Optimal Patching Schemes for Efficient Multimedia Streaming

S. Sen, L. Gao, J. Rexford, D. Towsley

{sen,towsley}@cs.umass.edu

gao@cs.smith.edu

jrex@research.att.com

Presented by : **Shubho Sen**

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Outline

- Motivation
- Video Patching
- 2 novel Patching schemes
  - Periodic Buffer Reuse with thresholding (PBR)
  - Greedy Buffer Reuse (GBR)
- Evaluations of PBR and GBR
- Summary and ongoing work

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Streaming Video Distribution

Problem Setting

One-many streaming of prerecorded CBR video

High bandwidth, long-lived transmissions

Asynchronous clients

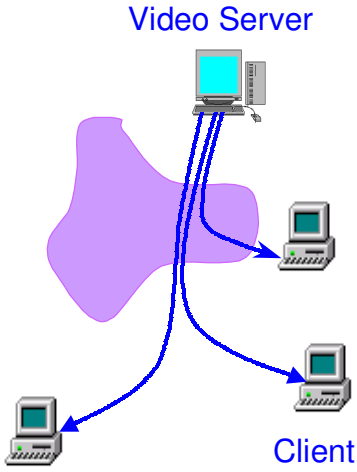
Goal: Efficient dissemination of low latency, high quality streaming video

Technology Trends

Growing multicast capability

Commodity PCs

- Store few minutes video data
- I/O, network bandwidth for multiple streams



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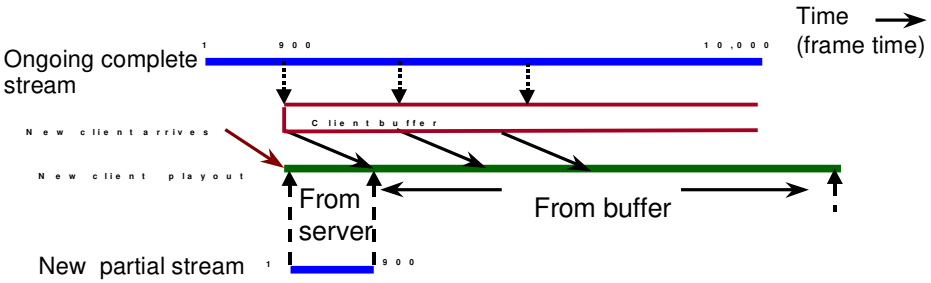
Video Patching [Carter,Gao,Hua]

Central ideas:

- Workahead buffering
- Reception from multiple streams
- Partial reception from earlier started transmission



Advantage: Server, Network bw reduction w/o startup delay

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Periodic Buffer Reuse (PBR) Patching

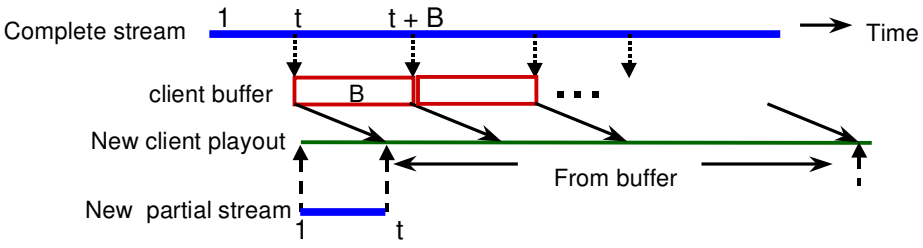
Client arriving t time units after first : Patch to *single* existing transmission - the complete stream

Intuition

- Receive from complete stream whenever buffer available
- A frame on new channel received *as late as possible*

B = client buffer size, **N** = video size in frames

Case t ≤ B: First t frames from server, remaining suffix from complete stream



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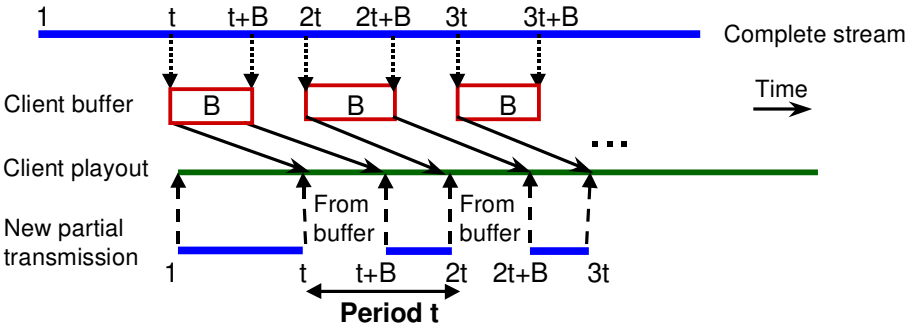
PBR Patching (Contd)

Case t > B :



- Similar observation by Carter and Long

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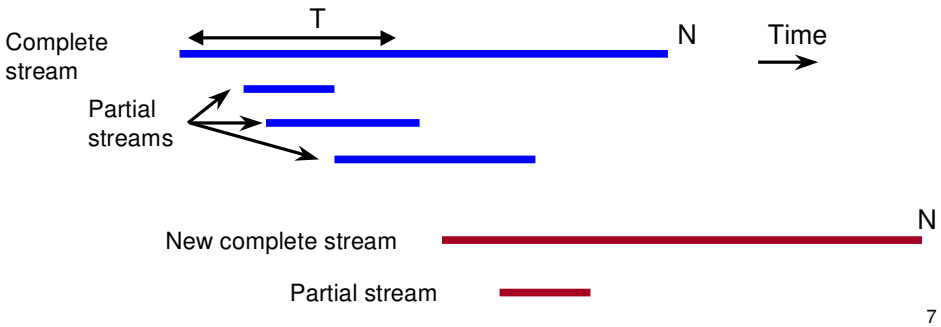
PBR Patching uses Thresholding

- Threshold T
- Client arrival ≥ T time units after starting complete stream
  ⟹ triggers new complete stream
- Intermediate arrivals : Patch to *most recently initiated* complete stream



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PBR Patching - Analysis and Threshold Computation

- **Metric** - expected total # frames transmitted per client
- Closed form solution using renewal theory,
  - Depends on T, B, N, client arrival process (mean arrival rate, P[one or more arrivals at any time])
  - Approximation to compute value from closed form
- Obtain threshold T_{opt} that minimizes metric
- Evaluation - compare with Restricted Buffer Reuse (RBR) patching [Gao:99]

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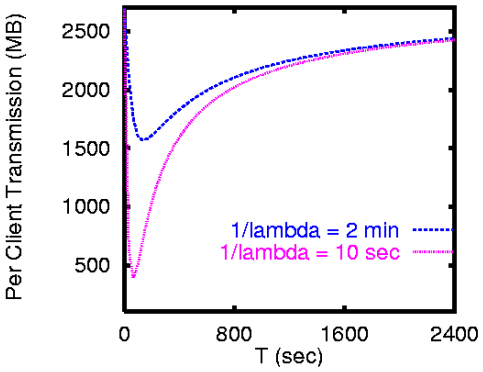
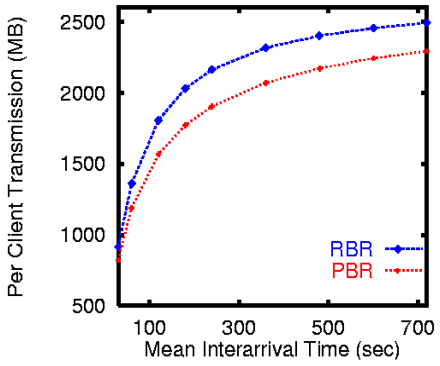
PBR Patching - Evaluation

Poisson Arrivals, 1 hour long 6 Mbps CBR Video, B = 45 MB



- Choice of T important



- PBR produces lower transmission overheads than RBR

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Greedy Buffer Reuse (GBR) Patching

PBR - disadvantages

- Client patches to ***single*** existing transmission - Most recently initiated complete stream
- Listens to at most two streams simultaneously
- Performance sensitive to choice of T (T_{opt} depends on arrival process)

What is the best performance that patching can achieve?

- Allow client to patch to *any* ongoing transmissions
- Aggressively use client workahead buffering

$\Rightarrow$ Greedy Buffer Reuse (GBR) patching

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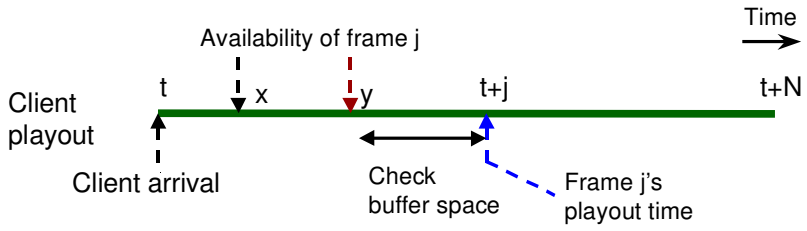
GBR Patching algorithm

Key: Minimize workahead buffer residency times to maximize buffer reuse - Client receives frame *as late as possible*

Algorithm: Executed at new client arrival time, ind. of future arrivals

In order of increasing frame number,

- Check for frame availability and buffer space
- Receive latest copy of frame from an existing stream if possible
- Otherwise receive from server just before playout time



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GBR Patching - Properties

Globally optimal patching algorithm

- No other patching algorithm requires fewer frames from server
  - Over **all** patching policies that do not introduce startup latency
- Independent of arrival process
- Performance lower bound for evaluating patching schemes

Practical Issues

- Complexity O(NB) per client arrival
- No explicit constraint on # streams/channels a client may listen to simultaneously
- No constraint on frequency of channel joins/leaves

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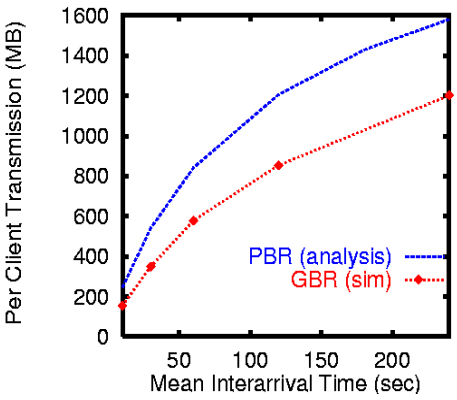
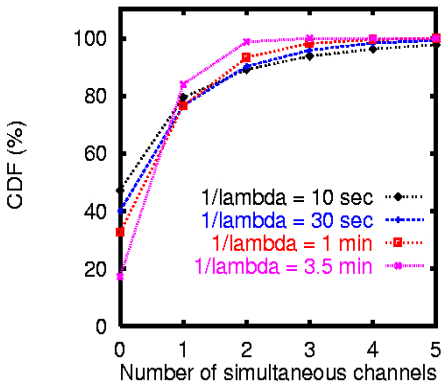
GBR Patching - Evaluation

Poisson arrivals, 1hour long 6Mbps CBR video, B = 90 MB





- GBR significantly outperforms PBR
- Clients rarely listen to more than 3-4 channels simultaneously

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Conclusions and Ongoing Work

- Presented 2 novel patching algorithms - PBR and GBR
- GBR as basis for practical patching algorithms
  - Reduce frequency of channel join/leaves
  - Incorporate explicit constraint on # channels a client listens to simultaneously
- Proxy-based patching is a promising service
  - Architecture and protocol issues
- Implementing streaming server testbed to investigate patching

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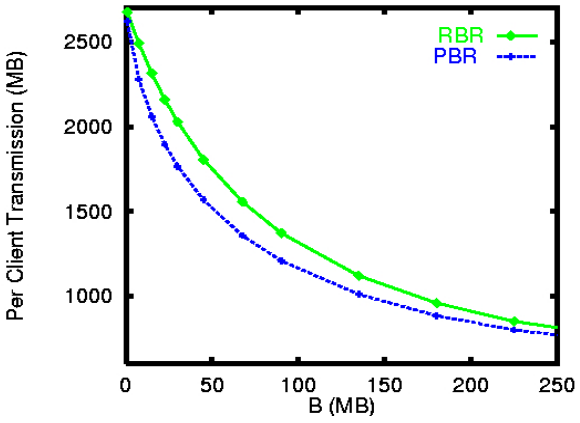
PBR Patching - Evaluation

Poisson arrivals, 1hour long 6Mbps CBR video, 1/lambda = 2 min



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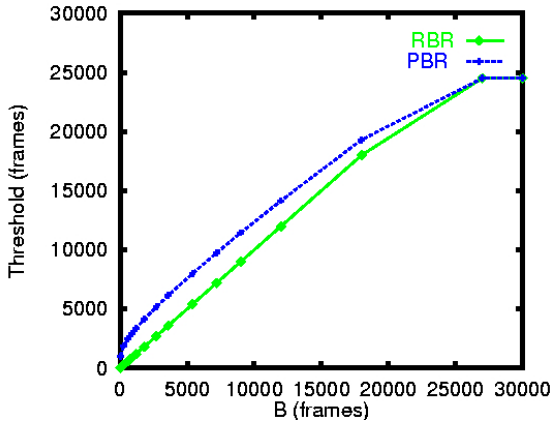
PBR Patching - Evaluation

Poisson arrivals, 1hour long 6Mbps CBR video, 1/lambda = 2 min



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