A Measurement Study of Available Bandwidth Estimation Tools

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Available Bandwidth Estimates

Available Bandwidth

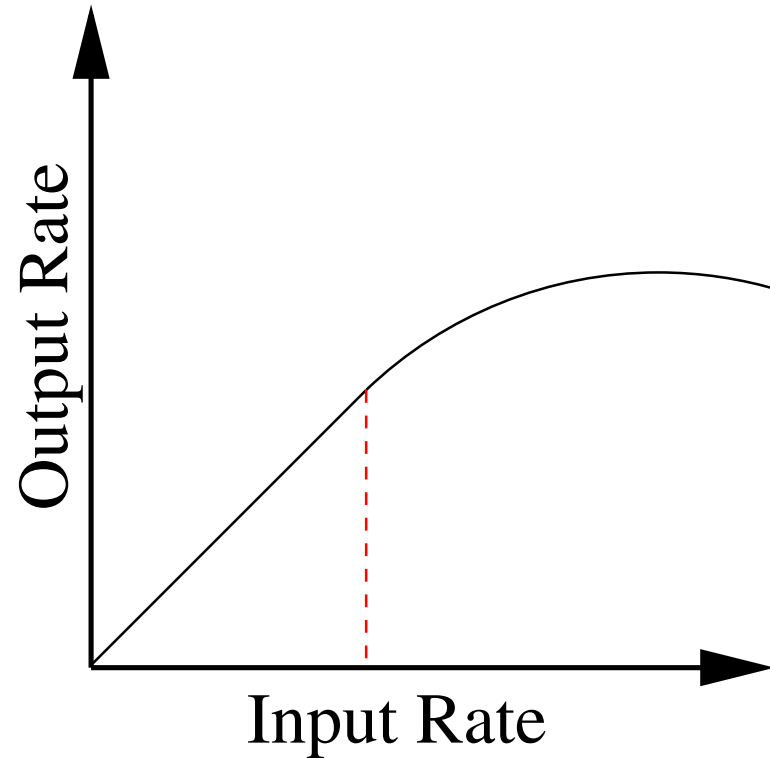- Find the End to End spare capacity between two hosts

Many Existing Tools

- Pathload, IGI, PTR, TOPP, Delphi, PathChirp

How well do these tools work in the Internet?

- Compare three different measurement approaches
  - ▷ Pathload, Spruce, IGI

Probe Rate Model: Pathload

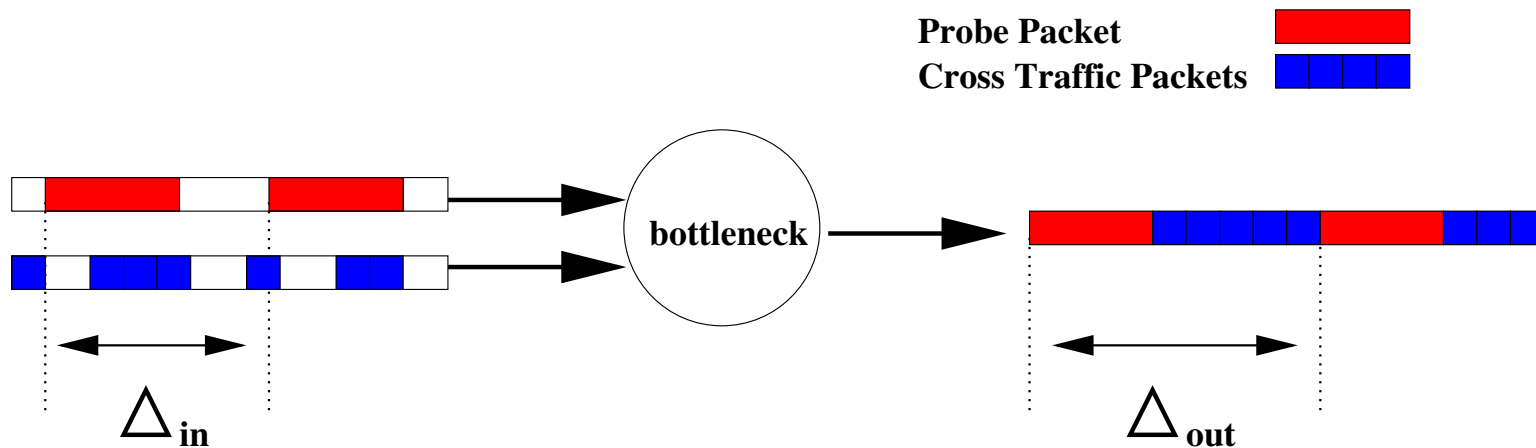Find highest sending rate for a train of packets without adding delay

Probe Gap Model: Spruce

Single bottleneck with capacity C.

Send pair with time gap Δ_{in}, observe Δ_{out}.

- pick Δ_{in} to ensure queue is never idle

$$ABW = C \times \left(1 - \frac{\Delta_{out} - \Delta_{in}}{\Delta_{in}} \right)$$

Combination Approach: IGI

Use Probe Rate model to find knee where input rate and output rate are equal

- ensures that queue doesn't empty during a packet train

Use Probe Gap model to calculate Available Bandwidth

MRTG test: Absolute Accuracy

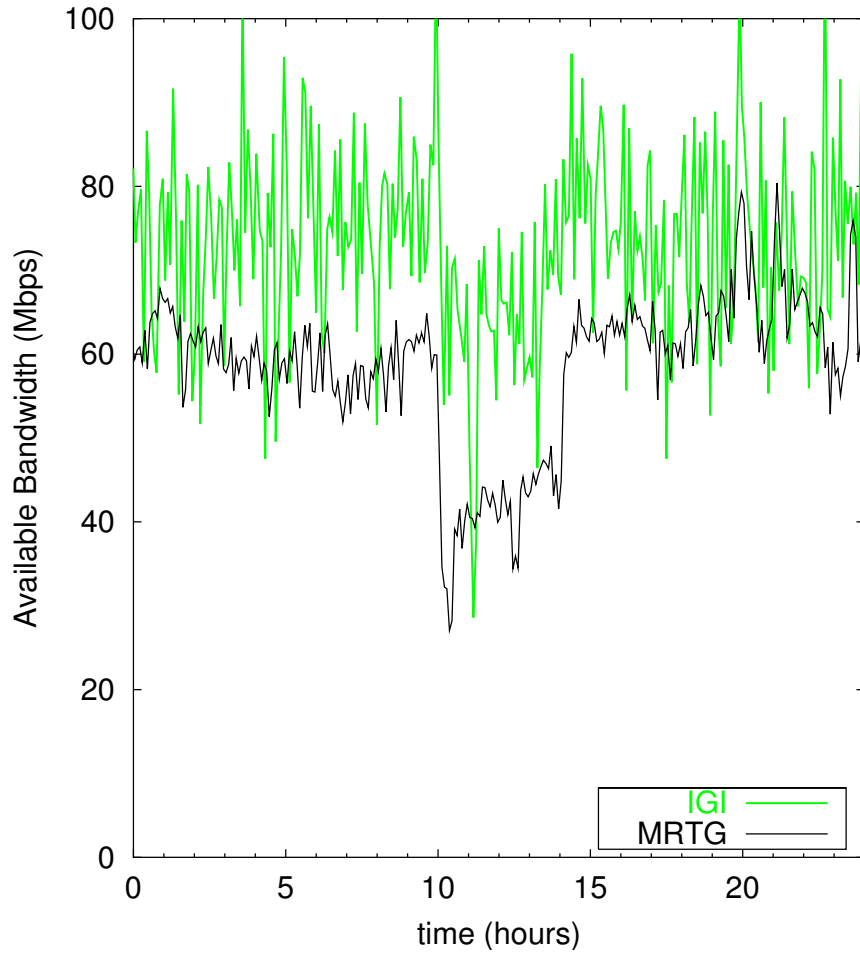Routers log average traffic rate every 5 minutes, use to calculate Available Bandwidth

Can only test a few paths where we know full topology and have access to router logs
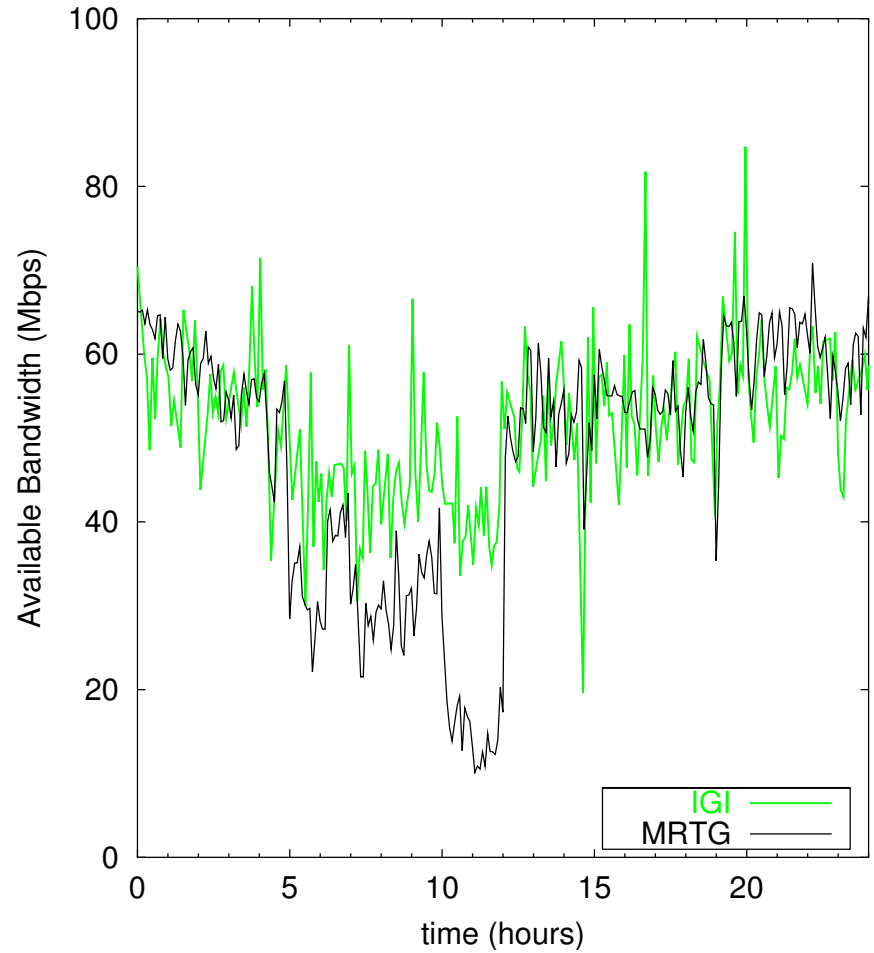
Monitored two paths for a week

- Berkeley → MIT

  ▷ 17 Hops, 76 ms RTT

- MIT LCS → MIT Datacenter
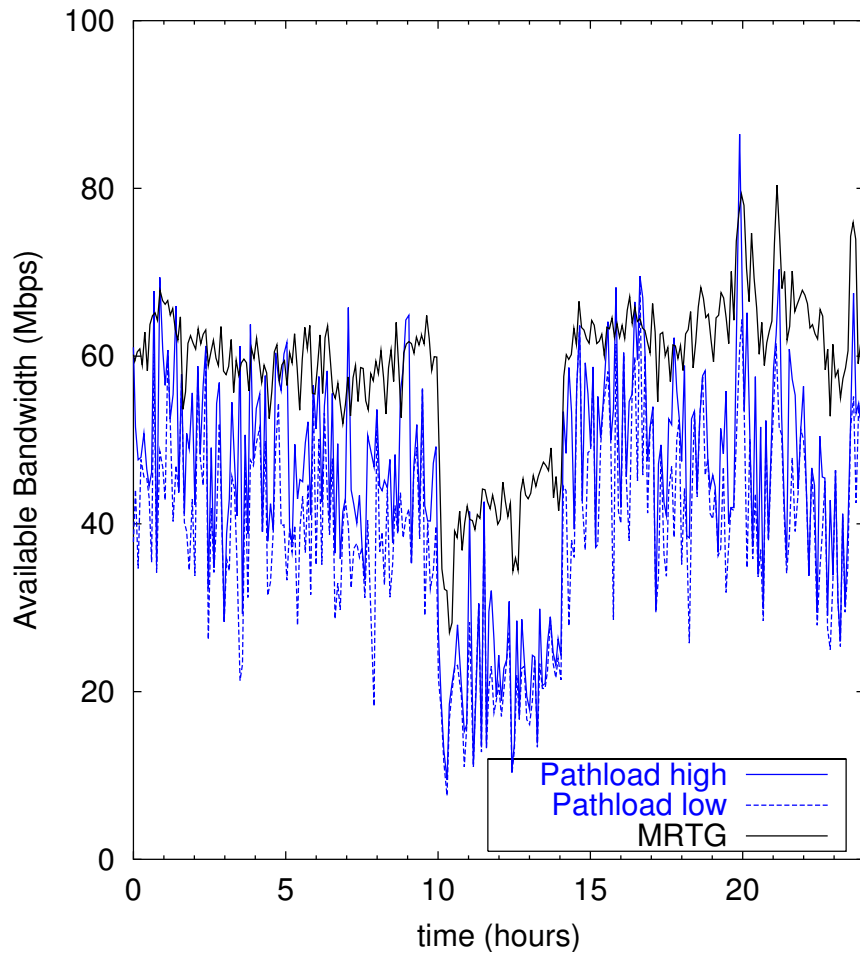
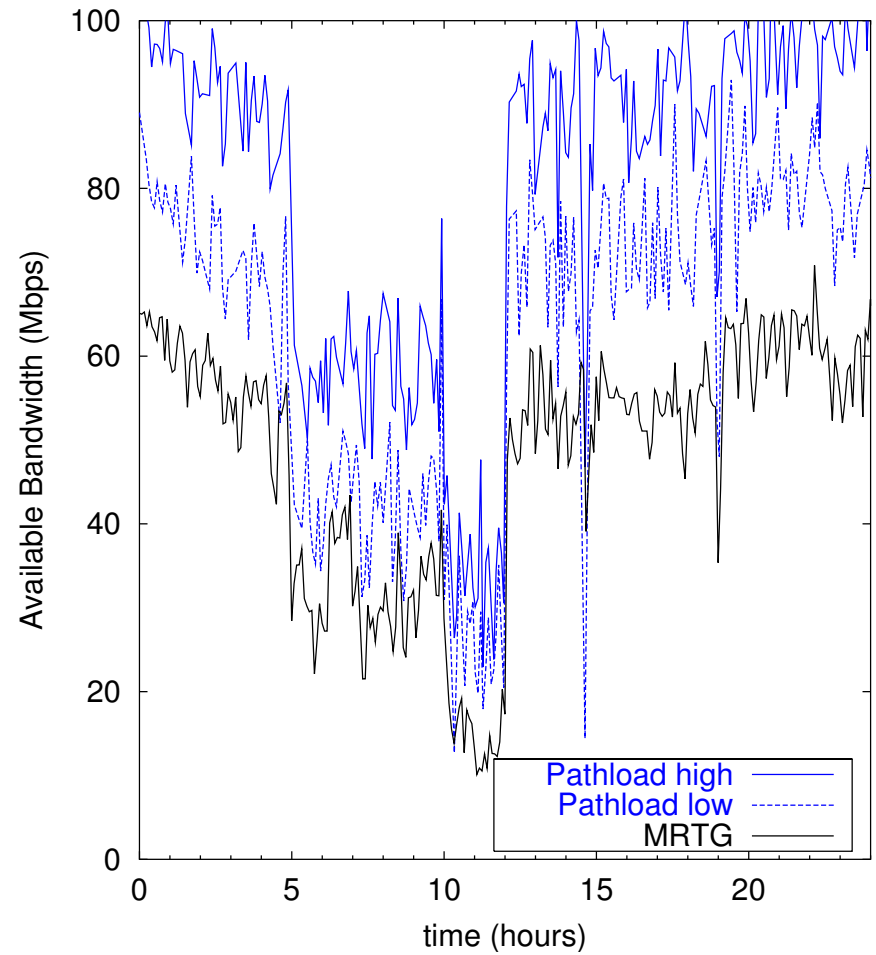 ▷ 5 hops, 4ms RTT

IGI MRTG Results

$Berkeley \rightarrow MIT$

$LCS \rightarrow MIT\ Datacenter$

Pathload MRTG Results

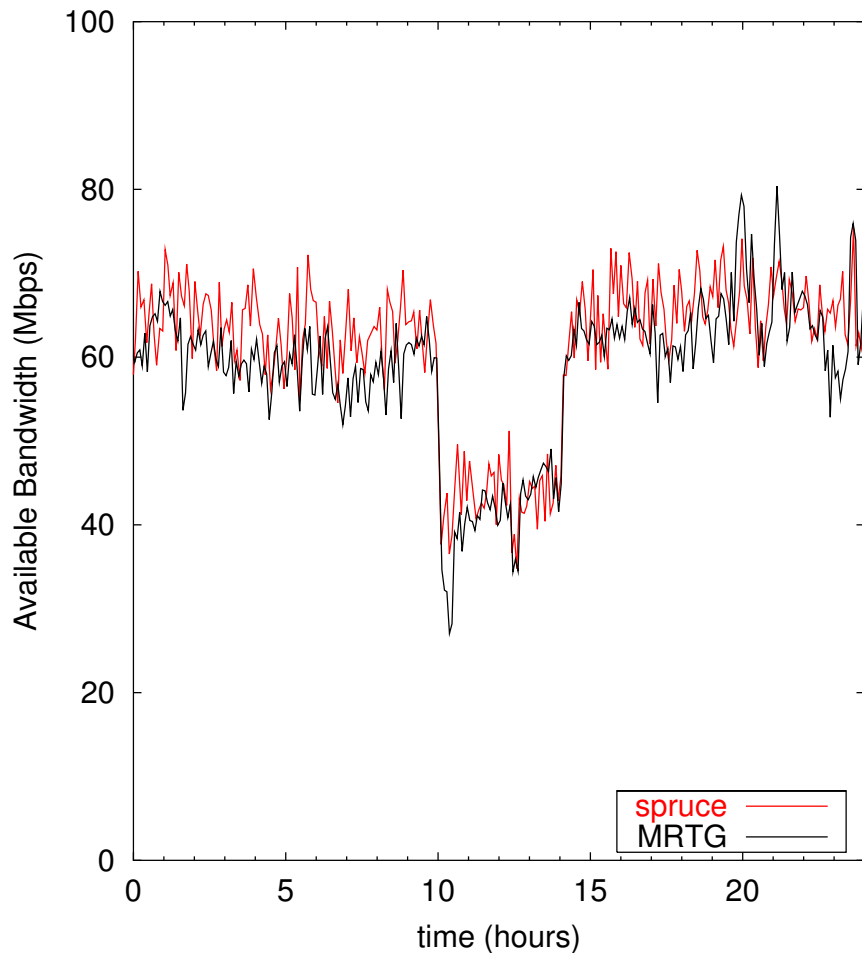$Berkeley \rightarrow MIT$
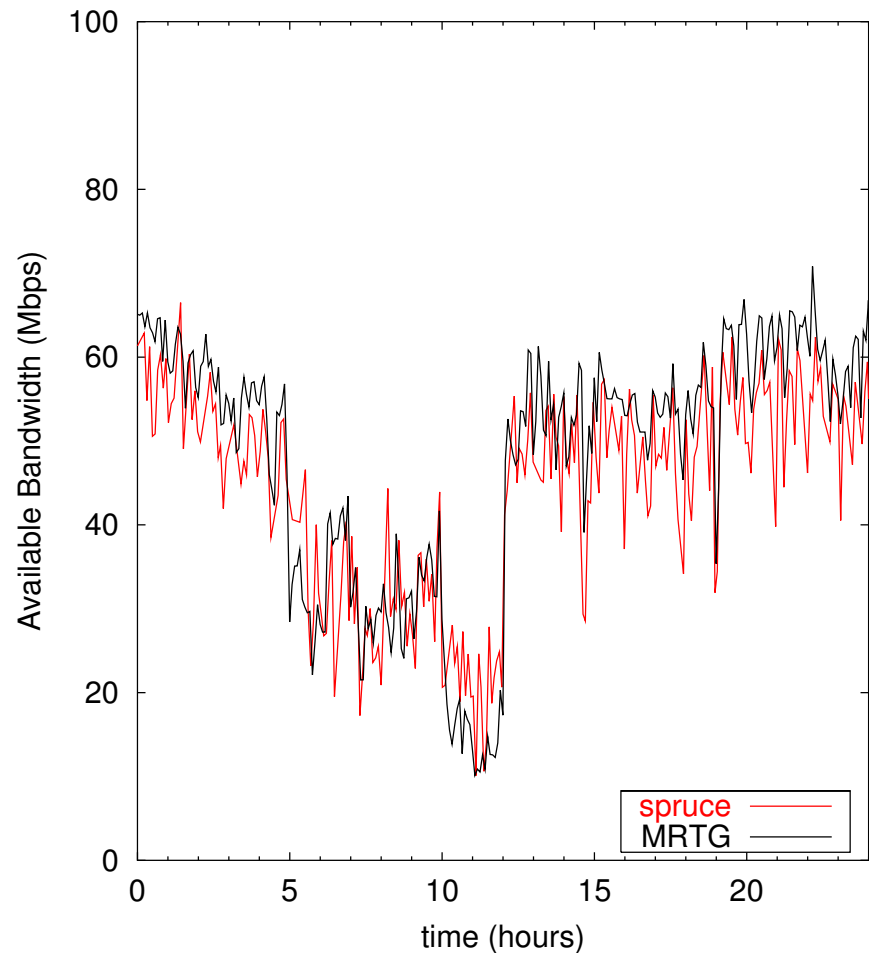
$LCS \rightarrow MIT\ Datacenter$

Spruce MRTG Results

Berkeley → MIT

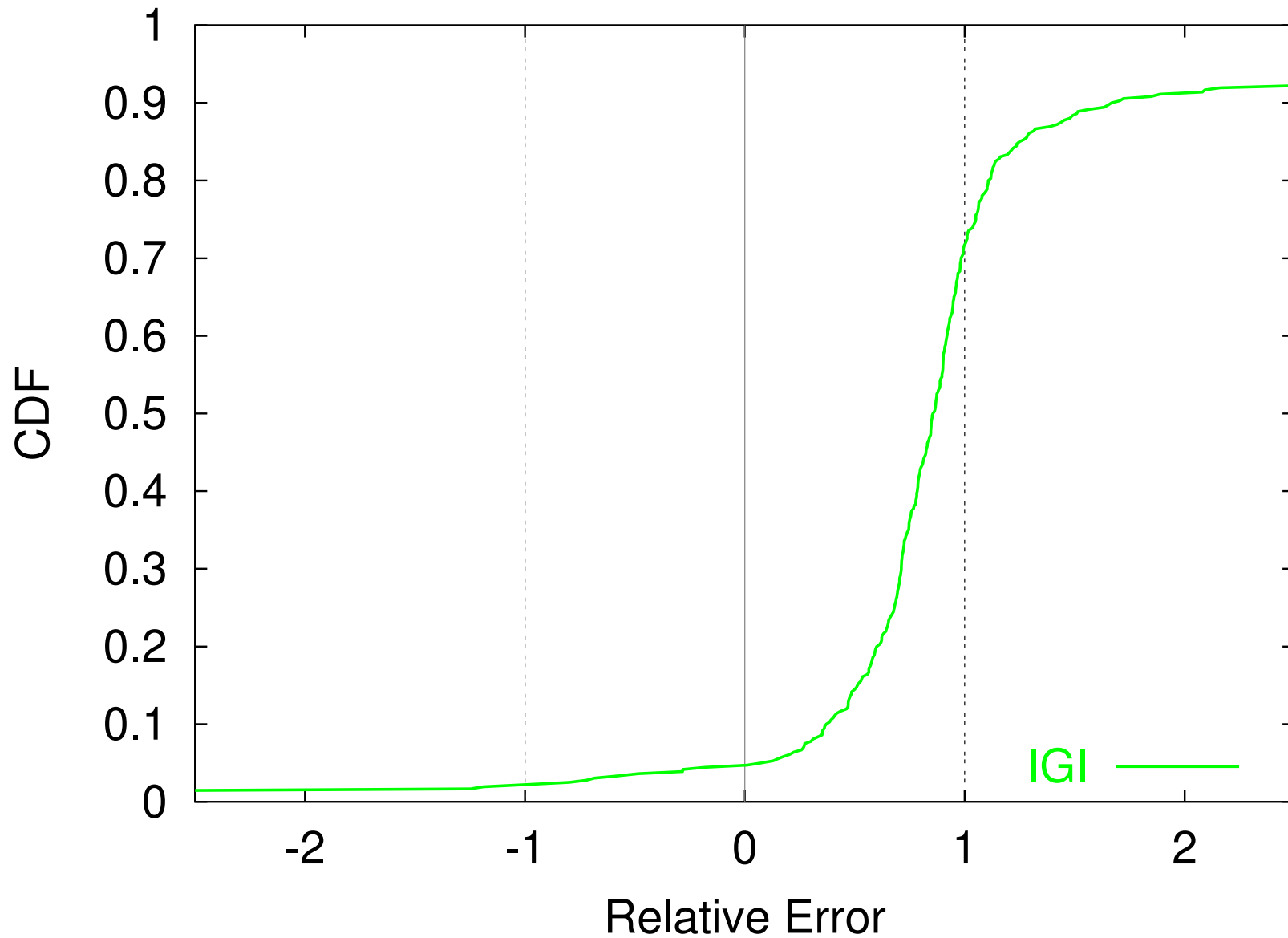*LCS → MIT Datacenter*

Differential Test: Relative Accuracy

Want to test a large variety of paths, but don't know the correct ABW to compare

- Solution: Induce a known change in ABW, and measure change

  ▷ Run tool $\rightarrow M_1$

  ▷ Start cross traffic flow at rate $\Gamma = M_1/2$
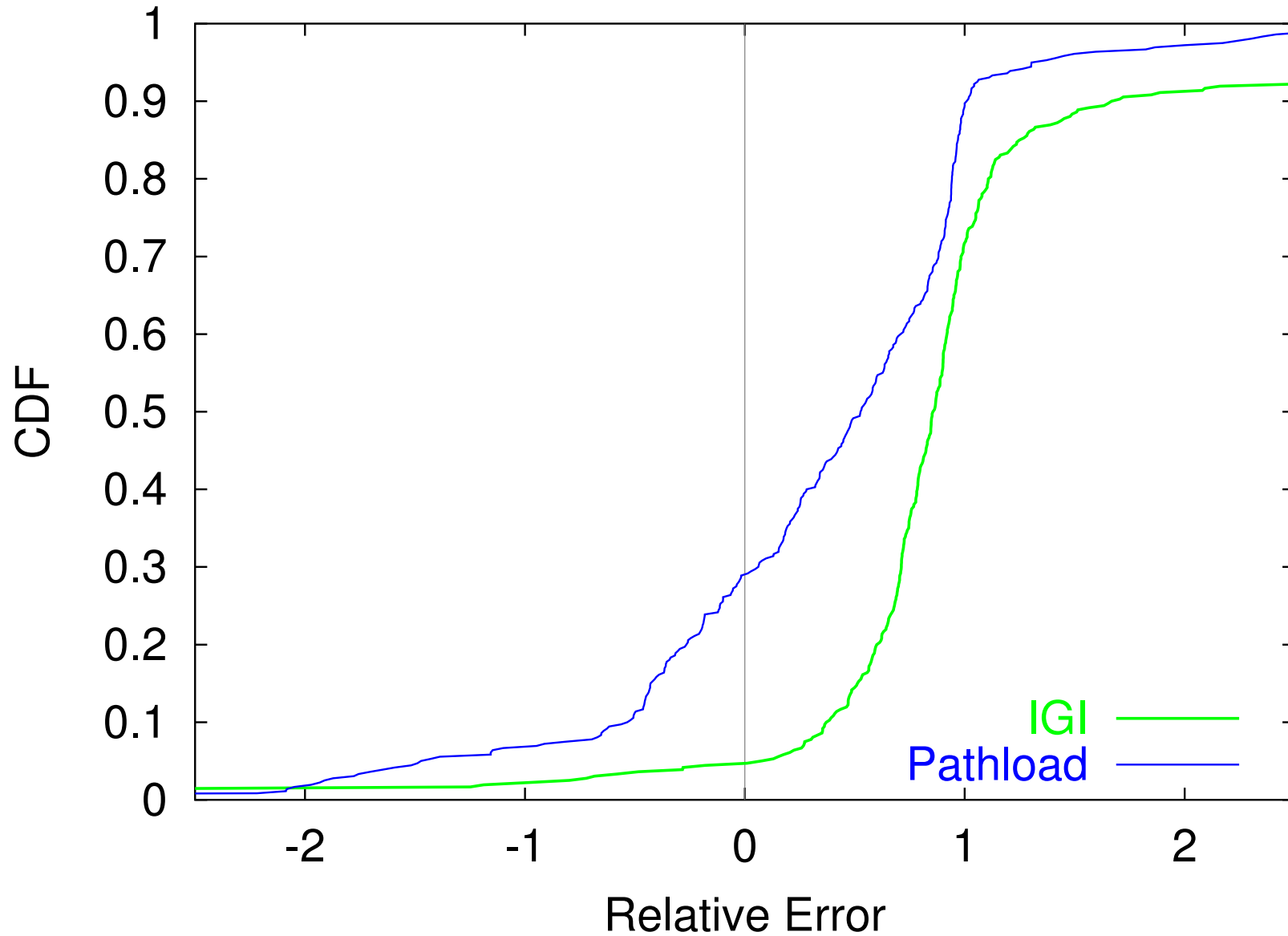
  ▷ Run same tool $\rightarrow M_2$

$$Relative\ Error = \frac{\Gamma - (M_1 - M_2)}{\Gamma}$$

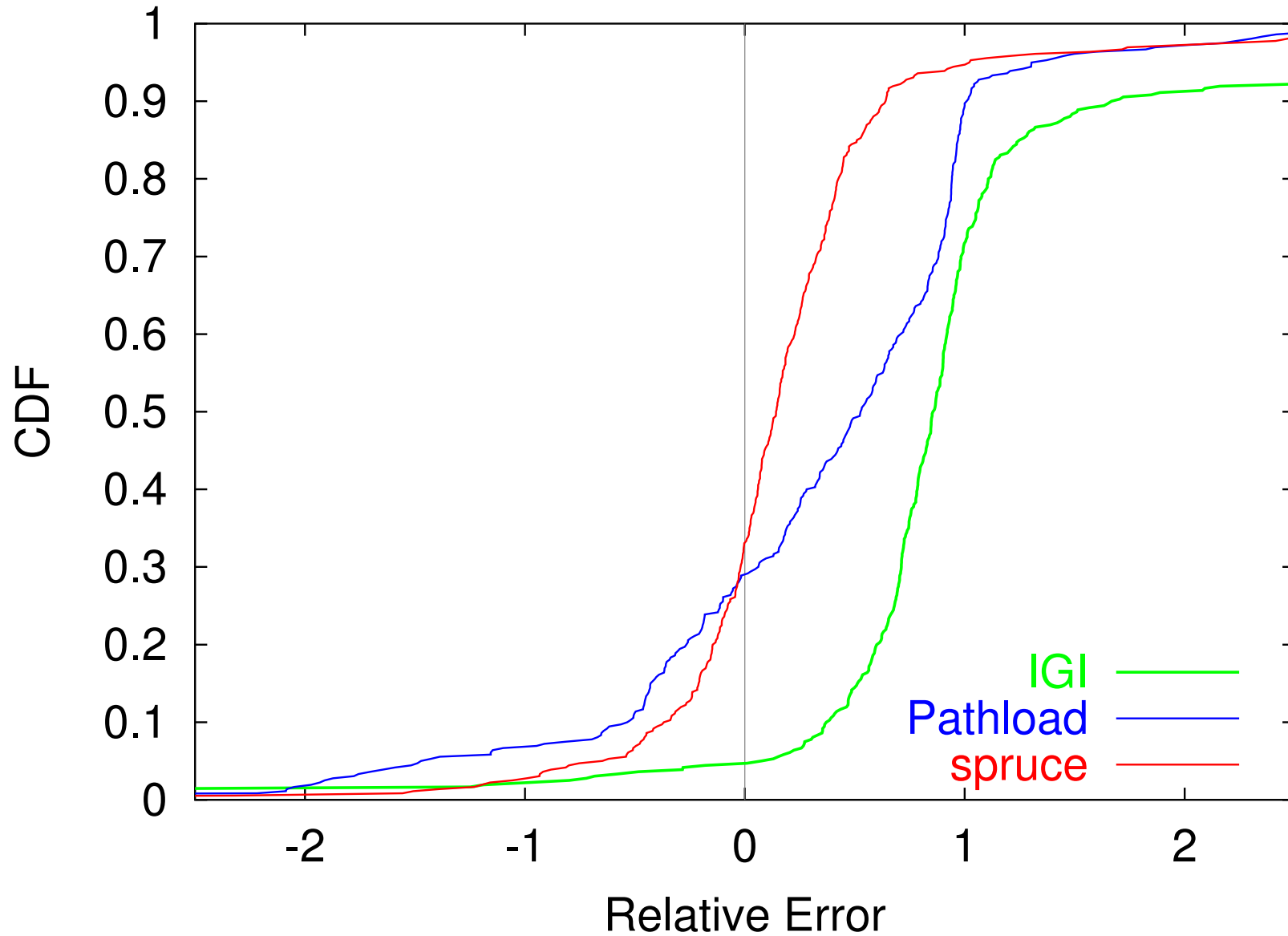400 Paths, Planetlab & RON testbeds, speeds ranging from DSL through 100 Mb/s

Differential Test Results

Differential Test Results

Differential Test Results

Conclusions

Differential test for evaluating bandwidth estimation tools where reference values are unknown

Evaluated three ABW tools on a wide variety of paths

- IGI is unresponsive to changes in available bandwidth
- Pathload may either under or over estimate ABW
- Spruce is more accurate than other tools
    - ▷ 70% of measurements within 30% of correct value