Speed Measurements of Residential Internet Access

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News headlines question broadband access speed

Ofcom calls for clarity in broadband speed ads — BBC — July 26, 2010

Debate fires up on speed of, access to the Internet — Kansas.com — Aug. 15, 2010

FCC: Consumers Get Half of Advertised Broadband Speed — PCWorld — Aug. 17, 2010

Who cares?

- Policymakers want to regulate broadband access
  - $\rightarrow$ FCC Open Internet Apps Challenge
  - $\rightarrow$ FCC and Ofcom working with SamKnows to distribute routers
- Users want to test their connections
  - $\rightarrow$ Speedtest.net, ComScore, Grenouille.fr, NDT, Netalyzr, etc.
- ISPs want to provision their network

Speed metrics

- *Capacity* $\rightarrow$ maximum link/path transmission rate
- *TCP achievable throughput* $\rightarrow$ average speed of single TCP transfer
- *Available bandwidth* $\rightarrow$ residual link/path capacity

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- *TCP achievable throughput* → average speed of single TCP transfer
  - ✘ depends on factors exogenous to access ISPs
- *Available bandwidth* → residual link/path capacity
  - ✔ measures what users can get in their homes

Approaches to measure available bandwidth

- Flooding-based tools

  $\rightarrow$ Large parallel TCP transfers & post-processing

- Optimized-probing tools

  $\rightarrow$ Trains and pairs of probes with varying sizes and spacing

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- Flooding-based tools
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  - ✔ Measures the effective available bandwidth
  - ✘ Large overhead
- Optimized-probing tools
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- Flooding-based tools
  - → Large parallel TCP transfers & post-processing
  - ✔ Measures the effective available bandwidth
  - ✘ Large overhead
- Optimized-probing tools
  - → Trains and pairs of probes with varying sizes and spacing
  - ✔ Lower overhead
  - ✘ Measures the theoretical available bandwidth

This paper ...

- Evaluate the tools in ADSL and cable networks
  - → Tools selection
  - → Testing methodology
  - → Accuracy
    - → Tools that use small probes underestimate the bandwidth
    - → Home gateways cannot sustain the high packet rate of probes
  - → Overhead

Tools

Flooding-based tools

iperf } → 10 parallel TCP connections, 10 seconds transfer

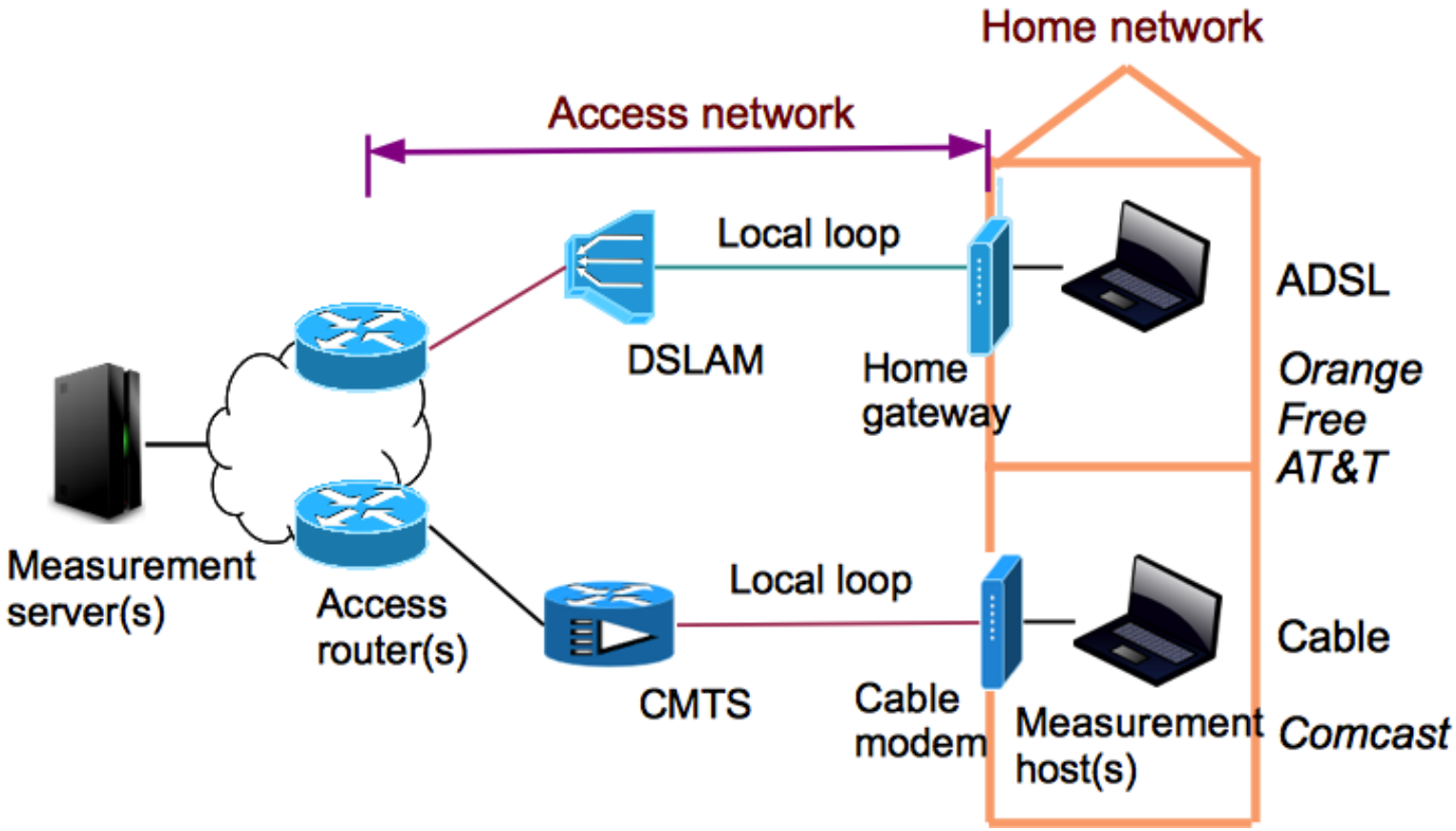
Optimized-probing tools

pathload, *pathchirp* } → **probe-rate model**

spruce, *igi/ptr* } → **probe-gap model**

Measurement setup

- Full control over end-hosts $\rightarrow$ **controlled traffic** on the local loop
- The **bottleneck** is the local loop



Accuracy of available bandwidth estimation tools

Tool	Pckt. Size	Comcast Avg (Mbps)	Orange Avg (Mbps)
UDP capacity	1440B	20.60/22.93	15.80
parallel TCP	1440B	19.20/22.00	15.04
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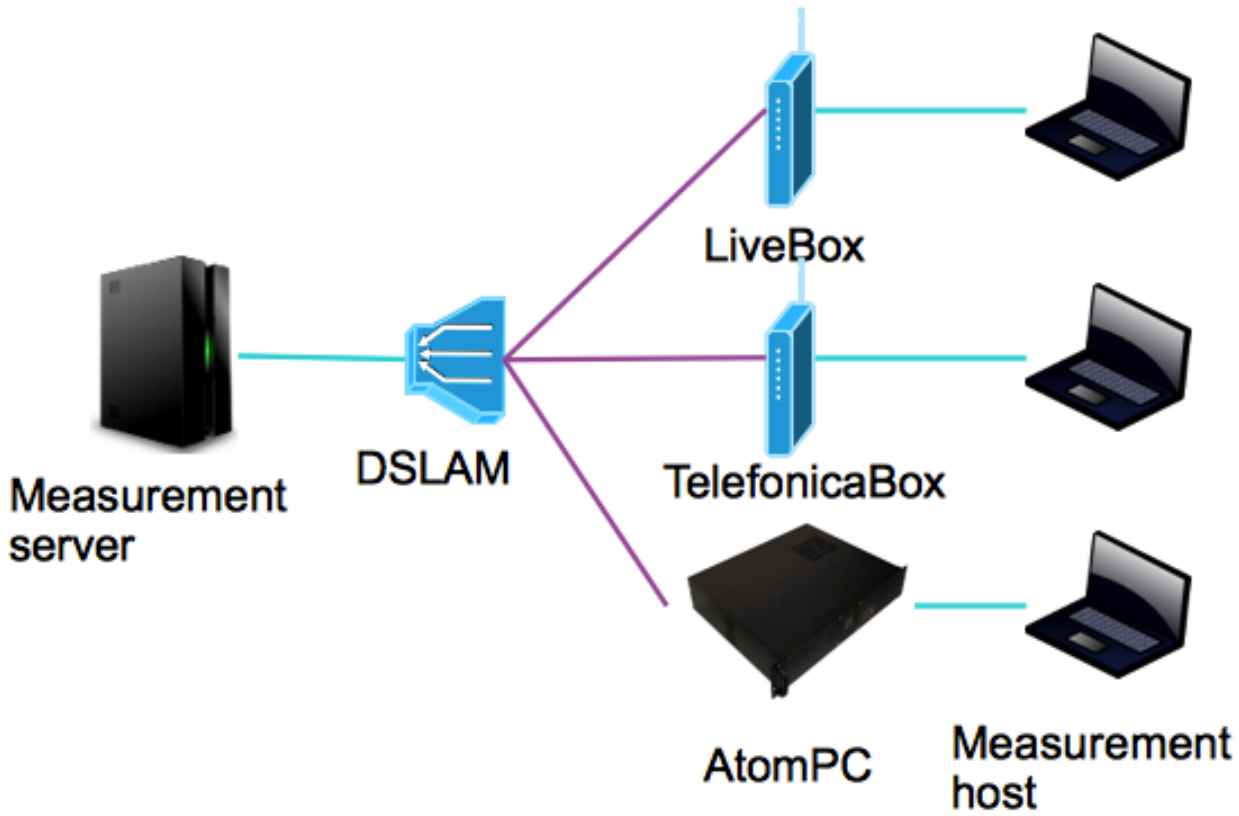
- Spruce, pathload with large probes and parallel TCP are accurate
- Tools that use small probes underestimate the bandwidth

Why tools with small probes underestimate the bandwidth?

- Optimized-probing tools work well in core/academic networks
- Packet rate limitation on the ADSL part of the network
  - $\rightarrow$ DSLAM?
  - $\rightarrow$ Gateways?
  - $\rightarrow$ ATM encapsulation?

Controlled experiments to explain underestimation



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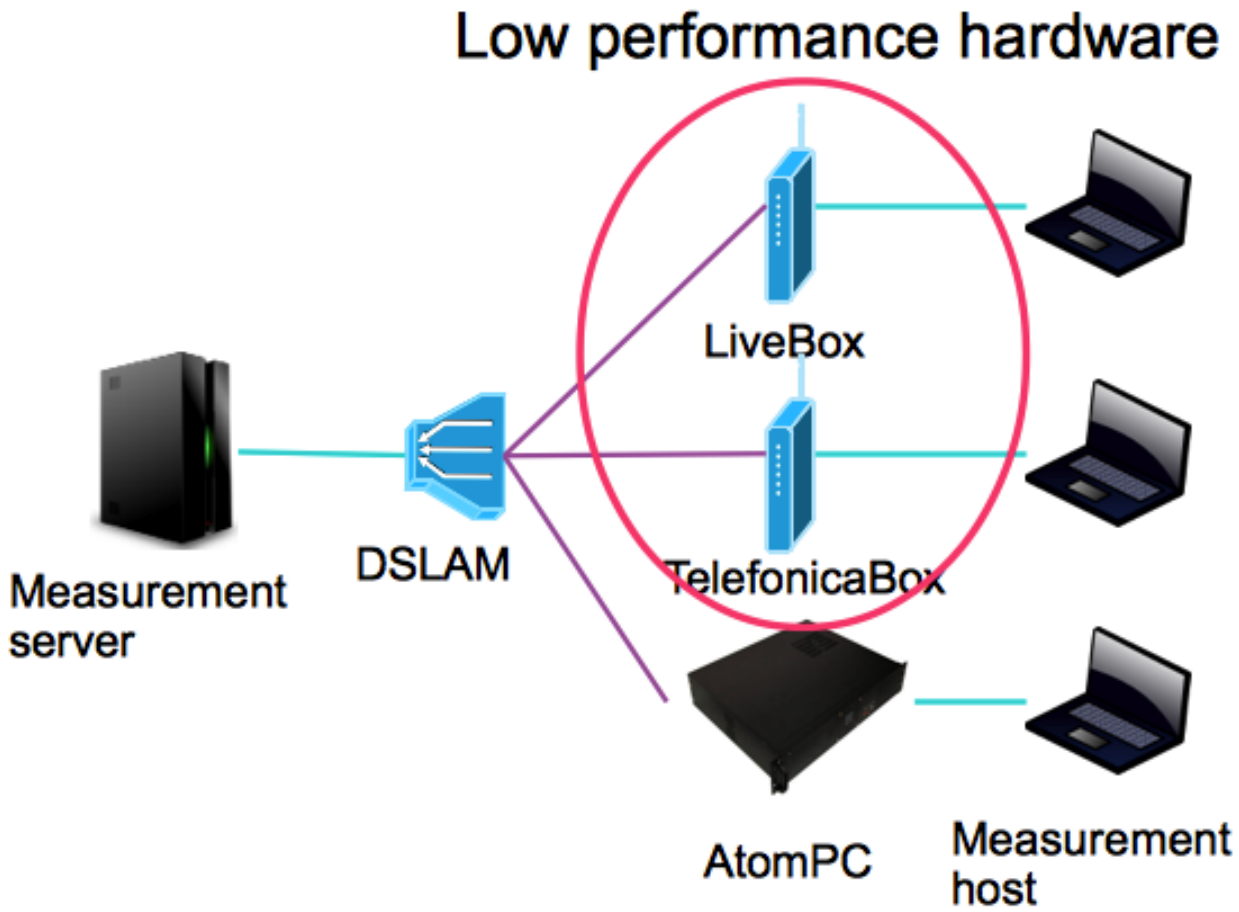

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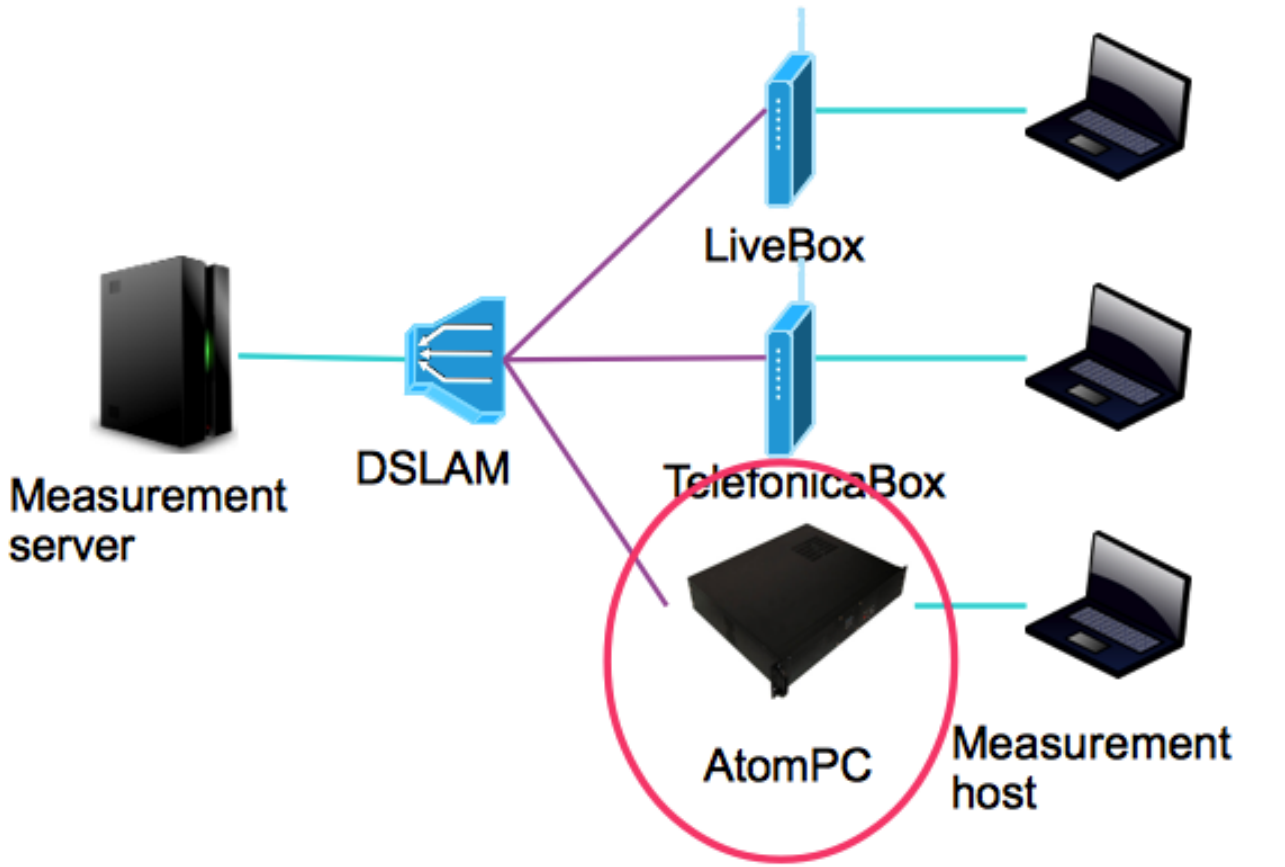
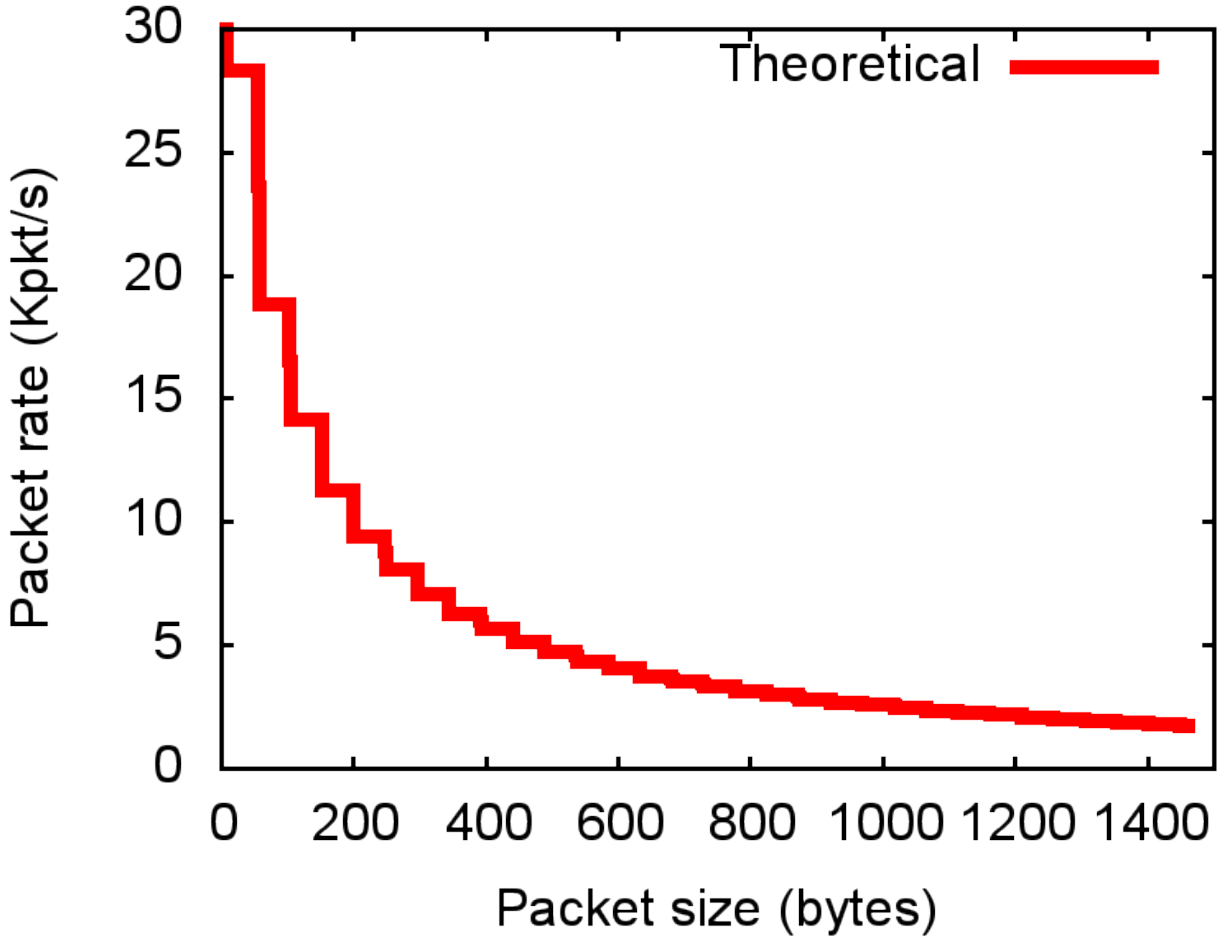


High performance hardware

Maximum achievable packet rate



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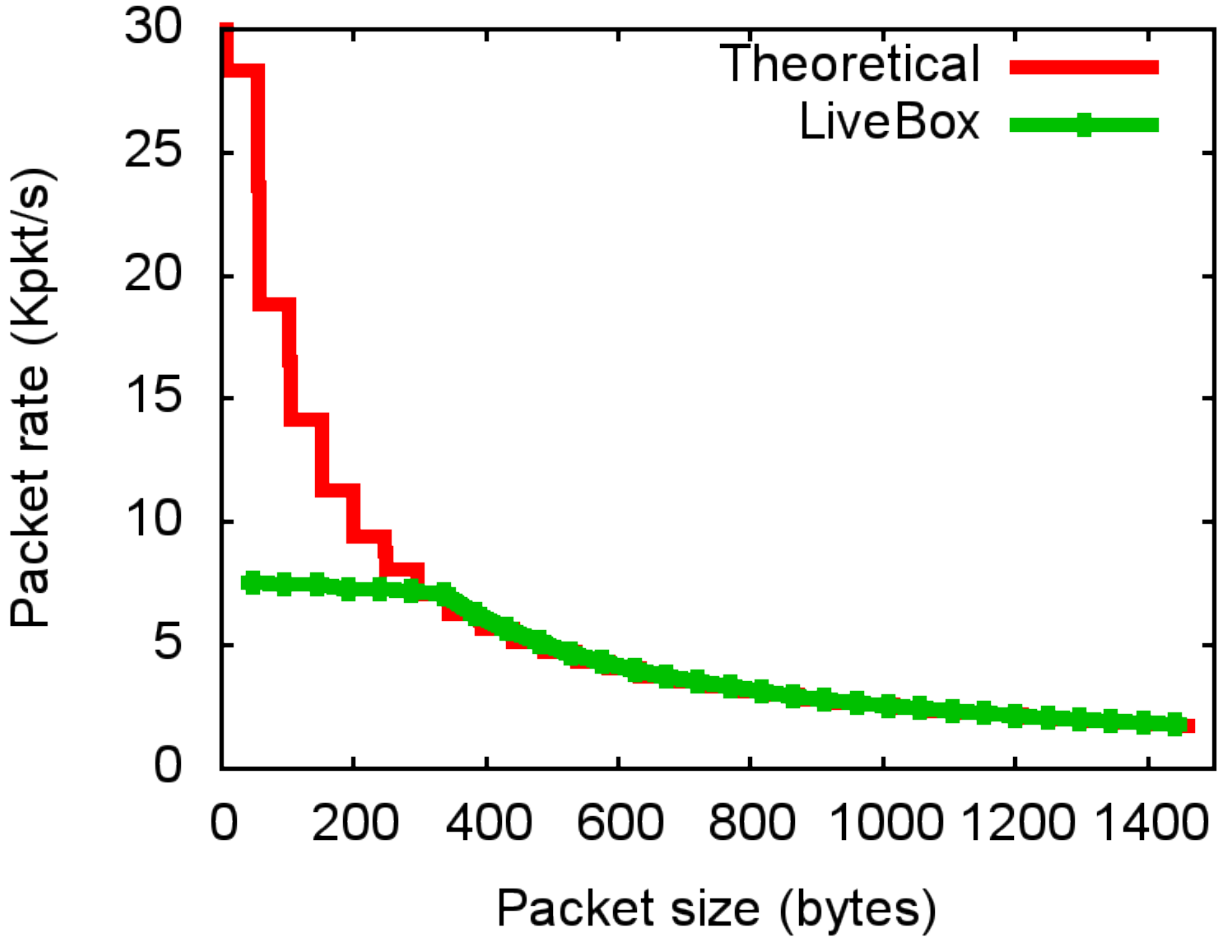

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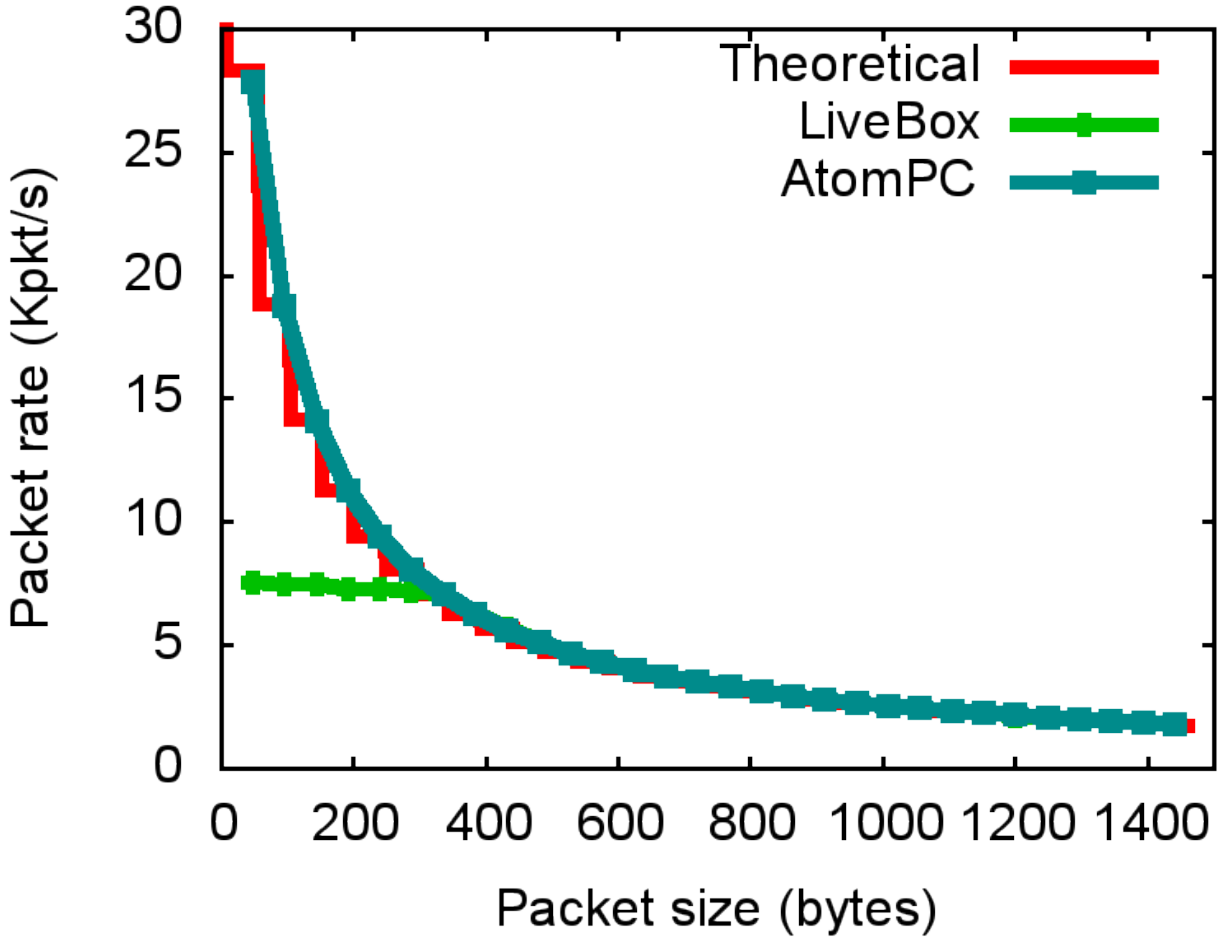

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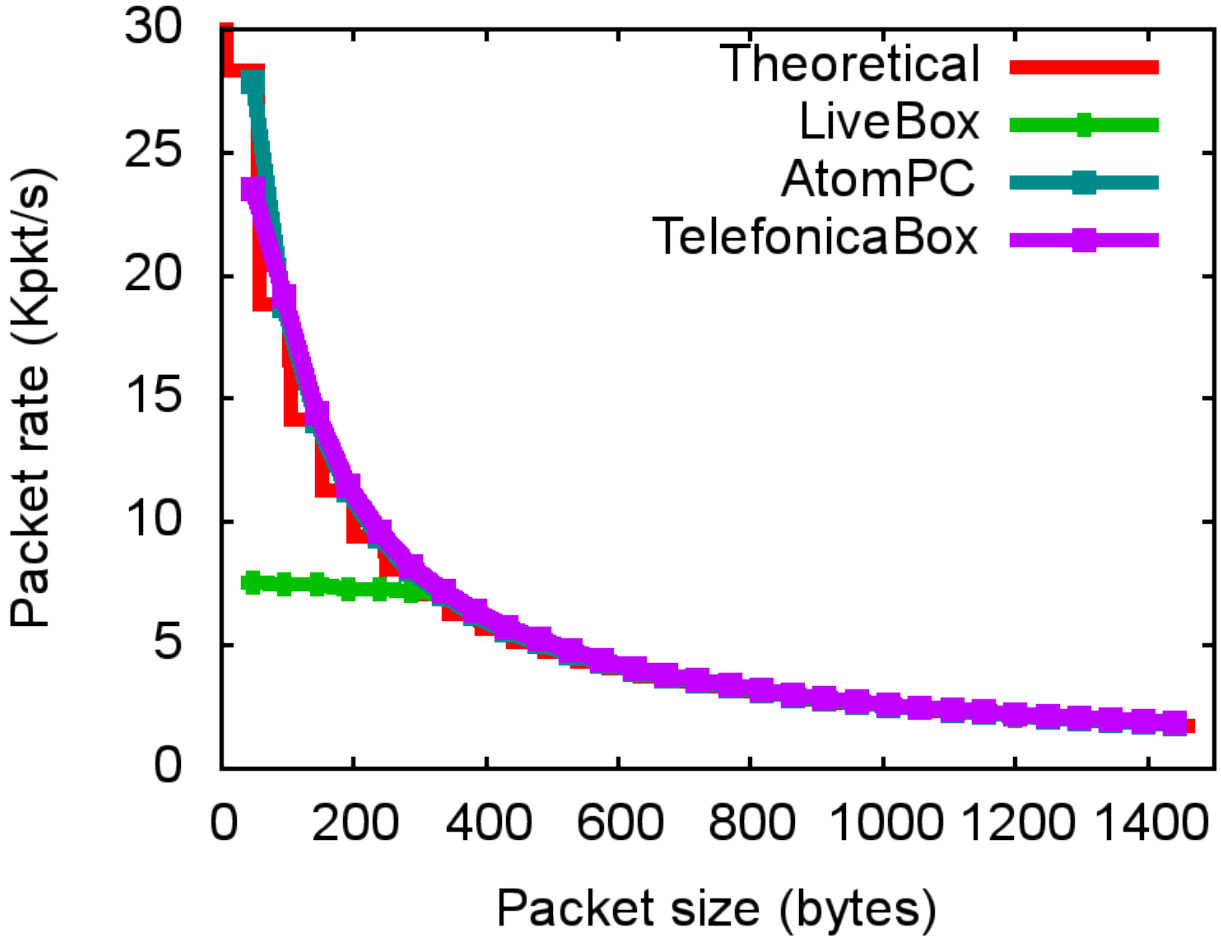

Summary of findings on accuracy

- Spruce, pathload with large probes and parallel TCP are accurate
- Tools that use small probes underestimate the bandwidth
- Home gateways cannot sustain the high packet rate of probes
- Low-performance hardware and network-address translation are limiting factors
- The limit is true for all 40 gateways we tested

Overhead of available bandwidth estimation tools

Tool	Pckt. Size	Orange (Kbytes)	Comcast (Kbytes)
parallel TCP	1440B	20,908	26,844/19,177
pathload	1440B	8,528	12,582
pathload	200B	622	2,041
spruce	1440B	288	288

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Summary of findings on overhead

- Overhead of flooding-based tools $\gg$ optimized-probing tools
- Spruce has the lowest overhead

  BUT $\rightarrow$ needs interrupt coalescence disabled

  $\rightarrow$ assumes knowledge of capacity

Guidelines

- Both flooding-based tools and optimized-probing tools are necessary
  - Flooding-based tools are necessary because of cross traffic
  - Optimized-probing tools are necessary for frequent measurements

Frequency \ **Control**	**Full**	**No**
One shot	parallel TCP	parallel TCP
Repeated	spruce	pathload