TCP-based background data transfer using inline network measurement

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Outline

- Introduction
- Objective
- Related work in background TCP data transfer
- Proposed mechanism
- Performance evaluation
- Conclusion & future work

Introduction

- Prioritized data transfer for ``better'' Internet services
  - e.g. Contents Delivery Network (CDN)
    - If backup data transfer is set to lower priority, they can be transferred without affecting user-requested data transfer
- Achieving that by TCP Reno is very difficult
  - TCP Reno cannot avoid affecting the foreground traffic
    - TCP Reno continues to increase its congestion window size until a packet loss occurs

Objective

- Achieve TCP-based background data transfer
  ImTCP-bg (ImTCP background mode)
- Satisfying the following two objectives is important:
  - No adverse effect on foreground traffic
  - Full utilization of the network link bandwidth
- Proposed scheme utilizes results of inline network measurement

Previous studies about TCP-based background data transfer

- Main objective is unaffecting foreground traffic
  - e.g. TCP Nice [9], TCP-LP [10]
    - Achieving lower-prioritized data transfer (rather than TCP Reno) by using RTT as an indication of network congestion
- These protocols cannot efficiently utilize the available bandwidth
  - Degree to which the congestion window size can decrease is fixed and too large
  - No way for obtaining the network bandwidth information

[9] A. Venkataramani, R. Kokku, and M. Dahlin, "TCP Nice: A mechanism for background transfers," in Proceedings of the 5th Symposium on Operating Systems Design and Implementation, Dec. 2002.
[10] A. Kuzmanovic and E. W. Knihtly, "TCP-LP: A distributed algorithm for low priority data transfer," in Proceedings of IEEE INFOCOM 2003, Apr. 2003.

Inline measurement TCP (ImTCP)

- One of inline network measurement techniques
  - Use only data/ACK packets transmitted in TCP
  - Measure available bandwidth of the network path from arrival intervals of ACK packets
- Features
  - Small number of packets used for measurement
  - Continuously and quickly yielding measurement results
  - Only sender TCP modification is enough for measurement

ImTCP's Problems for background data transfer

- ImTCP does not always provide reliable measurement results for available bandwidth
  - ImTCP cannot measure the available bandwidth when the congestion window size is small
  - Measurement accuracy depends on network environment
    - e.g. RTT, number of active connections, etc
- Background data transfer based on the unreliable result may affect the foreground traffic

ImTCP-bg mechanisms

- Judge whether or not a measurement result is reliable by using the observed RTT value

$$\frac{RTT_{cur}}{RTT_{min}} > \delta$$

δ : threshold $(1 \leqq \delta)$

RTT_{cur} , RTT_{min} : current/minimum RTT value

- Control the congestion window size according to these two mechanisms
  - Bandwidth-based mechanism
  - Enhanced RTT-based mechanism

Bandwidth-based mechanism

- Case when the measurement result is reliable
  - Control the congestion window size by using the measurement result of available bandwidth
    - Smooth the measurement result

$$\overline{A} \leftarrow (1-\gamma) \times \overline{A} + \gamma \times A_{cur}$$

γ : smoothing parameter ($0 \leqq \gamma \leqq 1$)

A_{cur} : the current available bandwidth

    - Determine the upper limit of congestion window size

$$maxcwnd = \overline{A} \times RTT_{min}$$

RTT_{min} : minimum RTT value

  - The other congestion controls are the same as TCP Reno

Enhanced RTT-based mechanism

- Case when the measurement result is unreliable
  - Decrease the congestion window size according to the observed RTT value
    - Determine the value by using the current/minimum RTT

$$cwnd \leftarrow cwnd \times \frac{RTT_{min}}{RTT_{cur}}$$

RTT_{min} : minimum RTT value
RTT_{cur} : current RTT value

  - Preserve the upper limit of congestion window size

Performance evaluation

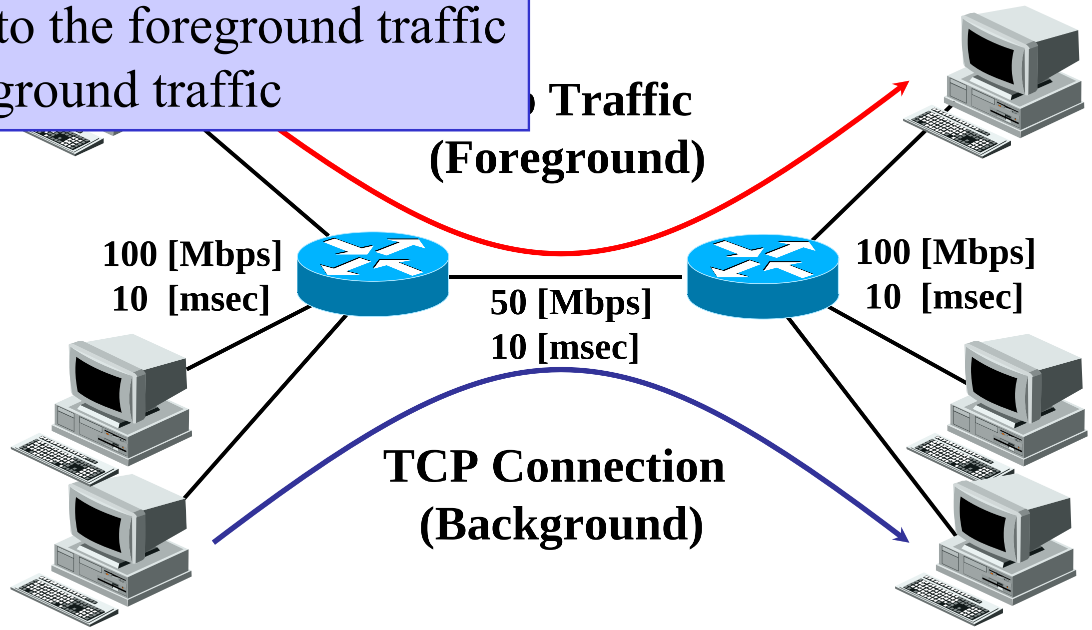
- Simulation experiments by using ns-2
  - Case of one connection
  - Case of multiple connections
- Performance comparison of ImTCP-bg
  - TCP Reno
  - TCP Nice
  - TCP-LP

Case of one connection

Performance metric:
- Degree of affection to the foreground traffic
- Throughput of background traffic

Router:
Drop-tail
buffer size is 1000 packet

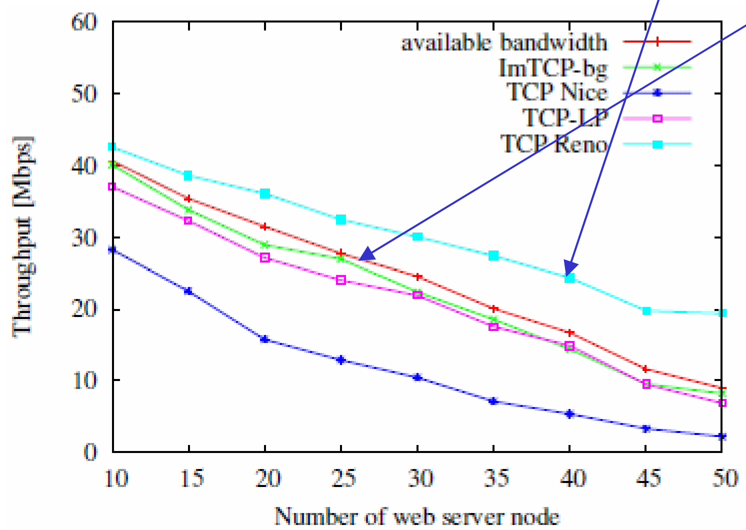
Parameter settings:
$\gamma = 1/8,\ \delta = 1.2$

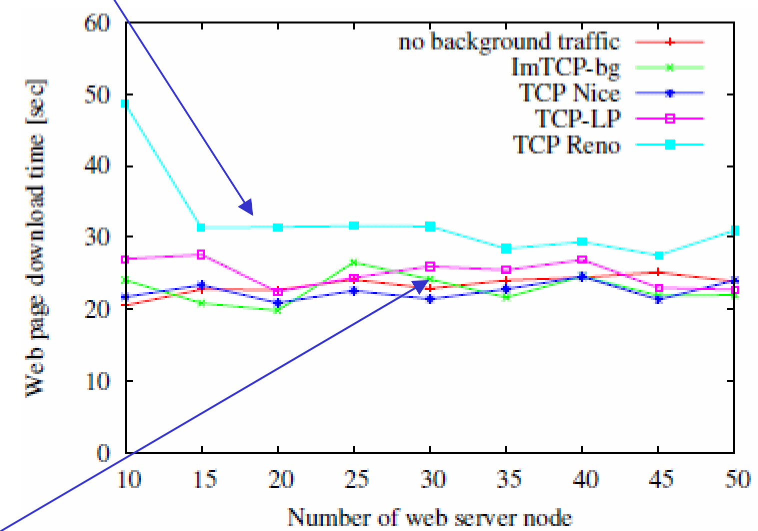


Network environment

Average throughput of the ImTCP-bg connection is the closest to the available bandwidth

ImTCP-bg has the most ideal characteristics for background data transfer





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For TCP Nice, TCP-LP, and ImTCP-bg, the average download time is almost identical to the case of no background traffic

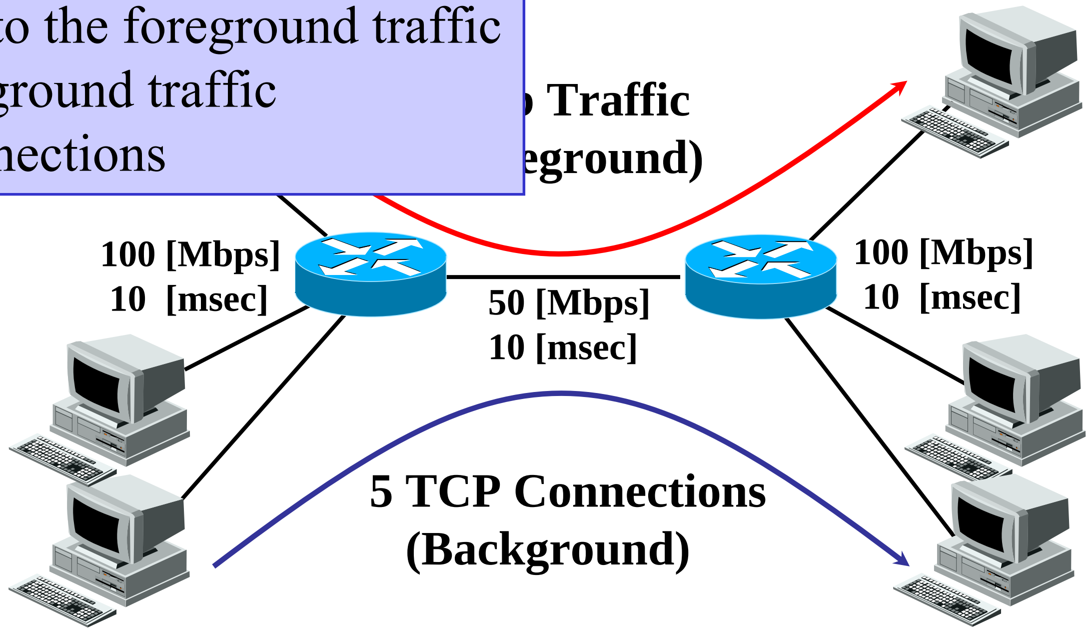
Case of multiple connections

Performance metric:

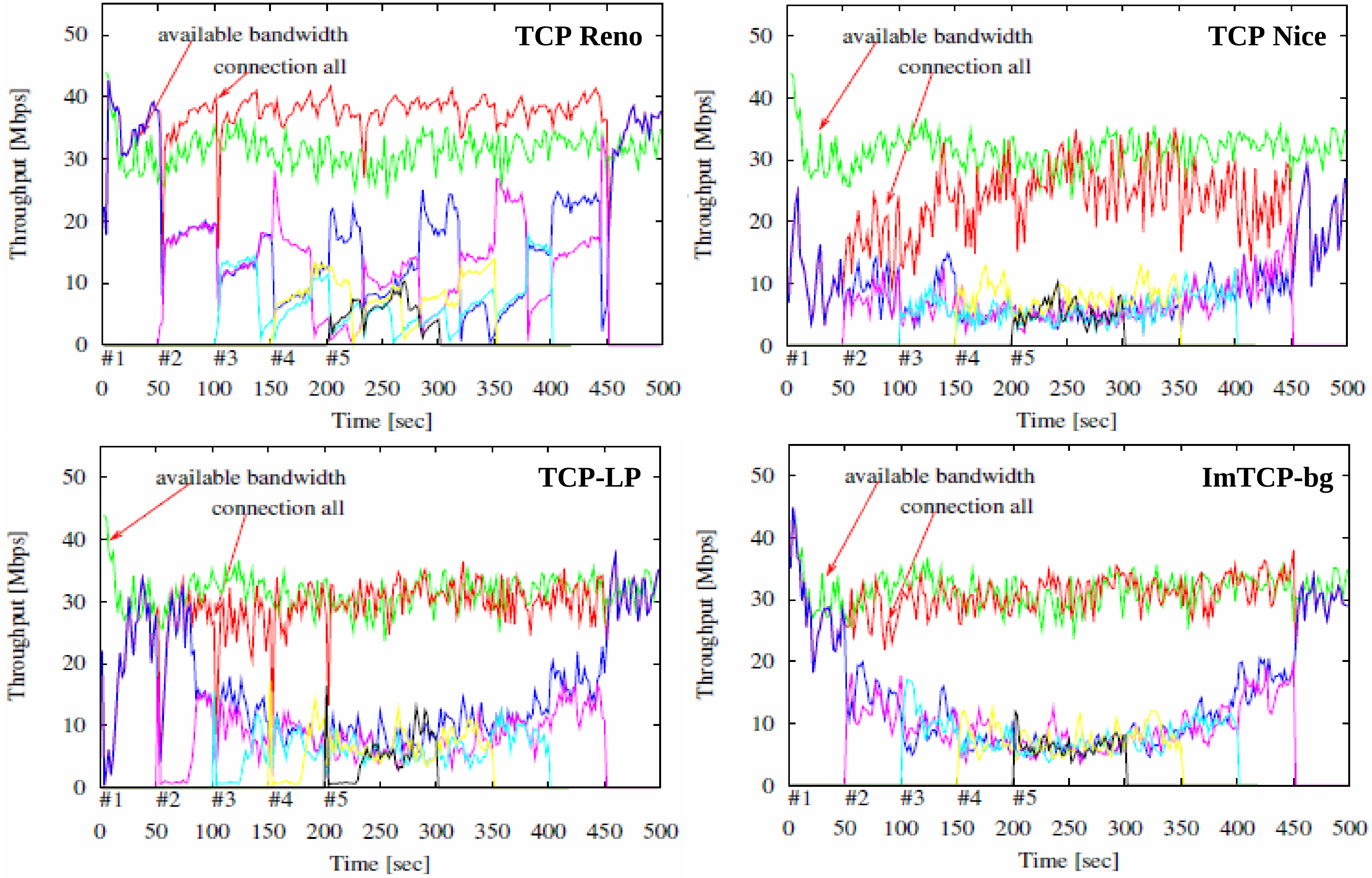
- Degree of affection to the foreground traffic
- Throughput of background traffic
- Fairness among connections

Router:
Drop-tail
buffer size is 1000 packet

Parameter settings:
γ **= 1/8,** δ **= 1.2**



Network environment

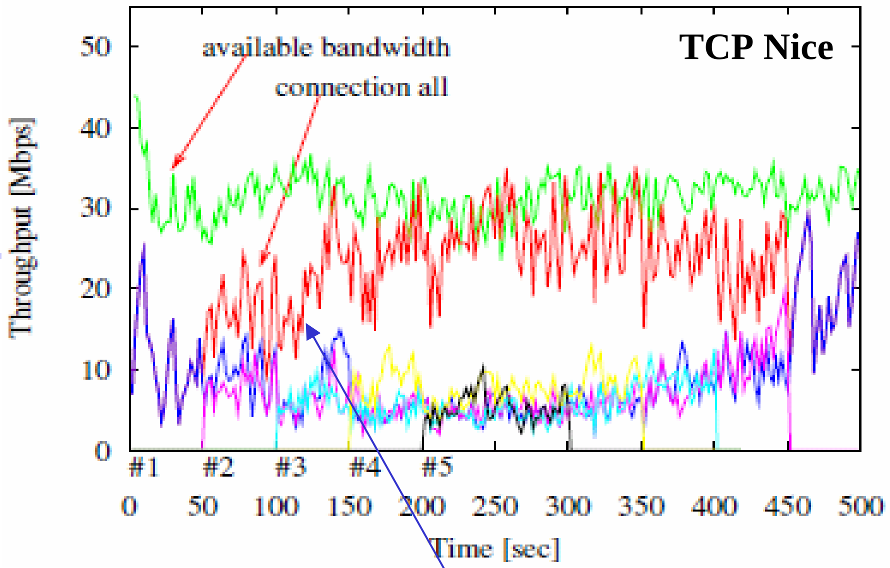


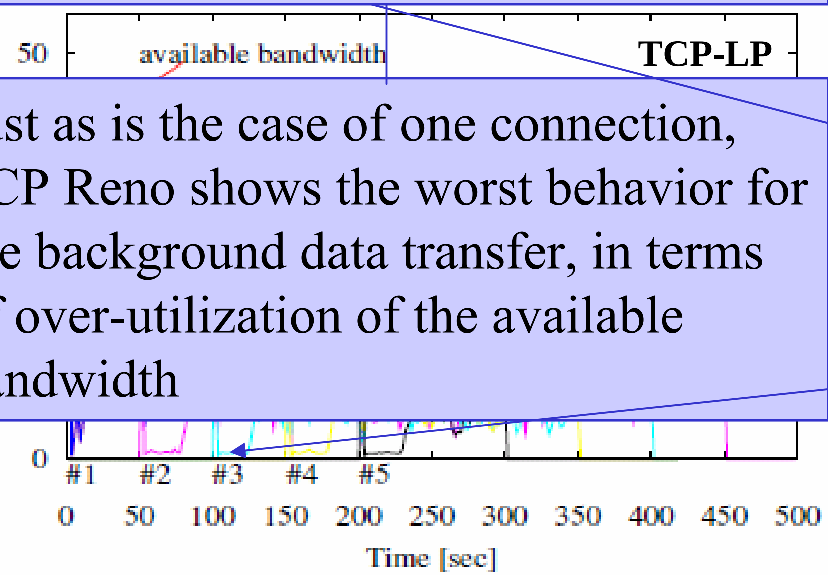
Change of throughput

ImTCP-bg can utilize the available bandwidth even when the number of connections is one

Change in the throughput of each ImTCP-bg connection is stable

Fairness among ImTCP-bg connections are as well as that of TCP Nice or TCP-LP connections

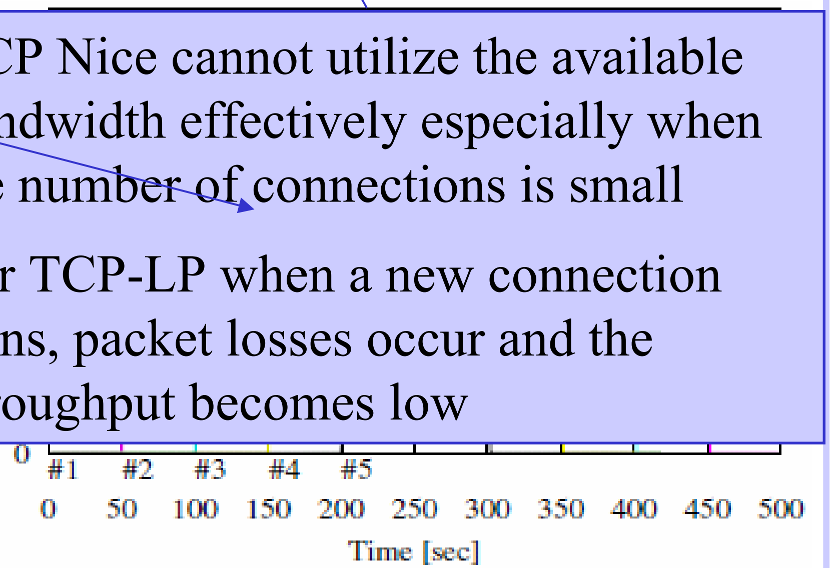




Just as is the case of one connection, TCP Reno shows the worst behavior for the background data transfer, in terms of over-utilization of the available bandwidth

TCP Nice cannot utilize the available bandwidth effectively especially when the number of connections is small

For TCP-LP when a new connection joins, packet losses occur and the throughput becomes low



Change of throughput

Conclusion & Future work

- Conclusion
  - We introduced a new background TCP data transfer
    - It uses an inline network measurement technique
  - We investigated the effectiveness of ImTCP-bg through simulation experiments
    - No bad effect on foreground traffic
    - Full utilization of the network available bandwidth
- Future work
  - Consideration about parameter settings
  - Performance evaluation in an actual network

Thank you for your attention