Hyperconnectivity and the Approaching Zettabyte Era

June 2, 2010

This white paper is part of the Cisco® Visual Networking Index (VNI), an ongoing initiative to track and forecast the impact of visual networking applications. This paper presents some of the key 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, please see the paper "Cisco VNI: Forecast and Methodology, 2009–2014."

Executive Summary

Annual global IP traffic will exceed three-quarters of a zettabyte (767 exabytes) in four years. Global IP traffic grew 45 percent during 2009 to reach an annual run rate of 176 exabytes per year or 15 exabytes per month. In 2014, global IP traffic will reach 767 exabytes per year or 64 exabytes per month. The average monthly traffic in 2014 will be equivalent to 32 million people streaming Avatar in 3D, continuously for the entire month.

Global IP traffic will quadruple from 2009 to 2014. Overall, IP traffic will grow at a compound annual growth rate (CAGR) of 34 percent.

Hyperconnectivity has emerged as an important dynamic that has the potential to greatly increase traffic. In the past year, it has become clear that visual networking applications are often used concurrently with other applications and sometimes even other visual networking applications, as the visual network becomes a persistent backdrop that remains "on" while the user multitasks or is engaged elsewhere. This trend accompanies what is sometimes called the widgetization of Internet and TV, as network traffic expands beyond the borders of the browser window and the confines of the PC.

There are four key enablers of hyperconnectivity, and all four are poised for strong growth. Multitasking and passive networking, the two key pillars of hyperconnectivity, are enabled by: (a) the growing penetration of high-speed broadband, (b) the expansion of digital screen surface area and resolution, (c) the proliferation of network-enabled devices, and (d) the increases in the power and speed of computing devices.

Global Internet Highlights

In 2014, the Internet will be four times larger than it was in 2009. By year-end 2014, the equivalent of 12 billion DVDs will cross the Internet each month.

Peer-to-peer (P2P) is growing in volume, but declining as a percentage of overall IP traffic. P2P file-sharing networks are now carrying 3.5 exabytes per month and will continue to grow at a moderate pace with a CAGR of 16 percent from 2009 to 2014. Other means of file sharing, such as one-click file hosting, will grow rapidly at a CAGR of 47 percent and will reach 4 exabytes per month in 2014. Despite this growth, P2P as a percentage of consumer Internet traffic will drop to 17 percent of consumer Internet traffic by 2014, down from 39 percent at the end of 2009.

Global Video Highlights

Internet video is now over one-third of all consumer Internet traffic, and will approach 40 percent of consumer Internet traffic by the end of 2010, not including the amount of video exchanged through P2P file sharing.

The sum of all forms of video (TV, video on demand, Internet, and P2P) will continue to exceed 91 percent of global consumer traffic by 2014. Internet video alone will account for 57 percent of all consumer Internet traffic in 2014.

Advanced Internet video (3D and HD) will increase 23-fold between 2009 and 2014. By 2014, 3D and HD Internet video will comprise 46 percent of consumer Internet video traffic.

Video communications traffic growth is accelerating. Though still a small fraction of overall Internet traffic, video over instant messaging and video calling are experiencing high growth. Video communications traffic will increase sevenfold from 2009 to 2014.

Real-time video is growing in importance. By 2014, Internet TV will be over eight percent of consumer Internet traffic, and ambient video will be an additional five percent of consumer Internet traffic. Live TV has gained substantial ground in the past few years: globally, P2P TV is now over 280 petabytes per month.

Video-on-demand (VoD) traffic will double every two and a half years through 2014. Consumer IPTV and CATV traffic will grow at a 33 percent CAGR between 2009 and 2014.

Global Mobile Highlights

Globally, mobile data traffic will double every year through 2014, increasing 39 times between 2009 and 2014. Mobile data traffic will grow at a CAGR of 108 percent between 2009 and 2014, reaching 3.5 exabytes per month by 2014.

Almost 66 percent of the world's mobile data traffic will be video by 2014. Mobile video will grow at a CAGR of 131 percent between 2009 and 2014. Mobile video has the highest growth rate of any application category measured within the mobile data portion of the Cisco VNI Forecast at this time.

Regional Highlights

IP traffic is growing fastest in Latin America, followed closely by the Middle East and Africa. Traffic in Latin America will grow at a CAGR of 51 percent between 2009 and 2014.

IP traffic in North America will reach 19 exabytes per month by 2014 at a CAGR of 30 percent. Monthly Internet traffic in North America will generate 2.8 billion DVDs worth of traffic, or 11.3 exabytes per month.

IP traffic in Western Europe will reach 16 exabytes per month by 2014 at a CAGR of 36 percent. Monthly Internet traffic in Western Europe will generate 3.1 billion DVDs worth of traffic, or 12 exabytes per month.

IP traffic in Asia Pacific will reach 17 exabytes per month by 2014 at a CAGR of 35 percent. Monthly Internet traffic in Asia Pacific will generate 3.7 billion DVDs worth of traffic, or 14.9 exabytes per month.

IP traffic in Japan will reach 4 exabytes per month by 2014 at a CAGR of 32 percent. Monthly Internet traffic in Japan will generate 0.7 billion DVDs worth of traffic, or 2.8 exabytes per month.

IP traffic in Latin America will reach 3.5 exabytes per month by 2014 at a rate of 51 percent. Monthly Internet traffic in Latin America will generate 751 million DVDs worth of traffic, or 3 exabytes per month.

IP traffic in Central and Eastern Europe will reach 2.5 exabytes per month by 2014 at a rate of 38 percent. Monthly Internet traffic in Central and Eastern Europe will generate 514 million DVDs worth of traffic, or 2.1 exabytes per month.

IP traffic in the Middle East and Africa will reach 1 exabyte per month by 2014 at a rate of 45 percent. Monthly Internet traffic in the Middle East and Africa will generate 182 million DVDs worth of traffic, or 727 petabytes per month.

Note: *An interactive Cisco VNI Forecast widget is available to enable users to create custom forecast charts by region, by country, by application, and by end-user segment. The Cisco VNI Forecast widget can be accessed from http://downloads.ciscovnipulse.com.*

Global Business Highlights

Business IP traffic will grow at a CAGR of 21 percent from 2009 to 2014. Increased adoption of advanced video communications in the enterprise segment will cause business IP traffic to grow by a factor of 2.6 between 2009 and 2014.

Business Internet traffic will grow at a faster pace than IP WAN. IP WAN will grow at a CAGR of 17 percent, compared to a CAGR of 20 percent for business Internet and 93 percent for business mobile data traffic from 2009–2014.

Business video conferencing will grow 10-fold over the forecast period. Business videoconferencing traffic is growing almost three times as fast as overall business IP traffic, at a CAGR of 57 percent from 2009–2014.

Web-based video conferencing will grow 180-fold from 2009–2014. Web-based video conferencing is the fastest growing subcategory (183 percent CAGR from 2009–2014) within the business portion of the Cisco VNI Forecast at this time.

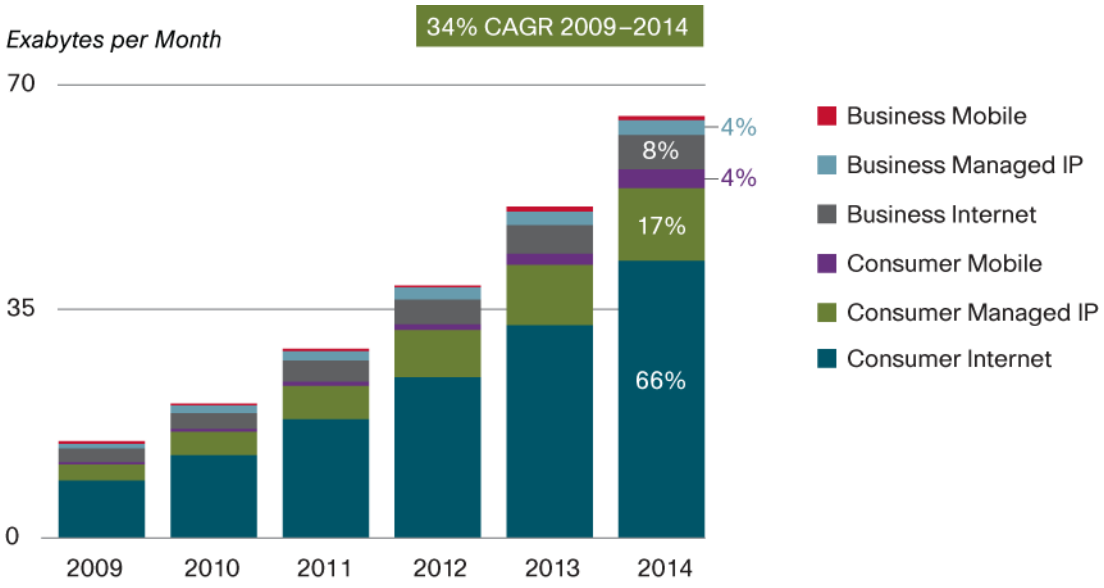
HD video conferencing will account for over half (57 percent) of business video conferencing traffic in 2014, up from 31 percent in 2009.

Over one-half of business videoconferencing traffic will travel over the Internet by 2014.

Visual Networking, Hyperconnectivity, and High Definition

Largely due to visual networking in all its various forms, Cisco expects global IP traffic to quadruple from 2009 to 2014. As Figure 1 shows, overall IP traffic is expected to grow to 64 exabytes per month by 2014, and 56 of those are due to consumer traffic. Consumer traffic, in turn, is driven by IP transport of VoD over the metro (11 exabytes per month in 2014), Internet video streams and downloads (almost 24 exabytes per month in 2014), and the exchange of video and other files through P2P and other file-sharing systems.

Figure 1. Cisco VNI Forecasts 64 Exabytes per Month of IP Traffic in 2014

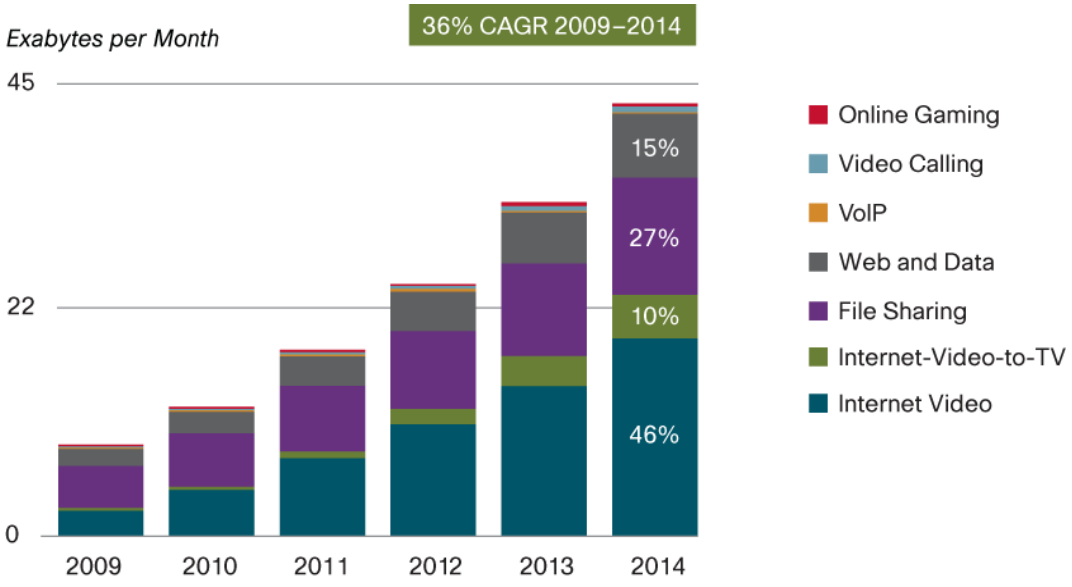


Source: Cisco VNI, 2010

For more details, see the paper entitled "Cisco VNI: Forecast and Methodology, 2009–2014."

Figure 2 shows the components of consumer Internet traffic growth. Of the 42 exabytes per month of consumer Internet traffic that will be generated every month in 2014, nearly 60 percent will be due to Internet video.

Figure 2. Cisco VNI Global Consumer Internet Traffic Forecast



Source: Cisco VNI, 2010

The dynamics of traffic growth can be understood in terms of traffic growth trends and enablers.

- **Hyperconnectivity**: Last year's forecast identified hyperconnectivity as a key trend driving traffic growth. Hyperconnectivity refers to active multitasking on one hand, and passive networking on the other. Passive networking consists largely of background streaming and downloading. Ambient video (nannycams, petcams, home security cams, and other persistent video streams) is an element of passive networking that opens up the possibility for the number of video minutes crossing the network to greatly exceed the number of video minutes actually watched by consumers.
- **High definition**: High-definition video continues to make its way onto both the public Internet and managed IP networks. By 2014, about three-quarters of IP VoD traffic, and about half of Internet video traffic, will be due to high definition content.
- **Transference**: Transference is a label that can be applied to a number of related trends. Most importantly, there is the migration of media consumption from one network to another; for instance, traffic has the potential to rapidly and greatly increase when consumers migrate their live television minutes from the broadcast network to VoD or Internet. This has been observed in mobile data traffic during the last year; traffic increased more rapidly than would be expected from organic growth, because of the migration of laptops and other portables to the mobile network. Secondarily, there is the transference of expectations from one network to another. Again, mobile is a key example of this: User expectations of an open Internet with fast response times has put traffic pressure on mobile network infrastructures.

Several key enablers are creating a technology landscape conducive for IP traffic growth:

- **Increasing screen space**: 12 billion square feet of multi-screen surface area by 2014 (consumer devices).
- **Increasing broadband speed**: the average global residential Internet connection download speed is 35 times faster in 2010 (4.4 megabits per second) than 2000 (127 kilobits per second).
- **Increasing computing power**: a multicore system with a 64-bit operating system can make use of 4 billion times the RAM, compared to a 32-bit system. Quad-core systems such as the Intel Core i7 are now shipping. Once software is developed to take full advantage of the new processing capabilities, each core has the potential to generate as much traffic as a single PC.

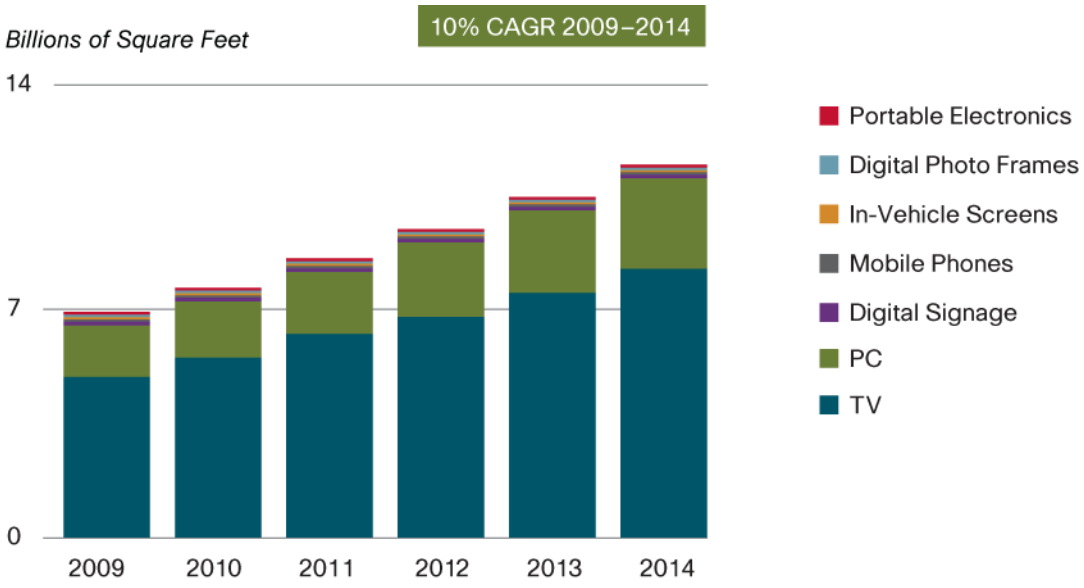
Each of these enablers is discussed in turn, below.

Enablers of IP Traffic Growth

With the cost of large LCD screens continuing to decline, consumers and businesses alike can afford to expand the number and size of their digital screens. The increased global adoption of flat-panel screens also allows residential consumers and business users to expand their screen surface area without sacrificing any floor space.

In addition to acquiring more and larger TV and PC screens, digital screens are proliferating along with other consumer devices: e-book readers, handheld gaming consoles, large-screen mobile handsets, in-vehicle GPS display screens, digital picture frames, picoprojectors, TelePresence screens, IP phone screens, and digital advertising and sales displays. The total surface area of all digital screens across the world in 2014 will be 1.7 times what it was at the end of 2009. There will be 1.6 square feet of screen space per capita in 2014.

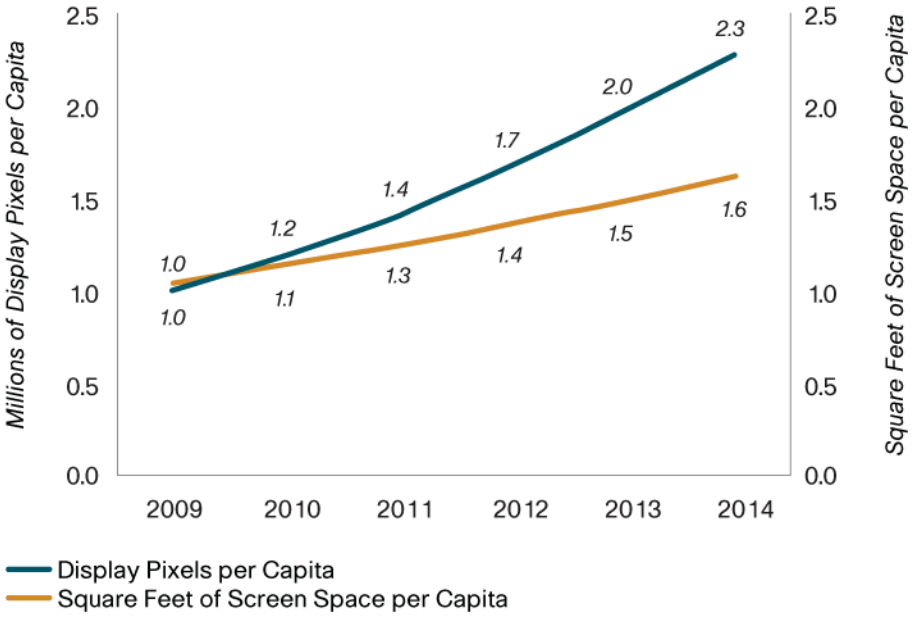
Figure 3. Installed Screen Surface Area Continues to be Dominated by TV and PC Screens



Source: Cisco VNI, 2010

The average resolution of each screen is growing alongside the total screen surface area. The number of total display pixels captures the growth of the screen surface area and the resolution, together. By 2014, there will be 2.3 million display pixels per capita, up from 1.0 million display pixels per capita at the end of last year.

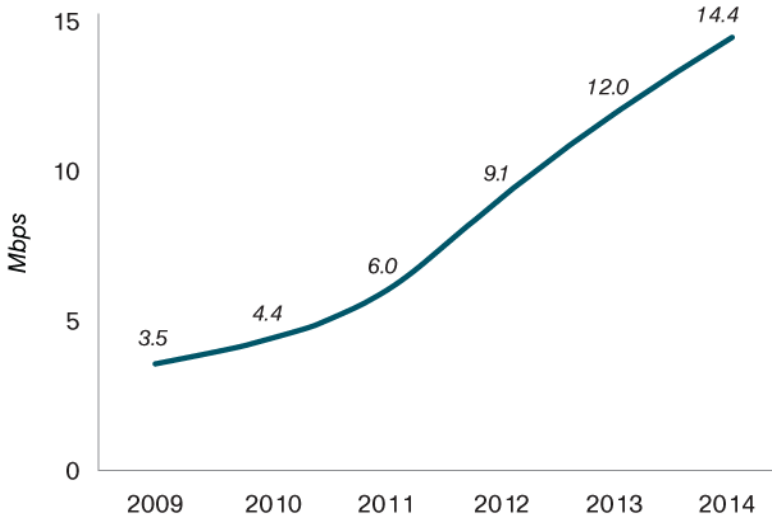
Figure 4. Total Display Pixels per Capita Will More Than Double Between 2009 and 2014



Source: Cisco VNI, 2010

Broadband speed is another key enabler of IP traffic. Broadband speed improvement results in increased consumption and usage of high-bandwidth content and applications. The global average broadband speed continues to grow and will quadruple from 2009 to 2014.

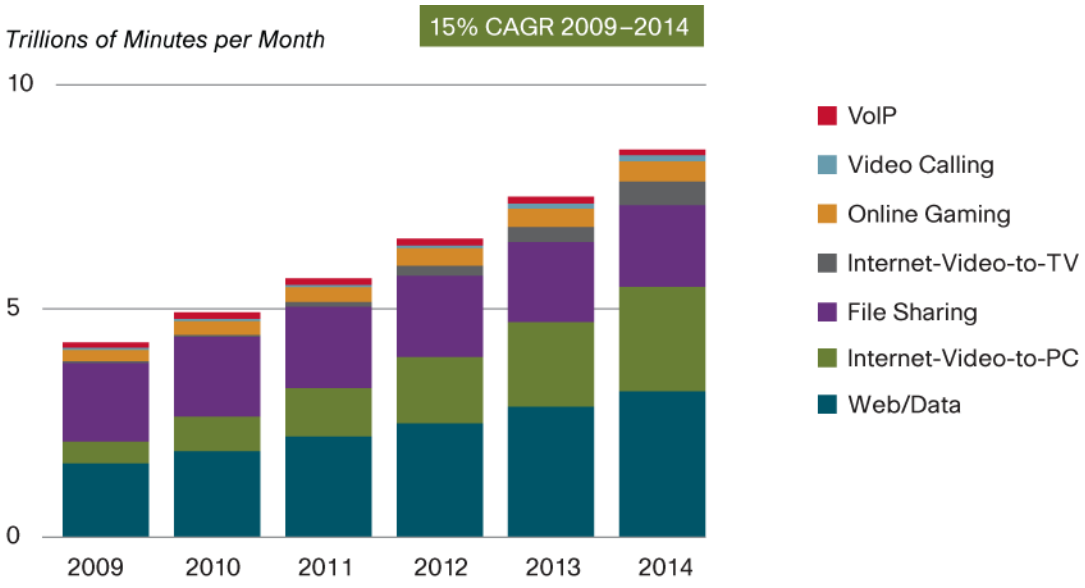
Figure 5. Average Global Broadband Speed Will Quadruple to Reach 14.4 Mbps in 2014



Source: Cisco VNI, 2010

Screen space, resolution, computing power, and broadband speed can be captured in two summary metrics: minutes of use, and bytes per minute. According to the VNI forecast, overall Internet minutes of use will double over the forecast period, and Internet video minutes will quintuple. Bytes per minute of Internet use will increase 237 percent from 2009 to 2014, from 2.3 megabytes per minute, to 5.5 megabytes per minute.

Figure 6. Consumer Internet Minutes of Use Will Reach 7.7 Trillion Minutes per Month in 2014



Source: Cisco VNI, 2010

A comparison of Figures 2 and 6 yields some interesting insights. While Internet video is only 33 percent of Internet minutes in 2014, it is nearly 60 percent of traffic.

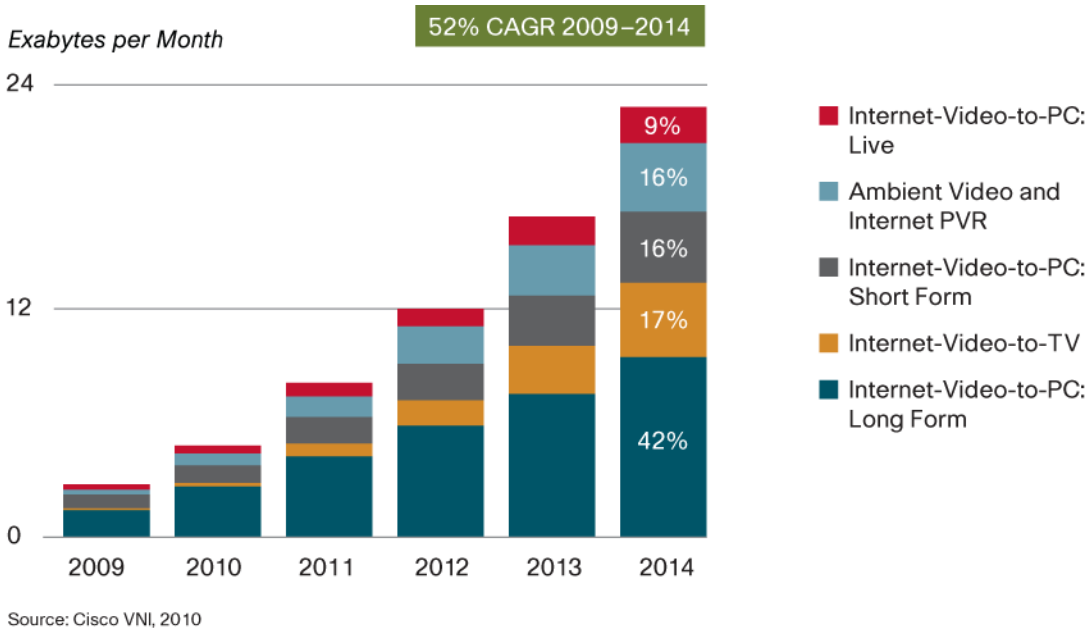
Global IP Traffic Growth: Residential

"Looking at the proliferation of personal web pages on the Net, it looks like very soon everyone on Earth will have 15 megabytes of fame." —M.G. Sriram, PhD

M.G. Sriram's milestone prediction has long since passed. Each of us now has much more than 15 megabytes of fame: there is a gigabyte of traffic that crosses the Internet every month per capita. One-third of that gigabyte is comprised of video content, and by 2014, approximately 60 percent of consumer Internet will be video.

While the overall application mix is shifting toward video, video is undergoing internal shifts of its own. In particular, real-time video is growing in importance. Real-time video includes Internet TV, video communications, and ambient video. Live content is gaining ground fast: globally, live Internet TV will be almost 10 percent of total Internet video traffic by 2014.

Figure 7. Internet TV and Ambient Video Are Key Drivers of Internet Video Growth



Source: Cisco VNI, 2010

Implications of Shifts in Residential Traffic Application Mix: Symmetry

With all the video uploading that consumers do today, people often think that upstream bandwidth must be growing faster than downstream, and that symmetric bandwidth will be a requirement for the typical Internet user within a few years. However, traffic data does not support this case—upstream traffic has been flat as a percentage for several years. Table 1 shows the historical data for the North American participants in the Cisco VNI Usage program.

Table 1. Upstream Has Remained Flat as a Percentage of Residential Traffic

Upstream Residential Broadband Traffic in North America, 2007–2010				
	1H2007	**1H2008**	**1H2009**	**1H2010**
Upstream as a percentage of total traffic	31%	24%	25%	23%

Why has traffic not become more symmetric? The explanation lies in the decreasing contribution of P2P as a component of overall traffic. Peer-to-peer, by definition, is highly symmetric traffic, with between 40 to 60 percent of P2P traffic consisting of upstream traffic (see Table 2). For every high-definition movie downloaded, approximately the same amount of traffic is uploaded to a peer. Now, video is beginning to take over, but most of the video streams that cross the network today have a highly asymmetric profile, comprised mostly of downstream traffic, except in areas where P2P TV is prevalent (in China, for example). 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.

Table 2. P2P Traffic is More Symmetric than Other Forms of Traffic

Upstream Residential Broadband Traffic in North America by Application, 2007-2010	
	1H2010
Upstream as a percentage of P2P traffic	44%
Upstream as a percentage of all other traffic	12%

Rather than wondering why traffic has not become more symmetric, we might wonder why it has not become even less symmetric, given the pronounced decline of P2P as a percentage of traffic. Here the importance of video sharing, uploads, and video communications can be seen. The application mix of upstream traffic has shifted so that while over 70 percent of upstream traffic was due to P2P in the first half of 2007, today less than 60 percent of upstream is P2P. The extra bandwidth has been taken up by the growth of video in the upstream.

It appears likely that residential Internet traffic will remain asymmetric for the next few years. However, there are a number of scenarios that could result in a move towards increased symmetry:

- **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, this will drive traffic toward symmetry again.

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

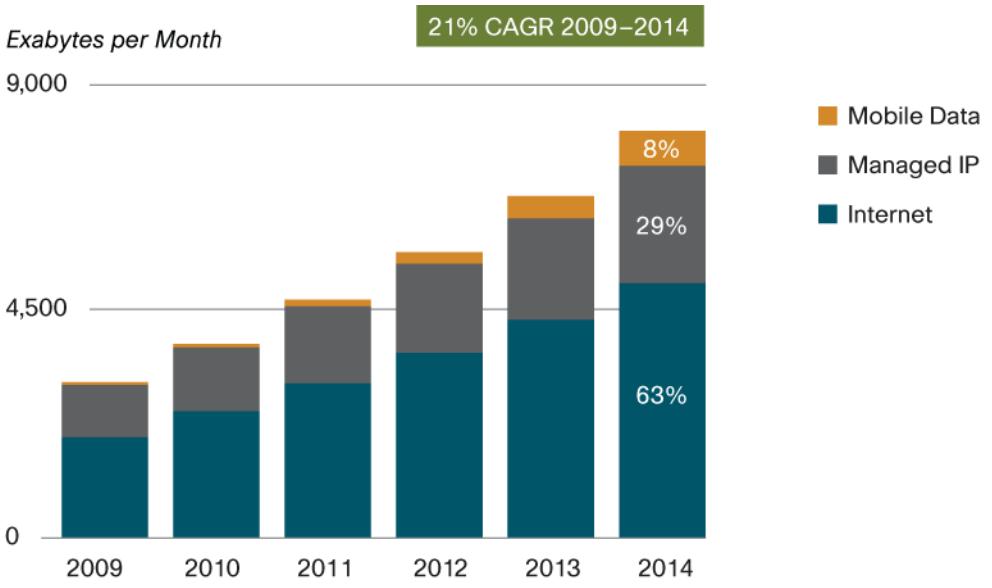
Global IP Traffic Growth: Business

"The inbox culture is dead. To solve problems and make decisions efficiently, we must often come together in real time rather than wait for the email, the file, or for somebody else's input." —Evan Rosen, author of The Culture of Collaboration

"A connected world places an enormous premium on people who are fluent in communications." —Geoffrey Moore, author of the blog "Dateline Davos: The shifting power equation"

Total business Internet traffic is more than twice the volume of managed IP (IP WAN), and business Internet will grow at a faster pace than managed IP.

Figure 8. Global Business IP Traffic Will Grow at a CAGR of 21 Percent from 2009–2014

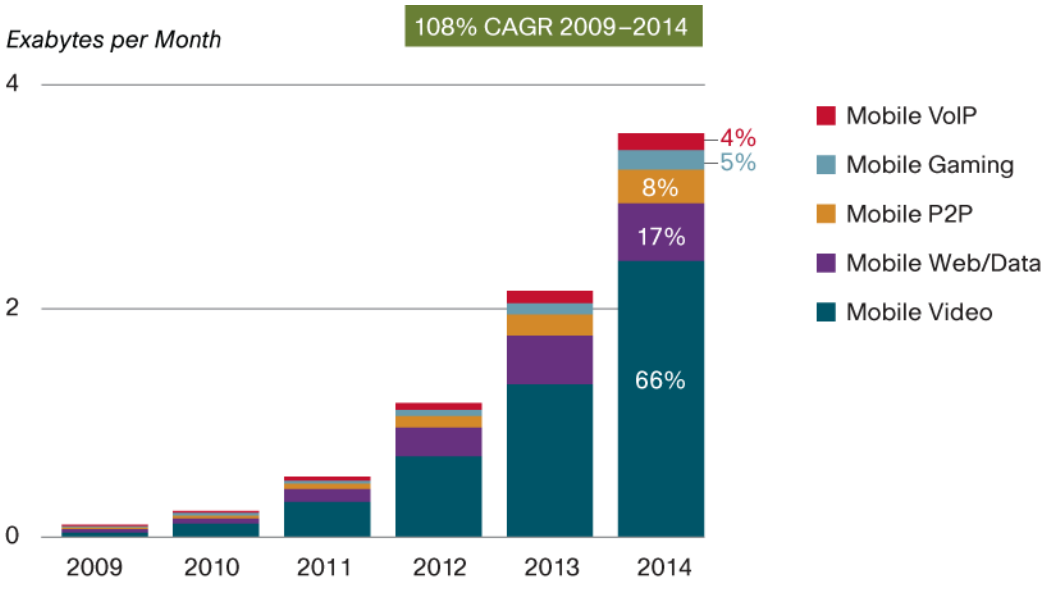


Source: Cisco VNI, 2010

Global IP Traffic Growth: Mobile

Mobile video will be responsible for the majority of mobile data traffic growth between 2009 and 2014. As Figure 9 shows, overall mobile data traffic is expected to grow to 3.5 exabytes per month by 2014, and over 2.4 of those are due to mobile video traffic.

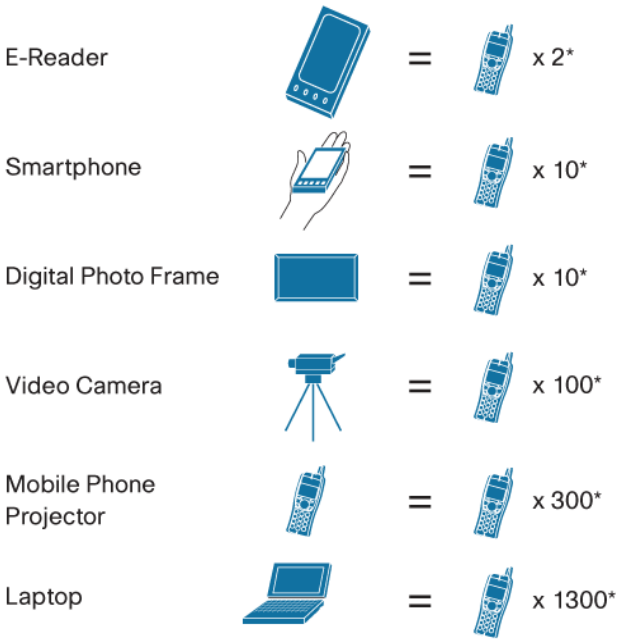
Figure 9. Global Mobile IP Traffic Will Grow at a CAGR of 108 Percent from 2009–2014



Source: Cisco VNI, 2010

The advent of laptops and high-end handsets onto mobile networks is a key driver of traffic, since these devices offer the consumer content and applications not supported by the previous generation of mobile devices. Chief among these new sources of traffic is video, but other applications such as P2P are already making an impact. Despite the relatively small number of laptops with mobile broadband aircards today, P2P traffic from those devices already accounts for 20 percent of all mobile data traffic globally. As shown in Figure 10, a single laptop can generate as much traffic as 1300 basic-feature phones, and a smartphone creates as much traffic as 10 basic-feature phones. iPhones, in particular, can generate as much traffic as 30 basic feature phones.

Figure 10. High-End Handsets and Laptops Can Multiply Traffic



** Monthly Basic Mobile Phone Data Traffic*

Source: Cisco VNI Mobile, 2010

Wildcards: Trends to Watch

Cisco's approach to forecasting IP traffic is conservative, and there are certain emerging trends that 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 broadcast to unicast.

- **Applications that might migrate from offline to online**: The key application to watch in this category is gaming. Gaming-on-demand and streaming gaming platforms have been in development for several years, with many planned for release in 2010 and 2011. If a significant amount of gaming activity moves online, the traffic increases could be extraordinary. As shown by the University of California, San Diego's "How Much Information?" study[1], the total information created by gameplay is 117 exabytes per month. Only a fraction of this crosses the network today, but should streaming gaming take hold, gaming could quickly become one of the largest Internet traffic categories.

[1] See http://hmi.ucsd.edu/howmuchinfo.php for the full report, published in 2009.

- **Behavior that might migrate from broadcast to unicast**: Live TV, network DVR, TV Anywhere. The majority of video minutes still reside on the broadcast network. Should a significant number of these minutes migrate to a unicast platform, the traffic increase could be dramatic.
- **New consumer behavior**: 3DTV. The most likely scenario for home 3DTV is that it will take three to five years to gain momentum. However, 3DTV on the PC may gain momentum earlier, since it requires only a software decoder rather than a hardware decoder and therefore does not require any purchase or subscription beyond what is already paid for PC Internet access.

For More Information

For more information on Cisco's IP traffic forecast, please see the paper "Cisco VNI: Forecast and Methodology, 2009–2014" and visit the other resources and updates at www.cisco.com/go/vni. Inquiries can be directed to traffic-inquiries@cisco.com.

Appendix A: Cisco's Global IP Traffic Forecast

Table 3 shows the summary of Cisco's global IP traffic forecast. For more information, please see the paper "Cisco VNI: Forecast and Methodology, 2009–2014."

Table 3. Global IP Traffic, 2009–2014

IP Traffic, 2009–2014							
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**CAGR 2009–2014**
By Type (PB per Month)							
Internet	10,942	15,205	21,181	28,232	36,709	47,176	34%
Managed IP	3,652	4,963	6,771	8,851	11,078	13,199	29%
Mobile Data	91	228	538	1,158	2,132	3,528	108%
By Segment (PB per Month)							
Consumer	11,602	16,534	23,750	32,545	43,117	55,801	37%
Business	3,083	3,862	4,740	5,697	6,801	8,103	21%
By Geography (PB per Month)							
North America	5,115	7,091	10,051	12,988	16,136	19,019	30%
Western Europe	3,495	4,818	6,712	9,261	12,417	16,158	36%
Asia Pacific	3,920	5,367	7,295	9,815	12,985	17,421	35%
Japan	1,068	1,539	2,149	2,855	3,591	4,300	32%
Latin America	438	680	1,026	1,527	2,274	3,479	51%
Central Eastern Europe	493	678	938	1,306	1,815	2,510	38%
Middle East and Africa	157	223	319	490	700	1,018	45%
Total (PB per Month)							
Total IP Traffic	**14,686**	**20,396**	**28,491**	**38,242**	**49,919**	**63,904**	**34%**

Source: Cisco VNI, 2010

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

Mobility: Includes mobile data and Internet traffic generated by handsets, notebook cards, WiMAX

Internet: Denotes all IP traffic that crosses an Internet backbone

Non-Internet IP: Includes corporate IP WAN traffic, IP transport of TV/VoD, and mobile "walled-garden" traffic

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