Implementation and evaluation of an inline network measurement algorithm and its application to TCP-based service

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Contents

Background

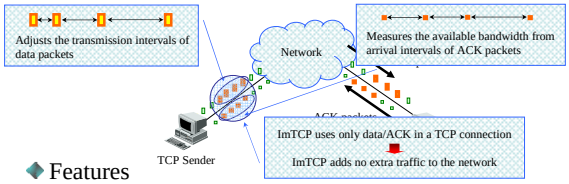
- Varied service-oriented networks have emerged
  - e.g., CDNs, P2P networks, Grid networks, IP-VPN
- Acquiring the bandwidth information is important
  - To use the resource of bandwidth effectively
  - To improve the quality of the network services
- Our research group proposed ImTCP and its application
  - ImTCP is a new inline network measurement technique
  - ImTCP-bg is a new TCP-based background data transfer mechanism using the measurement results of ImTCP
- We confirmed the effectiveness through simulations

Objective

- Simulation evaluations are insufficient to confirm the effectiveness of measurement-related mechanisms
  - Simulation condition is ideal compared to the actual network

- Investigate the effectiveness of ImTCP and ImTCP-bg on actual networks
  - Implement these techniques in FreeBSD 4.10 kernel system
  - Evaluate the Performance on actual networks

Inline measurement TCP (ImTCP)



- Features
  - Small number of packets used for measurement
  - Continuously and quickly yielding measurement results
  - Only sender TCP modification is enough for measurement

[14] M. L. T. Cao, G. Hasegawa, and M. Murata, ``Available bandwidth measurement via TCP connection,'' in Proceedings of IFIP/IEEE MMNS 2004 E2EMON Workshop, Oct. 2004.

ImTCP background mode (ImTCP-bg)

- TCP-based background data transfer technique
  - No bad effect on other traffic
  - Full utilization of the available bandwidth
- Controls the congestion window by using the measurement results
  - Smoothes the measurement results

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

(γ: smoothing parameter ($0 \lessapprox \gamma \leqq 1$); A_{cur}: the current available bandwidth)

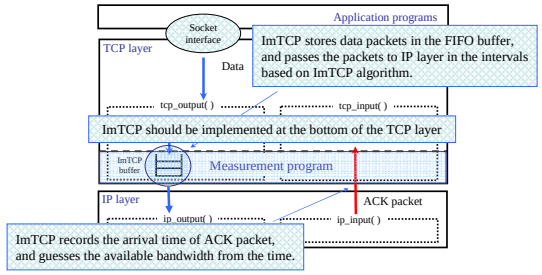
  - Determines the upper limit of the congestion window

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

(RTT_{min}: minimum RTT value)
- ImTCP-bg also uses the RTT-based mechanism
  - Measurement results are not always reliable
  - Background data transfer may affect other traffic
- The other congestion controls are the same as TCP Reno

[15] T. Tsugawa, G. Hasegawa, and M. Murata, ``Background TCP data transfer with inline network measurement,'' in Proceedings of Asia-Pacific Conference on Communications (APCC 2005), Oct. 2005.

Implementation of ImTCP



Implementation of ImTCP-bg

- Modify the function of updating congestion window
  - Congestion window is updated when an ACK packet is passed to TCP
  - Congestion control algorithm of ImTCP-bg should be implemented in the ACK processing of TCP protocol

Implementation of ImTCP-bg congestion control algorithm

✓ Set the upper limit of congestion window (*snd_maxcwnd*)
- Based on the measurement results of ImTCP
- Set *snd_maxcwnd* to *snd_cwnd* when *snd_cwnd* > *snd_maxcwnd*

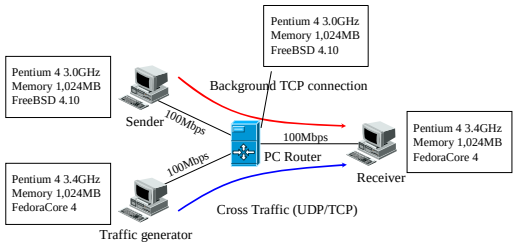
✓ Check RTT values
- Smoothed RTT (*t_srtt*) and the minimum RTT (*t_rttbest*)
- Decrease the congestion window (*snd_cwnd*) when *t_srtt* reaches the RTT threshold

Implementation issues

- Issues in kernel timer resolution
  - Resolution of the kernel system timer is coarse
  - Reduce the accuracy of measurement results
- Resolution of the timer is determined by the parameter *HZ*
  - *HZ*=100: ImTCP can measure up to 1.2 Mbps
  - *HZ*=100,000: ImTCP can measure up to 1.2Gbps
- High *HZ* affects the performance of the system
  - Timer interrupts by the kernel system occur frequently

We should consider the trade-off relationship between the timer resolution and the performance of the system.

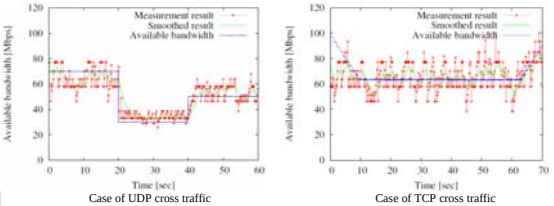
Evaluations in an experimental network



✓ DUMMYNET is installed in the PC Router
✓ The minimum value of RTTs is set to 30 msec
✓ *HZ* at the sender host (Sender) is set to 20,000

Evaluations in an experimental network (1/2)

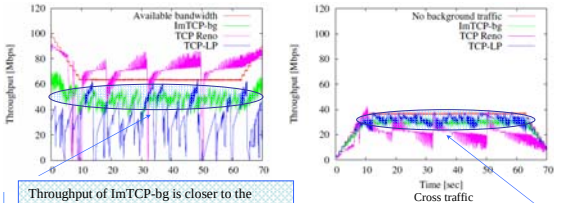
Measurement accuracy of ImTCP



Change of the available bandwidth and the measurement result

Evaluations in an experimental network (2/2)

Performance evaluation of ImTCP-bg

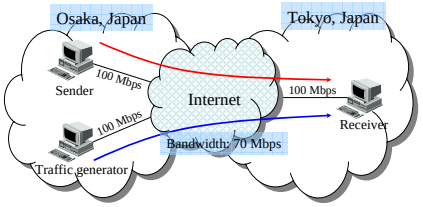


Throughput of ImTCP-bg is closer to the available bandwidth than that of TCP-LP.

ImTCP-bg can utilize the available bandwidth, while not affecting competing traffic

ImTCP-bg and TCP-LP does not almost decrease the throughput of cross traffic.

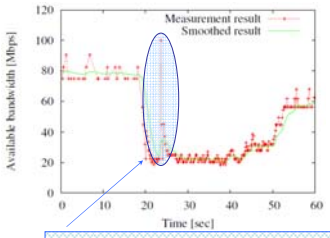
Experiments in the actual Internet



- ✓ 16 hops exist in the network path from Osaka to Tokyo
- ✓ The minimum value of RTTs is 17 msec
- ✓ The upper limit of the bandwidth between Osaka and Tokyo is 70 Mbps
- ✓ *HZ* at the sender host (Sender) is set to 20,000

Experiments in the actual Internet (1/2)

Measurement results of ImTCP



Generate UDP cross traffic
- 0 bps from 0 to 20 sec
- 50 Mbps from 20 to 40 sec
- 30 Mbps from 40 to 60 sec

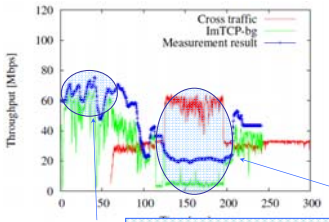
Change o

This may be caused by the short burst-traffic injected onto the Internet.

results

Experiments in the actual Internet (2/2)

Results of ImTCP-bg



ImTCP-bg can limit the throughput within the measurement result.

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ImTCP-bg can decrease the amount of data transmission when the measurement result is inaccurate.
The total throughput of cross traffic does not decrease.

Conclusions and future works

- Conclusions
  - We evaluated the performance of ImTCP and ImTCP-bg
    - Implement these mechanisms to FreeBSD 4.10 kernel system
    - Experiment on actual networks
  - We confirmed the effectiveness of our proposed mechanisms on actual networks
  - Implementation code of ImTCP and ImTCP-bg is found at our web site
    - http://www.anarg.jp/imtcp/
- Future works
  - Evaluate the performance in other actual network environments
  - Propose other useful mechanisms based on the measurement results

Thank you for your attentions