

エンドホスト間のネットワークパスの物理帯域のインライン計測手法

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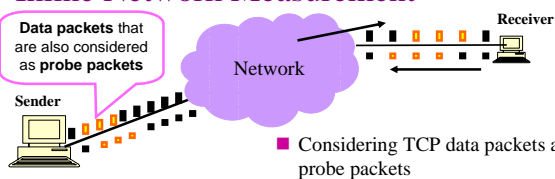
Content

- Inline measurement TCP (ImTCP)
 - A TCP version that can measure available bandwidth
- Packet-pair based capacity measurement technique
 - Proposed equation for calculating capacity
- Capacity measurement function for ImTCP
- Simulation results
- Summary

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Previous Work: Inline Network Measurement

Data packets that are also considered as probe packets



Inline measurement TCP
Active measurement without extra probe traffic

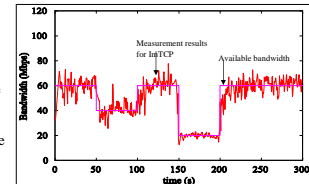
- Considering TCP data packets as probe packets
- Adjusting the transmission intervals of some data packets
- Measuring the available bandwidth from arrival intervals of ACK packets

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ImTCP

Available bandwidth measurement

- Principle: Examine trend in arrival intervals:
 - Increase
 - ✓ transmission rate > available bandwidth
 - No Increase
 - ✓ transmission rate < available bandwidth
- Reducing packets used in measurement
 - Varying transmission rate of probe packet streams
 - Technique for limiting the search range of a measurement
- Acceptable measurement accuracy
- No decrease in TCP transmission speed



Refer: C. Man et. al "Available bandwidth measurement via TCP connection" E2EMON-2004

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Objective of the Research

Enable simultaneous measurement of both available bandwidth and capacity in ImTCP

■ ImTCP

Available bandwidth measurement

Capacity measurement **New**

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Capacity & Available Bandwidth

Both are required at the same time!

- Network transport protocols
 - Optimizing link utilization (capacity)
 - Avoiding congestion (available bandwidth)
- Routing & server selection in service overlay networks
 - Information concerning both capacity & available bandwidth offers better selection
 - When available bandwidth highly fluctuates
 - ✓ Capacity information is used
- Other cases
 - ISP's charging policy

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Capacity Measurement Approaches

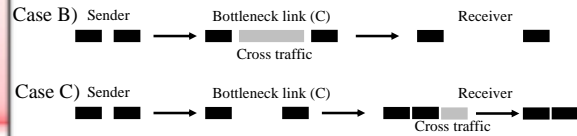
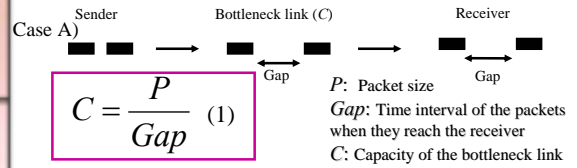
- One packets
 - Probe packets in various sizes
 - Packet Tailgating,...
- Hop-by-hop
 - Probe packets in different TTLs
 - Pchar, Pathchar,...
- Packet pairs
 - CapProbe, Pathrate, *Suitable for inline measurement*

Question: Better than existing packet pair based methods?

- Making use of available bandwidth information that is available in ImTCP

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Packet Pair's (PP) Principle



Equation (1) leads to bad results if PP is in Cases B) or C)

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Proposed Capacity Measurement Algorithm

- Existing tools
 - Using PPs that are in case A)
- Proposed method
 - Calculation based on PPs in both cases A) and B)

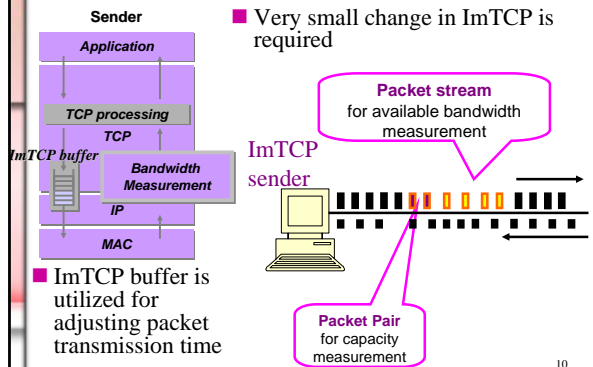


L: Average amount of cross traffic
 $L = (C - A)$
A: available bandwidth
 δ : sending interval of PP

$$C = \frac{P - \delta A}{Gap - \delta} \quad (2)$$

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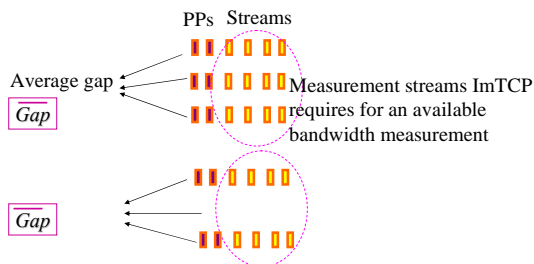
Creating Packet Pair in ImTCP



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Capacity Measurement in ImTCP (1)

I. Grouping of PPs



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Capacity Measurement in ImTCP (2)

I. Grouping of PPs

II. Calculation of "Samples"

Gap → Sample

If $P/\delta \sim A$

$$Sample = \frac{P}{Gap} \quad (1)$$

otherwise,

$$Sample = \frac{P - \delta A}{Gap - \delta} \quad (2)$$

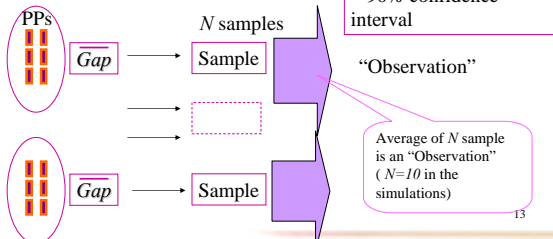
- When transmission rate of PP is approximately available bandwidth

- Packets may pass the bottleneck link without being cut into by cross traffic
- (1) is deployed
- (2): sensitive to the noise in results of A because $\frac{P - \delta A}{Gap - \delta} \sim 0$

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Capacity Measurement in ImTCP (3)

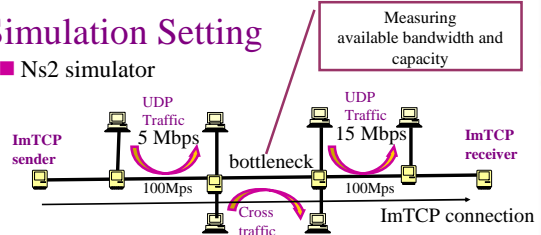
- I. Grouping of PPs
- II. Calculation of "Samples"
- III. Statistical analysis



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Simulation Setting

- Ns2 simulator

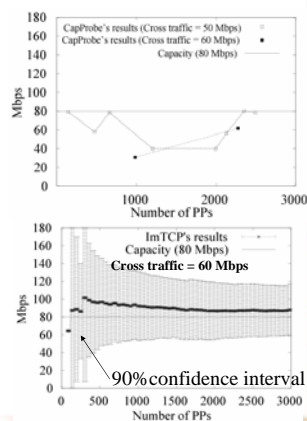


- Capacity of the bottleneck link is 80Mbps
- All other links are 100Mbps
- Cross traffic at the bottleneck link is varied
- Examine the capacity measurement results when the network load changes

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Simulation Results

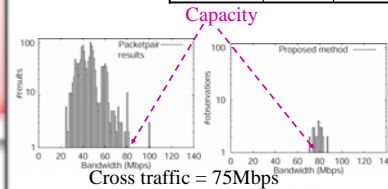
- Capacity=80Mbps
- Cross traffic
 - average transmission rate is 60Mbps
 - made of UDP connections, packet size distribution of Internet traffic
- CapProbe (Kapoor et al '04) does not perform well
 - The size of PPs can not be adapted appropriately when implemented in TCP
- Proposed method delivers good results
 - Longer TCP connections, better results



Simulation Results

- Capacity=80Mbps
- Cross traffic
 - made of UDP connections, packet size 400-600 Bytes

Cross traffic at the bottleneck link	Results for ImTCP	90% confidence interval for results of ImTCP	Pathrate's (Dovrolis et al '04) results as implemented in TCP
75 Mbps	78.98 Mbps	15.27 Mbps	49.00 Mbps
60 Mbps	79.63 Mbps	18.81 Mbps	48.00 Mbps



Proposed method can deliver good results even when the network load is heavy.

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Summary

- Capacity measurement function for ImTCP
- Validation of the measurements by simulation results

Next works

- Implementation of ImTCP in real network environment
- More information: <http://www.anarg.jp/imtcp>

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