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

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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

Features

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

Inline measurement TCP (ImTCP)

- Adjusts the transmission intervals of data packets
- Measures the available bandwidth from arrival intervals of ACK packets

ImTCP uses only data/ACK in a TCP connection
ImTCP adds no extra traffic to the network

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
  - Determines the upper limit of the congestion window
  - Measurement results are not always reliable
  - The other congestion controls are the same as TCP Reno

References

Implementation of ImTCP

- Records the arrival time of ACK packet
- ImTCP stores data packets in the FIFO buffer, and passes the packets to IP layer in the intervals based on ImTCP algorithm.

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

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.

Measurements in experimental network

- Background TCP connection
- Cross Traffic (UDP/TCP)

Measurement accuracy of ImTCP

- Change of the available bandwidth and the measurement result

Performance evaluation of ImTCP-bg

- ImTCP-bg and TCP-LP does not almost decrease the throughput of cross traffic.
- ImTCP-bg can utilize the available bandwidth without affecting competing traffic.
Experiments in the actual Internet

- 16 hops exist in the network path from Osaka to Tokyo
- The minimum value of RTT 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

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

Results of ImTCP-bg

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