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QoE-aware Multiple-Server Streaming over HTTP

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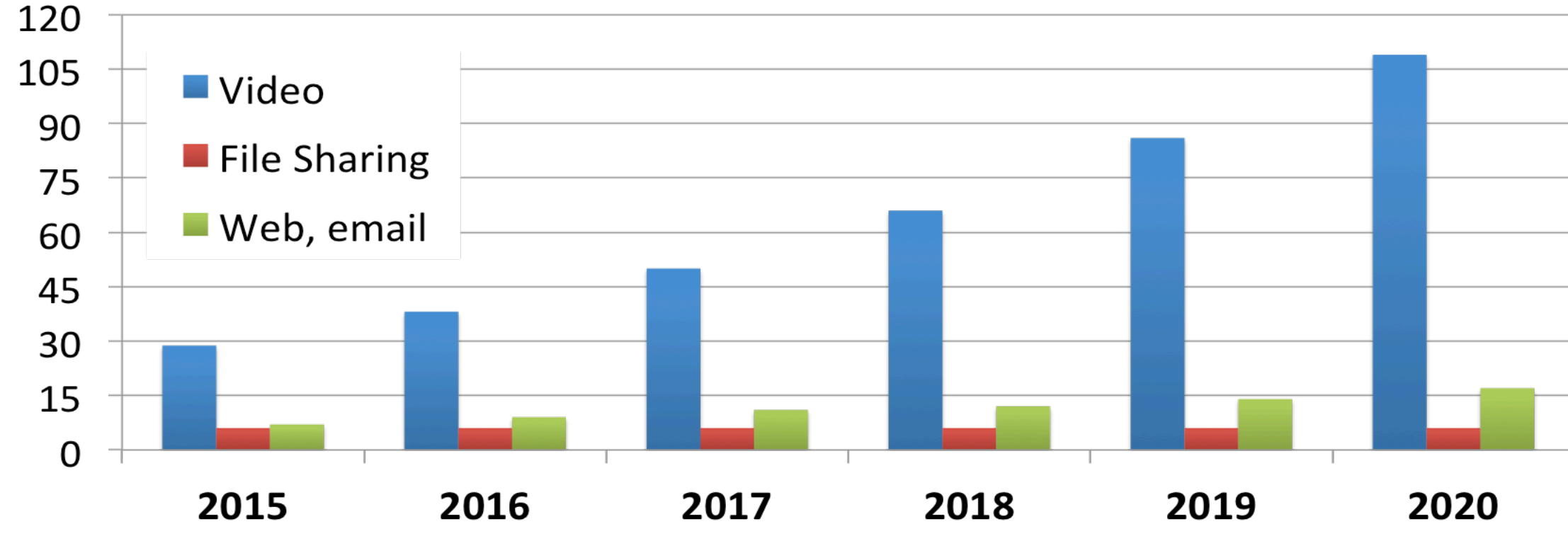
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Context: Media Delivery in the Future Media Internet

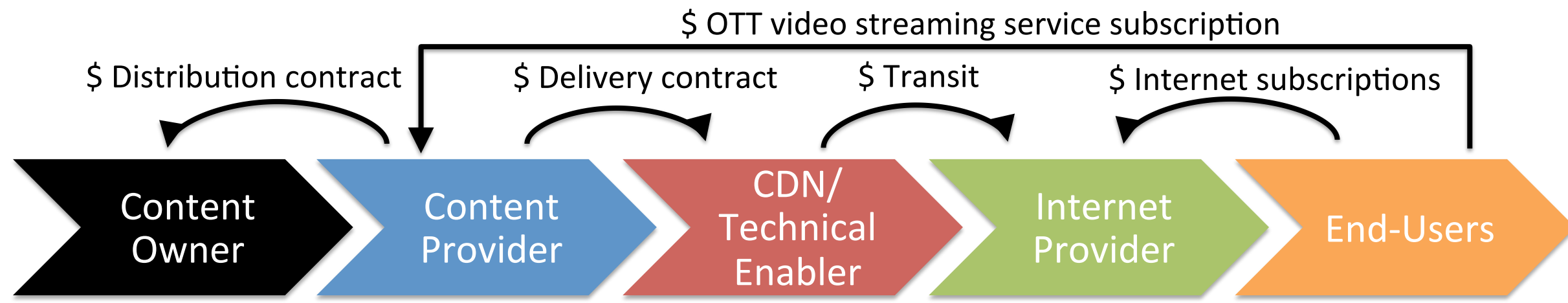
Traffic Forecasts

ExaB/month Consumer Internet Traffic (2015-2020) - Cisco VNI

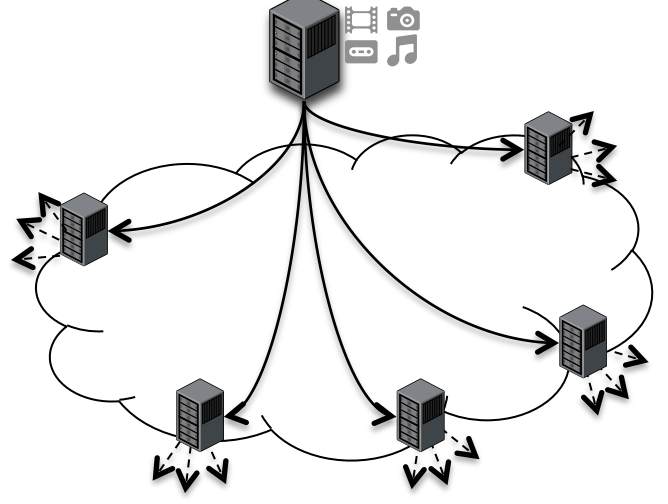


- More users
- More content
- Higher demand for quality
- =>
- Almost **82%** of today's internet traffic
- A two-fold increase by 2020

The media delivery chain

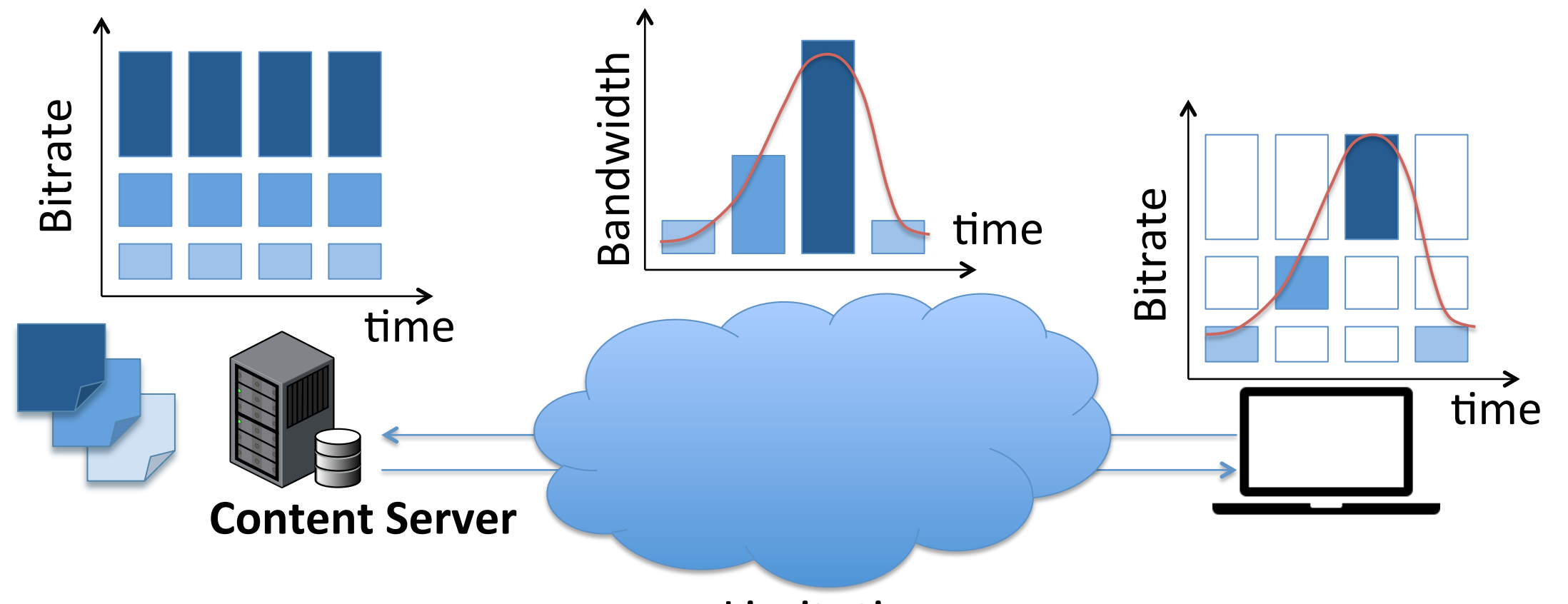


Content Delivery Networks



- Highly efficient and scalable
- High operating and scaling costs
- Often over-provisioned infrastructure to meet end-users' QoE demand

DASH: Dynamic Adaptive Streaming over HTTP



Pros:

- Avoid video freezing by adjusting desired quality to the network conditions
- Increase Quality of Experience (QoE)

Limitations:

- Non-resilient to network or server impairments
- Limited by the throughput delivered by one server

Today's and tomorrow's challenges

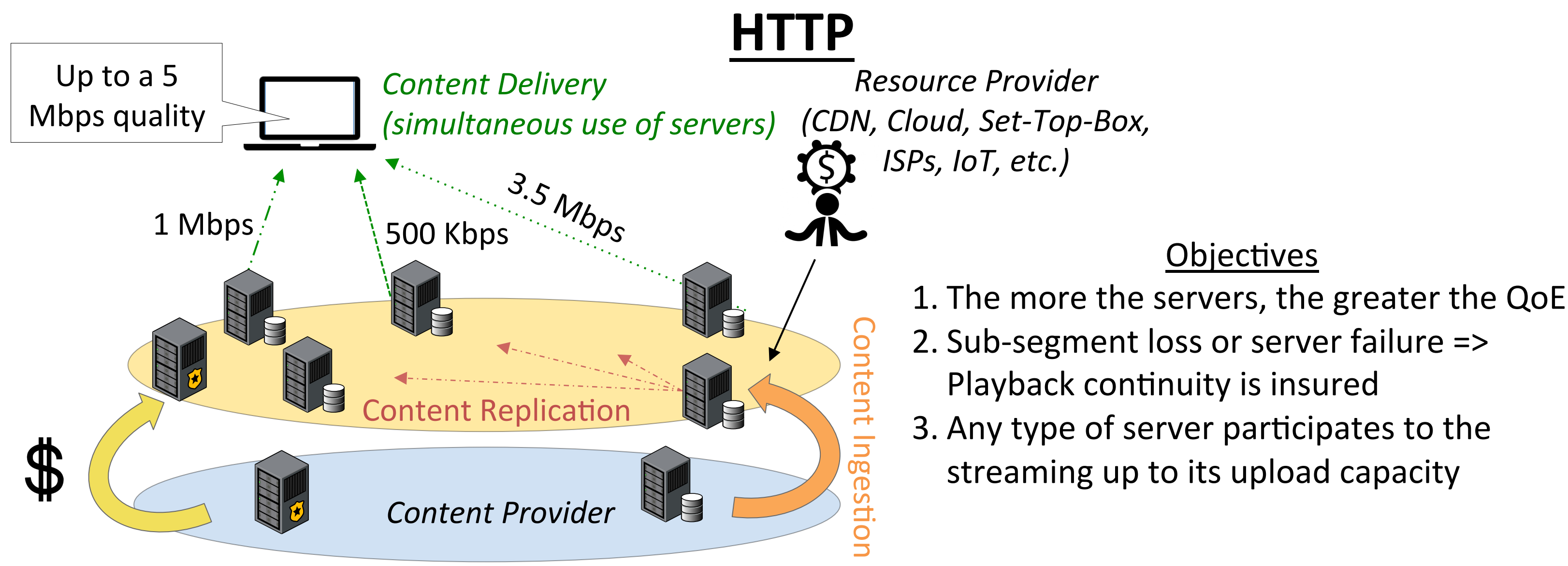
The **problem**: QoE along with scalability costs are major issues in the design of future content delivery solutions.

The **challenges**: Bandwidth aggregation on multiple network paths; Adaptability to communication channel heterogeneity; Uninterrupted video streaming; Quality- and server- adaptation.

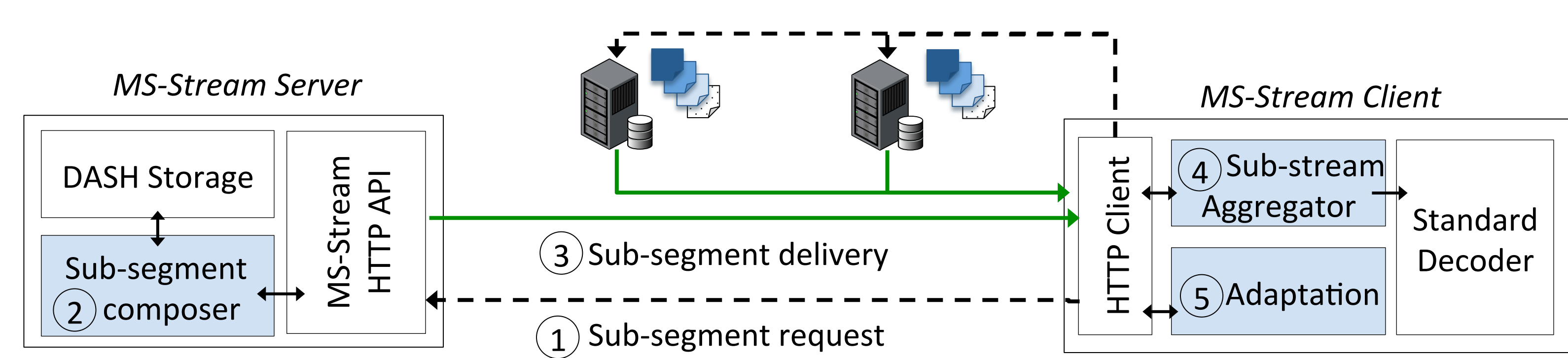
The **proposition**: A DASH-evolving client-centric **Multiple-Source Streaming (MS-Stream)** protocol that simultaneously uses multiple servers in order to provide high QoE and reliability in heterogeneous environments

Contributions

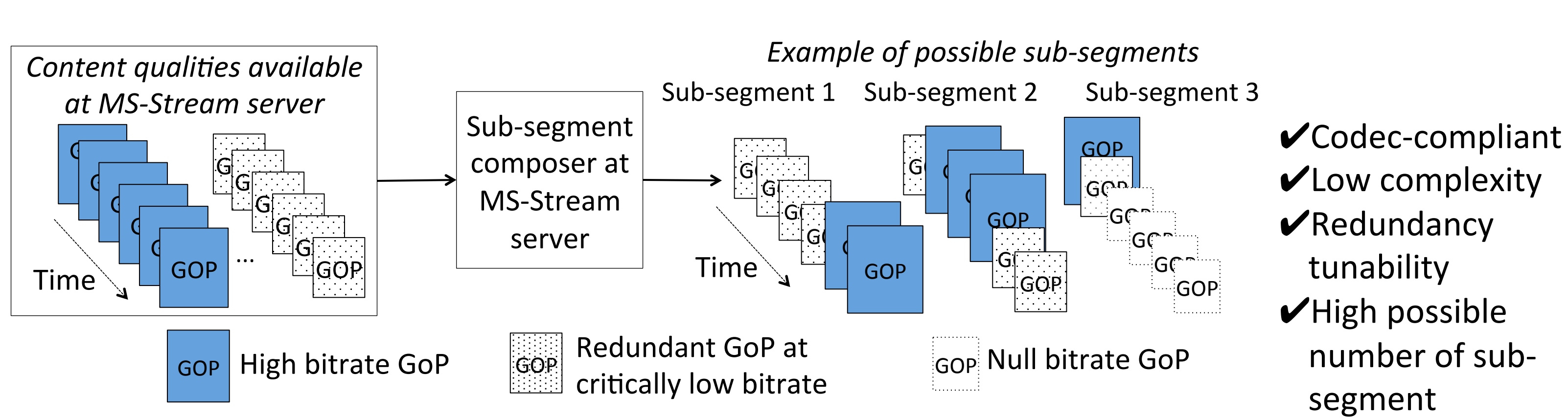
MS-Stream: Dynamic Adaptive Multiple-Source Streaming over HTTP



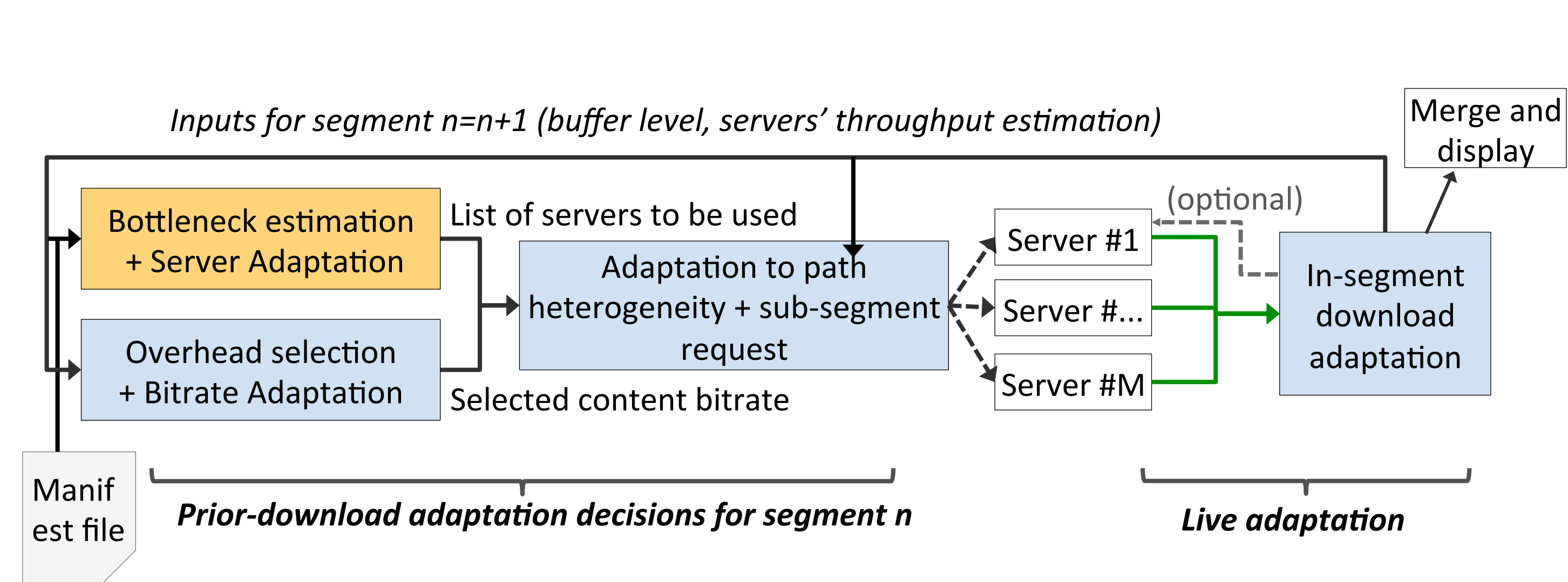
A DASH-based streaming protocol architecture



Standard-compliant sub-segment composition



A two-phase consumption and adaptation algorithm

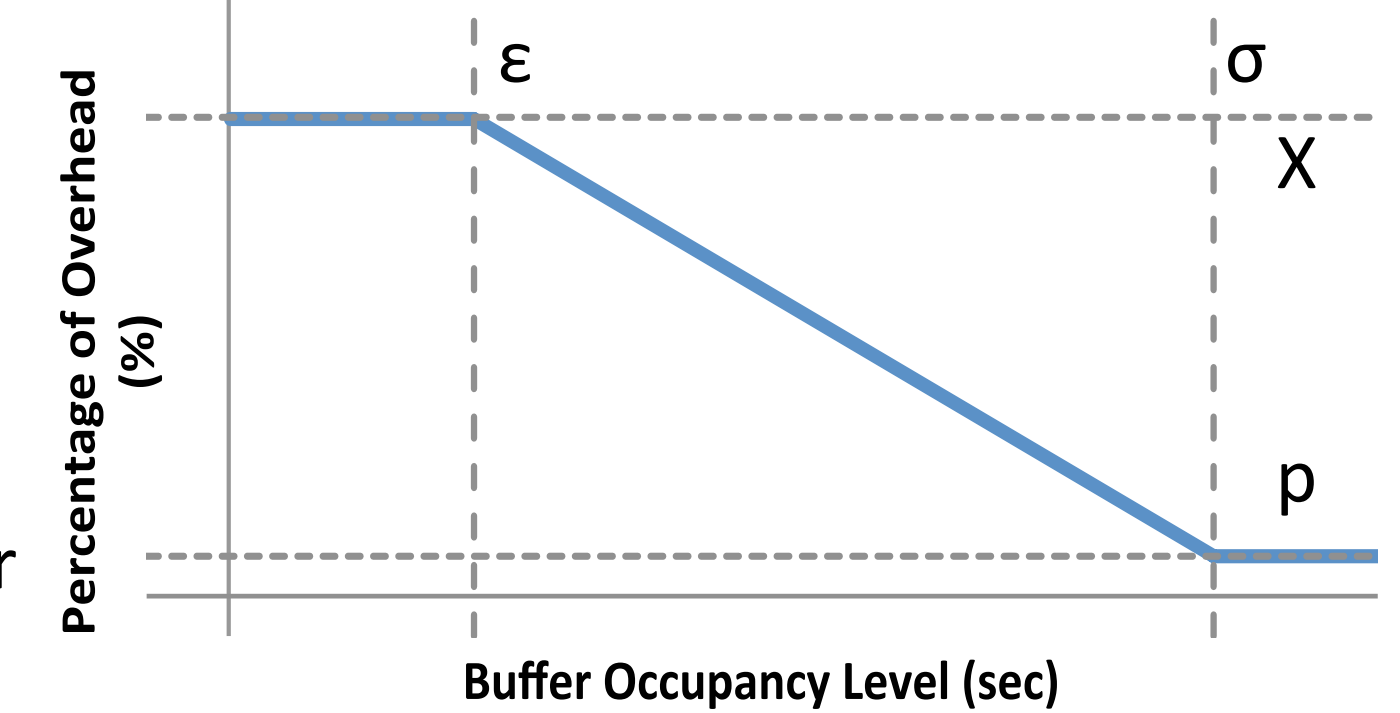


Bottleneck estimation and server adaptation:

- Estimating the presence and the type of bottleneck (at server or at client side) based on TCP connections' throughput stability in time (78% reliable);
- Additive-Increase Multiplicative-Decrease approach to adjust the number of simultaneously used servers (based on bottlenecks, target bitrate).

Overhead selection:

- Limiting and minimizing bandwidth consumption overhead due to GoP redundancy.
- Minimization method based on client buffer occupancy



Adaptation to path heterogeneity:

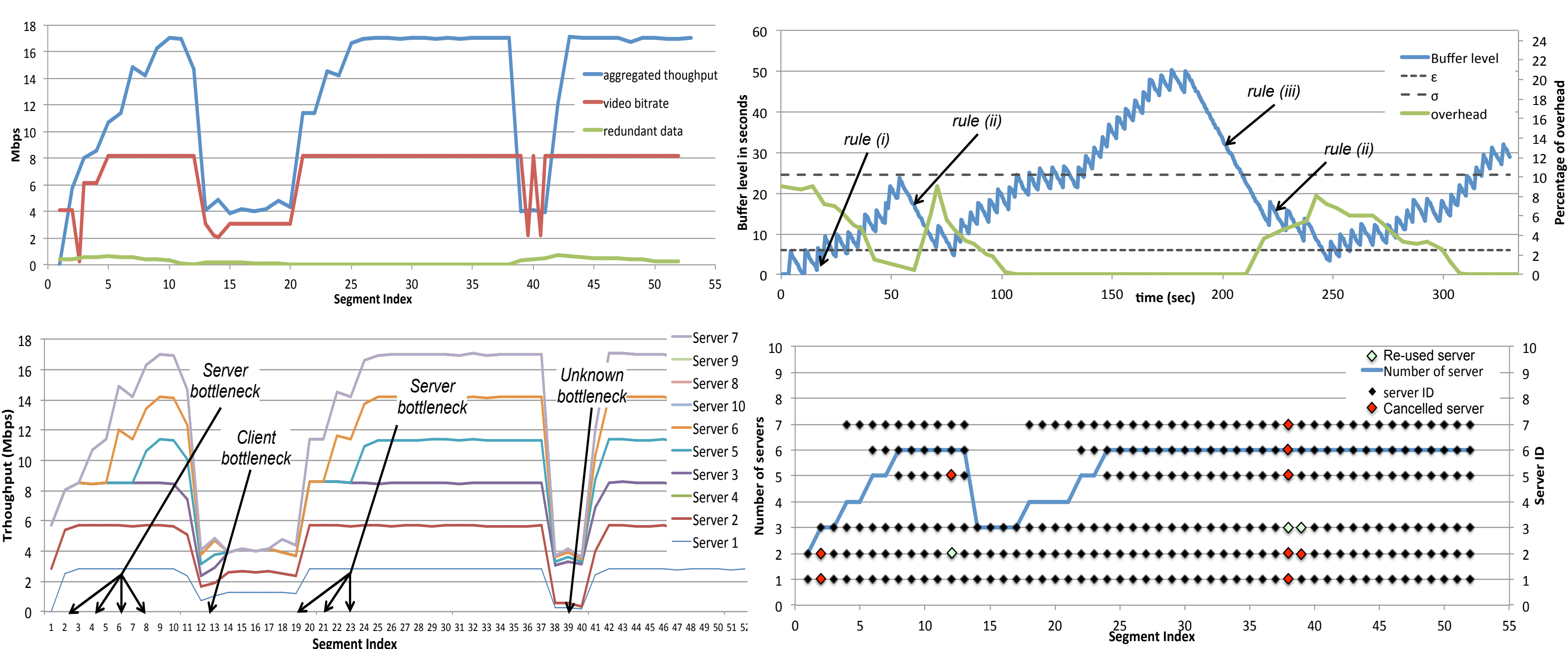
- Assigning sub-segment delivery to servers according to their observed goodput.

In-segment download adaptation

- Monitor sub-segment downloads progress;
- Three in-segment download adaptation rules to cancel late sub-segment delivery or re-assign the delivery of missing GoPs to other servers.

Functional validation

A 10-server test-bed; a 10-min video; 8 bitrates (from 1 to 8 Mbps), redundant bitrate at 150Kbps



Significant Results

Evaluation over the Internet (DASH versus MS-Stream)

Eval ID	Available Thr. (Mbps)	# of clients	# of servers	O_{max}	ϵ (sec)	σ (sec)	Mean Bitrate (Mbps)	Avg. Quality Changes	Avg. Rebuffering	Avg. Start-up delay	Avg. BW overhead	Avg. Used servers
DASH_0	10	1	1	-	-	-	7.90	5.10	0	2.21 sec	0%	1
DASH_1	20	2	1	-	-	-	6.87	10.32	7.22	4.11s sec	0%	1
MS_0	10	1	10	10%	6	25	7.97	3.21	0.01	1.58 sec	3.91%	9.52
MS_1	20	2	10	10%	6	25	7.43	5.32	0.31	1.57 sec	4.37%	7.59
MS_2	20	2	10	10%	12	25	7.78	4.11	0.29	1.56 sec	6.43%	7.68
MS_3	20	2	10	15%	12	25	7.80	4.69	0.19	1.65 sec	9.12%	7.61

References

- J. Bruneau-Queyreix, M. Lacaud, D. Negru, J. Batalla, and E. Borcoci, « QoE Enhancement Through Cost-Effective Adaptation Decision Process for Multiple-Server Streaming over HTTP » in *IEEE International Conference on Multimedia and Expo (ICME)*, 2017.
- J. Bruneau-Queyreix, M. Lacaud, D. Negru, J. Batalla, and E. Borcoci, « Adding a New Dimension to HTTP Adaptive Streaming through Multiple-Source Capabilities », in *IEEE MultiMedia Magazine (in press)*, 2017.
- J. Bruneau-Queyreix, M. Lacaud, D. Negru, J. Batalla, and E. Borcoci, « MS-Stream: A Multiple-Source Adaptive Streaming Solution Enhancing Consumers Perceived Quality », in *IEEE Consumer Communications and Networking Conference (CCNC)*, 2017.
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