Available Bandwidth Measurement and Sampling

Bandwidth Estimation Workshop

CAIDA/SDSC

Jin Guojun

Lawrence Berkeley National Lab.

Dec. 9, 2003

Overview

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

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 asynch probe.
      - routers reply one ICMP to a large UDP packet is good for asynchronous train probe, but less efficient for synch 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 (?)

Available Bandwidth

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

$A(t_s, t_e)$ = Capacity - Traffic

$= C \times (1 - U)$

$$= C \times \left(1 - \frac{1}{t_s - t_e}\int_{t_s}^{t_e} U(\chi)\right)$$

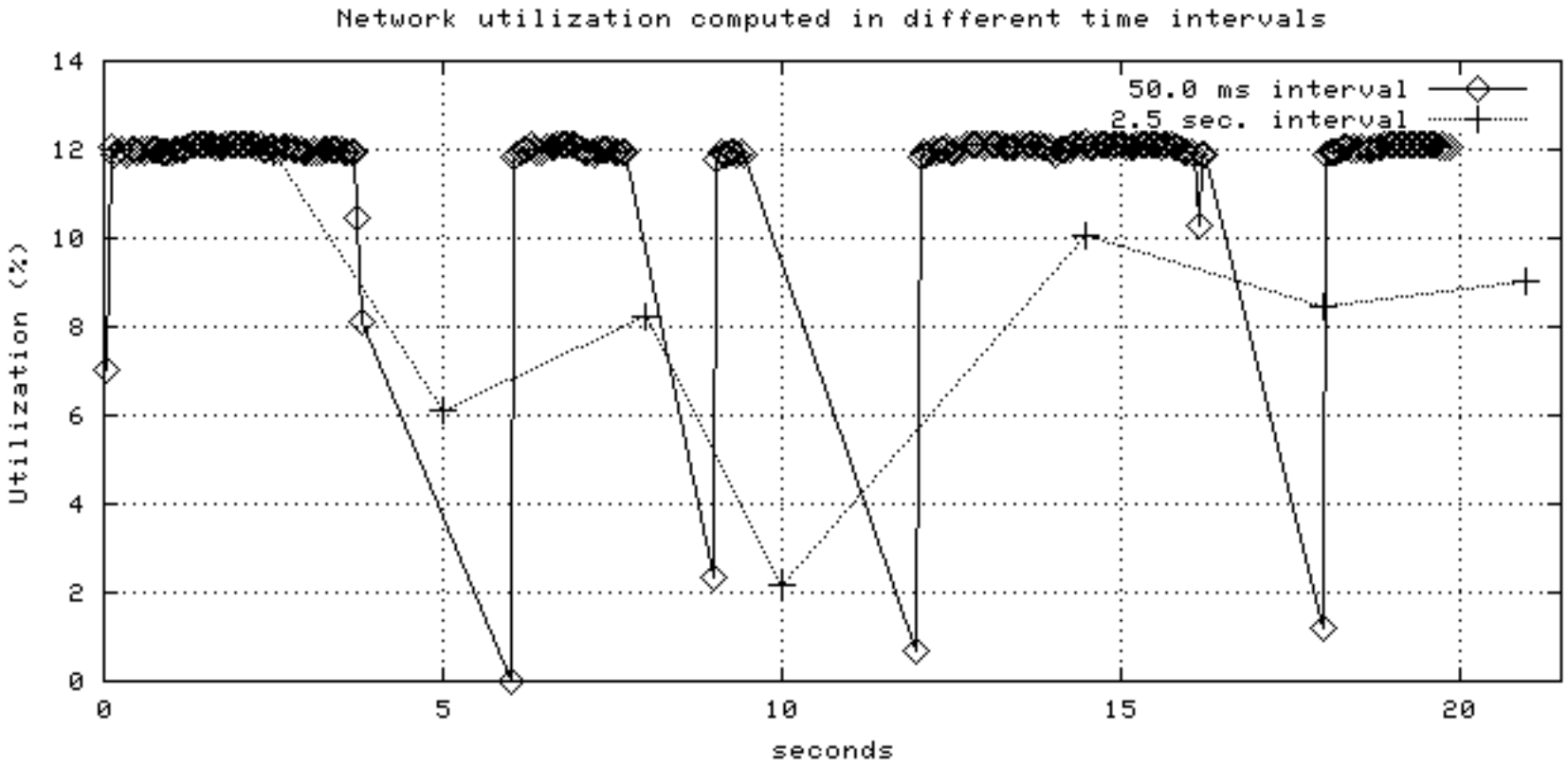
$$\neq A(T_{window}) \quad = C \times \left(1 - \frac{1}{\tau}\int_{t}^{(t+\tau)} U(\chi)\right)$$

$T_{window} = t_s - t_e = \tau$

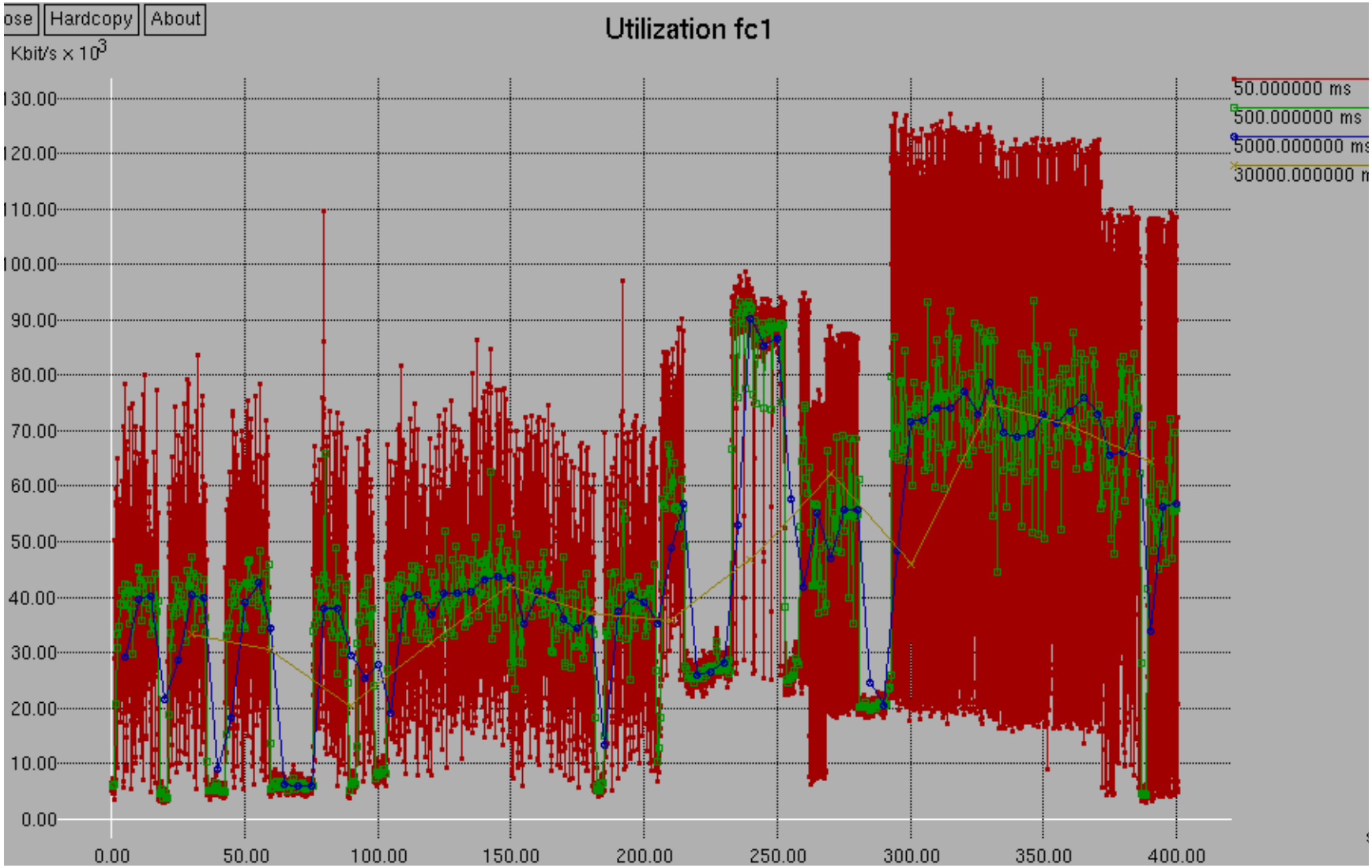
t_s is the time when the measurement started

t_e is the time when the measurement ended

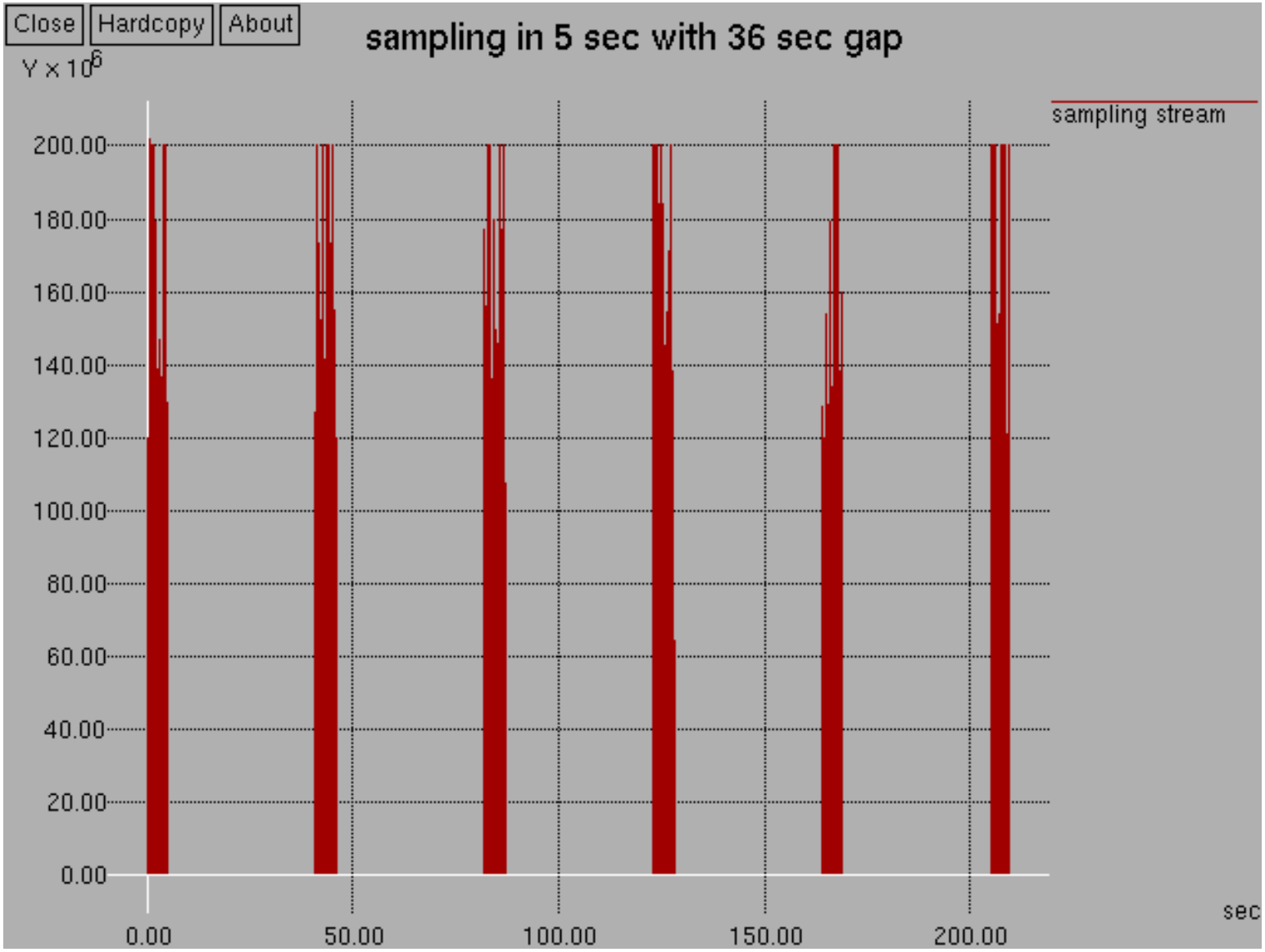
Available Bandwidth is Time Sensitive



Available Bandwidth Measurement and Sampling



Sampling


Close
Hardcopy
About
sampling in 5 sec with 36 sec gap
Y x 10^6
sampling stream
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
50.00
100.00
150.00
200.00
sec

Sampling

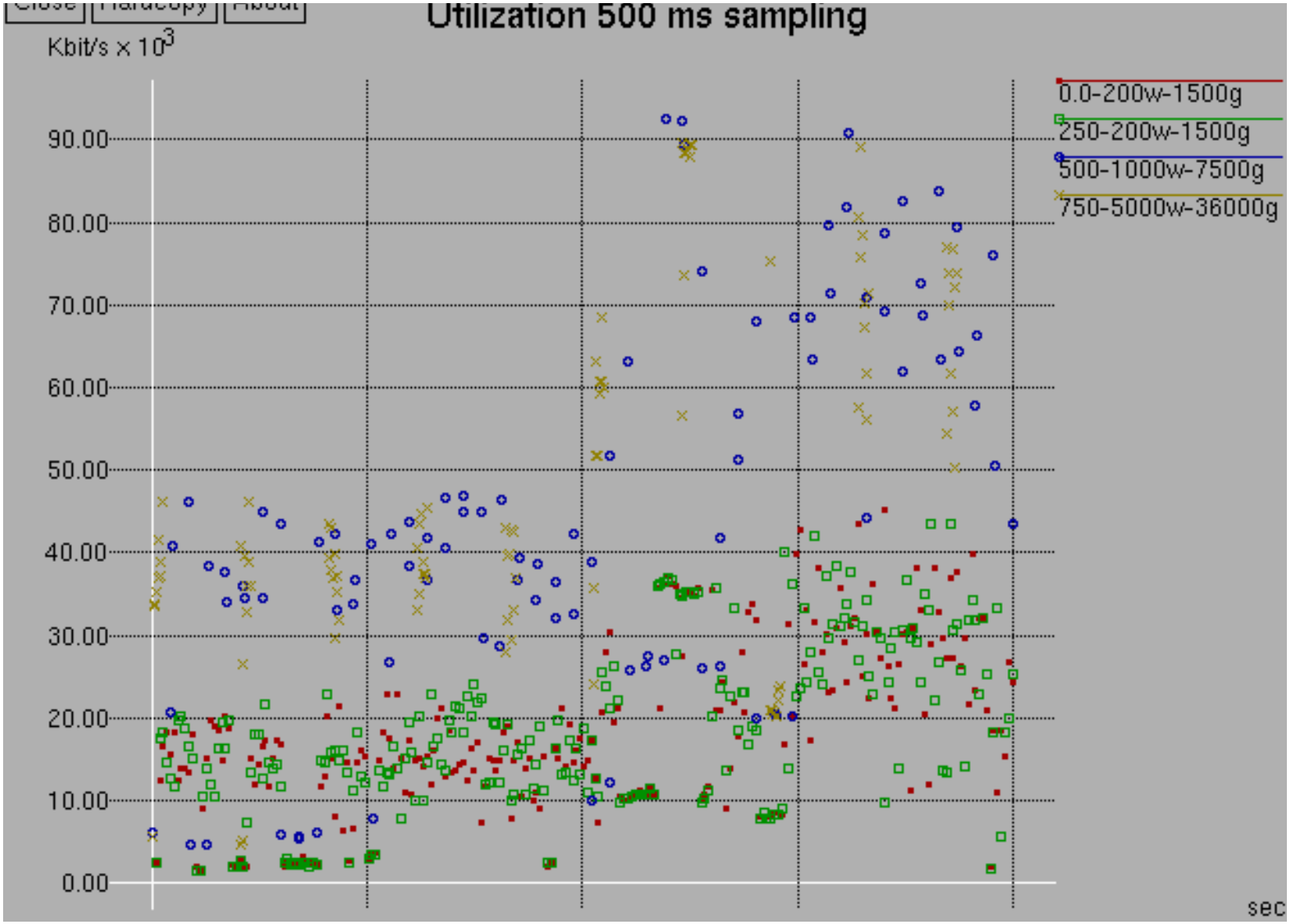
The average value of samples collected in a fixed internal during a period of time does not represent the average available bandwidth during that period:

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

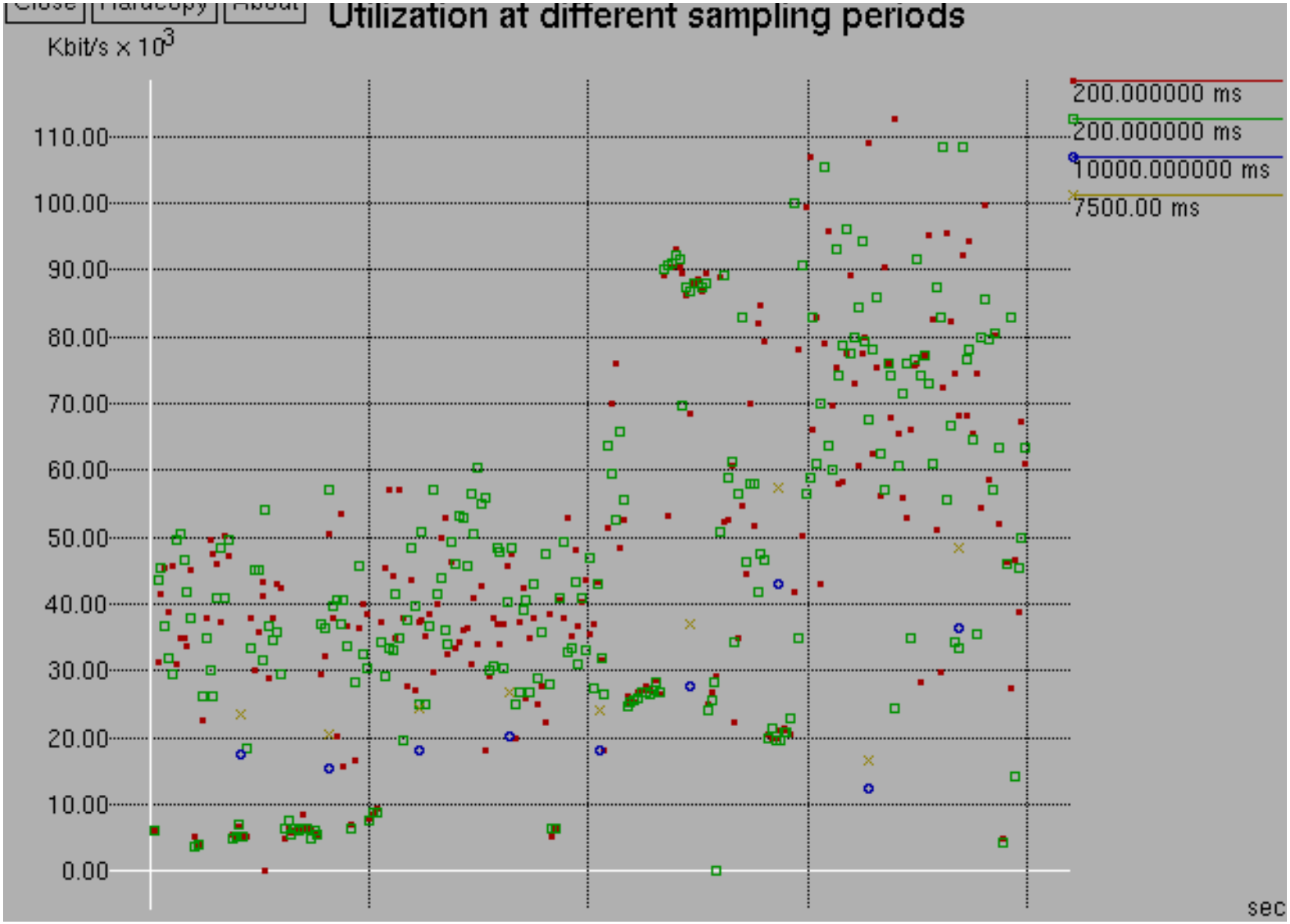
  $= \frac{1}{m}\Sigma\int_0^{mc\tau} A(t_0 + x, t_0 + x + \tau)$

  $\neq A(t_0, t_0+mc\tau+\tau)$

Averaging in 500ms window



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?