Smoothing Variable-Bit Rate Video in an Internetwork

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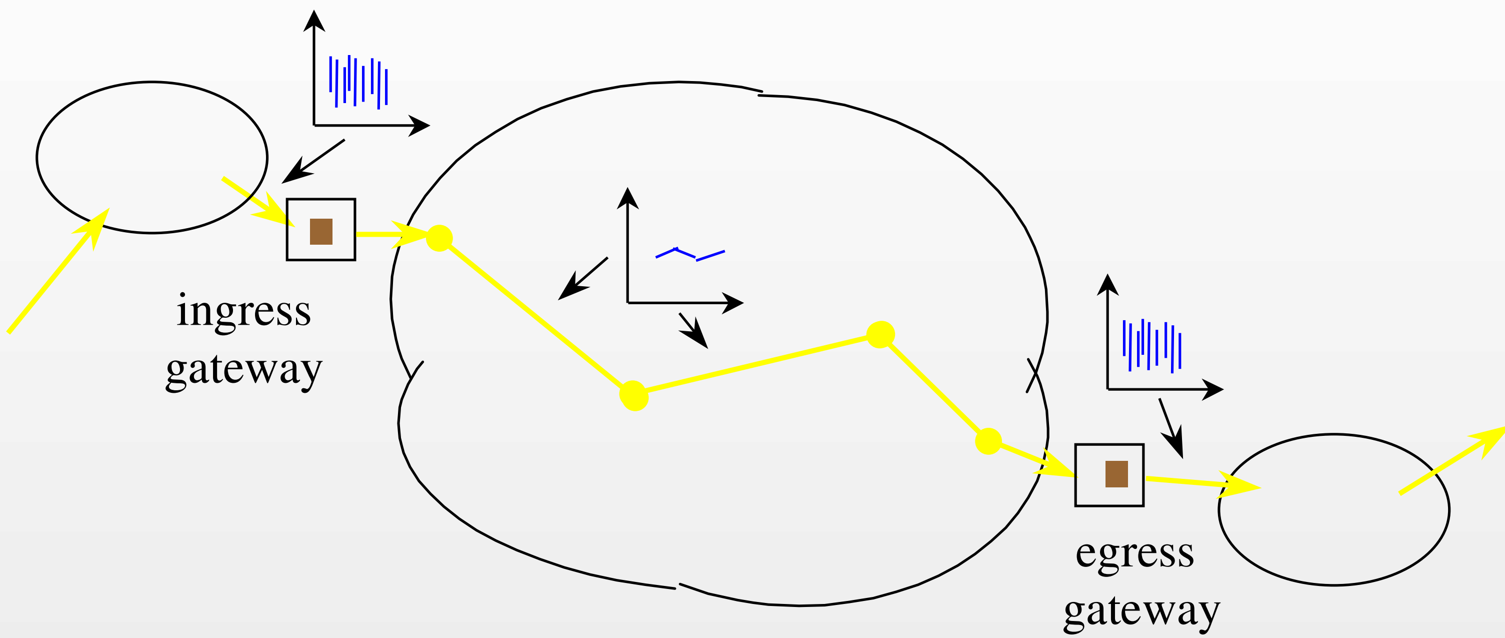
Transmission of VBR Video



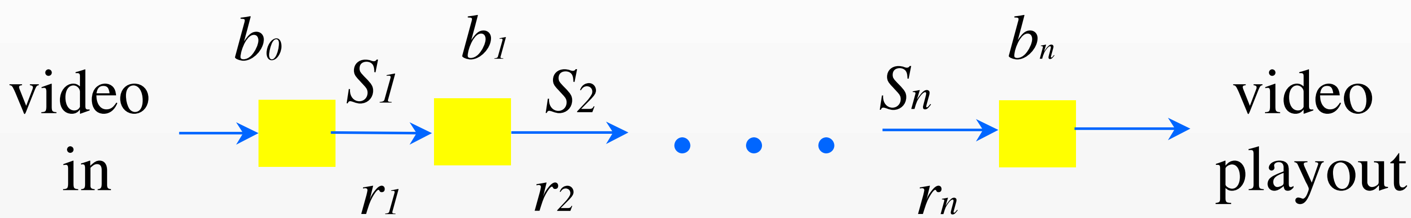
buffer at ingress and egress gateways

how should VBR video be shaped/smoothed
for transmission through network?

Outline

- the smoothing problem
- single link problem and relation to internetwork problem
- optimal smoothing for internetwork problem
- performance evaluation
- summary

Model and Problems



n+1 nodes, n links

source - 0

b_i - size of buffer at node i

r_i - peak rate for link i

S_i - transmission schedule for link i

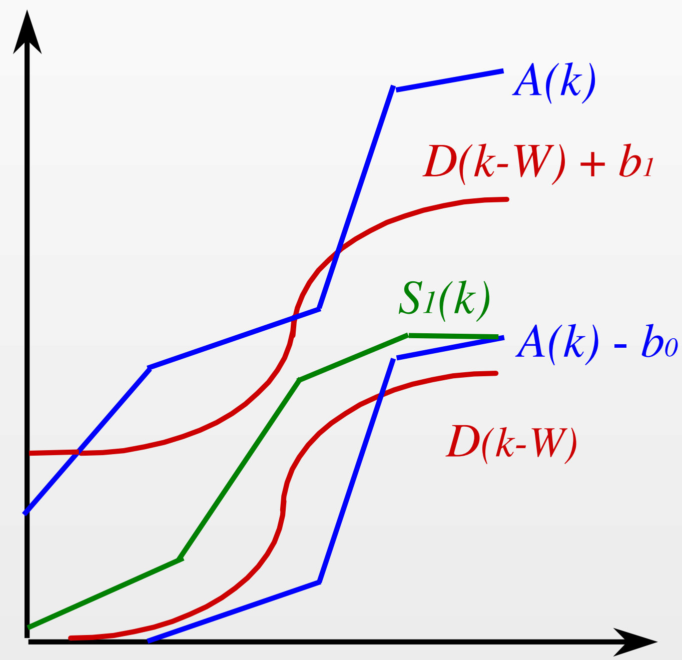
Determine video schedules $\{S_i\}$ so as to

- minimize peak rates $\{r_i\}$ subject to buffer constraints $\{b_i\}$

- minimize buffer sizes $\{b_i\}$ subject to rate constraints $\{r_i\}$

Single Link Problem

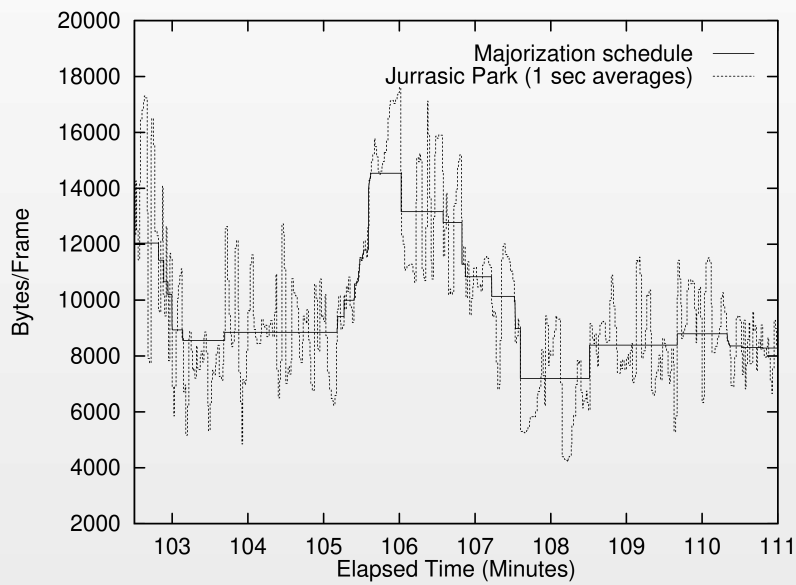
- time is discrete, k=1,2,3,...
- $D(k)$ - no bytes played out by time k
- $A(k)$ - no. bytes arrived by time k
- $S_1(k)$ - no bytes transmitted by time k
- startup delay W



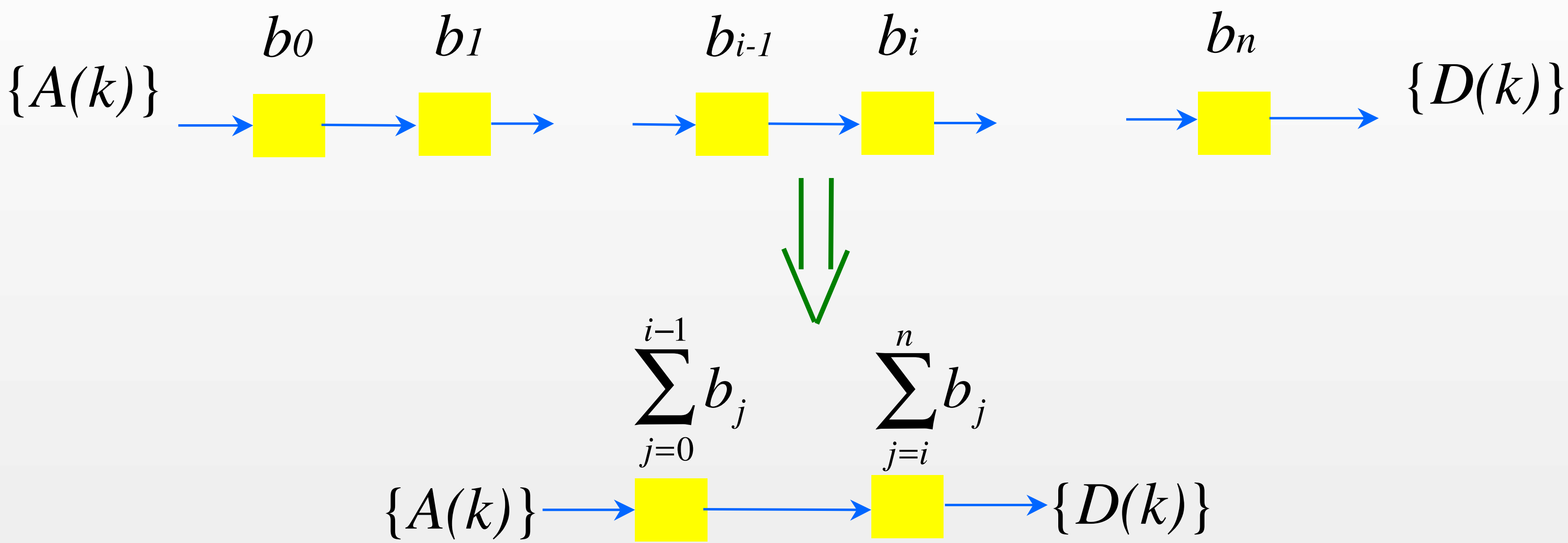
time - k

Solution to Single Link Problem

- $O(N)$ shortest path algorithm finds majorization schedule $\{S_1(k)\}$ that minimizes any Schur-convex function of scheduled rates
  - peak rate
  - rate variance
- exhibits certain monotonicity properties in b_0 and b_1



Tandem System Revisited



Key result: problem decomposes into n independent single link problems

Buffer Allocation

Q: given total buffer of size B, where to allocate in tandem system?

A: allocate to end nodes:

$$b_0, b_n > 0, \qquad b_0 + b_n = B$$

$$b_i = 0, \qquad i = 1,\ldots,n$$

Also peak rate $p(b_0)$ is convex function of b_0

And when $A = D$, $p(b_0) = p(B-b_0)$

Performance Evaluation

System parameters

- total buffer size *B*, startup latency *W*

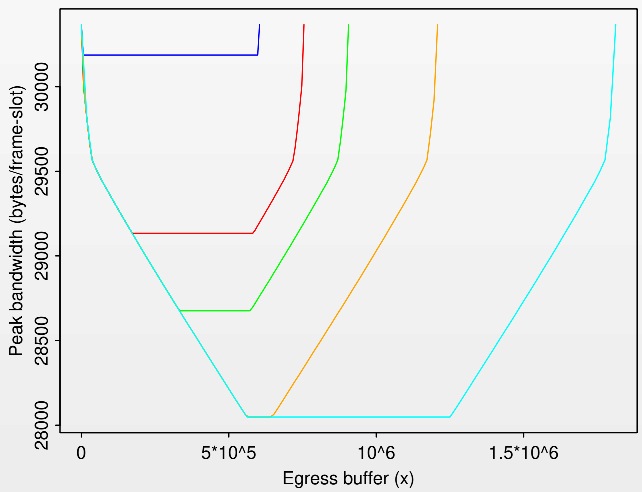
Performance metrics

- peak rate
- coeff. of variation (stdrd deviation/mean)

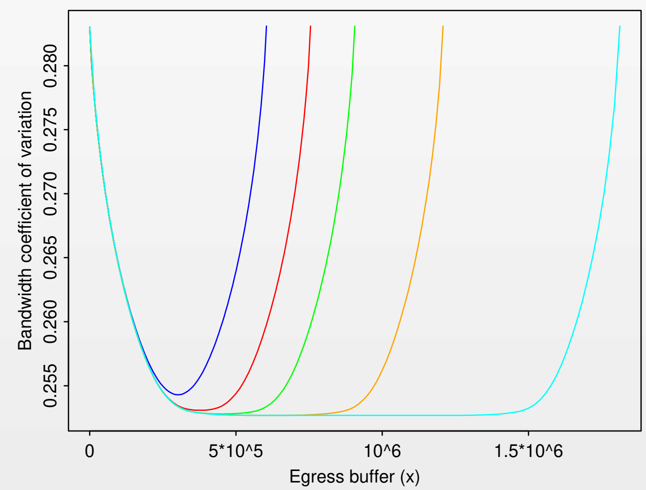
for motion-JPEG encoding of *Beauty and the Beast*

Effect of Varying Egress Buffer Allocation

peak rate vs. egress
buffer alloc *x*



coeff of variation vs. egress
buffer alloc *x*



B = 590kB, 735kB, 885kB, 1.18mB, 1.77mB
W = 20 frames

Summary

- developed optimal smoothing algorithms for internetworking environment
- established properties of optimal buffer allocation
  - allocate at ends
  - convexity of peak rate
  - symmetry
- demonstrated smoothing benefits with example