AKAMAI WHITE PAPER

Improving Online Video Quality and Accelerating Downloads

The FastTCP Network Enhancement

Akamai
FASTER FORWARD

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OVERVIEW

The Internet was not designed for speed. In the early '80s, the original architects were focused on reliability, and speed was a secondary concern. After all, how fast does a network need to be for text? Today, all of that has changed. People now spend a substantial amount of time online consuming their daily news, watching movies and TV shows, playing games, downloading music, and updating software. With increased usage of the Internet, speed is now the focus – and reliability is just assumed. An ideal solution to increase speed is to improve throughput by enhancing the protocols used to transmit data over the Internet, in a manner that does not require any new hardware or software.

Transmission Control Protocol (TCP) is the mainstream standard protocol for sending files and transferring data on the Internet and was designed to ensure the accurate delivery of data between computers. TCP's reliability is what has contributed to its longevity. However, TCP's limitations become apparent as more visitors experience poor quality due to low throughput caused by long latencies and high packet loss. As the need for an enhanced version of the protocol became clear, a new, enhanced standards-compliant version of traditional TCP was developed now known as FastTCP.

This whitepaper discusses why speed, or throughput, is so critical for today's Internet users, provides a historical perspective on the Internet's TCP protocol underpinning and describes how the FastTCP protocol addresses the needs of today's Internet. Finally, some comparative data is presented showing the improvements that have been gained by using FastTCP across the Akamai Intelligent Platform™.

THE NEED FOR SPEED

Speed is crucial in today's fast-paced world, especially on the Internet. People spend a substantial amount of time online consuming their daily news, watching movies and TV shows, playing games, downloading music and updating software. Coupled with the rise in Internet usage has come an expectation for near-instantaneous content delivery. Internet users further expect their online experience to be superior in quality, with a quick start-up time and no interruptions. Whether they are streaming an online video news clip, watching a sporting event or downloading a favorite song, a high-quality experience has become the expectation.

Let's look at the impact of speed and online video quality on user behavior. Studies have shown that poor web experiences result in a loss of viewership, loyalty and brand equity for sites. One prominent study titled "Video Stream Quality Impacts Viewer Behavior"[1] by Dr. Ramesh Sitaraman, one of the world's leading authorities on Internet-scale distributed systems and services, confirmed this phenomenon. The study revealed that a 2-second delay in video streaming caused by start-up time triggers significant abandonment rates, with each additional second having a 5.8% viewer drop-off; at the 10-second mark, over a 45% decline in viewership is recorded as seen in Figure 1. The study further determined that a viewer who experiences a rebuffer delay equal to 1% of the video duration plays 5% less of the video in comparison to a similar viewer who experienced no rebuffering. Finally, the study concluded that a viewer who experienced a failed video startup is more than 2% less likely to revisit the same site within a week than a similar viewer who did not experience a failure, suggesting adverse effects on brand perception.

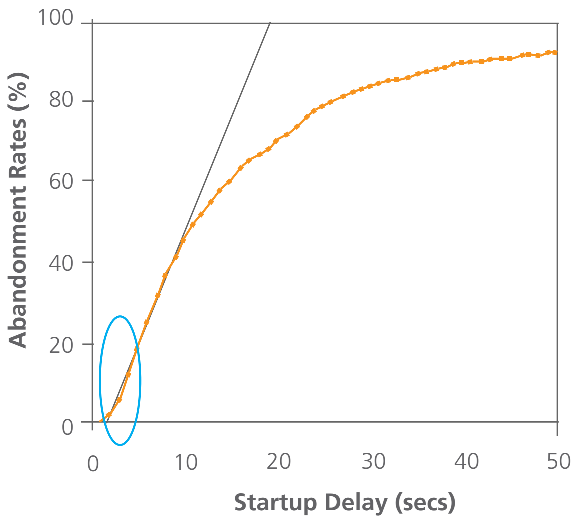


FIGURE 1: ABANDONMENT RATES BY STARTUP TIME. VIEWERS BEGIN TO ABANDON WHEN THE VIDEO STARTUP TIME EXCEEDS 2-SECONDS, WITH EACH ADDITIONAL SECOND HAVING A 5.8% VIEWER DROP-OFF

As video streaming traffic rates continue to increase, too many packets are sent over networks with limited bandwidth, causing them to become congested and backlogged. For the average visitor looking to stream a video, this translates into slow startup time, increased buffering or in some cases no availability for a video stream. These negative experiences directly impact the bottom line of video content providers who rely on video advertising and who value repeat visitors because they are highly engaged, loyal and consume more content. The need for speedy content delivery is no longer an option for online video distributors, but has become a necessity to compete and thrive in a faster paced, more connected world.

Now, let's look at how speed affects online downloads. Across the software landscape, delivering large files to increasingly impatient consumers by having them download a software update that takes several minutes is no longer acceptable. Companies that distribute software as a business model have to make sure the download time and consumer experience matches consumer expectations. Otherwise, these businesses risk tarnishing their brand and losing customers to competitors.

Armed with an understanding of the importance of speed on the Internet and how poor performance affects both viewers and companies alike, an examination of what causes the Internet to be slow provides the basis for evaluating the latest technology being deployed to help speed things up.

Regardless of available bandwidth, low throughput is at the heart of poor quality experiences on the Internet. Researchers studying the problem have identified long latencies and packet loss as key impediments to throughput. As the Internet has become more congested, researchers have begun to investigate existing Internet protocols that govern much of today's Internet data transmission and directly affect throughput. One of the foundation protocols on which the Internet was built, Transmission Control Protocol (TCP), behaves rather poorly in high latency/high packet loss applications and has become the focus of enhancements designed to improve Internet performance.

[1] *Video Stream Quality Impacts Viewer Behavior: Inferring Causality Using Quasi-Experimental Designs" by Principal Dr. Ramesh Sitaraman, a faculty member at the University of Massachusetts at Amherst and an Akamai Fellow*

TRANSMISSION CONTROL PROTOCOL

TCP is the original protocol for sending files and transferring data on the Internet. The HTTP protocol, which the World Wide Web was built on, uses TCP. TCP was first introduced in 1974 by Vinton Gray Cerf and Robert Elliot Kahn, both recognized as "the fathers of the Internet"[2], and remains in today's Internet. Over 90% of applications are built on top of TCP, and TCP has been included as a standard component of all OSs since about the mid-1990s. Traditional TCP was designed to ensure the accurate delivery of data between computers, and its reliability is what has contributed to its longevity.

The way TCP ensures file delivery is through a process of assured data transfer that involves sending data over the network in packets and receiving confirmation that the packets were transferred successfully. Once the sender receives delivery confirmation, it will send another packet and begin to slowly increase the speed. TCP can send multiple packets of data in a group and then wait for the acknowledgement for them all before sending another group. The size of this group is referred to as the TCP window. By increasing the number of packets in a window (the "window size"), the throughput of the connection is increased in a process known as congestion control. The purpose of congestion control is to limit the rate of data transfer in relation to how much the network can accommodate successfully without being overwhelmed.

TCP steadily increases the speed of file transfers by increasing the window size, or expanding the number of packets it sends without receiving an acknowledgment; however, when there is packet loss due to congestion, the algorithm deployed for congestion control quickly decreases the rate of packet transfer by cutting the size of this window almost by half, as depicted in Figure 2. An analogy used to describe this inefficiency would be cooking stew on a stove with an on/off switch and no temperature control. The result is that the stew constantly boils over before the stove is turned off in order for it to cool down, only to be turned on again for the stew to boil over once more.

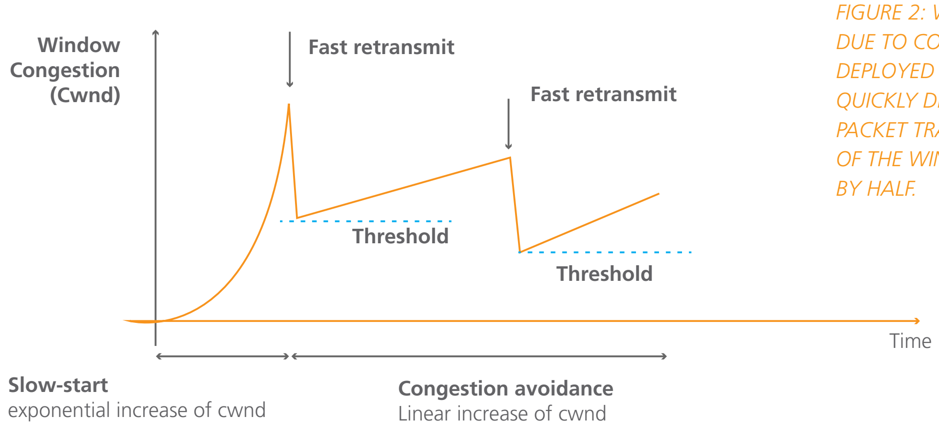


FIGURE 2: WHEN THERE IS PACKET LOSS DUE TO CONGESTION, THE ALGORITHM DEPLOYED FOR CONGESTION CONTROL QUICKLY DECREASES THE RATE OF PACKET TRANSFER BY CUTTING THE SIZE OF THE WINDOW CONGESTION ALMOST BY HALF.

When TCP was first introduced, its designers had a far greater need to be concerned with reliable data transmission than speed given that Internet volumes were extremely low by comparison. Today, the Internet handles huge amounts of data as well as live events attended by millions of viewers around the world. As a result, the inefficiency of TCP has become increasingly apparent with greater network congestion errors due to lower throughput and packet loss.

Out of increasing necessity, researchers as far back as the '90s began exploring a solution to TCP's limitations that would accelerate large file transfers and serve high-quality video streams for companies in a seamless, efficient and inexpensive fashion. They knew the ideal solution would not require a complete overhaul of the Internet, or for companies to pay for expensive hardware or software upgrades, costly maintenance or additional staff to manage a new system. An innovative new technology would counter traditional TCP limitations to provide both greater speed and reliability to improve end-user experiences. This solution, known as FastTCP, is available today as part of the Akamai Intelligent Platform.

[2] *http://en.wikipedia.org/wiki/Vint_Cerf*

AKAMAI'S FASTTCP OVERCOMES TCP LIMITATIONS

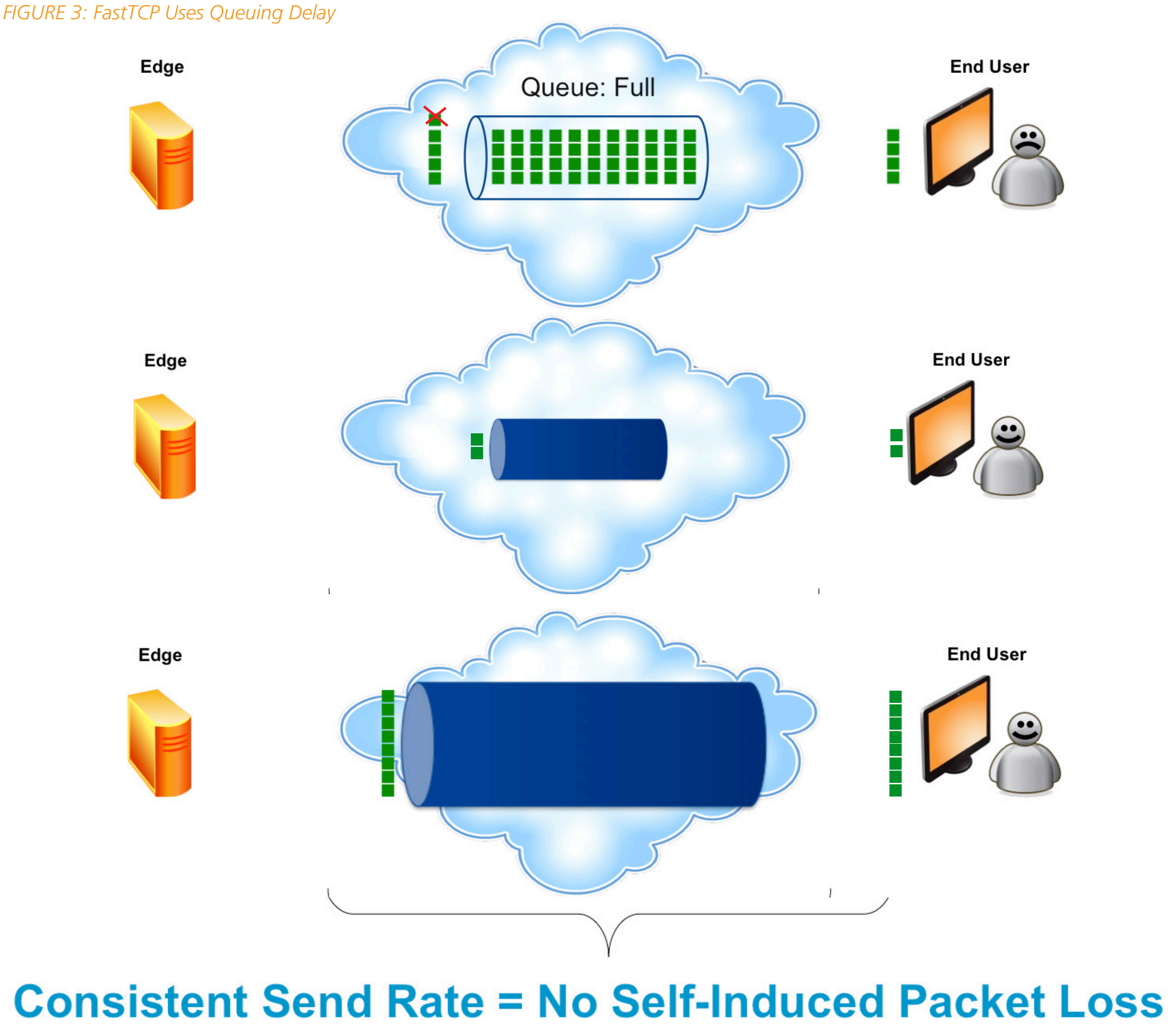
A new enhanced standards-compliant version of traditional TCP was developed at CalTech in 2003, adding a missing congestion control capability that avoids network congestion and the associated packet loss.

This new version of TCP became known as FastTCP and is protected by several patents. Standard TCP detects congestion and slows down when it detects that packets are being dropped, so the average sending rate depends on the loss probability. Relying on low loss probabilities to sustain high data rates is ineffective over congested networks. FastTCP employs a new algorithm that maintains an optimal packet send rate without exceeding the network's available bandwidth. The way this algorithm functions is by using what is called queuing delay instead of packet loss for congestion control. This allows for better optimization of throughput as illustrated in Figure 3. FastTCP can only help if there is excess available bandwidth that loss-based TCP cannot take advantage of.

The role of congestion control is to moderate the rate at which data is transmitted, according to the capacity of the network and the rate at which other users are transmitting. Congestion control in FastTCP looks to support a continuous queued flow of packets throughout the network. Using a TCP flow's round-trip time (RTT), the number of packets waiting in queues for the TCP flow can be estimated by the difference between the minimum RTT observed when there is no queuing and the current measured RTT. As a result, when there are few packets queued, the transmission speed can quickly increase, while if there are too many packets queued, the speed can be optimally decreased.

This allows FastTCP to remove the slow ramp up and excessive slowdown characteristic of traditional TCP by employing a more "intelligent" congestion-control algorithm. As a result, FastTCP can more effectively transfer data across a network while avoiding overflows.

FIGURE 3: FastTCP Uses Queuing Delay



FastTCP is a better protocol because of the advantages of delay as a measure to control network congestion to improve throughput, offering:

- Best use of available bandwidth
- Resilience to random packet loss
- Reduced additional delay added by loss-based protocol over slow links
- No requirement for special hardware or client software
- Reliability with significantly improved throughput

FastTCP is 100% backward compatible with TCP and can be deployed as a sender-side only implementation — with no client side software required. In fact, the sender uses FastTCP while the receiver is running standard TCP. This is the only practical solution for media and large file distribution to the masses. The benefits of FastTCP are maximized by deploying it across the largest possible number of network elements that send packets to users, which is where the Akamai Intelligent Platform comes in. By deploying the FastTCP protocol in Akamai's Edge servers, which serve 15-30% of the Internet's traffic, FastTCP's benefits are available to Akamai's customers and the consumers of their online content.

Akamai acquired the FastTCP technology[3], its experts and patents and with the Akamai Intelligent Platform, has the sole ability to deploy this technology ubiquitously. Akamai's deployment brings the benefits to a global population faster than would be possible otherwise.

AKAMAI'S FASTTCP ACCELERATES VIDEO DISTRIBUTION & DOWNLOADS

Akamai's deployment of FastTCP across the Akamai Intelligent Platform now makes the benefits of FastTCP widely available and accelerates both video streams and software downloads for improved live and on-demand streaming, progressive media downloads (PMD), and HTTP downloads around the world. Streamed video from Akamai can now sustain higher bitrates, less rebuffering and faster startup time, while file downloads are completed faster. The resultant higher quality viewing and download experiences make for much happier users, higher engagement rates and more monetization opportunities for Akamai customers.

For customers that only have a single bitrate video file that uses progressive media downloads, Akamai's FastTCP will deliver a better quality performance. FastTCP delivers higher bitrate files in the same amount of time as a lower quality bitrate file that was used before the FastTCP deployment.

FastTCP has allowed for greater audience viewability by improving performance for the end user. Audiences that had an average video performance prior to the FastTCP deployment now have an improved performance. FastTCP has increased end user quality-of-experience by raising the average throughput and thereby increasing the fraction of the audience that can receive commercially acceptable video quality.

During the initial deployment of FastTCP across Akamai's platform, we measured the benefits for some major network providers in the following regions:

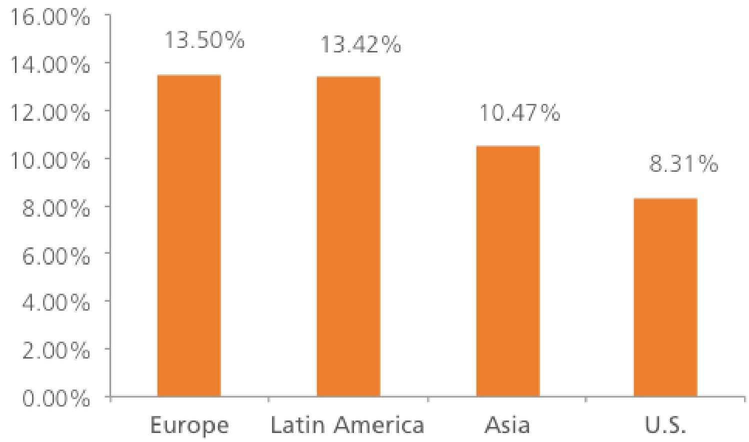
- Average delivery of content from outside of China into China saw a 40% throughput improvement
- India: 19% average throughput improvement
- Switzerland: 24% average throughput improvement
- Canada: 10% average throughput improvement

[3] *Akamai Acquires FastSoft: http://www.akamai.com/html/about/press/releases/2012/press_091312.html*

Using Akamai's Analytics solution to measure before and after deployment of FastTCP showed enhancements in the quality of streaming video content. The enhancements are helping Akamai customers enjoy faster startup times across different accounts all over the globe, as seen in Figure 4, substantially increasing end-user satisfaction and engagement times. In addition, rebuffering improvements in excess of 40% were observed in sampled networks in the U.S., India and Europe. These improvements have dramatically reduced the number of times a video stream delivered by Akamai pauses or stalls, which has been shown to increase viewer retention rates.[4]

Percentage of Improvement in Startup Time with Video Streaming Across the Globe

FIGURE 4: WITH FASTTCP'S DEPLOYMENT ACROSS AKAMAI'S INTELLIGENT PLATFORM, STARTUP TIME HAS IMPROVED ACROSS DIFFER-ENT ACCOUNTS WOLDWIDE..



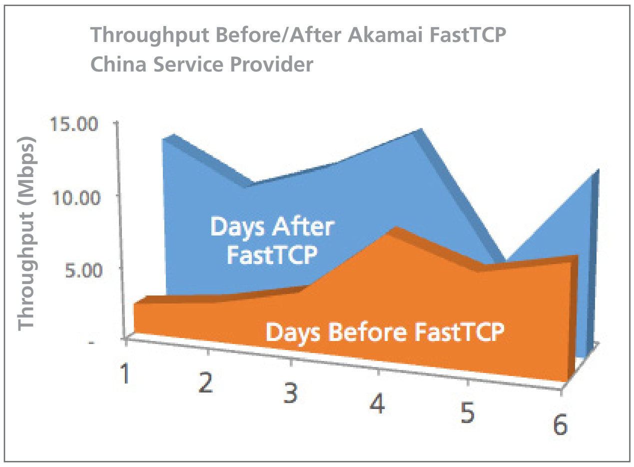
BENCHMARKS

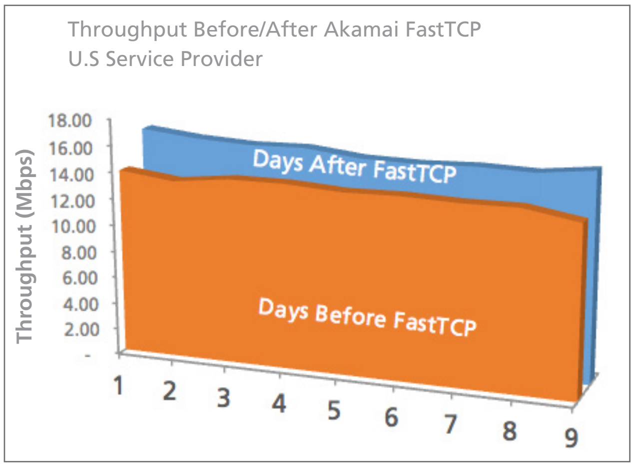
Additional benchmark testing performed during Akamai's worldwide network deployment of FastTCP shows that average throughput collected from sample regional networks a week before and after the FastTCP deployment indicated significant improvements in certain customer and end-user requests. The results ranged from 8% in Japan to 22% in Europe for increased improvement in download time for music/MP3s, games and videos.

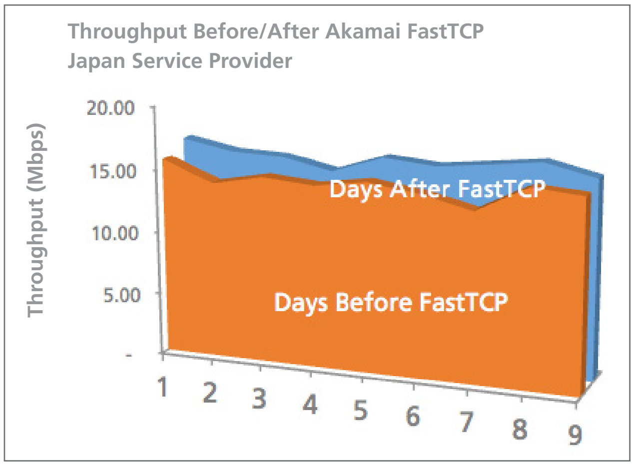
The charts below show the positive impact on throughput provided by FastTCP across five global regions.

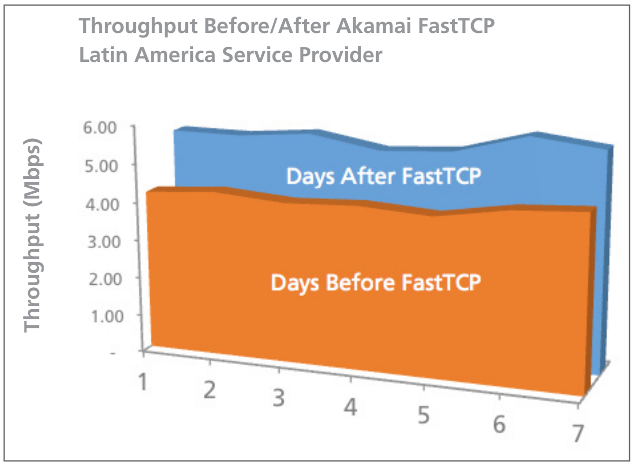
	China	U.S.	Japan	Latin America	Europe
Mean Before FastTCP	5.34	13.64	14.82	4.31	9.64
Min. Before FastTCP	1.40	12.89	13.57	4.16	6.31
Max. Before FastTCP	8.63	13.99	15.86	4.60	10.87
Mean After FastTCP	10.94	15.65	16.00	5.60	11.73
Min. After FastTCP	5.56	15.25	14.83	5.34	11.30
Max. After FastTCP	14.21	16.40	16.81	5.98	12.38
Mean Improvement	105.00%	14.80%	8.00%	29.80%	21.70%
Min. Improvement	298.40%	18.30%	9.30%	28.30%	79.10%
Max. Improvement	64.60%	17.20%	6.00%	30.10%	13.90%

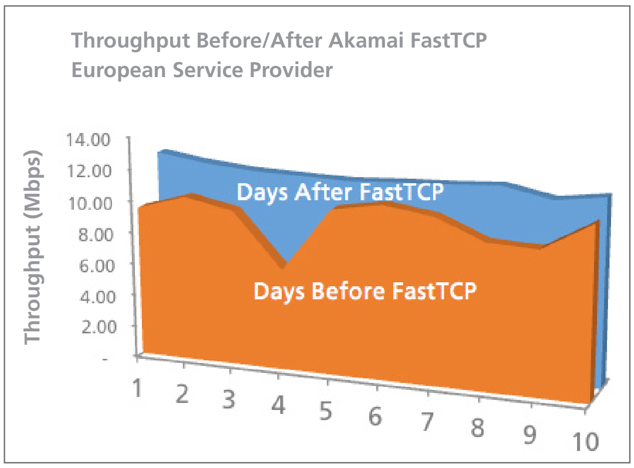
[4] *Akamai Press Release: Akamai Introduces Advanced Technology to Speed Downloads and Improve Online Video Quality Across its Global Platform - September 13, 2013*


Throughput Before/After Akamai FastTCP
China Service Provider
Throughput (Mbps)
15.00
10.00
5.00
-
Days After FastTCP
Days Before FastTCP
1
2
3
4
5
6


Throughput Before/After Akamai FastTCP
U.S Service Provider
Throughput (Mbps)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
-
Days After FastTCP
Days Before FastTCP
1
2
3
4
5
6
7
8
9


Throughput Before/After Akamai FastTCP
Japan Service Provider
Throughput (Mbps)
20.00
15.00
10.00
5.00
-
Days After FastTCP
Days Before FastTCP
1
2
3
4
5
6
7
8
9


Throughput Before/After Akamai FastTCP
Latin America Service Provider
Throughput (Mbps)
6.00
5.00
4.00
3.00
2.00
1.00
-
Days After FastTCP
Days Before FastTCP
1
2
3
4
5
6
7


Throughput Before/After Akamai FastTCP
European Service Provider
Throughput (Mbps)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
-
Days After FastTCP
Days Before FastTCP
1
2
3
4
5
6
7
8
9
10

Akamai FASTER FORWARD

As the global leader in Content Delivery Network (CDN) services, Akamai makes the Internet fast, reliable and secure for its customers. The company's advanced web performance, mobile performance, cloud security and media delivery solutions are revolutionizing how businesses optimize consumer, enterprise and entertainment experiences for any device, anywhere. To learn how Akamai solutions and its team of Internet experts are helping businesses move faster forward, please visit www.akamai.com or blogs.akamai.com, and follow @Akamai on Twitter.

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