On the Interactions Between Layered Quality Adaptation and Congestion Control for Streaming Video

11th International Packet Video Workshop

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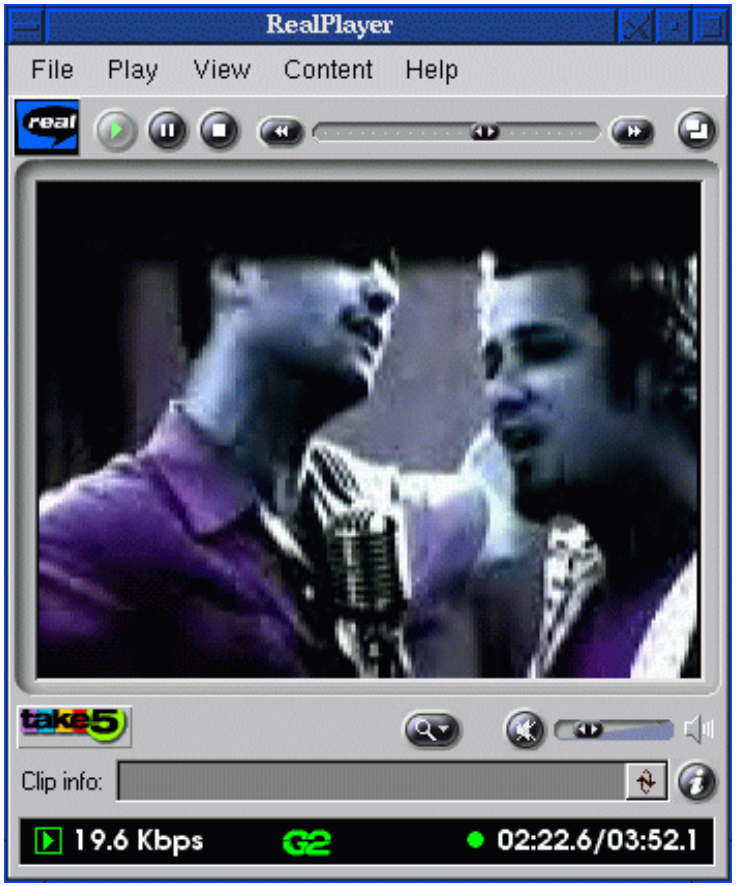
http://nms.lcs.mit.edu/projects/videocm/

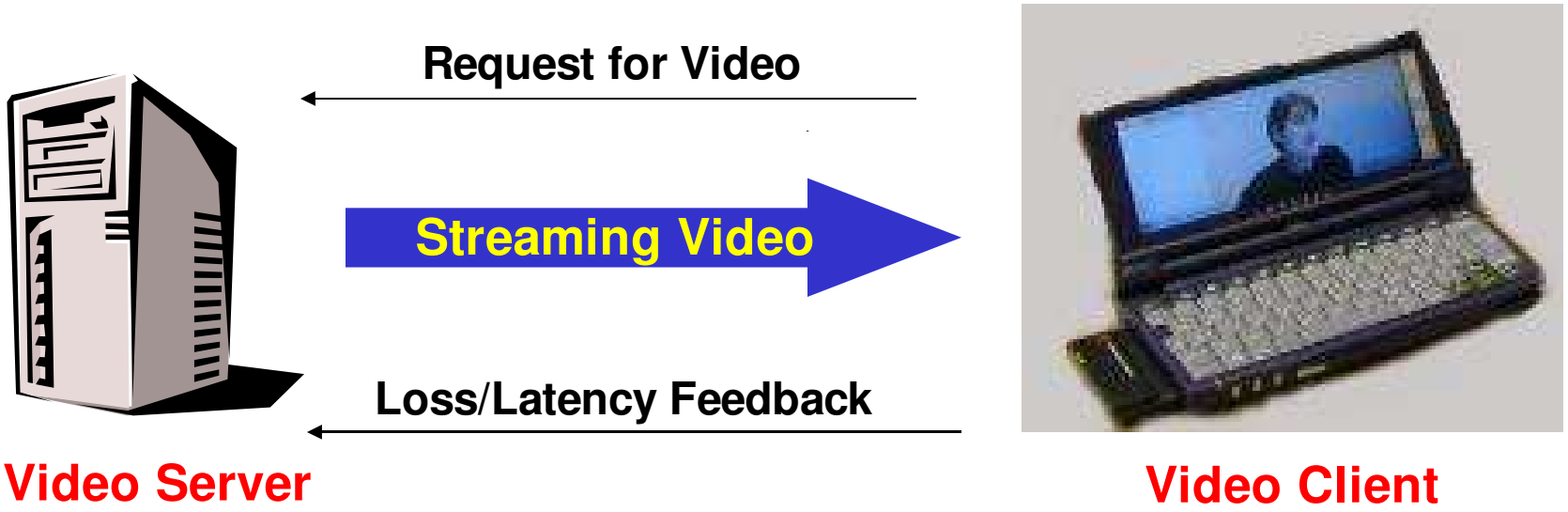
Not Like Watching TV!



Why Is This Happening?

- The Internet poses several problems for the delivery of data
  - Variable Bandwidth
  - Variable Delay
  - Packet Loss
- Very detrimental to interactive video delivery
- **How do we transmit video on the Internet in the face of varying bandwidth?**

System Context



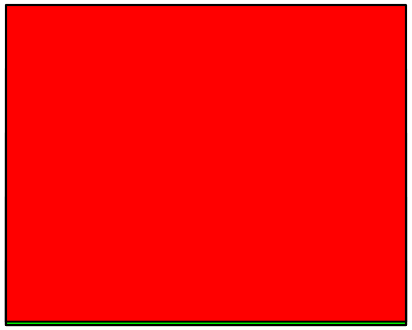
- This talk is about bandwidth adaptation
- *Conclusion:* The combination of smooth congestion control and clever receiver buffering can overcome the evils of bandwidth variation!

Bandwidth Adaptation

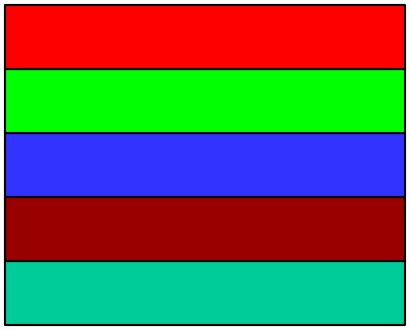
- Available bandwidth varies with time
- Servers should adapt to varying bandwidth
  - **Congestion Control:** Transmission rate must
    - correspond to available bandwidth
    - be *TCP-friendly*
  - **Quality Adaptation:** Quality of video should correspond to transmission rate
- *Limited capacity for buffering!*

Layered Video

- *Simulcast:* Each layer is independent
- *Hierarchical:* Higher depends on lower
  - Base/Enhancement layers
  - Linear granularity (*C* bits/layer)

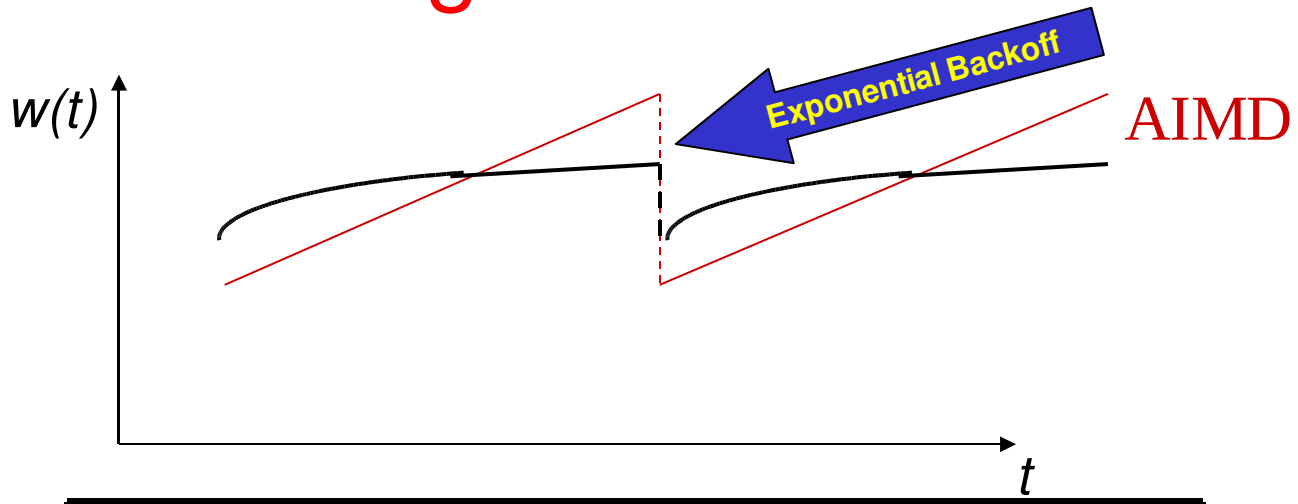


Simulcast Layering



Hierarchical Layering

Binomial Congestion Control



	AIMD	Binomial
Increase	α	$\alpha / \mathbf{w}^{K}$
Decrease	β **w**	β $\mathbf{w}^{L}$

- Trade-off between increase aggressiveness and decrease magnitude
- K+L=1 implies TCP-friendly [Bansal, INFOCOM 2001]
- SQRT has a modest backoff (~$R^{1/2}$) => attractive for streaming media

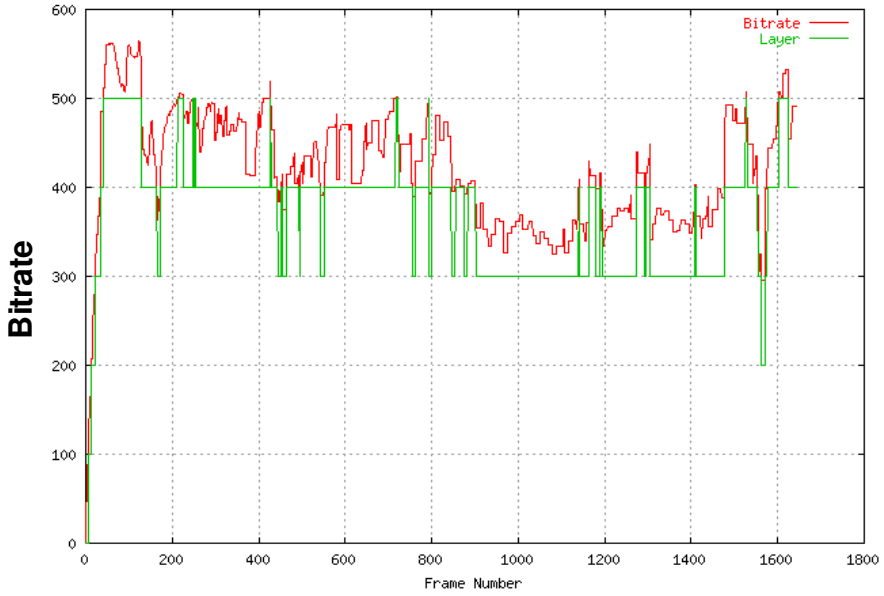
Reduced Oscillations

In many cases, AIMD drops multiple layers in one backoff! This is not the case with SQRT.

Rate oscillations in SQRT are much less pronounced than in AIMD.

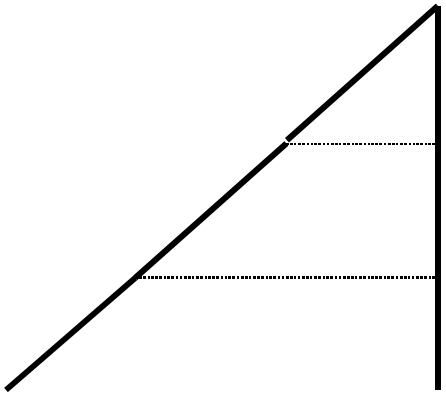
AIMD

SQRT

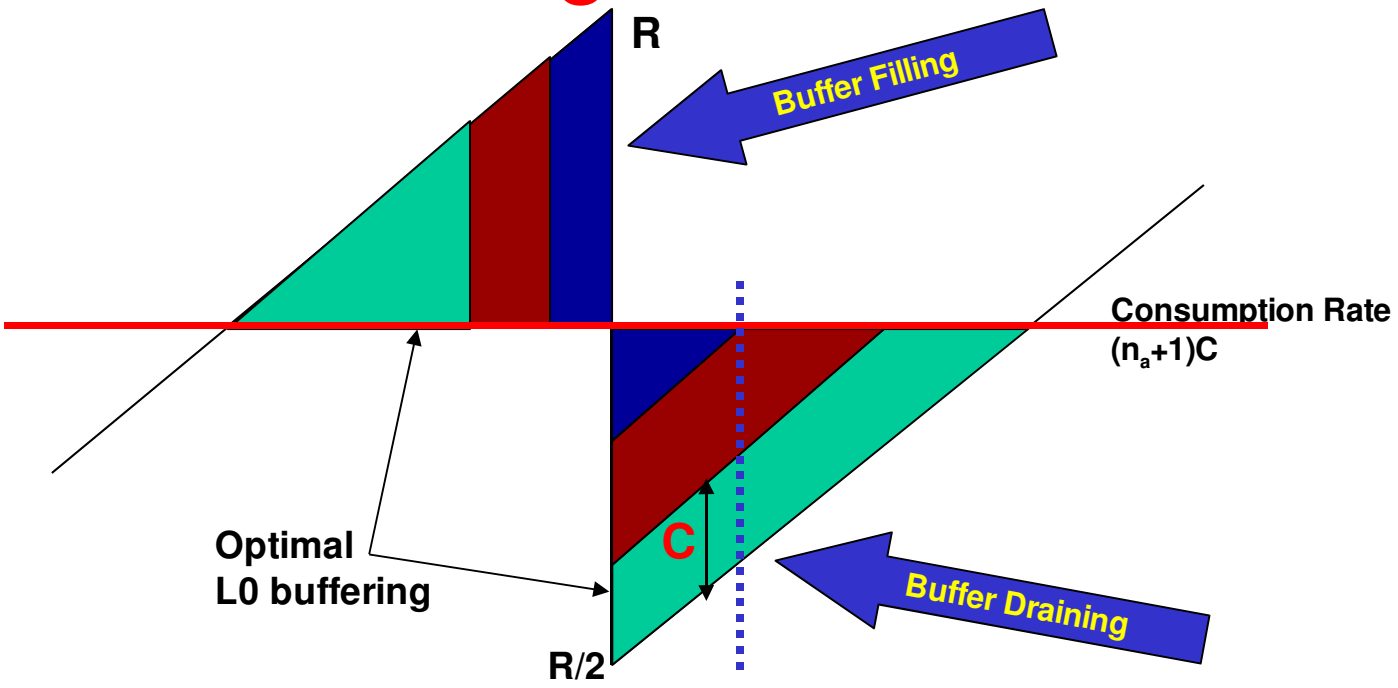


Layered Quality Adaptation

- *Tailor video to available bandwidth!*
- Can be immediate or receiver-buffered
  - Rejaie et al., SIGCOMM '99

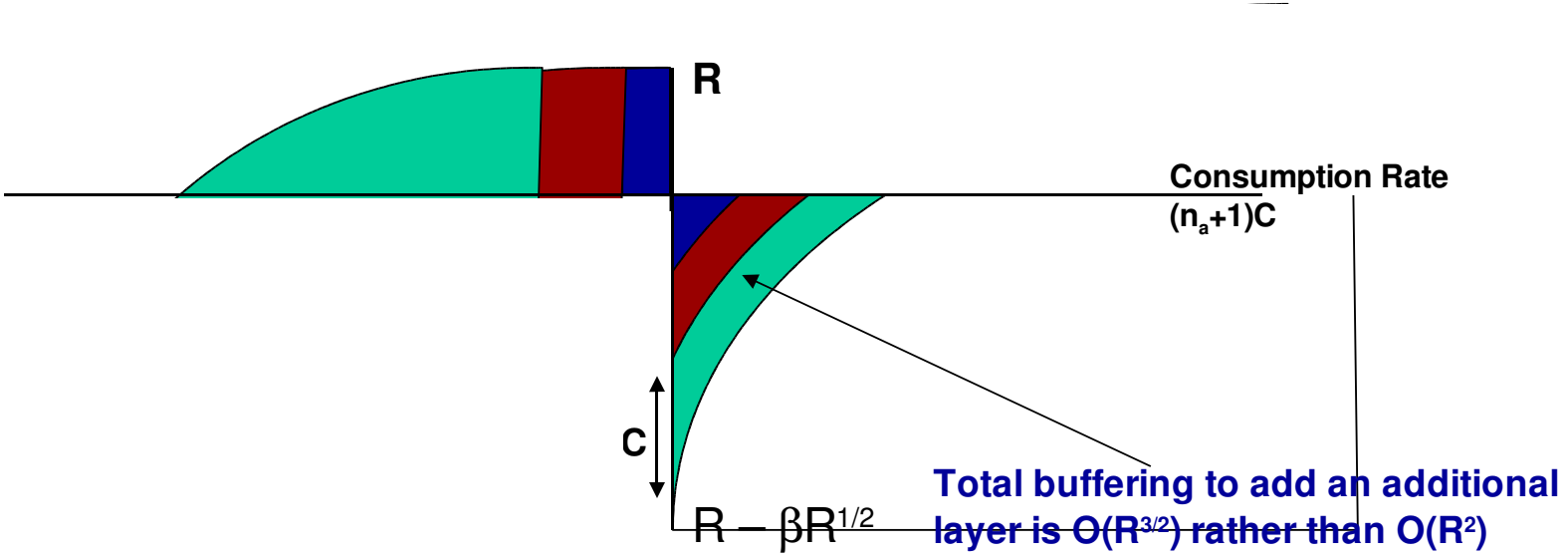


Receiver Buffering



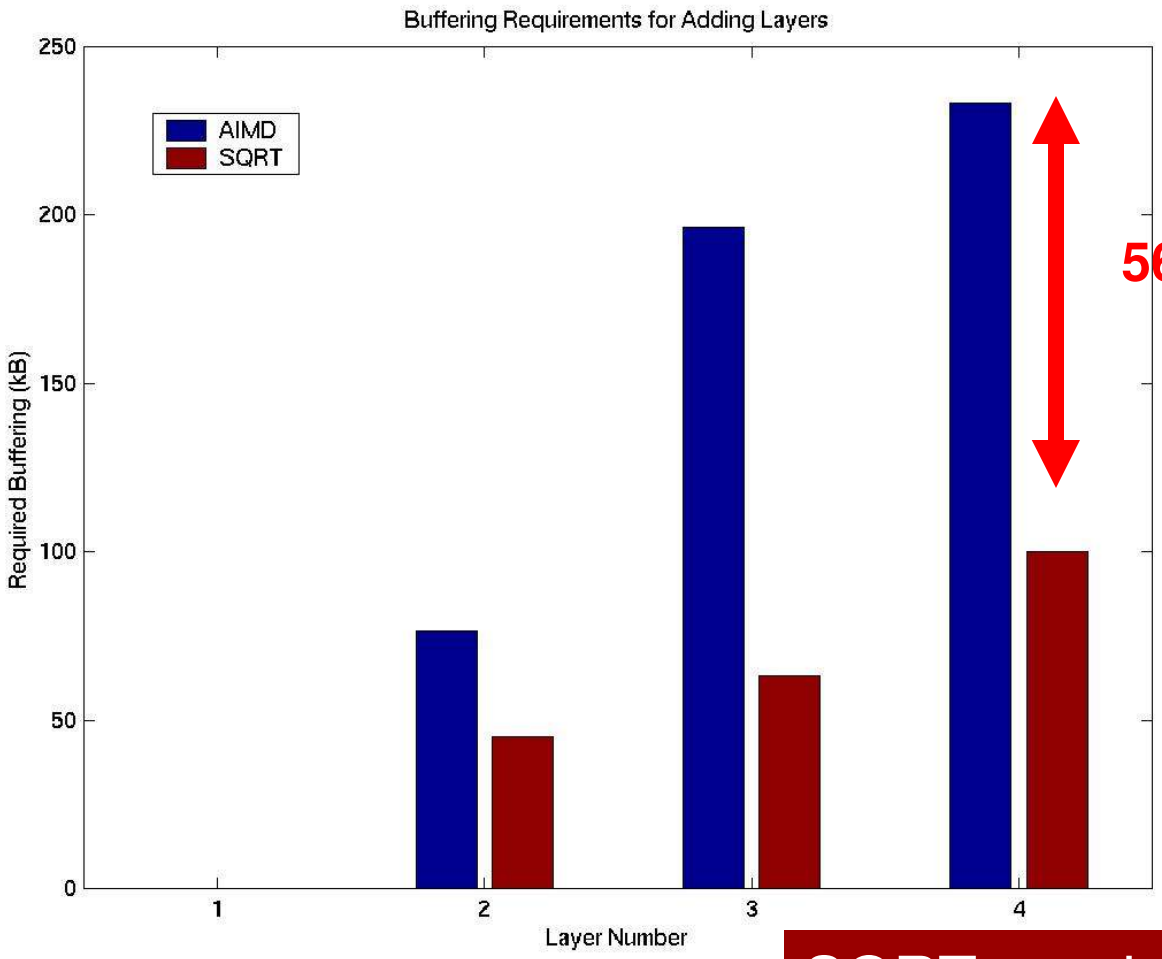
- Allocate more buffer space to lower layers
- Add a layer when the following conditions are met:
  - Enough bandwidth is available
  - Enough video is buffered to sustain a backoff and continue playing all of the layers (including the new layer)

Interaction of SQRT and QA: *We Win!*



- With SQRT:
  - Smaller Oscillations
  - Less buffering required for quality adaptation

Reduced Buffering



56% less buffering to add 4 layers

SQRT requires less buffering to add layers!

Conclusion

- Combination of SQRT congestion control with receiver quality adaptation enables smooth video delivery
  - Reduces rate oscillations
  - Reduces buffering/Increases interactivity
- Software is available
  - Includes selective reliability for packet loss
  - **`http://nms.lcs.mit.edu/software/videocm/`**

Extra Slides

Outline

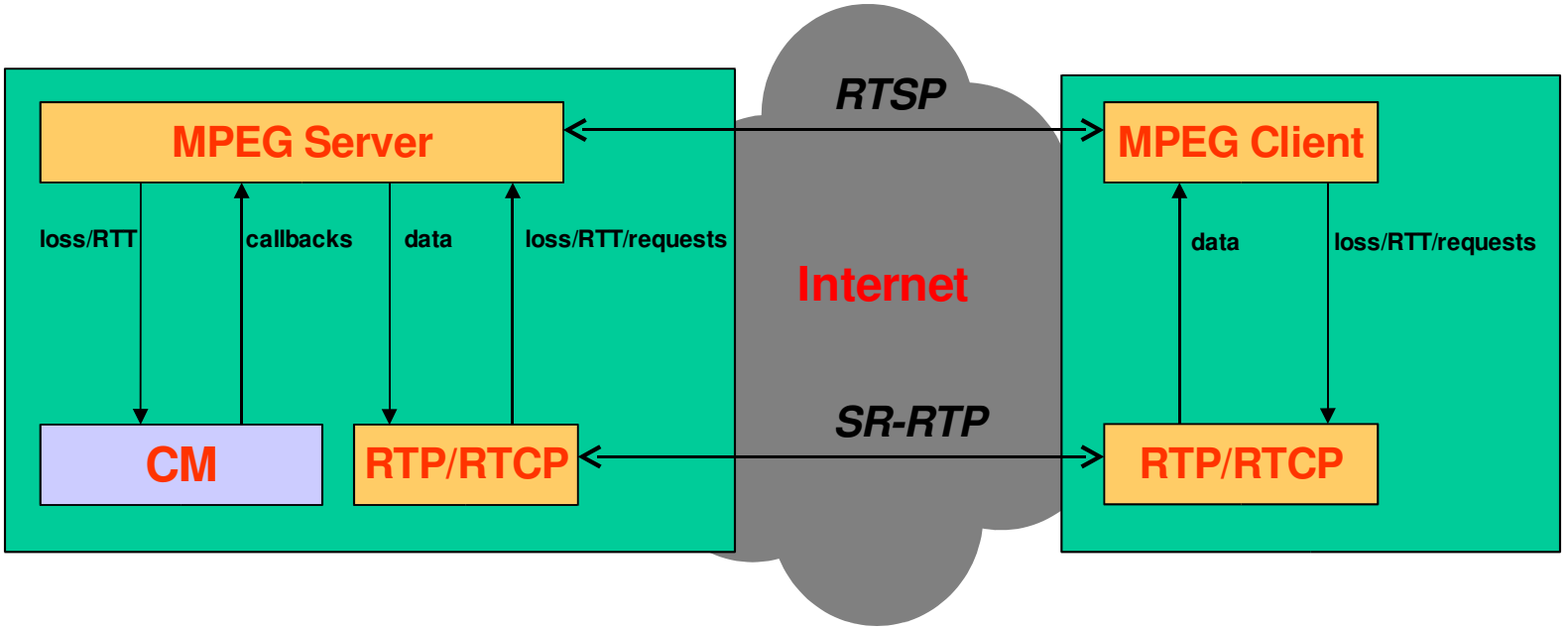
- Problem Overview
- Background
  - Bandwidth Variation
  - Quality Adaptation
  - Binomial Congestion Control
- Approach
- Results
- Conclusion

The Goal

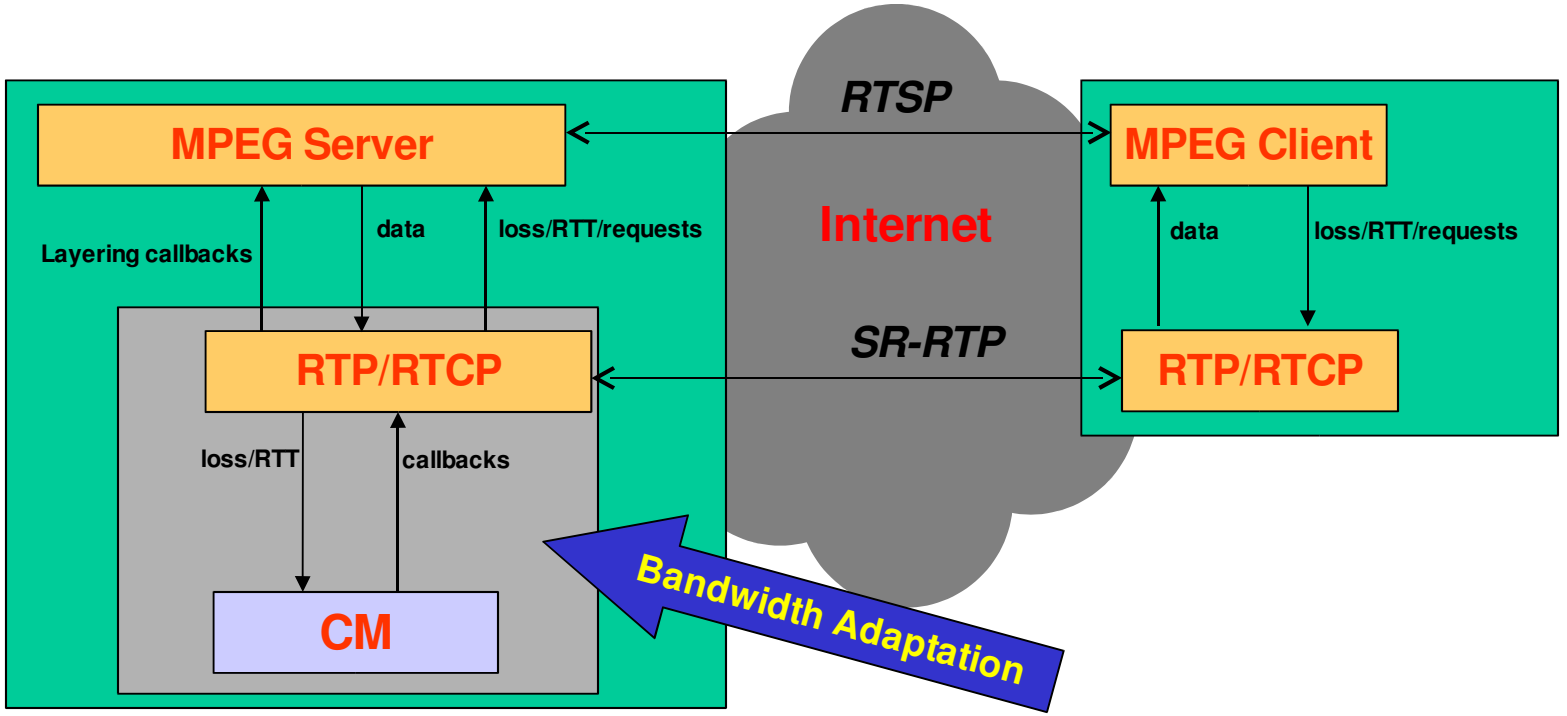
- TCP-friendly congestion control
- Reduce rate oscillations:
  - Limit size of playout buffer
  - Smooth perceptual quality
- Limit receiver buffering for QA
  - Reach acceptable playout rate faster
  - More interactivity in certain cases (i.e., if RTT and RTT jitter are small)

Results of SQRT

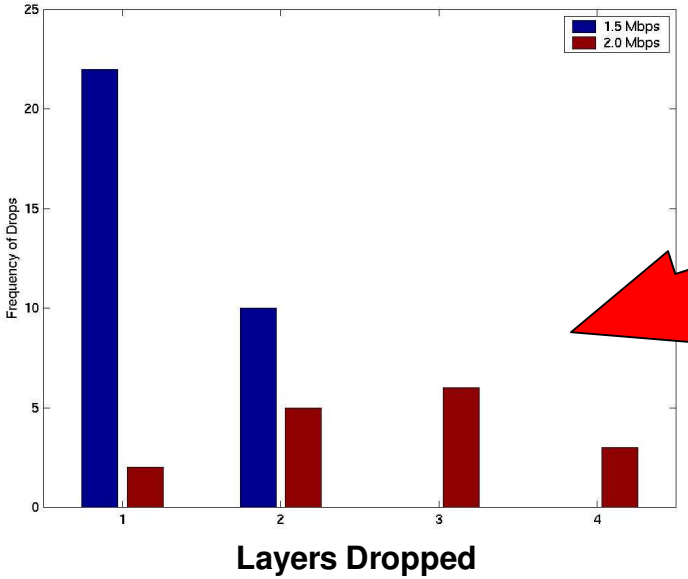
- Tested on emulated network conditions with Dummynet and SURGE toolkit
- SQRT reduces rate oscillations for:
  - Immediate adaptation
  - Receiver-buffered QA
- Also reduces buffering:
  - Less jitter due to rate oscillations
  - Backoffs less severe => less QA buffering
  - Can play out at higher layers more quickly
  - More interactivity


RTSP
MPEG Server
MPEG Client
loss/RTT
callbacks
data
loss/RTT/requests
Internet
data
loss/RTT/requests
SR-RTP
CM
RTP/RTCP
RTP/RTCP

System Architecture



Reduced Oscillations



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