Available Bandwidth Measurement and Sampling

Jin Guojun

Distributed Systems Department
Lawrence Berkeley National Laboratory
1 Cyclotron Road, Berkeley, CA 94720
g_jin@lbl.gov

Measuring available bandwidth (A_{bw}) is not only for knowing the network status, but also to provide information to network applications on how to control their outgoing traffic and fairly share the network bandwidth. Some applications require very short sampling time and high sampling frequency, not only measurement accuracy. In this workshop, we propose to discuss what bandwidth estimation algorithms and sampling methods can be used with different application requirements.

There are roughly 3 classes of use cases for bandwidth estimation algorithms: instantaneous, short term, and long term.

1. instantaneous A_{bw} could be used to design a more efficient yet fair network transmission protocol. For example, a reliable UDP-based protocol such as SABUL[3] or RBUDP[4] could use A_{bw} to determine its sending rate. In this case, ideally A_{bw} can be measured from the actual data packets, not requiring additional probe packets be sent into the network
2. short term: An example of this use case would be an intelligent data forwarding agent. For example, this data forwarder could dynamically filter or summarize incoming sensor data based on the A_{bw} of the outgoing path. This would typically be a few seconds.
3. long term: An example of this use case would be to select the optimal source to download a file from based on an A_{bw} estimate for the duration of the file transfer. This would typically be a few minutes.

As network utilization is a function of time, available bandwidth (A_{bw}) is very time sensitive during it's measurement. This feature affects not only the bandwidth measurement, but also the network transmission protocol design. In [2], we addressed how various hardware and software components affect the accuracy of available bandwidth measurements, especially on high-speed network paths. In this workshop, we propose to discuss these and other key issues that affect the ability to measure available bandwidth and build future network transmission control protocols.

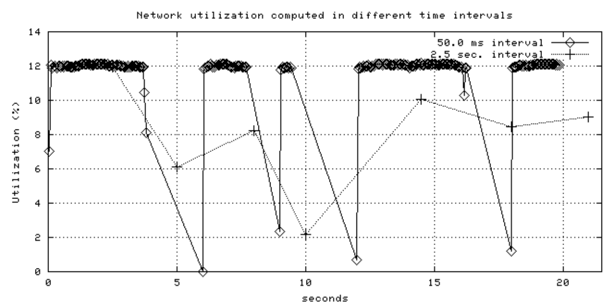

Figure 1   Available bandwidth results at 2 different time intervals

Timing accuracy is critical to measure available bandwidth, but not capacity. This makes available bandwidth measurement more difficult. In measuring capacity, we can collect a number of measurements during a given time frame, then apply linear regression on the data set to finalize the analysis to obtain a converged result. In measuring available bandwidth, this is almost impossible. That is, unless the network traffic is relatively steady, convergence over a longer period of time is not a useful method for obtaining available bandwidth results. Fig. 1 show that the variance of available bandwidth results averaged over different time intervals. This figure points out that the value for the available bandwidth result depends on how the results will be used. Therefore the averaging method used to compute available bandwidth can vary. A common solution is to sample available bandwidth value over a short (may be very short) time interval, and repeat the sampling over a period of time. Each sample can be used for instantaneous requirements, and averaging multiple samples to provide estimates for applications that run for a long time.

Designing a sampling algorithm is not trivial because measuring available bandwidth (A_{bw}) must also not perturb current traffic, especially TCP traffic, in order to obtain an accurate result. Fig. 2 shows that the longer the measurement stream, the worse the interference will be with the cross traffic. Therefore, the sampling algorithm depends on following factors: 1) how fast an A_{bw} measurement tool can make a measurement and how much

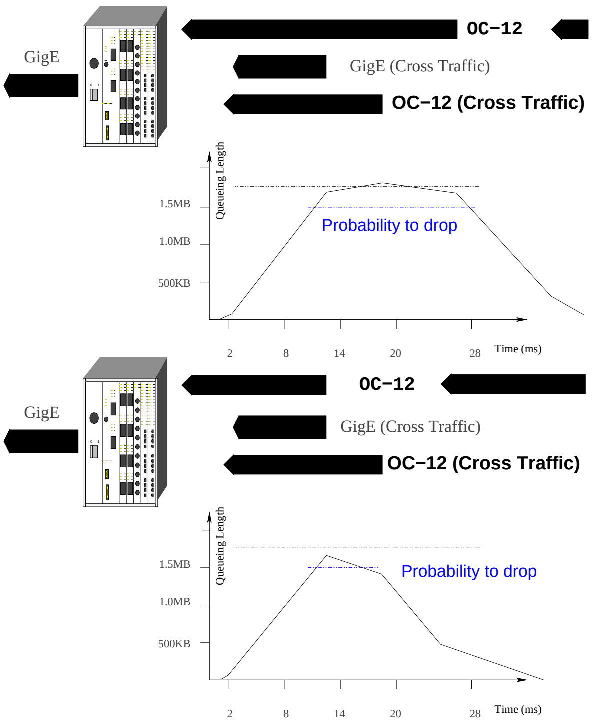

Figure 2 Packet drop probability, window size vs. burst size

traffic the tool generates; 2) what is the usage scenario for the A_{bw} results; 3) how often the measurement can and should be repeated.

The sampling process can be explored by use cases. The instantaneous case has very restricted requirement that A_{bw} measurement needs to be repeated often and each A_{bw} sampling must be done very quickly to reflect the current traffic situation, for example, in less than 1/4 round trip time (RTT). This type of application requires a very fast and non-intrusive A_{bw} measurement algorithm. The sampling frequency for short lived applications is between a number of RTT and a several seconds. The requirement for sampling speed needs to be relatively fast and non-intrusive. Most known A_{bw} measurement algorithms are suitable for long term requirement. For short lived applications, the sampling speed is more important, for large data transfer, the average available bandwidth is more proper, but the valley frequency of the available bandwidth history is also critical to avoid congestion.

In this workshop, we will discuss several available bandwidth measurement tools and their algorithms to show how they fit with different network applications.

Besides the timing and sampling issue, intrusiveness issue is also an important factor to the measurement accuracy. We need to discuss using the maximum burst size theory [1] to ensure that available bandwidth measurement algorithms are not affecting over traffic on the path.

Fig. 3 shows that if a burst size is short, the burst will not cause deep queueing in a congested router (b) unless in an extreme case (a) that all traffics suddenly aggregate at the same time, in which case no method can avoid queueing delays, or even packet loss.

For network bandwidth measurements, the burst cannot be too small without sacrificing accuracy [2]. Thus, finding the optimal burst size to balance accuracy and non-intrusiveness is an interesting topic for the network bandwidth measurement.

The MBS is the maximum number of bytes that can be sent continuously from the source host to the destination host without causing any of network elements along the path, including the receiving host, to drop a packet. This is an important characteristic missing from most other tools.

ACKNOWLEDGMENTS

This work was supported by the Director, Office of Science. Office of Advanced Scientific Computing Research. Mathematical, Information, and Computational

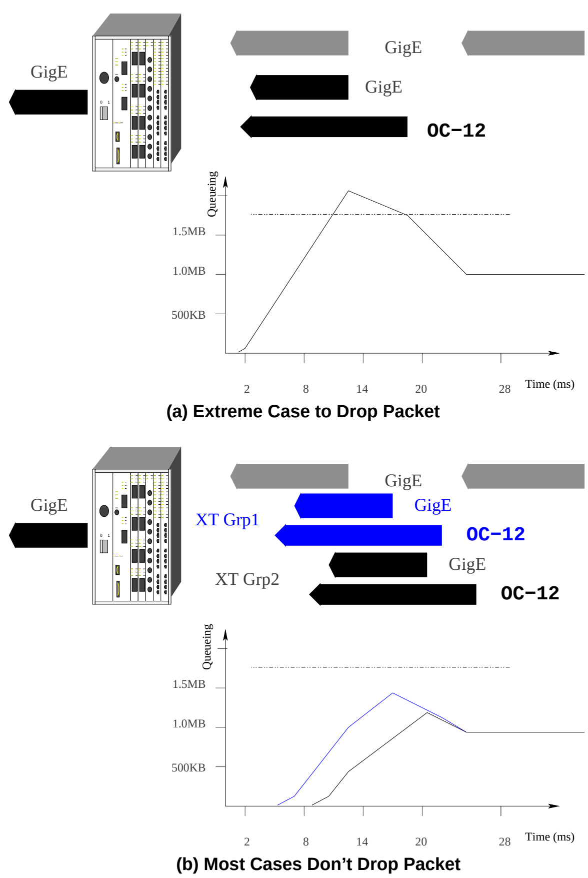

Figure 3 Queueing affected by burst pace

Sciences Division under U.S. Department of Energy Contract No. DE-AC03-76SF00098. This is report no. LBNL-53919

References

[1] G. Jin, B. Tierney Netest: A Tool to Measure Maximum Burst Size, Available Bandwidth and Achievable Throughput, Proceedings of the 2003 International Conference on Information Technology Aug. 10-13, 2003, Newark, New Jersey, LBNL-48350.

[2] G. Jin, B. Tierney System Capability Effects on Algorithms for Network Bandwidth Measurement , Proceedings of the Internet Measurement Conference Oct. 27-29, 2003, Miami, Florida, LBNL-48556

[3] http://www.evl.uic.edu/eric/atp/sabul.pdf

[4] http://www.evl.uic.edu/eric/atp/