QoE-based Multi-Stream Scalable Video Adaptation over Wireless Networks with Proxy

Hao Hu, Xiaoqing Zhu, Yao Wang, Rong Pan, Jiang Zhu and Flavio Bonomi
Electrical & Computer Engineering, Polytechnic Institute of NYU
Advanced Architecture and Research, Cisco Systems, Inc.

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Outline

- Challenges of mobile video streaming
- Proxy-based solution
  - Optimization framework
  - Iterative algorithm
  - Practical design
- Performance evaluation
Challenges of Mobile Streaming

- Highly dynamic wireless channel
- Heterogeneous link qualities
- Multiple competing streams
Proposed Proxy-Based Solution

- Estimate per-link throughput
- Monitor bottleneck queue
- On-the-fly SVC rate adaptation
Optimization Objective

\[
\begin{align*}
\text{max} & \quad \{q_i, f_i\} \\
\text{s.t.} & \quad \sum_j \frac{R_j}{C_j} + \sum_i \frac{R_i(f_i, q_i)}{C_i} \leq \gamma
\end{align*}
\]

- Based on parametric rate and perceptual quality models \cite{Zhan et al., 2008}
- Combinatorial complexity: \( \sim O((N_q N_f)^I) \)
An Iterative Approach

\[ \tilde{Q}_i(R_i) \]

Find optimal \((q_i, f_i)\) combination

\[ \max \left\{ R_i \right\} \sum_i w_i \tilde{Q}_i(R_i) \]

s.t. \[ \sum_j \frac{R_j}{C_j} + \sum_i \frac{R_i}{C_i} \leq \gamma \]

- A utility maximization problem
- Iterative solution exists
Iterative vs. Exhaustive Search

- **Running time**
  - Exhaustive: ~500ms
  - Iterative: 0.17 ms

- **Total Normalized MOS**
  - ~5% efficiency loss

- **Graph**
  - Link Throughput (Kbps) vs. Total Normalized MOS
  - Black line: Exhaustive Search
  - Red line: Iterative
System Diagram

Video R-Q parameters

Video packets

SVC video source

Optimal rate calculation

Bottleneck queue size
Estimated link throughputs

Video packets

SVC video adaptation

Bottleneck queue

Video packets

Dynamic links
Single Stream over a Dynamic Link

- Video server
- FTP source
- Proxy
- Video receiver
- FTP Sink

Downtown Mountain View, CA
Streaming over A Single Dynamic Link

Demo

Faster recovery

Competes fairly with TCP
Multiple Competing Streams

TFRC

Proxy-Based

Link- and media-aware allocation

Graceful quality degradation

Average Video Rate (kbps)

Number of Nodes

Average Normalized Quality

Number of Nodes
Differential Services among Users

- Nine users divided in three groups, sharing a common AP
- All users have PHY rate of 12Mbps
Conclusions

- Resource sharing at the wireless bottleneck based on video rate and perceptual quality models
  - Link- and media-aware rate allocation
  - Naturally supports differential services among users
- Proxy-based streaming using SVC:
  - Lightweight in-network adaptation
  - Fast reaction to wireless link dynamics
- Competes fairly with TCP flows