

# Live & On-Demand Video Delivery *without* Interruption

*Wireless optimization – the unsolved mystery*



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*- Improving the way the world connects -*

WHITE PAPER

## Live On-Demand Video Streaming without Interruption

Adaptive bitrate and content delivery networks:

*Are they enough to achieve high quality, uninterrupted Internet video streaming?*

The short answer is “no.” This paper will discuss a new video streaming technology called **transport acceleration**, along with how it can be deployed to deliver the uninterrupted, high quality video viewing experience today’s wirelessly connected Internet user expects.

The transformation of the Internet into a video delivery platform is driving the need for reliable and fast content delivery services. According to a Cisco Systems report, ninety percent of today’s Internet traffic is video -- with Netflix alone accounting for 21 percent of that traffic. Cable companies, pay-per-view and broadcast networks, online media companies, and motion picture production/distribution services are searching for ways to improve the end user experience. This is necessary in order to overcome the challenges of delivering video content smoothly, at high resolution, and without the frustrating interruptions of re-buffering.

Since streaming video technology was introduced in the 1990s, new Internet protocols and data delivery technologies have been developed to provide a better viewer experience. Two of the most prominent developments in this area are adaptive bitrate streaming and content delivery networks (CDNs).

These new developments have considerably improved video streaming and quality. However, the stakes have been raised with the rapid growth of video traffic, the advent of HD streaming content (which requires high throughput rates), a growing consumer expectation for cable-quality delivery, and most recently, the growing demand of video delivery across the “wireless last hop.”

Even with these changes to the way video is transported on the Internet, web-delivered video can still be low resolution with jerky delivery. That’s due to the unpredictable nature of data transport and latency on the Internet. No matter how quickly you transfer content over the wired Internet, the last link is increasingly a wireless hop to a customer’s laptop, tablet, or smartphone. The “bursty” nature of Internet traffic, and the constantly changing latency on a wireless network, results in frequent network congestion. This holds up video packets and starves the receive buffers on a video player, resulting in a pause for more data to refresh the buffer. This “pause” happens regardless of the bandwidth between the streaming server and the wireless or mobile access point just before the “wireless last hop.”

### Transport Acceleration

The stakes are high in the world of streaming video, as user frustration can kill a business model. Thus, the industry is adapting new technologies that promise to end buffer refresh pauses. A new method has recently been introduced called *transport acceleration*, which complements both adaptive bitrate and CDNs to deliver an even better user experience for streaming video.

Transport acceleration boosts the speed of the video data from the server to the user – whether it’s coming from an “origin” server or from a CDN edge PoP. By accelerating the data, this technology replaces “bursty” traffic patterns with a more even and high-speed data flow that is ideal for video and other real time traffic. This traffic flow keeps video player buffers full, so that the video player is rarely waiting for content. This is only effective if the **wireless last hop** is addressed along with normal wired Internet congestion issues.

This eliminates annoying buffering pauses and other delays, delivering a completely smooth viewing experience. Transport acceleration also delivers the highest quality video image because the adaptive bitrate technology does not need to constantly adjust the resolution of the video in order to decrease buffering.

Transport acceleration technology is integrated into a network near the video server – either the origin server or the CDN PoP. This means that distance and the last mile connection quality are not issues, because the video stream is accelerated all the way from origin to the end-user through the wireless last hop.



## Techniques for Improving Video Quality

The success of YouTube (and other early streaming video players) has led to new market entrants that offer either for-pay or ad-supported video models – both of which require great performance to attract and keep viewers. This, in turn, has helped to spur the evolution of the HTTP protocol to support adaptive bitrate streaming to improve video performance.

Many companies are deploying adaptive bit rate technology to automatically adjust to end-user bandwidth fluctuations. The downside to this is that as the user connection fluctuates, the bit rate will adjust up and down, so the user experience can be negatively impacted. Badu stabilizes the stream of data, keeps the buffer full, and ensures that the highest bit rate is delivered at all times.

Adaptive bitrate streaming technology is embedded into leading computer and tablet video players, and communicates with the video server to control the video flow. It replaces earlier protocols such as the real-time transport protocol (RTP) and the real-time streaming protocol (RTSP).

Adaptive bitrate streaming works by monitoring the user's bandwidth throughput and CPU performance in real-time -- adjusting the quality of the stream accordingly throughout the viewing experience. The technology automatically adapts to the user's network and playback conditions when those conditions change, resulting in streaming video that is of much higher quality than was previously possible.

Adaptive bitrate delivers faster start times and lowers the amount of buffering to deliver a smoother stream. But the inherent promise of constantly adjusting the speed of the stream to reduce buffering also compromises the speed and steadiness of the stream, resulting in fuzziness and distortion. This problem is exacerbated by new high definition (HD) technology, which is higher resolution and therefore more data heavy. In many cases, the resolution of an HD stream will be diminished drastically to keep up the steady flow of the video, and sometimes even that's not enough to prevent a buffer refresh. The introduction of Ultra HD (UHD) is only going to make this worse.

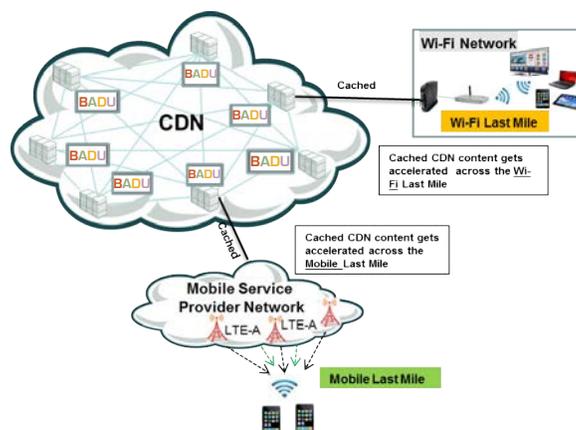
## CDNs

Another solution for Internet video is the content delivery network. CDNs deliver faster start times by caching video content in servers spread out geographically in points-of-presence (PoPs) that are close to end-users. A copy of the video is stored in each of these servers, oftentimes in multiple resolutions. When a user requests that video, the request is routed to the PoP closest to them, shortening the distance the content has to travel and improving quality by reducing latency. CDNs are complementary to adaptive bit rate streaming technology, and can be used together to provide even higher quality streaming. Today's video content is typically streamed from a video server (located at a CDN or cloud) to a user's desktop computer, laptop, tablet, or mobile phone. A video player receives this continuous stream of data bytes and plays back the stream at a preset frame rate. Most video players require a certain number of bytes to be buffered in memory at any given time in order to ensure non-interrupted playback of the content. If the amount of buffered data falls below this threshold, the player stops playing the video stream until the buffer fills up again.

There are two solutions to keep the buffer full, and prevent interruptions in video playback. The first solution delays the start of video playback until a sufficient number of bytes have been received; it then continues to receive the rest of the content. The second solution only buffers slightly more than the threshold, and relies on the data bytes being streamed just in time to avoid emptying the playback buffer.

The second solution works well in a LAN environment, but it usually doesn't work at all over the Internet because today's TCP cannot adequately sustain high download speeds. Thus, most content providers use the first solution, where video clips are downloaded in their entirety (even if a user only watches the first few seconds). Most of the downloaded bytes will be thrown away, wasting bandwidth for both the content provider as well as the user.

But even the combined solution doesn't always result in perfect video. While CDNs get the content closer to the customer, they don't solve the buffering issue -- nor do they address the "last mile," or "wireless last hop." The "last mile" is the distance from the closest CDN PoP to the end-user's wireless router (or cellular network radio tower). The "wireless last hop" is the wireless portion of the end-to-end connection (the Wi-Fi network or mobile last mile on your cellular network) to the end user device.



WarpTCP™ from Badu Networks is the leading transport acceleration software solution. It is based on the company's auto-tuning approach which was developed to deliver content across both wired and wireless networks.

Badu technology helps solve this problem, to deliver just enough bytes for continuous playback without interruptions. The performance boost comes from two areas. First, WarpTCP™ can react and recover much better against high packet loss on paths with latency greater than 50ms. Second, WarpTCP™ is much smarter about tuning the send and receive windows for optimum throughput in challenging wired and wireless environments.

Badu transport acceleration combines patented algorithms to: (1) dynamically adjust data transfer rates to match congestion levels, (2) eliminate TCP slow-start, (3) recover lost packets much more quickly than normal TCP, and (4) auto-tune sender and receiver windows to maximize throughput.

WarpTCP™ accelerates dynamic websites, live and on-demand video streaming, virtualized desktops and file downloads by combining intelligent window sizing and smart congestion control to reduce the effects of frequently changing network conditions, network latency and packet loss. It accelerates streaming and downloaded videos across the Internet or private networks to improve quality and playback performance. Videos start up much faster and streaming is "smoothed out" to eliminate playback hiccups and delays. The following benchmark illustrates the benefit to video delivery over the mobile last mile.

Badu's WarpTCP™ is efficient in networks with extreme latency changes, like Wi-Fi and the Mobile last mile. This increases throughput and keeps packets flowing smoothly. It also recovers quickly from data and packet loss, smoothing out video transmission and enabling faster transfer speeds. Figure 1 shows the dramatic difference in throughput of video being streamed across an LTE-A network to a moving train.

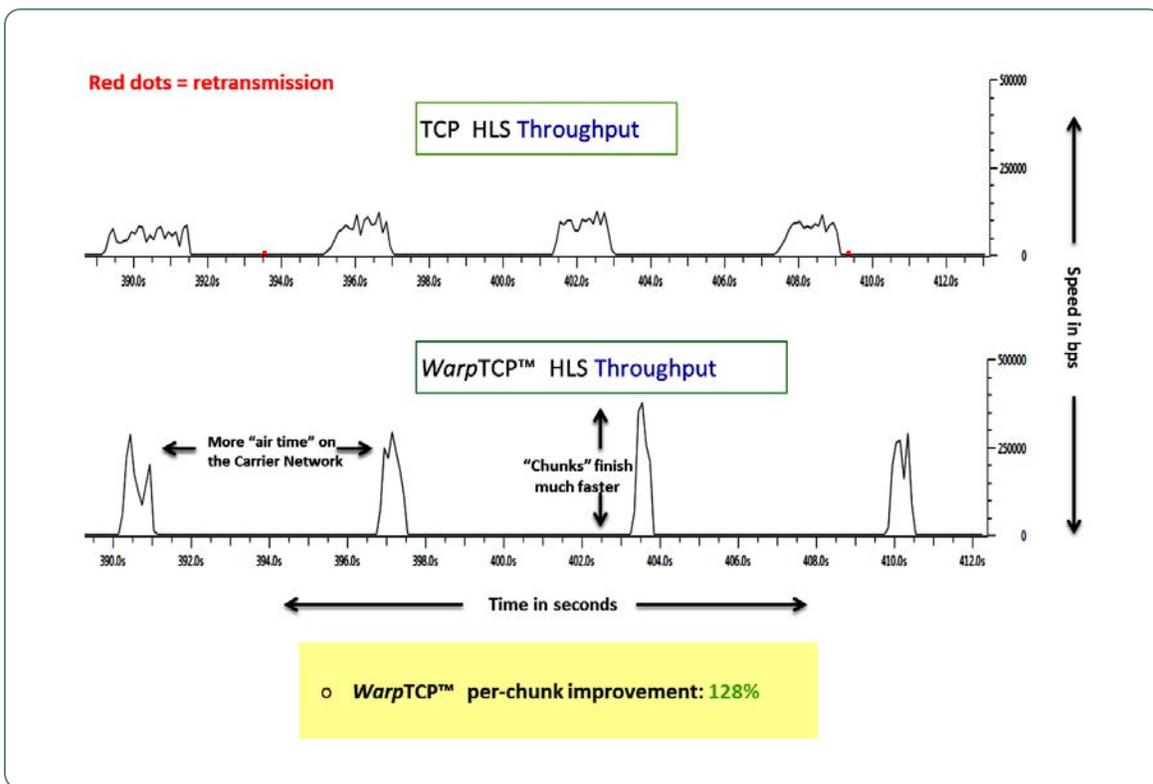
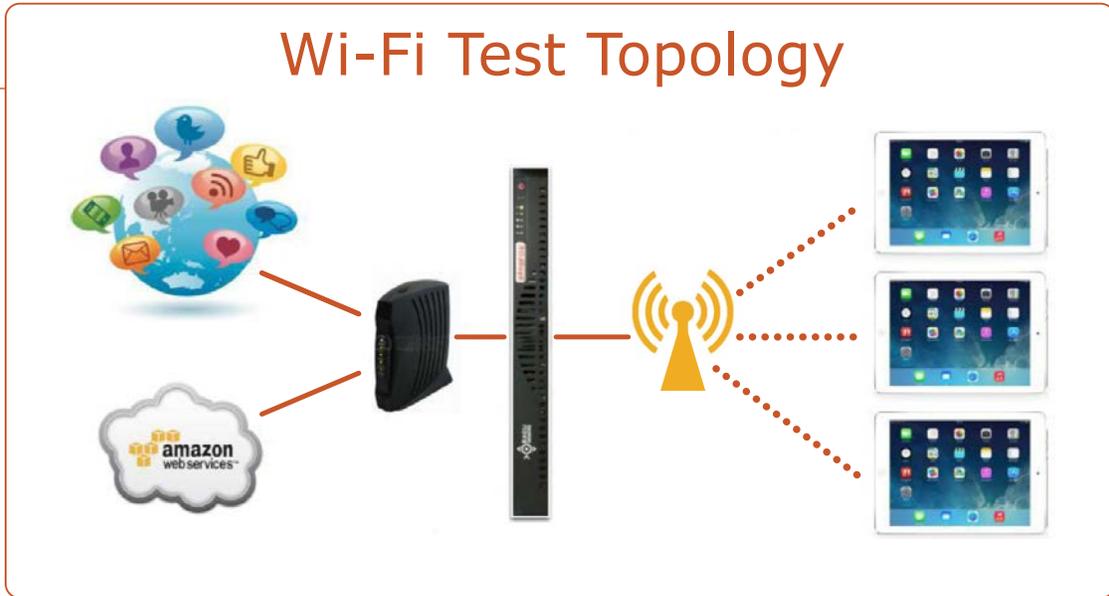


Figure 1

This picture shows the results of a test with and without Badu applied. Content was delivered from a wireless carrier network. With Badu acceleration turned on, initial start time decreases dramatically. Video chunks finish much faster, freeing up network bandwidth. Badu smooths the performance by eliminating re-buffers.

## Test Bed Setup



## Test Results

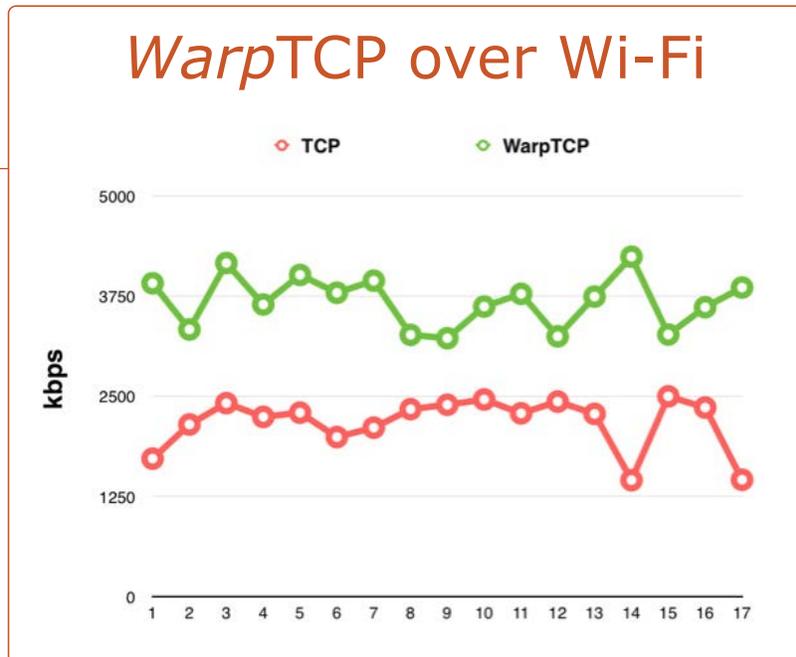


Figure 2

Test results for 900KB download over a Wi-Fi Network

Badu works in conjunction with CDNs and adaptive bitrate solutions when cached content is stored near the end-user. This results in the best streaming media experience possible by stabilizing the video stream and minimizing the effects of packet loss and jitter. It ensures that the data stream from the server to the end-user's video player is constant, with minimal delay. This virtually eliminates delivery problems in the last mile including the wireless last hop.

Adaptive bitrate technology also benefits from Badu technology, which ensures that the bitrate maintains maximum quality and buffer refreshes are minimized.

## Conclusion

Advancements in network technology and Internet protocols have opened up a whole new world of entertainment for web users. This is also a golden revenue-generating opportunity for any OTT (over-the-top) business model deployed by cable companies, pay-per-view networks, broadcast networks, and online media companies to offer streaming media services over the Internet for the future.

When the technology was in its infancy, early adopters were so excited about the availability of streaming media on their computers that they were willing to overlook poor picture quality and frequent pauses. The technology has advanced, and streaming media has become a prevalent form of entertainment for even the most technology-ignorant users. Poor quality and frequent buffering pauses are no longer tolerated—especially if the user has paid a service provider for the content.

New network technologies and delivery models are needed to deliver the quality that people want, improve speed, and ensure consistent data delivery. With adaptive bitrate streaming, a content delivery network, and transport acceleration technology – like Badu’s *WarpTCP™* – content providers can be sure that the users are getting the best possible user experience.

