# QoE Optimization in Live Streaming

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BITMOVIN
Software to Solve Complex Video Problems

ATHENA

Christian Doppler
Forschungsgesellschaft

The Christian Doppler laboratory **ATHENA** (**A**dap**T**ive Streaming over **H**TTP and **E**merging **N**etworked Multimedi**A** Services) is jointly proposed by the Institute of Information Technology at Alpen-Adria-Universität Klagenfurt (AAU) and Bitmovin GmbH to address current and future research and deployment challenges of HAS and emerging streaming methods.

# Why is Live video Streaming an NP-complete Problem?

## Optimizing

>QoE
>Serving Cost
>Fairness
>Revenue

## Satisfying

>End-to-End Latency
>Resource consumption
>Energy consumption
>Security and Privacy
>Service Availability

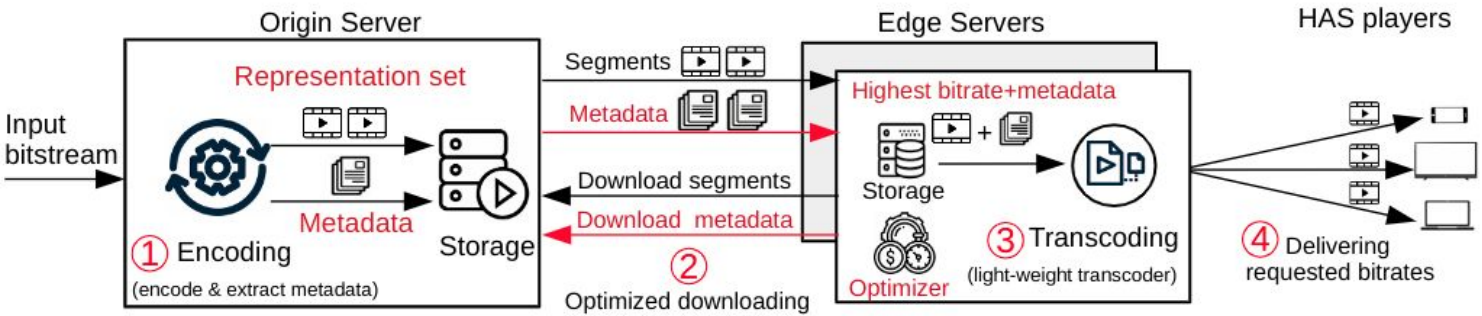
## Determining

>Data path
>Multi-path data transmission
>Function placement
>Cach Management
>Per-title encoding
>Bitrate Ladder
>Segment size

# Solutions' Taxonomy

**Convex Optimization**

- High time complexity
- ADMM techniques for distributed solutions
- Convergence time
- Not applicable for time-varying and real-time scenarios




A. Erfanian, H. Amirpour, F. Tashtarian, C. Timmerer and H. Hellwagner, "**LwTE: Light-Weight Transcoding at the Edge**," in IEEE Access, vol. 9, pp. 112276-112289, 2021, doi: 10.1109/ACCESS.2021.3102633.

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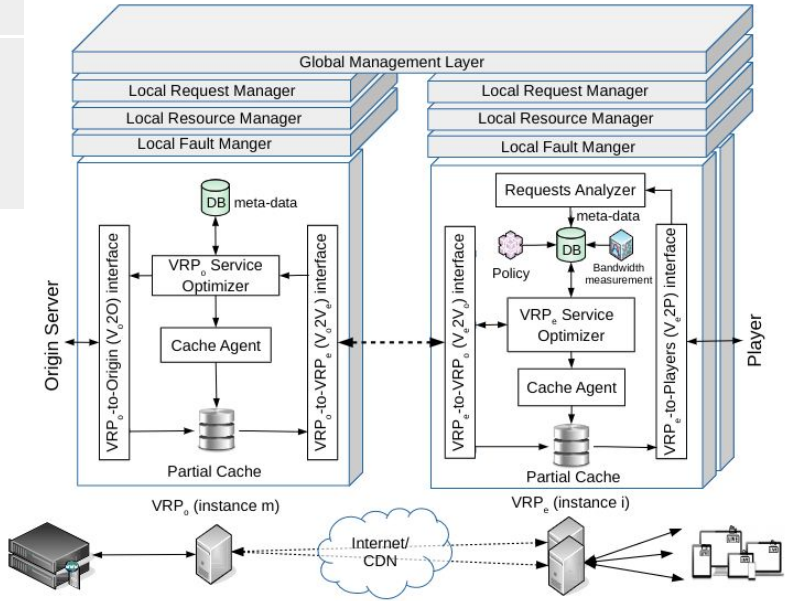
**Meta-heuristic**

- Local optimum solution
- Simulated-annealing
- Evolutionary algorithm




F. Tashtarian, A. Bentaleb, A. Erfanian, H. Hellwagner, C. Timmerer and R. Zimmermann, "**HxL3: Optimized Delivery Architecture for HTTP Low-Latency Live Streaming**," in IEEE Transactions on Multimedia, doi: 10.1109/TMM.2022.3148587.

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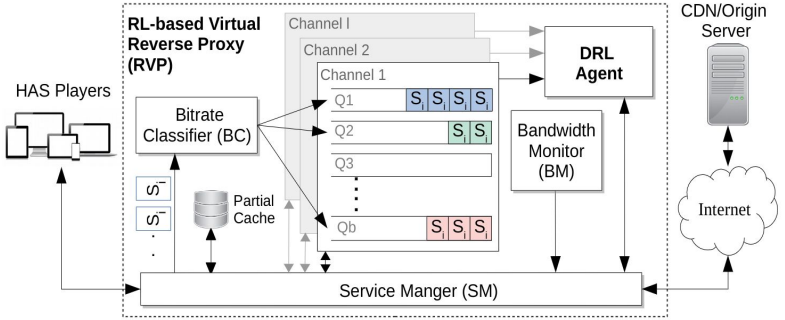
**Machine Learning & AI techniques**

- Useful techniques for real-time applications
- Applicable for unknown environment
- Accurate in its predictions
- Suitable for distributed solutions
- Various techniques for different scenarios
  - Supervised learning
  - Unsupervised learning
  - Semi-supervised learning
  - Reinforcement learning




Tashtarian, F., Falanji, R., Bentaleb, A., Erfanian, A., Mashhadi, P. S., Timmerer, C., ... & Zimmermann, R. (2021, December). Quality **Optimization of Live Streaming Services over HTTP with Reinforcement Learning**. In *2021 IEEE Global Communications Conference (GLOBECOM)* (pp. 1-6). IEEE.

# Selected Publications 2021


Live Streaming Optimization, RL QoE, SDN, NFV Distributed System

- LEADER: A Collaborative Edge- and SDN-Assisted Framework for HTTP Adaptive Video Streaming
  - R. Farahani, F. Tashtarian, C. Timmerer , M. Ghanbari, H. Hellwagner
  - **IEEE ICC**
- Quality Optimization of Live Streaming Services over HTTP with Reinforcement Learning
  - F Tashtarian, R Falanji, A Bentaleb, A Erfanian, PS Mashhadi, ...
  - **IEEE GLOBECOM**
- Days of future past: an optimization-based adaptive bitrate algorithm over HTTP/3
  - D Lorenzi, M Nguyen, F Tashtarian, S Milani, H Hellwagner, C Timmerer
  - **ACM CoNEXT workshop, EPIQ**
- LwTE-Live: Light-weight Transcoding at the Edge for Live Streaming
  - A Erfanian, H Amirpour, F Tashtarian, C Timmerer, H Hellwagner
  - **ACM CoNEXT workshop, ViSNEXT**
- A Distributed Delivery Architecture for User Generated Content Live Streaming over HTTP
  - F Tashtarian, A Bentaleb, R Farahani, M Nguyen, C Timmerer, ...
  - **IEE LCN**
- CSDN: CDN-Aware QoE Optimization in SDN-Assisted HTTP Adaptive Video Streaming
  - R Farahani, F Tashtarian, H Amirpour, C Timmerer, M Ghanbari, ...
  - **IEEE LCN**
- LwTE: Light-Weight Transcoding at the Edge
  - A Erfanian, H Amirpour, F Tashtarian, C Timmerer, H Hellwagner
  - **IEEE Access**
- ES-HAS: an edge-and SDN-assisted framework for HTTP adaptive video streaming
  - R Farahani, F Tashtarian, A Erfanian, C Timmerer, M Ghanbari, ...
  - **ACM MMSys Workshop NOSSDAV**
- OSCAR: On optimizing resource utilization in live video streaming
  - A Erfanian, F Tashtarian, A Zabrovskiy, C Timmerer, H Hellwagner
  - **IEEE Transactions on Network and Service Management**

# Publications 2022

- HxL3: Optimized delivery architecture for HTTP low-latency live streaming
  - F Tashtarian, A Bentaleb, A Erfanian, H Hellwagner, C Timmerer, ...
  - **IEEE Transactions on Multimedia**
- QoCoVi: QoE-and cost-aware adaptive video streaming for the Internet of Vehicles
  - A Erfanian, F Tashtarian, C Timmerer, H Hellwagner
  - **Elsevier Computer Communications**
- CoPaM: Cost-aware VM Placement and Migration for Mobile services in Multi-Cloudlet environment: An SDN-based approach
  - S Shahryari, F Tashtarian, SA Hosseini-Seno
  - **Computer Communications**
- RICHTER: hybrid P2P-CDN architecture for low latency live video streaming
  - R Farahani, H Amirpour, F Tashtarian, A Bentaleb, C Timmerer, ...
  - **ACM MHV**
- Video streaming using light-weight transcoding and in-network intelligence
  - A Erfanian, H Amirpour, F Tashtarian, C Timmerer, H Hellwagner
  - **ACM MHV**


Live Streaming
Optimization, RL
QoE, SDN, NFV
Distributed System

# ALIS'22 workshop

Colocated with ACM Multimedia 2022
10 – 14 October
Lisbon, Portugal

## ARTIFICIAL INTELLIGENCE FOR LIVE VIDEO STREAMING

### CO-CHAIRS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University of Louisiana, USA

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### IMPORTANT DATES

Submission deadline:
20 June 2022

Acceptance notification:
29 July 2022

Camera-ready deadline:
21 August 2022

### CONTACT US

https://athena.itec.aau.at/alis22/
E-mail: alis22@itec.aau.at

### TOPICS OF INTEREST

- AI-based resource allocation for live streaming
- Using AI/ML techniques for optimizing Interactive Streaming and User-Generated Content
- The tradeoff between QoE enhancement and network overhead: AI approaches
- Using AI/ML at the network edge and the cloud for supporting video streaming
- AI/ML-enabled caching of video chunks
- Experience and lessons learned by deploying AI/ML algorithms for large-scale network-assisted video streaming
- Design, analysis, and evaluation of AI-based Adaptive Bitrate (ABR) algorithms for video streaming
- Network aspects in video streaming: cloud computing, virtualization techniques, network control, and management, including SDN, NFV, and network programmability
- AI/ML-based solutions for supporting streaming applications high-speed user mobility
- Analysis, modeling, and experimentation of WebRTC, Low-Latency DASH, and Low-Latency CMAF for DASH
- Reproducible research in adaptive video streaming: datasets, evaluation methods, benchmarking, standardization efforts, open-source tools
- AI/ML-based techniques for live streaming in 5G and 6G networks
- AI/ML-based techniques for improving infotainment QoE in automotive applications.

ATHENA 5G IANA acm Association for Computing Machinery SIGMM