Available Bandwidth Measurement via TCP Connection

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Bandwidth-related metrics (end-to-end path)

Objective of this research

- Capacity
  - Maximum possible bandwidth
- Available bandwidth
  - Maximum unused bandwidth
  - Capacity minus utilized bandwidth
- Bulk-Transfer-Capacity (BTC)
  - Achievable throughput of one TCP connection

Available bandwidth

- Data transmission control
- Service overlay networks: routing, server selection
  - Quick and continuous information required
- Network topology design
- Network troubleshooting

Measuring available bandwidth

- Observing traffic at routers
  - Good for network administrators
- Passively observing traffic at end hosts
  - No effect on other traffic
  - Low accuracy
  - Requires time
- Actively injecting probe traffic to the network
  - High accuracy
  - Probe traffic is required
  - Affects other traffic

Our approach

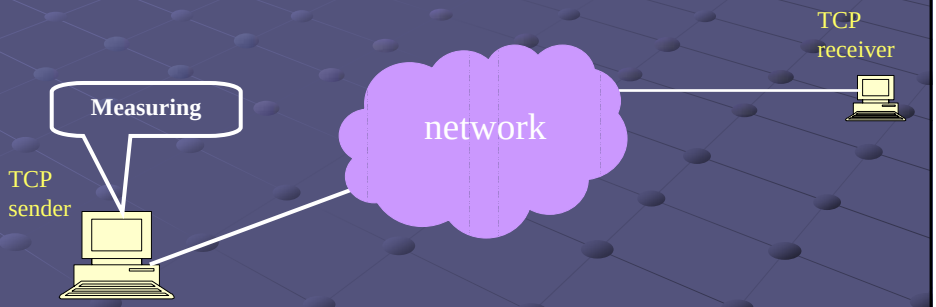
- Active measurement
- Adding no extra traffic to the network

- Inline measurement
  - Using data packets in a TCP connection as probe packets

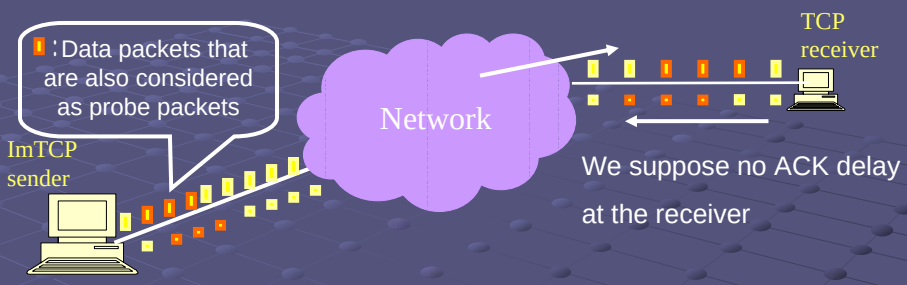
Research goal

We introduce ImTCP（Inline Measurement TCP)

- Measurement at the TCP sender
- Available bandwidth of the network path between TCP sender and receiver



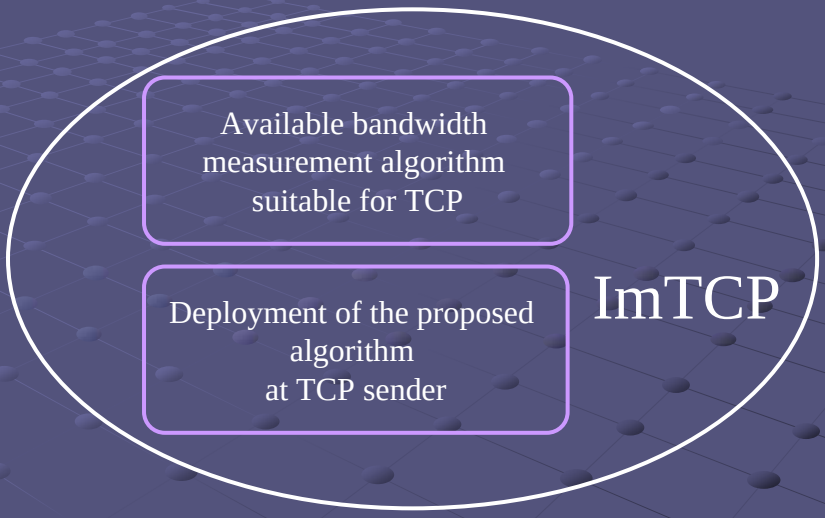
Inline measurement TCP



- Adjusting the transmission intervals of some data packets
- Measuring the available bandwidth from arrival intervals of ACK packets

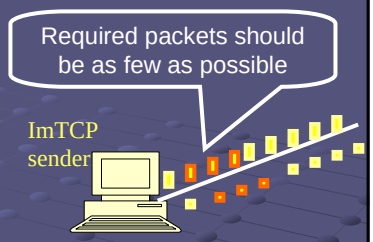
  Related research: TCP Westwood
  Passive measurement basing on ACK arrival rate

Content of the research



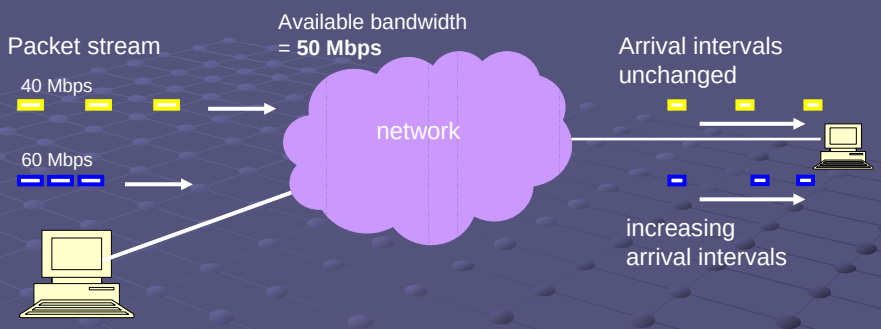
Measurement algorithm for TCP

1. Small number of packets used for measurement
   - Deployed in TCP
2. Small effect on other traffic
   - should not transmit at so high rate
3. Continuously and quickly yielding measurement results



- Choosing a suitable algorithm from existing ones
- Adding adaptation
- ⇒ Our proposed measurement algorithm

PathLoad

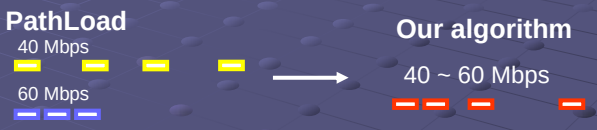


- Streams of probe packets
- Principle:
  Increasing trend in arrival intervals → transmission rate > available bandwidth
- Binary searching in the range 0 bps ~ Link Capacity

Why not being applied to TCP:
- many probe packets required
- long time required

New features in the proposed algorithm

- Varying transmission rate in a stream
  - Probing a larger range of bandwidth
  - Reducing the number of packets in a stream (from 100 to 5)



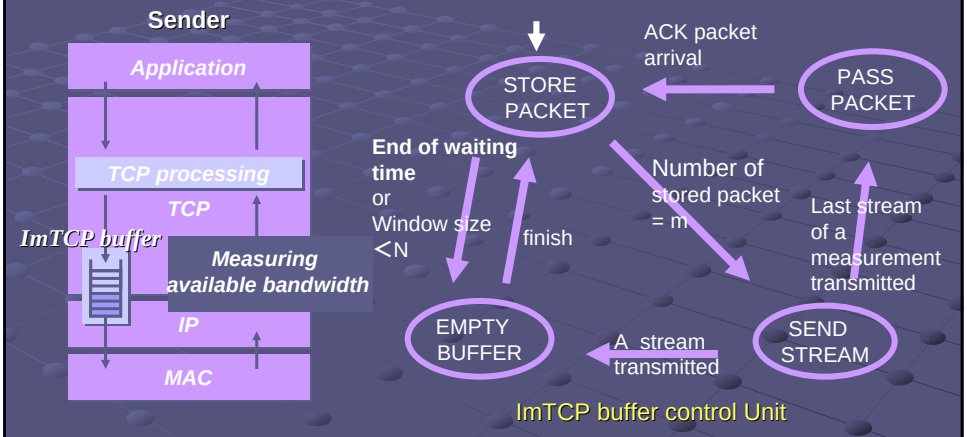
- Limiting the search range of a measurement

  Deploying statistic information of previous measurement results
  - Reducing the number of streams in each measurement
    - Fast measurement (from 120 streams in PathLoad to approximately)
  - Avoiding sending streams at very high rate
    - No effect on other traffic

Proposed measurement algorithm

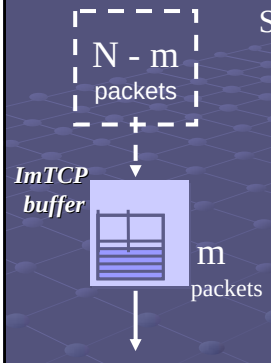
Reference:
Cao Man, Go Hasegawa and Masayuki Murata, "A new available bandwidth measurement technique for service overlay networks," in Proceedings of Workshop on End-to-End Monitoring Techniques and Services (E2EMON - 2003), Sept. 2003.

Adjusting packet transmission time



- ImTCP buffer is utilized for adjusting packet transmission time

Parameter setting



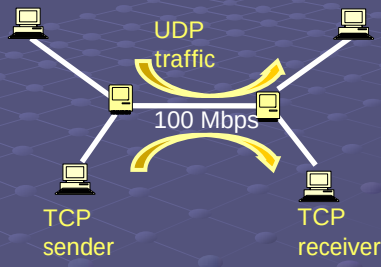
Shortening the packet storing time

- N: Number of packets in a packet stream
- We start the transmission of a stream when m packets are available (m<=N)
- The remaining part (N-m packets) are supposed to arrive during the transmission of the first m packets

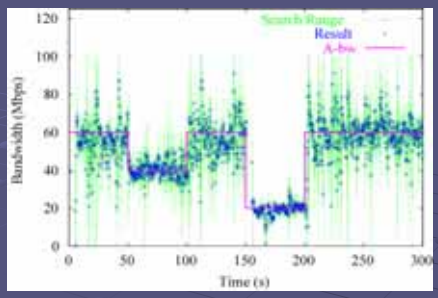
- Dynamic setting of m
  - Set *m* = *N* initially. 2<=m<=N
  - If *F* successive measurements are completed successfully, then decrement *m* by 1. We set F=2.
  - If a stream creation fails, then increment *m* by 1 and create the stream again.

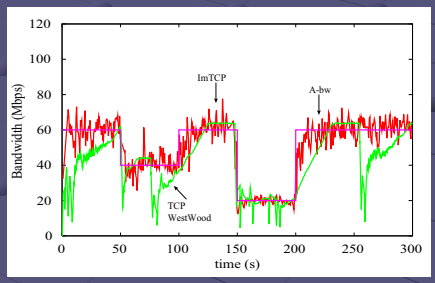
Measurement results for ImTCP

Ns-2 simulation results



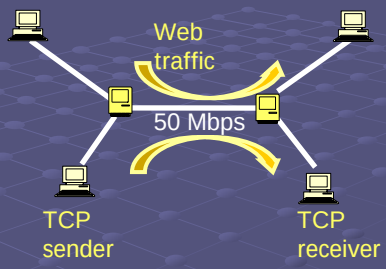
We change the available bandwidth by changing the transmission rate of UDP traffic



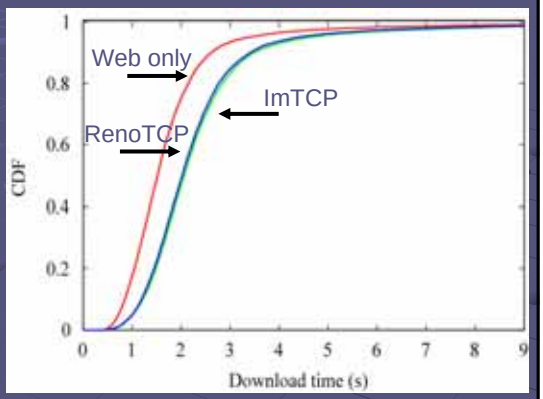


- The measurement results of ImTCP reflect better the change of available bandwidth than that of TCP Westwood (Passive measurement)

Effect on traffic in the same network

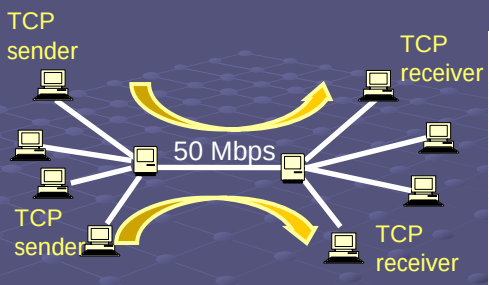


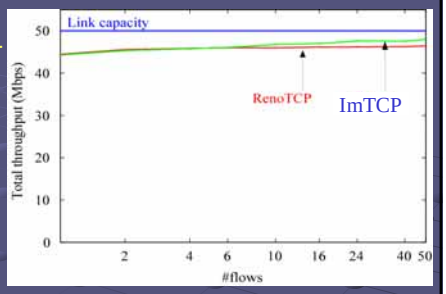
We investigate the effect of ImTCP/RenoTCP on Web page download time of the Web traffic

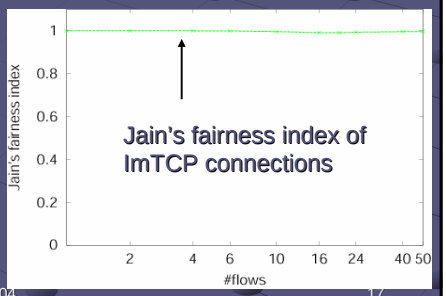


- ImTCP/RenoTCP have the same effect on the Web traffic
  - ImTCP does not cause extra effect
- ImTCP/RenoTCP have almost the same throughput

Bandwidth utilization and fairness







TCP connections share a 50 Mbps bottleneck link

- ImTCP and Reno TCP have the same link utilization
- There is fairness between ImTCP connections

Conclusion

- Conclusion
  - We introduced ImTCP, a TCP version where the sender can measure the available bandwidth
- Future works
  - Protocol implementation of ImTCP in a real system
  - Receiver-based ImTCP
  - Capacity measurement