Measuring packet loss--the next frontier

Steven Bauer, David Clark (MIT)

Oct 27, 2015

FCC Open Internet Order

Open Internet Order 2015

With respect to network performance, we adopt the following enhancements:

- The existing transparency rule requires disclosure of actual network performance. In adopting that requirement, the Commission mentioned speed and latency as two key Measures. **Today we include packet loss as a necessary part of the network performance disclosure.**

- We expect that **disclosures to consumers of actual network performance data should be reasonably related to the performance the consumer would likely experience in the geographic area in which the consumer is purchasing service**.

- We also expect that network performance will be **measured in terms of average performance over a reasonable period of time and during times of peak usage.**

Paragraph 166 in
http://transition.fcc.gov/Daily_Releases/Daily_Business/2015/db0312/FCC-15-24A1.pdf

Open Internet Order 2015

"Participation in the Measuring Broadband America (MBA) program continues to be a safe harbor for fixed broadband providers in meeting the requirement to disclose actual network performance."

Footnote 411 in
http://transition.fcc.gov/Daily_Releases/Daily_Business/2015/db0312/FCC-15-24A1.pdf

Will packet loss of interconnection links be reported?

- FCC's Measuring Broadband America currently is **designed to primarily measure access network performance**
- Video streaming tests are being conducted but will only measure paths associated with video content

Required reporting of loss perversely incentivizing bufferbloat (we disagree)

Forbes / Tech

FEB 27, 2015 @ 2:27 PM 6,478 VIEWS

This One Clause In The New Net Neutrality Regs Would Be A Fiasco For The Internet

POST WRITTEN BY
Nicholas Weaver

Nicholas Weaver is computer security researcher at the International Computer Science Institute in Berkeley, Calif.

Valley Voices
CONTRIBUTOR

Voices on technology and change FULL BIO

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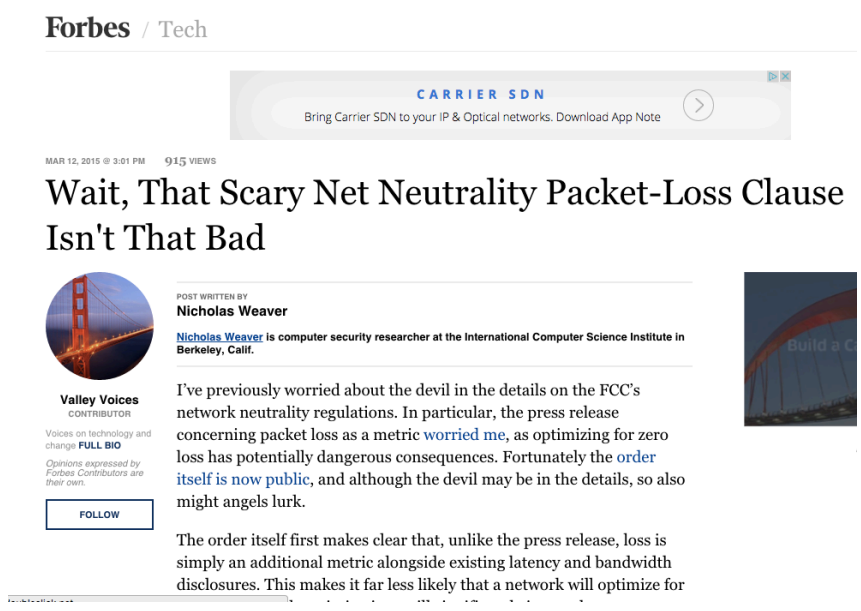
FOLLOW

I don't trust Internet Service Providers. I've focused much of my research since 2008 on ways in which the Internet fails due to ISP misbehavior, including detecting how ISPs can inject adds into content, how ISPs blocked BitTorrent, how ISPs have manipulated a key Internet protocol for ads and profit, and how network carriers inject tracking into user traffic. For those who want to measure the network for themselves, they can download the free (and ad-free) Android tool I helped develop, Netalyzr.

If this sordid history of ISP shenanigans doesn't make you believe in the



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MAR 12, 2015 @ 3:01 PM 915 VIEWS

Wait, That Scary Net Neutrality Packet-Loss Clause Isn't That Bad

POST WRITTEN BY
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Nicholas Weaver is computer security researcher at the International Computer Science Institute in Berkeley, Calif.

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FOLLOW

I've previously worried about the devil in the details on the FCC's network neutrality regulations. In particular, the press release concerning packet loss as a metric worried me, as optimizing for zero loss has potentially dangerous consequences. Fortunately the order itself is now public, and although the devil may be in the details, so also might angels lurk.

The order itself first makes clear that, unlike the press release, loss is simply an additional metric alongside existing latency and bandwidth disclosures. This makes it far less likely that a network will optimize for

http://www.forbes.com/sites/valleyvoices/2015/02/27/this-one-clause-in-the-new-net-neutrality-regs-would-be-a-fiasco-for-the-internet/

http://www.forbes.com/sites/valleyvoices/2015/03/12/wait-that-scary-net-neutrality-packet-loss-clause-isnt-that-bad/

History

Selected IETF RFCs and loss measurement

RFC	Title	Date
2680	A One-way Packet Loss Metric for IPPM	Sept 1999
3357	One-way Loss Pattern Sample Metrics	Aug 2002
3393	IP Packet Delay Variation Metric for IP Performance Metrics (IPPM)	Nov 2002
3432	Network performance measurement with periodic streams	Nov 2002
3611	RTP Control Protocol Extended Reports	Nov 2003
6374	Packet Loss and Delay Measurement for MPLS Networks	Sept 2011
6534	Loss Episode Metrics for IP Performance Metrics (IPPM)	May 2012
Internet Draft	Model Based Bulk Performance Metrics	Dec 2013 - Mar 2015

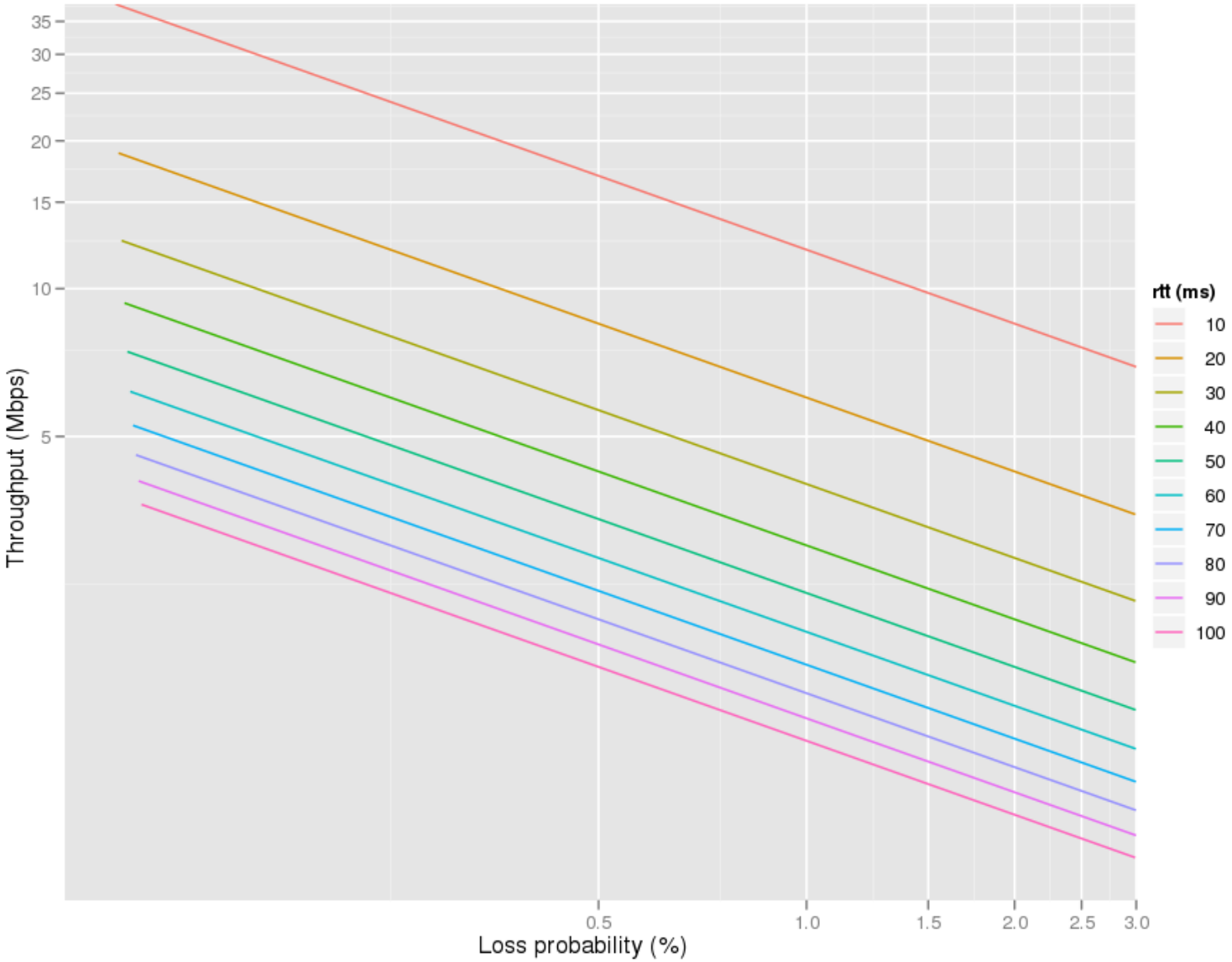
One way loss metrics in IETF

- Considered important as loss can be asymmetric
- Bulk of traffic often flows in one direction
- Not how most loss is being measured by regulators

Loss and throughput

Loss, throughput and delay

$$BW = \frac{MSS}{RTT}\frac{C}{\sqrt{p}}$$

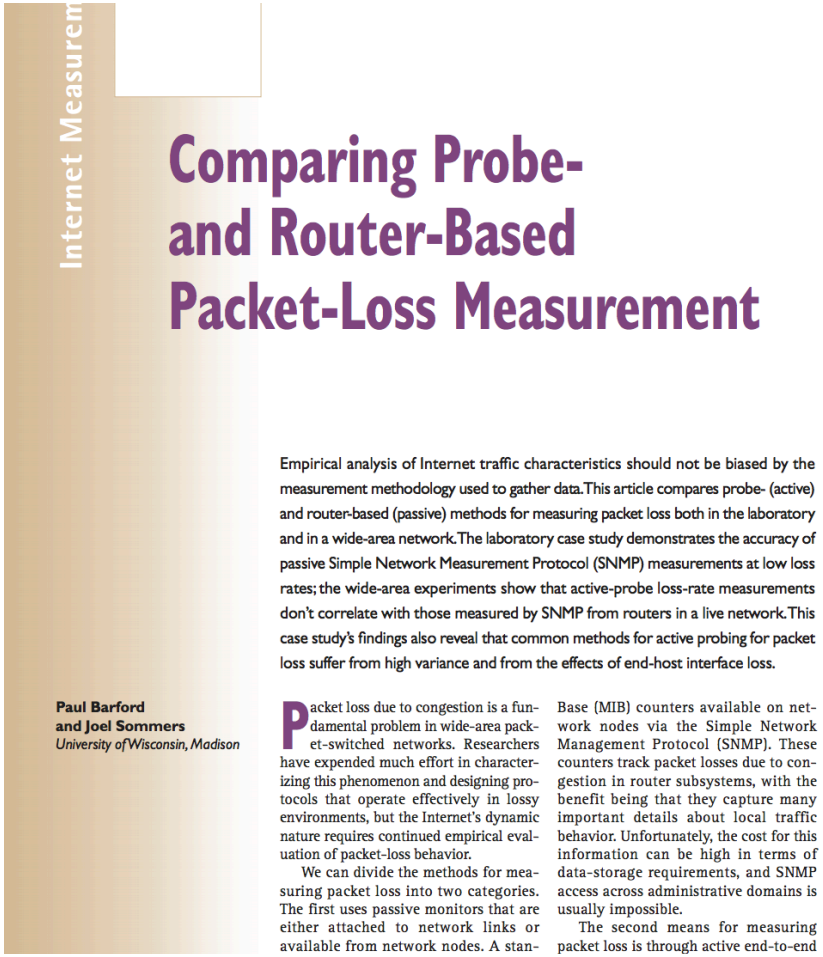

35
30
25
20
15
10
5
Throughput (Mbps)
0.5
1.0
1.5
2.0
2.5
3.0
Loss probability (%)
rtt (ms)
10
20
30
40
50
60
70
80
90
100

Important points

- Loss rate is *not* an "independent variable".
  - Loss rate swings to control congestion.
  - Zero losses is not the right answer.
  - ISPs do not control the TCP behavior
- So how do we measure loss rate?

How do probe-and router-based packet-loss measurement compare?

Barford, P.; Sommers, J., "Comparing probe-and router-based packet-loss measurement," in Internet Computing, IEEE , vol.8, no.5, pp.50-56, Sept.-Oct. 2004



Internet Measurem

Comparing Probe- and Router-Based Packet-Loss Measurement

Empirical analysis of Internet traffic characteristics should not be biased by the measurement methodology used to gather data. This article compares probe- (active) and router-based (passive) methods for measuring packet loss both in the laboratory and in a wide-area network. The laboratory case study demonstrates the accuracy of passive Simple Network Measurement Protocol (SNMP) measurements at low loss rates; the wide-area experiments show that active-probe loss-rate measurements don't correlate with those measured by SNMP from routers in a live network. This case study's findings also reveal that common methods for active probing for packet loss suffer from high variance and from the effects of end-host interface loss.

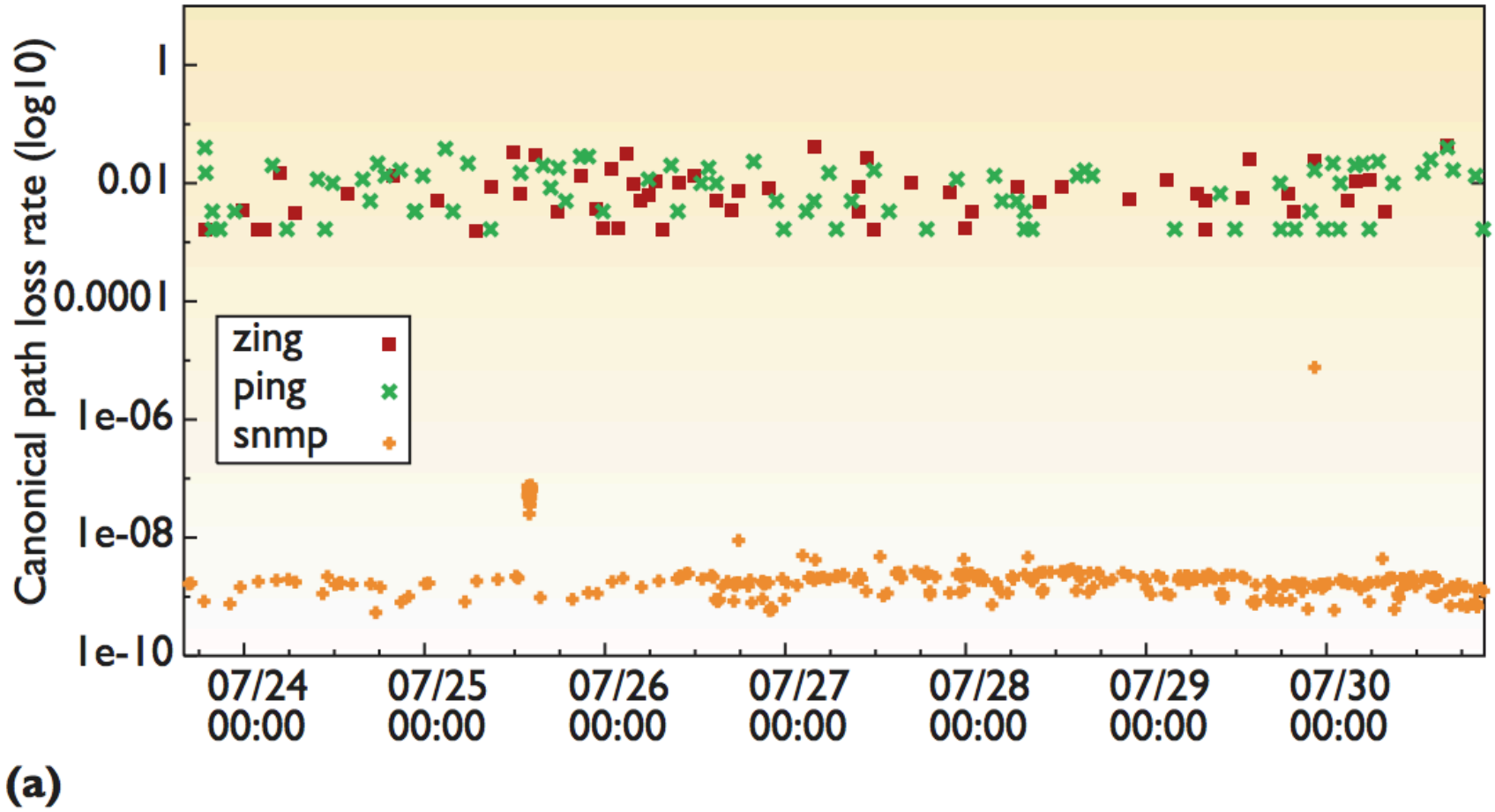
Paul Barford
and Joel Sommers
University of Wisconsin, Madison

Packet loss due to congestion is a fundamental problem in wide-area packet-switched networks. Researchers have expended much effort in characterizing this phenomenon and designing protocols that operate effectively in lossy environments, but the Internet's dynamic nature requires continued empirical evaluation of packet-loss behavior.

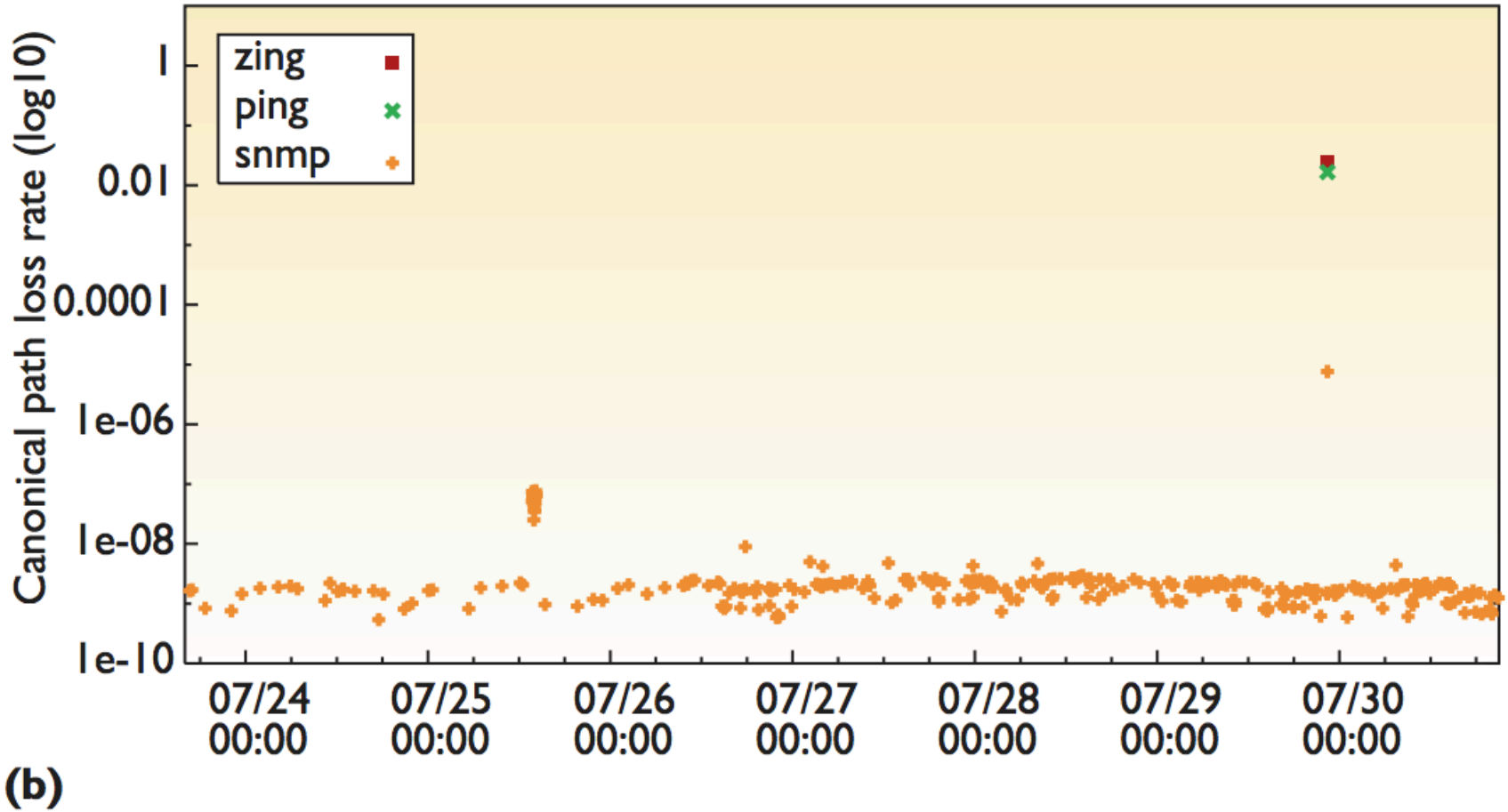
We can divide the methods for measuring packet loss into two categories. The first uses passive monitors that are either attached to network links or available from network nodes. A standard Base (MIB) counters available on network nodes via the Simple Network Management Protocol (SNMP). These counters track packet losses due to congestion in router subsystems, with the benefit being that they capture many important details about local traffic behavior. Unfortunately, the cost for this information can be high in terms of data-storage requirements, and SNMP access across administrative domains is usually impossible.

The second means for measuring packet loss is through active end-to-end

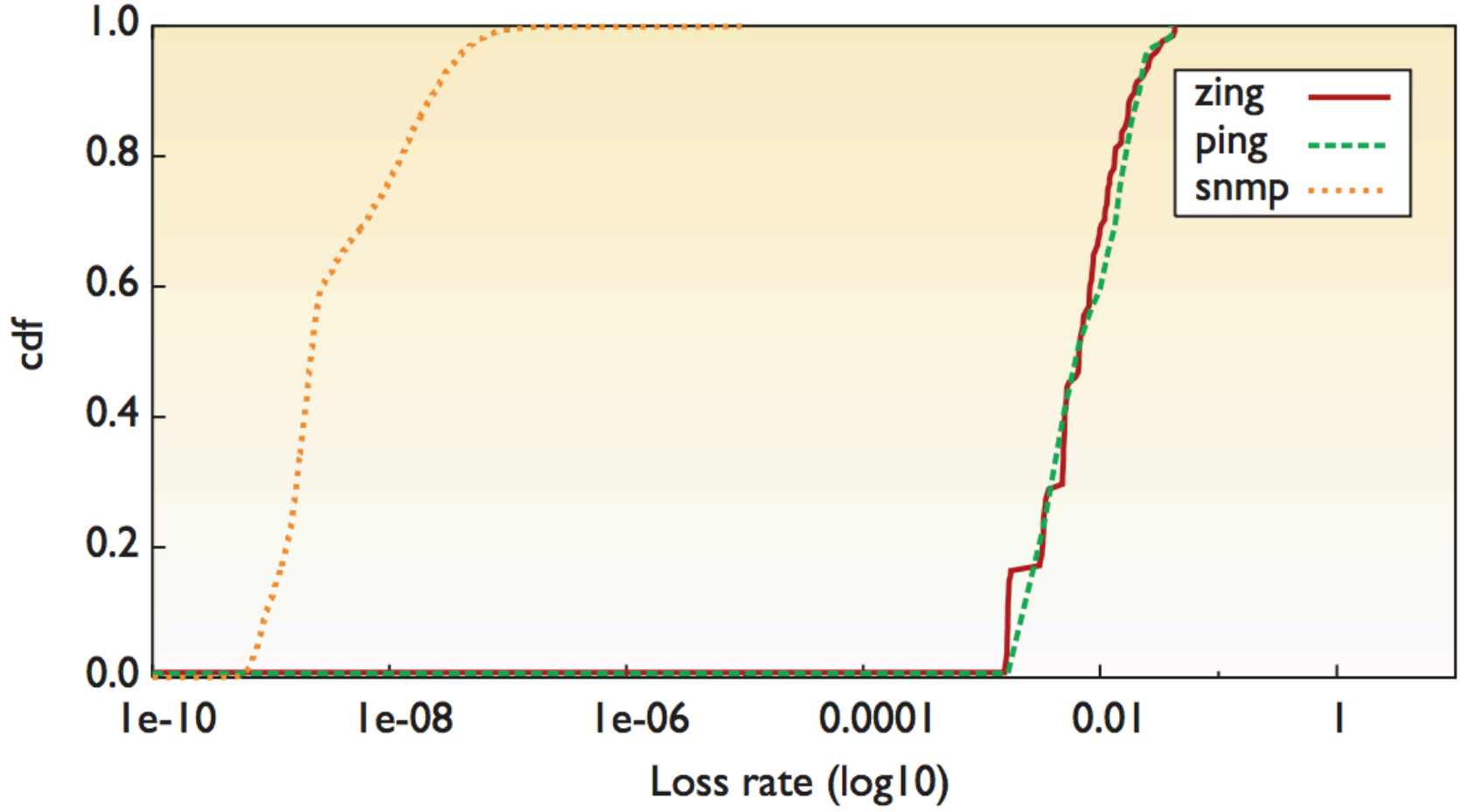
Comparing Probe and Router-Based Packet-Loss Measurement



Comparing Probe and Router-Based Packet-Loss Measurement



Loss rates during loss intervals



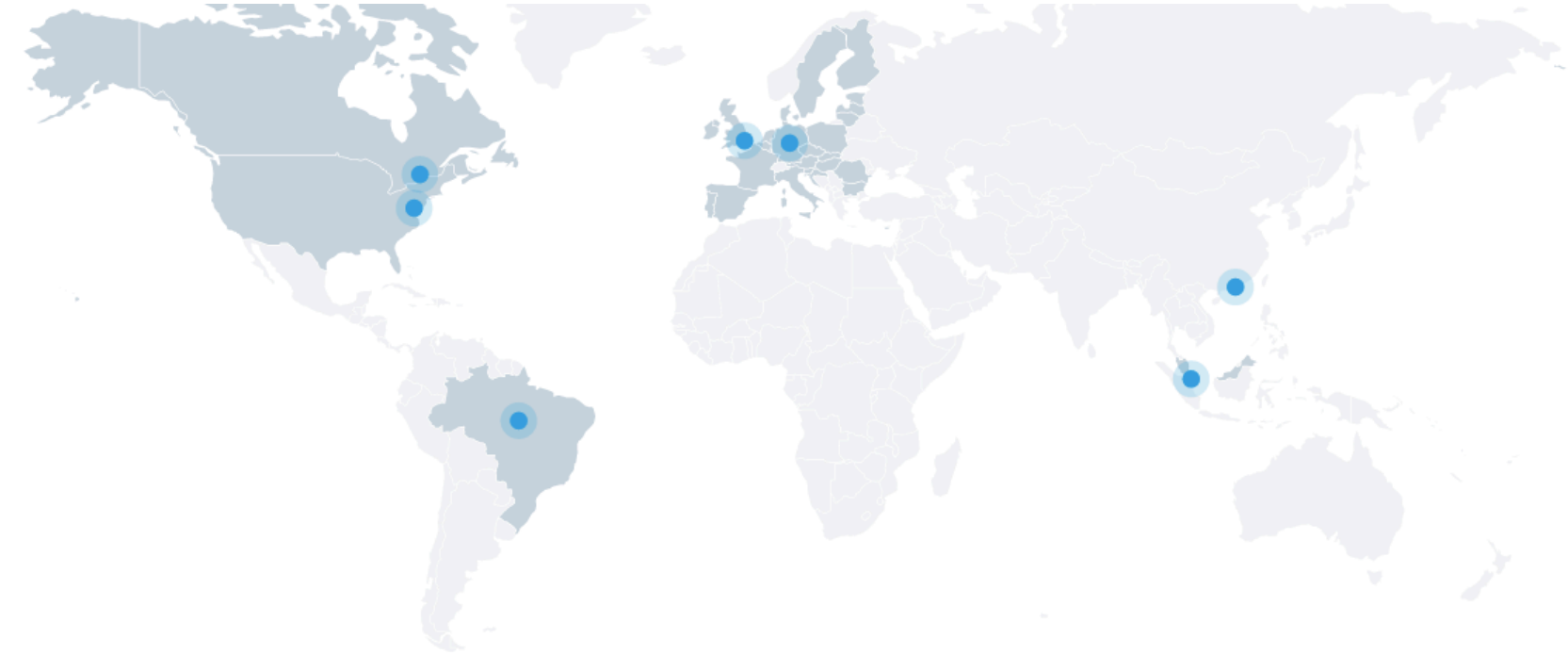
Samknows tests

Loss measures

Test	Primary measure(s)
Download speed	Throughput in Megabits per second (Mbps) utilizing three concurrent TCP connections
Upload speed	Throughput in Mbps utilizing three concurrent TCP connections
Web browsing	Total time to fetch a page and all of its resources from a popular website
UDP latency	Average round trip time of a series of randomly transmitted UDP packets distributed over a long timeframe
UDP packet loss	Fraction of UDP packets lost from UDP latency test
Video streaming	Initial time to buffer, number of buffer under-runs and total time for buffer delays[23]
Voice over IP	Upstream packet loss, downstream packet loss, upstream jitter, downstream jitter, round trip latency
DNS resolution	Time taken for the ISP's recursive DNS resolver to return an A record[24] for a popular website domain name
DNS failures	Percentage of DNS requests performed in the DNS resolution test that failed
ICMP latency	Round trip time of five regularly spaced ICMP packets
ICMP packet loss	Percentage of packets lost in the ICMP latency test
Latency under load	Average round trip time for a series of regularly spaced UDP packets sent during downstream/upstream sustained tests
Availability[25]	Total time the connection was deemed unavailable for any purpose, which could include a network fault or unavailability of a measurement point
Consumption[26]	A simple record of the total bytes downloaded and

http://data.fcc.gov/download/measuring-broadband-america/2014/Technical-Appendix-fixed-2014.pdf

Samknows Internet measurements use by regulators



https://www.samknows.com/regulators

How regulators have reported loss measurements in public reports

Regulator	Report date	Loss metric	Notes	Links
United States FCC	July 2014, Feb 2013, July 2012, Aug 2011		Never reported on loss	https://goo.gl/tlz6oB https://goo.gl/PsHP5A
European Commission	October 2013, March 2012	Averages derived from UDP latency tests	Compare loss averages to averages in US	http://goo.gl/0uhdLt http://goo.gl/TJlg6e
Singapore	Ongoing	Averages derived from UDP latency tests	Calculate loss to targets in US	http://goo.gl/LtrJ8t
UK Ofcom	12 reports from 2008-2014 (every 6 months)		Only reported on loss in first report	http://goo.gl/a05dea
Brazil	7 reports from 2013 – 2015 (every six months)	Threshold metric drived from UDP latency tests	Report metric is % of time loss is below 2%	https://goo.gl/yQhYuN

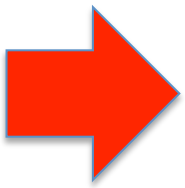
Loss results from other countries using Samknows

EU 2013 Report

Technology and Period	xDSL Peak	xDSL 24hr	Cable Peak	Cable 24hr	FTTx Peak	FTTx 24hr	EU Peak	EU 24hr
Packet Loss (%)								
October 2013	0.50%	0.35%	0.20%	0.18%	0.39%	0.22%	0.39%	0.27%
March 2012	0.7%	0.4%	0.3%	0.3%	0.3%	0.3%	0.5%	0.4%

EU 2013 Report Comparing packet loss in EU and US

Well…



.4 Packet Loss

Figure EU.1-42 is the comparison of packet loss during the peak period between Europe and the USA, split by technology. As was the case in March 2012, all acces technologies in the USA displayed significantly lower packet loss compared to Europe. In actuality, the difference is not significant and can be negligible with respect to broadband performance for individual users

Technology	Europe	US
xDSL	0.50%	0.23%
FTTx	0.40%	0.17%
Cable	0.21%	0.15%

Figure EU.1-42: Comparison of Packet Loss between Europe and the USA, by technology

EU Packet loss of cable technology during peak periods, split by country

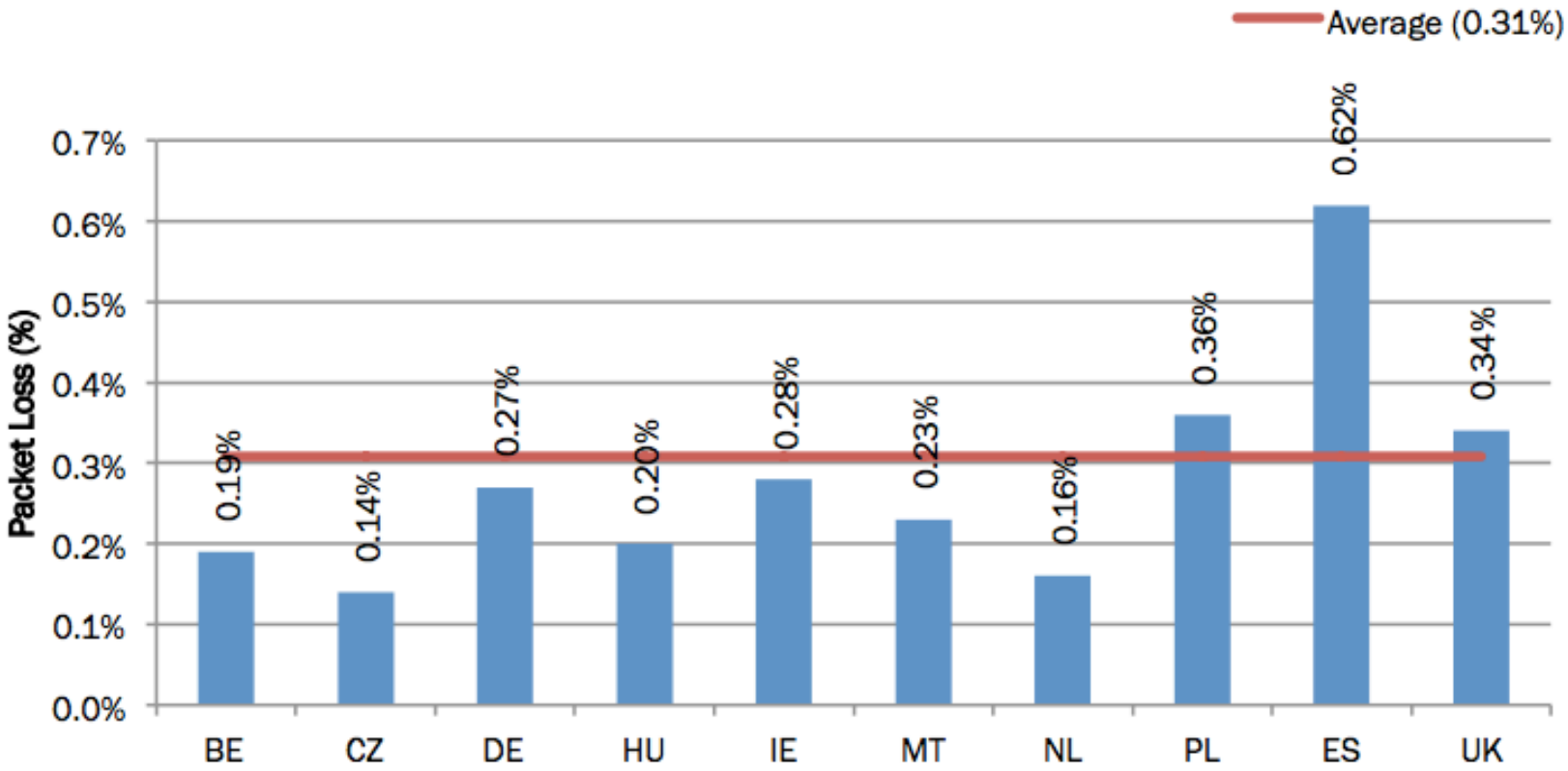


Figure EU.2-17: Packet loss of cable technology during peak periods, split by country

EU Packet loss of FTTx technology during peak periods, split by country

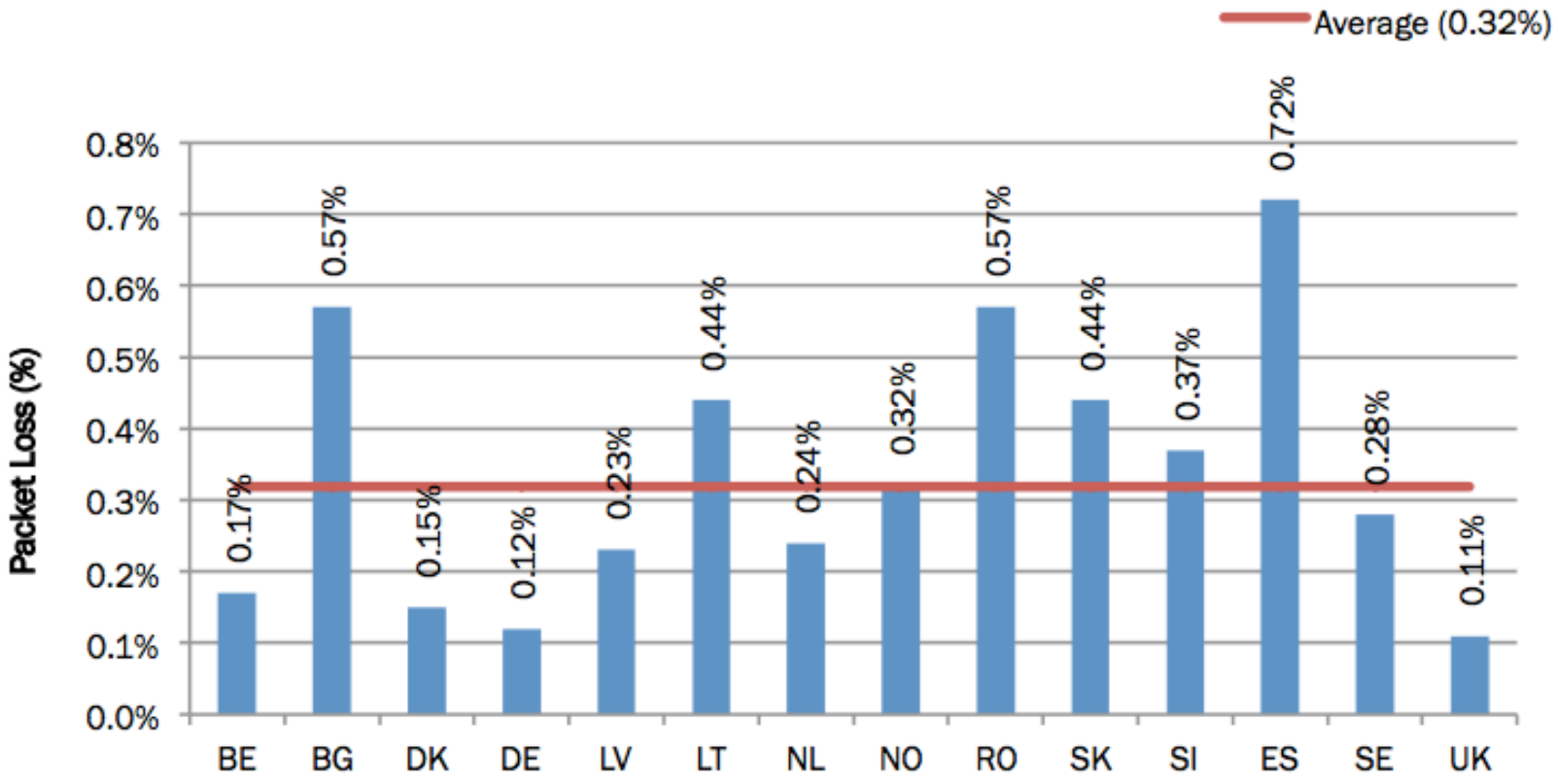
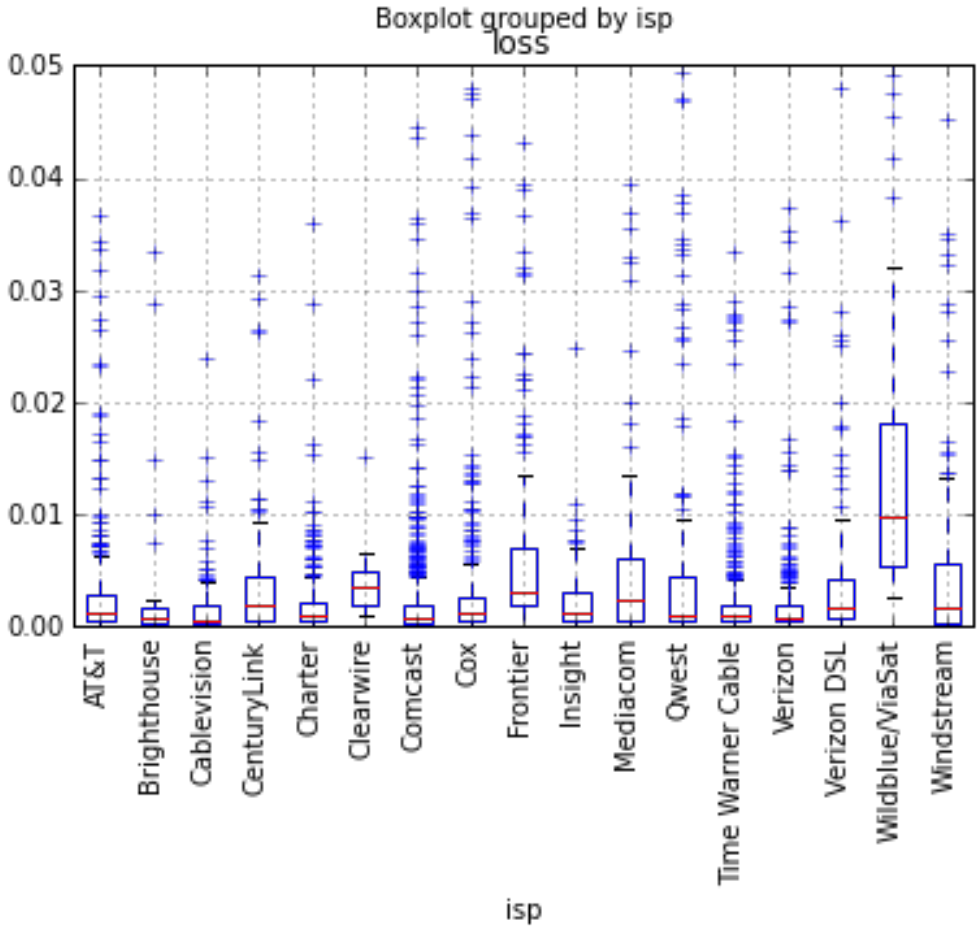


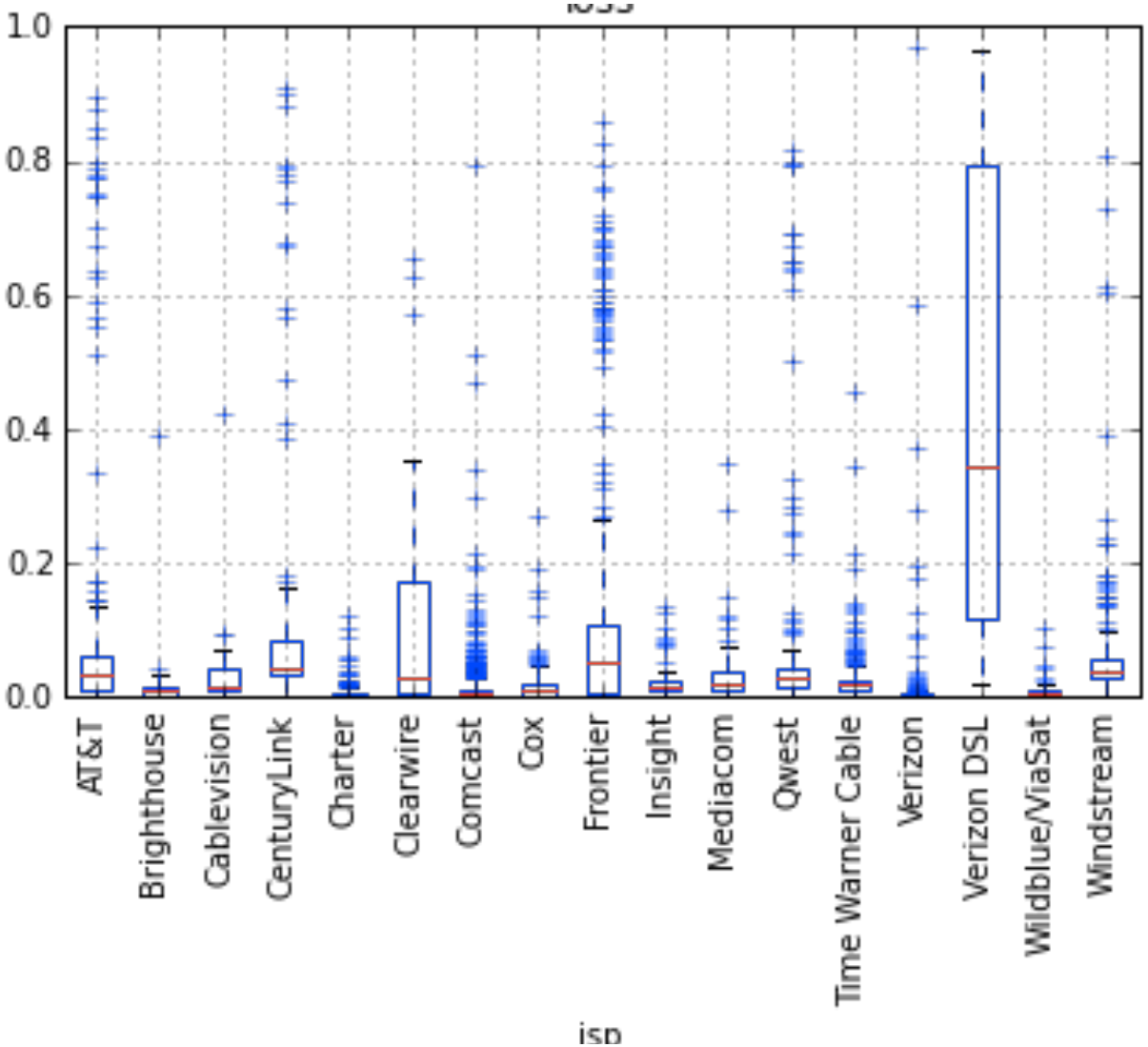
Figure EU.2-18: Packet loss of FTTx technology during peak periods, split by country

Packet loss in the United States
Samknows data

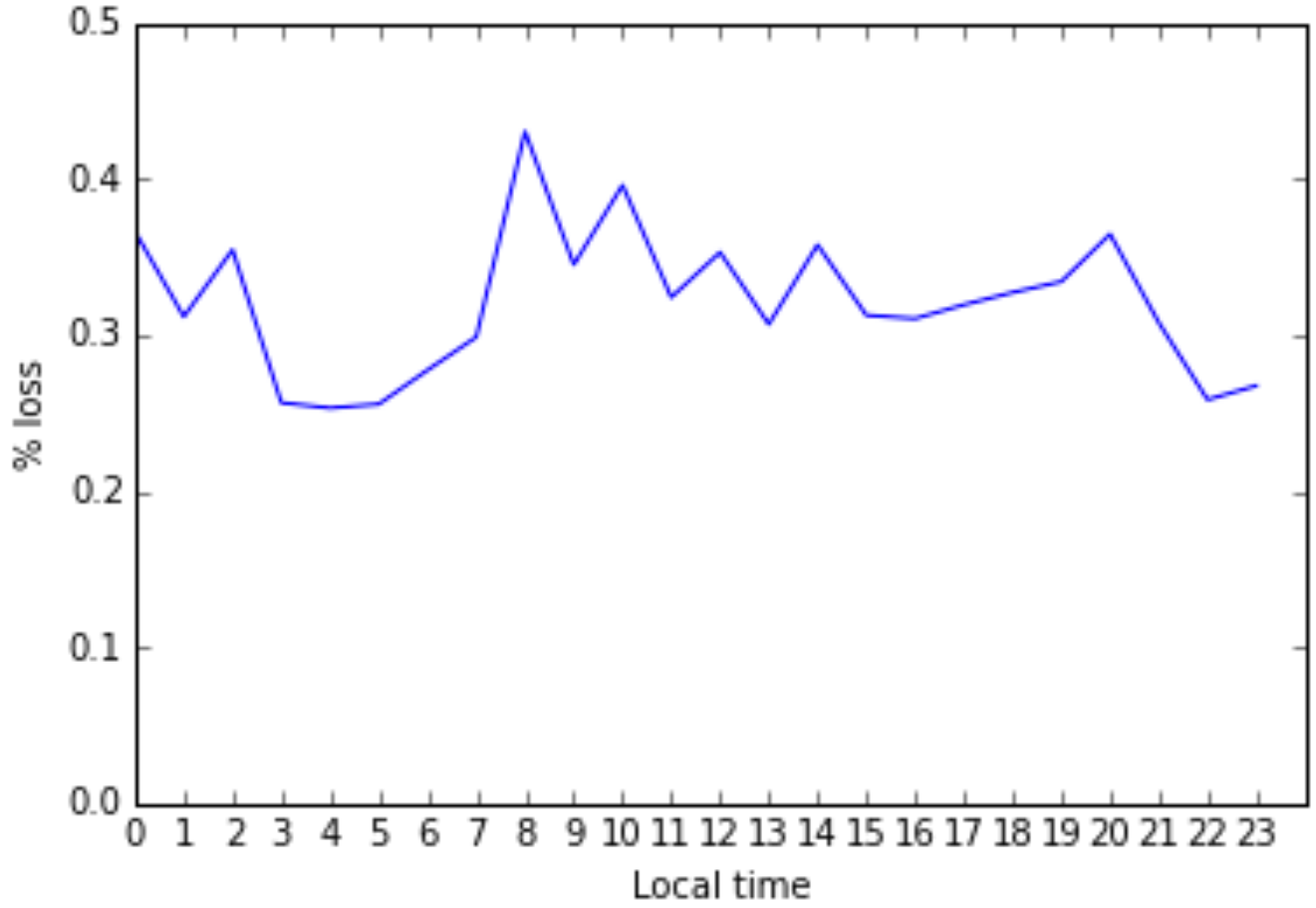
Loss as measured by UDP test



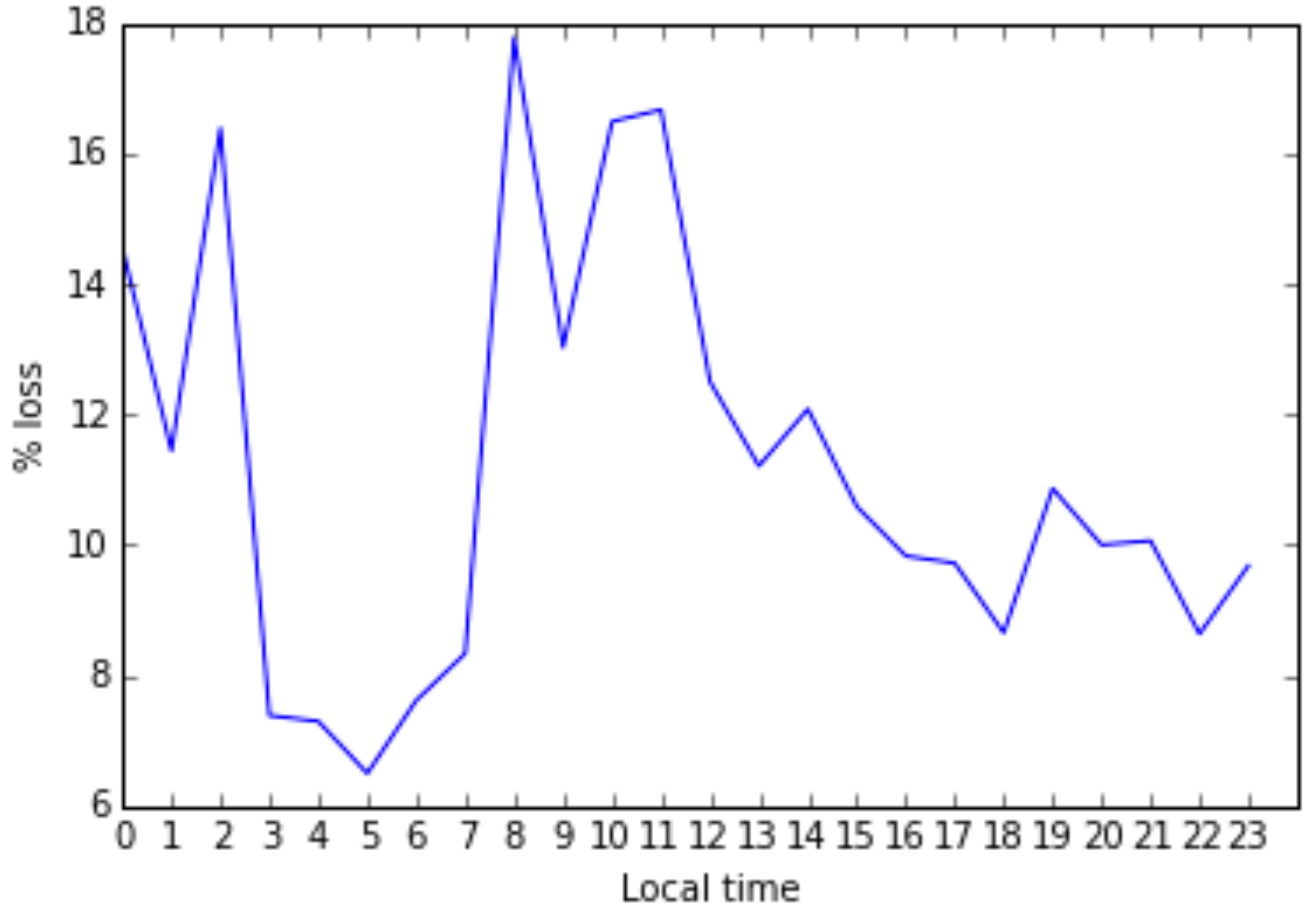
UDP loss during upload test (24 hours)



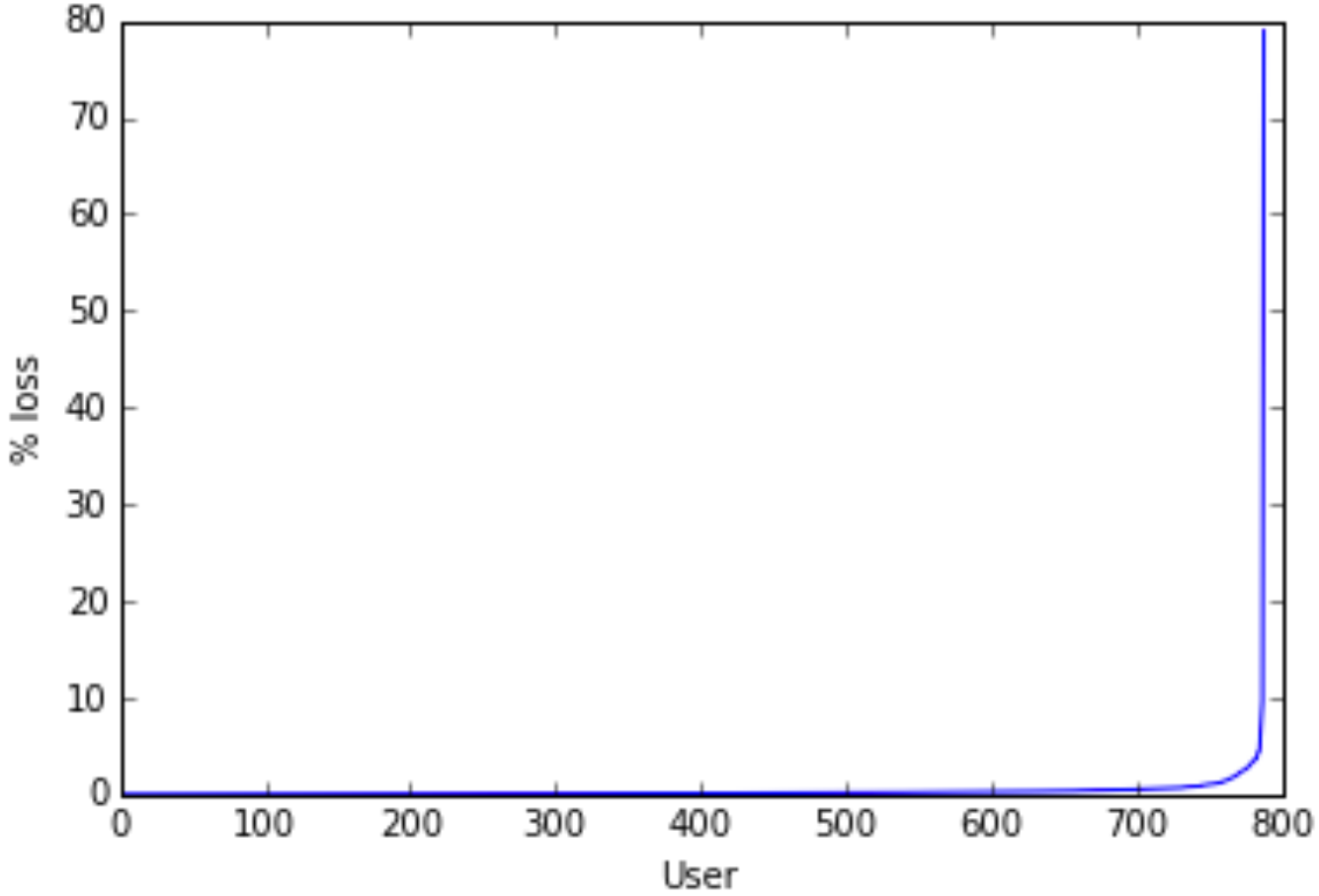
Packet loss by hour for one provider



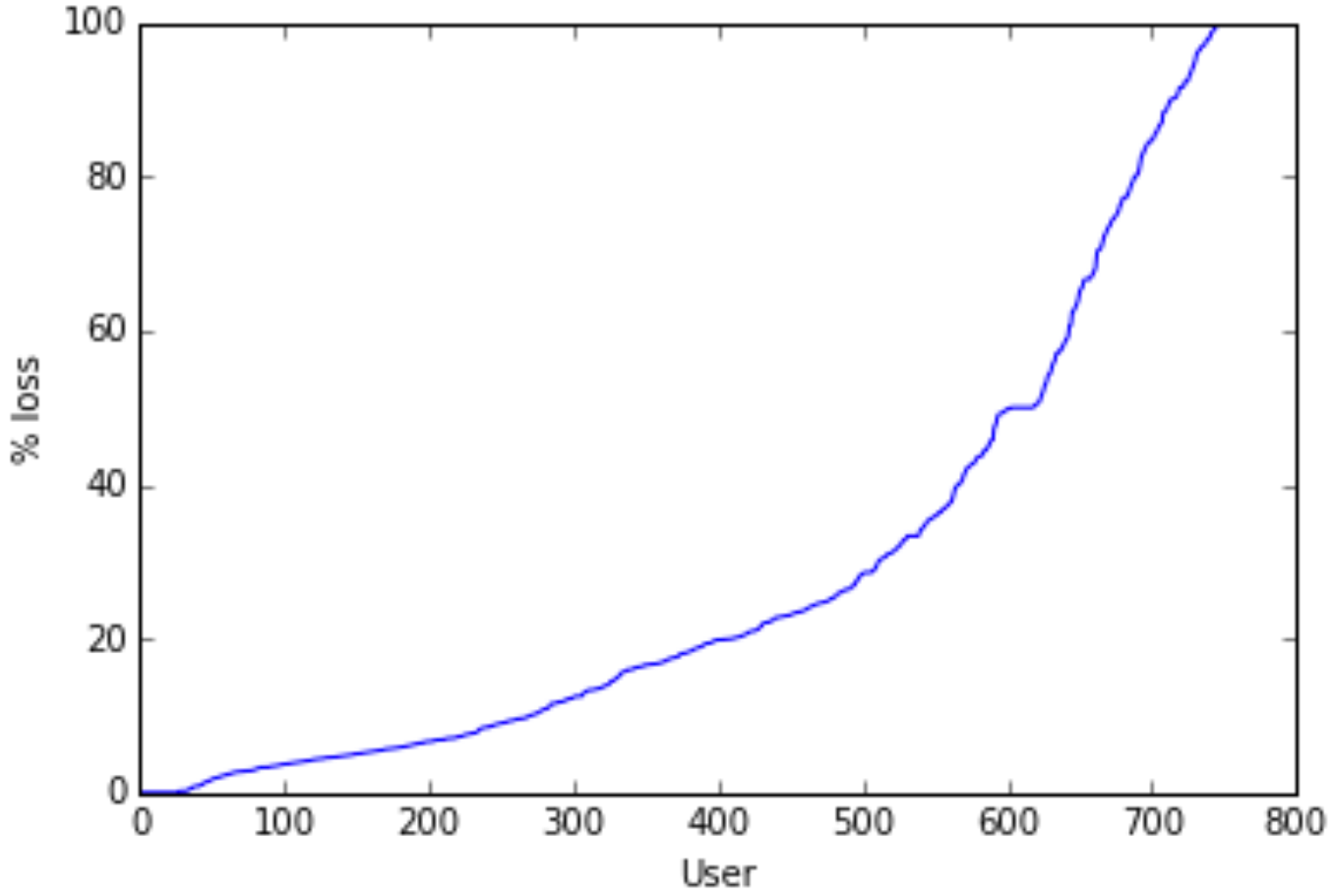
% loss at top 99.5 percentile by hour



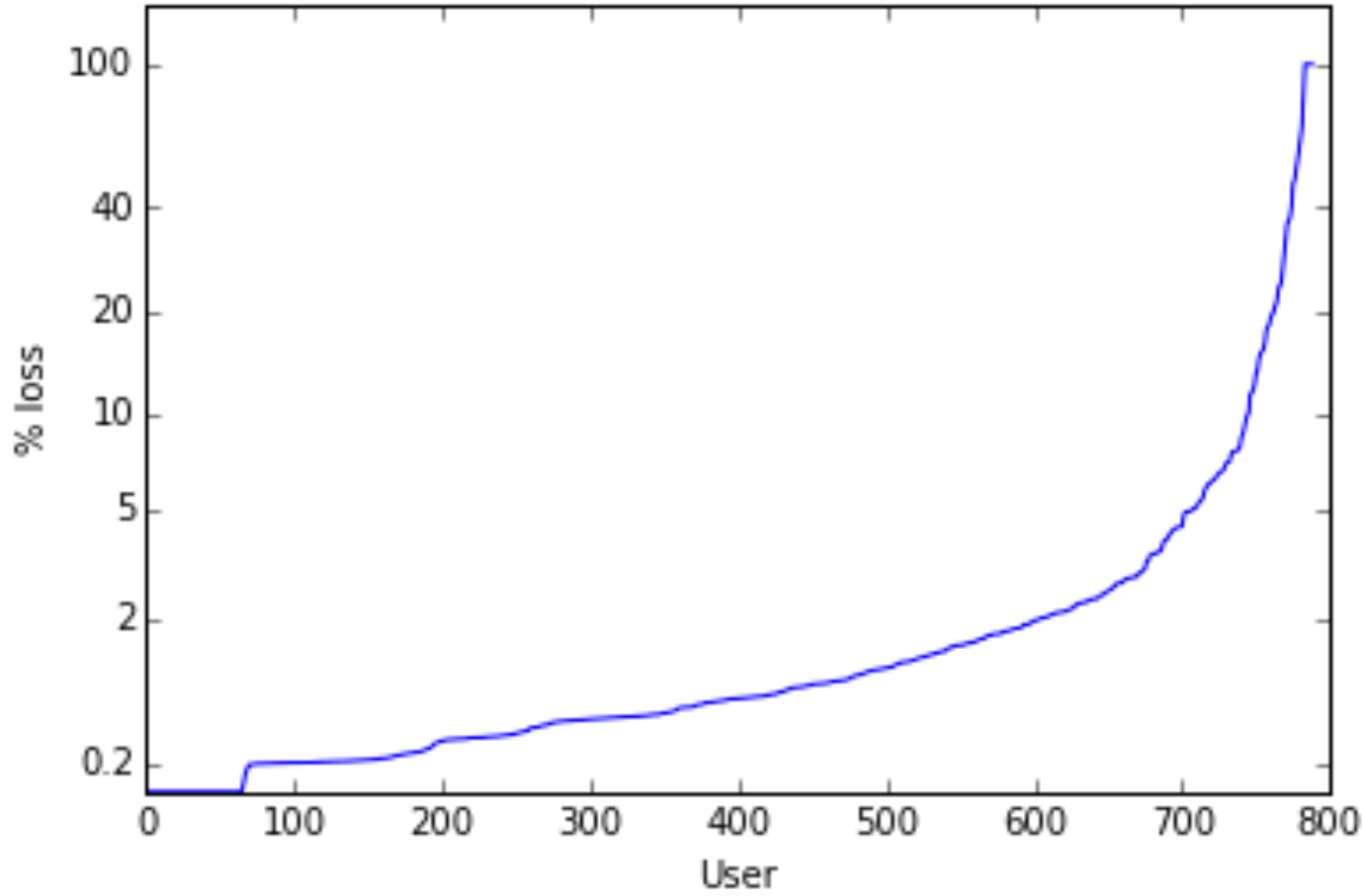
Mean % loss per user



Max % loss in any hour by user over month



98.5 percentile loss by user over month



Discussion

High-level conclusions

- Loss rate due to congestion is not an independent variable.
  - ISPs do not control several of the critical variables.
  - The right answer for loss rate is not zero.
- Different measurement methods for loss may give very different answers.
  - Need to agree (with the FCC) on what the accepted method will be.
- Not measuring uniform distribution
  - Mixture of good and bad experiences