Speed Measurements for Residential Internet Access

Oana Goga, Renata Teixeira

CNRS and UPMC Sorbonne Universites

Workshop on Active Internet Measurements
CAIDA, February 10th, 2011

Do residential Internet customers get what they pay for?

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

- Policymakers want to regulate broadband access
- Users want to test their connections

  $\rightarrow$ Speedtest, ComScore, Grenouille, NDT, Netalyzr etc.
- ISPs want to provision their network

Speed metrics

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

Should we use TCP achievable throughput?

- TCP achievable throughput is what users actually get
- Metric of choice: FCC, SamKnows, speedtest, genouille

BUT indirect measurement of what ISPs can guarantee (subject to congestion, flow control)

- Depends on many factors: RTT, transfer size, host constrains, single/parallel TCP connections, slow start
- High overhead

Should we use available bandwidth/capacity?

- Available bandwidth and capacity are what ISPs provision
  - link quality $\rightarrow$ capacity
  - no congestion on access link $\rightarrow$ available bandwidth

- Lower overhead
- Designed for core/academic networks

BUT access networks might differ on an number of aspects

  - asymmetric bandwidth, gateway modems, traffic shaping

Contributions

- Evaluate available bandwidth estimation tools in commercial ADSL networks
  - Finding: tools that use small probes systematically underestimate bandwidth
- Investigate the cause of the problem in controlled setting
  - Finding: home gateways cannot sustain the high packet rate of measurement probes

Tools

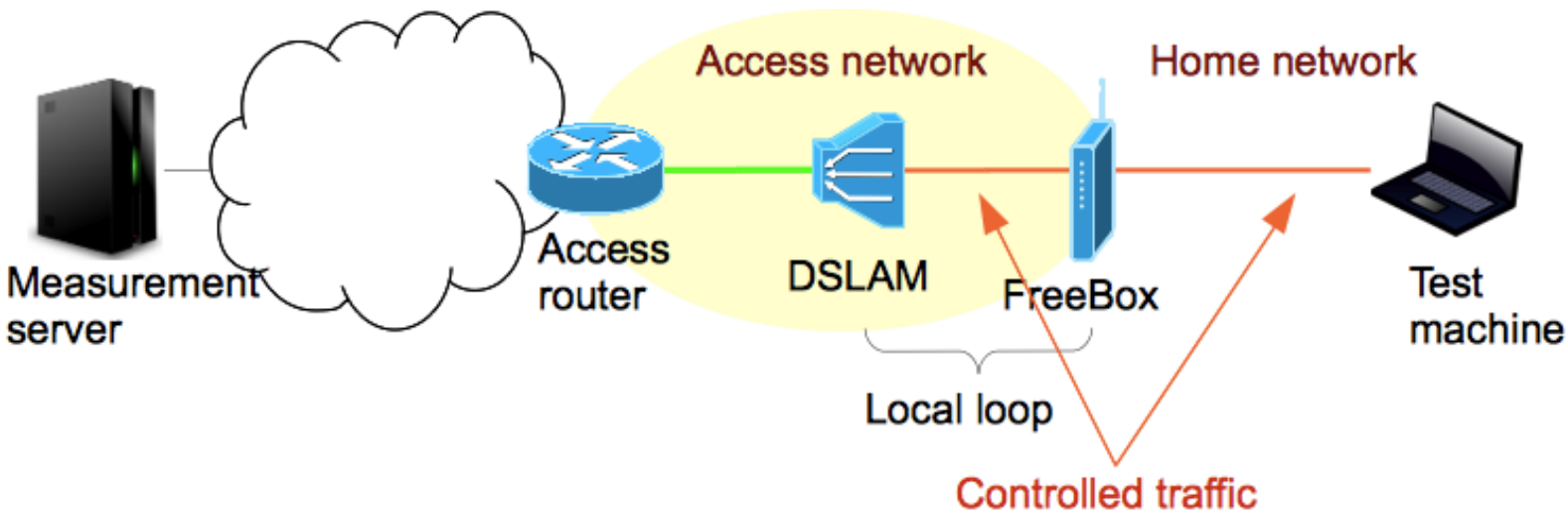
pathload, *pathchirp* } → **probe-rate model**, cooperative, one-way delay

abwprobe } → probe-rate model, **non-cooperative**, RTT

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

Measurement Setup

- Semi-controlled setup: test tools over commercial ADSL networks
  - commercial Free and Orange ADSL2+ line (advertised: 24M/1M ATM, estimated: 18M IP)
  - full control over end-hosts → **controlled traffic** on the local loop
  - the **bottleneck** is the local loop



Available Bandwidth Estimation

Tool	Pckt. Size	Free Avg (Mbps)	Orange Avg (Mbps)
iperf (UDP)	1500B	15.92	15.52
pathchirp	1000B	17.50	16.56
spruce	1492B	16.67	15.77
pathload	200B	6.09 – 6.27	12.29 – 12.81
ptr	500B	11.09	11.76
igi	500B	10.73	12.52
abwprobe	1440B	12.70 – 12.91	12.56 – 12.88

Available Bandwidth Estimation

Tool	Pckt. Size	Free Avg (Mbps)	Orange Avg (Mbps)
iperf (UDP)	1500B	15.92	15.52
pathchirp	1000B	17.50	16.56
spruce	1492B	16.67	15.77
pathload	200B	6.09 – 6.27	12.29 – 12.81
ptr	500B	11.09	11.76
igi	500B	10.73	12.52
abwprobe	1440B	12.70 – 12.91	12.56 – 12.88

Available Bandwidth Estimation

Tool	Pckt. Size	Free Avg (Mbps)	Orange Avg (Mbps)
iperf (UDP)	1500B	15.92	15.52
pathchirp	1000B	17.50	16.56
spruce	1492B	16.67	15.77
pathload	200B	6.09 – 6.27	12.29 – 12.81
ptr	500B	11.09	11.76
igi	500B	10.73	12.52
abwprobe	1440B	12.70 – 12.91	12.56 – 12.88

Available Bandwidth Estimation

Tool	Pckt. Size	Free Avg (Mbps)	Orange Avg (Mbps)
iperf (UDP)	1500B	15.92	15.52
pathchirp	1000B	17.50	16.56
spruce	1492B	16.67	15.77
pathload	200B	6.09 – 6.27	12.29 – 12.81
ptr	500B	11.09	11.76
igi	500B	10.73	12.52
abwprobe	1440B	12.70 – 12.91	12.56 – 12.88

Available Bandwidth Estimation

Tool	Pckt. Size	Free Avg (Mbps)	Orange Avg (Mbps)
iperf (UDP)	1500B	15.92	15.52
pathchirp	1000B	17.50	16.56
spruce	1492B	16.67	15.77
pathload	200B	6.09 – 6.27	12.29 – 12.81
ptr	500B	11.09	11.76
igi	500B	10.73	12.52
abwprobe	1440B	12.70 – 12.91	12.56 – 12.88

Available Bandwidth Estimation

Tool	Pckt. Size	Free Avg (Mbps)	Orange Avg (Mbps)
iperf (UDP)	1500B	15.92	15.52
pathchirp	1000B	17.50	16.56
spruce	1492B	16.67	15.77
pathload	200B	6.09 – 6.27	12.29 – 12.81
ptr	500B	11.09	11.76
igi	500B	10.73	12.52
abwprobe	1440B	12.70 – 12.91	12.56 – 12.88

Available Bandwidth Estimation

Tool	Pckt. Size	Free Avg (Mbps)	Orange Avg (Mbps)
iperf (UDP)	1500B	15.92	15.52
pathchirp	1000B	17.50	16.56
spruce	1492B	16.67	15.77
pathload	200B	6.09 – 6.27	12.29 – 12.81
ptr	500B	11.09	11.76
igi	500B	10.73	12.52
abwprobe	1440B	12.70 – 12.91	12.56 – 12.88
pathload		16.29 – 16.32	15.52 – 15.66
ptr	1440B	14.82	14.57
igi		13.8	14.01

Available Bandwidth Estimation

Tool	Pckt. Size	Free Avg (Mbps)	Orange Avg (Mbps)
iperf (UDP)	1500B	15.92	15.52
pathchirp	1000B	17.50	16.56
spruce	1492B	16.67	15.77
pathload	200B	6.09 – 6.27	12.29 – 12.81
ptr	500B	11.09	11.76
igi	500B	10.73	12.52
abwprobe	1440B	12.70 – 12.91	12.56 – 12.88
pathload		16.29 – 16.32	15.52 – 15.66
ptr	1440B	14.82	14.57
igi		13.8	14.01

Available Bandwidth Estimation

Tool	Pckt. Size	Free Avg (Mbps)	Orange Avg (Mbps)
iperf (UDP)	1500B	15.92	15.52
pathchirp	1000B	17.50	16.56
spruce	1492B	16.67	15.77
pathload	200B	6.09 – 6.27	12.29 – 12.81
igi	500B	10.73	12.52
abwprobe	1440B	12.70 – 12.91	12.56 – 12.88
pathload		16.29 – 16.32	15.52 – 15.66
ptr	1440B	14.82	14.57
igi		13.8	14.01

probe size affects the estimation → packet rate limitation on downlink?

Available Bandwidth Estimation

Tool	Pckt. Size	Free Avg (Mbps)	Orange Avg (Mbps)
iperf (UDP)	1500B	15.92	15.52
pathchirp	1000B	17.50	16.56
spruce	1492B	16.67	15.77
pathload	200B	6.09 – 6.27	12.29 – 12.81
ptr	500B	11.09	11.76
igi	500B	10.73	12.52
abwprobe	1440B	12.70 – 12.91	12.56 – 12.88
pathload		16.29 – 16.32	15.52 – 15.66
ptr	1440B	14.82	14.57
igi		13.8	14.01

Available Bandwidth Estimation

Tool	Pckt. Size	Free Avg (Mbps)	Orange Avg (Mbps)
iperf (UDP)	1500B	15.92	15.52
pathchirp	1000B	17.50	16.56
spruce	1492B	16.67	15.77
pathload	200B	6.09 – 6.27	12.29 – 12.81
			76
igi	500B	10.73	12.52
abwprobe	1440B	12.70 – 12.91	12.56 – 12.88
pathload		16.29 – 16.32	15.52 – 15.66
ptr	1440B	14.82	14.57
igi		13.8	14.01

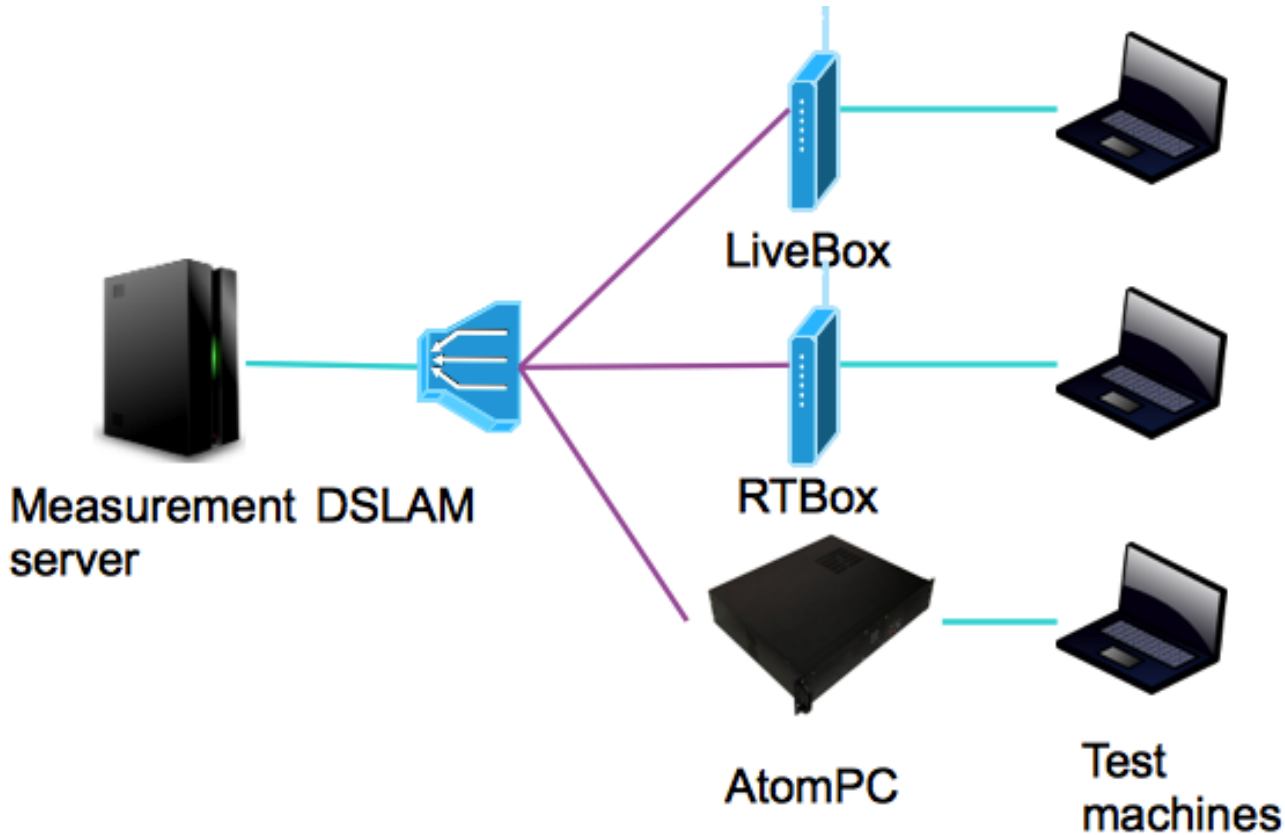
packet rate limitation on the upload link?

Who limits the packet rate?

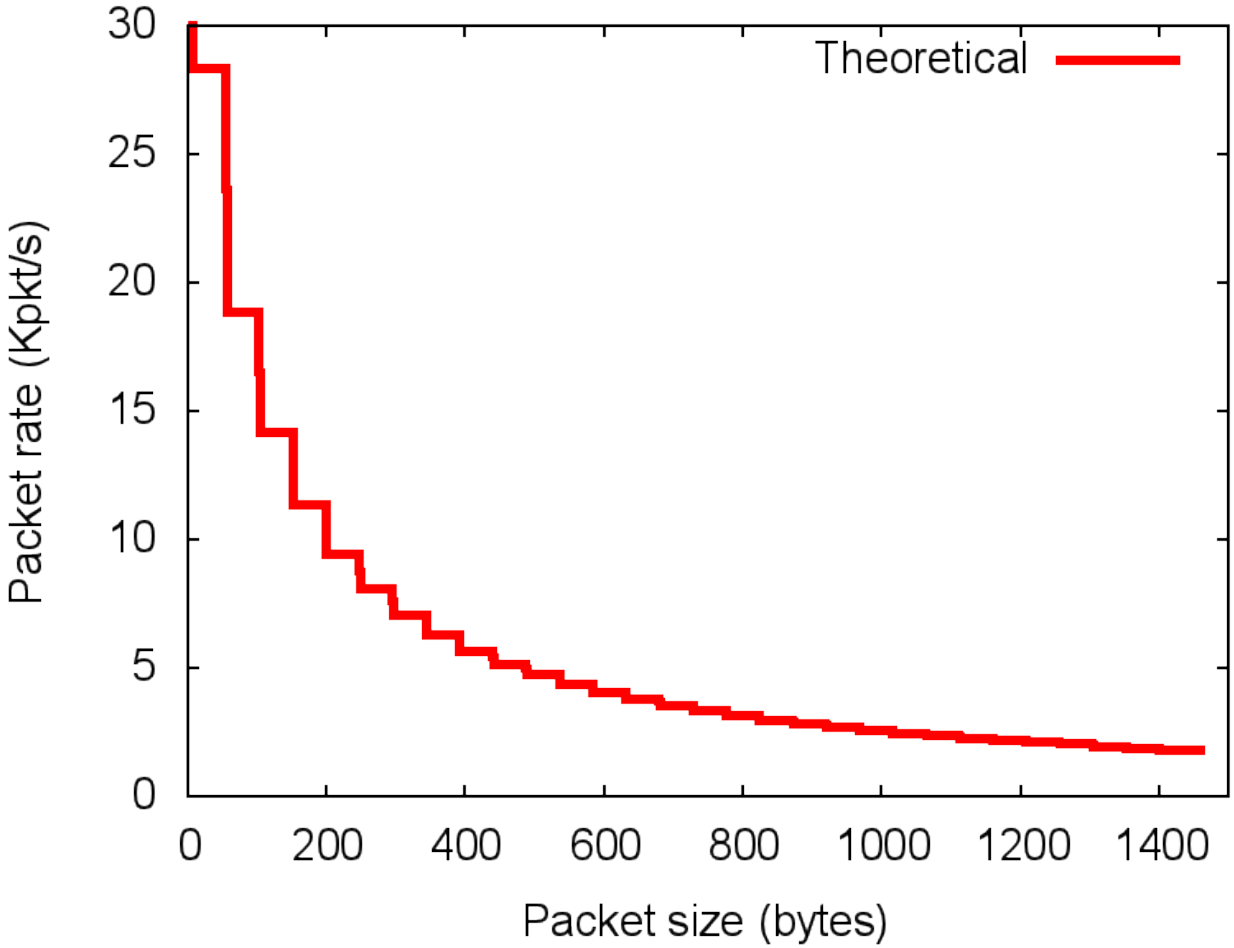
- Tools work well in core/academic networks
  $\rightarrow$ limitation on the ADSL part of the network
  - DSLAM?
  - gateways?
  - ATM encapsulation?

Bottleneck Identification - Controlled Experiments

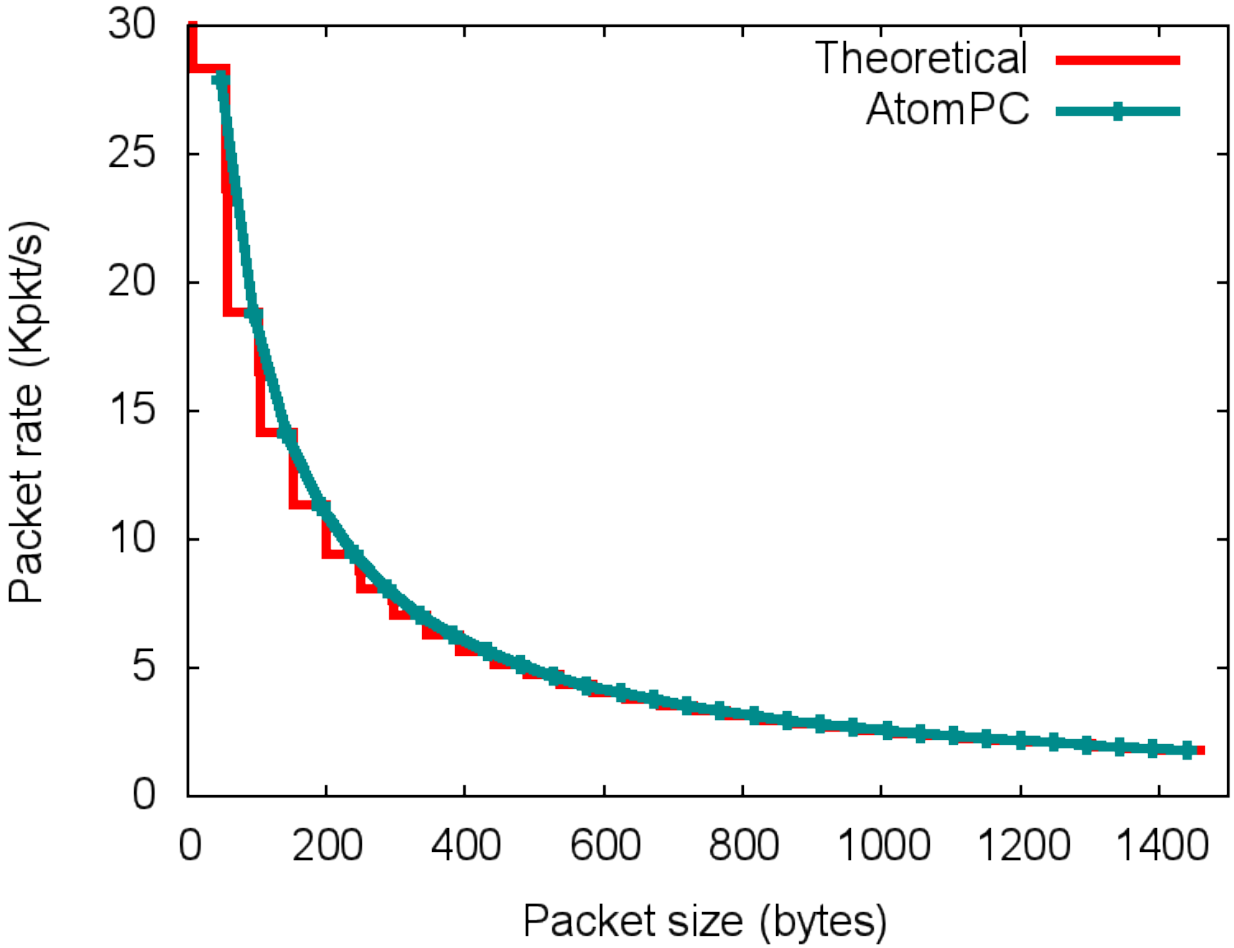
- Commercial gateway (LiveBox, RTBox) $\rightarrow$ **low performance**
- Intel ATOM processor platform + ADSL card (AtomPC) $\rightarrow$ **high performance**



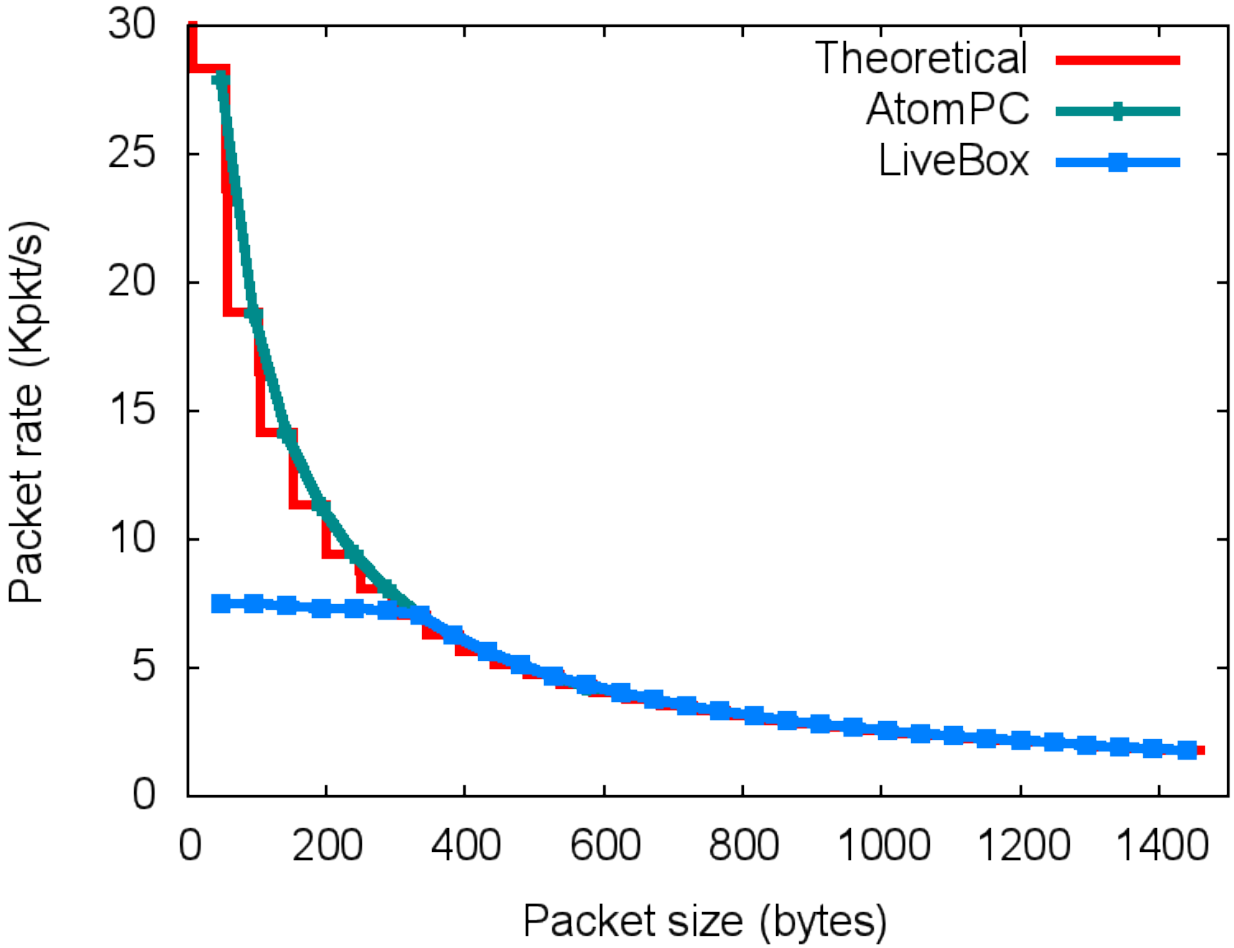
Gateways are the Bottleneck



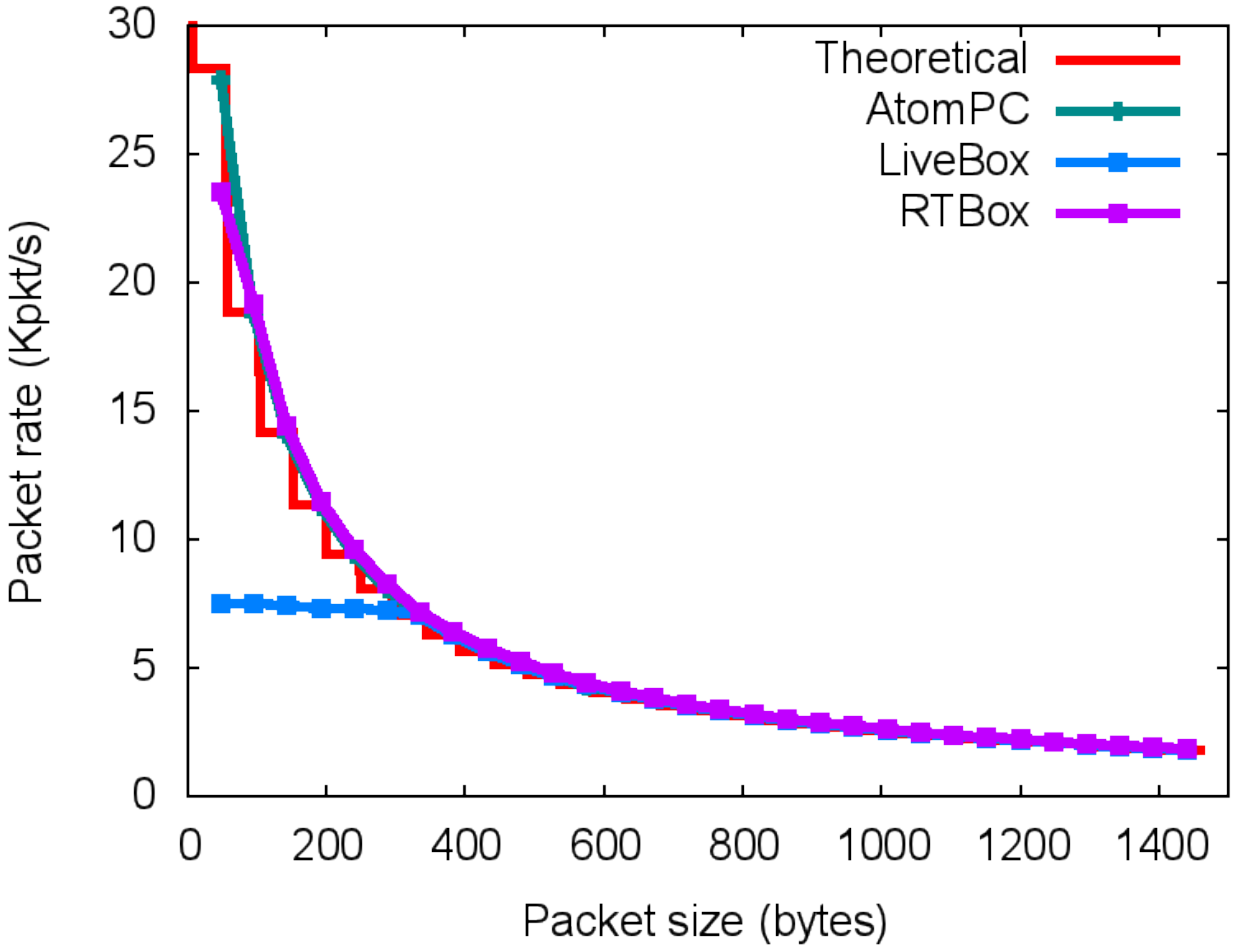
Gateways are the Bottleneck



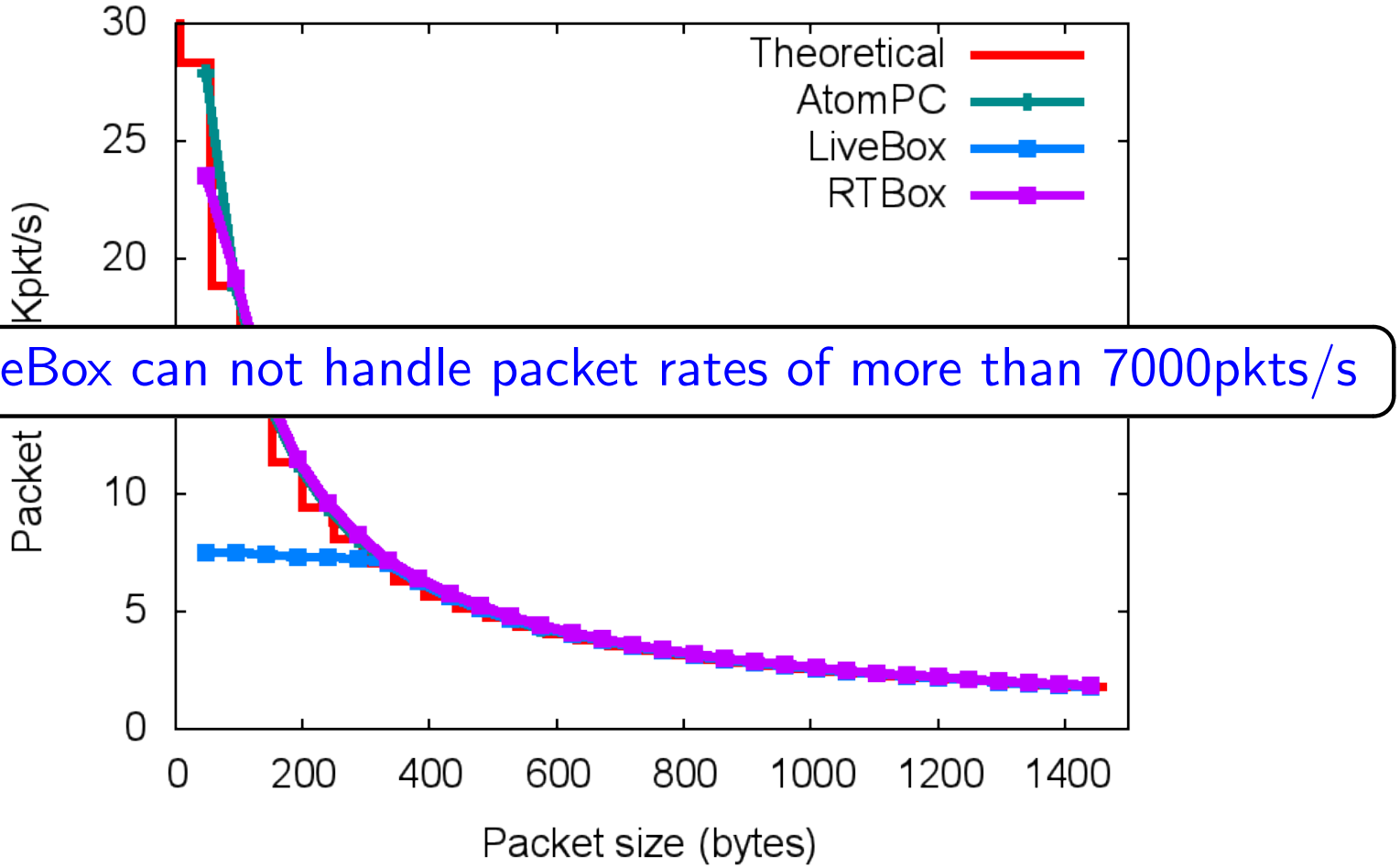
Gateways are the Bottleneck



Gateways are the Bottleneck

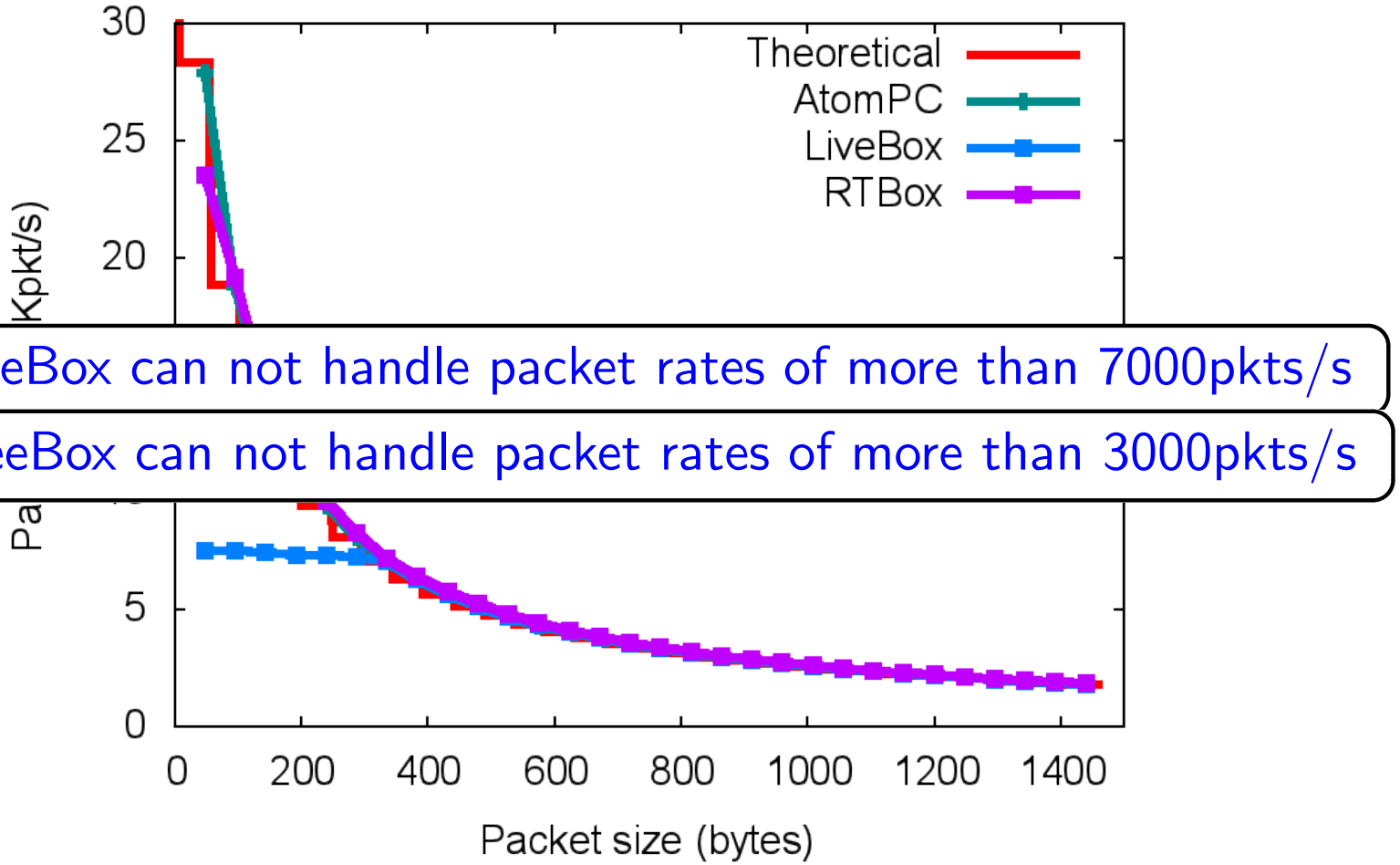


Gateways are the Bottleneck



LiveBox can not handle packet rates of more than 7000pkts/s

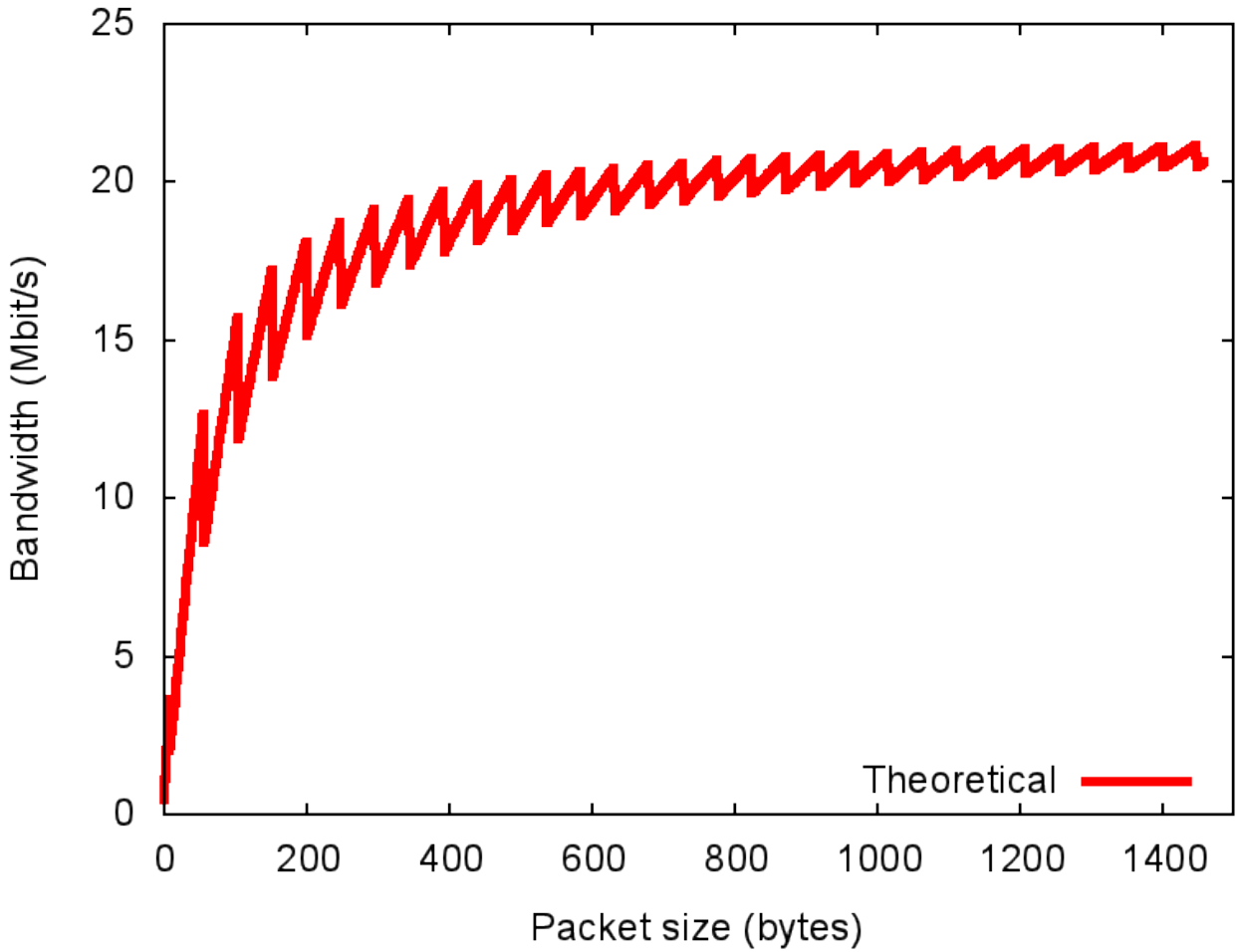
Gateways are the Bottleneck



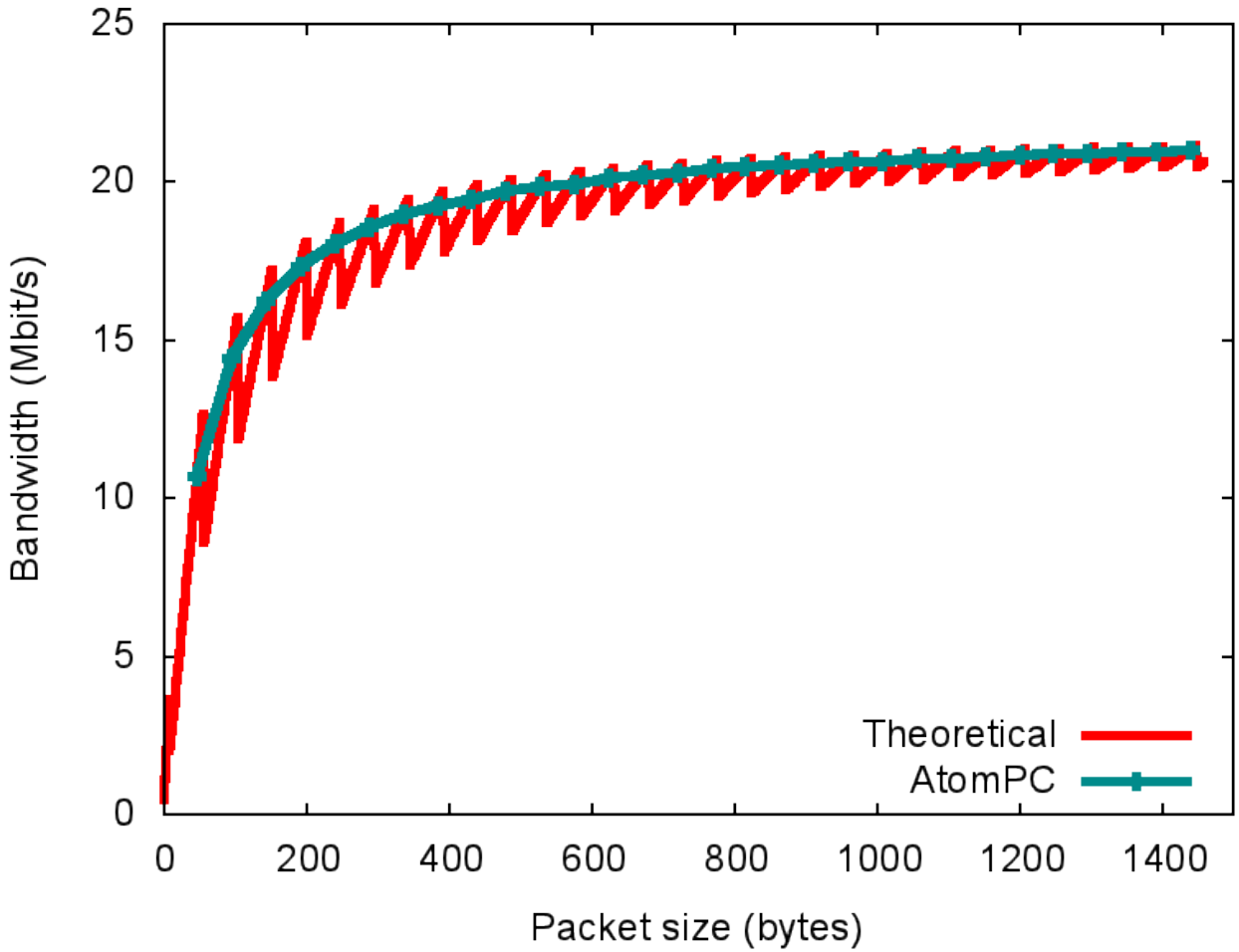
LiveBox can not handle packet rates of more than 7000pkts/s

FreeBox can not handle packet rates of more than 3000pkts/s

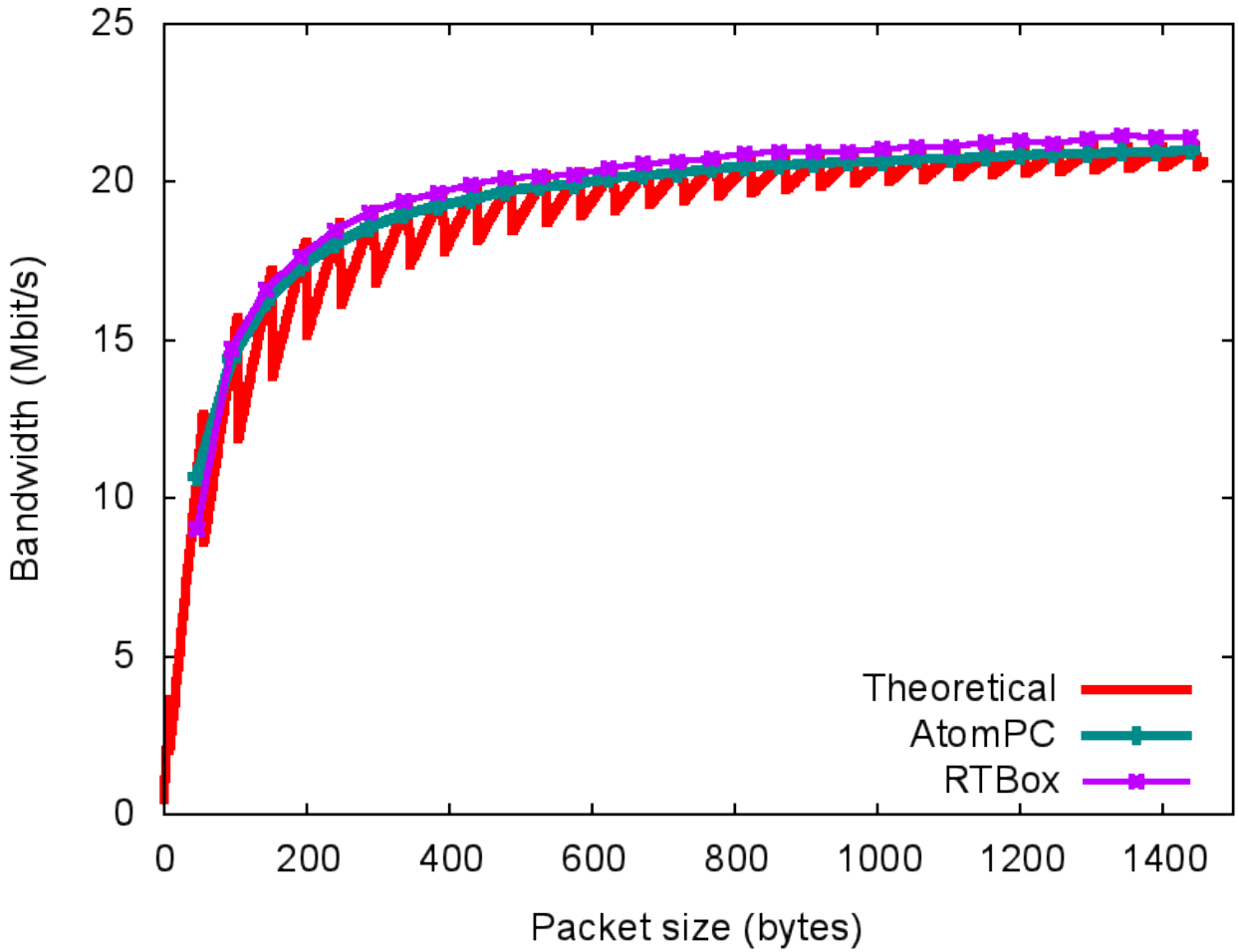
Implications on the maximum bandwidth



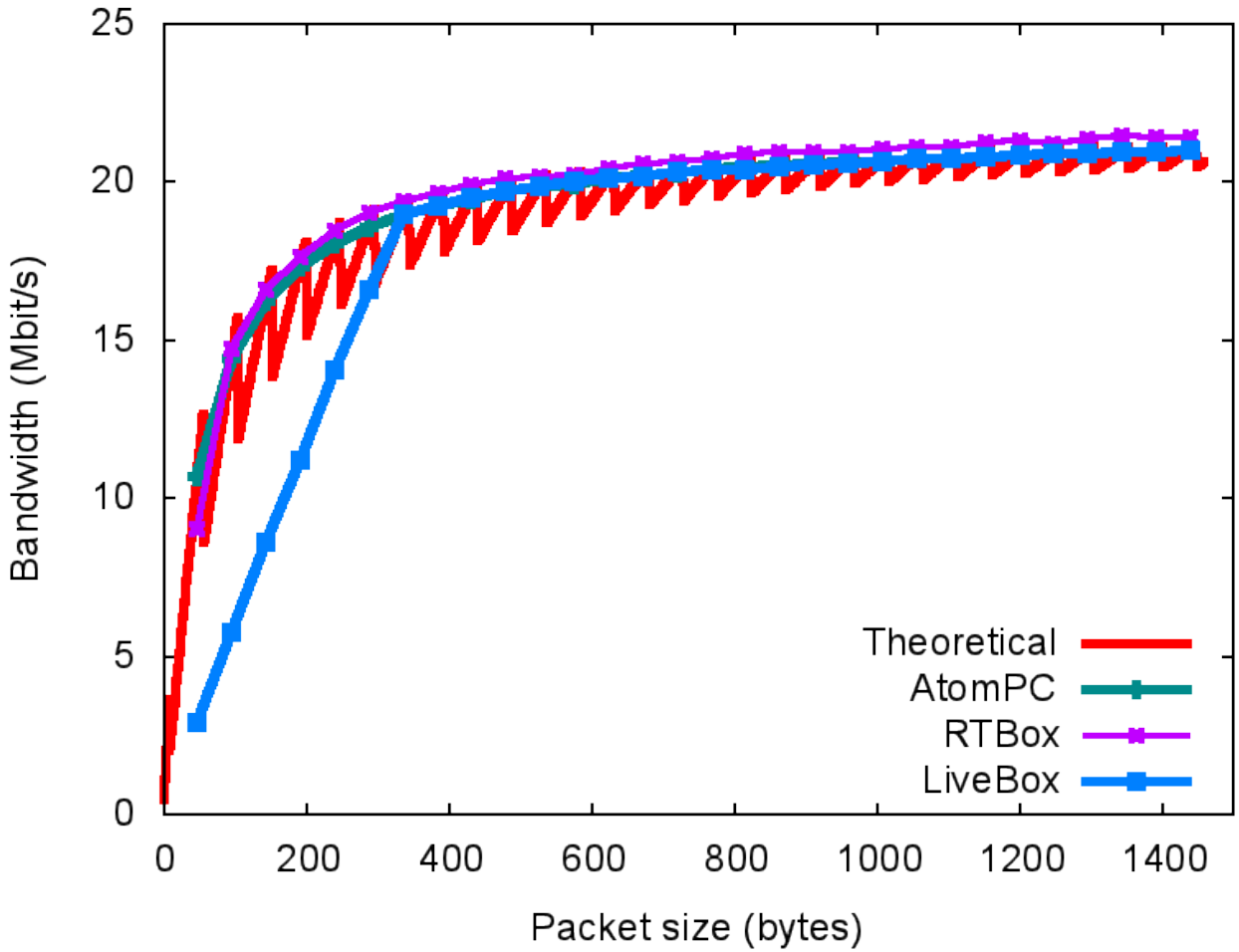
Implications on the maximum bandwidth



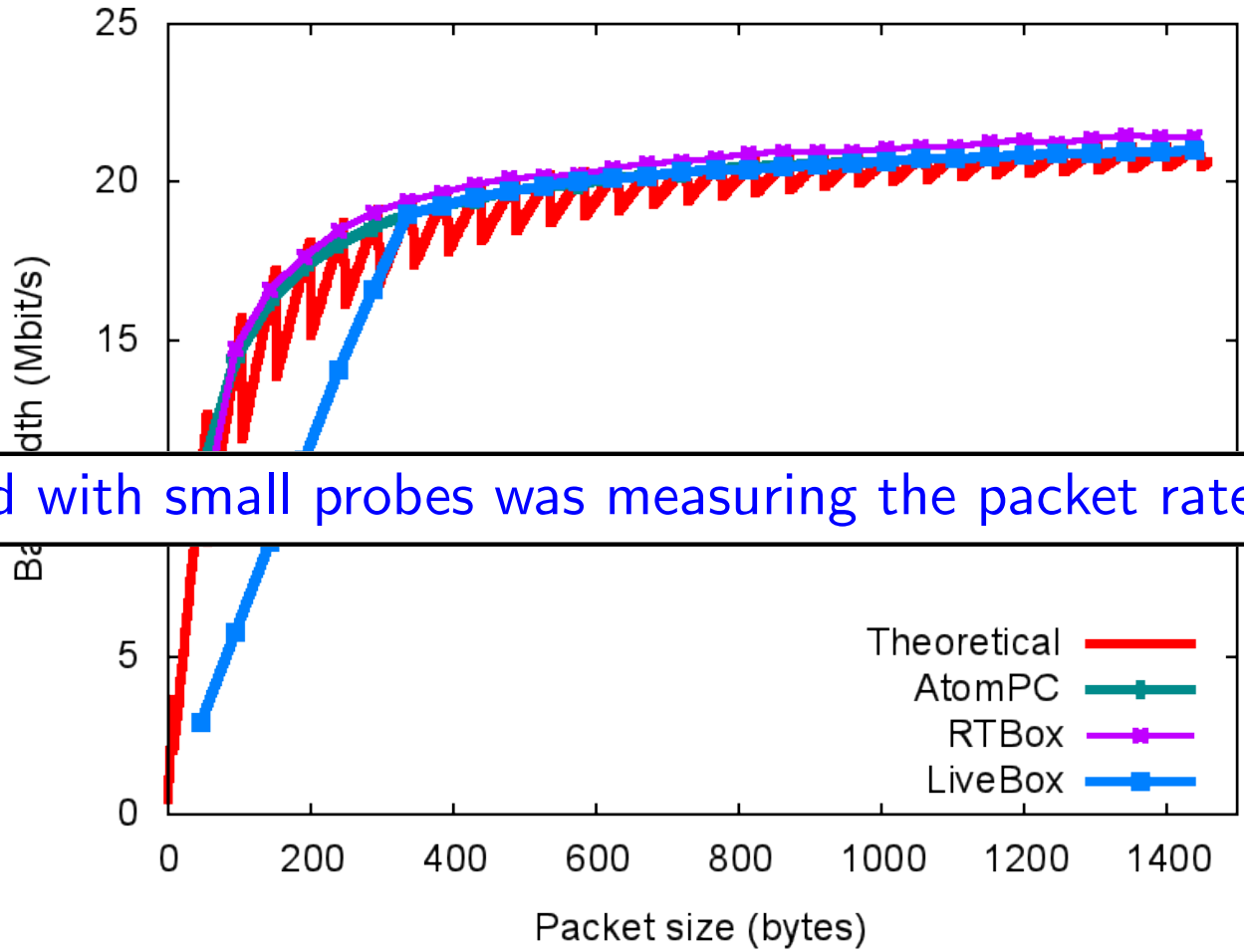
Implications on the maximum bandwidth



Implications on the maximum bandwidth



Implications on the maximum bandwidth



pathload with small probes was measuring the packet rate limitation

Conclusions

- Several tools underestimate the available bandwidth because
  - gateways have limited resources
    $\Rightarrow$ probes hit a packet rate bottleneck before a bandwidth bottleneck
  - real time OSes can improve this limitation
  - how wide spread is the problem?

- Available bandwidth should be considered for speed regulation
  - good estimations when is measured corectly
  - lower overhead $\Rightarrow$ scalable