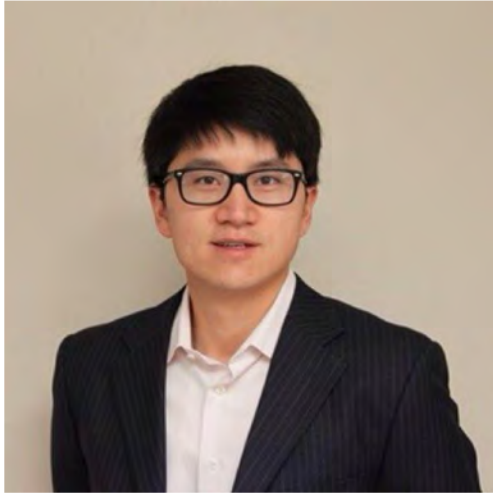




Low-latency Live Streaming at Scale

Yueshi Shen | August 2018, Denver

About Speaker



Yueshi Shen

Principal Research Engineer, Twitch

- In charge of Twitch's core video technologies: codec, HLS, ABR playback, video quality, low latency
- Inventor of AV1's Switch-Frame and has filed 15 patents
- Oversees Twitch's transcoder team
- Principal Engineer at OnLive, worked on ultra low latency (<100ms) video streaming
- Earlier career in the linear TV and semiconductor industries, worked on MPEG-2/H.264 ad splicing, ASIC H.264/SVC codec

yshen@twitch.tv

What is Twitch.tv?

World's largest live-streaming platform



Twitch In a Nutshell:

Easy video broadcasting, Interactive live streaming



twitch Following Browse Try Prime Search

P4wnyhof Videos 171 Clips Collections Events Edit Follow Subscribe

Ash 17
LATEST DONATION: curt513-43
TOP DONATION: Emmerich43
LATEST SUBSCRIBER: nms40234
Variety Stream! Player Unknown 80 00:26:59

P4wnyhof 13
This Dragon Priest is insane O_o - BattleGrounds for Charity Tournament!!!! ICharity 2,774 21,295,850 Edit Share

Hearthstone VarietyStreaming TUMILO

yshen watching P4wnyhof stream...

p4wnyhof

Top Cheer by Alierules 1601
INVITATIONAL - <https://goo.gl/wdP4By> You can find all Infos about the Tournament here: <https://goo.gl/aUP7Vp>

d0dg3myfart Hi!

obeymydog7: im enjoying wild myself with kazakus

maxthemilan: @Xygyg thanks bruh =)

hriBot: All games directly from the Publishers up to -70% cheaper at our Partner Instant-Gaming: <https://goo.gl/yhk44A>

hriBot: FREE P4wnyhof Subscription and other perks as an Amazon-Prime-Member. Try it out here: <https://twitch.amazon.com/prime>

RemberK: @P4wnyhof but if I'll not play wild i can disenchant everything out of rotation sure? i mean, i dont have money to buy a lot of packs

Nero_Evax: I want a new 1-cost murloc

lanGod: is it wild heroic brawl today?

Nicky205: will anything rotate out in jul/august? @P4wnyhof

Doctor_Apricot: any advice on how to get legendary rank these days?

Send a message Chat

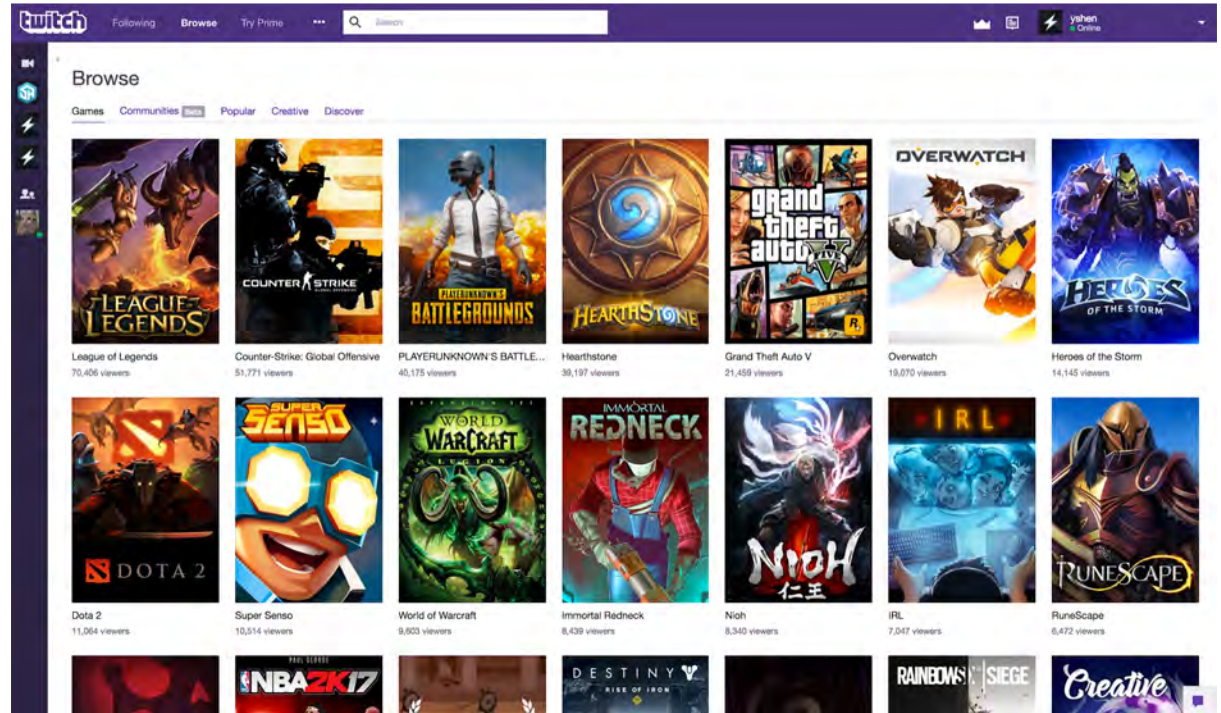
Content on Twitch.tv

Interactive Live & VOD

Games, eSports, original content

Community for gamers & creative arts

Social video platform



Twitch's Scale Numbers, 2017

15+

MILLION

unique daily visitors

2+

MILLION

unique monthly
broadcasters

355

BILLION

minutes watched

E3 2018 June 12-14

Windows Central

ORDER: [XBOX ONE X](#) | [SURFACE BOOK 2](#) | [NEW DELL XPS 13](#)

Xbox E3 2018 briefing sets Twitch record of 1.7 million concurrent viewers

Microsoft pulls ahead again.

15 Jun 2018



E3 2018 was an absolute blast for gamers because a lot of exciting titles were announced. Publishers like Microsoft and Sony showcased incredible experiences like [Gears 5](#) and a [Resident Evil 2](#) remake.

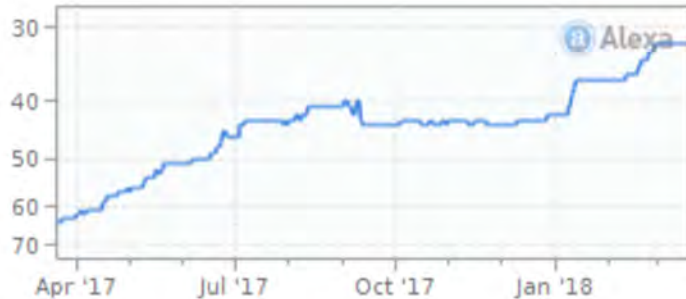
Twitch's Growth

How popular is twitch.tv?



Alexa Traffic Ranks

How is this site ranked relative to other sites?



Global Rank [?]

32 ▲ 11

Rank in [United States](#) [?]

13

Alexa Rank History:

2011/7	411,522
2012/1	2,344
2014/4	267
2017/1	73
Now	32

We are the 3rd most popular video website behind YouTube and Netflix

Interactivity:

Twitch's differentiation from linear TV



Live Demo & Broadcaster's Feedback

Piebo VOD recording: <https://www.twitch.tv/videos/279506342##>

Takarita clip: <https://clips.twitch.tv/TemperedIntelligentCheddarRiPepperonis>

Traditional Live Broadcast vs. Interactive Live Streaming



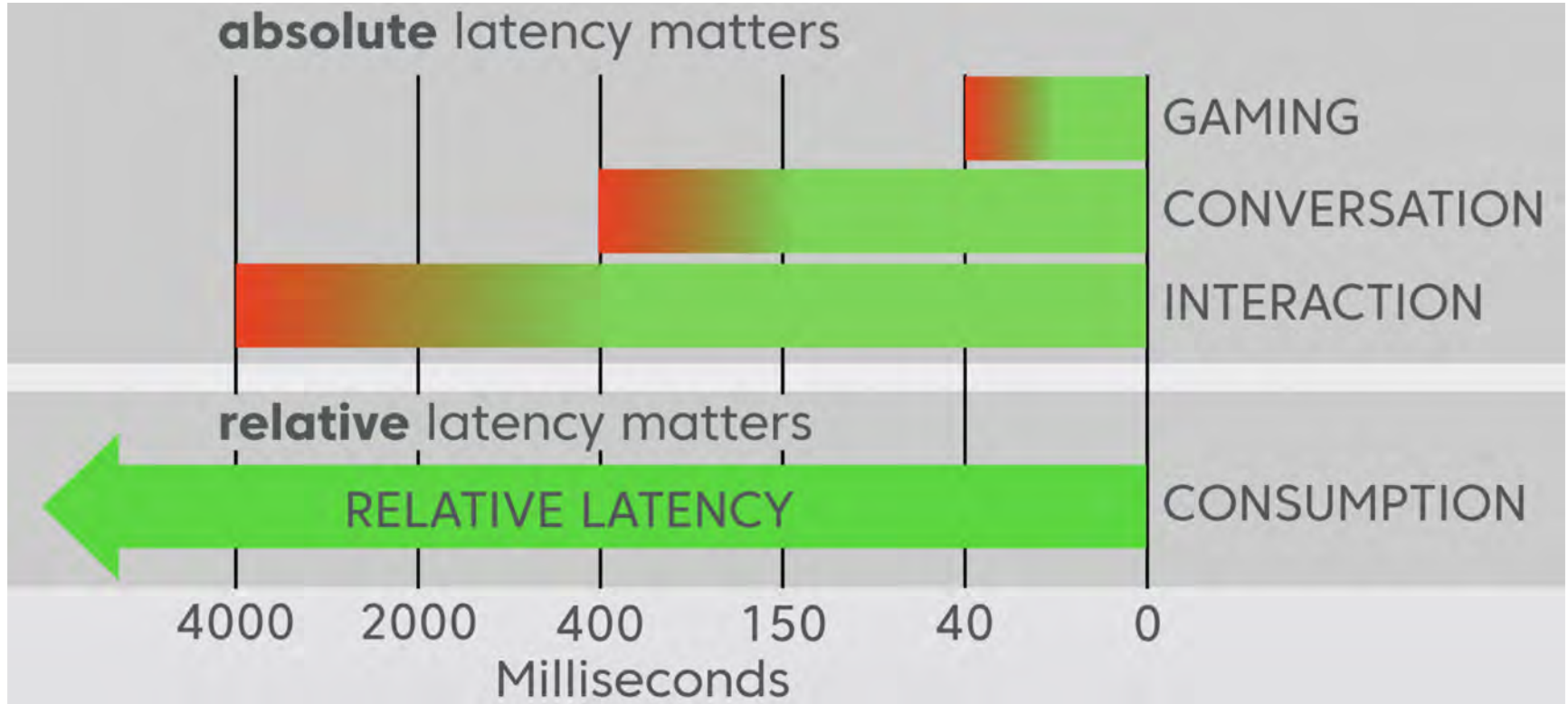
The screenshot shows the Twitch interface for a live stream by user 'P4wnyhof'. The stream is titled 'This Dragon Priest is insane O_o - BattleGrounds for Charity Tournament!!! | Charity'. The video player displays a Hearthstone game in progress, with the streamer's face visible in a small window at the bottom left. The chat on the right shows several messages from viewers, including 'Top Cheer by Allferules' and 'Invitational - https://goo.gl/wdP4By'. The stream has 2,774 likes and 21,295,850 views.

Twitch Extension:

Let viewers help streamers who are playing the game as Show Directors



Low Latency Facilitates Communication



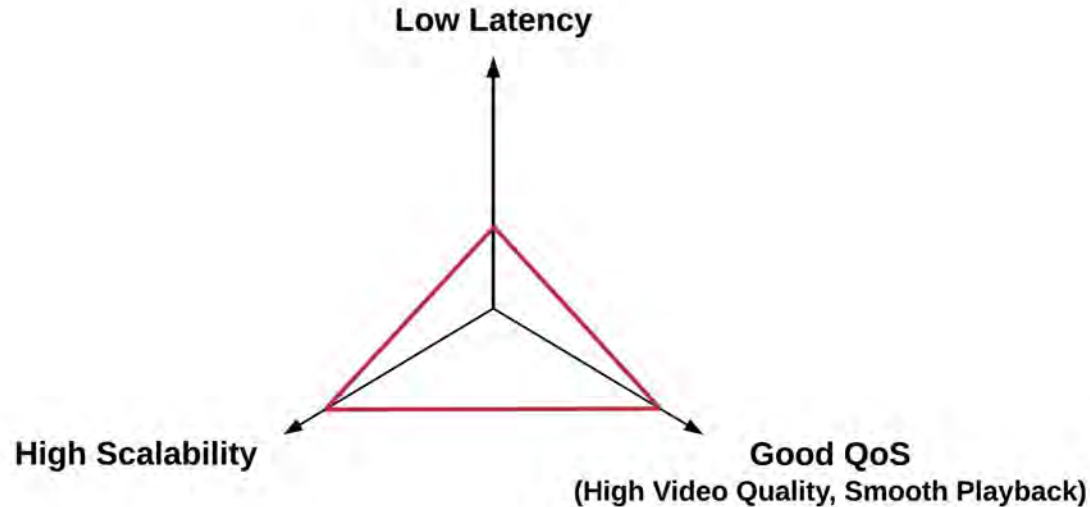
P2P vs. Broadcast:

Trade-off among latency, scalability, and QoS



Trade-off Based on Applications

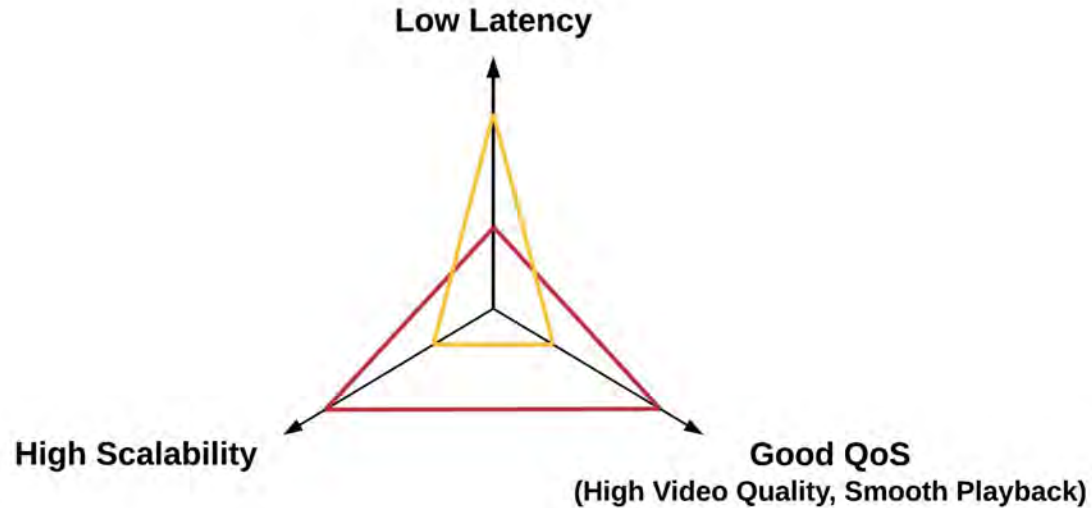
— Linear TV, OTT Live Streaming



Trade-off Based on Applications

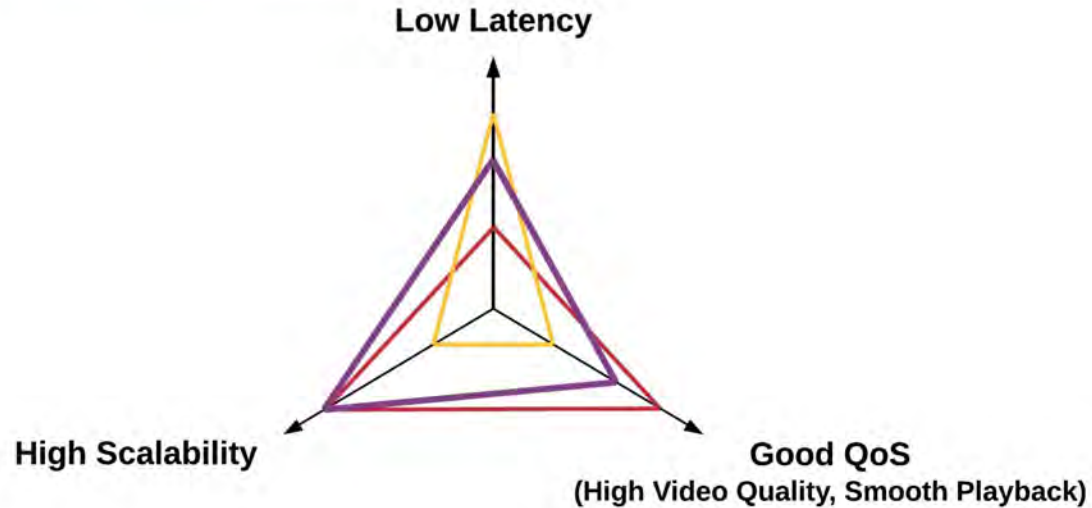
— Linear TV, OTT Live Streaming

— Teleconferencing



Trade-off Based on Applications

- Linear TV, OTT Live Streaming
- Teleconferencing
- Twitch's Interactive Live Streaming

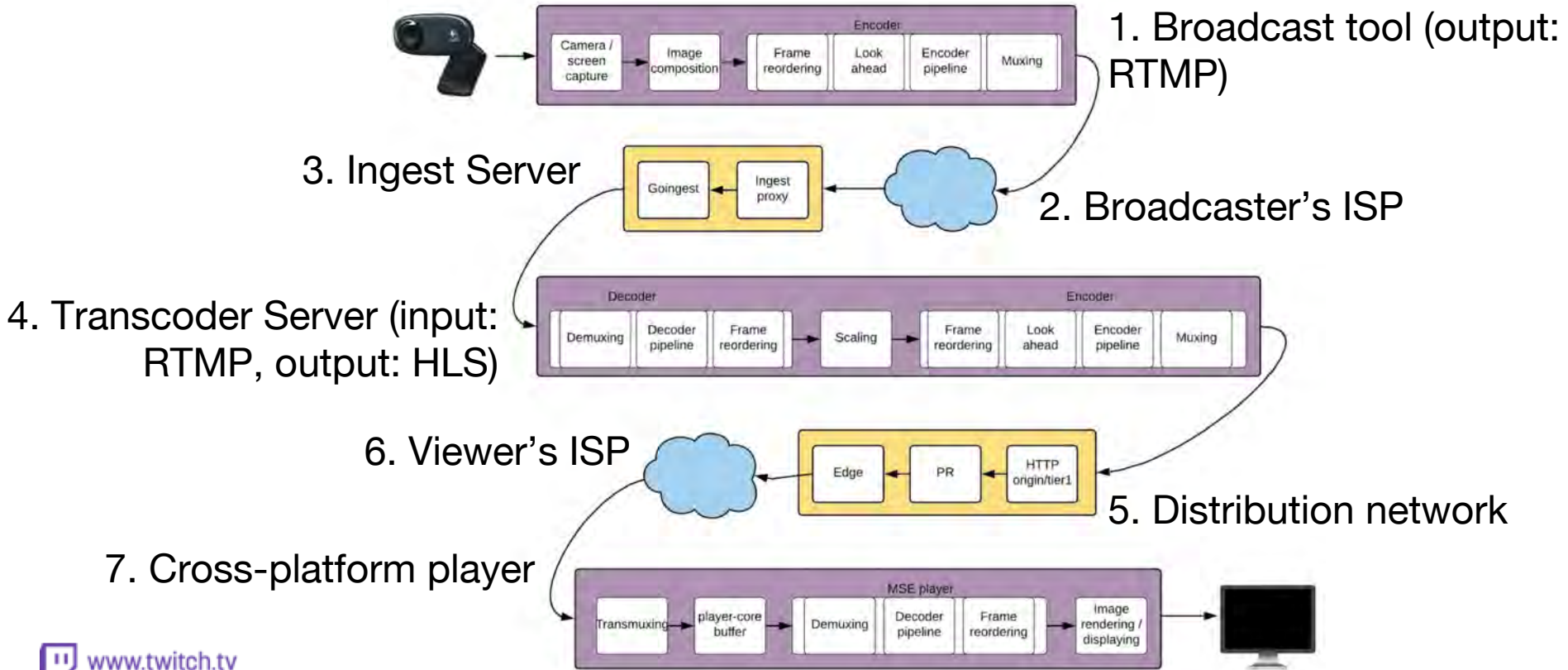


Backend

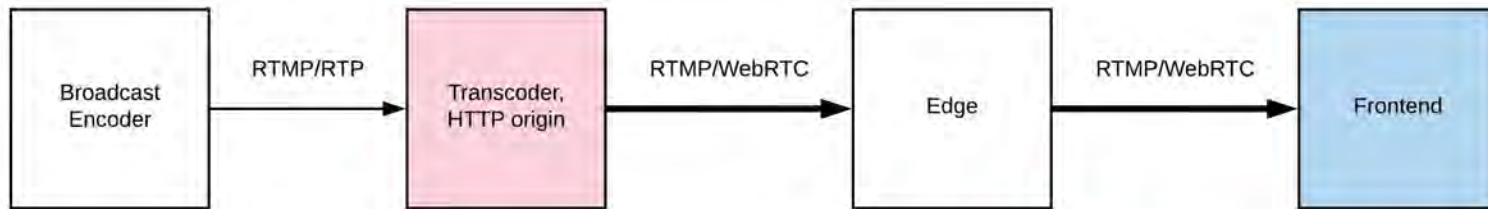
Video distribution pipeline, still HTTP streaming



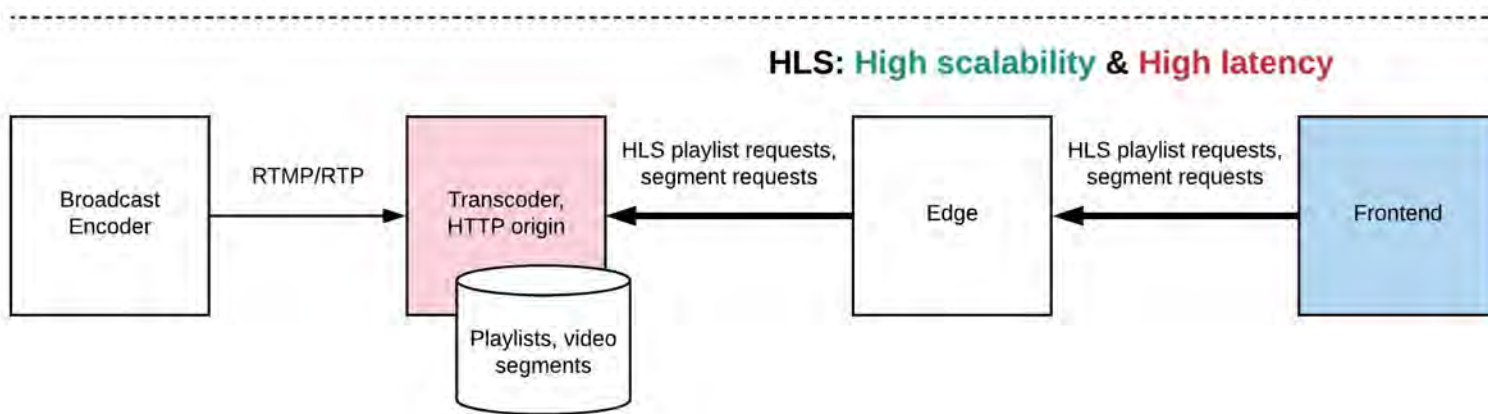
HTTP-Streaming-Based Video Contribution/Distribution Pipeline



Live Streaming: Pull vs. Push

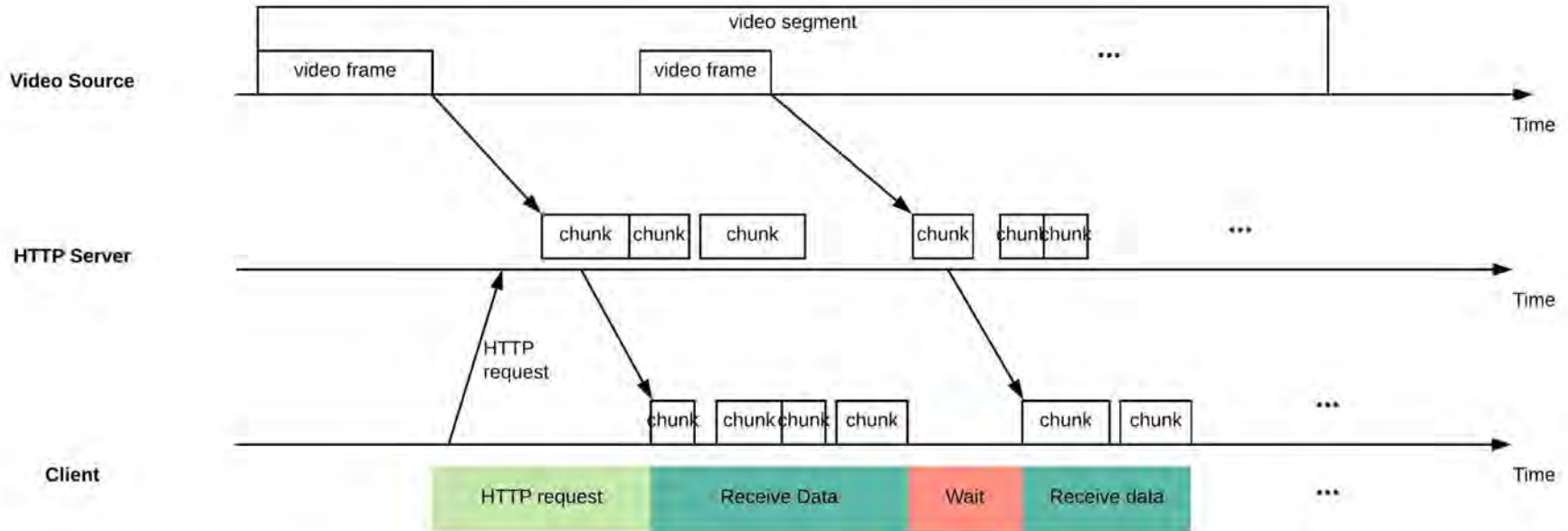


RTMP: Low scalability & Low latency



HLS: High scalability & High latency

HTTP Chunked Transfer Encoding



Where Are My Milliseconds?

	Median Latency without HTTP Chunked Transfer Encoding	Median Latency with HTTP Chunked Transfer Encoding
1. <i>Broadcast Tool</i>	1s	1s
2. <i>Broadcaster's ISP</i>	100ms	100ms
3. <i>Ingest Server</i>	50ms	50ms
4. <i>Transcoder</i>	2.5s	0.5s
5. <i>Distribution Network</i>	200ms	200ms
6. <i>Viewer's ISP</i>	100ms	100ms
7. <i>Playlist</i>	1s	0s
8. <i>Player buffer</i>	5s	2.5s
Total	9.95s	4.45s

IndIEFOXx Daily Sub Goal @10

Video Resolution:	1800x900
Display Resolution:	1169x293
FPS:	60
Skipped Frames:	444
Buffer Size:	3.40 sec.
Latency To Broadcaster:	3.61 sec.
Playback Rate:	6036 Kbps
Memory Usage:	84 MB
Backend Version:	2.5.16-32c910e0

Stream Chat Rooms

carlosrb458 24,100

JayLynxx 2,000

Dexflotoys 1,500

night of souls

vladchampagne: it sound like fapping sound

vladchampagne: bro...

vladchampagne:

olschoolmer: #suoathed sedated

vladchampagne: Kinda

Send a message

Chat



Name	Status	Type	Initiator	Size	Time	Waterfall	1.7 min	2.5 min	3.3 min	4.2 min	5.8 r
CvgDq4zqobnRnEwKncKwFavacvFwmyUgTmMknNscMf...wncBellyQeTbXQrcqW...	200	octet-stream	Other	1.5 MB	1.94 s						
CvgDLaVbMalBtUmayNNem6UDcL7iGzXiaQlppNu9guZV3RtJm...qy4EhDHsmsa8atw8BvORj5...	200	octet-stream	Other	1.5 MB	1.99 s						
CvgDuuwq08ae8NalaS_M9E8v8hmLjUuwK2AEu4PYXmcj945Zd...YNLEhAoTSqkGCwieNvnm6...	200	octet-stream	Other	1.5 MB	2.06 s						
CvgDF3kJbnJYT9Nhzysl6GdeWjvUjvM8F5_PWJNp2xr0oHk1Z...mmTEhCe7iwm9Ma6Gp4waE...	200	octet-stream	Other	1.5 MB	1.89 s						
CvgD7M8gf8ptmkn4wWbcA8hnxgbAh9RFNj5HitodrNtEnx...XalEhDBWFYzxeZeUc81sx2...	200	octet-stream	Other	1.5 MB	1.98 s						
CvgDkiCQdi4i-cx3-Uc_U8EpmY_EEGCg3D0zTtppjOakE5blbv...ppeEhA-yQGwCafmZQPYWU...	200	octet-stream	Other	1.5 MB	2.02 s						
CvgDI95-HMOpu2PFIFdaTtB0vctEiOfZhDG9gVID8PzUtTcv...3V-EhBbzCd5elKKNzePZ3KWA...	200	octet-stream	Other	1.5 MB	1.97 s						
CvgD3kvddgTp9AFJ4Uqnb34EVymboi4Kc2IESqlyPkK417G...Fh4EHCKCamQZA4DDelZU0TX...	200	octet-stream	Other	1.5 MB	1.98 s						
CvgDT3i7Kq-naqAAsRrdnjt_wGs0S5NzHHY5a5ABH_GhvaeoQIW...SGyEhCHZRV0lkaIQXWOJa...	200	octet-stream	Other	1.6 MB	2.06 s						
CvgDFIq-3NOLnima44xevjVcJFw_gElyBguhozz60Kyc8Y7qV...wQzEhB3t1_QYvDpWAQoYZI...	200	octet-stream	Other	1.5 MB	1.98 s						
CvgDqxgdDYxYL_98qVcQKPN_FSQPFukCqksZzh4rZJ-Ub9gwym...JHrEhDEUYlsw_dVcb1bqfl...	200	octet-stream	Other	1.5 MB	1.93 s						
CvgDbi-hKZcGi4yldcckchY95NcMPTdbSXtcAyOJwHws2njSJA...DO6EhA_3L2JB5YPsc55AXc...	200	octet-stream	Other	1.5 MB	1.96 s						
CvgDa7f4cd9_ac54dLkMHzvA7jdo7eUujYekCoqzbUIRB7Rn...S8xEdXNR6iDONslGqf4Z...	200	octet-stream	Other	1.5 MB	2.02 s						
CvgDztIBL2elHct3PzKY2rFhAG_gvEacheARz1FaFSQ7PH980iz...V0YEhAI4BwofZAdpGdYfB_P...	200	octet-stream	Other	1.6 MB	1.98 s						
CvgDzye99YgckwydSj0rko-Ee1cBOxdLjct-ol2Ja3qT0cVE...12DEhA_uoHVuH-BfyAVRjJj...	200	octet-stream	Other	1.4 MB	1.97 s						

Backend Stability Example:

HTTP request time of a replication site

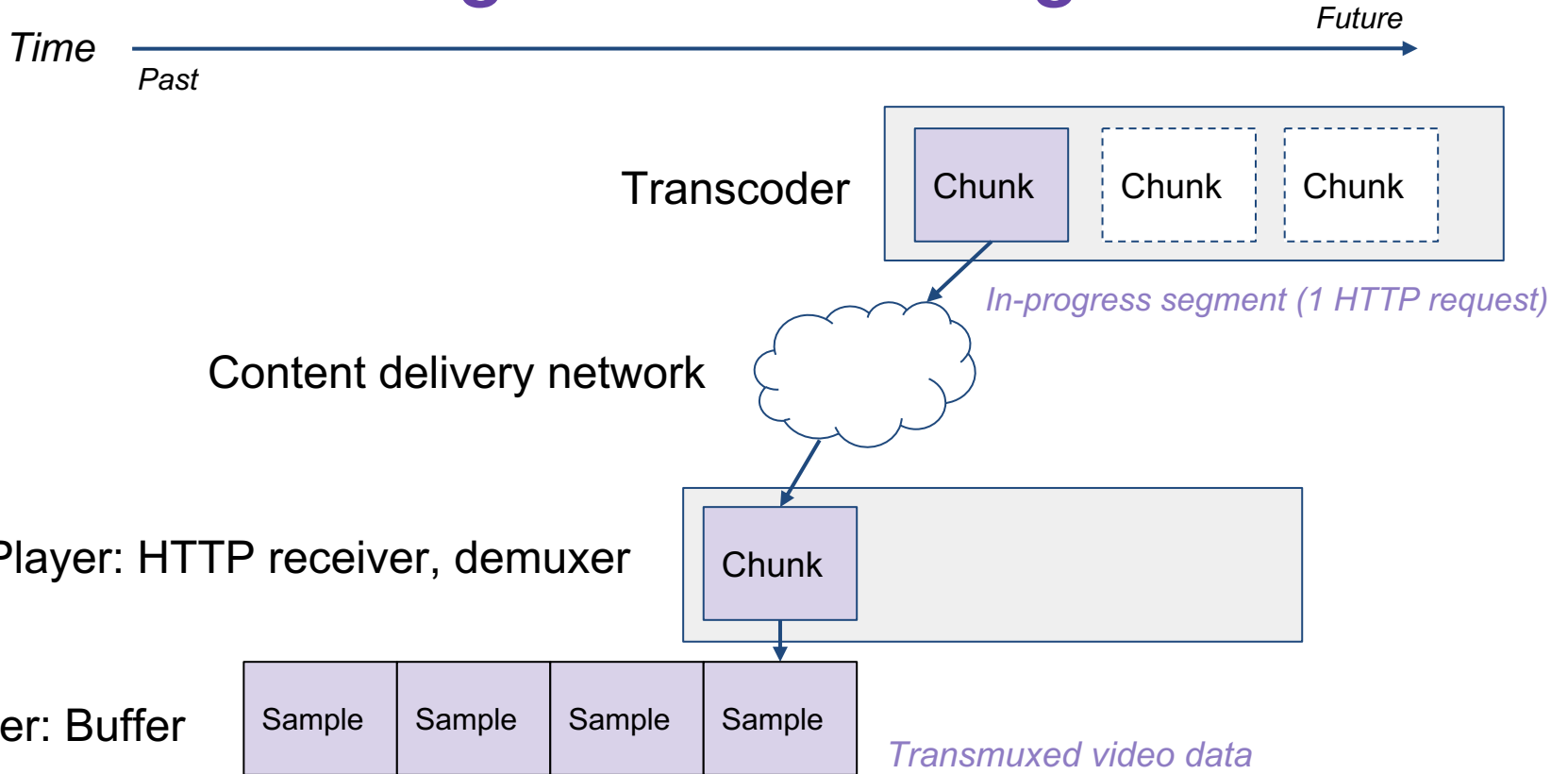


Frontend

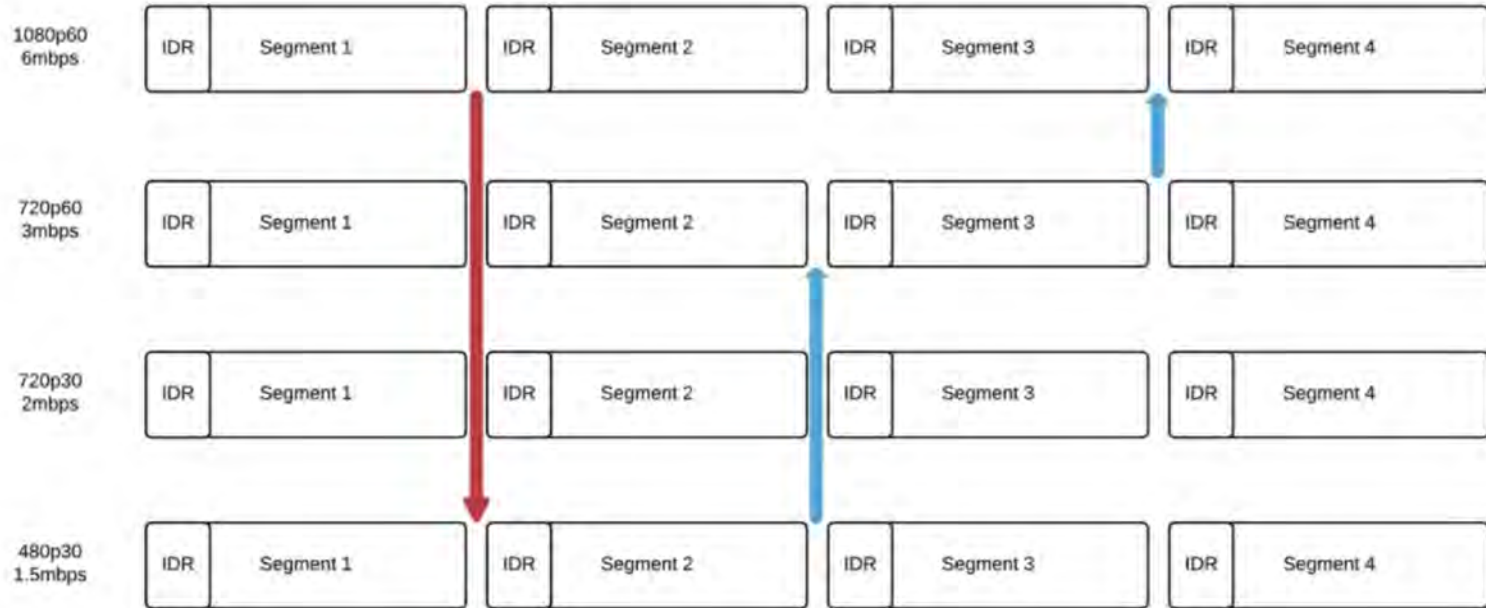
HTTP streaming, ABR, buffer control



Segment Streaming

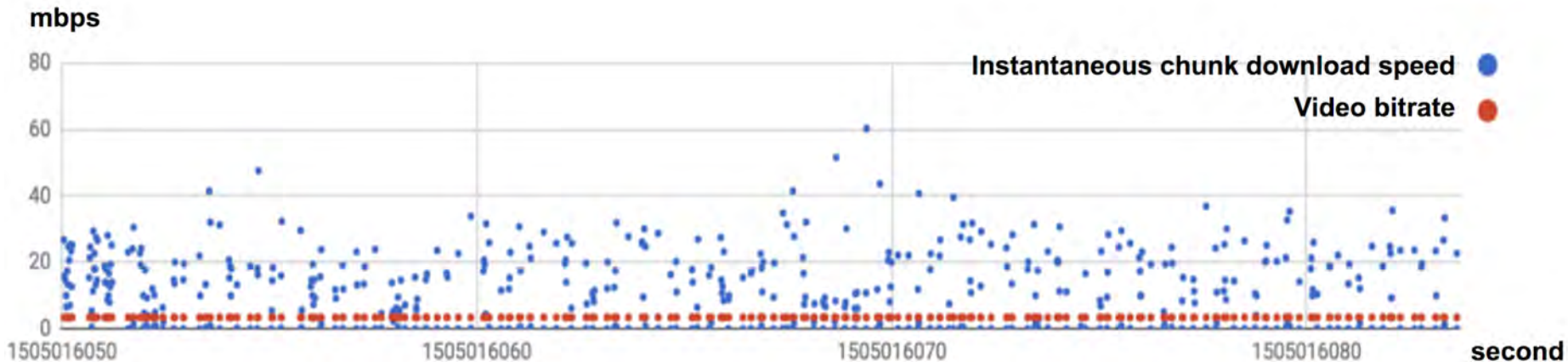


Adaptive Bitrate (ABR) Playback



$$\text{playback bitrate} = f(\text{download bandwidth}, \text{player buffer level}, \dots)$$

HTTP Chunked Transfer Encoding = NOISY Input



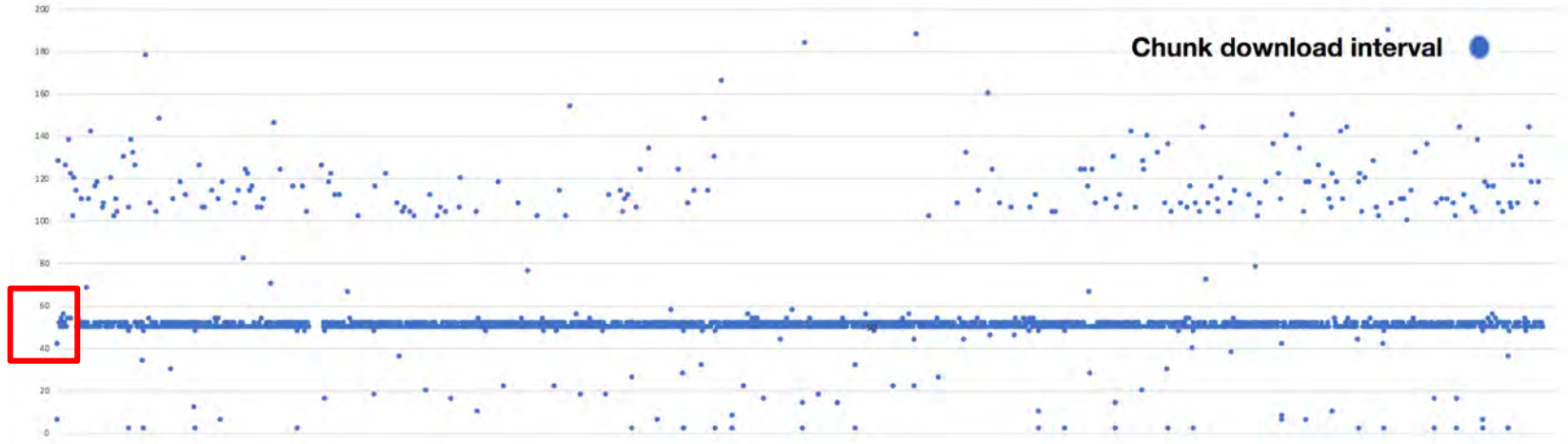
What is my download bandwidth???

Streams API Support

Firefox | about:config

Search: .streams

Preference Name	Status	Type	Value
dom.streams.enabled	default	boolean	false
javascript.options.streams	default	boolean	false



Reference: https://developer.mozilla.org/en-US/docs/Web/API/Streams_API/Using_readable_streams

Summary

Twitch is world's largest live streaming platform, with 15+ million daily unique visitors and 2+ million monthly unique broadcasters

Twitch's live streaming model creates strong interaction between broadcasters and their audiences. **Low latency streaming for scalable broadcast is a different technical problem from low latency streaming for point-to-point communication.**

Achieving low latency along with scalability and QoS requires full control of the entire video ingest/distribution pipeline, as well as innovations in both backend and frontend

HTTP Chunked Transfer Encoding is utilized across transcoder, origin, replication/edge and player to realize median 4.5s glass-to-glass latency, including <0.5s latency in transcoder and <2.5s latency in player



Thank You and Questions

Yueshi Shen

yshen@twitch.tv

