# Designing a Relative Delay Estimator for Multipath Transport


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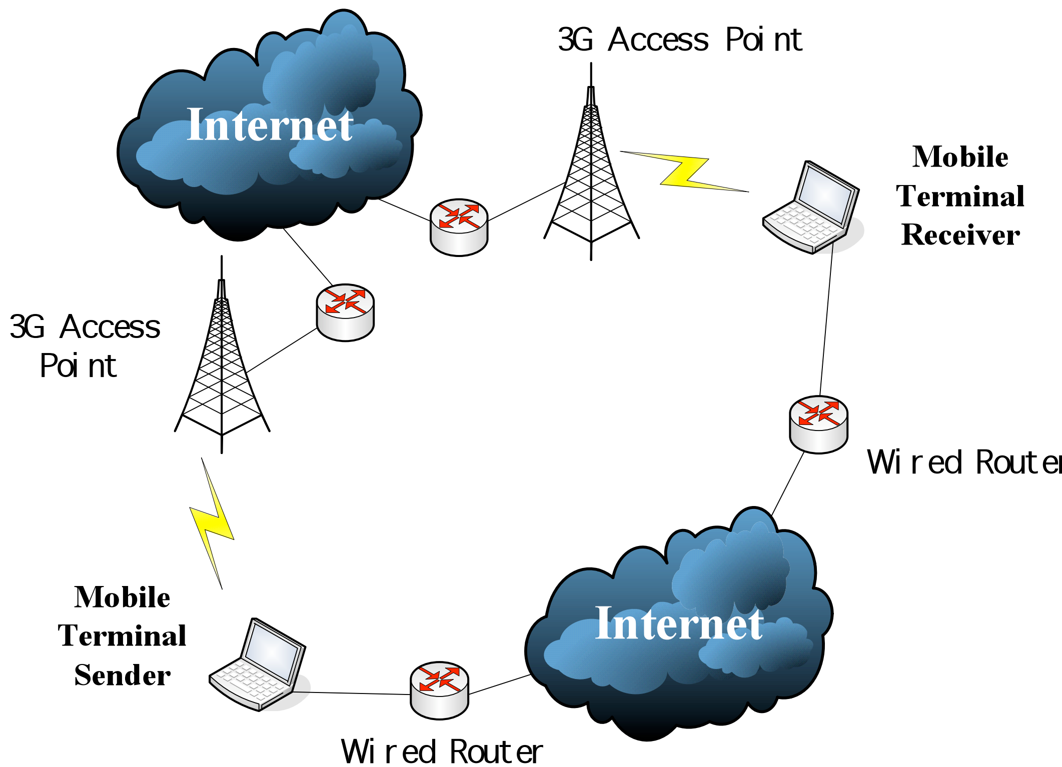
# Outline

- Background and Motivation
- Relative Delay Estimator
- Evaluation results
- Summary

# Background


Internet
3G Access Point
Mobile
Terminal
Receiver
3G Access
Point
Wired Router
Mobile
Terminal
Sender
Internet
Wired Router

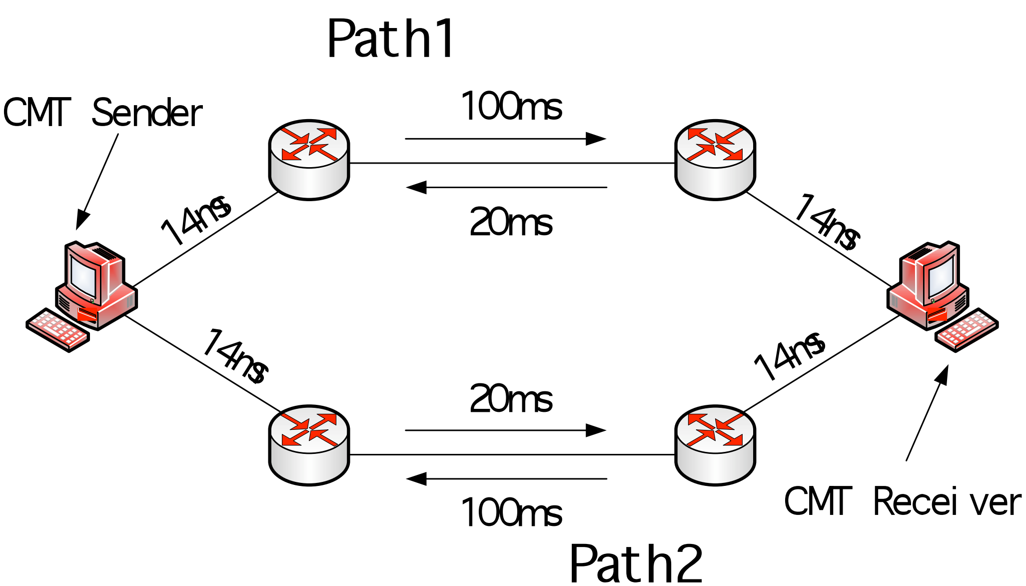
# Background

- Problems
  - Out-of-order packet
  - Cwnd increase wrongly
  - Unnecessary fast retransmission
- Solutions
  - TCP-based multipath protocols
  - SCTP-based multipath protocols

How to make it ***better***

# Motivation

How to select suitable path for retransmission



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# Relative Delay Estimator

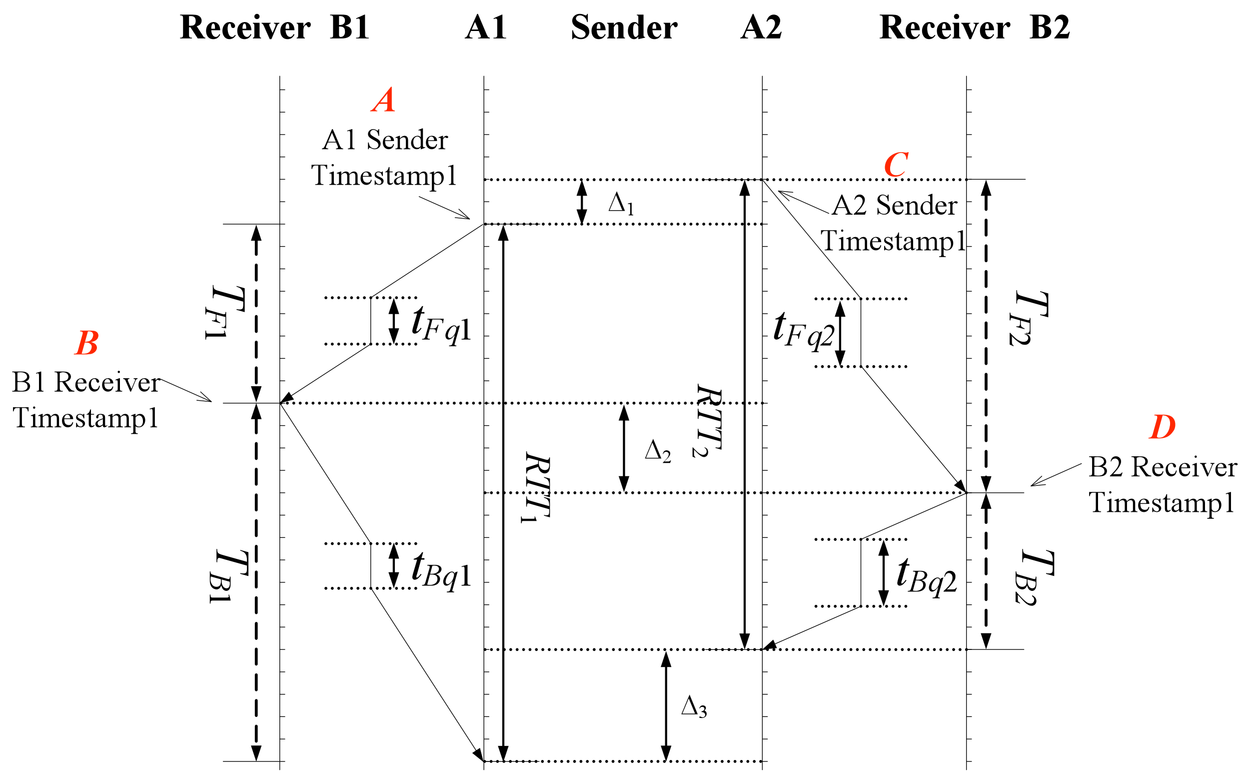
$$RTT = T_F + T_B$$

$$RTT_1 = T_{F1} + T_{B1}$$

$$RTT_2 = T_{F2} + T_{B2}$$

$$T_{F1} - T_{F2} = \Delta_2 - \Delta_1$$

$$T_{B1} - T_{B2} = \Delta_3 - \Delta_2$$



# Relative Delay Estimator

- *LastInSenderTS* – the sender timestamp contained in the last data packet
- *LastInReceiverTS* – the receiver timestamp contained in the last ACK packet
- *LastRecvTime* – local timestamp when the last ACK packet was received by the sender

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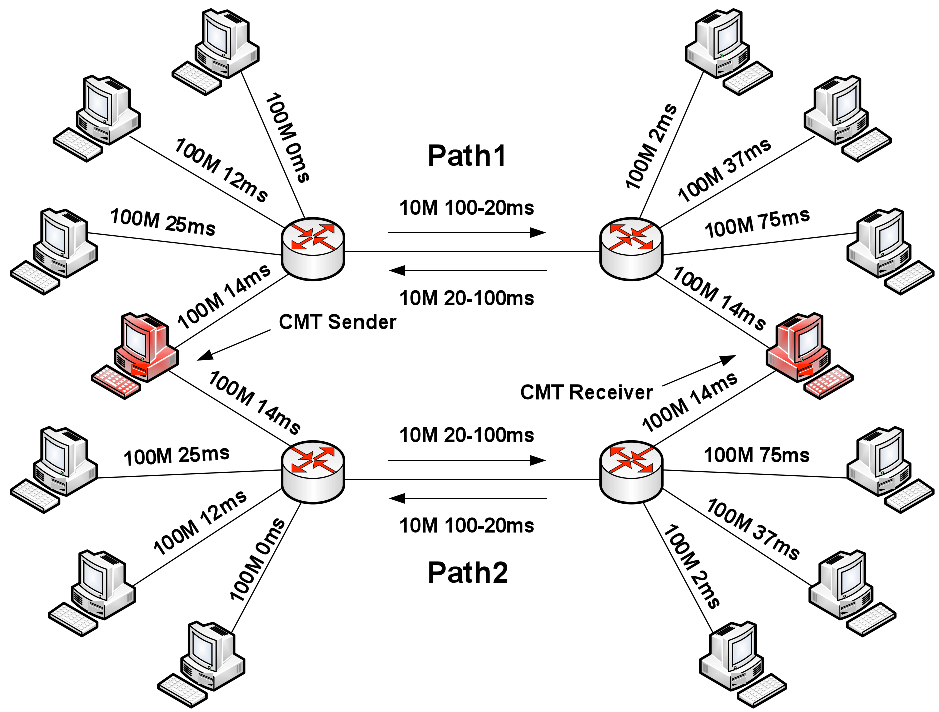
# Evaluation results

| | |
|---|---|
| Platform | NS2-2.33 |
| Bandwidth and delay | Based on * |
| Application Layer | FTP, Video, Flow generate |
| Bandwidth Delay Product (BDP) | 100 |
| Receiver Buffer Size | 64000 bytes |
| Type of Routers | Drop Tail, RED |
| Round Trip Time | 120ms |
| Simulation Time | 200s |
| Number of Seeds | 20 |




* L. Andrew, C Marcondes, S. Floyd, L. Dunn, R. Guillier, W. Gang, L. Eggert, S. Ha, I. Rhee. Towards a Common TCP Evaluation Suite. In PFLDnet 2008, March 2008

# Evaluation results

- Original path selection schemes:
  - **CWND**: retransmit to the path with largest congestion window. A tie is broken by random selection
  - **LOSSRATE**: retransmit to the path with lowest loss rate. A tie is broken by random selection
  - **SSTHRESH**: retransmit to the path with largest slow start threshold. A tie is broken by random selection
  - **SAME**: retransmit to the path where last loss occurred
  - **ASAP**: retransmit to any path for which the sender has congestion window space available

# Evaluation results

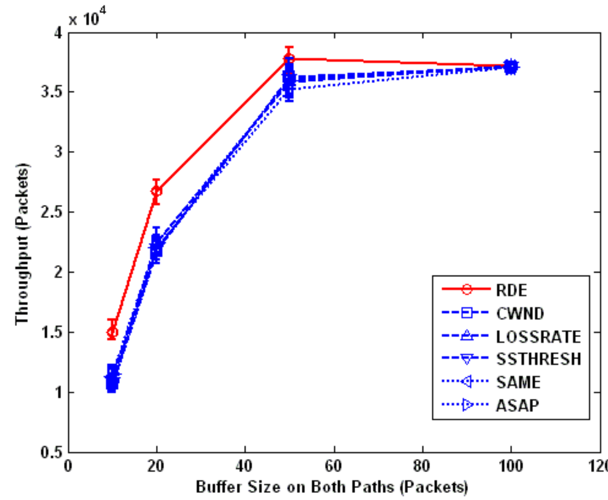
## Scenario 1:

*changes in the router buffer, same drop rates*

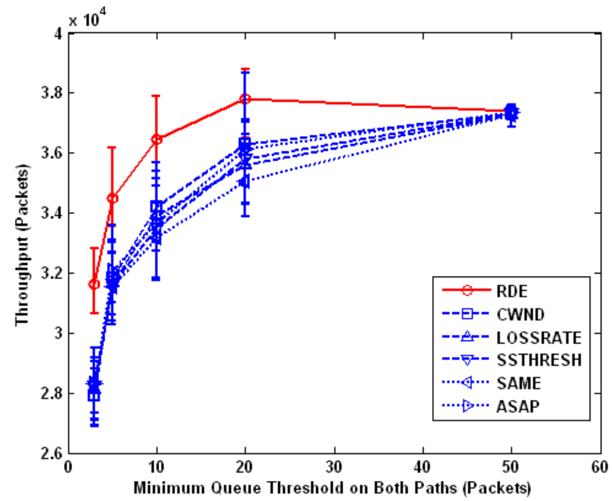
Set the forward delay on path1 and path2 to 100ms and 20ms, respectively.

Drop Tail routers: buffer sizes equal to 10%, 20%, 50% and 100% of the BDP value.

RED routers. the minimum queue threshold are set to 50, 20, 10, 5, 3.




Drop Tail




RED

# Evaluation results

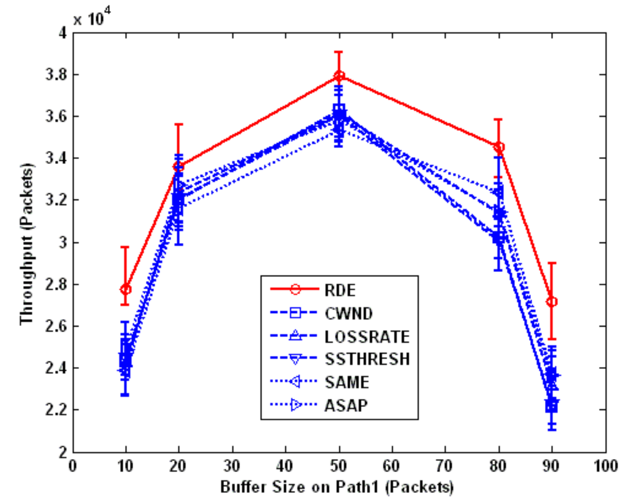
## Scenario 2:

*changes in the router buffer, different drop rates*

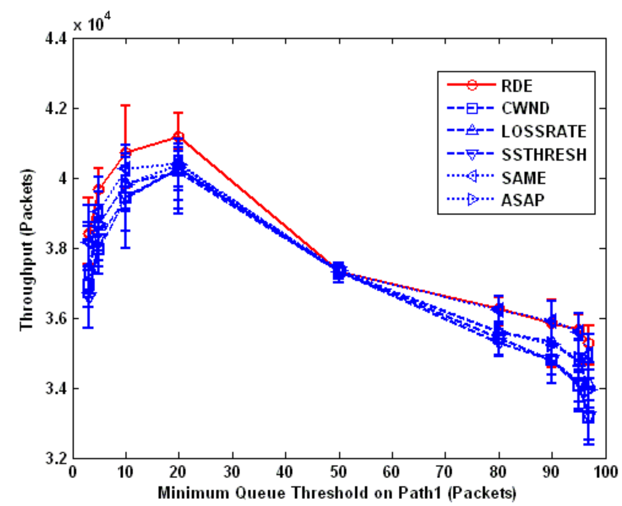
Set the forward delay on path1 and path2 to 100ms and 20ms. Hold the sum of buffer size (or the minimum threshold) on two path in the same value.

Drop Tail routers: buffer sizes of path 1 is set to 10, 20, 50, 80 and 90.

RED routers. The minimum thresholds of path 1 are set to 3 to 97.




Drop Tail

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# Evaluation results

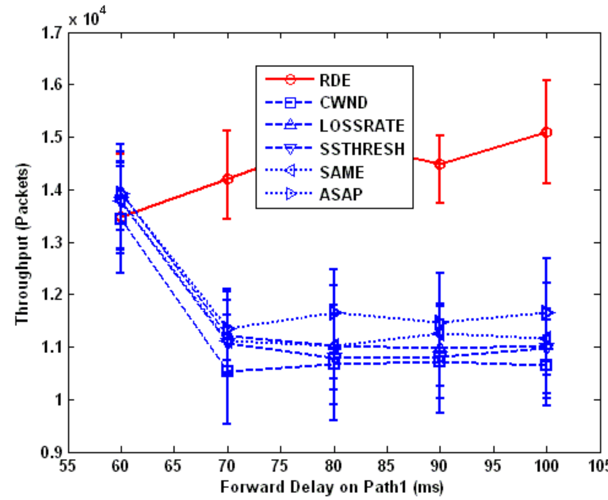
## Scenario 3:

*variation of one way delay, same drop rates*

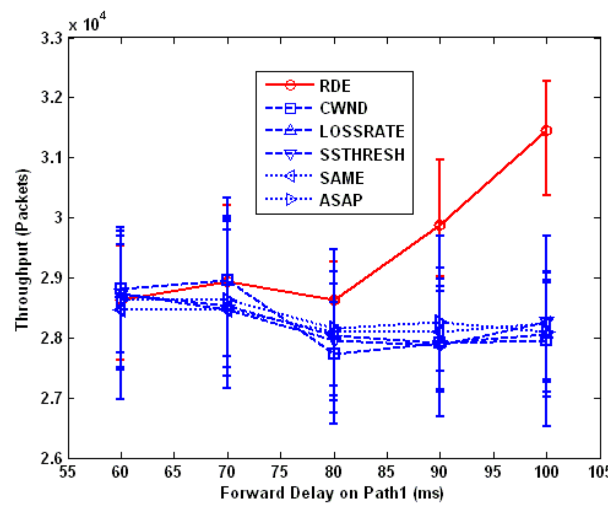
Adjust the forward delay on path1 from 100ms to 60ms. The forward delay on path2 is adjusted corresponding.

Drop Tail routers: The buffer sizes on path 1 and path 2 are set to 10 and 90.

RED routers. The minimum queue size threshold on path 1 and path 2 are set to 3 and 97.




**Drop Tail**




**RED**

# Evaluation results

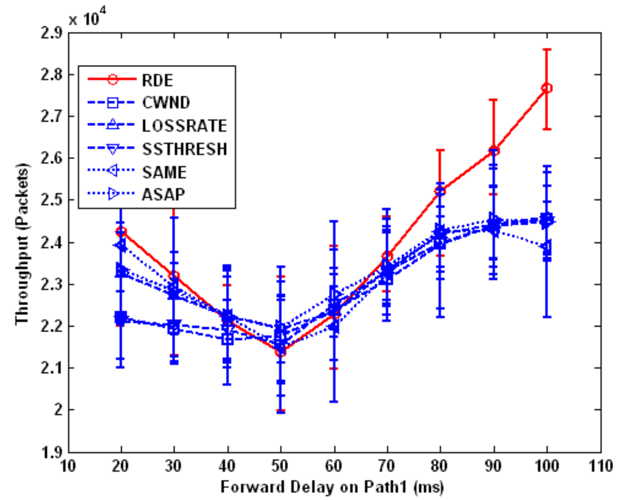
## Scenario 4:

*variation of one way delay, different drop rates*

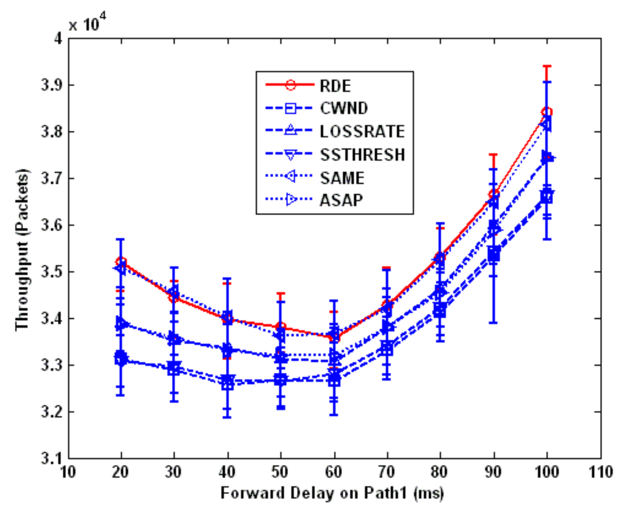
Adjust the forward delay on path1 from 100ms to 60ms. The forward delay on path2 is adjusted corresponding.

Drop Tail routers: The buffers of the drop tail routers on path1 and path2 are set to 10 packets and 90 packets, respectively.

RED routers. the minimum queue size threshold are set to 3 packets and 97 packets on path1 and path2




**Drop Tail**




**RED**

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# Summary

- Current conclusions:
  - RDE can be implemented in both TCP-based and SCTP-based multipath transport protocols
  - The performance of RDE-based path selection scheme is better than other 5 schemes when forward and backward delay are quite different
- Future works:
  - Improve the efficiency of RDE
  - Bandwidth estimation
  - Shared bottleneck detection

# Thank you & Questions?