Rate Allocation for Multi-User Video Streaming over Heterogeneous Access Networks

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Multiple Access Network

How to have efficient utilization of all networks simultaneously?

Flows  Middleware  Internet  802.11x  LAN/WAN
Outline

- Network and Video model
- Rate allocation schemes
  - Media-aware allocation
  - H∞-optimal allocation
  - Additive Increase Multiplicative Decrease (AIMD)-based heuristics
- Performance evaluation
- Video demo

Network Model
**Video Distortion Model**

![Graph showing Video Distortion Model]

- Late loss due to congestion
- \( D_{enc} = D_0 + \frac{\theta}{R - R_0} \)
- \( D_{loss} = \kappa P_{loss} \)
- \( D_{dec} = D_{enc} + D_{loss} \)

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**Media-Aware Allocation**

- **Optimization objective:**
  
  \[
  \min_{R} \sum_{s} D_{dec}^t \quad \text{Ensure Unique solution}
  \]

  \[
  s.t. \quad R^t_s = \rho_n R^t
  \]

  \[
  \rho_n = \frac{ABR_n^t}{\sum_n ABR_n^t} \quad \text{Balanced Utilization}
  \]

- **Distributed approximation:**
  
  \[
  \min_{R^s} D^s(R^s) + \sum_n \kappa' P_{loss}(\rho_n R^s)
  \]

  Contribution to video distortion

  Contribution to congestion
**H$^\infty$-Optimal Allocation**

- Linear state-space system
- Bandwidth variations - unknown disturbances
- Worst-case optimization
- Decoupled control of streams
- No RTT, DR characteristics

[Alpcan et al. 2007]

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**AIMD-Based Heuristics**

- Reactive to congestion

![Diagram](attachment:image.png)

- **Greedy AIMD**: choose network with maximum instantaneous ABR
- **Rate Proportional (RP) AIMD**: allocation in proportion to average ABR
Simulation Methodology

Good quality

Bad quality

Aggregate Video Rate over Ethernet

30% background traffic, 300ms playout deadline
Allocated Video Rate

Media-Aware

H∞-Optimal

AIMD Rate Proportional

Packet Loss Ratio and Delay

Packet Loss Ratio (%)

Delay (ms)

30% background traffic, 300ms playout deadline
Received Video Quality

Network Utilization
Harbor

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Conclusions

- Framework for *simultaneous* rate control and allocation, adaptive to network and video
- Evaluation & comparison of 4 diverse schemes with HD video streams
- Benefits of proactive rate allocation:
  - Less fluctuation in rate
  - Reduced packet loss and delay
  - Improved received video quality
- Benefits of media-aware allocation:
  - More balanced video quality among the streams

Implications

- Quality of service (QoS) provisioning for rate-demanding and delay-sensitive media applications
- Convergence of multiple networking technologies
- Seamless soft handover for mobile devices