Bandwidth Allocation Policies for Unicast and Multicast Flows

Arnaud Legout
Jörg Nonnenmacher
Ernst W. Biersack

Institut Eurecom, Sophia Antipolis, France

EURECOM

Overview

- Introduction
- Model
- Analytical results
- Simulations
- Practical aspects
- Conclusion

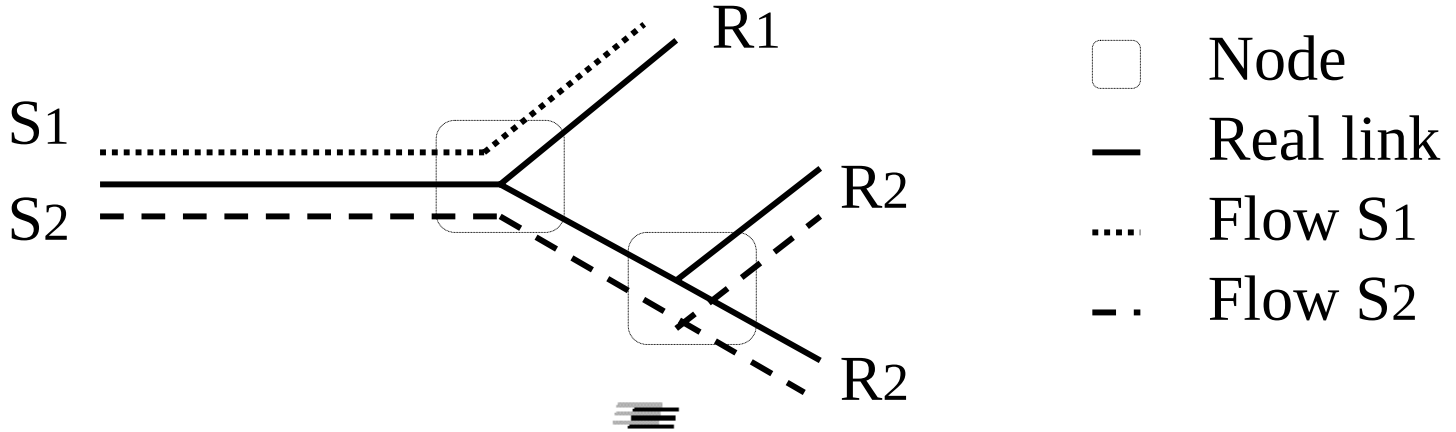
Introduction

- Multicast is a very attractive data delivery.

- Multicast is implemented in new routers.
- Multicast is still not deployed due to:
  - lack of congestion control.
  - no incentive to use multicast.
- Our new bandwidth allocation policy gives an incentive to use multicast.

Model: Allocation policies

- Receiver Independent (RI):
  - Does not make any changes in the current bandwidth allocation policies. The benchmark.
- Linear Receiver Dependent (LinRD):
  - Gives to multicast the bandwidth used by the equivalent of unicast connection.
- Logarithmic Receiver Dependent (LogRD):
  - Rewards multicast with its bandwidth saving on the network.



Model: Criteria

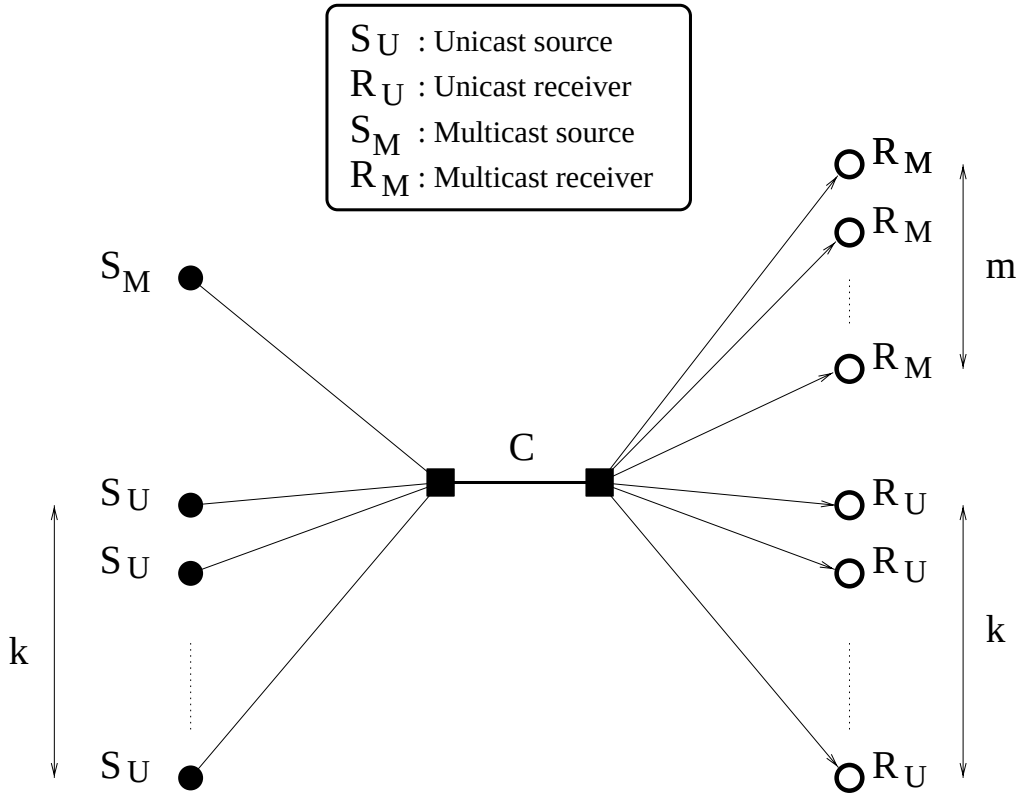
- Receiver satisfaction:
  - Mean bandwidth.
- Fairness:
  - Standard deviation of the bandwidth seen by the receivers.
- Optimality:
  - receiver satisfaction and fairness are inconsistent.
  - We evaluate the trade-off between receiver satisfaction and fairness.

Model: assumptions

- Knowledge in every network node of:
  - every flow on an outgoing link.
  - the number of receivers per flow reached via an outgoing link.
- All flows are CBR.
- No arriving or departing flows.
- Each node makes the bandwidth allocation independently.
- A receiver sees the minimum allocated bandwidth along its path.
- The sources can send via cumulative layered transmission.

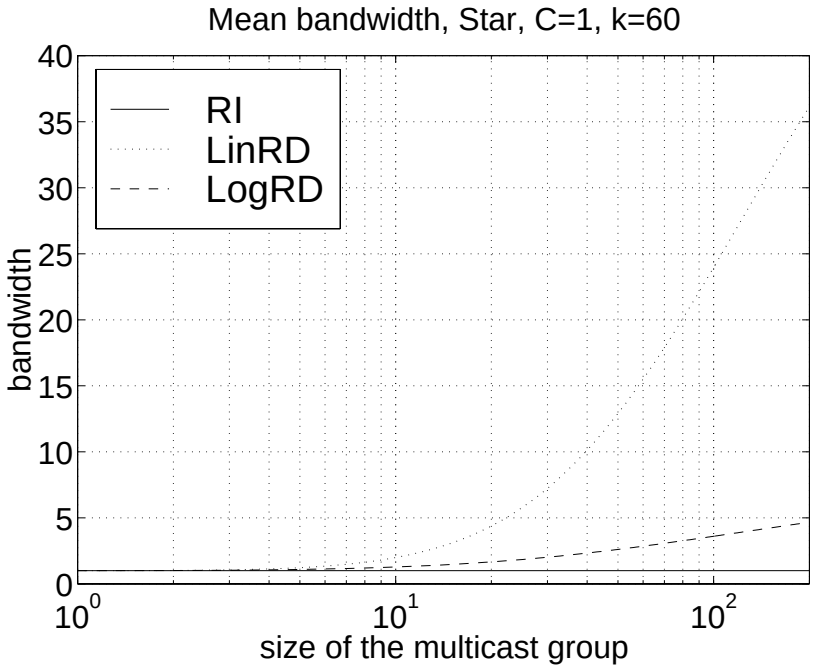
Analytical study

- Star topology

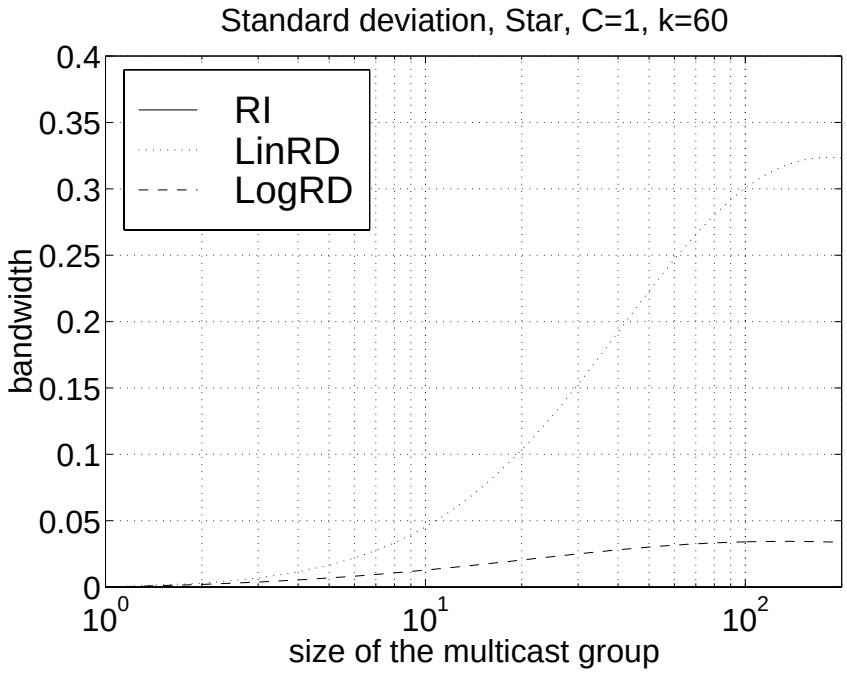


Analytical study

- Mean bandwidth



- Standard deviation



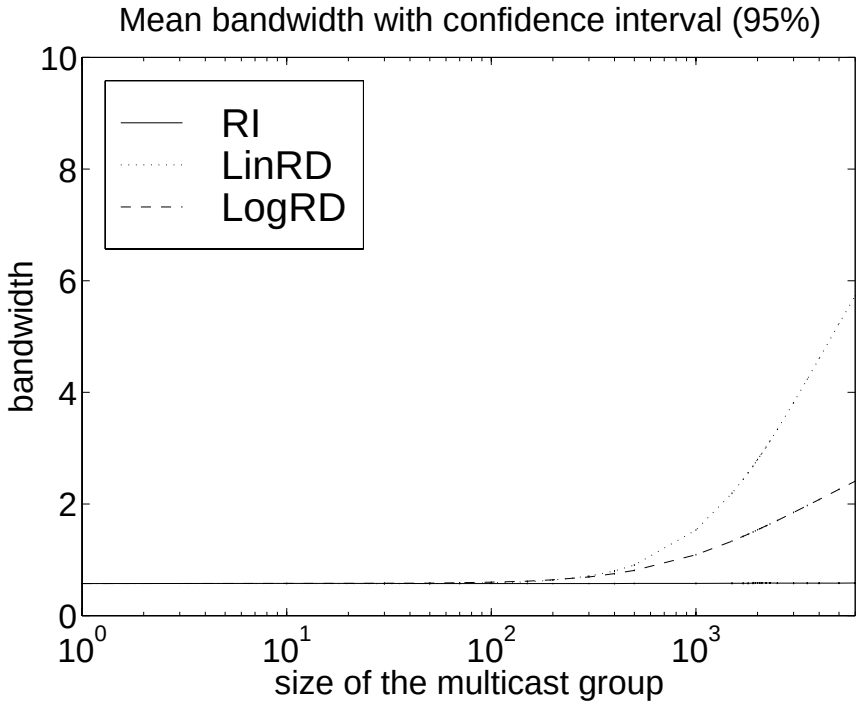
- LinRD considerably increases receiver satisfaction.
- But LinRD is not fair.

Simulations

- Study on a hierarchical topology:
  - 1 WAN, 20 MANs, and 180 LANs.
- Create a unicast environment, which aim is to study the deployment of multicast, with 2000 unicast flows.
- Two scenarios:
  - One increasing multicast group.
  - An increasing number of multicast groups.

Simulations: varying the MC group size

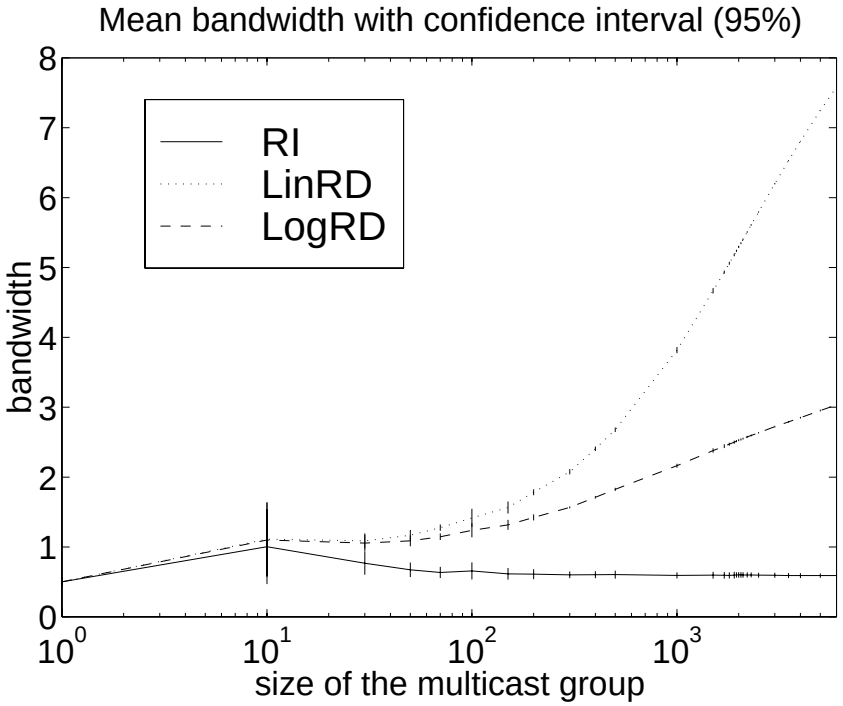
- Mean bandwidth



- The two RD policies highly improve receiver satisfaction.

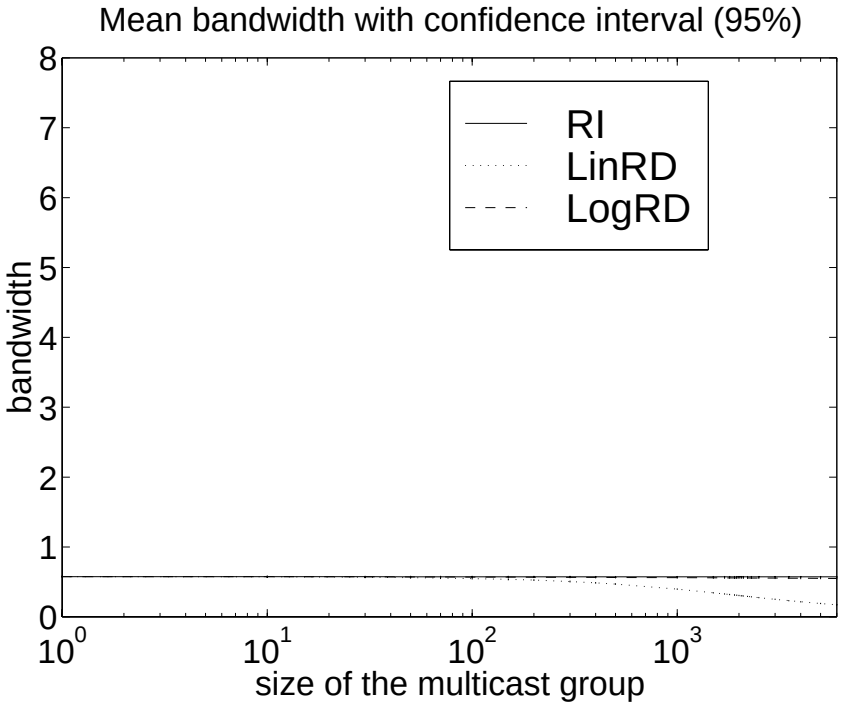
Simulations: varying the MC group size

- Mean bandwidth for MC receivers



- LogRD increases receiver satisfaction.

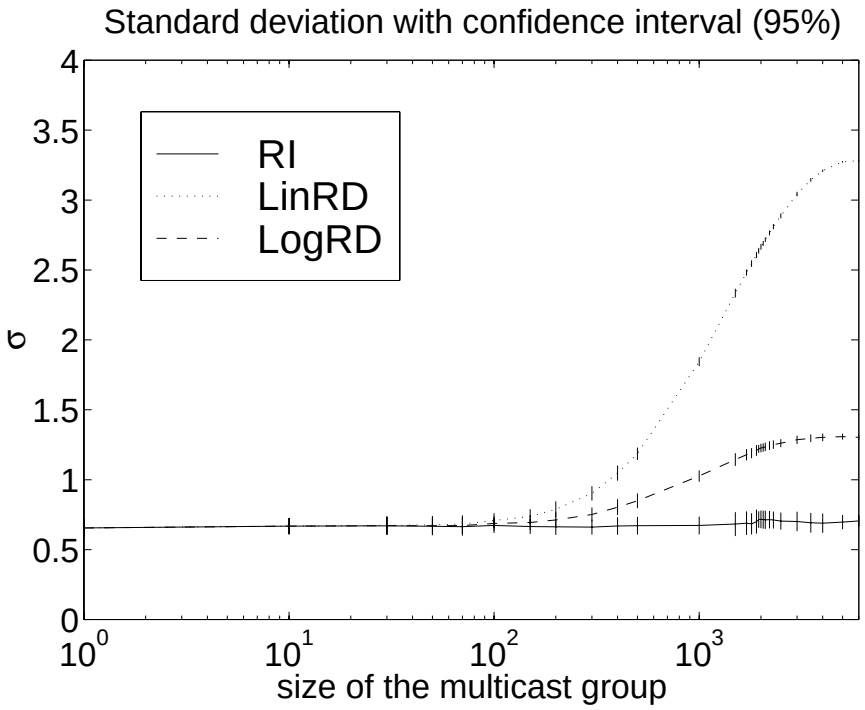
- Mean bandwidth for UC receivers



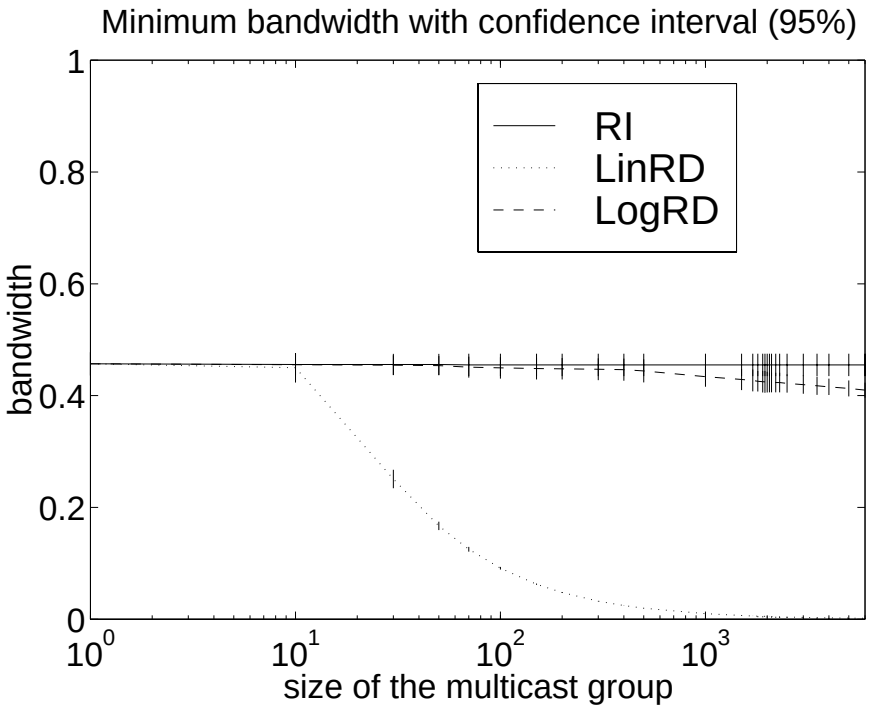
- LogRD does not starve unicast flows.

Simulations: varying the MC group size

- Standard deviation



- Minimum bandwidth



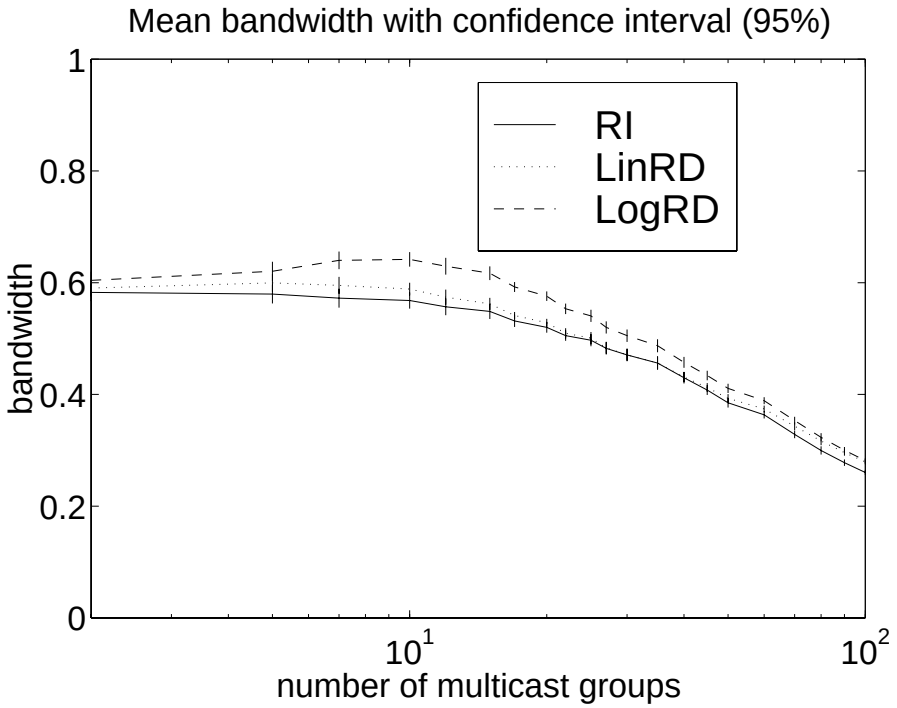
- LogRD is more fair than LinRD.
- LinRD starves the worst case receiver.

Simulations: varying the MC group size

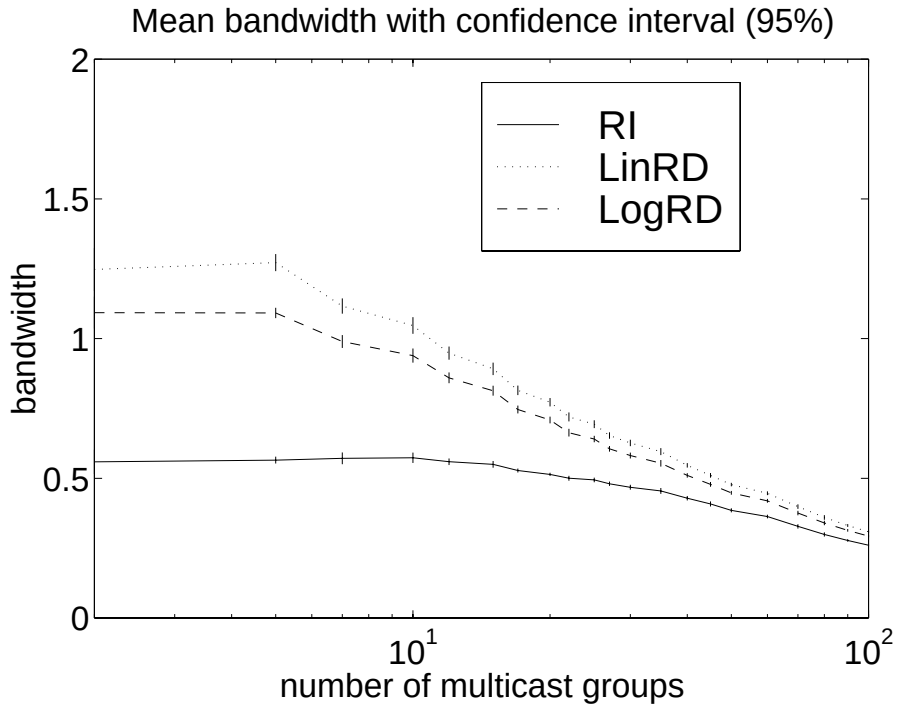
- RI policy:
  - Receiver satisfaction and fairness are not influenced by an increase in the multicast group size.
- The receiver dependent policies:
  - Significantly increase receiver satisfaction.
- LinRD policy:
  - Leads to high unfairness.
  - Starves unicast flows.
- LogRD policy performs best:
  - Keeps fairness close to the one of RI.
  - Does not starve unicast flows.

Simulations: varying the # of MC groups

- Mean bandwidth



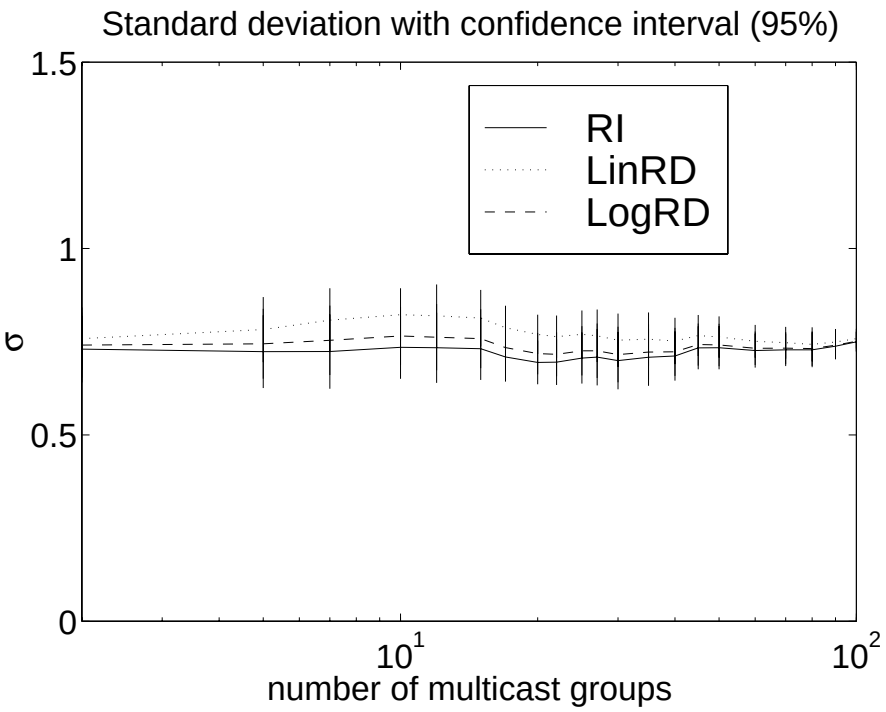
- Mean bandwidth for MC receivers



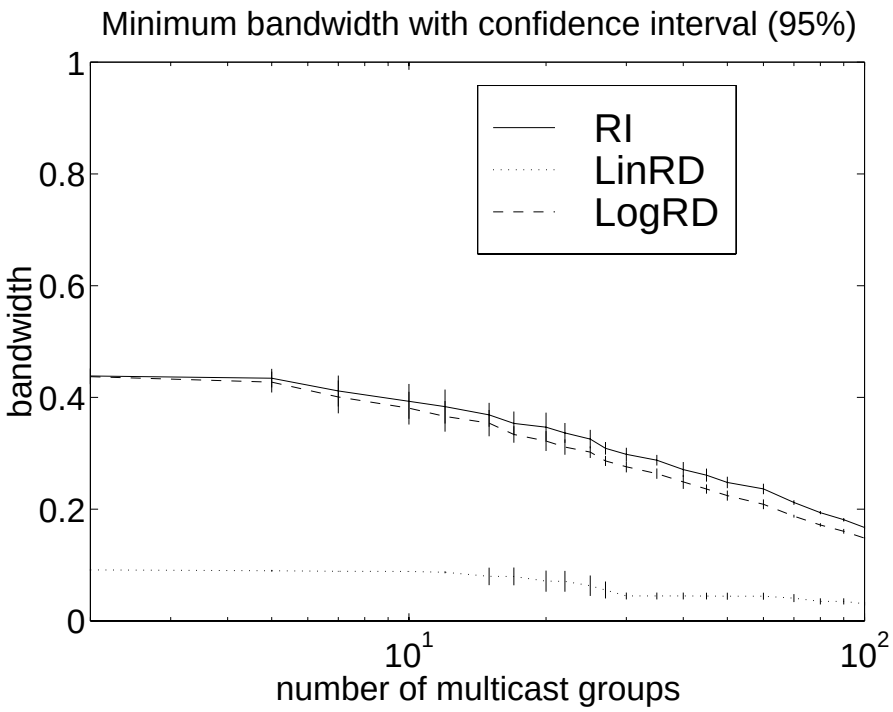
- The two RD policies highly improve the MC receiver satisfaction.

Simulations: varying the # of MC groups

- Standard deviation



- Minimum bandwidth



- The LinRD policy starves the worst case receiver.

Simulations: varying the # of MC groups

- LogRD achieves the best trade-off between receiver satisfaction and fairness:
  - LogRD highly improves the mean bandwidth for the multicast receivers.
  - LogRD does not significantly decrease the minimum bandwidth compared to the RI policy.
- Mean bandwidth, for all the receivers, slightly better for the LogRD policy than for the others policies.
- Same standard deviation for the three policies for all the receivers.

Practical aspects

- Knowing the number of receivers downstream:
  - business model for charging.
  - Useful for feedback implosion avoidance.
- Introducing the LogRD inside routers:
  - WFQ to realise the bandwidth allocation.
- Introducing LogRD in a real network is practically feasible.

Conclusions

- Our LogRD bandwidth allocation policy performs best:
  - highly improves the receiver satisfaction for the MC receivers.
  - does not significantly affect the fairness.
- LogRD gives an incentive to use multicast.

Thanks

The hierarchical topology