TOWARDS JOINT LOSS AND BITRATE ADAPTATION IN REALTIME VIDEO STREAMING

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Key Takeaways

Realtime multimedia traffic: 5% -> 17%

TCP -> low-latency demands
UDP -> packet loss problem

Video quality and bitrate can be slightly sacrificed to trade for the most significant delay.

Oppugno: a coupled framework compatible with adaptive bitrate (ABR) control and existing loss control mechanisms based on DRL.

This talk: Joint Loss and Bitrate Adaptation

Outline

- **Problem** — Unsatisfied QoE in realtime streaming services
- **Motivation** — Comprehensively fine-tuning different QoE metrics
- **Solution** — The Oppugno framework
- **Evaluation**

Unsatisfied QoE in Realtime Streaming

Remote work

Online education

Entertainment

- Stringent Delay Requirement: ≤ 150 ms
- UDP-based protocol: unsatisfactory QoE!

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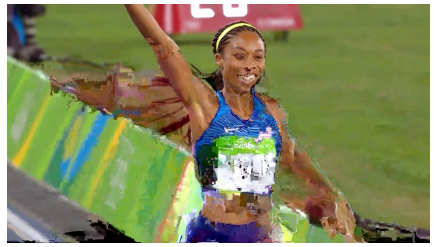
Limitations of Existing Works

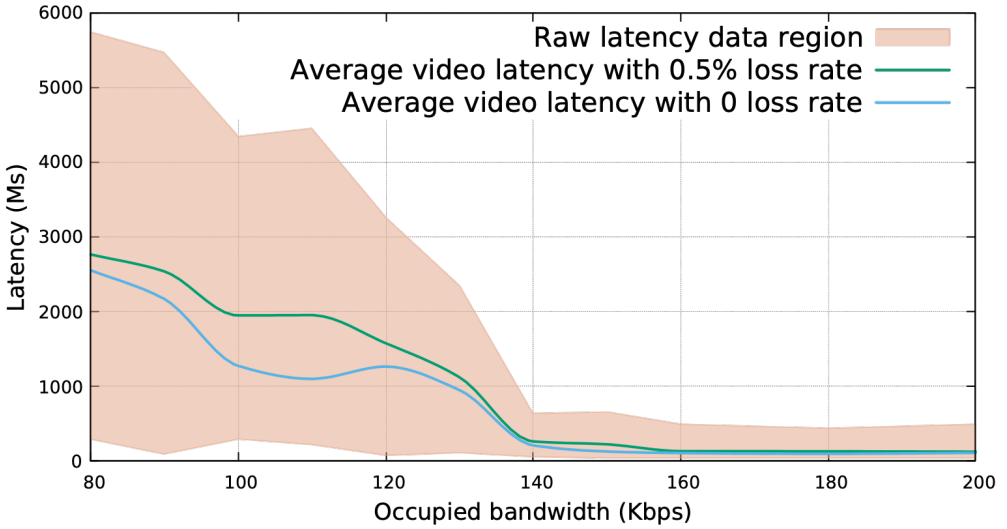
1. Packet loss problem induced by UDP-based transmission will lead to video distortion
2. Previous ABR algorithms cannot solve the QoE decrease caused by loss.
3. Emerging advanced transport protocols also cannot solve the problem of QoE adaption well.

loss rate = 0.2%

loss rate = 1%



loss rate = 2%



Insights

- The opportunity rises in comprehensively fine-tuning different QoE metrics (bandwidth, delay, video quality) to optimize user QoE in realtime streaming scenarios.

- Our insights are two-fold:

  1. Packets with bit error or packet loss can be ***tolerated*** at the expense of video quality to avoid retransmission and further improve QoE.

  2. Extra bandwidth can be leveraged for redundant coding such that loss can be ***corrected*** without retransmission.

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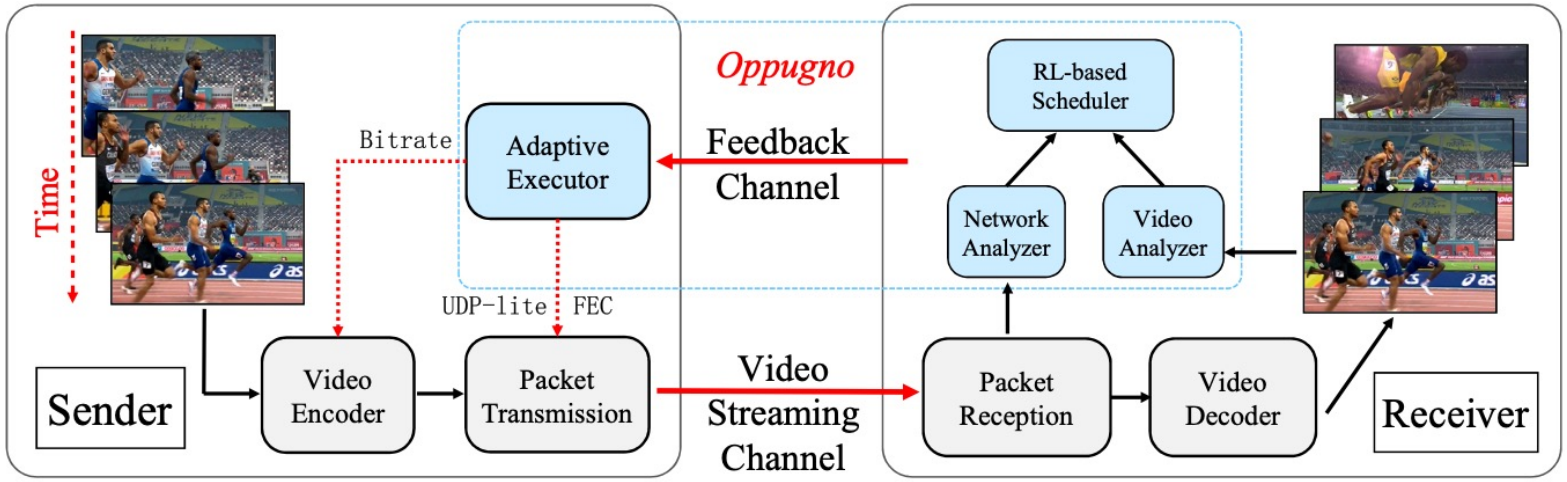
The Oppugno Framework

- Oppugno, a coupled framework that generates a DRL-based algorithm to integrate the loss adaption and bitrate adaption for realtime video streaming services jointly.

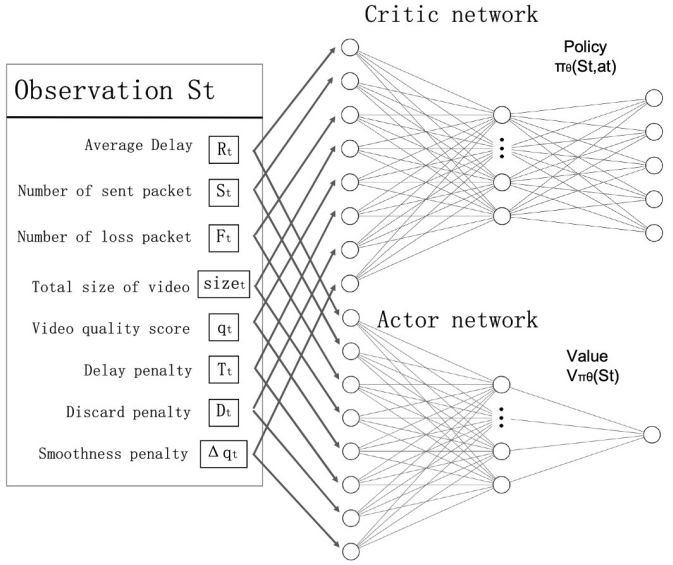
- QoE Design

$$QoE = \sum_{i=1}^{N} q(R_n, L_n, D_n) - \alpha \sum_{i=1}^{N} T_n$$
$$- \beta \sum_{i=1}^{N-1} |q(R_{n+1}, L_{n+1}, D_{n+1}) - q(R_n, L_n, D_n)|$$

The Oppugno Framework



- Receiver-driven Control
- Leveraging Existing UDP Mechanisms
- Proximal Policy Optimization



The PPO learning algorithm

Outline

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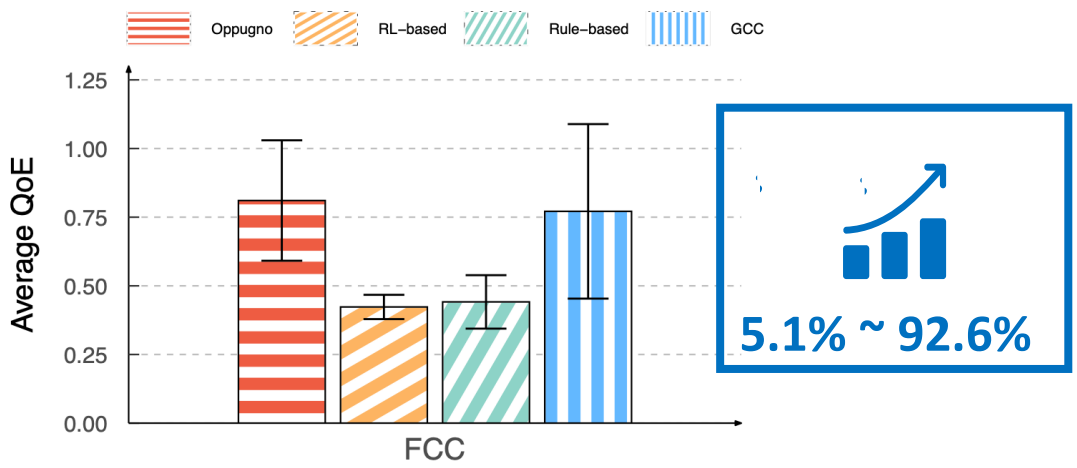
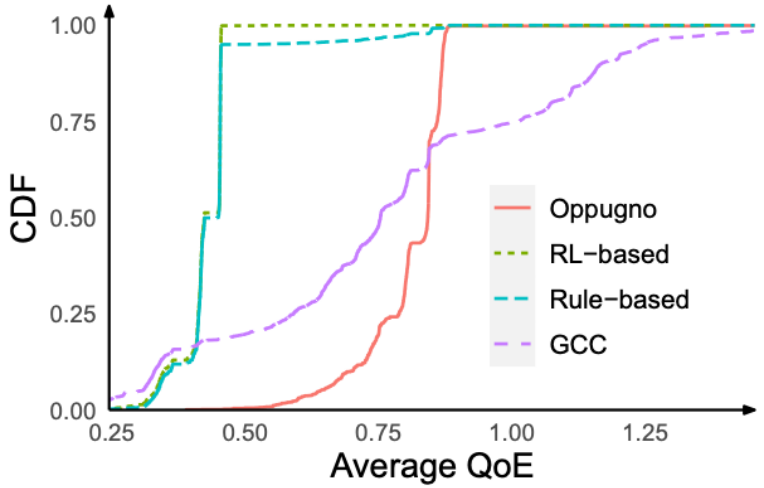
Evaluation

➢ Performance with Real-world Data:

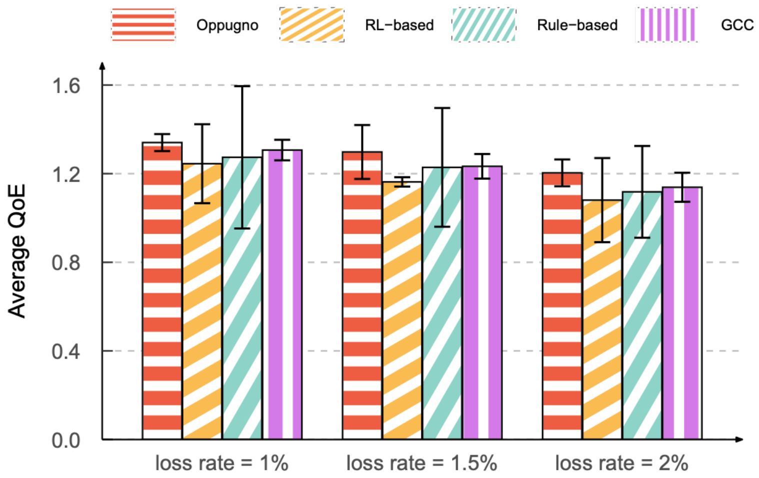


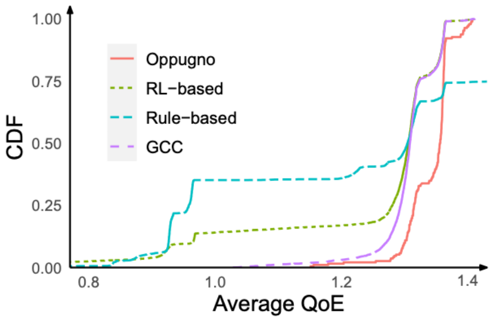


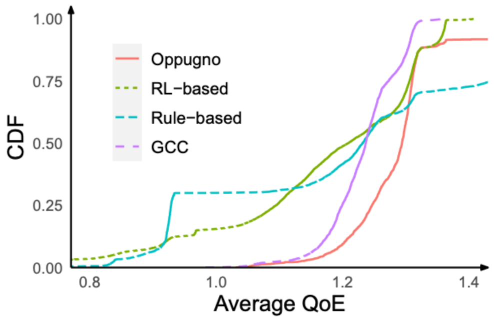
- ➢ Oppugno outperforms all the baselines with higher QoE
- ➢ Oppugno achieves more stable and concentrated QoE scores

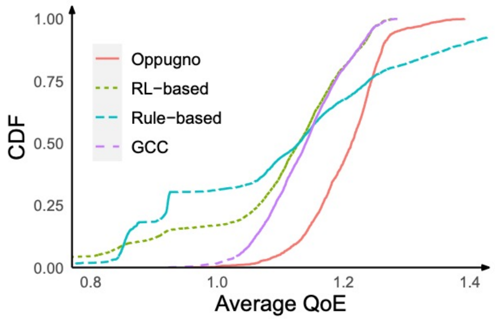
Evaluation

➢ Performance of Generalization:









3.9% ~ 11.6%

loss rate = 1% loss rate = 1.5% loss rate = 2%

➢ Oppugno has a good generalization ability to adapt to environments with different loss rates

Conclusion

- Oppugno: combines loss adaptation and bitrate adaptation with PPO algorithm.
- It takes the trade-off between bandwidth and acceptance of packet errors into consideration.
- Extensive trace-driven experiments confirms Oppugno's superiority with a 3.9% ~ 11.6% improvement.

Thank you!

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