Will Video Kill the Internet?

How video is straining the physical design of the Internet

A white paper from EdgeConneX®

Content is the driving force of all things digital. But current Internet infrastructure wasn't designed to support the immense amount of data that it is expected to handle today – and even more so, tomorrow. The original purpose of the Internet was to enable sharing of information in small packets, not to share massive media and video files between individuals and/or the masses. Further complicating matters are the numerous residential homes, businesses and mobile devices that are consuming more and more video and content across the Internet. Our insatiable demand for new media is straining the traditional network infrastructure, and in many cases, the network is overwhelmed or even incapable of delivering requested packets at the speed users require.

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INTRODUCTION

"Video is the first application that is breaking the ability of networks to scale quickly and efficiently to provide consumers the best user experience."

- Clint Heiden,
Chief Commercial Officer,
EdgeConneX

According to Cisco®'s Visual Networking Index (VNI)[1], an ongoing initiative to track and forecast the impact of visual networking applications, by 2015 the annual global IP traffic is expected to surpass the zettabyte threshold. By 2017, 51 percent of all Internet traffic will cross content delivery networks. This is an increase of 34% from 2012. During this same time period, it is expected that the gigabyte equivalent of all movies ever made will cross over global IP networks every three minutes. That is 13.8 petabytes of information every five minutes. In other words, this voracious demand for video content is forcing providers to scale quickly (and inefficiently) across antiquated infrastructure that has not yet been designed to optimize delivery of video. Video is the first bandwidth-intensive application that individual end-users have grown accustomed to consuming. This rapid demand is occurring far faster than the networks can react, and this inability to scale quickly and efficiently hinders the networks' ability to ensure consumers a positive user experience. Simply put, the network is clogging up with data that exceeds its capacity and the physical build out of new infrastructure cannot keep up. Video is the first application that is breaking the ability of networks to scale quickly and efficiently to provide consumers the best user experience.

Content Delivery Network (CDN) Traffic, 2012-2017

With the emergence of popular video streaming services that deliver Internet video to the TV and other device endpoints, CDNs have prevailed as a dominant method to deliver such content. Globally, 65 percent of all Internet video traffic will cross content delivery networks in 2017, up from 53 percent in 2012 (Table 8).

Furthermore, Akamai Technologies points out that the first major challenge for content providers is providing a high-quality streaming experience for their views, where videos are available without failure, they startup quickly, and stream without interruptions. In order to do so, CDNs must employ several techniques for transporting media content from its origin to servers at the edges of the Internet where they are cached and served with higher quality to the end user.[2]

This paper explores the infrastructure of the Internet across the United States to pinpoint its strengths and weaknesses. It will also identify a new architectural paradigm

[1] "Cisco Visual Networking Index: Forecast and Methodology, 2012-2017." Cisco. Cisco Systems, Inc. 29 May 2013. 5 November 2013. http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-481360_ns827_Networking_Solutions_White_Paper.html.

[2] Krishnan, S.S., Sitaraman R.K. "Video Stream Quality Impacts Viewer Behavior: Inferring Causality Using Quasi-Experimental Designs." Akamai Technologies. 2012. 5 November 2013. http://www.akamai.com/dl/technical_publications/video_stream_quality_study.pdf.

that will change the way content is not only delivered, but also experienced by each and every user across the Internet. EdgeConneX will outline the innovative and necessary steps that are currently being taken to implement a new Internet architecture that meets the demands of users expecting both access to content and a satisfactory user experience.

Table 8. Global Content Delivery Network Internet Traffic, 2012-2017

CDN Traffic, 2012-2017							
	2012	2013	2014	2015	2016	2017	CAGR 2012-1017
By Geography (PB per Month)							
North America	4,630	6,484	9,127	12,349	16,581	21,766	36%
Asia Pacific	2,468	3,347	4,617	6,444	8,876	12,065	37%
Western Europe	2,792	3,517	4,542	5,723	7,298	9,323	27%
Central and Eastern Europe	437	586	809	1,163	1,611	2,150	38%
Latin America	465	597	747	967	1,204	1,470	26%
Middle East and Africa	71	103	142	197	265	351	38%
Total (PB per Month)							
CDN Internet traffic	10,863	14,633	19,984	26,842	35,834	47,124	34%

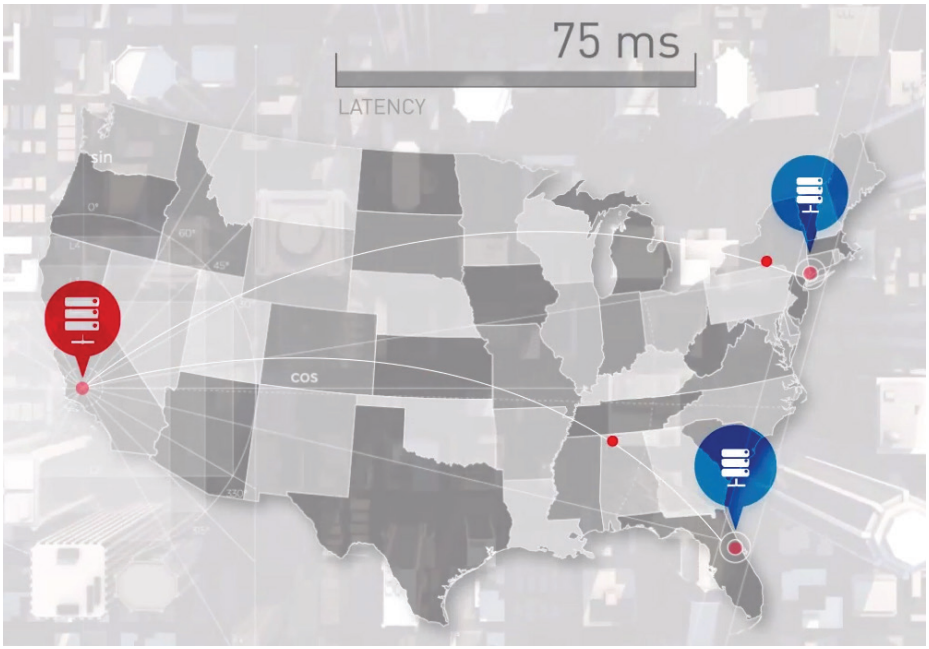
Source: Cisco VNI, 2013

THE PHYSICAL LANDSCAPE OF TODAY'S INTERNET

The Internet infrastructure of 2013 was originally designed in the mid-1990s. At the time of inception and initial implementation, we couldn't imagine what the data demand could look like more than 20 years later – and today's infrastructure is nearing its limit.

Our current highway system and roadways are crumbling and new ramps are designed and constructed daily. Imagine our roadways consumed with 18-wheeler tractor-trailers that simply get bigger and bigger. On today's information highway, it's not the small packets that are taking over, it's the large monstrous digital files that stress the infrastructure in a similar way that only tractor-trailers could do on our physical highways. This concept can also be applied to today's Internet infrastructure, which is the driving force of data consumption. Our infrastructure also needs to be re-designed to improve its on- and off- ramps, making it not only more accessible to users, but also wider to support greater bandwidth requirements.

In 1991[3], after the 'Acceptable Use Policy' (AUP) of the Internet was modified to allow for commercial use, the first Commercial Internet Exchange (CIX) was established. This was known as a leading industry association of ISPs that consisted of General Atomic (CERFnet), Performance Systems International, Inc. (PSInet) and UUNET Technologies, Inc. (AlterNet). The founding principal of this Network Access Point (NAP) was to provide more flexible routing to companies that use the Internet. The original commercial NAP allowed each of the CIX members to route traffic over the same network without violating Internet AUPs.



3 "Internet Traffic Exchange: Developments and Policy." 1998. The Organisation for Economic Co-operation and Development (OECD). 1998. 3 November 2013. http://www.oecd.org/sti/2091100.pdf.

By 1997, there were four primary NAPs recognized by the National Science Foundation (NSF) in the U.S.: Pacific Bell's San Francisco NAP, MAE East in the District of Columbia operated by MFS Datanet; Chicago NAP, Ameritech's Advanced Data Services Network Exchange Point; and the Sprint NAP in New York (note: MAE-New York, a WorldCom public exchange point for ISPs is not considered one of the first four NAPs recognized by the NSF).[4] Compare this to today's infrastructure with Internet exchange points across major cities, with the following nine locations considered primary Internet Exchange locations: Atlanta, GA; Chicago, IL; Los Angeles, CA; Miami, FL; New York, NY; San Francisco, CA; Dallas, TX; Ashburn, VA; and Seattle, WA.

Further consideration of these interconnection points illustrates that the data center space accommodating the Internet infrastructure in these regions is also strained – not just due to space demand, but also the proximity to networks, power and end-users alike. Let's consider Ashburn, VA, undoubtedly one of the first four Internet Exchange hubs in the U.S. Currently, there is just over 10 million square feet of data center space in that market. Compare this to the San Francisco Bay Area, another original hub in the U.S., where there is over 15 million square feet. Internet traffic, demand and reach grew tremendously over the past 20 years since it became commercialized. It is now a highly complex, multi-layered network that connects hundreds of millions of people across the world. What we don't know is what the Internet will look like in five, ten or twenty years from now. According to the NSF[5], research into quantum computing suggests that computers will be prevalent across all aspects of our lives, even more so than today. Their research suggests that the future computers in our homes, cars and offices will be faster than today's supercomputers. And if this is the case, how must the Internet be optimized to ensure the demand, data, and more importantly in many cases, the user experience is not compromised?

"This shift categorically changes the way we must look at the design of the Internet, the way we disseminate data across networks and ultimately, how we get content to the homes and offices of the hundreds of millions of users."

- Rob Hopewell, VP of Sales, EdgeConneX

In order to accomplish the goals of providers delivering content to end-users, today's network architecture must move away from legacy designs such as standard Broadband Network Gateway/Broadband Remove Access (BNG/BRAS) routers and must adopt a distributed network architecture based on enhanced, terabit-speed BNGs and CDN caches.[6]

In order to do so, the current long-haul network infrastructure, which was built in the late 1990s and early 2000s, needs to be revisited and re-distributed to ensure greater connectivity to regional infrastructure points that are currently in development. Further to regional network infrastructure deployment, which feed into metro area networks are wireless solutions that

4 "Internet Traffic Exchange: Developments and Policy." 1998. The Organisation for Economic Co-operation and Development (OECD). 1998. 3 November 2013. http://www.oecd.org/sti/2091100.pdf.

5 Cruikshank, D. "NSF and the Birth of the Internet." National Science Foundation. National Science Foundation. 5 November 2013. http://www.nsf.gov/news/special_reports/nsf-net/textonly/00s.jsp.

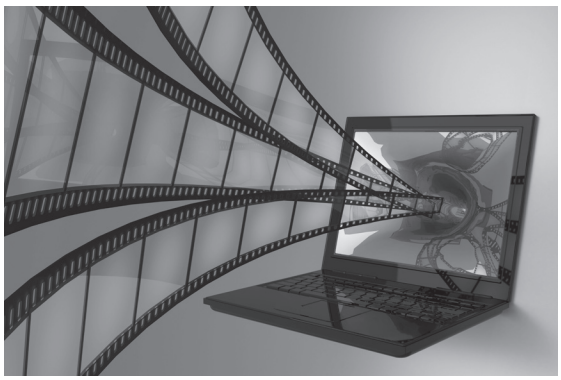
6 "Video Shakes Up the IP Edge." Alcatel-Lucent. 2012. 4 November 2013. http://www3.alcatel-lucent.com/wps/DocumentStreamerServlet?LMSG_CABINET=Docs_and_Resource_Ctr&LMSG_CONTENT_FILE=White_Papers/Video_Shakes_Up_IP_Edge_EN_Whitepaper.pdf.

must enable big bandwidth capabilities to meet the growing demand of mobile users. These same wireless solutions must be able to support the distribution of streaming content while connecting back to the fiber network infrastructure, which must be able to support both wireline and wireless bandwidth use. This is further straining the core network infrastructure across the U.S.

In reviewing regional and metro network solutions and capabilities, a key factor that must be considered is the role that cable companies and operators play as they distribute content to end-users in each of their localized markets. Cable operators must adjust more than ever to meet the delivery and viewing quality demanded by their end-users since they are the point of delivery of the Internet, cable and voice services to most residential and small businesses across the country. Today's cable companies are delivering more on-demand choices, challenged with the continued infrastructure migration and upgrades to high-definition viewing as well as the requirement to provide high speed broadband connections that enable Internet and support the plethora of Internet-based video applications that include live streaming, gaming, immense data downloads, and more.

> According to Akamai Technology's study "*Video Stream Quality Impacts Viewer Behavior: Inferring Causality Using Quasi-Experimental Designs", viewers who experience a failed visit are less likely to return within a time period than a viewer who experienced a normal visit.*

OTT VIDEO - BEYOND TODAY'S LIMITS



According to Juniper Research's study on the mobile TV and video market released in July 2013[7], revenues from streaming and download services on mobile and tablet devices (excluding fixed line devices) are expected to reach $9.5 million (up from $4.5 million in 2012) This is a prime example of Over-the-Top Content (OTT) demand and ultimate strain on our current network infrastructure. Furthermore, according to ABI Research, the OTT video market passed the $8 billion revenue mark internationally in 2012, a 60 percent year-over-year growth[8], and is predicated to reach over $20 billion by 2015.[9]

OTT refers to the delivery of video and audio over the Internet without a multiple system operator involved in the control of distribution of the content[10]. The challenge this poses

[7] "Mobile TV and Video Service Revenues to Approach $10 Billion by 2017." Juniper Research, 8 July 2013. Web. 4 Nov. 2013. http://www.juniperresearch.com/viewpressrelease.php?pr=385.
[8] "Over the Top (OTT) and Multiscreen Video Services." Rep. no. MD-OTMS-159. N.p.: ABI Research, n.d. Web. https://www.abiresearch.com/research/product/1015961-over-the-top-ott-and-multiscreen-video-ser/.
[9] https://www.abiresearch.com/press/over-60-growth-in-worldwide-over-the-top-video-rev
[10] "Over-the-top Content." Wikipedia. Wikimedia Foundation, Inc., 16 January 2014. Web. 4 November 2013. http://en.wikipedia.org/wiki/Over-the-top_content.

is that the provider may be aware of the contents of the data transporting over its network, but it is not responsible or able to control the viewing abilities, copyrights or other redistribution of the content. More specifically, OTT is the delivery of third-party content that simply uses the IP network as a means to transport IP packets. Thus, users who want to access OTT content (i.e. Netflix, Hulu, Wii, Xbox 360, and more) must rely on the quality of their network providers' network and the bandwidth, speed and latency capabilities that they have to offer. Companies such as cable operators are expected to provide optimal network connectivity services without visibility into the type of content their networks must deliver – or the ultimate quality its end-users receive. This will continue to create network demand and quality issues as demand increases year-over-year.

Residential users and today's infrastructure weaknesses have created a 'perfect storm' of issues related to the way information is accessed and distributed across the Internet. Immense amounts of data packets are transported across great distances between major city hubs, and localized packets must wait their turn to access the long-haul pipes in order to get to where they are going. Certainly, there are network design solutions that attempt to address these issues such as the class of service capabilities in MPLS networks, but that is a temporary fix for a growing problem that is nearly exploding as you read this.

Content providers such as Netflix, Amazon, Google and others are attempting to address these issues by force-fitting a network design solution in order to bring their data closer to end-users. They are doing so by seeking data center and colocation providers and physical locations that are near major user groups and populations that access their content. This cobbled solution is challenging because companies providing colocation and data center services want to do so centrally with accessibility available to many different providers and solutions – not just to provide an improved content viewing experience for end-users. Thus, the implementations act as a band-aid to a larger issue that network delivery providers must also address. This is exacerbated by network provider challenges, forcing them to opt into costly network solutions or sub-optimal colocation solutions - that fail to deliver quality end-user experiences. Furthermore, the problem persists because the Internet is operated and run by commercial businesses. This means that as these businesses look forward at the projected demand their networks will be required to meet, they will be dedicated to finding ways that maximize what they already have rather than investing in infrastructure that would ultimately need to be pieced together - not based on a brand new architecture or a holistically designed solution. And with $20 billion in OTT revenue expected by 2015, this grave problem requires a dramatic solution.

REDESIGNING THE ON- AND OFF-RAMPS TO ENABLE BETTER DELIVERY OF VIDEO

The goal of any infrastructure is to make it accessible, easy to use and reliable. It should be very much like the plumbing in your house. You know it needs to be installed and connected correctly, while working each and every time you need the water to run - for any and all purposes. Similar to our expanding highway system, we know it requires maintenance, improved access, expanded capabilities and the capacity to support different types of transportation vehicles. Internet infrastructure is expected to be very similar; a plug-and-play network that provides a satisfactory user experience even as end-user demands and utilization increase. Therefore, content providers and CDNs must find a way to continually improve the speed of content delivery while simplifying the process.

This evolution needs a redesigned on- and off-ramp system that must start somewhere. In today's content-driven world, the goal is to create a superior user experience while also alleviating the strain on the underlying network it relies on for delivery. This sounds like a dream come true!

However, on the one hand you have content providers and on the other you have network operators - both serving the same customers with competing goals that are not necessarily complementary. While content provider revenues continue to increase, network operator revenues are decreasing. Serving today's end-users are cable operators delivering fixed-rate voice, data and TV plans to meet a variety of budgets. But as content consumption increases, their rates stay the same while the investment required to support this demand increases. This dichotomy is the crux of our problem.

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- Clint Heiden, Chief Commercial Officer, EdgeConneX

In order for end-users to view content, it must first be accessed through an Internet provider who delivers data. As outlined above, the existing infrastructure today forces the providers to pick up content in major hubs, straining costs, adding latency and causing end-user frustration. What if we revisited the way that we store and access the data? Today's model of 'bigger is better' data centers that are built to serve the needs of everyone are not focused or specialized enough to support the simplest needs of content delivery: content at the edge. CDN providers want and need the ability to host its content as close to the end-user as possible in order to assure the best user experience available.

SOLUTION: A NEW EDGE TO THE INTERNET

As explored, end-users are demanding that their cable networks provide high quality broadband Internet access globally. Furthermore, the rise in popularity of OTT content provides a two-fold challenge for cable operators: 1) demand threatens traditional video revenue streams and 2) drives the need to increase capacity, which requires heavy investments in broadband infrastructure. Therefore, new strategies must be implemented to help providers cope with the traffic growth and demand on their existing networks while they continue to provide services and deploy emerging network technologies to continue overall improvements.

Network caching is not new. As a matter of fact, companies like Cisco tout transparent caching, the technique used to transparently intercept traffic from a web browser and redirect it to a cache device to retrieve the content that was previously cached.[11] This type of solution helps network and cable operators in a number of ways by:

- Reducing network costs associated with expanding backbone network and Internet transit links;
- Improving end-user experience by bringing content closer, increasing the quality for the users;
- Identifying and saving popular content as close to the subscribers as possible; and
- Supporting OTT traffic while managing CDN and multi-screen services.

Combined, caching technologies alleviate strain on long haul and regional networks while providing a higher quality and more reliable experience for end-users. This is the goal of EdgeConneX and its Edge Data Center® solutions.

The new way people use the Internet requires a new perspective on the way networks access and store content, as well as where they store it and thus deliver it to end customers. EdgeConneX's goal is to enable this by providing content and caching network providers with greater and more reliable access to local connectivity in order to distribute content locally – where the eyeballs are aggregated.

WHAT THE NEW EDGE LOOKS LIKE

The new edge of the Internet is made up of localized colocation and data center facilities that are purpose-built to provide local and metro network connectivity, while hosting content that will be accessed and delivered over the local network. Where these facilities are located matters immensely. Identifying and constructing network and

[11] "Transparent Caching with the Content Switching Module Configuration Example." Cisco. Cisco Systems, Inc., 30 Nov. 2005. Web. 5 Nov. 2013. http://www.cisco.com/en/US/products/hw/modules/ps2706/products_configuration_example09186a0080226359.shtml.

content 'warehouses' requires a physical location in proximity to the greatest number of users in the greatest number of locations. Furthermore, with the network and power demands required by content delivery solutions, space requirements are rather small in comparison to a core network location. Facilities can be right-sized and optimized to meet the specific needs of the hardware they will house. This means facilities that are 10,000 square feet or less will be capable of handling 7 kW to 20 kW per rack. The space, power and connectivity of an Edge Data Center focuses on providing the optimal environment for housing, accessing and delivering content faster and more reliably than ever before – creating superior end-user viewing experiences.

In a nutshell, EdgeConneX's edge of network solutions are creating a new edge of the Internet by constructing purpose-built 'content warehouses' across a distributed colocation footprint, strategically positioned nearest to key broadband provider aggregation points to ensure the best end-user experience. This solution alleviates the burden on today's overloaded network infrastructure. Not only does this provide a great user experience by improving latency and quality of service, reducing download times and ensuring reliable streaming, but it also improves the economics of delivering content – particularly OTT video that does not generate revenue for operators directly. This new edge is the evolution required to manage, deliver and support the growing demand of OTT video across the U.S. Internet infrastructure.

SUMMARY

Approaching the big bandwidth demands of end-users requires a new way of thinking about the physical layer of our infrastructure. As a community, we must rethink how we use the existing infrastructure and redesign the functionality in order to accommodate the new architecture required to support the thousands of data bits of information consumers continue to demand.

All of the research conducted by independent analyst firms, equipment providers and network operators indicates the same thing – continued demand for access to more and more bandwidth at cheaper rates with a much better user experience; a recipe that works for the content providers but not the network operators. Today, video is the first application that is breaking the network's ability to scale quickly and efficiently. Tomorrow it could be the way we use the Internet to drive our cars[12]. At the end of the day, it's not simply about 'making things faster,' it's about redesigning the information highway in order to accommodate growing amounts of content so that the highway can deliver the content quickly, reliably and with consistency to consumers.

EdgeConneX has created an infrastructure designed to handle video on the Internet today and well into the future. Our Edge Data Centers ease the burden on long-haul network infrastructure while improving the speed, delivery and quality of the content hosted.

[12] "Self-Driving Car Test: Steve Mahan." Perf. Steve Mahan. Google Jobs. Google, n.d. Web. 4 Nov. 2013. http://www.google.com/about/jobs/lifeatgoogle/self-driving-car-test-steve-mahan.html.

The way we disseminate data across networks and how we get content to the homes and offices of the hundreds of million of users has redefined the way we look at the edge of the Internet. The evolution has begun. Join EdgeConneX in redefining the infrastructure of the Internet to create a better user experience while alleviating the strain on the underlying network.

Learn more by visiting www.edgeconnex.com.