Activating and Deactivating Repair Servers in Active Multicast Trees

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Overview

- Background and related work
- Performance evaluation framework
- Algorithm for dynamic activation/deactivation Repair Servers (RS) in a multicast tree
- Simulation results

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Background & Related Work

- Reliable multicast protocols using local recovery
  - Receiver based local recovery
    - RMTP, S. Paul, JSAC '97
    - STORM, H. Zhang, NOSSDAV'97
    - N. Maxemchuk, ICNP'98
    - M. Lucas, IC3N'97
  - Server based local recovery
    - AER, S. Kasera '98
- Server based local recovery provides better performance, but consumes additional resources
    - S. Kasera, '98
    - D. Rubenstein, Info'99
    - P. Osland, Umass TR'99

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Why Dynamically Activate an RS?

RS's

- Advantage:
  - Fast recovery
  - NAK suppression
  - Saving bandwidth
- Disadvantage:
  - Require resources (buffering, compute)

Why dynamically activate?

- Minimize use of resources that are not needed
- Dynamically respond to changing link loss, tree structure

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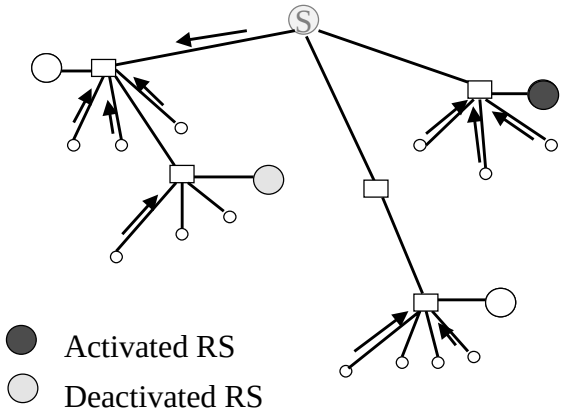
How to Dynamically Activate/Deactivate an RS



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Evaluation With NO RS

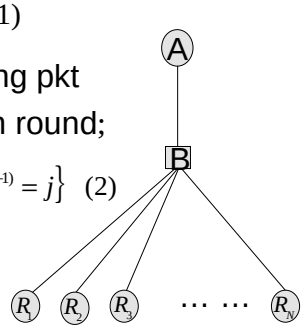
$$F(x) = \frac{1}{|R|} \cdot \sum_{i \in R} P\{X_i \le x\}$$

$$= \frac{1}{N} \cdot E[\#\ \text{rcv's who get packet before time } x]$$

$$= \frac{1}{N} \cdot \sum_{i=1}^{N} i \cdot P\{T^{(d)} = i\} \quad (1)$$

$T^{(d)}$:number of receivers getting pkt by the d-th retransmission round;

$$P\{T^{(l)} = i\} = \sum_{j=0}^{i} P\{T^{(l)} = i \mid T^{(l-1)} = j\} \cdot P\{T^{(l-1)} = j\} \quad (2)$$



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Evaluation With an RS

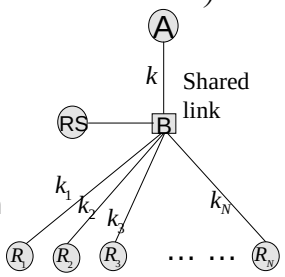
- Condition on # of times pkt lost on shared link and on downstream link:

$$F(x) = \frac{1}{|R|} \cdot \sum_{i \in R} P\{X_i \le x\}$$

$$= \frac{1}{N} \cdot \sum_{i \in R} \left(\sum_{k=0}^{\infty} \sum_{k_i=0}^{\infty} 1\left(X_i(k,k_i) \le x\right) \cdot P\{K_i = k_i\} \cdot P\{K = k\} \right) \quad (3)$$

k :is the number of losses prior to the first successful transmission of a packet on path AB

k_i :is the number of losses prior to the first successful transmission of a packet on path BR_i



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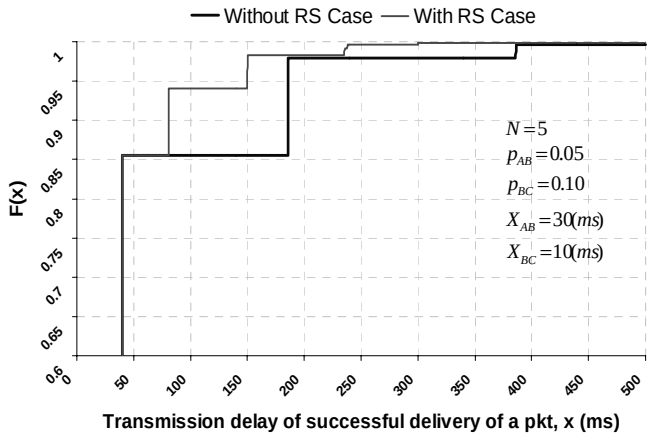
Numerical Case Study



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Algorithm to Dynamically Activate an RS

- Measurement at each RS periodically
  - Smoothed packet loss rate, $\hat{P}_{loss}^{k}$
  - Upstream RTT, R_u
  - $\phi = R_u \times \hat{P}_{loss}^{k}$
- Two-threshold mechanism control RS (de)activation
  - RS activated, if $\phi > t_h$;
  - RS deactivated, if $\phi < t_l$; $t_l < t_h$

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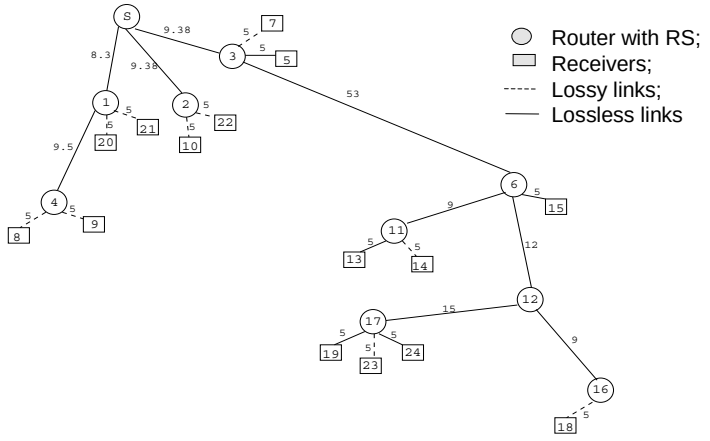
Simulation



$$\rho = \frac{\text{Total active duration of all RSs}}{\text{Total running time} \times \text{Number of RSs}}$$

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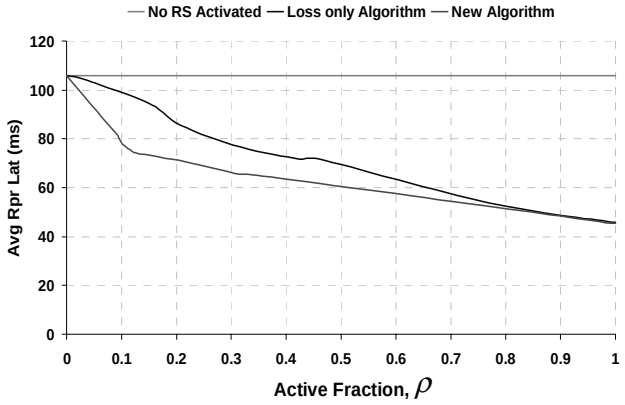
Average Repair Latency



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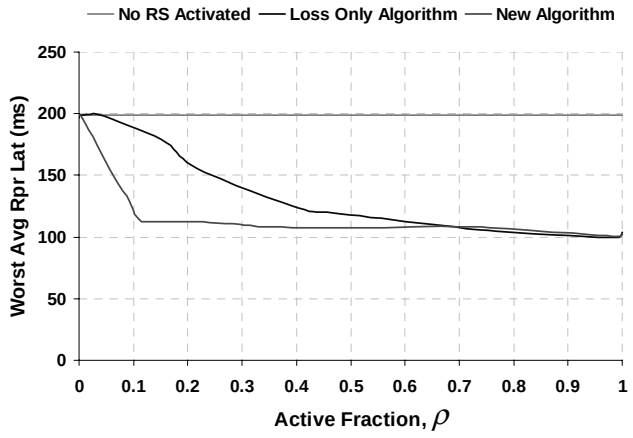
Worst Average Repair Latency



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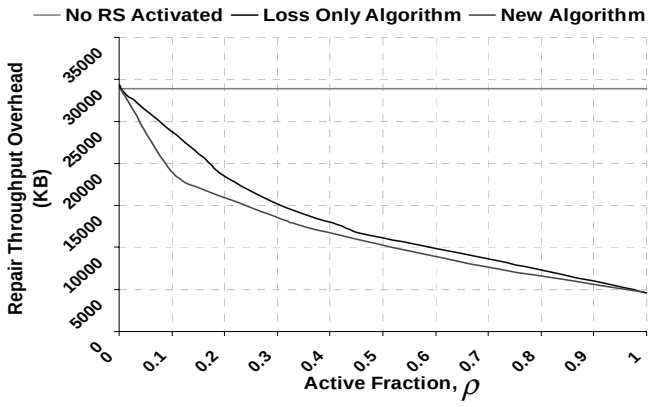
Repair Throughput Overhead



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Summary

- Remarks
  - Performance evaluation framework
    - Application deadline, time based factors, link loss rate, number of receivers
  - Dynamic activation/deactivation RS algorithm
    - Delay-sensitive applications
    - Adaptive to changing network parameters
  - Simulation results
    - Significantly improved retransmission delay
    - Much of performance gain is achievable by having only a relative small fraction of RSs being active.
- Future work
  - Burst loss; performance gain vs. RS density

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