Active Resource Allocation in Active Networks

Diane Kiwior and Stephen Zabele
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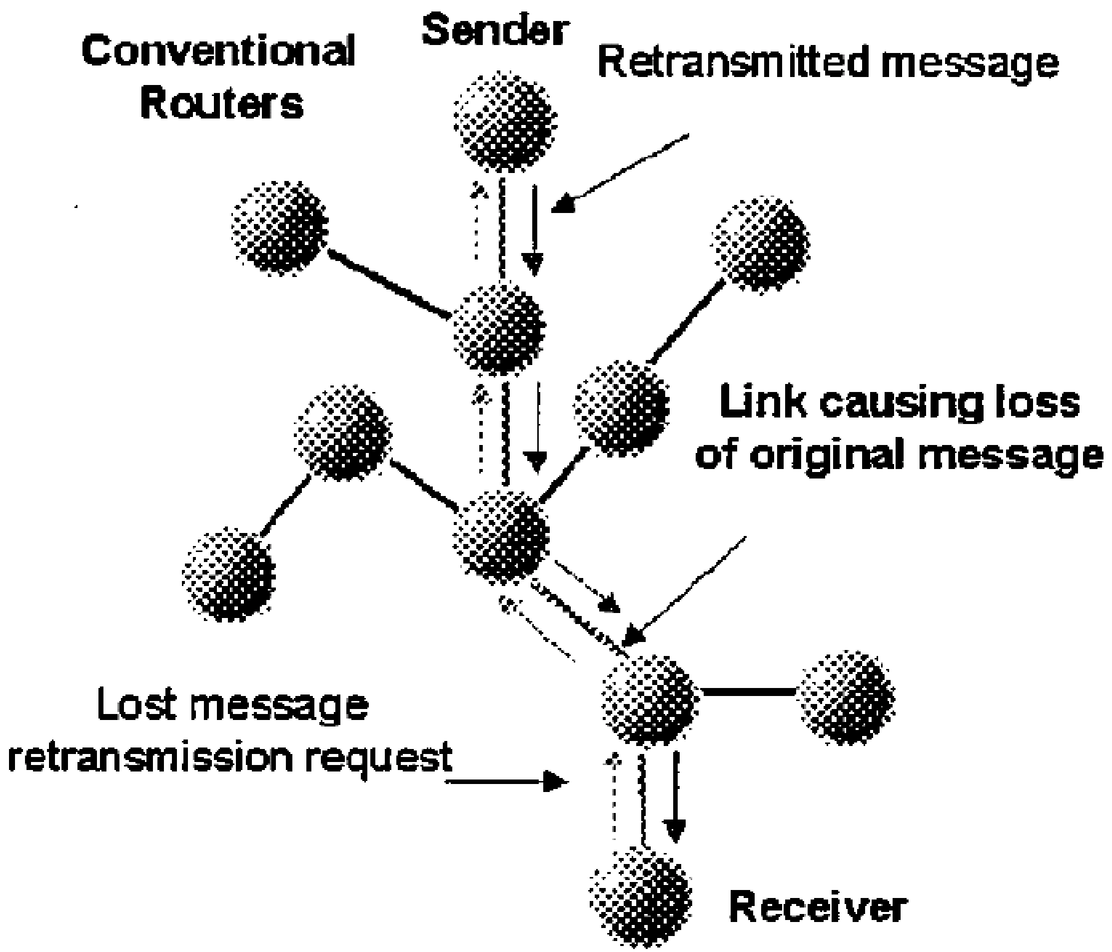
Introduction

- Active networking demands additional resources on network nodes, however, adding processing to unsuitable nodes may impede network performance.
- This paper explores the relationship between the performance gains afforded by active services and the number and location of active nodes within a network.

Reliable Multicast
Traditional Error Recovery



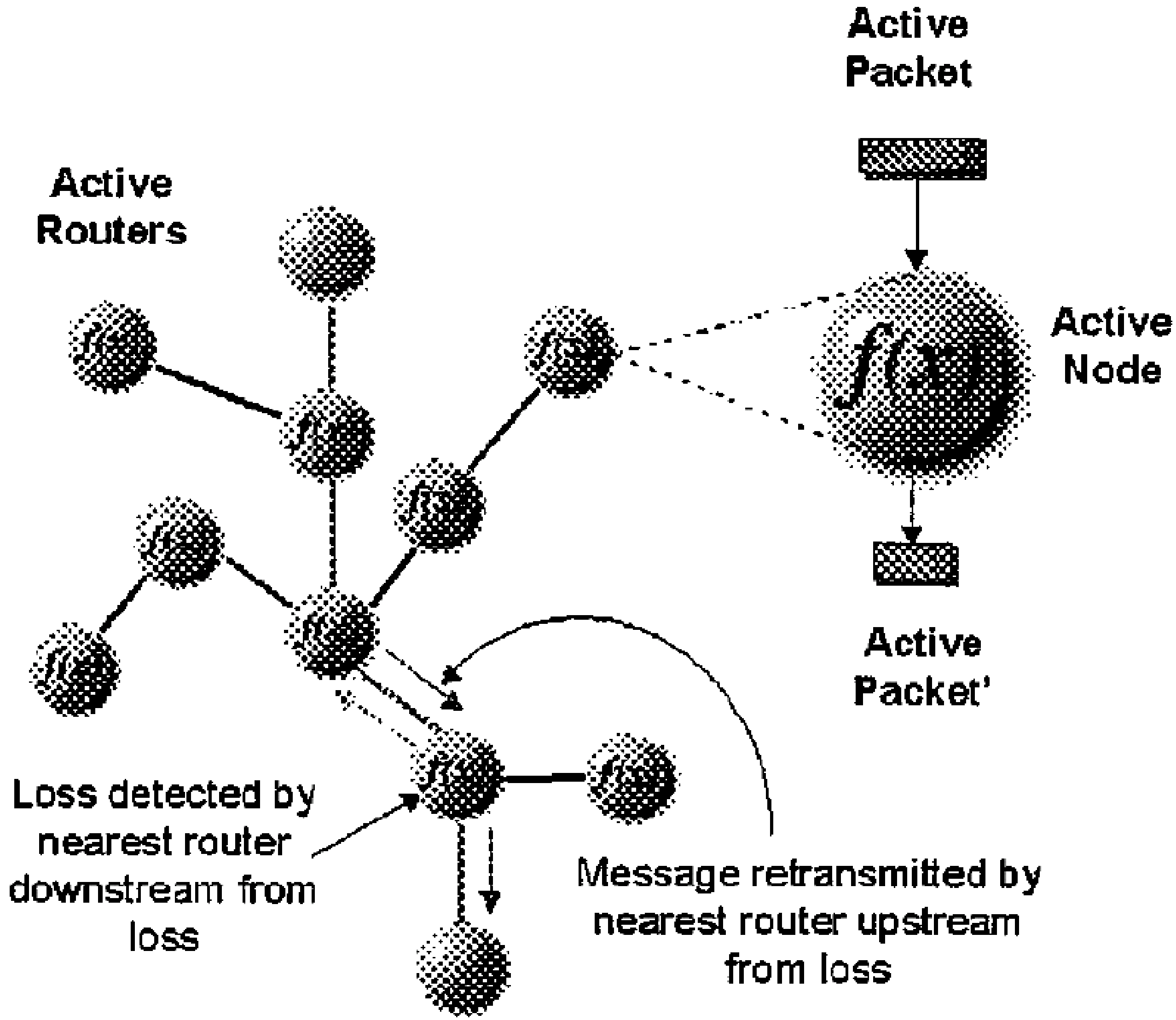
Traditional Error Recovery

- Drawbacks:
  - Long repair latency of 1-RTT
  - Bandwidth waste for packet retransmission by multicast
  - Unnecessary duplication of repair packets
  - Implosion of retransmission requests at sender
- Determination of uni-cast or multi-cast retransmission

AER/NCA

- Active Error Recovery/Nominee-based Congestion Algorithm
- NACK-based and reliable multicast protocol for active networks
- **Repair Servers** (RS's) support processing and buffering resources for loss recovery.

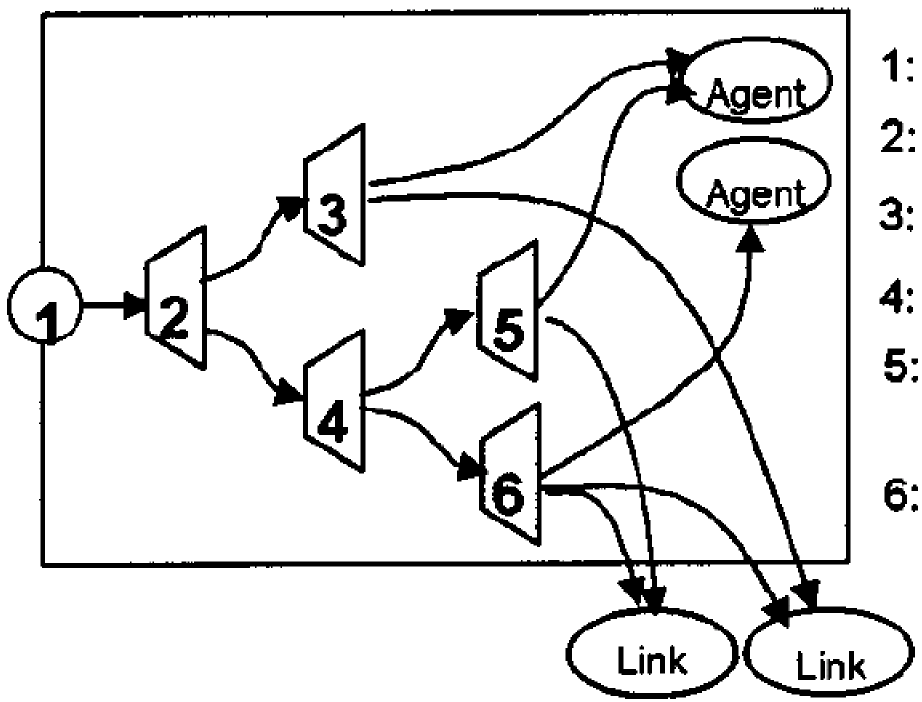
AER/NCA


Active
Packet
Active
Routers
Active
Node
Active
Packet'
Loss detected by
nearest router
downstream from
loss
Message retransmitted by
nearest router upstream
from loss

AER/NCA

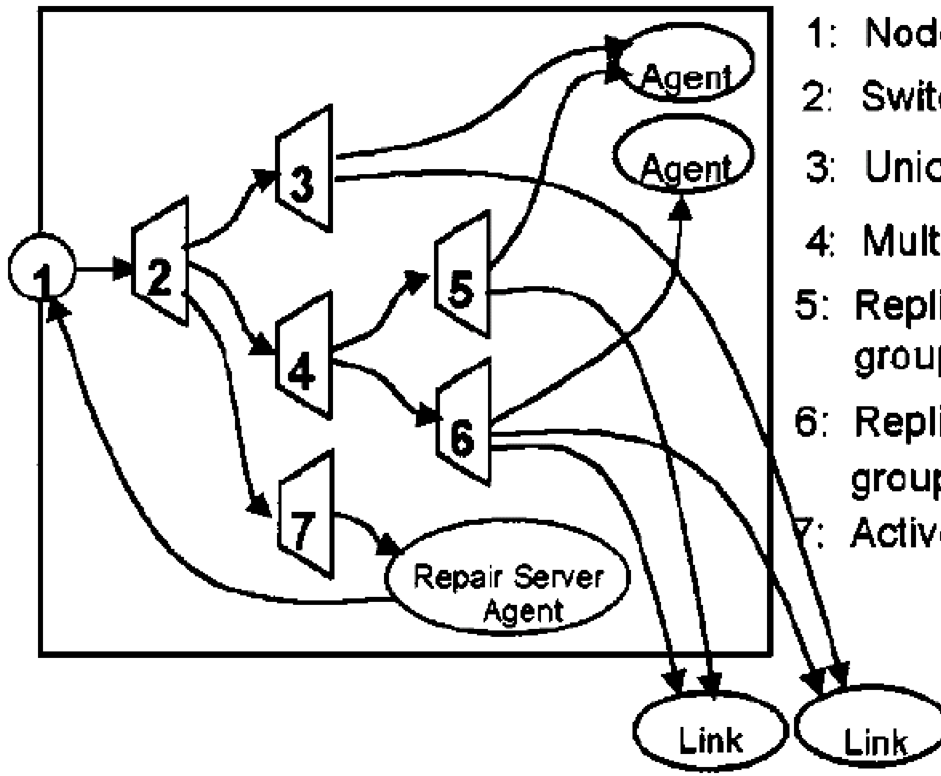
- Key services:
  - Packet caching
  - Loss detection (sequence number)
  - Loss recovery (subcast)
  - Retransmission scoping
  - Packet aggregation
- Overhead of repair notification
  - Unbalanced tree
- Cache coordination: clustering/aging

Standard *ns* Multicast Node



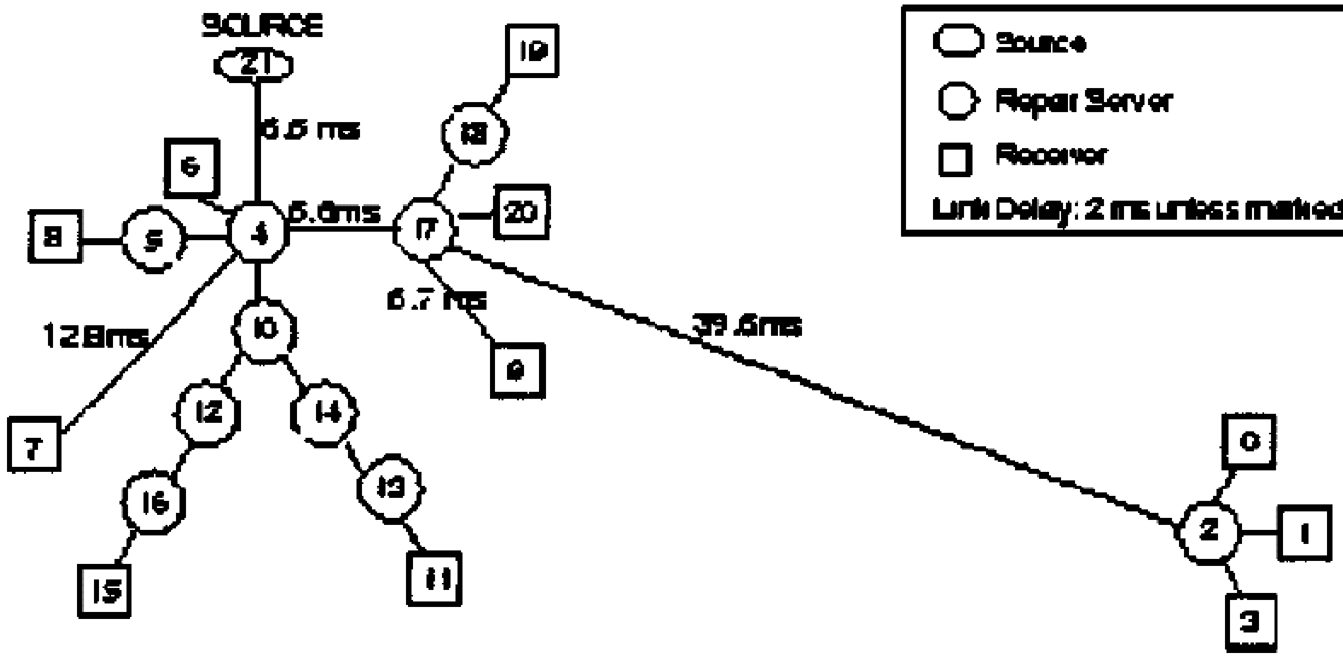
1: Node entry point
2: Switch
3: Unicast Classifier
4: Multicast Classifier
5: Replicator for group <S1,G1>
6: Replicator for group <S2,G2>

Enhanced *ns* Multicast Node



1: Node entry point
2: Switch
3: Unicast Classifier
4: Multicast Classifier
5: Replicator for group <S1,G1>
6: Replicator for group <S2,G2>
7: Active Classifier

Simulation Topology



Simulation Settings

- 10 routers and 10 hosts
- Link bandwidth of 1.5 Mbps
- Link loss probability of 1%
- A session of 5000 1KB packets
- Each router is configured to be active or inactive, resulting in 1024 combinations.

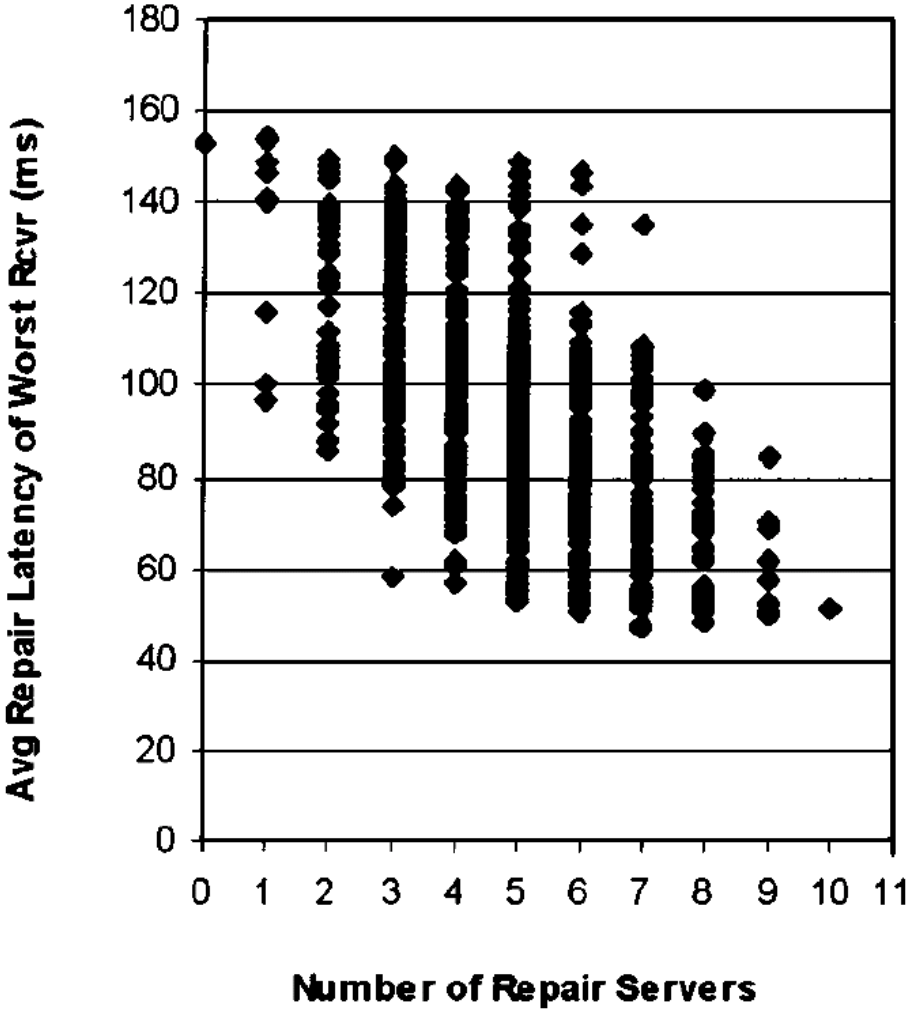
Simulation Goals

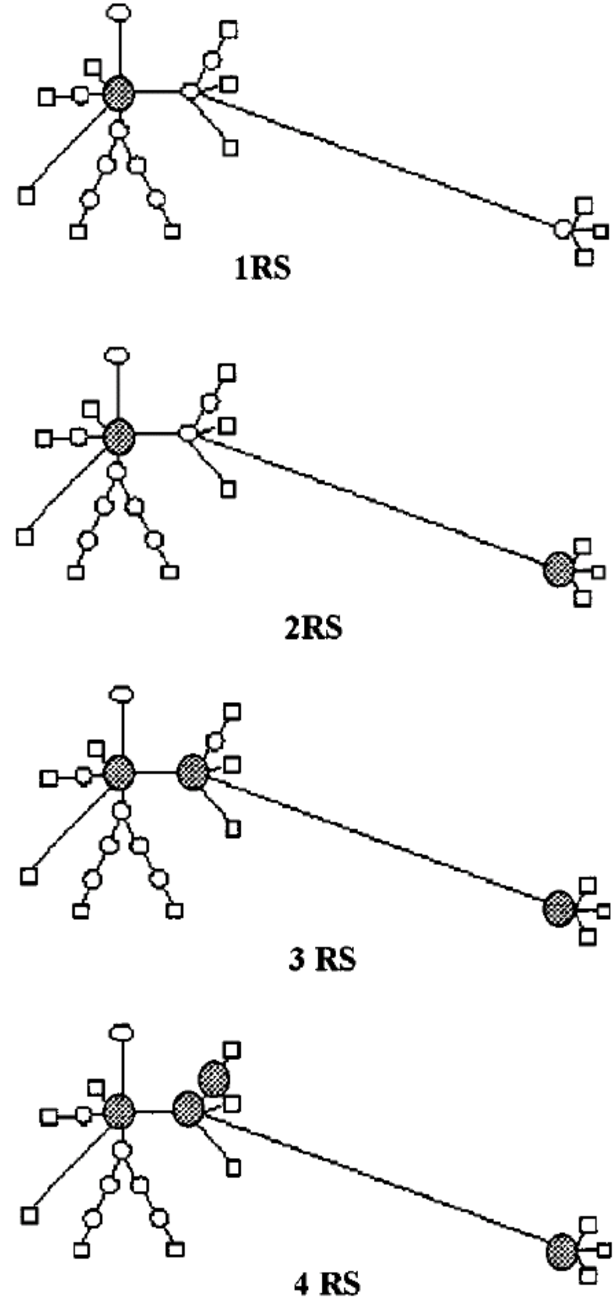
- Identify the max. achievable gain realized by active services at all possible locations
- Evaluate the relationship between the number of active servers and the max. gain
- Develop insights into the optimal location of active services
- Compare the performance of dynamic activation scheme with static scheme

Performance Metrics

- Repair latency: the time required to recover a missing packet
- Packet-link Unit: one packet-link equals on packet traversing on link

Repair Latency



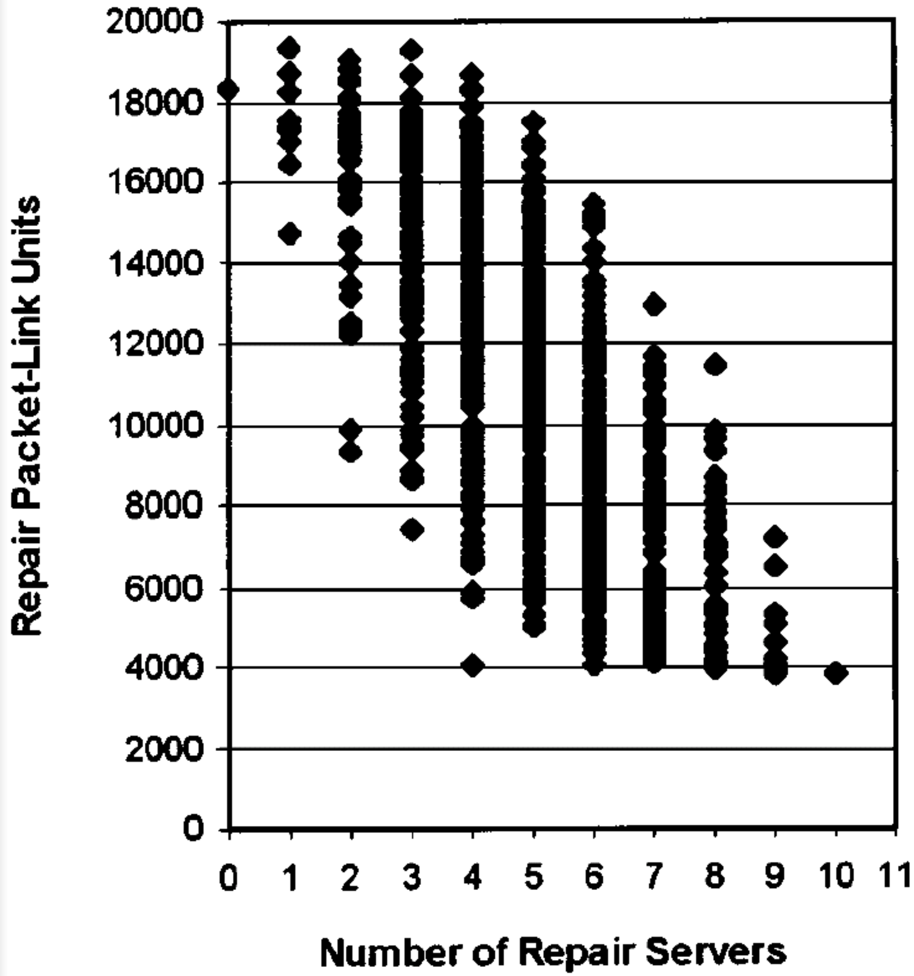


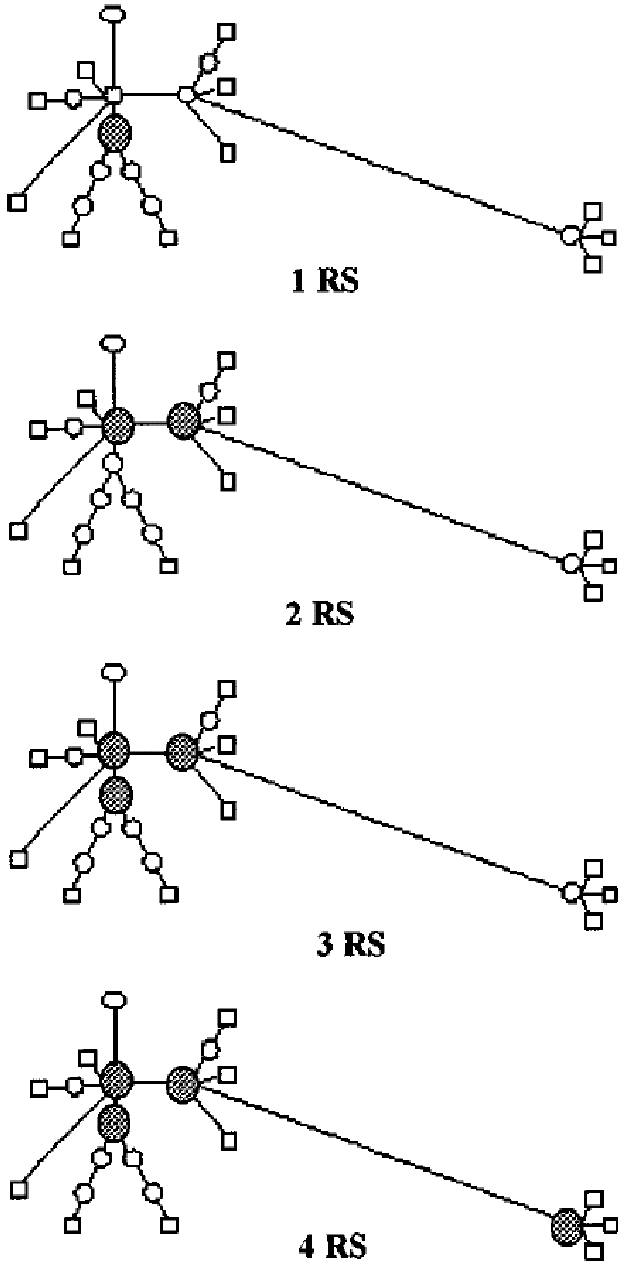
Repair server placement: minimum repair latency.

Repair Latency

- 75% reduction with 10 RS's
- 92% with 3 optimally placed (op-)RS's
- Optimized location are suggested with min. sum of R-RS/R-S link delays.
- Experiment with 25 RS's topology:
  - 44% reduction with one op-RS
  - 76% reduction with 3 op-RS's

Repair Overhead





Repair server placement: minimum repair overhead.

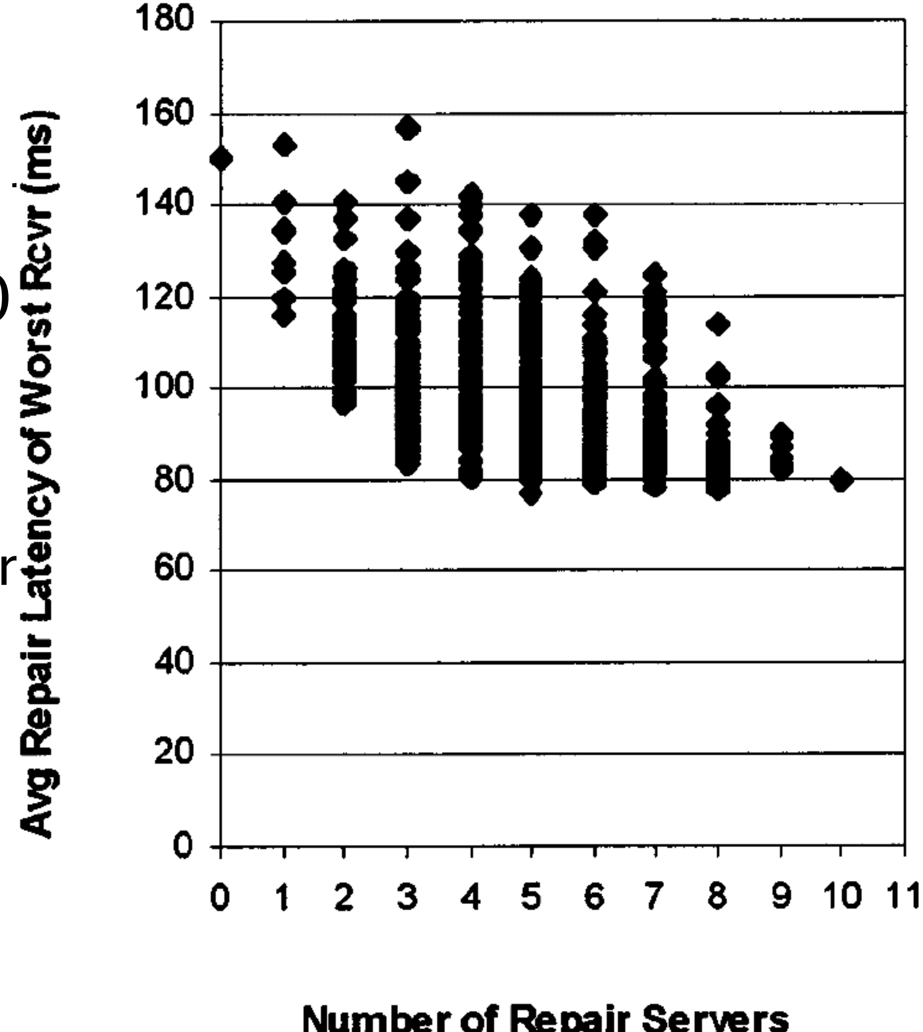
Repair Overhead

- 80% reduction with 10 RS's
- 96% with 3 op-RS's
- Optimized location are suggested with min. sum of R-RS/R-S hops.
- Experiment with 25 RS's topology:
  - 12% reduction with one op-RS
  - 60% reduction with 3 op-RS's

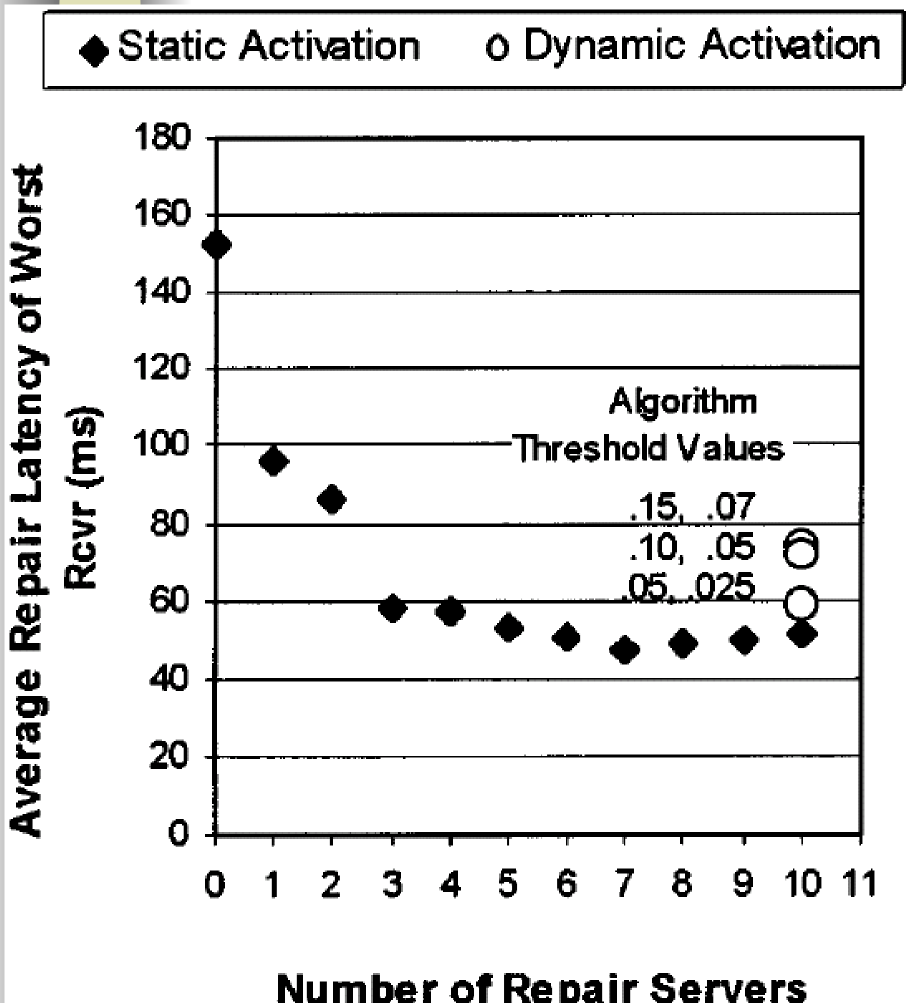
Dynamic Repair Server (De)Activation

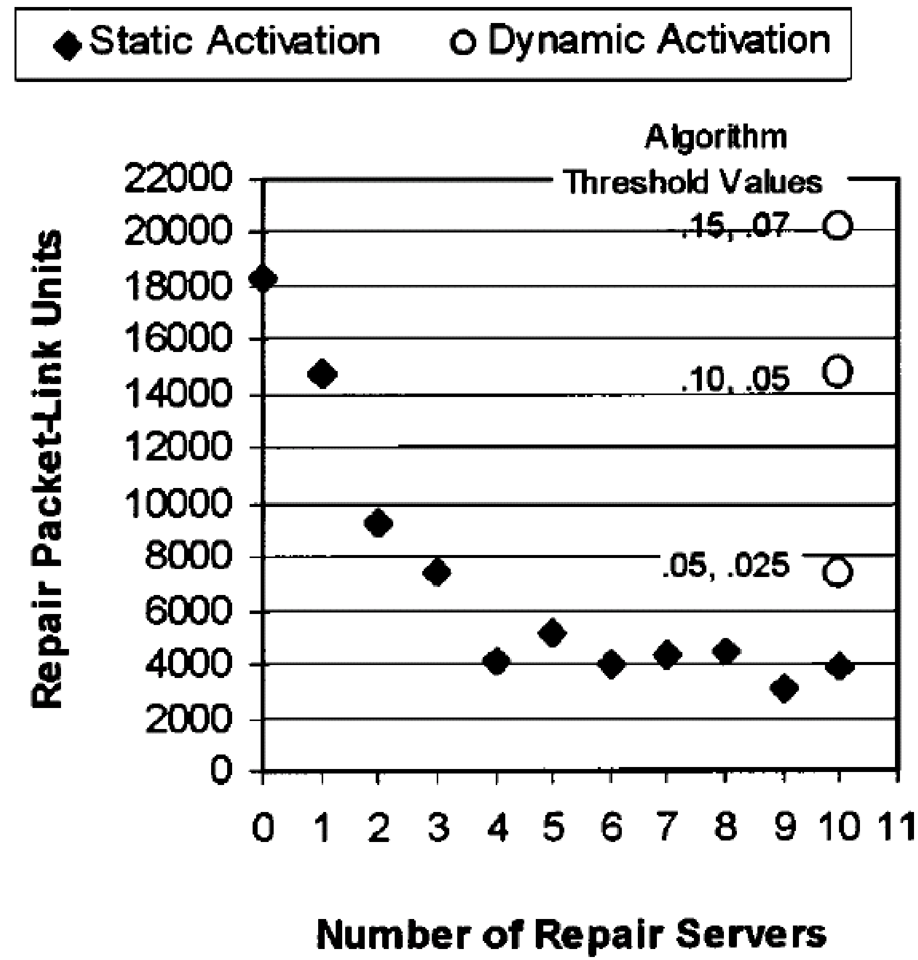
- Loss probability
- Threshold_high of 0.
- Threshold_low of 0.0

- ?? Variances
  - Loss/location/number
- ?? Loss assignment



Threshold Values





Conclusion

- Active services improve reliable multicast performance in terms of reduced repair latency and bandwidth usage.
- A small number of repair servers can realize significant benefits.
- Dynamic activation–deactivation of active services can achieve better resource utilization.
- Significant performance gains can be achieved with a minimal number of optimally placed active services.

Discussions

- Co-existence of Traditional IP Networks and Active Networks
- Deployment of active services
  - Gateway v.s. automatic distribution of transaction (pre)processing
- Application-oriented or User-oriented active services
  - E.g. adaptive transcoding of streaming media