Inline Network Measurement: TCP with a Built-in Measurement Technique

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

Object 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
- Network topology design
- Network trouble shooting
- …

Measuring available bandwidth

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

Our approach

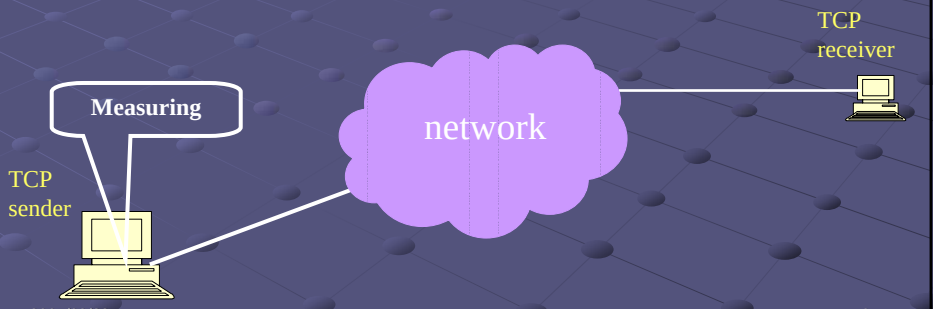
- Active measurement
- Adding no extra traffic to the network

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

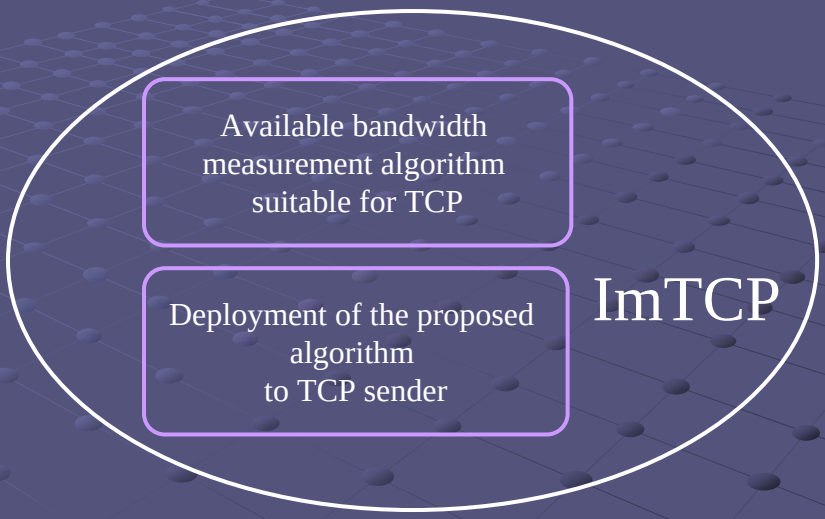
Research purpose

We introduce ImTCP（Inline Measurement TCP)

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



Content

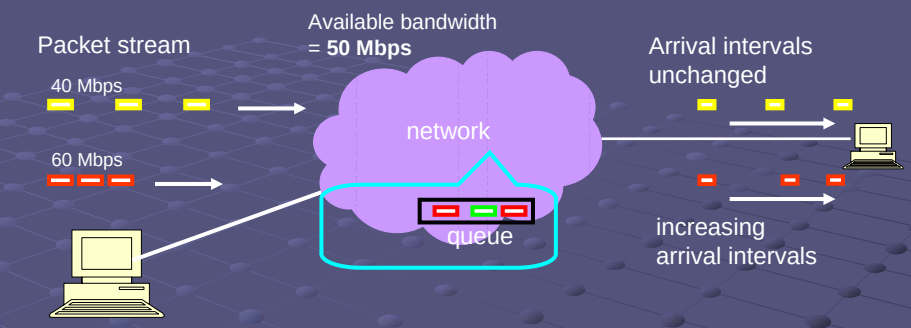


Measurement algorithm for TCP

1. Small number of probe packets
   - Deployed in TCP
2. Small effect to other traffic
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

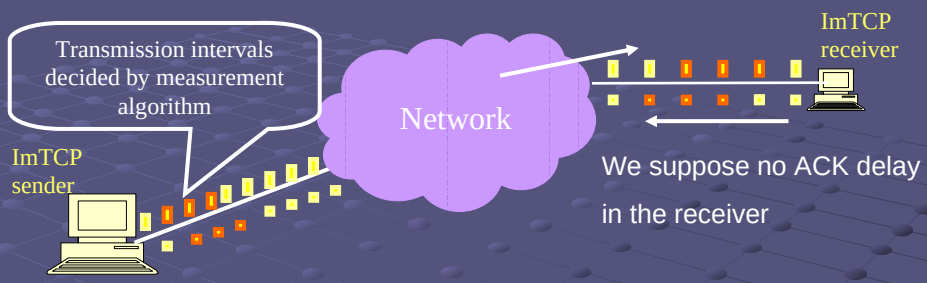
New features in the proposed algorithm

- Varying transmission rate in a stream
  - Reducing the number of packets in a stream
- Limiting the search range of a measurement
  Deploying statistic information of previous measurement results
  - Reducing the number of streams in each measurement
    - Fast measurement
  - Avoiding sending streams in very high rate
    - No affect to other traffic

The proposed algorithm is suitable for inline measurement

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), Sept. 2003.

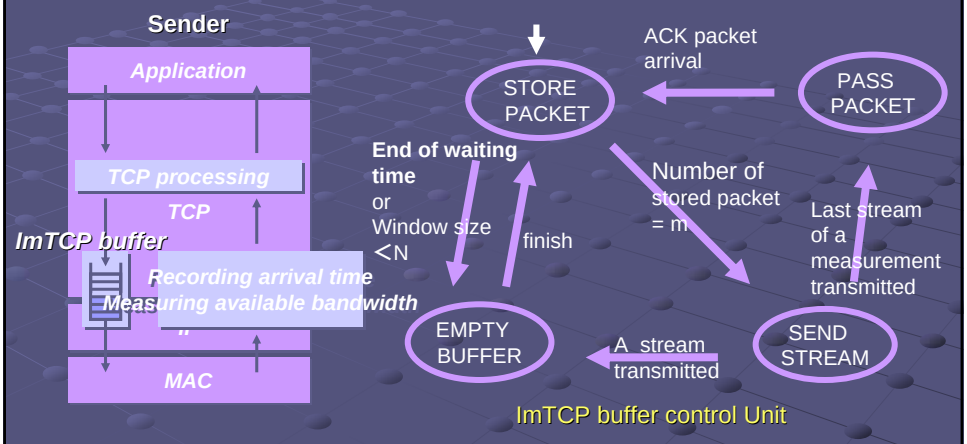
Inline measurement TCP



- 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

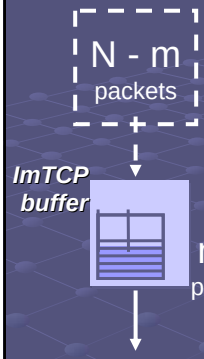
Adjusting packet transmission time



- ImTCP buffer is utilized for adjusting packet transmission time

Parameter setting

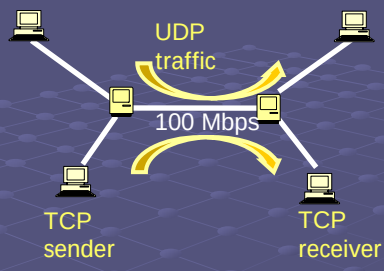
Shortening the packet storing time



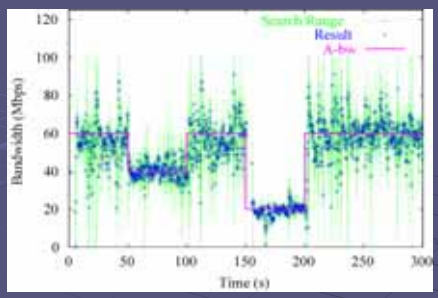
- N: Number of packets in a packet stream
- We start the transmission of a stream when m packets are available (m<=N)
- The left part (N-m packets) are supposed to arrive during the transmission of the m packets

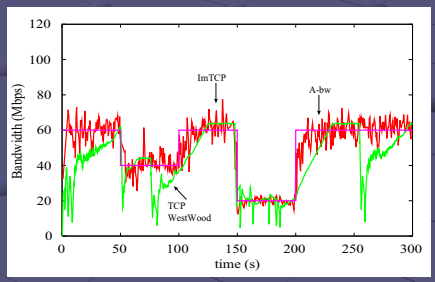
- Dynamic setting of m
  - Set *m* = *N* initially. 2<=m<=N
  - If *F* successive measurements are completed successfully, then decrement *m* by 1. We set F=2.
  - If a stream creation fails, then increment *m* by 1 and create the stream again.

Measurement results for ImTCP



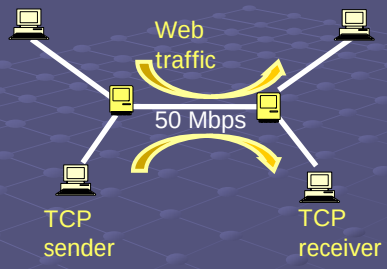
We oscillate the available bandwidth by changing the transmission rate of UDP traffic

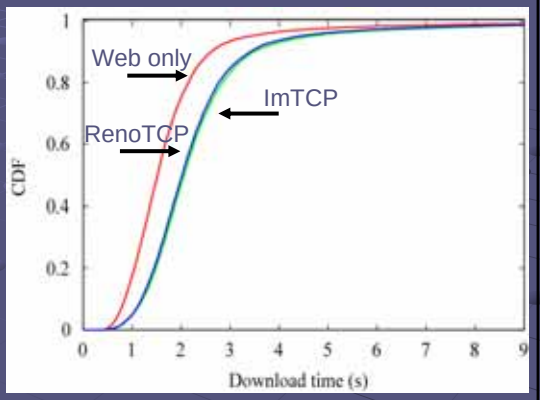




- The measurement results of ImTCP reflect well the change of available bandwidth than that of TCP Westwood (Passive measurement)

Effect on traffic in the same network

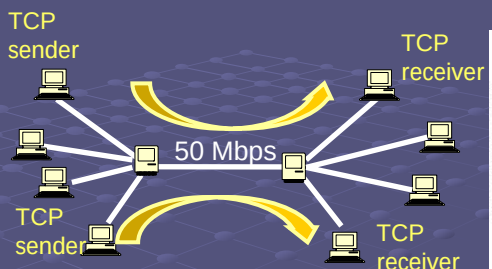


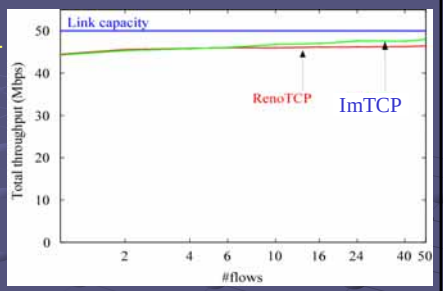


We investigate the effect of ImTCP/RenoTCP on Web page download time of the Web traffic

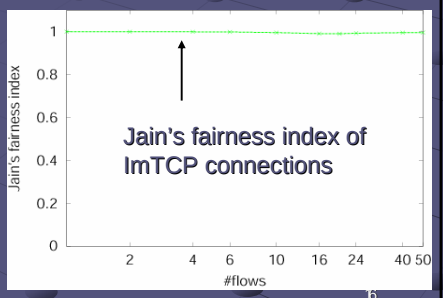
- ImTCP/RenoTCP have the same effect on the Web traffic
  - ImTCP does not cause extra effect
- ImTCP/RenoTCP have almost the same throughput

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 of which the sender can measure the available bandwidth
- Future works
  - Implementation of ImTCP
  - Receiver-based ImTCP
  - Capacity measurement