Improving the Robustness of TCP to Non-Congestion Events

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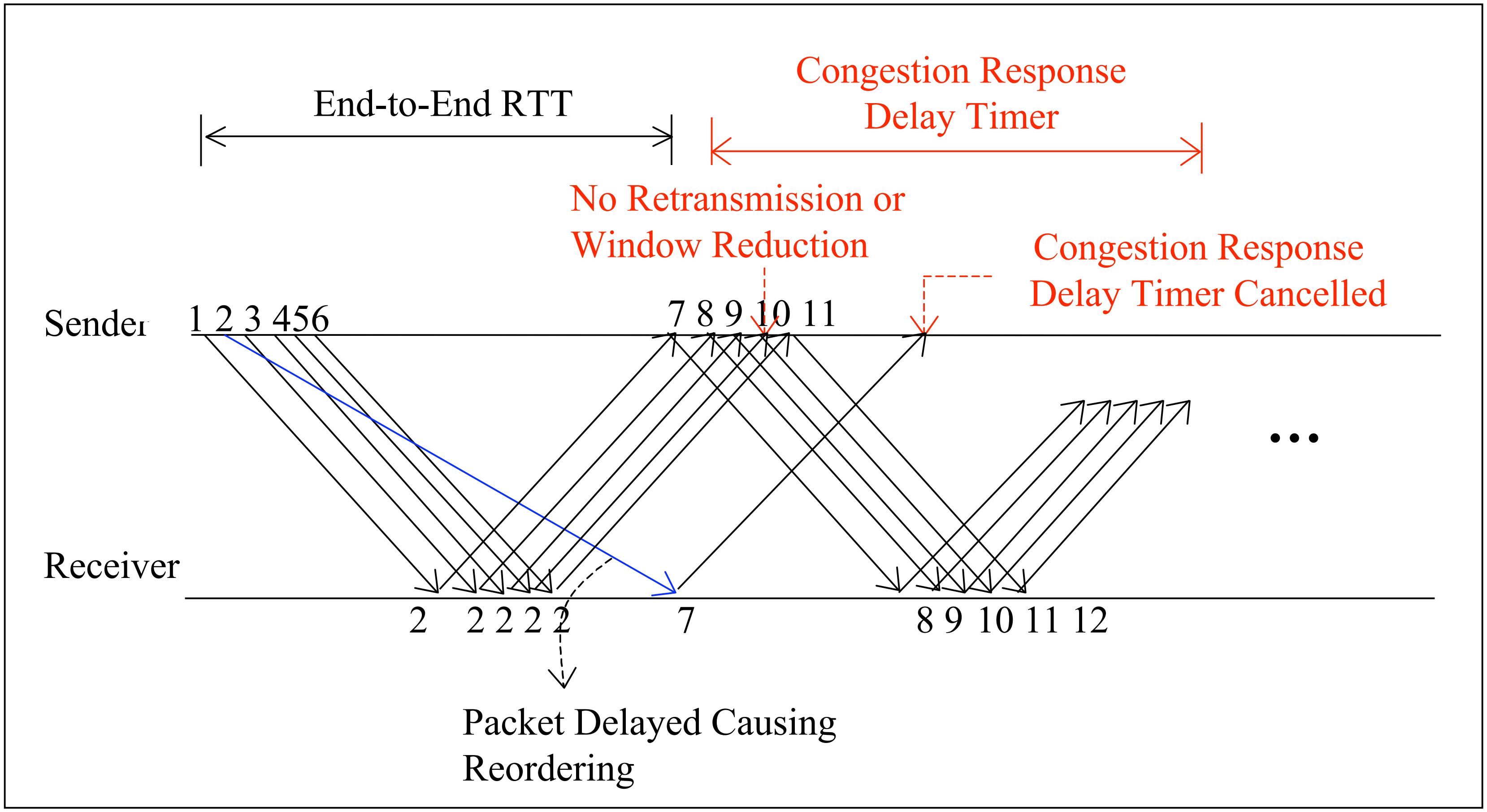
Outline

- Problem Statement
- Proposed Solution
  - Modifications to TCP
  - Choice of □
  - Other details
- Evaluation
  - Wireless networks with channel errors
  - Wired networks with packet reordering
- Conclusions

Problem Statement

- TCP’s behavior: On receipt of three dupacks retransmit the packet and reduce cwnd by half.
- Caveat : Not all 3-dupack events are due to congestion (Ex: channel errors in wireless networks, reordering etc.)
- Result : Sub-optimal performance in networks with non-negligible non-congestion events.

Problem Statement / Proposed Solution



Proposed Solution

- TCP’s 3-dupack mechanism a heuristic
  - Allows mild reordering
  - Time to revisit this heuristic in new networks
- Proposal: Change this delay to one window (RTT)
- Allows enough time for underlying mechanisms to recover from non-congestion events.
- Essentially a tradeoff between wrongly inferring congestion and promptness of response to congestion.

Proposed Solution
(Modifications to TCP)

- Delay triggering of congestion response algorithms by □during congestion avoidance phase.
- During the delay □, send one new packet for every dupack (similar to limited transmit algorithm)
- If cumulative acknowledgment received before the delay timer □expires, cancel congestion response
- Else, trigger fast retransmit/recovery.

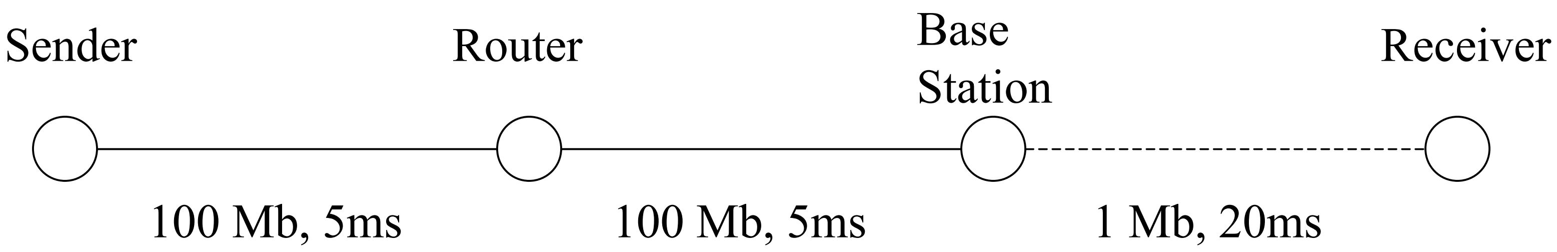
Proposed Solution
(Choice of □)

- Should be large enough to recover from non-congestion event.
  - For the wireless network, should be atleast equal to the round trip time of the wireless portion of the network.
  - For the case of reordering, no fixed lower bound.
- Should be small enough to avoid expensive RTO
- Suggested value : one RTT (end-to-end)

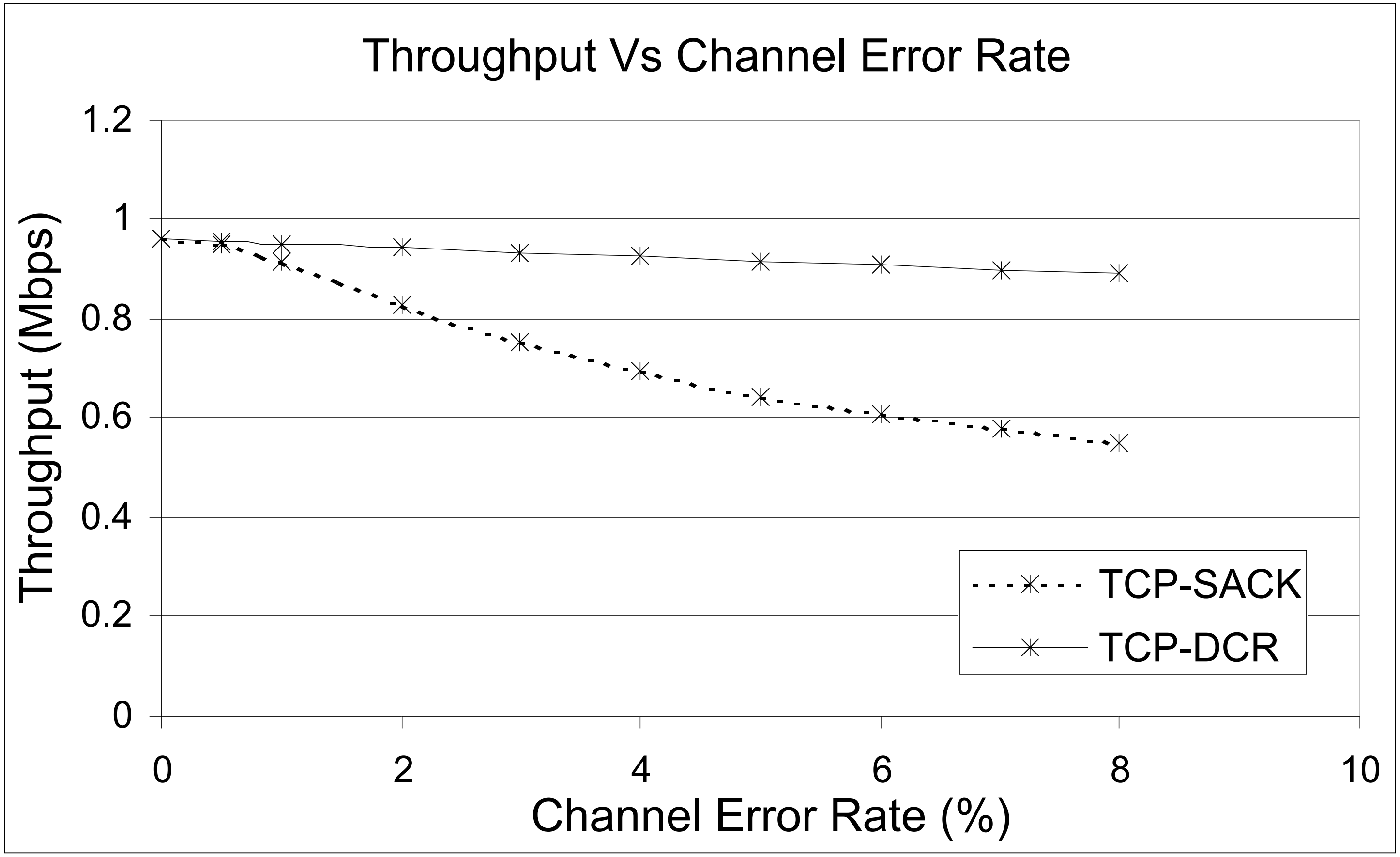
Proposed Solution (Other Details)

- □can be implemented based on a timer or by changing the dupthresh.
- During times of congestion, the required buffer size at receiver is twice that of unmodified TCP
  - availability of buffer space ensures maximum benefit
  - lack of buffers causes no harm
- During the delay □the sender is ack-clocked, uses limited transmit
  - during non-congestion events, packets continue to be sent
  - during congestion, sending rate is at best the same as when the first dupack was received

Wireless Channel Errors -- Topology Explanation for next slide (To be removed from final version)



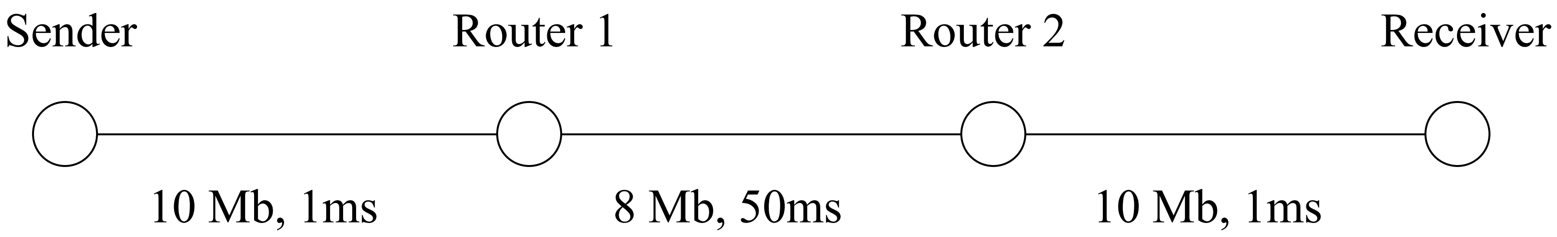
Wireless Channel Errors



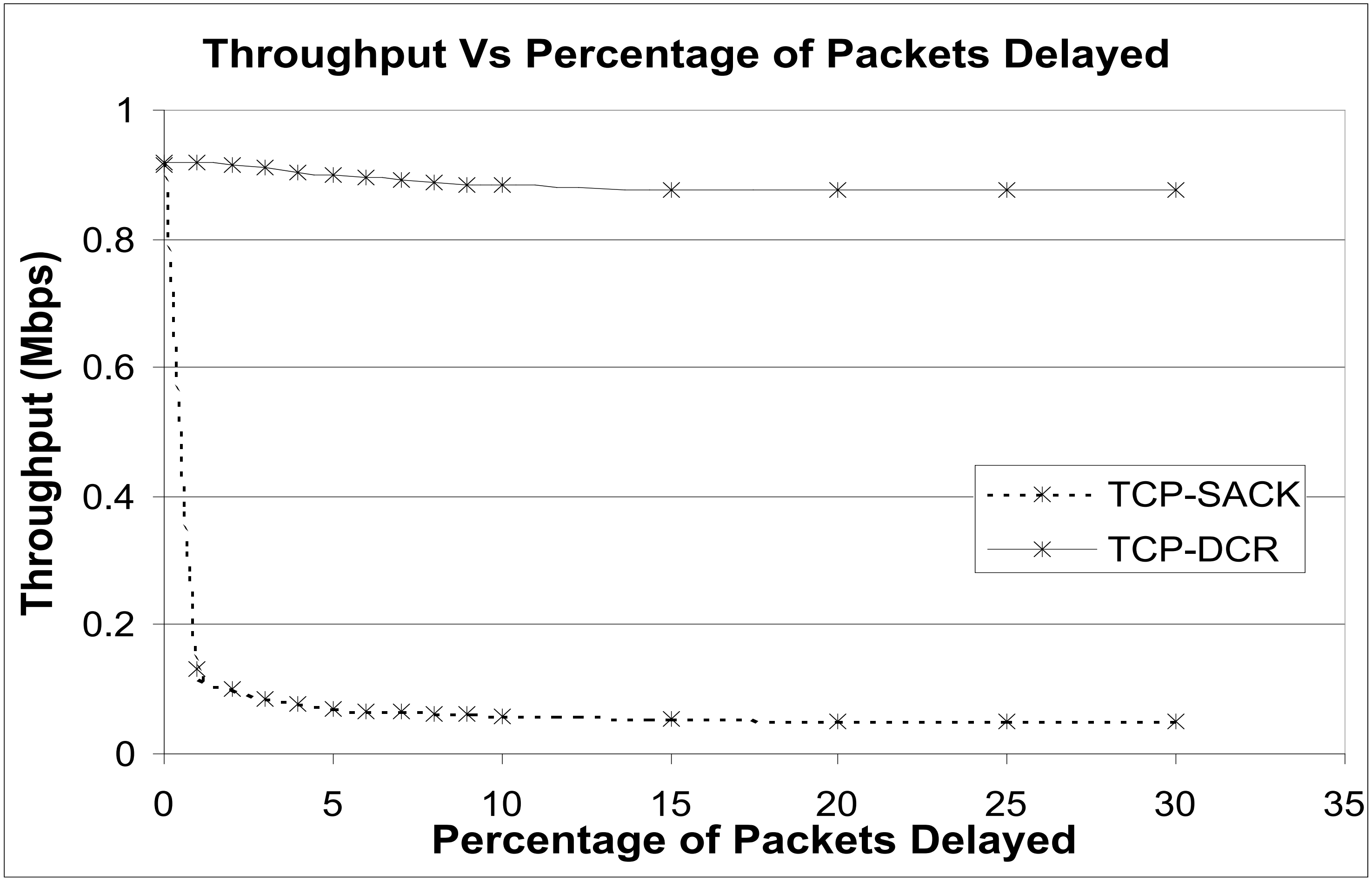
Wireless Channel Errors (cont.)

- TCP-SACK reduces sending rate for channel errors
- Result : Degraded performance as channel error rate increases
- Other concerns :
  - When available wireless bandwidth is large, TCP-SACK cannot utilize it well
  - When wireless delay is large, it takes larger time to recover from window reduction degradation in performance more drastic

Packet Reordering -- Topology
Explanation for next slide
(To be removed from final version)



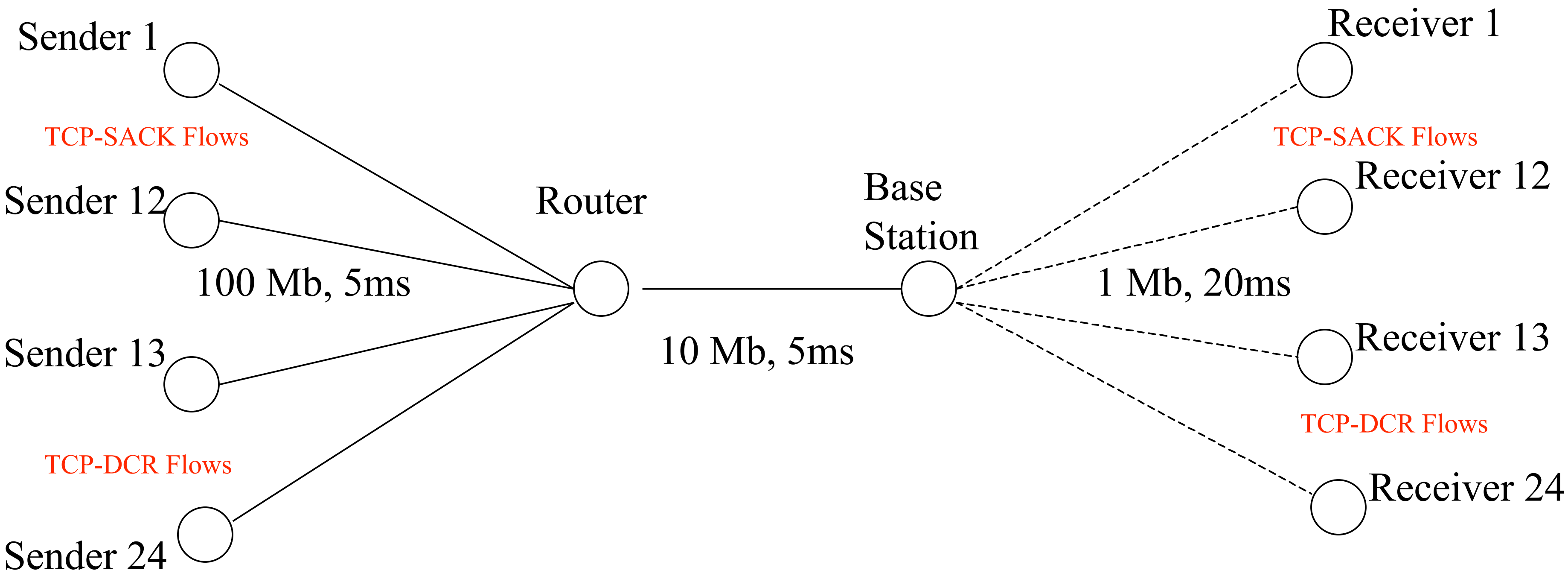
Packet Reordering



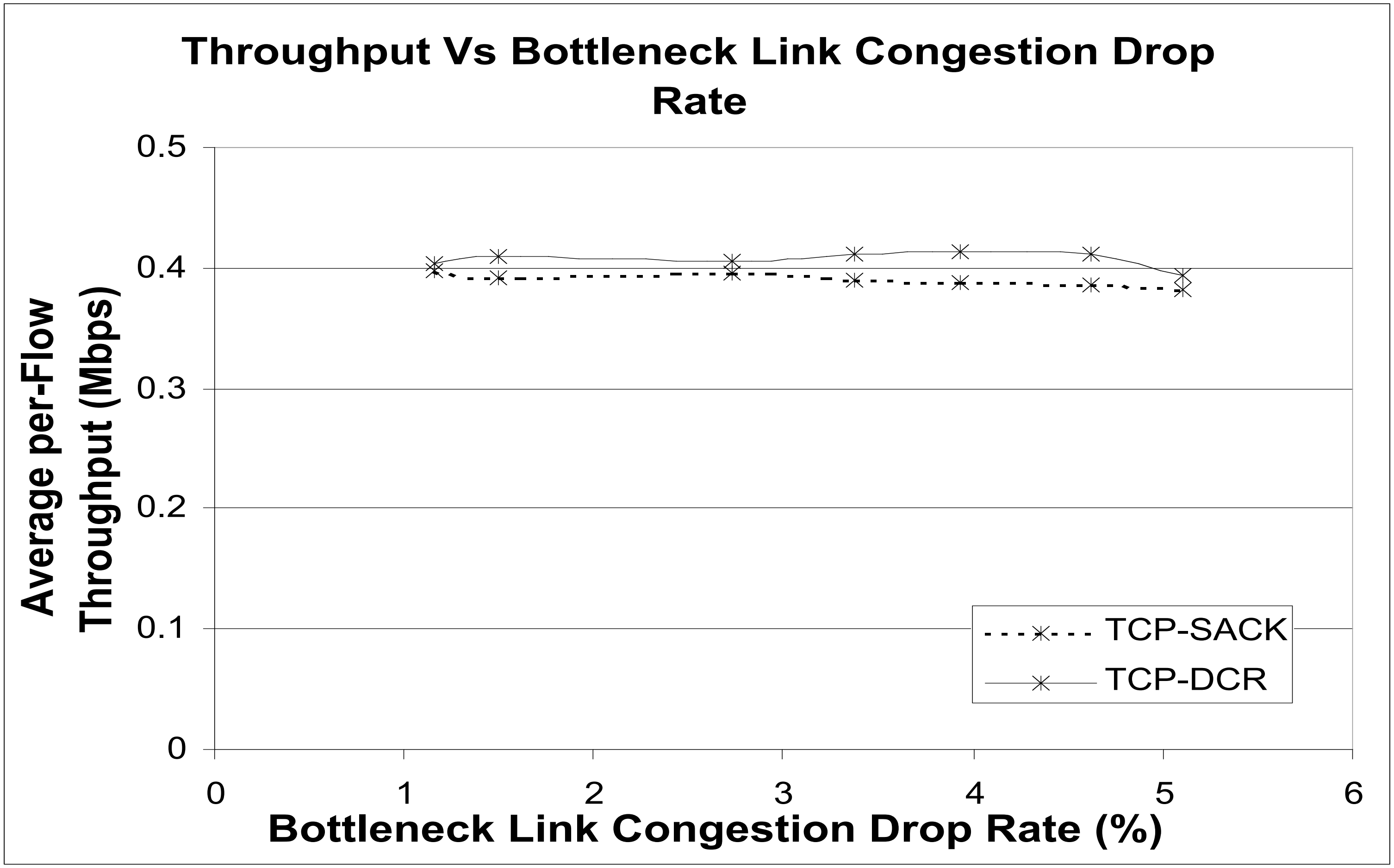
Packet Reordering (cont.)

- TCP-SACK wrongly infers delayed packet as congestion
- Result : Degraded performance in networks with non-negligible packet reordering
- Other concerns :
  - Requirement of near in-order delivery imposes limitations on new routing schemes.

Congestion Only -- Fairness (Topology) Explanation for next slide (To be removed from final version)



Congestion Only -- Fairness

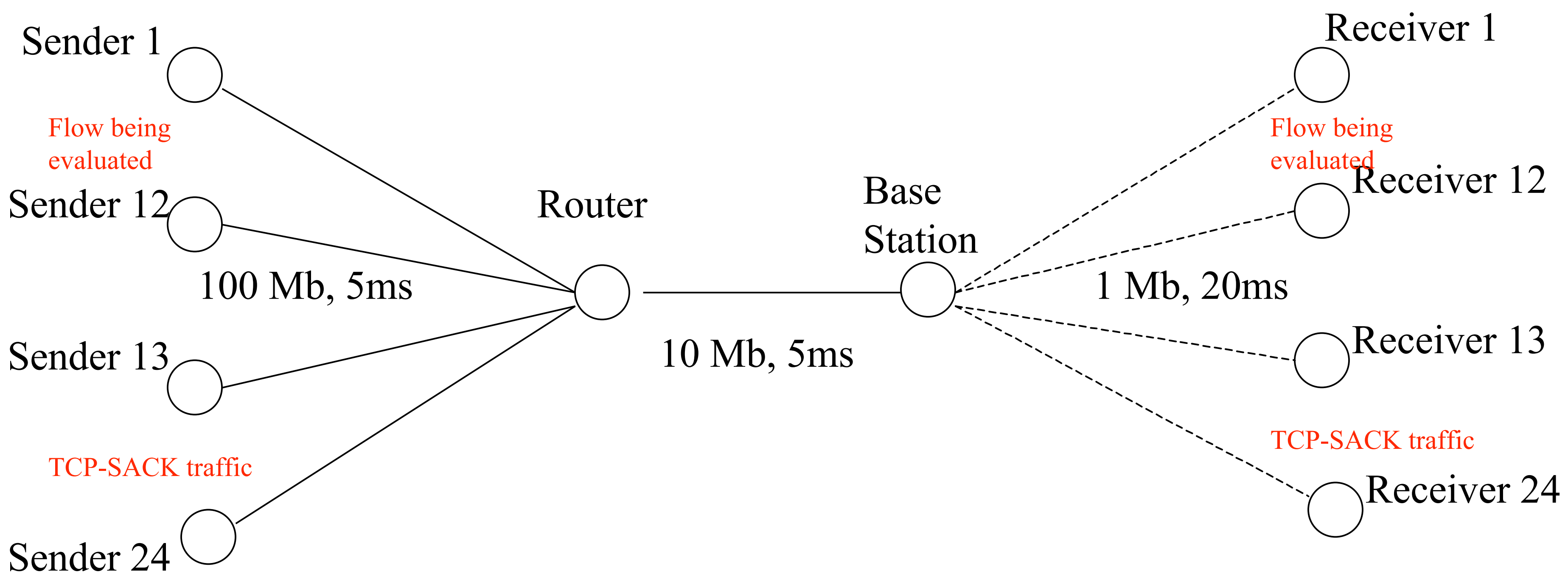


Congestion Only -- Fairness (cont.)

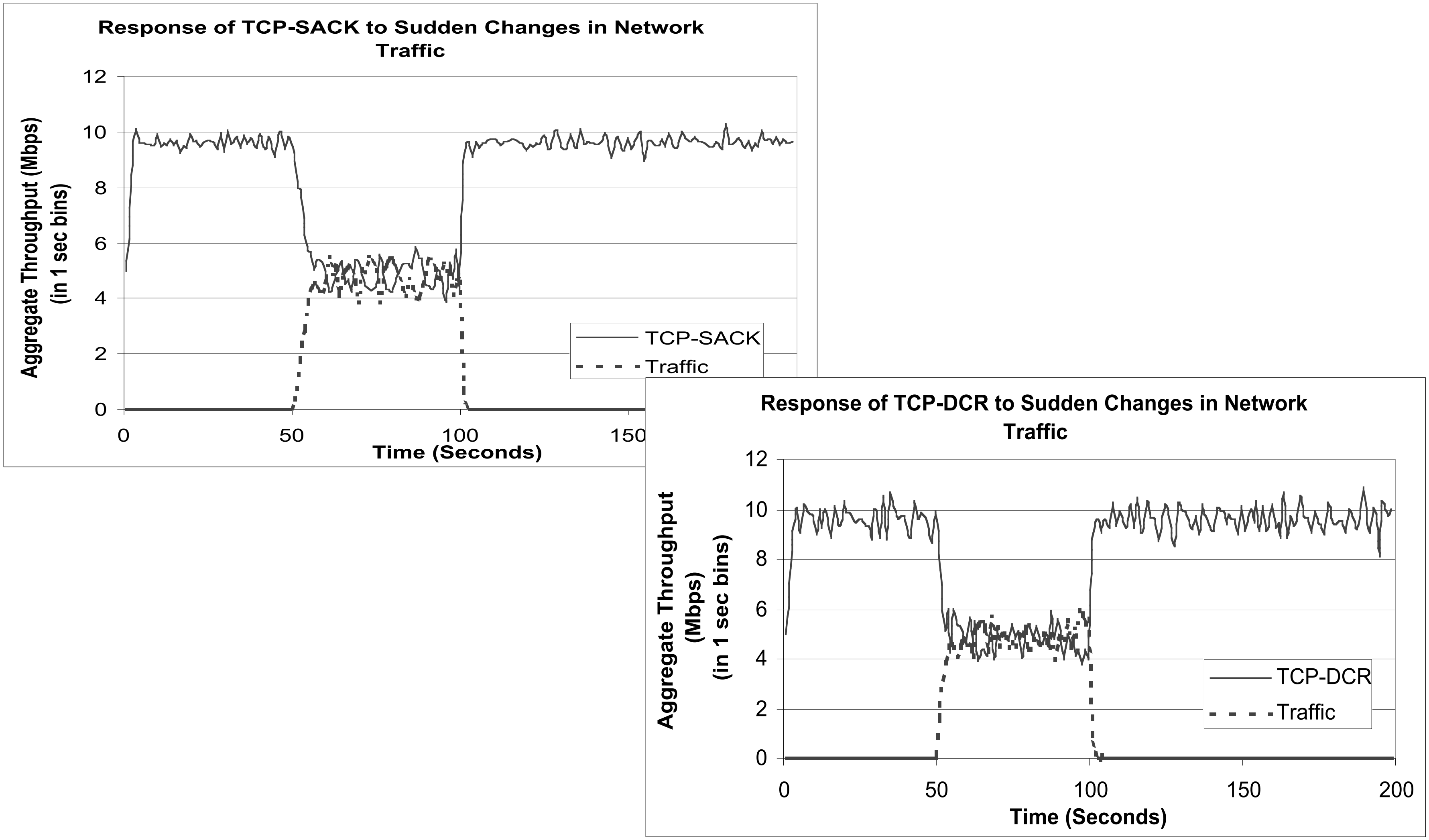
- During the delay period TCP-DCR is still ack-clocked
- Limited Transmit is used during the delay period
- Overall protocol behavior is still AIMD

□ Overall performance of TCP-DCR similar to competing TCP-SACK flows for different congestion rates

Congestion Only -- Sudden Changes in Traffic Explanation for next slide (To be removed from final version)



Congestion Only -- Sudden Changes in Traffic



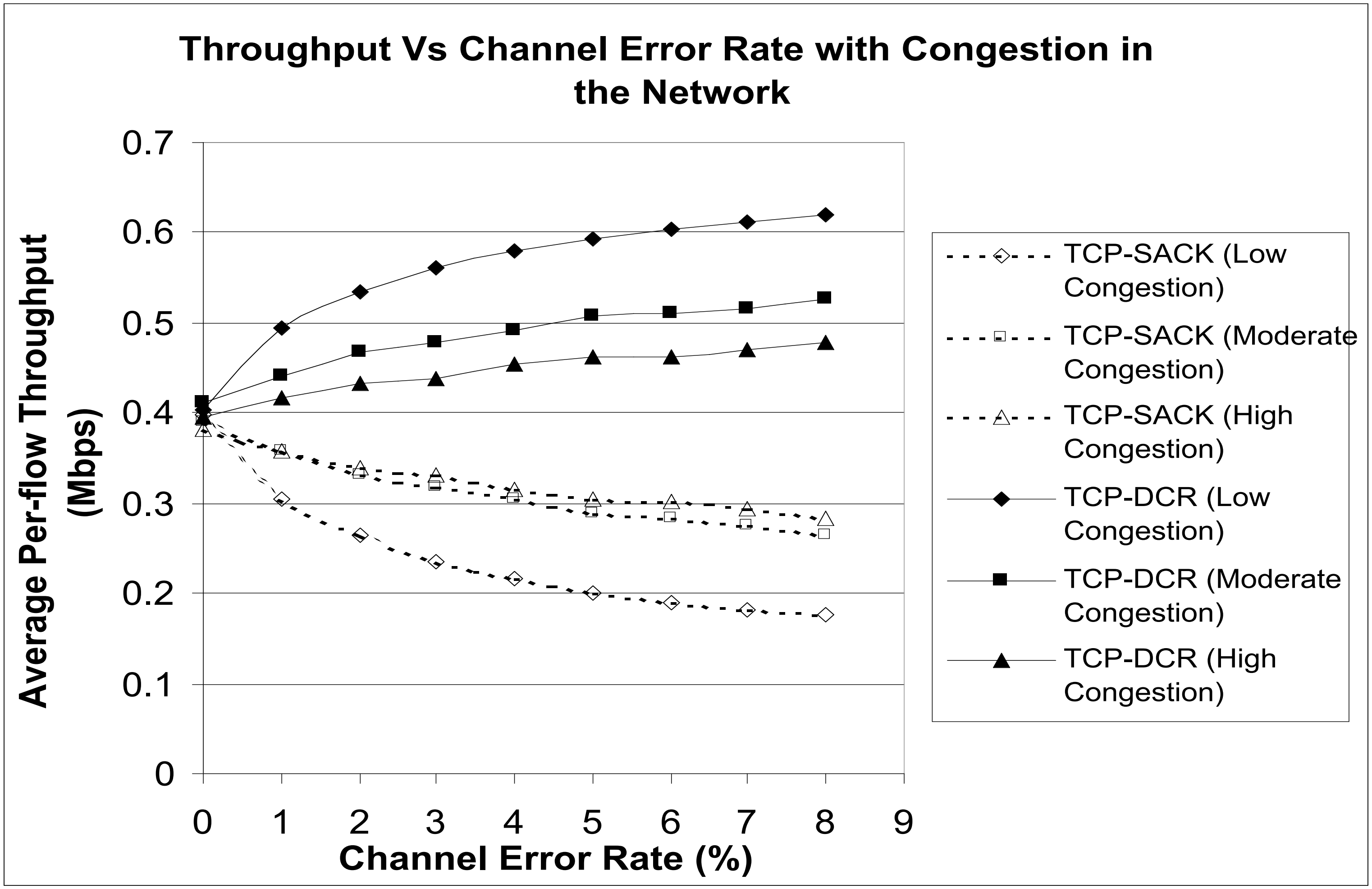
Congestion Only -- Sudden Changes in Traffic (cont.)

- TCP-DCR relinquishes and reclaims bandwidth in similar fashion to TCP-SACK

Channel Errors and Congestion -- Topology (To be removed from final version)

Same as “Congestion Only -- Fairness”

Channel Errors and Congestion



Channel Errors and Congestion (cont.)

- For both TCP-SACK and TCP-DCR, T 1/p
- In case of TCP-SACK, p = (congestion loss rate + channel error rate)
- In case of TCP-DCR, p = congestion loss rate
- For lower congestion rate, competing TCP-DCR flows get better throughput
- As congestion increases, difference in throughput between TCP-DCR and TCP-SACK flows decreases

Conclusions

- Significant performance improvement with non-congestion events
- Similar to unmodified versions of TCP in the absence of non-congestion events
- Simple to implement
  - Linux implementation - less than 10 lines of code changed
- Unified solution, handling multiple issues

For Further Details….

- “TCP-DCR: Making TCP Robust to Non-Congestion Losses”

  http://dropzone.tamu.edu/techpubs/2003/TAMU-ECE-2003-04.pdf

- “TCP-DCR: A Novel Protocol for Tolerating Wireless Channel Errors”

  http://dropzone.tamu.edu/techpubs/2003/TAMU-ECE-2003-01.pdf