Available Bandwidth Measurement and Sampling

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Bandwidth Estimation Workshop

CAIDA/SDSC

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Overview

• Difficulty on Ultra high-speed network measurement
• Use cases
• Available Bandwidth ($A_{bw}$) is time sensitive
• $A_{bw}$ Sampling
• Summary
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Measure Ultra High-speed Network

• Link speed over 1000 Mbit/s (and exceed the system I/O bus)
  * I/O interrupt coalescing
  * Technical difficulty to send packet
     - Avoid method based on major kernel modification.
     - I/O bandwidth is not enough to saturate available network bandwidth
     - Ensure the packets sent with less gaps
     - Hop-by-hop
       • routers reply multiple ICMP to a large UDP packet is good for synchronous train probe, bad for async probe.
       • routers reply one ICMP to a large UDP packet is good for asynchronous train probe, but less efficient for synth probe.

• Packet arrival time is short
  * Signal to noise ratio is low
    - Use on NIC timer
      • Availability — which vendors make it
    - Use CPU clock counter (CCC) — not very useful in user space
      • How to transfer this information from kernel to user space
    - Use long train — large MTU may not be a solution
      • Experiment shows that longer train does not provide higher accuracy
Use Cases of Available Bandwidth

• Information system
  * Network characterization service
  * Tools

• Application
  * Protocol Design
  * Smart Data Forwarding and Scheduling
  * Bulk Data Transfer (?)
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Available Bandwidth

- **Available bandwidth** \((A)\) is the capacity minus cross traffic (utilization \(\sim U\)) over a given time interval. This is applicable to paths, links, or routers and switches.

\[
A(t_s, t_e) = \text{Capacity} - \text{Trafﬁc} \\
= C \times (1 - U) \\
= C \times \left(1 - \frac{1}{t_s - t_e} \int_{t_s}^{t_e} U(\chi) \right) \\
\neq A(\text{Window}) = C \times \left(1 - \frac{1}{\tau} \int_{t}^{(t + \tau)} U(\chi) \right)
\]

\(T_{\text{Window}} = t_s - t_e = \tau\)

- \(t_s\) is the time when the measurement started
- \(t_e\) is the time when the measurement ended
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Available Bandwidth is Time Sensitive

Network utilization computed in different time intervals
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Utilization fc1

Kbit's x 10^3

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Sampling

Sampling in 5 sec with 36 sec gap

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Sampling

The average value of samples collected in a fixed interval during a period of time does not represent the average available bandwidth during that period:

\[
\frac{1}{m} \left[ A(t_0, t_0 + \tau) + A(t_0 + c\tau, t_0 + c\tau + \tau) + A(t_0 + 2c\tau, t_0 + 2c\tau + \tau) + \ldots + A(t_0 + mc\tau, t_0 + mc\tau + \tau) \right]
\]

\[
= \frac{1}{m} \sum_{0}^{mc\tau} A(t_0 + x, t_0 + x + \tau)
\]

\[\neq A(t_0, t_0 + mc\tau + \tau)\]
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**Averaging in 500ms window**

![Utilization 500 ms sampling graph]

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Sampling in different durations and periods
Sampling Usage

• Instantaneous sampling is suitable for network protocol design.

• Results from a shorter time frame can be use for information system.

• Long period measurement may not represent a meaningful value. Bulk data transfer needs to get historical information from network characterization service (information system) to determine its transfer strategy.
Summary

• Probe burst needs to have a certain length. Too long or too short of a probe burst will not give accurate $A_{bw}$ information.

• Use application traffic to measure $A_{bw}$
  * For building network protocols

• Use active probe traffic to measure network characteristics
  * For building user level tools to diagnose / analyze network status and to provide network information to users and applications

• Use Internet Measurement Protocol to provide information
  * This can be used in different applications
  * This involves feasibility and security issues
  * Can users specify sampling time frame?