet traffic (Figure 24). In 2016, wired devices accounted for less than half of Internet traffic, at 38 percent.

Figure 24. Global internet traffic, wired and wireless



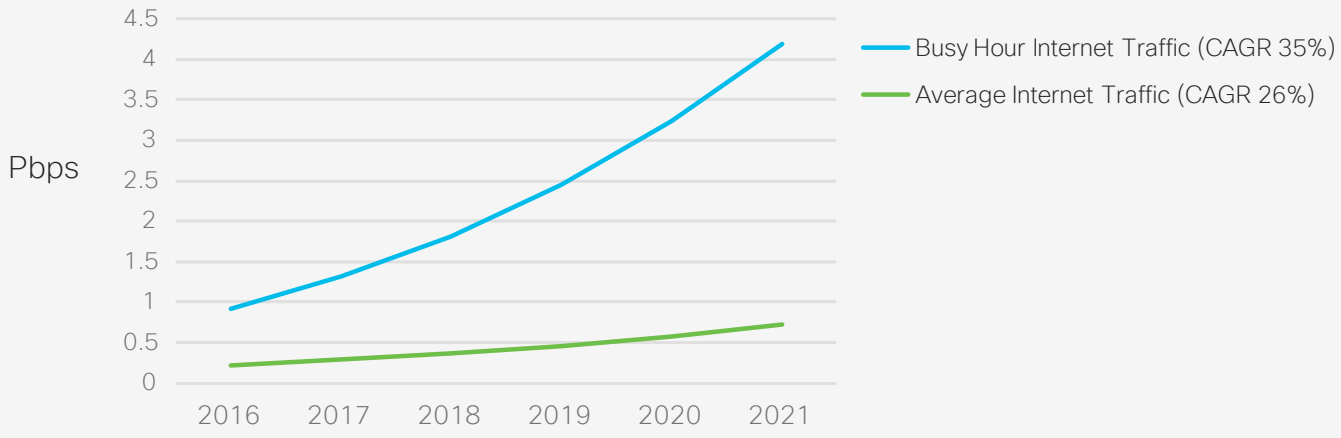
Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

Trend 9: Traffic-pattern analysis (peak compared to average and CDN uptake and SD-WAN)

Although average Internet traffic has settled into a steady growth pattern, busy hour traffic (or traffic in the busiest 60 minute period of the day) continues to grow more rapidly than average Internet traffic. Service providers plan network capacity according to peak rates rather than average rates. In 2016, busy hour Internet traffic grew 51 percent, and average traffic grew at 32 percent. Between 2016 and 2021, global busy hour Internet use will grow at a CAGR of 35 percent, compared with 26 percent for average Internet traffic (Figure 25).

Video is the underlying reason for accelerated busy hour traffic growth. Unlike other forms of traffic, which 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 25. Busy hour compared with average internet traffic growth

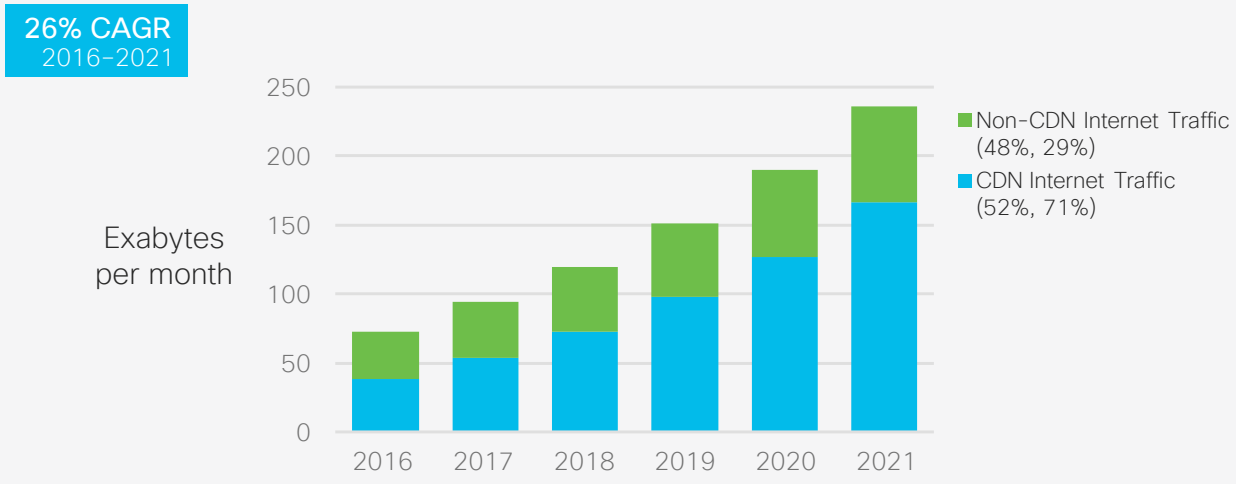


Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

Changes in traffic topology are being brought about by the increasing role of content delivery networks (CDNs) in data delivery. CDNs will carry 71 percent of total Internet traffic by 2021 (Figure 26), up from 52 percent in 2016. Although network performance is usually attributed to the speeds and latencies offered by the service provider, the delivery algorithms used by CDNs have an equal if not more significant bearing on video quality.

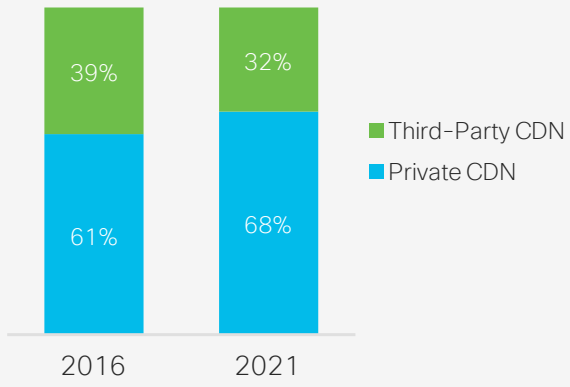
Much CDN traffic is carried by private CDNs rather than third-party CDNs. Private CDNs are those built and operated by content providers for their own content, and only their content. Private CDN capacity is not available to other content providers for purchase. Large private CDN operators include Google, Amazon, Facebook, and Microsoft. Sixty-eight percent of CDN traffic will be carried by private CDNs by 2021 (Figure 27).

Figure 26. Global content delivery network internet traffic, 2016 and 2021



Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

Figure 27. Private and third-party content delivery network internet traffic, 2016 and 2021

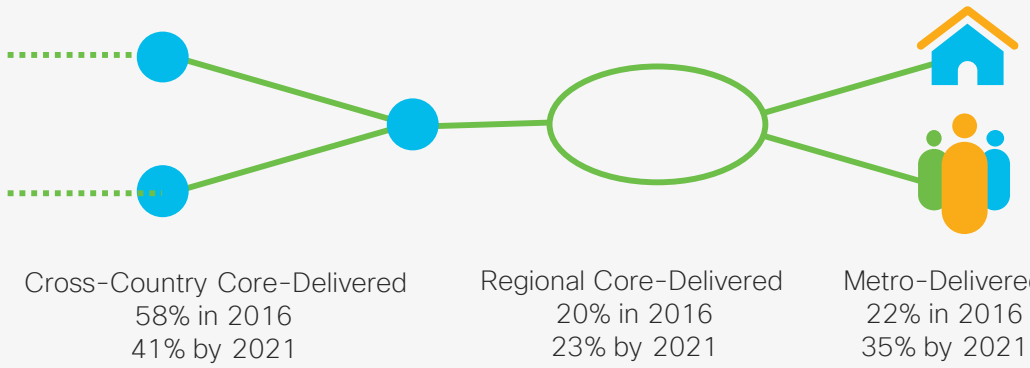


Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

CDNs will carry traffic closer to the end user, but presently much CDN traffic is deposited onto regional core networks, so the percentage of metro-delivered traffic is lower than the CDN traffic share. However, metro-delivered traffic is growing faster than core-delivered traffic and will account for 35 percent of total end-user traffic by 2021, up from 22 percent in 2016 (Figure 28).

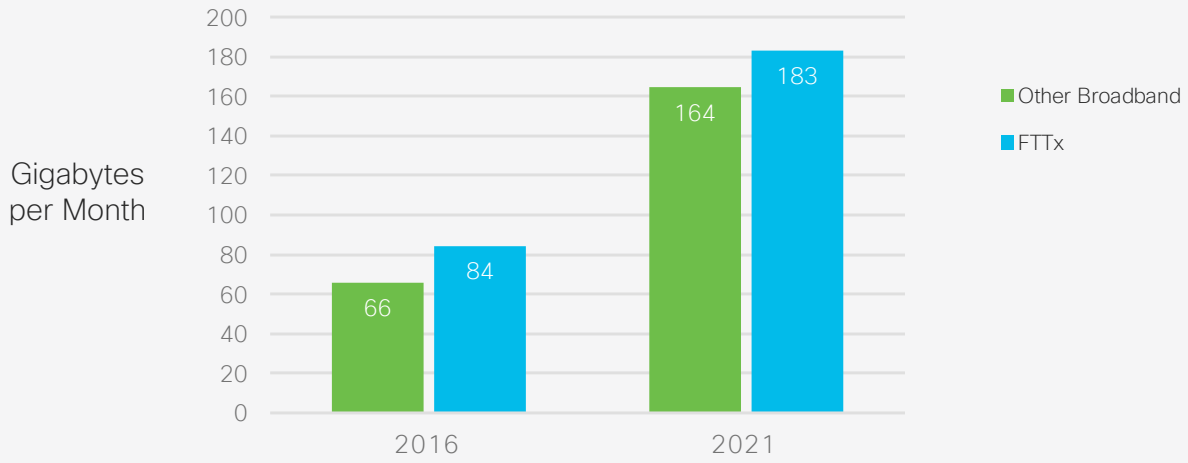
Speed is a critical factor in Internet traffic. When speed increases, users stream and download greater volumes of content, and adaptive bit-rate streaming increases bit rates automatically according to available bandwidth. Service providers find that users with greater bandwidth generate more traffic. In 2016, households with high-speed fiber connectivity generated 28 percent more traffic than households connected by DSL or cable broadband, globally (Figure 29). The average FTTH household generated 84 GB per month in 2016 and will generate 183 GB per month in 2021.

Figure 28. Internet traffic moving closer to the edge



Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

Figure 29. Fiber-Connected households generate more traffic than households with other sources of broadband



Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

To limit the volume of traffic, service providers can institute use-based tiered pricing and data caps.

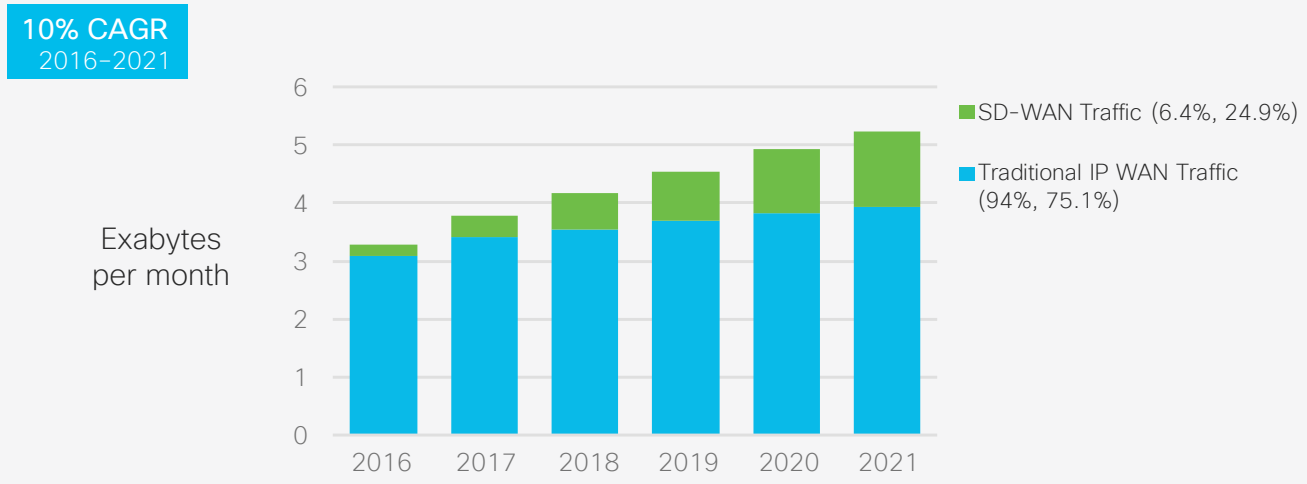
On mobile networks, by looking at the use of more than 33,000 lines from Tier-1 mobile operators from 2010 to 2016, we found that monthly traffic from the top 1 percent of users is down to 18 percent of overall use compared to 52 percent in 2010, showing the effects of tiered pricing. With mobile penetration reaching a saturation point in many countries across all regions, the trend has been toward tiered plans as a way to monetize data and effectively manage or throttle the top users of traffic. On the fixed networks, data caps continue to increase to match subscribers' growing appetite for video. In the United States, Tier-1 carriers are offering a variety of fair usage limits today, as high as 1 TB per month. A large provider in Japan has a 30-GB-per-day upload cap. In several countries, Netflix has a sizable percentage of the Internet video minutes and traffic.

Wildcard traffic generators such as Twitch.TV, a live streaming service in which video gamers watch each other play, has established itself on many fixed networks around the world.

Data caps affect a larger percentage of mobile users than fixed users. With Tier-1 carriers, approximately 12 percent of mobile users consume more than 2 GB per month (a common mobile data cap), whereas only 1.4 percent of fixed users consume more than 500 GB per month (a common fixed data cap).

A final trend relating to the technology coordinating traffic flow is the adoption of SD-WAN in the enterprise. SD-WAN traffic will grow at a CAGR of 44 percent compared to 5 percent for traditional MPLS-based WAN. SD-WAN will increase 6-fold and will be 25 percent of WAN traffic by 2021.

Figure 30. Global enterprise SD-WAN traffic



Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

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.

- **Growth of smartphones** as the "communications hub" for social media, video consumption, tracking IoE/digitization applications (et al.), as well as traditional voice. This trend demonstrates the effect that smartphones have on how consumers and businesses users access and use the Internet and IP networks.
- **Internet gaming** is seeing a resurgence—the traffic will grow nearly tenfold between 2016 and 2021. Gaming on demand and streaming gaming platforms have been in development for several years, with many newly released in the last couple of years. With traditional gaming, graphical processing is performed 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. As cloud gaming becomes popular, gaming could become one of the largest Internet traffic categories.
- **Virtual reality and augmented reality:** With new hardware available to individuals, and a growing body of content to consume, VR and AR have experienced high growth in recent years. Traffic associated with virtual and augmented reality applications is poised to grow 20-fold by 2021. This growth stems mainly from the download of large virtual reality content files and applications, but a significant wild card is the potential adoption of virtual reality streaming, which could raise our prediction of high-growth even higher.
- **Immersive video:** This emerging traffic type can cause significant new network design implications as it is a high-bandwidth consuming application. Social media platforms such as Facebook have launched support for spherical, or immersive video that integrates multiple camera angles to form a single video stream and can be watched from the viewer's preferred perspective. It can generate bit rates 3 to 10 times greater than non-immersive HD bit rates.
- **Video surveillance:** New Internet-connected video surveillance cameras upload a constant video stream to the cloud for remote viewing. With a steady flow of video traffic from each camera, video surveillance is already having an effect on overall Internet traffic. It accounts for 3 percent of Internet video traffic today and will grow 15-fold to reach 13 percent by 2021. If such devices become mass market in the next five years, we could see video cameras generating a significantly higher volume of traffic, since Internet-enabled cameras can produce up to 300 GB per camera per month for full HD-resolution monitoring of high-activity areas.

For more information

For more information about the Cisco IP traffic forecast, refer to "Cisco VNI: Forecast and Methodology, 2016–2021" 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, country, application, and 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.

Appendix: Cisco global IP traffic forecast

Table 8 shows a summary of the Cisco global IP traffic forecast. For more information and additional tables, refer to "Cisco VNI: Forecast and Methodology, 2016–2021."

Table 8. Global IP Traffic, 2016–2021

IP Traffic, 2016–2021							
	2016	2017	2018	2019	2020	2021	CAGR (2016–2021)
By Type (Petabytes [PB] per Month)							
Fixed Internet	65,942	83,371	102,960	127,008	155,121	187,386	23%
Managed IP	22,911	27,140	31,304	35,226	38,908	42,452	13%
Mobile data	7,201	11,183	16,646	24,220	34,382	48,270	46%
By Segment (PB per Month)							
Consumer	78,250	99,777	124,689	154,935	190,474	232,655	24%
Business	17,804	21,917	26,220	31,518	37,937	45,452	21%
By Geography (PB per Month)							
Asia Pacific	33,505	43,169	54,402	68,764	86,068	107,655	26%
North America	33,648	42,267	51,722	62,330	73,741	85,047	20%
Western Europe	14,014	17,396	21,167	25,710	30,971	37,393	22%
Central and Eastern Europe	6,210	7,451	8,940	11,016	13,781	17,059	22%
Latin America	5,999	7,502	9,141	10,861	12,909	15,464	21%
Middle East and Africa	2,679	3,910	5,538	7,773	10,941	15,490	42%
Total (PB per Month)							
Total IP traffic	96,054	121,694	150,910	186,453	228,411	278,108	24%

Source: Cisco VNI, 2017.

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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