White Paper

The Exabyte Era

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 "Global IP Traffic Forecast and Methodology 2006–2011".

EXECUTIVE SUMMARY

The Internet is not collapsing under the weight of streaming video. In the near term, the most formidable challenge that online video poses for the Internet will be flash crowds rather than the overall volume of traffic. In terms of absolute volume, much of the impact of video will be in the form of peer-to-peer (P2P) file exchange. As high-definition video content makes its way onto P2P networks, P2P traffic will grow at about 35 percent per year, decreasing only slightly to 30 percent per year in 2011.

YouTube is just the beginning. Online video will experience three waves of growth. Thanks to the YouTube effect, online video has grown rapidly. In North America, online video has jumped from 7 percent of traffic in 2005 to18 percent of traffic in 2007. In response to this remarkable development, many service providers are accelerating their capacity upgrade plans. But the Internet is not collapsing under the weight of YouTube traffic, nor is it likely to. Global online video traffic is still relatively modest at 11 percent of consumer Internet traffic, and even as it increases four-fold between 2007 and 2011, Internet video to the PC screen will soon be exceeded by a second wave driven by the delivery of Internet video to the TV screen. Beyond 2015, a third wave of video traffic will be driven by video communications.

Video communications and dynamic video content will ultimately test the Internet more than pre-recorded video content. Service providers have a host of options available to help ease the burden of on-demand video traffic. Real-time video communications, on the other hand, will be a bandwidth burden with few remedies.

The sheer volume of video creates the potential for traffic "surprises." Consumer behavior evolves slowly, but the hefty size of video files means that mass adoption is not necessary for massive shifts in traffic patterns. This phenomenon is similar to the P2P phenomenon, wherein service providers and network operators were taken by surprise when a small number of Internet users began to generate a very large amount of traffic. Like P2P, video makes Internet traffic less predictable than ever, and should certain unexpected scenarios develop, the forecast from Cisco® may prove too conservative.

Non-Internet IP video will generate more traffic than Internet video. The twin trends of on-demand viewing and high-definition video are driving very rapid growth in cable video and IPTV traffic transported over IP in the metro. Consumer IP growth will reach 18 exabytes per month by 2011, but only 7 exabytes of that is Internet traffic. The remainder is primarily due to the transport of commercial video-on-demand (VoD) offerings.

Video changes the equation for service providers. Video consumes more than its weight in bandwidth, in the sense that consumers pay much less per megabyte for video than for any other content or service. With the advent of over-the-top services, services are no longer tied to underlying connectivity, and it is increasingly the case that service revenue is no longer tied to connectivity revenue. However, consumers are not in the habit of valuing services according to how much bandwidth they consume. In response, consumers may develop a more advanced bandwidth vocabulary, and service providers will develop new revenue models.

Video will shift the topology of IP traffic. Growth in the core is strong, and growth in the metro is even stronger. Between 2006 and 2011, core IP traffic will triple, and metro IP traffic wil quadruple. Beyond 2015, traffic growth in the core will begin to accelerate again, as non-cacheable video content gains popularity.

There's more to the Internet than video. Though the volume of video traffic obscures all else, there are other trends that deserve attention, such as the growth of mobile data traffic, the growth of Web traffic in developing regions, and the growth of business IP traffic driven by increasing broadband penetration of small businesses.

HIGHLIGHTS OF CISCO'S IP TRAFFIC FORECAST

Following are highlights of Cisco's global IP traffic forecast. For more details, please see the companion paper "Global IP Traffic Forecast and Methodology 2006–2011".

After a brief mid-decade slowdown, IP traffic will nearly double every two years through 2011. Total IP traffic will nearly quintuple in the five-year period from 2006 to 2011. Driven by high-definition video and high-speed broadband penetration, consumer IP traffic will bolster the overall IP growth rate so that it sustains a fairly steady growth rate through 2011, growing at a compound annual growth rate (CAGR) of 37 percent and nearly quintupling the monthly traffic run rate from 2006 to 2011.

Consumer IP traffic will surpass business IP traffic in 2008. Consumer IP traffic will grow at a CAGR of 57 percent from 2006 to 2011, compared to 21 percent for business IP traffic. Consumer IP traffic will surpass 18 exabytes per month by 2011.

Peer-to-peer (P2P) traffic will quadruple between 2006 and 2011, reaching 3 exabytes per month. P2P traffic still dominates Internet traffic and growth is not slowing. P2P will grow by the equivalent of 10 million DVDs each month, on average. Three exabytes per month is the equivalent of 750 million DVDs each month. P2P traffic growth will be driven by the global increase in high-speed broadband penetration, the increasing use of P2P for standard-definition video file exchange, and the advent of high-definition video file exchange and television content using P2P technology.

Despite its continued growth, P2P traffic will decrease as a percentage of overall Internet traffic. Internet video streaming and downloads are beginning to take a larger share of bandwidth, and will grow from 8 percent of all consumer Internet traffic in 2006 to 27 percent in 2011. P2P makes up 53 percent of all consumer Internet traffic in 2006, but despite quadrupling in size, will only make up 42 percent of consumer Internet traffic in 2011.

Global Internet video (excluding P2P) is estimated to be approximately 120 petabytes per month in 2006, which is nearly 5 times the amount of traffic crossing the U.S. Internet backbone in 2000. By 2011, global Internet video traffic will grow to 86 times the 2000 U.S. Internet backbone.

Internet video-to-PC will increase by a factor of nearly 10 between 2006 and 2011, reaching just under 1 exabyte per month. By 2011, the equivalent of 250 million DVDs each month will cross the Internet.

Internet video-to-TV will increase by a factor of 10 between 2007 and 2011, reaching over 1 exabyte per month. Internet video-to-TV traffic will eclipse Internet video-to-PC traffic by 2009. Gaming consoles equipped for video streaming will drive much of the early Internet-to-TV traffic. Internet-enabled set-top boxes (STBs) are currently available for purchase by consumers, and will be increasingly deployed by IPTV and (later) cable providers. While Internet video-to-PC is dominated by short-form and lower-quality content, video-to-TV traffic will be composed of longer-form and higher-definition content, which means that the far smaller number of video-to-TV streamers and downloads will generate a larger amount of traffic than the greater number of video-to-PC viewers.

Non-Internet IP video will increase by a factor of 20 between 2006 and 2011, reaching over 10 exabytes per month. Consumer IP traffic generated by the transport of cable and IPTV VoD content will grow the fastest, quickly surpassing consumer Internet traffic.

Mobile Internet will grow by a factor of 17, reaching 63 petabytes per month. Over the next few years, portable computers with HSPA and WiMAX cards will drive traffic growth. Together, traffic from 3.5G and WiMAX will make up more than half of all mobile data traffic by 2011.

Japan's mobile data traffic is nearly 50 percent higher than any other region. However, by 2011, the rest of Asia-Pacific will surpass Japan.

Internet traffic is growing fastest in developing markets, followed closely by Asia-Pacific. Even though Internet video is not yet a large factor in developing markets, the rapidly increasing Internet penetration and the advent of high-speed connections to a greater number of universities will result in developing markets having the highest growth rate through 2011.

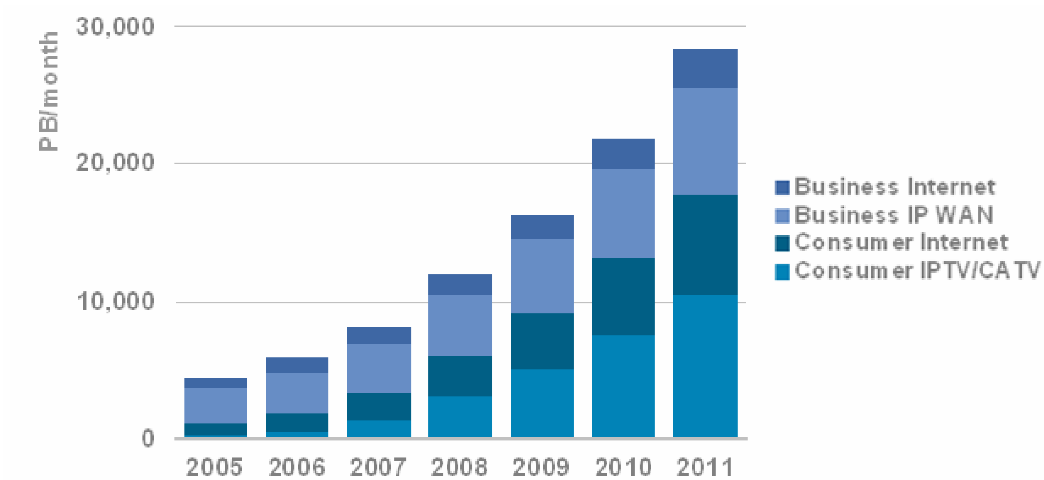
Business IP traffic will grow fastest in developing markets and Asia-Pacific. North America, Western Europe, and Japan will have slower growth rates. In volume, North America will continue to have the most business IP traffic through 2011, followed by Western Europe and then Asia-Pacific.

Business Internet traffic will grow at a CAGR of 23 percent from 2006 to 2011, driven by increased broadband penetration in the small business segment. Business IP WAN traffic will grow at a slightly slower 21 percent during the same period, driven by the adoption of video applications.

Stating the Obvious: Video is Driving IP Traffic Growth

According to Cisco's global IP traffic forecast, consumer video will be responsible for much of the traffic growth between 2006 and 2011. As Figure 1 shows, overall IP traffic is expected to grow to 29 exabytes per month by 2011, and 18 of those are due to consumer traffic. Consumer traffic, in turn, is driven by IP transport of VoD over the metro (10 exabytes per month in 2011), Internet video streams and downloads (2 exabytes per month in 2011), and the exchange of video files through P2P (over 2 exabytes per month in 2011).

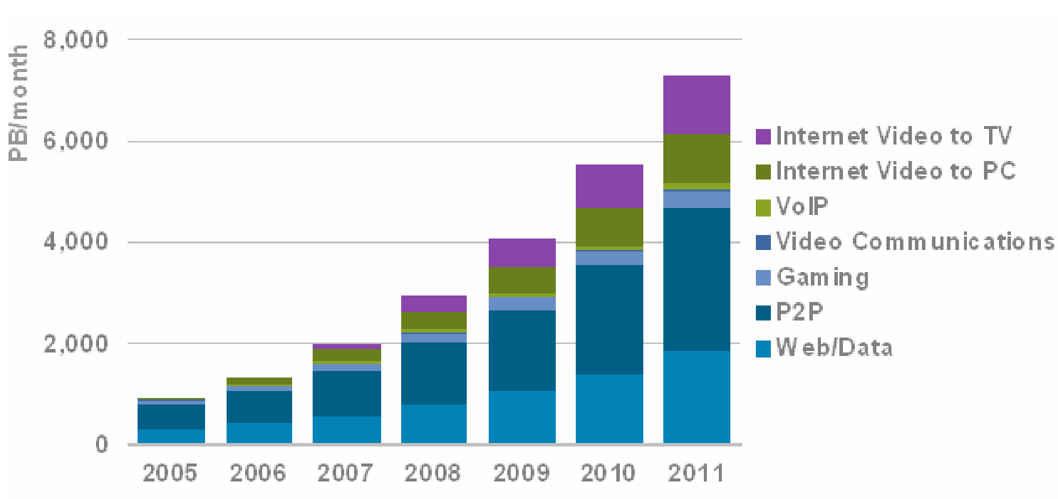
Figure 1. Cisco Forecasts 29 Exabytes per Month of IP Traffic in 2011



For more details, see the paper entitled "Global IP Traffic Forecast and Methodology 2006–2011".
Source: Cisco, 2007

Figure 2 shows the components of consumer Internet traffic growth. Of the 7 exabytes per month of consumer Internet traffic that will be generated every month in 2011, nearly 30 percent is due to Internet video, and an additional 30 percent is due to the exchange of video files through P2P (total P2P is 42 percent of consumer Internet traffic).

Figure 2. Cisco's Global Consumer Internet Traffic Forecast



Source: Cisco, 2007

Given the importance of video in IP traffic growth, this paper will focus on video as the driver of global IP traffic growth.

YouTube Is Just the Beginning

"Four percent of all the bits going across high-speed Internet lines at Comcast is YouTube." Brian L. Roberts, CEO of Comcast, February 2007.

"Only about 2 percent of our traffic in Europe is estimated to be YouTube traffic… We're not concerned about it." Mike Fries, CEO of Liberty Global, February 2007

YouTube traffic is both big and small: big enough to impress but not yet big enough to overwhelm service provider networks. It is nothing short of amazing that a site launched at the end of 2005 has grown to take up 4 percent of all traffic by the end of 2006. By Cisco's estimates, YouTube accounts for 20 percent of online video traffic in North America in 2007, and online video amounts to 18 percent of overall North American consumer Internet traffic. In response to this remarkable development, many service providers are accelerating their capacity upgrade plans. But the Internet is not collapsing under the weight of YouTube traffic, nor is it likely to. Even more significant than the traffic it generates is the new era of online consumer behavior that YouTube represents.

What YouTube Really Means

The success of sites like YouTube and MySpace brings to light the social aspect of video. Entertainment is not the sole purpose of video; in addition to delivering information and providing entertainment, video can serve as a centerpiece for social interaction or as a means of expression. The "couch potato" phenomenon may have been overemphasized. Television has always been a platform for social and familial interaction as much as it has been a vehicle for delivering content.

Given the varied aspects of video, it is difficult to say that "content is king." The throne appears to belong instead to the combination of communications and content[1]. This combination has shown itself to be powerful enough to have enticed millions of Internet users to do something they previously showed little interest in doing: watching low-quality video on a small screen. YouTube offers more than unique content, it offers a platform for social interaction. YouTube viewers are not watching video despite the computer screen, but because of it – the PC is ideal for interactivity, even if only the simple but effective ability to send a link. Traditional television may begin to seem less desirable than video that can be sent, shared, tagged, clipped, mashed up, and chatted about. Video as pure entertainment will always have its place, but even so it may turn out that to future generations, the home theater silo and its isolated video experience will appear quaint.

The Separation of Video into its Various Aspects

With the advent of multiple video platforms, the video experience has separated into its component aspects. When content is primary, the home theater is the best platform. When the social aspect is primary, the PC is best suited because it offers interactivity and social networking. When the creative or expressive aspect is primary, the PC and the mobile device are best suited.

[1] Andrew Odlyzko has long been a defender of communications against the "content is king" camp. See "Content is not king", First Monday, February 2001 and "Finding a Voice: Learning from History", pages 58-64 in Connected Homes, F. Gil de Bernabe y Varela, ed., Cisco, 2004. See also http://www.dtc.umn.edu/~odlyzko/doc/recent.html.

As the video experience migrates to new platforms, the traffic shifts accordingly. This framework can explain many of the shifts in IP traffic patterns that will occur over the next five years, and can be used to think through future scenarios, and to identify contingencies:

- Without Internet-enabled set-tops, there is little incentive for high definition content to cross the Internet, with the exception of video files downloaded via P2P and then burned to DVD. Conversely, with the advent of Internet-enabled set-tops (including gaming consoles), Internet video traffic can be expected to surge.
- Even when internet-enabled set-tops are widely deployed, not all Internet video viewing will migrate to the television screen. Until gaming consoles, next-generation set-tops, or advanced remotes bring interactivity to the television experience, any user seeking a social or conversational viewing experience will continue to view video on the PC. Mobile devices are also well suited to sharing short video clips, so a portion of social video viewing traffic will migrate to mobile networks.
- Viewers who are more motivated by content than experience or social interaction will seek out content in the most convenient form, be it mobile, laptop, or TV. As more content becomes available online, usage will migrate from TV to other devices. In European and Asian with an average of one television set per household, laptops and mobile devices will serve as additional screens.
- Viewers who are looking for passive diversion rather than social interaction, content, or experience will rely on mobile TV services while away from home and traditional broadcast programming while at home.

The traffic shifts that will likely result from the device shifts outlined above are explored in Table 1.

Table 1. Video Trends and Traffic Shifts

Video Trends, Implications, and Contingencies				
Trend	**Network**	**Today**	**Tomorrow**	**Impact**
High-Definition	Commercial network	Experience is the primary driver of HD traffic, and the HD experience is tied to the home theater. Therefore, the majority of traffic is delivered by the network attached to the home theater, the commercial video service.	The commercial network will still be important in delivering content, especially with advanced features such as multiple angles and dynamic customization.	The main impact of high definition broadcast on commercial networks will be in the access portion of the network, especially for IPTV providers. A high-definition household with multiple sets and DVRs will easily exceed the capacity of DSL.
	Internet	A small population of early adopters is using media gateways and other means (DVD burning) to transfer downloaded high-definition content to the high-definition set.	Devices that directly Internet-enable the home theater will drive significant traffic to the Internet, as viewers turn to the Internet for niche content and other unique content not available through commercial on-demand services	Extremely high impact. It is primarily due to the heft of high-definition content that Internet-to-TV traffic will bypass Internet-video-to-PC traffic by 2009 and will exceed 1 exabyte per month in 2011.

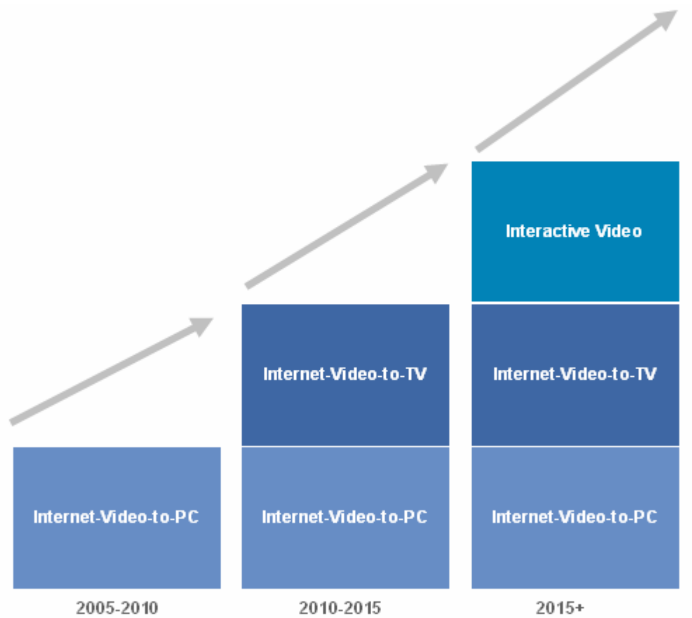
On-Demand	Commercial Network	Commercial on-demand networks are experiencing high growth.	Commercial on-demand services will continue to experience high growth. When content is available on both Internet and commercial on-demand, and when viewers don't require the interactivity or portability of the PC or mobile device, viewers will tend to prefer commercial on-demand for the speed and ease with which they can access the content.	Extremely high impact not only in the last mile, but in the metro. The transport of video-on-demand far outweighs the transport of broadcast traffic.
	Internet	Viewers have turned to the Internet to view or purchase missed episodes that are not available through commercial on-demand.	In addition to those who look to the Internet for content not available elsewhere, there will be migration of video traffic to the Internet and mobile networks from viewers who are seeking the convenience of watching on PC or mobile device.	Some amount of time-shifting traffic will be channeled over the Internet, but to the extent that the content is available through VoD, much of this traffic will remain on the commercial network. In contrast, most placeshifting traffic will travel over the Internet. If placeshifting is offered by service providers in the future, its use will broaden to include close-to-home applications, and it will significantly impact the network.
Conversational Viewing	Internet	Because interactivity is required for conversational viewing, the PC is the preferred device, and the Internet is its network. For the most part, conversational viewing is being offered by platforms like Joost, or by PCCW.	Short-term, conversational viewing may cause much video traffic to migrate from the commercial network to the Internet. Long-term, the video portion of this traffic has the potential to shift back to the commercial network, if devices that lend interactivity to the home theater appear on the scene.	The draw of conversational viewing has the potential to be a major driver of long-form video viewing on the PC, and therefore a major driver of Internet video traffic. Mass adoption of conversational viewing is not assumed to take place before 2011 in the forecast, but the potential exists for earlier-than-expected adoption.
Social Networking	Internet	Because interactivity is required, the PC is the preferred device.	In the near term, this traffic is likely to remain on the Internet with PC as interface, with some shift to mobile devices.	Social networking has already driven much of the short-form video viewing on the Internet today.
User-Generated Content	Internet	The PC is the preferred device for the creation and editing of video content.	The upstream traffic is likely to remain with the PC as an interface, and travel over the Internet.	Upstream user-generated content traffic is likely to grow, but compared to the downstream video trends, the traffic will be relatively light.
Video capture or video blogging	Internet	Today, video blogs are generally made with a webcam, or taken with a digital camera and transferred to PC.	Video capture and video blogging content is generally not edited, so there is no need for this traffic to pass through the PC. In the short term, this traffic will remain on the Internet with the PC as an interface, but as mobile phone cameras increase in quality, and as digital cameras are increasingly shipped with embedded wireless cards, the first mile will be 3.5G, Wi-Fi, or WiMAX.	Though the volume would be low compared to Internet video traffic, the impact on mobile networks will be high.

For a closer look at this framework, please see Appendix B: Understanding shifts in consumer video traffic.

Three Waves of Internet Video Growth

Based on the considerations described in the previous section, Cisco forecasts that there will be three waves of Internet video. The first phase is being driven by Internet video as viewed on the PC, the second phase will be driven by Internet delivery of video to the TV, and the third phase will be driven by video communications. Each phase will impact a different aspect of the network. The first two phases will be felt primarily in the metro and access networks, while the third will impact the core (Figure 3).

Figure 3. Internet Video Will Drive Three Waves of Consumer Internet Traffic Growth



Source: Cisco, 2007

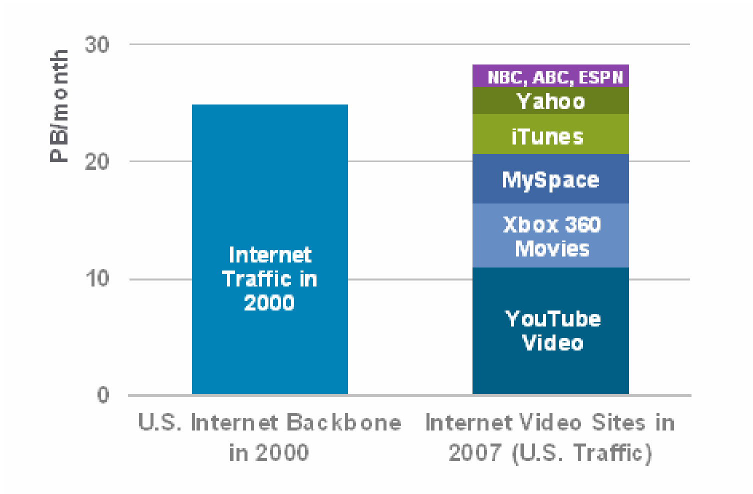
In addition to Internet video, there is very high growth in the IP transport of cable and IPTV video-on-demand services. See the section "There's More to IP Video than Internet Video," near the end of this paper.

The First Wave: Internet Video-to-PC

The attraction of a social experience of video has ignited a wave of Internet video. Once consumers are in the habit of watching online video, they are more likely to watch traditional video online as well, a cascading effect that has been dubbed "the YouTube effect." Even a straightforward, non-interactive, non-social video experience may prove attractive to viewers because (a) the PC is personal and portable; (b) content that is not available through a commercial VoD service may be made available on demand online by the content provider.

Thanks to the YouTube effect, online video has grown rapidly. But online video traffic viewed on the PC screen is still relatively modest at about 8 percent in 2006, growing to a respectable but not overwhelming 16 percent in 2011. The percentages may be modest, but the volumes are not. As Figure 4 shows, Internet video traffic in 2006 was more than the amount of traffic crossing the U.S. Internet backbone in 2000. Table 1 compares the volume of Internet video and gaming traffic with well-known benchmarks.

Figure 4. Internet Video Already Generates More Traffic than the Entire U.S. Backbone in 2000



Source: Public data, comScore, and Cisco estimates, 2007

Table 2. Internet Video and Gaming Traffic Benchmarks

	Terabytes per month
Google / YouTube – Worldwide (Cisco estimate for mid-2007)	45,750
U.S. Internet Backbone at Year End 2000	25,000
Google/ YouTube – United States (May 2007)	10,956
U.S. Internet Backbone at Year End 1998	6,000
Xbox 360 Movie/TV Downloads[2] (Cisco estimate for late 2006)	5,500
Fox Interactive (MySpace) – United States (May 2007)	4,148
Google – United Kingdom (April 2007)	3,709
iTunes audio and video downloads (2006)	3,500
MSN Messenger Video Calling (2006)	2,880
World of Warcraft (2006)	2,500
Yahoo – United States (May 2007)	2,361
ABC, NBC, ESPN, Disney – United States (May 2007)	1,854
Google – France (April 2007)	1,743
Viacom – United States (May 2007)	1,446
dailymotion.com – France (April 2007)	1,520
MSN Messenger Webcam (2006)	1,260
Time Warner – United States (May 2007)	1,129
Second Life (2006)	1,000
Cyworld video streams – downstream (January 2007)	815
Yahoo – United Kingdom (April 2007)	353
SightSpeed Video Calling (2006)	240
BBC – United Kingdom (April 2007)	196

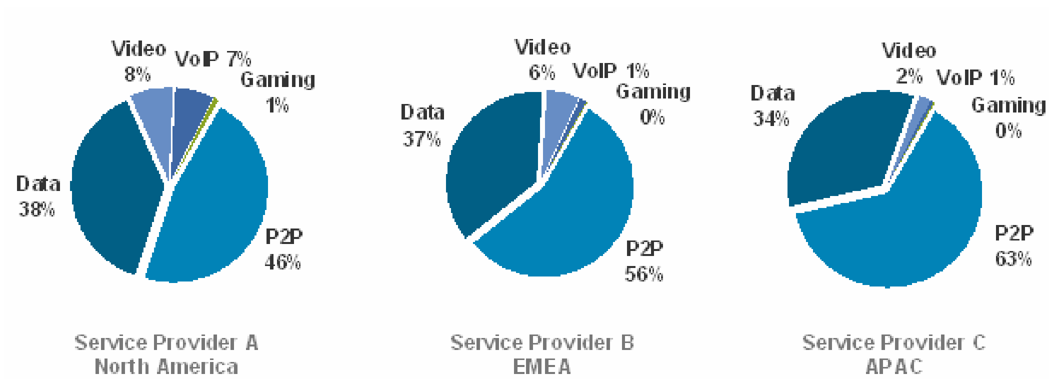
[2] Unlike the other figures in this table, which are based on public data on the number of streams or hours of viewing or gaming, the estimate for Xbox 360 video downloads is based on Cisco's assumption that 15 percent of the Xbox 360 installed base in the United States is downloading two high-definition movies per month, and two television shows per month.

Fox Interactive / MySpace – United Kingdom (April 2007)	159
Library of Congress book collection	136
Free.fr video streams – France (April 2007)	107
Orange "Business Everywhere" (January 2007)	74
Cyworld – video uploads (January 2007)	25
U.S. Internet Backbone at Year End 1994	20
YouTube – video uploads (2006)	13
Photobucket – video uploads (2006)	8
Photobucket – photo uploads (2006	6
3 – over-the-air downloads in 2006	5

Source: Public data and Cisco estimates, 2007

Given the impressive figures above, what is generating the majority of traffic, if not Internet video? Figure 5 shows the consumer Internet traffic mix for three service providers. Peer-to-peer is still the dominant type of traffic and ranges from 46 percent to 63 percent of total traffic, while video ranges from 2 percent to 8 percent.

Figure 5. Consumer Broadband Traffic by Application for Three Consumer Broadband Service Providers



This data is taken from three installations of the Cisco Service Control Engine, as part of Cisco's WeatherEYE traffic tracking initiative. It is meant as anecdotal evidence, and the traffic splits may not be representative of the entire region.

Source: Cisco, 2007

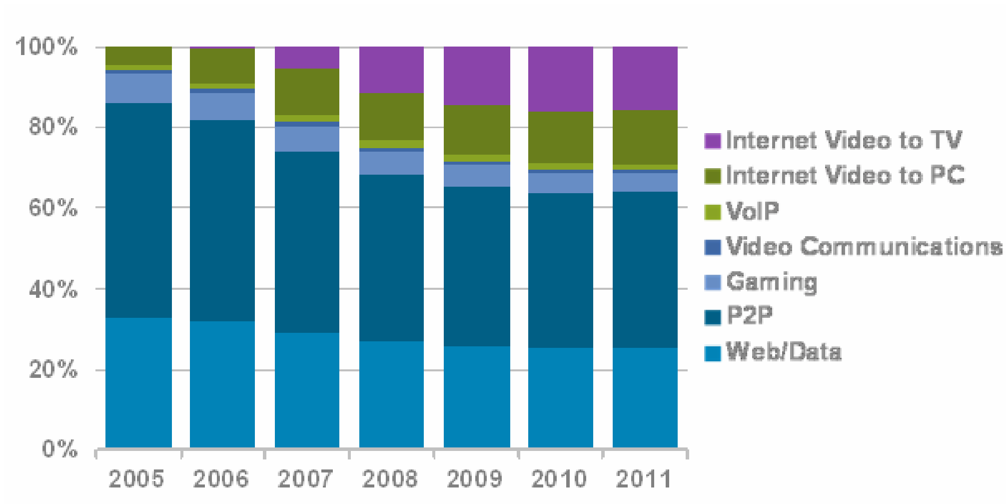
Note that P2P traffic is also being driven by the exchange of standard- and high-definition video files. Assuming video files account for at least 50 percent of P2P traffic, video is already the dominant type of content in terms of traffic. Driven by video, P2P is expected to grow at a CAGR of 34 percent from 2006 to 2011. However, because of the difficulties of estimating specific types of P2P traffic, video-to-PC is treated separately here. Given this definition, Internet video-to-PC does not compare to the volume of P2P seen by service providers today, and will pale in comparison to the second wave of Internet video, driven by Internet delivery of video to the TV screen.

However, there is an important factor that should be mentioned, which is Internet-TV-to-PC. The delivery of television broadcast content to the PC through P2P distribution, has the potential to drive PC-based video traffic much higher than the forecast projects. P2P television is not entirely new and has already created a small niche for itself among early adopters, but the population appears to have remained limited. If companies like Joost succeed in reaching a larger population, then PC-based video will continue to dominate Internet video traffic for a longer period than indicated in the forecast.

The Second Wave: Internet Video-to-TV

In terms of bandwidth, the traffic due to video will accelerate dramatically once Internet-enabled set-top devices are deployed by service providers. The viewing of Internet video by way of the STB will make up only a very small fraction of overall viewing in number of views, but because of the long-form and higher-definition nature of the content, Internet video-to-TV traffic will surpass Internet video-to-PC by 2009.

Figure 6. Cisco's Global Consumer Internet Traffic Forecast

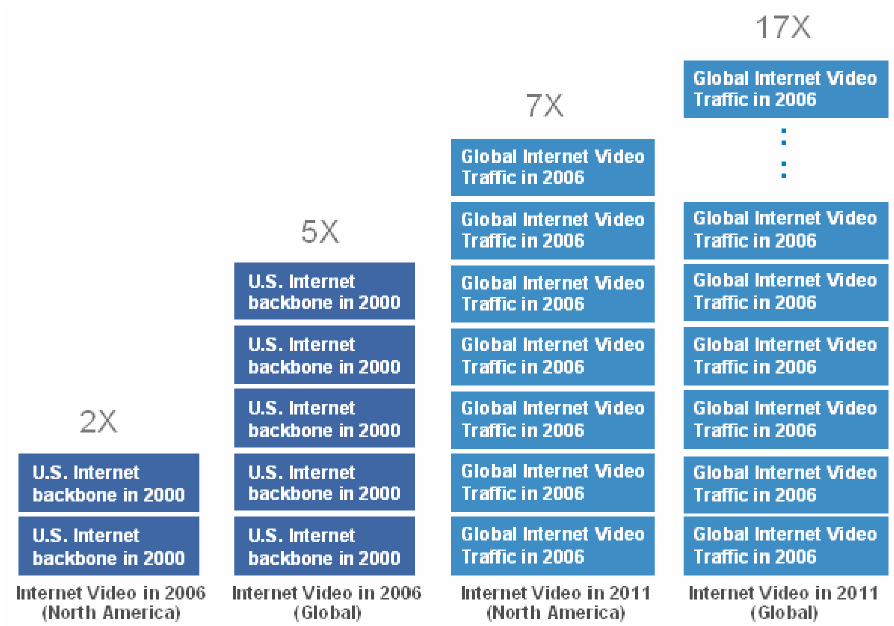


For more details, see Cisco's white paper entitled "Global IP Traffic Forecast and Methodology 2006–2011".
Source: Cisco, 2007

Drivers and Implications of the Second Wave

The next big thing is really big. The sheer volume of video is the key driver of the second phase of Internet video traffic growth. Forty hours of high-definition video generate as much traffic as a million e-mail messages. To put the scale of video into perspective, Figure 7 shows the growth of Internet video (both video-to-TV and video-to-PC, so it represents the first two waves of Internet video) in units of the U.S. Internet backbone in 2000. Global Internet video in 2006 was five times the 2000 U.S. Internet backbone, and global Internet video traffic in 2011 will be 17 times the global Internet video traffic in 2006. The numbers are large, even though Internet video will remain less than 50 percent of consumer Internet traffic through 2011 and the CAGR is 78 percent from 2006 to 2011 (relatively low given that it is starting from a very low traffic level in 2006).

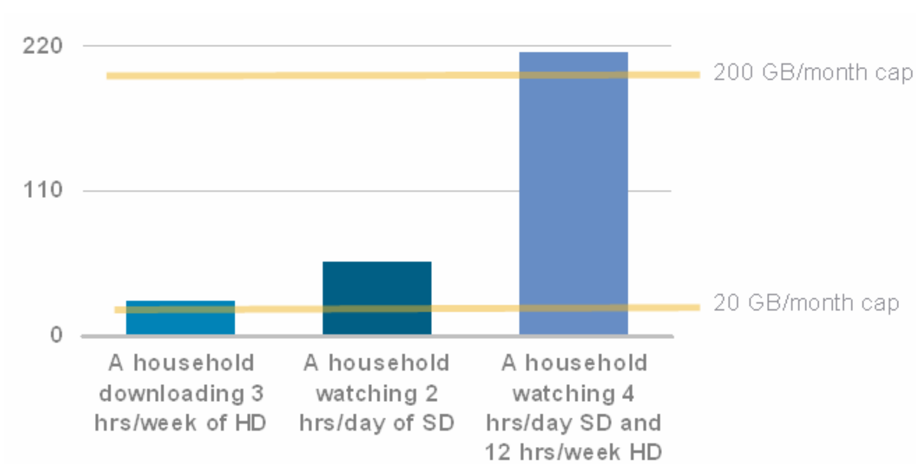
Figure 7. Global Internet Video Traffic Growth In Perspective



Source: Cisco, 2007

Today's "bandwidth hog" is tomorrow's average user. P2P bandwidth hogs have not elicited much sympathy from the general public, and service providers have been able to institute usage caps without causing much public outcry. However, a household downloading just 3 hours of high-definition content a week would generate at least 27 GB per month, which already exceeds the bandwidth caps of some service providers. Should Internet television become mainstream, 2 hours per day of standard-definition television viewing via the Internet would put a household at 54 GB per month. A household downloading 12 hours of high-definition video per week and 4 hours of standard-definition video viewing per day would easily exceed the most generous of service provider bandwidth caps, usually around 200 GB per month. Cisco's IP traffic forecast is based on much more conservative assumptions (generally less than 10 hours of Internet video content per month through 2011), but the forecast may prove too conservative if Internet delivery of television is adopted on a large scale.

Figure 8. How an Average Household May Exceed Service Provider Bandwidth Caps

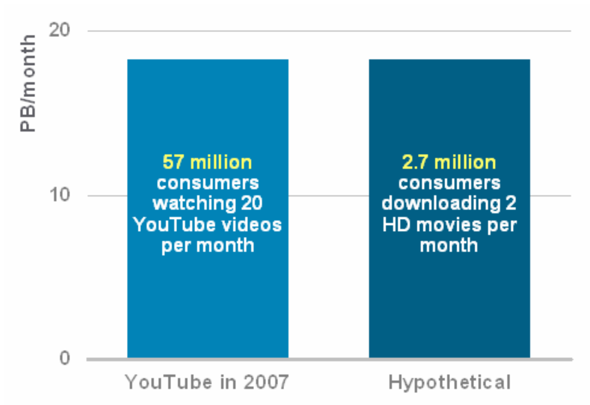


HD = High Definition

SD = Standard Definition
Source: Cisco, 2007

Minority rules. The weight of high-definition video means that, in video as in P2P, a small percentage of users can generate the majority of traffic, which makes forecasting video traffic growth less predictable than browsing or e-mail traffic. This is especially the case with high-definition video traffic. Figure 9 shows that 2.7 million high-definition video consumers can easily generate as much traffic as 57 million YouTube consumers.

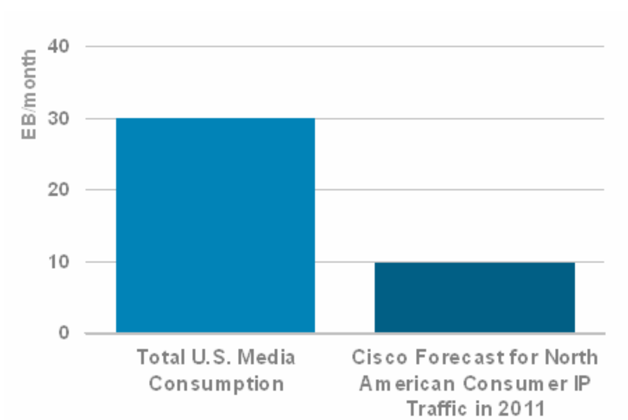
Figure 9. 57 Million YouTube Viewers Equal 2.7 Million High-Definition Video Consumers



Source: Cisco, 2007

How high can it go? The average U.S. adult consumes the equivalent of nearly 120 GB per month. The total media consumption for the U.S. is the equivalent of 30 exabytes per month. If all television viewing were on-demand (standard-definition), the sum total of metro IP traffic would approach this figure. Cisco's forecast for North American consumer IP traffic (including all consumer Internet traffic) in 2011 is less than 10 exabytes per month.

Figure 10. Total U.S. Media Consumption Is 30 Exabytes Per Month



Source: Cisco, 2007

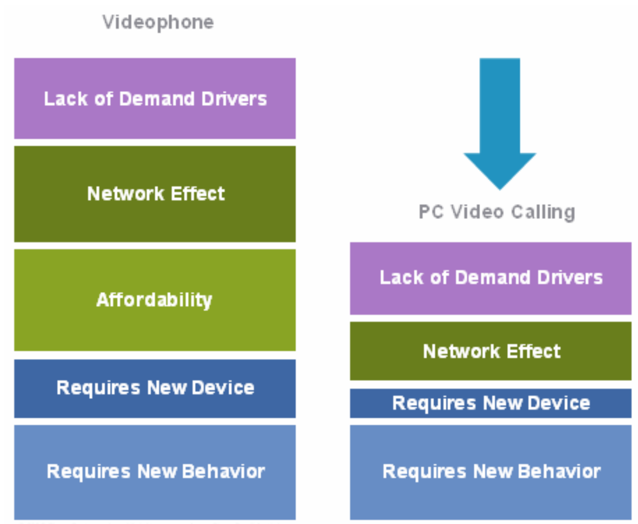
The Third Wave: Internet Video Communications

Beyond 2015, a third wave of video traffic will be driven by video communications.

Video calling has been touted as the next big thing repeatedly over the past several decades, each time with abysmal results. What reasons are there for thinking that video communications might drive a third wave of video traffic less than 10 years from now?

1. PC-based video calling does not have the same barriers to adoption as the videophone did. If the barriers to adoption for each market are stacked up and placed side-by-side, it becomes clear that PC-based video calling is significantly less encumbered than the videophone was.

Figure 11. PC-Based Video Calling Has Lowered the Barriers to Adoption for Video Calling

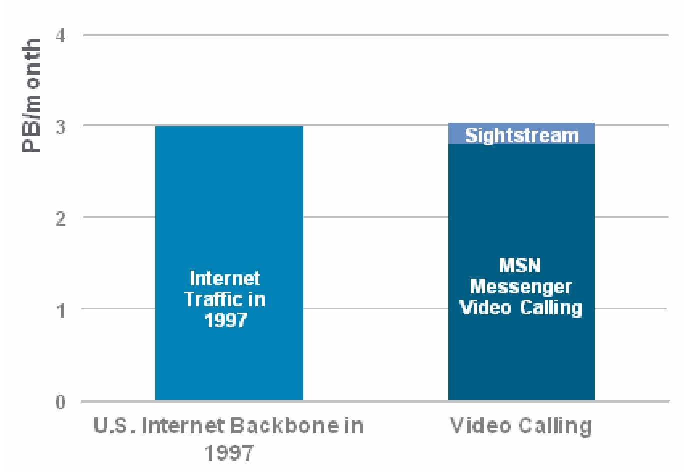


What is different about PC-based video calling?

- The target market for videophones as a consumer service was limited to geographically disperse families and couples. The potential market has broadened considerably with the advent of a new generation who has large networks of virtual friends and belong to multiple virtual communities.
- The network effect is still a barrier, but the addition of video to instant messenger networks is beginning to turn the network effect from a barrier to a driver.
- Webcams are inexpensive, easily available, and increasingly embedded within new PCs.
- PC-to-PC video calling is largely free, eliminating the affordability barrier.

For the above reasons, video calling is already generating a non-negligible amount of traffic. As Figure 12 shows, video calling traffic today exceeds the total amount of traffic crossing the U.S. Internet backbone in 1997.

Figure 12. Internet Video Calling Today Exceeds all U.S. Internet Traffic in 1997



2. The increasing use of video communication in the business arena will accelerate consumer adoption. Consumer and business technologies form a reinforcing loop. Employees may bring video communication technologies home, just as consumers brought instant messaging to work. Communications technologies increasingly move from one realm to the other.

3. Video communication is more than video calling. Video sharing, video monitoring, consumer telepresence, and telemedicine will join video calling in driving the third wave of video traffic.

The first webcam was launched in 1991, and the first PC-based video calling software was introduced in 1992. The diffusion of consumer technology can be slow, and reaching mass penetration can take from 7 years (like the DVD) to 20 years (like the mobile phone, or PC) or more. Because the barriers to video calling appear to be fading, it seems likely that PC-based video communications will reach mass adoption sometime between 2012 and 2015.

Challenges Posed by the Three Waves of Internet Video

The first two waves of Internet video will pose a number of challenges to service provider networks, but service providers have means of responding to these challenges, such as content delivery at the edge, push video distribution, and even P2P distribution.

It is the third wave of video communications that may be the most challenging, in that there are few means of coping with real-time video communications other than to transport it over the core. There is no way to cache real-time communications.

The challenges that accompany Internet video, along with possible responses, are listed below.

- **Flash crowds:** Mark Kortekaas, the CTO of CBS Interactive, identified the normalized traffic pattern exhibited by on-demand viewing as manageable and the bursty traffic pattern associated with live events as problematic. Even when the content is known in advance, and delivered at a content distribution node in the metro, flash crowds have the potential to generate a huge amount of traffic. In the example given by Mark Kortekass, if the 1.5 million New York metro viewers of the popular show *CSI* were to watch an episode online, it would require a 1 Tbps network to deliver the traffic and over 350 terabytes would be served in a single hour.

  Possible responses to the flash crowd problem: In theory, one-to-many content should not generate a large amount of traffic, as one copy is sent out to multiple receivers. The flash crowd problem is only a problem because today's Internet traffic is unicast. So the most obvious response to the flash crowd problem is the widespread implementation of IP multicast traffic standards by the industry. However, the complexity of inter-domain multicast implementation has hindered adoption, and adoption does not appear to be accelerating even with the recent traffic growth. A second response is to push the distribution of content even closer to the customer premises through edge delivery. A third option is to deliver the content through a peer-to-peer system, which has a more distributed traffic topology than the client-server topology of video server traffic. A fourth possible response is to continue distributing broadcast traffic through traditional means, but enable PCs and mobile devices to receive it through TV tuner cards.

- **Last-mile bottlenecks:** Most of the concern about last-mile bottlenecks centers not on Internet traffic but on IPTV or cable IP video traffic. This is the most pressing issue for service providers in regions like North America, where the standard broadband line is relatively slow. See the following section for more on the access bottleneck that IP video service providers will have to contend with. As for the Internet, the last mile is a potential bottleneck in a few ways: the upstream-to-downstream traffic ratio exceeds the upstream-to-downstream capacity ratio, steady streams of traffic over long periods of time (such as video downloads through P2P) challenge the assumption of burtsy traffic that underlies overbooking ratios, and the streaming of high-resolution video strains the bandwidth capacity of the access line.

  Possible responses to the last-mile bottleneck: One of the above problems is associated with streaming video, and the other two are primarily due to P2P downloads and uploads. For video downloads, one option that service providers are already employing is the enforcement of monthly caps on bandwidth consumption. Right now, bandwidth caps are precision strikes, because generally it is a small number of users (usually P2P users) who generate enough traffic to bypass the cap. However, bandwidth caps are a temporary measure, unless they grow along with traffic, because it will not be long before high bandwidth consumption is no longer restricted to a minority. As for streaming, this is a problem that concerns the content provider more than the connectivity provider. For content providers, the alternative to streaming is to push the most popular content to the user as a download so that it is then available on-demand. In a variation on this theme, the BBC iPlayer has an option for users to schedule overnight downloads of the next day's programming. Reduce the number of homes per serving area.

- **Is there a core bottleneck?** The backbone of the Internet appears to be coping well with the increase in traffic over the last year, though backbone operators have generally had to accelerate their upgrade plans. To content providers, the Internet backbone is a potential bottleneck, rather than a proven bottleneck. In fact, there is evidence that most bottlenecks seem to be located within an autonomous system, rather than at the exchange between networks.

  Possible responses to the potential bottleneck: In order to avoid any potential core bottlenecks and to speed delivery, much Internet video traffic is being pushed to the regional core networks if not all the way to the metro network, traveling along private content delivery networks for most of the distance. Content delivery networks have been around since the mid-nineties, but as the nature of Web content became more dynamic, the utility of content delivery has remained limited. Unlike dynamic Web content, the video content of today is mostly static and is a good candidate for content delivery. In addition to content delivery, direct content peering with major network operators is an option being considered by content providers.

Will there be a core bottleneck in the future? With the advent of video communications, the core may experience dramatic growth. Although video communications have been slow to take hold of the market and are not projected to have mass adoption in the next five years, there is already evidence that video calling has a solid footing among early adopters, and is not going to fade away. It is likely that service providers will see the trend far enough in advance to respond, but if a social networking application that involves live video gains popularity, there is potential for a traffic surge, and there are few responses available other than core upgrades.

Table 3. Network Implications of Traffic Growth

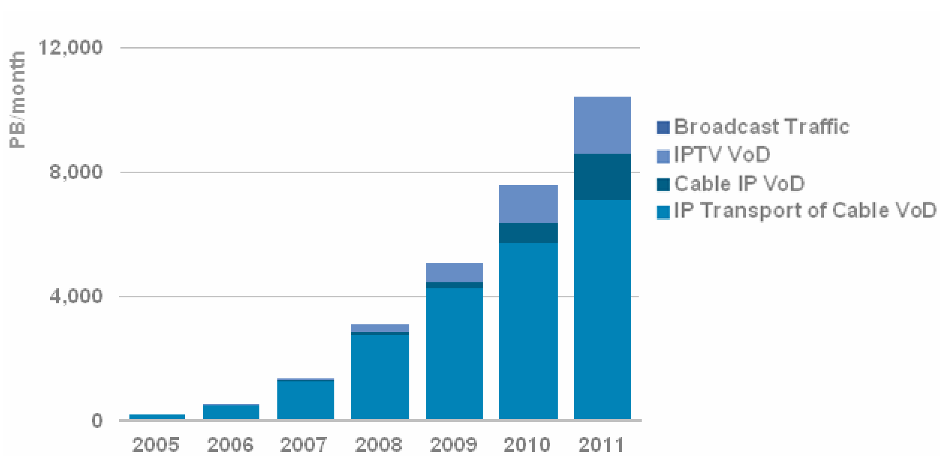
Trend	Potential Problem	Potential Solution
Internet video (on demand)	Metro and core – growth in average volume	Content delivery systems (CDS), capacity upgrades, advanced compression
Internet broadcast	First mile and data center – flash crowds	P2P content distribution, multicast
	Metro and core – flash crowds	CDS, multicast, P2P content dist.
P2P	Access – upstream bottleneck, uniform traffic pattern	Fewer homes per serving area, lower oversubscription ratios
	Core – growth in average traffic volume	P2P caching
Commercial VoD	Metro – growth in average traffic volume	CDS, capacity upgrades, compression
High Definition Content	Access – last mile IPTV bottleneck	Capacity upgrades
	Metro – growth in VoD traffic volume	CDS, capacity upgrades, compression

There Is More to IP Video than Internet Video

IP traffic growth is not synonymous with Internet traffic growth. With the convergence of traditional services over IP, two distinct types of consumer IP traffic emerge: public and commercial. Much of consumer IP traffic growth is due to the migration of commercial VoD traffic onto IP networks.

According to Cisco's IP traffic forecast, non-Internet IP video will exceed 10 exabytes per month by 2011. A large portion of this will be due to the transport over IP of cable VoD, where the VoD traffic travels over IP in the metro, but the set-top is not an IP set-top. VoD traffic that is IP all the way to the customer premises begins to make up a significant portion of the traffic starting in 2009.

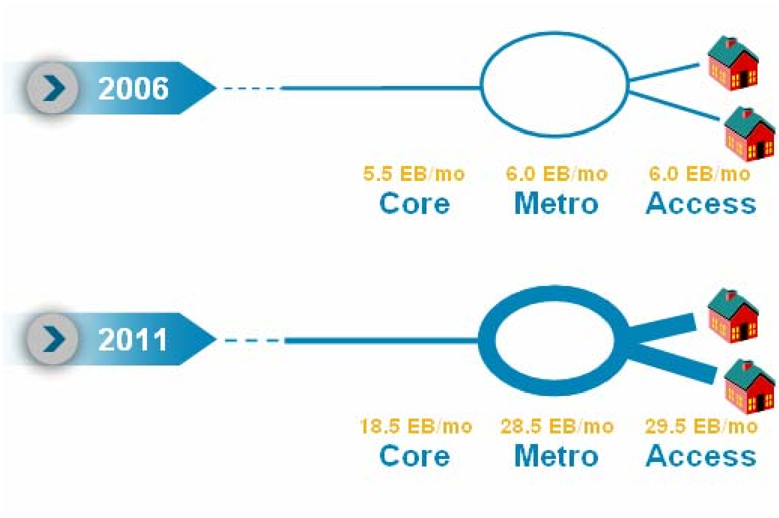
Figure 13. Cable and IPTV VoD Traffic Will Exceed 10 Exabytes per Month by 2011



Source: Cisco, 2007

Due to non-Internet IP video, IP traffic in the metro will outpace IP traffic in the core. The sum total of metro IP video traffic in 2011 will be more than twice the volume of core traffic, as shown in Figure 14.

Figure 14. Core Triples, Metro Nearly Quintuples by 2011

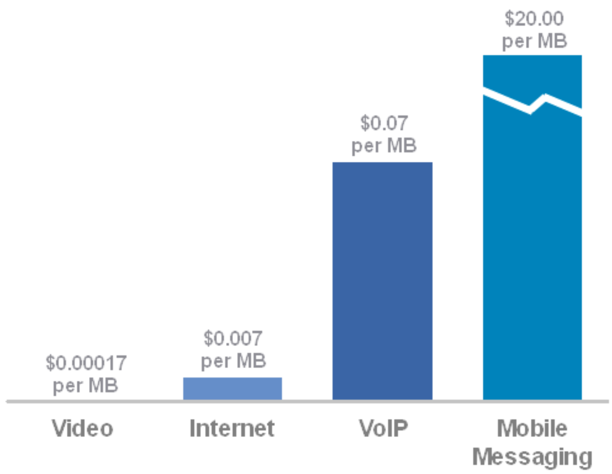


Source: Cisco, 2007

Video Consumes More Than its Weight In Bandwidth

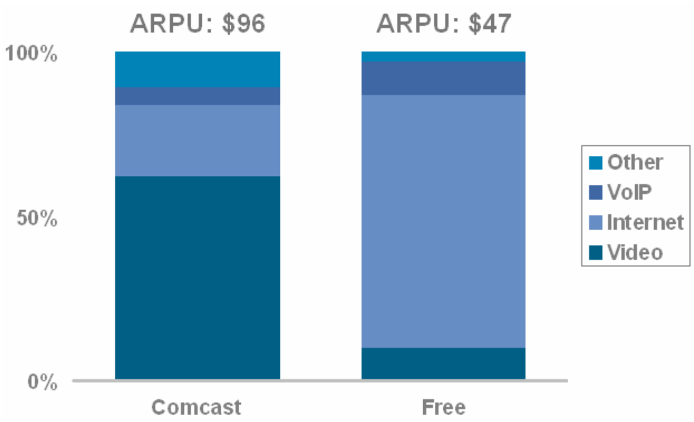
Video brings in a little over 1 percent of 1 cent per megabyte. Compare this to text messaging, which brings in $20 per megabyte, as shown in Figure 15. Such a comparison illustrates that service providers have charged for (and consumers have paid for) services, not megabytes. Until now consumer willingness to pay for a service has no correlation with the amount of bandwidth that service consumes.

Figure 15. Price per Megabyte



As Vint Cerf said way back in 1994, “Ultimately, somebody has to pay for all the capacity being used.” But a number of disruptive models have appeared on the scene to disturb this equation. Greenfield providers like Iliad’s Free are offering free voice and video with each broadband line. Over-the-top providers like Joost are offering video services free of charge and gaining revenue from advertising. In other words, services have been untied from connectivity. What used to be called "services" have been virtualized and could just as well be called "applications" or even "sites," with the exception of connectivity services. What seems to be in question at the moment is whether connectivity pricing will be closer to the pricing of three services or that of a single service.

Figure 16. Triple-Play and Convergence Are Creating Divergent Revenue Models



How will the current market turmoil play out?

Scenario 1: $100 connectivity. In this scenario, service providers would essentially re-create the traditional services model in a converged setting. Consumers would learn a new bandwidth vocabulary the way they have learned PC vocabulary; they would know the difference between best-effort and prioritized traffic, and will be more willing to pay by MB or for various content-type-specific guarantees. Service provider revenues from consumers would decline, but not drastically: consumers would pay US$70–100 for a pipe that would accommodate all services.

Scenario 2: $40 connectivity. Service provider revenue streams that come directly from consumers would decline drastically. The service provider would compensate with new revenue streams, from new sources such as:

- Content providers (content delivery)
- Advertisers (targeted advertising, interactive advertising, location-based services)
- Over-the-top Providers (personalization and services APIs like BT's Web21c)

Many of these new revenue streams are already being considered and deployed by service providers today, such as multi-platform targeted ad insertion and application platform provision. All hinge on the service provider having privileged access to all that flows over a consumer's broadband pipe, despite any asymmetry in revenue-per-bit.

FOR MORE INFORMATION

For more information on Cisco's IP traffic forecast, please see the paper "Global IP Traffic Forecast 2006–2011**.** Inquiries regarding the forecast or the content of this paper can be directed to Arielle Sumits at arielle@cisco.com. Press inquiries can be directed to Wilson Craig at wicraig@cisco.com.

APPENDIX A: Cisco's global IP traffic forecast

Table 4 shows the summary of Cisco's global IP traffic forecast. For more information, please see the paper "Global IP Traffic Forecast and Methodology 2006–2011."

Table 4. Global IP Traffic 2005–2011

IP Traffic 2005–2011							
	2005	2006	2007	2008	2009	2010	2011
By Type (terabytes per month)							
Internet	1,816,694	2,430,884	3,382,255	4,725,015	6,319,344	8,328,317	10,745,578
Non-Internet IP	2,739,119	3,540,687	4,999,932	7,486,482	10,385,496	14,021,792	18,263,036
By Segment (terabytes per month)							
Consumer	1,203,884	1,952,739	3,520,282	6,311,353	9,524,850	13,594,740	18,324,275
Business	3,349,121	4,013,218	4,851,118	5,881,093	7,147,513	8,703,119	10,605,126
Mobility	2,808	5,614	10,787	19,052	32,478	52,251	79,213
By Geography (terabytes per month)							
North America	1,202,288	1,641,494	2,712,564	4,302,503	5,988,661	7,744,256	9,880,353
Western Europe	782,125	1,034,156	1,423,688	2,185,444	3,122,000	4,559,131	6,094,734
Asia Pacific	838,934	1,146,659	1,557,330	2,256,136	3,099,706	4,190,139	5,570,718
Japan	260,480	376,342	514,477	745,915	1,061,950	1,474,965	1,886,451
Latin America	147,867	198,808	271,064	384,009	532,486	749,027	1,031,043
Central and Eastern Europe	73,353	102,608	147,157	224,652	346,356	541,716	806,918
Middle East and Africa	43,880	65,288	95,234	143,150	207,952	295,904	406,634
Multinationals (Business)	1,206,886	1,406,215	1,660,673	1,969,687	2,345,730	2,794,970	3,331,765
Total (terabytes per month)							
Total IP Traffic	4,555,813	5,971,571	8,382,187	12,211,497	16,704,840	22,350,109	29,008,615

Cisco, 2007

Definitions:

Consumer – includes fixed IP traffic generated by households, university populations, and Internet cafés

Business – includes all fixed IP WAN or Internet traffic generated by organizations (including government)

Mobility – includes mobile data and Internet traffic generated by handsets, notebook cards, Wi-Fi hotspots, WiMAX

Internet – denotes all IP traffic that crosses an Internet backbone

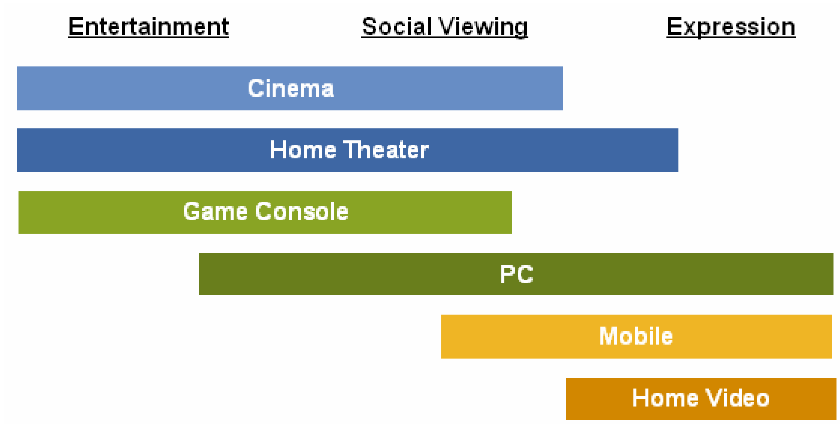
Non-Internet IP – includes corporate IP WAN traffic, IP transport of TV/VoD, and mobile "walled garden" traffic

Multinationals – includes business traffic that could not be determined to fall within a particular geographical boundary

APPENDIX B: Understanding Shifts in Consumer Video Traffic Patterns

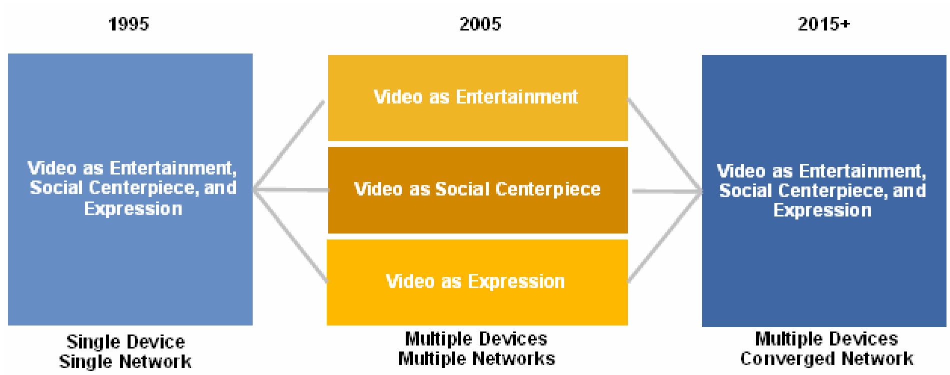
In the past the aspects of the video experience were bundled together within a single platform, the household television. Today there is more than one platform for video. With the advent of multiple video platforms, the video experience has separated into its component aspects. When content is primary, the home theater is the best platform. When the social aspect is primary, the PC is best suited because it offers interactivity, social networking, etc. When the creative or expressive aspect is primary, the PC and the mobile device are best suited. Figure 17 depicts the way in which different devices address different aspects of the video experience.

Figure 17. The Divergence of Video Platforms



Source: Cisco, 2007

Figure 18. Video Is Separating into its Various Aspects, to Be Reunited by Convergence



Source: Cisco, 2007

What does this have to do with IP traffic? We are not yet at the point where any device can be connected to any network. Today, as the video experience migrates to new platforms, the traffic shifts accordingly. This framework can explain many of the shifts in IP traffic patterns that will occur over the next five years, and can be used to think through future scenarios, and to identify contingencies.

High Definition

Viewers of high-definition content are seeking a certain experience, and the home theater is central to that experience. Content is secondary in that a viewer does not purchase a high-definition set in order to get access to content. The primacy of experience means that the traffic will flow over whatever network best serves the platform for that experience. High-definition traffic currently runs over commercial video networks because those are the networks plugged in to the home theater. The centrality of the home theater to the high-definition experience determines the network, but when the Internet plugs in to the home theater, Internet traffic will take a greater share (Figure 19).

Figure 19. The Home Theater is Central to the High-Definition Experience

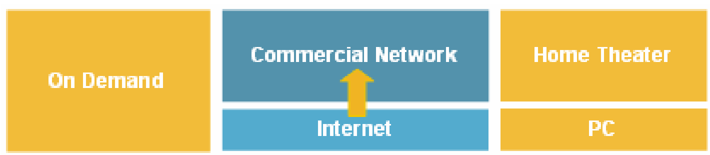
However, new devices are appearing that plug the Internet into the home theater[3]. With both the Internet and the multichannel network feeding into the home theater and theoretically giving the same level of experience, the secondary aspect – content – becomes more important. High-definition video traffic will flow to the Internet if it provides access to the content that the commercial video network does not.

[3] In the very early stages, most of these devices will be gaming consoles that can stream video from the Internet to the screen. These devices are already plugged in to the television set, often a high-definition screen, and generally belong to young, Internet-savvy users who are not deterred by long download times (up to a point). Internet video STBs are also making an appearance, but are likely to remain within a niche of early adopters. When Internet-enabled STBs are deployed by service providers, delivery of video through the Internet will skyrocket. This is a key assumption built in to Cisco's global IP traffic forecast.

On-Demand

Unlike high definition, where the experience is primary, in on-demand viewing the content is primary. (Keeping in mind that the trends are not mutually exclusive.) Because on-demand viewing is driven by content, the network that provides the content takes the front seat, with the device is relegated to the back (Figure 20). If a missed episode of a favorite series is available on both the Internet and the commercial VoD service, users will prefer the one that provides the best experience. If the episode is available through the Internet but not through the commercial video service, motivated viewers will go to the Internet for it. Less motivated viewers will be deterred by the experience the PC provides, and this will limit the amount of traffic that migrates from the commercial video network to the Internet. However, as the Internet is increasingly channeled into television screens, and as more content becomes available online, Internet VoD traffic is likely to surge. The network housing the desired content determines the device. As more content becomes available through the Internet and Internet users become more familiar with online video services, an increasing portion of on-demand traffic will travel over the Internet. Because experience is still a consideration, traffic will flow all the more once the Internet is connected to a home theater.

Figure 20. The Network Is Central to On-Demand Viewing



Social Viewing

Conversational viewing refers to a video experience where the video content is embedded in a social network or social interaction. Viewers can watch together, chat, and see who else among their friends is watching and what they are watching. The home theater does not support this level of interactivity, so the PC is the preferred device (Figure 21). Short-term, conversational viewing may cause much video traffic to migrate from the commercial network to the Internet. The draw of conversational viewing has the potential to be a major driver of long-form video viewing on the PC, and therefore a major driver of Internet video traffic. In Cisco's forecast, mass adoption of conversational viewing is not assumed to take place before 2011, but it is a potential wildcard that should be monitored closely. Over the long term, the video portion of this traffic has the potential to shift back to the commercial network, if devices that lend interactivity to the home theater appear on the scene. In this happens, traffic could shift back to the commercial network, where the video traffic travels over the commercial network, and the only traffic crossing the Internet is the chat and presence data.

Figure 21. The PC Is Central to Social Viewing