Optimizing live streams with peer-to-peer technology

White Paper

STREAMROOT
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Intended Readers

This White Paper is intended for online broadcasters, CDNs, video platforms and professionals all along the online video distribution chain.

Abstract

This White Paper introduces a new peer-based approach to live streaming to rise to the challenges of audience growth and ultra-HD technologies. It explains through statistics and a case study how peer-assisted video delivery can offer live streaming broadcasters a key competitive advantage, helping them scale to growing audiences, become less reliant on traditional network infrastructures, use traffic peaks to their benefit and greatly improve quality of service.
Live streaming: exponential growth and ultra-HD technologies leave broadcasters searching for solutions

An exploding market for live streams

Live streaming has become a key driver for the online video market. Skyrocketing consumption, increasing video quality and new uses have all contributed to staggering growth in this segment.

The power of real-time video content is vast and expanding. From sporting events to concerts, video game streaming and distance learning, live streams are taking center stage in both consumers’ living rooms and the online video industry.

Large-scale sporting events, sports news and post-game content are widely cited as the engine behind online video growth in 2014. According to the Adobe Digital Video Benchmark, sports streams grew 640% year-on-year, with events such as the World Cup in Brazil and the Sochi Olympics drawing record-breaking audiences.
For an idea of the magnitude, consider NCAA men’s basketball, whose 2014 opening weekend clocked in more individual live streams than the entire 2013 tournament.

Alongside sporting events, live video game streaming took off with massively popular e-sports and games like Minecraft. Twitch – where players can broadcast the game they are playing live to millions of viewers – generated more video traffic than HBO Go, and was acquired by Amazon for a whopping $970 million in August. Giants like Dailymotion have taken notice and begun to foray into this market.¹

### 4K and UHD technology

Live streams benefit from a loyal and engaged audience that seeks increasingly high-definition content across multiple screens: laptops, mobile and a new generation of OTT devices.

One of the most promising technologies is ultra-high definition (UHD), often referred to as 4k. As broadband penetration rises, platforms and cable operators are beginning to promise this kind of content (Vimeo, Netflix, Comcast via their streaming app on Samsung TVs). UHD technologies, however, come with challenges, as these files are 16 times larger than regular HD files, and thus require significantly greater bandwidth.²

#### The advent of 4k

| UHD files are 16 times larger than regular HD files. |

![Graph showing UHD TV sets (Millions)](image)

Source: Cisco VNI, 2014

Cisco predicts that more than 20% of connected flat-screen TVs will be UHD by 2018.
Broadcasters seeking solutions

Live streaming involves a unique set of technical challenges all along the supply chain. The stakes are particularly high when it comes to playout, where the slightest error can cause viewers to miss a crucial moment of the action. Files are exponentially larger; audiences are growing and are difficult to predict; broadcasters must adapt quickly to peaks by supplying bandwidth and caching video in various parts of the world.

Not surprisingly, outages are common as platforms struggle to cope with unprecedented demand: ESPN crashed when 1.4 million simultaneous viewers attempted to watch the US-Germany World Cup match; ABC’s debut live stream of the Oscars was down for most of the evening. Even the biggest actors with top-tier CDNs remain highly vulnerable.

Today many large players rely on a multi-CDN approach, where backup delivery networks act as fallbacks in case of a main server failure. Nevertheless, broadcasters still fear frequent network over-capacity and congestion. Even with multiple peering points and surrogate servers around the globe, unicast protocols ultimately fail to provide the reliability sought.

II. Peer-assisted delivery: optimize live streams by harnessing the power of your audience

The advantages of peer-assisted delivery

To ensure quality live streams without fear of server failure, broadcasters must reduce dependence on traditional delivery infrastructures. When combined with unicast delivery, peer-to-peer adaptive streaming can alleviate network congestion and help handle massive audiences.

Peer-assisted streaming allows viewers watching the same content at the same time to exchange video segments with other viewers rather than connecting to a server to obtain the content. The system is thus perfectly adapted to large groups of simultaneous users. It optimizes video playout as demand rises, and works better the more peers there are to share the video.

Peer-to-peer streaming can thus:

- **Free up congestion.**
  Data exchanges are decentralized, freeing up bandwidth and alleviating saturated networks.

- **Provide a natural defense against infrastructure malfunctions.**
  Peer-to-peer systems reduce dependence on CDNs and ensure that viewers can continue watching the live event even if part of the CDN infrastructure fails.

- **Reduce buffering and latency for viewers.**
  Each viewer collects the segment needed from the source that can provide it most quickly, significantly improving quality of service.

- **Cut bandwidth costs for broadcasters.**
  Initial tests show that costs can be cut by up to 70% with an effective peer-assisted solution.
StreamRoot’s approach to P2P streaming

StreamRoot offers cutting-edge peer-to-peer video streaming technology designed to optimize live streams. Our patent-pending solution is built on the latest Internet technologies and stands out from other solutions of this kind:

- **No plugins**
  Unlike other peer-to-peer systems, StreamRoot is transparent, requiring no plugin, extension or other installation from end users.

- **Optimized connections based on geolocation and network topology**
  Connections are faster and more efficient as peers are selected based on their location through topology-based prioritization algorithms. This is particularly useful for live events, which often feature concentrations of viewers in certain cities or countries.

- **Real-time analytics**
  StreamRoot’s user-friendly client dashboard allows content providers to monitor video playout statistics in real time: percentage streamed through the peer-to-peer network, bitrates, number of peer connections, etc.

- **No added latency**
  Peer-to-peer streaming does not add any downloading time on top of the latency inherent in streaming the live content.
To offer these advantages, StreamRoot leverages two new cutting-edge technologies. The first, WebRTC, allows direct and secure real-time communications between users without the problem of NATs and firewalls. It is included natively in browsers as a Javascript API, and is available as an open-source library distributed by Google for easy integration into any type of device.

The second is Media Source Extensions, another web standard designed for dynamic management of video streams directly in HTML5. Avoiding the need for cumbersome Flash systems, MSE has already been adopted by most browsers and is becoming standard for mobile devices, set top boxes and smart TVs.

Our technology can be decomposed into three main modules:

- **Media engine module** for adaptive bitrate streaming playback in HTML5 and Flash. It supports MPEG-DASH, Smooth Streaming and HLS. Dynamic adaptive streaming algorithms adapt to the viewer’s bandwidth to provide the best possible experience the user’s device and connection can offer at a given time.

- **Peer-to-peer module** for direct peer-to-peer data transfer between viewers. It uses multiple proprietary StreamRoot algorithms to optimize exchanges. Format agnostic, it can be used with DRMs and integrated into a custom player via a media interface.

- **Tracker** for establishing the peer-to-peer channel and dynamically selecting the best peers based on geographical and topological criteria. Built on lightweight and scalable technologies like Node.js and Redis, the tracker provides the security required by a professional video content distributor: geoIP and domain restriction, along with content integrity verification.

Today, StreamRoot provides the first and only workable peer-based alternative to unicast distribution that has been tested on a significant scale. The company has developed all of its algorithms in house, and has filed several patent applications for its various technologies.

StreamRoot is currently compatible with Internet browsers that have adopted WebRTC: Chrome, Firefox, Opera and soon Internet Explorer. Safari is likely to follow suit this year, in which case the solution would be available on all major desktop systems. Mobile (Android and iOS) and Smart TV compatibility is currently under development and is set to be fully functional during the year.
Case study on a Spanish soccer game

StreamRoot recently partnered with a Swiss platform that streams live sporting events.

The following data was taken from a 90-minute Spanish soccer match with a halftime report. The pilot was conducted with approximately 1,500 viewers tuning in from several continents, with the largest concentrations in Spain and Western Europe.

Parameters:

Maximum number of viewers participating in the trial: 1,500
Bitrate: 1,000 kbps
Geographical distribution:

<table>
<thead>
<tr>
<th>Country</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spain</td>
<td>80%</td>
</tr>
<tr>
<td>Argentina</td>
<td>6%</td>
</tr>
<tr>
<td>Switzerland</td>
<td>5%</td>
</tr>
<tr>
<td>Brazil</td>
<td>5%</td>
</tr>
<tr>
<td>Other</td>
<td>4%</td>
</tr>
</tbody>
</table>

Results:

40 to 50% peer-to-peer exchanges

As shown in Figure 1, StreamRoot consistently achieved between 40 and 50% peering, for a 40 to 50% reduction in bandwidth costs and network congestion.

Optimized pairing of viewers thanks to powerful geolocation algorithms

Connecting viewers who are close to one another facilitates data exchanges, minimizes latency, and reduces the risk of viewers needing to revert back to the server.

Figure 1: Amount of data streamed from the CDN and via P2P during the soccer game and halftime report
As illustrated in Table 1, the average distance between sets of peers decreased by more than three as the number of viewers increased from 100 to 1,500. This improvement speaks to the power of StreamRoot’s geoIP algorithms to intelligently select and connect viewers in the same geographical region, and to thereby optimize data exchanges.

Our analytics tools also allow broadcasters to identify where peers are located.

<table>
<thead>
<tr>
<th>Time</th>
<th>Control</th>
<th>First half</th>
<th>Halftime</th>
<th>Second half</th>
</tr>
</thead>
<tbody>
<tr>
<td>2:30</td>
<td>3:00</td>
<td>3:55</td>
<td>4:10</td>
<td>4:55</td>
</tr>
<tr>
<td>Number of viewers</td>
<td>100</td>
<td>800</td>
<td>1,500</td>
<td>1,200</td>
</tr>
<tr>
<td>Average distance (km)</td>
<td>850</td>
<td>281</td>
<td>257</td>
<td>282</td>
</tr>
<tr>
<td>Proximity of peers</td>
<td>100%</td>
<td>302%</td>
<td>331%</td>
<td>301%</td>
</tr>
</tbody>
</table>

Effective matching of viewers for balanced and efficient transfers
Table 2 below shows the average number of peers that each viewer was connected to during the game. On average, any given viewer could exchange segments with seven peers. The number of peers actively receiving data (leechers) was consistently equal to the number of peers actively sending data (seeders), indicating that data exchanges were balanced within the peering network; peers received as many segments as they sent.

Inactive peers are peers to which a viewer is connected but with which no data is exchanged. The average number of inactive peers per viewer remained under one for the large majority of the game, indicating that StreamRoot matching algorithms effectively paired viewers who could easily exchange segments.

<table>
<thead>
<tr>
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<td>2:30</td>
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<td>3:55</td>
<td>4:10</td>
<td>4:55</td>
</tr>
<tr>
<td>Number of viewers</td>
<td>100</td>
<td>800</td>
<td>1,500</td>
<td>1,200</td>
</tr>
<tr>
<td>Leechers (peers receiving data)</td>
<td>5.24</td>
<td>5.09</td>
<td>5.74</td>
<td>5.56</td>
</tr>
<tr>
<td>Seeders (peers sending data)</td>
<td>5.36</td>
<td>5.1</td>
<td>5.74</td>
<td>5.58</td>
</tr>
<tr>
<td>Inactive peers</td>
<td>0.92</td>
<td>1.14</td>
<td>0.57</td>
<td>0.64</td>
</tr>
<tr>
<td>Total peers</td>
<td>7.42</td>
<td>7.37</td>
<td>7.12</td>
<td>7.06</td>
</tr>
</tbody>
</table>
Download and upload speeds that ensured quality streaming

Table 3 shows the distribution of upload and download speeds obtained in the peer-to-peer network, as a percentage of P2P users falling into each speed range.

Table 3: download and upload speeds

<table>
<thead>
<tr>
<th>Speed Percentiles (kbps)</th>
<th>0-1000</th>
<th>1000-2000</th>
<th>2000-4000</th>
<th>4000-6000</th>
<th>6000-10000</th>
<th>10000-20000</th>
<th>20000+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum P2P download</td>
<td>27.12%</td>
<td>9.10%</td>
<td>27.64%</td>
<td>24.36%</td>
<td>10.82%</td>
<td>0.95%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Average P2P upload</td>
<td>62.41%</td>
<td>27.09%</td>
<td>9.72%</td>
<td>0.77%</td>
<td>0.01%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Maximum P2P upload</td>
<td>38.61%</td>
<td>5.01%</td>
<td>12.40%</td>
<td>17.61%</td>
<td>18.85%</td>
<td>7.21%</td>
<td>0.31%</td>
</tr>
</tbody>
</table>

In this table, the data for average download speeds has been omitted as the latter tend to hover around the bitrate*.

Maximum download speeds, on the other hand, were much higher, with more than 50% of users topping off at over 2Mbps. This result indicates that instantaneous peer-to-peer download speeds could be extremely rapid, and thereby could have allowed viewers to benefit from higher definition had adaptive bitrate streaming been available on this video.

When examining the average P2P upload data, we see that up speeds were on average close to the bitrate. A significant percentage of viewers, however, were able to upload at more than 2 and even up to 10Mbps. This capacity would allow them to act as “super seeders,” supplying segments to several others peers at once.

Lastly, the distribution of the maximum upload data towards even higher speeds indicates that viewers enjoyed large upload limits. Reasons for this include geographical proximity of peers, as well as StreamRoot’s smart signaling algorithms that take into account the ISP and network topology data of the peers.

**Conclusion:**

This first significant-scale use case allowed StreamRoot to confirm the power of its peer-to-peer technology on a live event. As more viewers tuned in, the effectiveness of its geolocation and matching algorithms rose, allowing for up to 50% bandwidth savings thanks to peer-to-peer exchanges. The company plans to build on this use case with tests currently scheduled with other live-streaming platforms on American basketball and European soccer games.

*There is no need to have speeds that are higher than the bitrate, as viewers cannot download content faster than it is made available.*
Live streaming is a driving force for the online video industry as a whole. As resolution increases, uses change and audience numbers multiply, tackling the technical challenges of streaming to large live audiences is becoming critical.

While improvements can be made all along the value chain, optimizing playout is especially important to keep audiences tuning in without buffering or unacceptable latency times.

In order to do this, broadcasters must find an alternative to traditional unicast broadcasting through CDNs.

Combined with CDN delivery, an effective peer-to-peer system can overcome the inefficiencies of unicast distribution without investing in heavy infrastructure. Peer-assisted delivery can free up congestion, improve latency, cut bandwidth costs and naturally safeguard broadcasters against server outages. Especially suited to large live audiences, peer-to-peer systems are increasingly effective as demand rises, the more peers there are available to share content.

StreamRoot’s proprietary, patent-pending solution leverages cutting-edge technologies to offer a highly effective peer-assisted playout. Through a plugin-free system, peers are selected intelligently via geolocation and matching algorithms, optimizing connections and turning large audiences into an asset.
About StreamRoot

StreamRoot offers a solution for video streaming combining standard unicast delivery (e.g. CDN) and peer-to-peer protocols based on HTML5 and WebRTC. Founded in France in 2013 by three engineers from Ecole Centrale de Paris, StreamRoot participated the Le Camping and Techstars Boston accelerator programs and has been recognized with numerous awards including the Trophée Startups Numérique and Hello Tomorrow Challenge.

At the leading edge of HTML5 adaptive streaming technology, StreamRoot created the first MPEG-DASH peer-assisted video player in HTML5 working for both Live and Video on Demand streaming, and has since expanded its expertise to other adaptive streaming formats and platforms. Using WebRTC, our Peer-to-Peer API creates an edge network made up of viewers, which relieves broadcasters’ server infrastructures and bandwidth without requiring any action from the end-user.

Now headquartered in the United States, StreamRoot is currently expanding its customer base in America and confirming the efficiency of peer-assisted delivery with large-scale use cases.

For more information or to try StreamRoot: contact@streamroot.io