End-to-end Methods for

Traffic Shaping Detection, Performance Problem Diagnosis, Home Wireless Troubleshooting

Partha Kanuparthy

Joint work with Constantine Dovrolis

AIMS 2011, CAIDA

Georgia Institute of Technology

MeasurementLab.org

Carnegie Mellon

Three Tools

- *ShaperProbe*: End-to-end detection of traffic shaping
  - GATech, M-Lab (under submission)
- *Pythia:* Detection, localization, diagnosis of performance problems
  - GATech, DoE (early work; 4 months)
- Troubleshooting home wireless networks
  - GATech, Intel Labs, CMU (early work; 6 months)

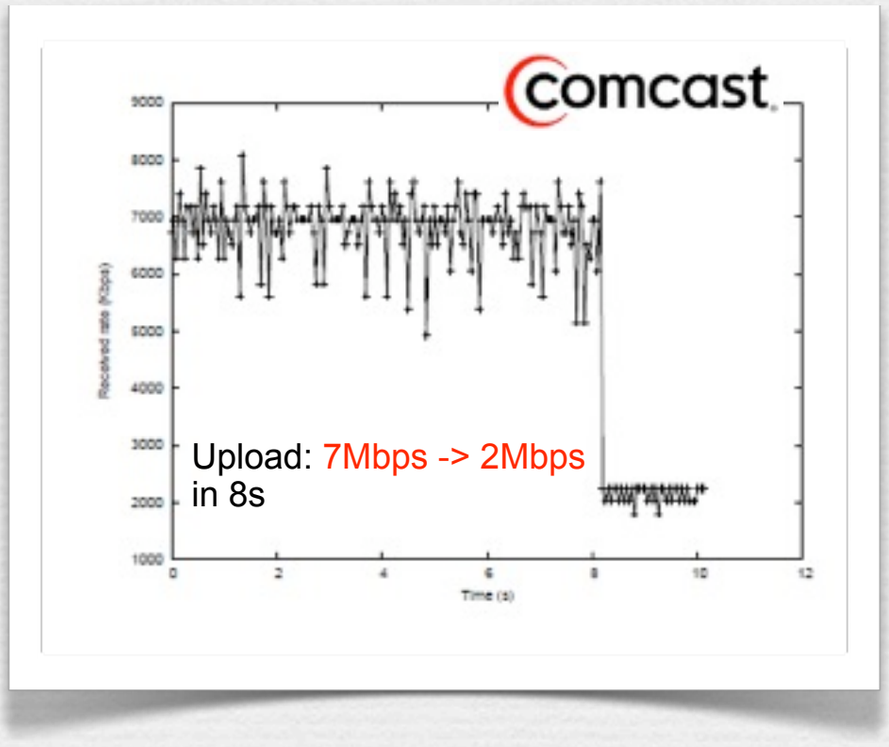
ShaperProbe: End-to-End Detection of Traffic Shaping

In this part..

- Detecting traffic shapers using active probing (ShaperProbe tool)
- ISP case studies

What is Traffic Shaping?

- Practice of dropping link speeds after a burst period
  - smoothes traffic
  - helps in managing/reducing congestion
  - pricing service tiers using shared infrastructure
- Why detect shaping?
  - SLA verification (customers)
  - configuration testing (operators)

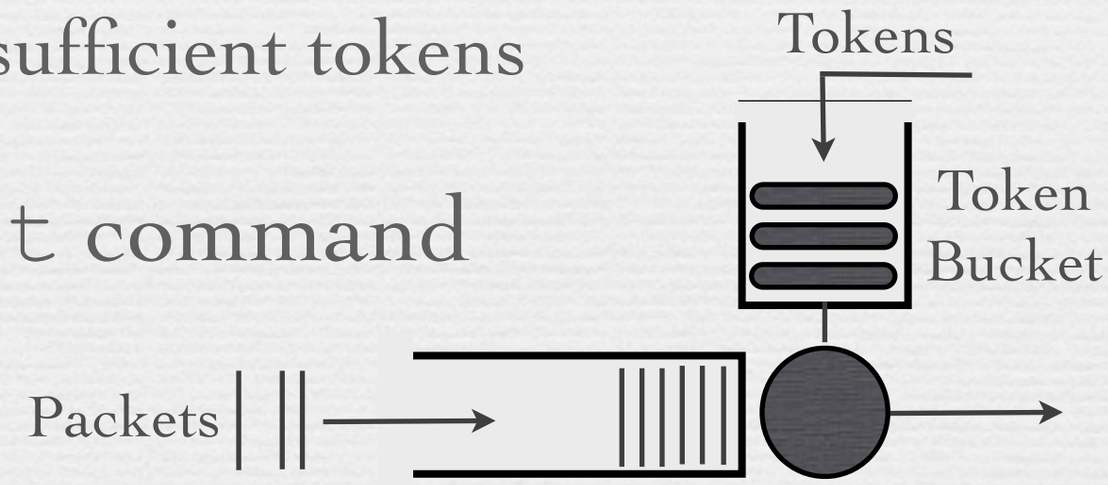


How long does the PowerBoost burst last?

A PowerBoost burst will normally last as long as the 10MB of a file download on Comcast's 6Mbps High-Speed Internet service, and as long as 5MB of a file upload.

Traffic Shapers

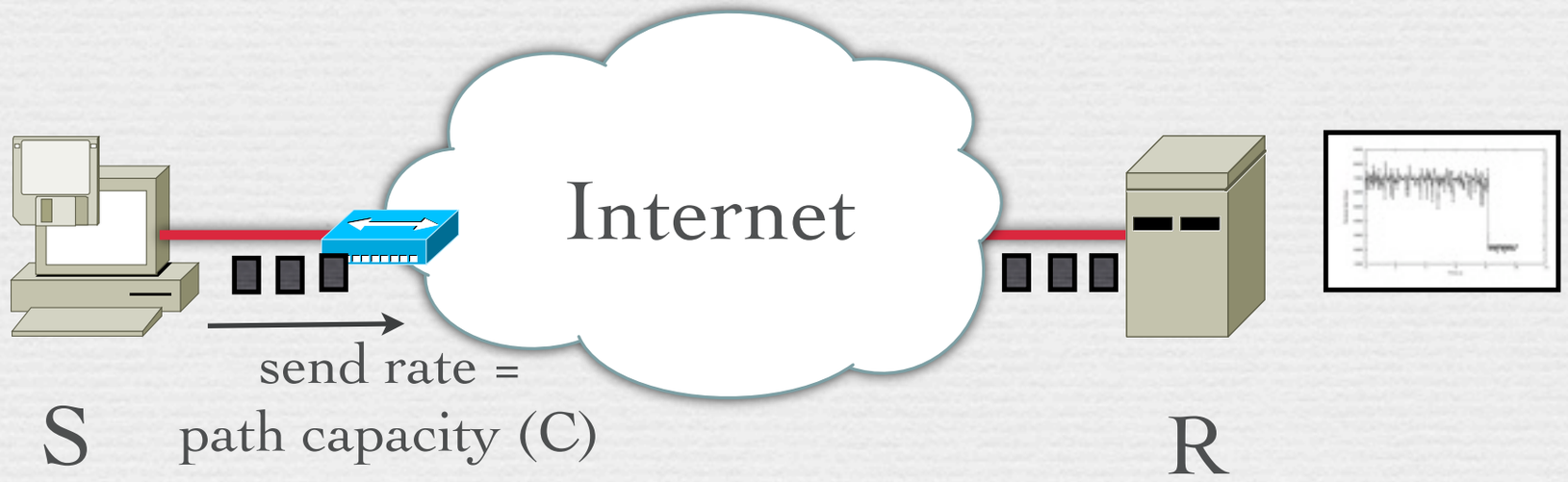
- Implemented using a Token Bucket at a link
  - accumulates tokens (bytes) at certain rate (bytes/s)
  - services packet when it has sufficient tokens
- Cisco devices: `rate-limit` command
- Shapers vs. Policers:
  - shapers queue packets waiting for tokens; policers drop
  - we detect both



Configuration: burst size, shaping rate

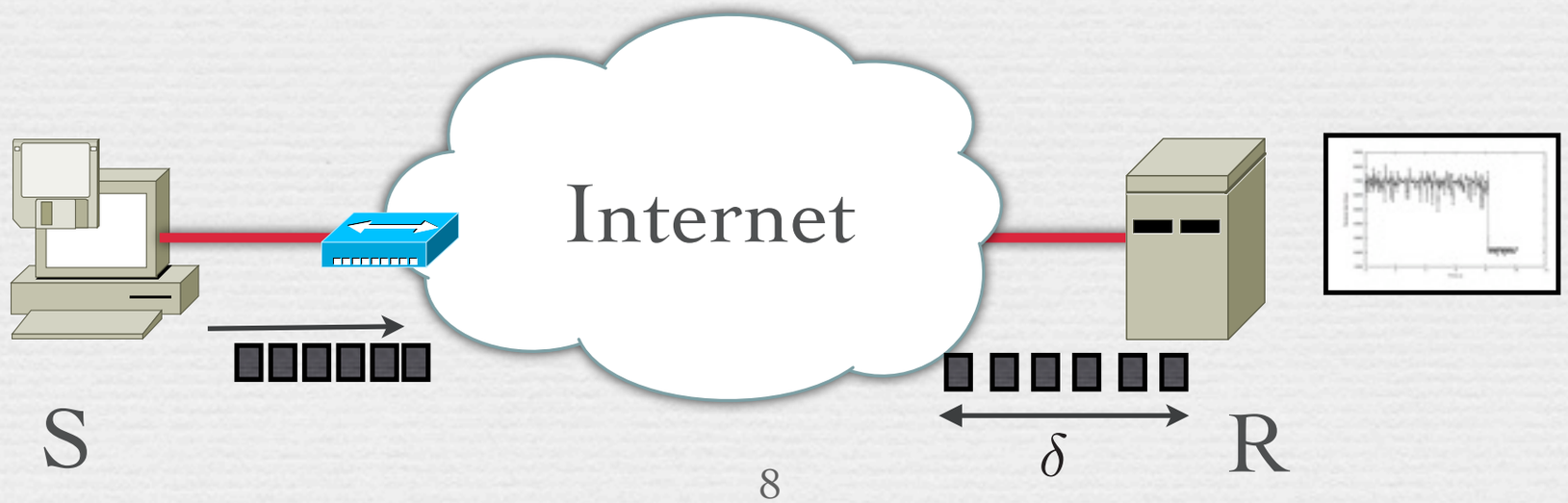
ShaperProbe: Design

- Sender (S) sends a constant-rate stream at rate C to receiver (R)
- R estimates received rate in small intervals
- Probing stops when either:
  - R sees a level shift in timeseries, or
  - after 60s



Design: Capacity

- Probing rate = path capacity C
- We estimate path capacity C before probing:
  - S sends packet trains of N back-to-back packets
  - R estimates capacity by measuring dispersion δ of each train: $\hat{C} = \frac{(N-1)S}{\delta}$ → packet size (1470B)



Design: Classification

- The probing stream can be designed to emulate well-known applications:
  - change payload, etc.
  - e.g., Skype, BitTorrent, ...
- some applications may be more likely to be shaped by ISP

Detecting Shaping

- Shaping is characterized by a level shift in received rate
  - we observe rate in intervals of 300ms

- Level shift point if:
  - all points before > all points after
  - min. # points before and after
  - "large" drop in median rate (factor of 1.1): $\tilde{R}_r(i)_{i=1\ldots\tau} > \gamma\,\tilde{R}_r(j)_{j=\tau\ldots n}$

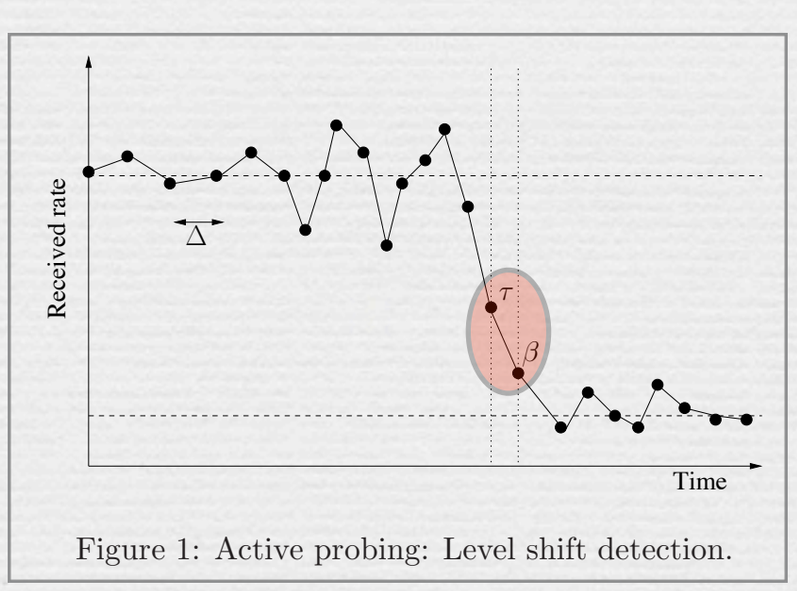


Figure 1: Active probing: Level shift detection.

Shaping Configuration

- We estimate shaping parameters in case of shaping:
  - shaping rate: median rate after level shift
  - burst size: based on bytes sent before level shift

$$\hat{\sigma} = \sum_{i=1}^{\tau} [R(i) - \hat{\rho}]\Delta \pm \frac{[R(i) - \hat{\rho}]\,\Delta}{2}$$

burst size (bytes)

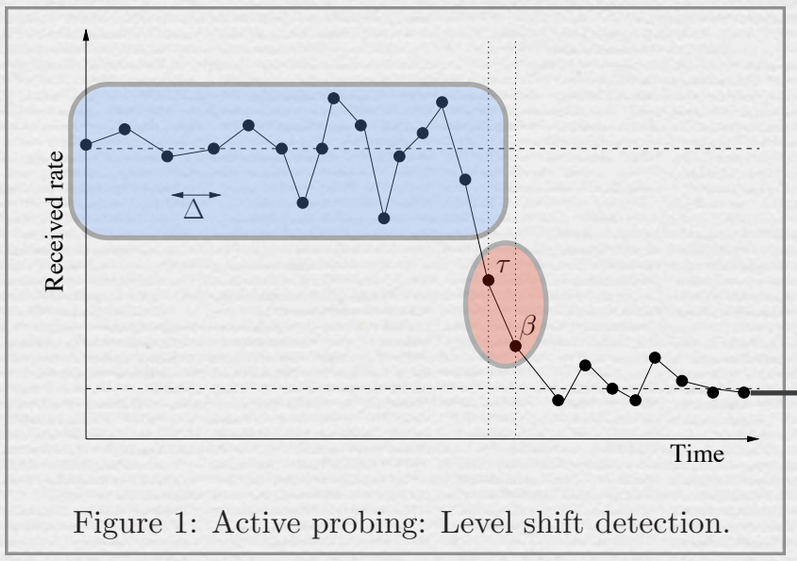


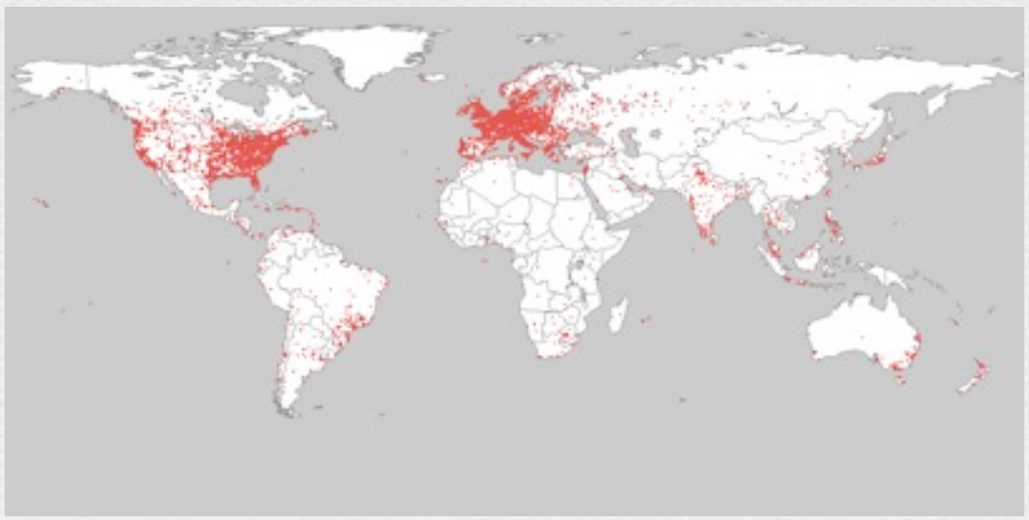
Figure 1: Active probing: Level shift detection.

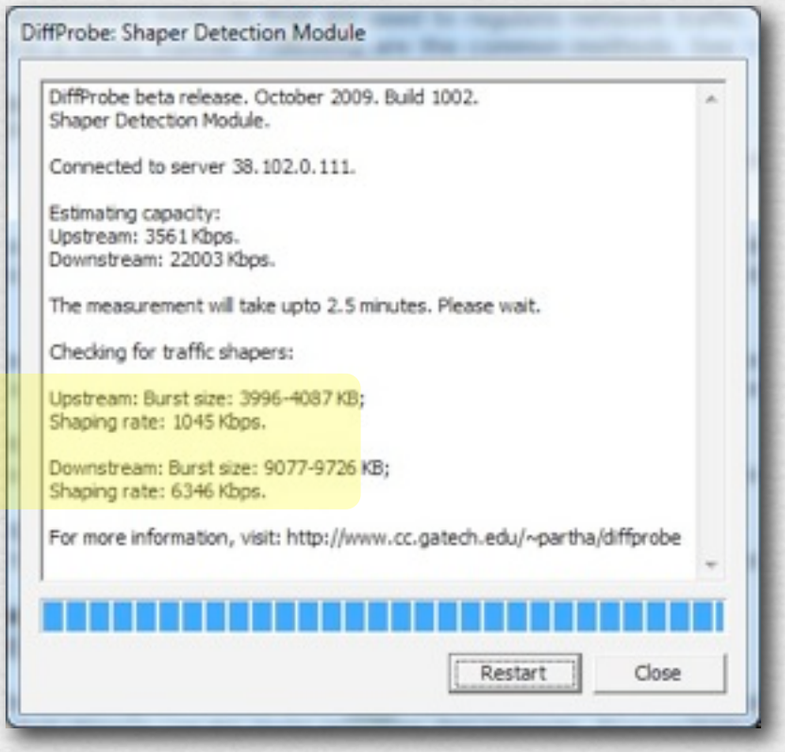
shaping rate (bps)

The ShaperProbe Service

MeasurementLab.org

- We run a service on M-Lab using 48 server replicas and a load balancer front end
  - servers connected to tier-1 ASes
- Open source client: supported on 3 platforms
- Currently 1500+ users a day





ShaperProbe users say...

ShaperProbe users say...

The measurement will take upto 2.5 minutes. Please wait.

Checking for traffic shapers:

Upstream: Burst size: 9548-9622 KB;
Shaping rate: 10714 Kbps.

Downstream: Burst size: 19371-19972 KB;
Shaping rate: 53274 Kbps.

For more information, visit: http://www.cc.gatech.edu/~partha/diffprobe

You can run ShaperProbe to get a more accurate idea of your speeds.
»www.measurementlab.net/measureme···iffprobe

ShaperProbe is actually meant to detect any shaping on your line, however because of that it runs tests for a longer time than any test site I know, resulting in a highly accurate reading.

I do know that I sustain ~2.8 MB/s via torrent or usenet when I've tried that to test. I haven't foun
eliable single-connection test as of yet (except for shaperprobe).

Some are more accurate than others. There's a tool called Shaperprobe that you can use, you can find a link to it from in here somewhere, that will give you the most accurate reading IMO.

to forum · permalink · · 2010-06-05 13:08:02 · reply

in my zip code to both
et at that moment, I was

sustaining my 16mbps on an 8mbps plan. Chatted online and yes the 50/10 was available, ordered and ultimately got it.

Yes the best way is for a large download going past the boost so above is my example. I have also found that shaperprobe seems to do a good job estimating both the boost and sustained levels.

»www.cc.gatech.edu/~partha/diffpr···robe.exe

reak

& P2P TIPS, TRICKS AND INFO.

It's the most accurate thing that I've come across to date other than
ransfers...

to forum · permalink · · 2010-03-24 18:57:00 · reply

Traffic Shaping with ShaperProbe

May 07, 09 by sharky 13,695 views

reply to K2NNJ
Flash based speed tests really haven't kept up with technology. Try ShaperProbe
»www.measurementlab.net/measureme···iffprobe

It will give you a good idea of your provisioned speed and your speed with Power Boost.
--
[Insert Comcast employee disclaim

recommended "Shaper Probe" is the good stuff. Real life transfers are of course the most accurate.
I have to agree there. ShaperProbe has been spot on every time I've tried it.

Shaping in ISPs: some observations

Overview of Data
(till Sept. 2010)

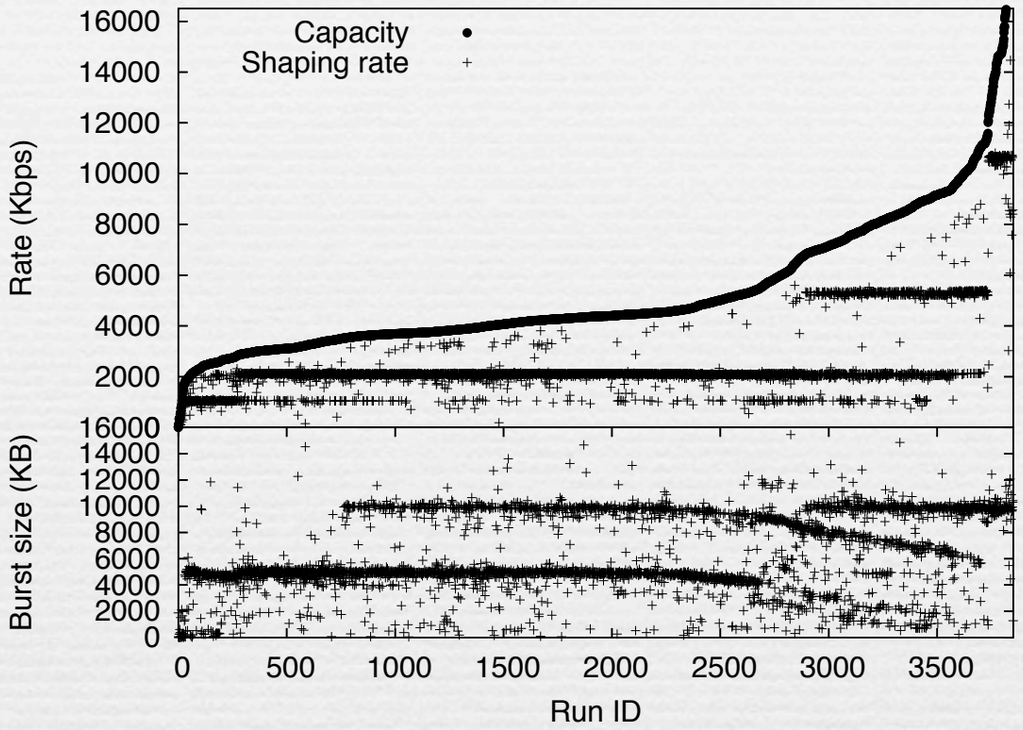
- M-Lab service has been up for a year (100k+ runs)
- We look at a subset of 37,540 runs from 2,000+ ASes
- Shaping detections in top-5 ASes in terms of runs:

ISP	Upstream (%)	Dwnstrm. (%)
Comcast	75.4 (3851/5105)	82.5 (3506/4248)
Road Runner	6.4 (69/1073)	63.3 (513/811)
AT&T	13.4 (114/849)	17.7 (125/707)
Cox	63.4 (399/629)	56.5 (252/446)
MCI-Verizon	5.1 (25/490)	7.3 (31/426)

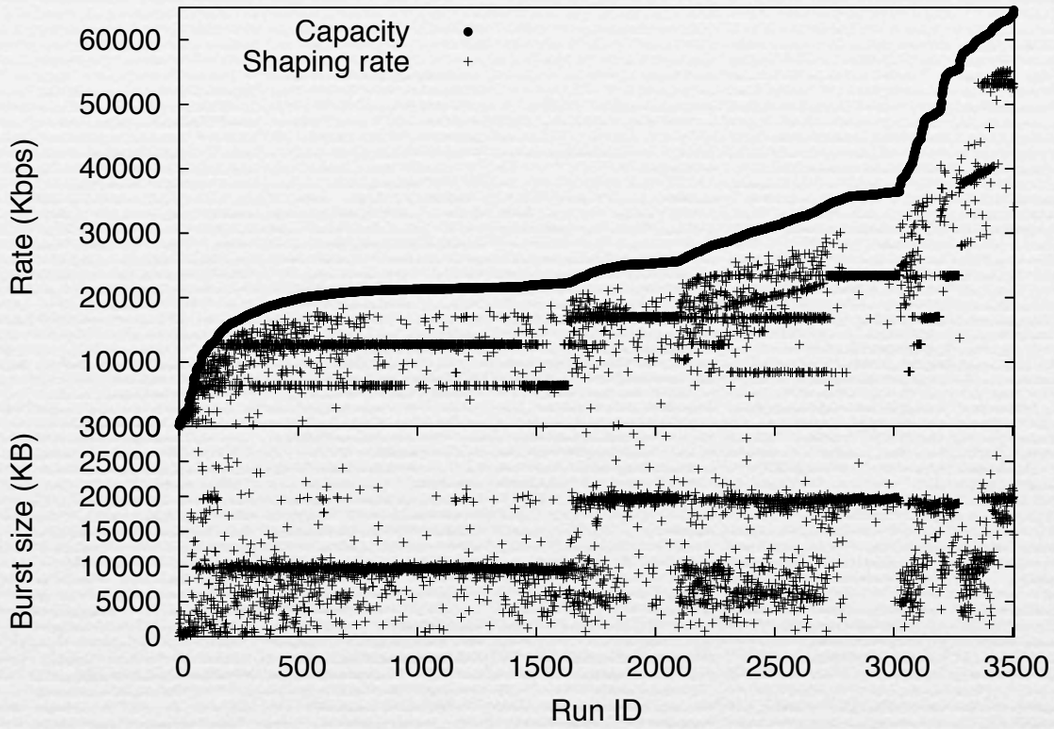
Shaping factors

- There isn't a "yes-no" answer to "Is my ISP shaping traffic?"
- Factors that affect shaping detections in an ISP:
  - tier of service
  - geographical region
  - link type: DSL? cable? Ethernet?
  - time-of-day
  - load conditions

Case study: Comcast



(a) Upstream.



(b) Downstream.

C (Mbps)	ρ (Mbps)	σ (MB)	Burst duration (s)
3.5	1	5	16.7
4.8	2	5, 10	15.2, 30.5
8.8	5.5	10	25.8
14.5	10	10	18.8

(a) Upstream.

C (Mbps)	ρ (Mbps)	σ (MB)	Burst duration (s)
19.4	6.4	10	6.4
21.1	12.8	10	10.1
28.2	17	20	14.9
34.4	23.4	20	15.3

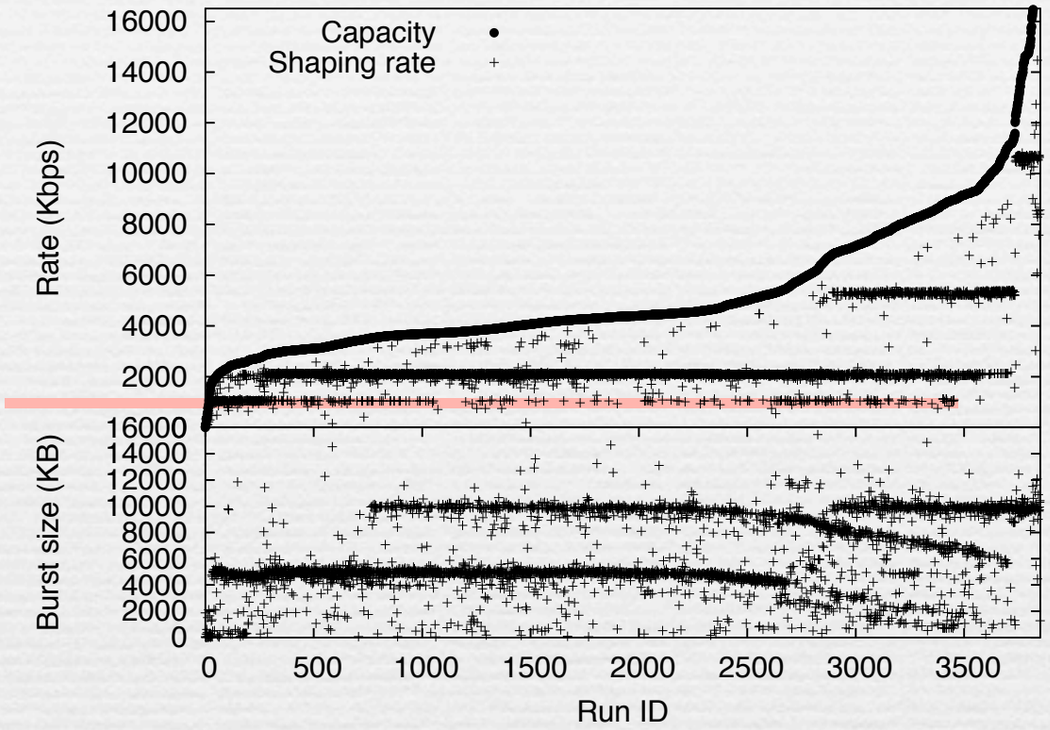
(b) Downstream.

Comcast Business Class Internet (May 12, 2010). `http://business.comcast.com/internet/details.aspx`.

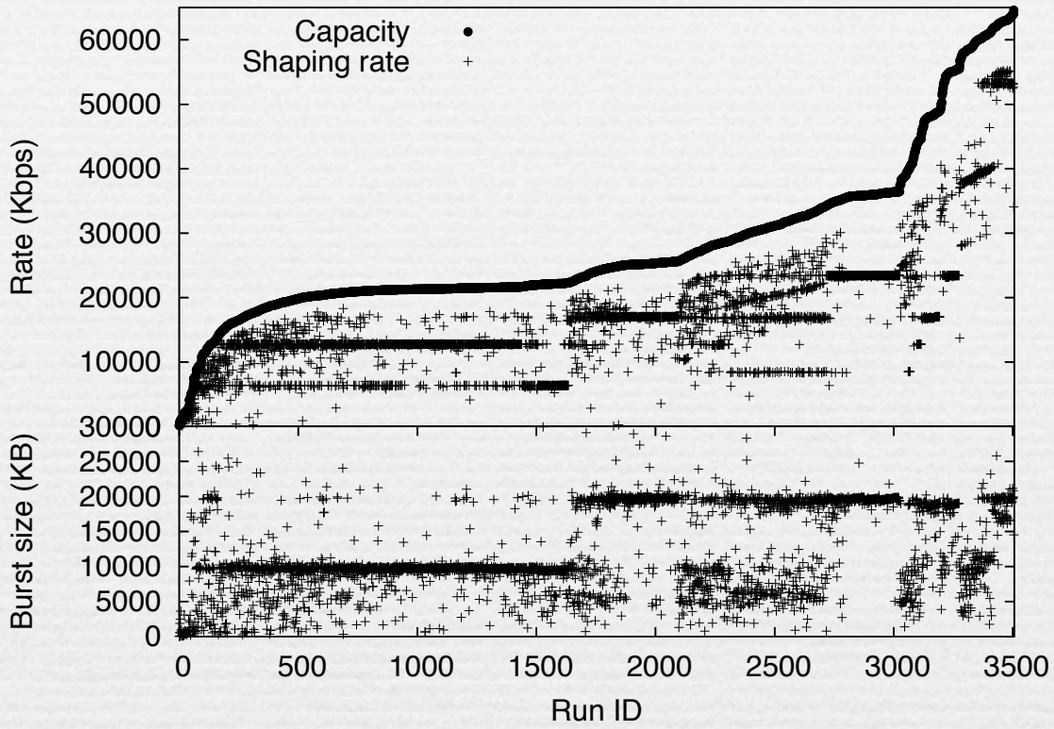
Comcast High Speed Internet FAQ: PowerBoost. `http://customer.comcast.com/Pages/FAQListViewer.aspx?topic=Internet&folder=8b2fc392-4cde-4750-ba34-051cd5feacf0`.

Comcast High-Speed Internet (residential; May 12 2010). `http://www.comcast.com/Corporate/Learn/HighSpeedInternet/speedcomparison.html`.

Case study: Comcast



(a) Upstream.



(b) Downstream.

C (Mbps)	ρ (Mbps)	σ (MB)	Burst duration (s)
3.5	1	5	16.7
4.8	2	5, 10	15.2, 30.5
8.8	5.5	10	25.8
14.5	10	10	18.8

(a) Upstream.

C (Mbps)	ρ (Mbps)	σ (MB)	Burst duration (s)
19.4	6.4	10	6.4
21.1	12.8	10	10.1
28.2	17	20	14.9
34.4	23.4	20	15.3

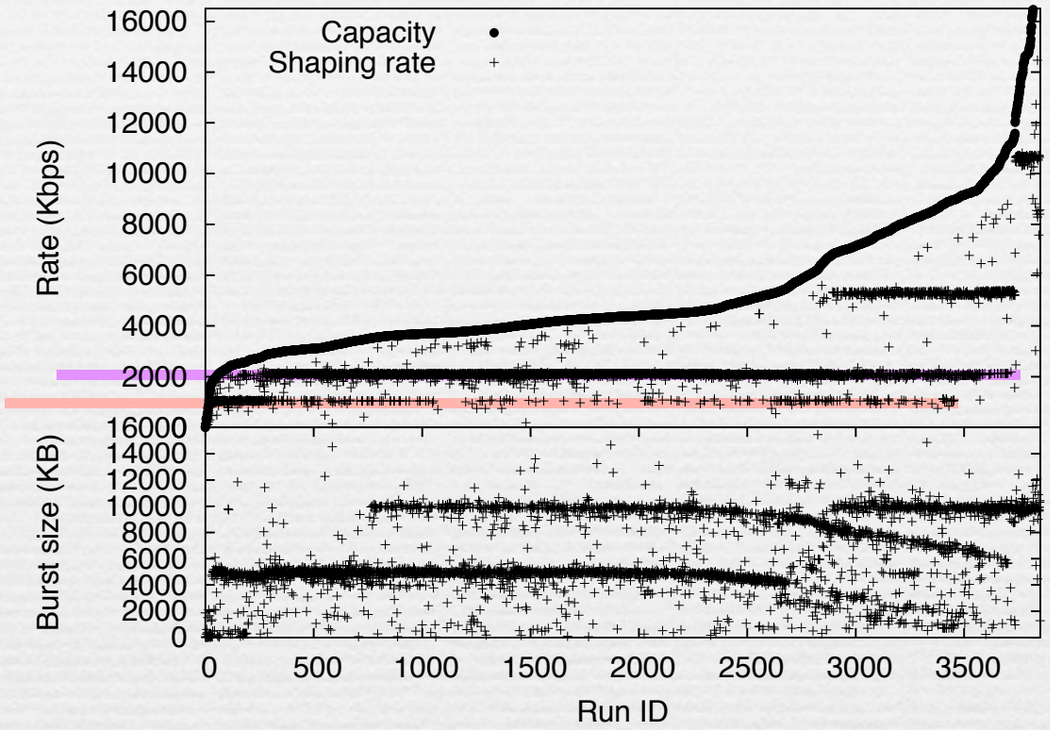
(b) Downstream.

Comcast Business Class Internet (May 12, 2010). `http://business.comcast.com/internet/details.aspx`.

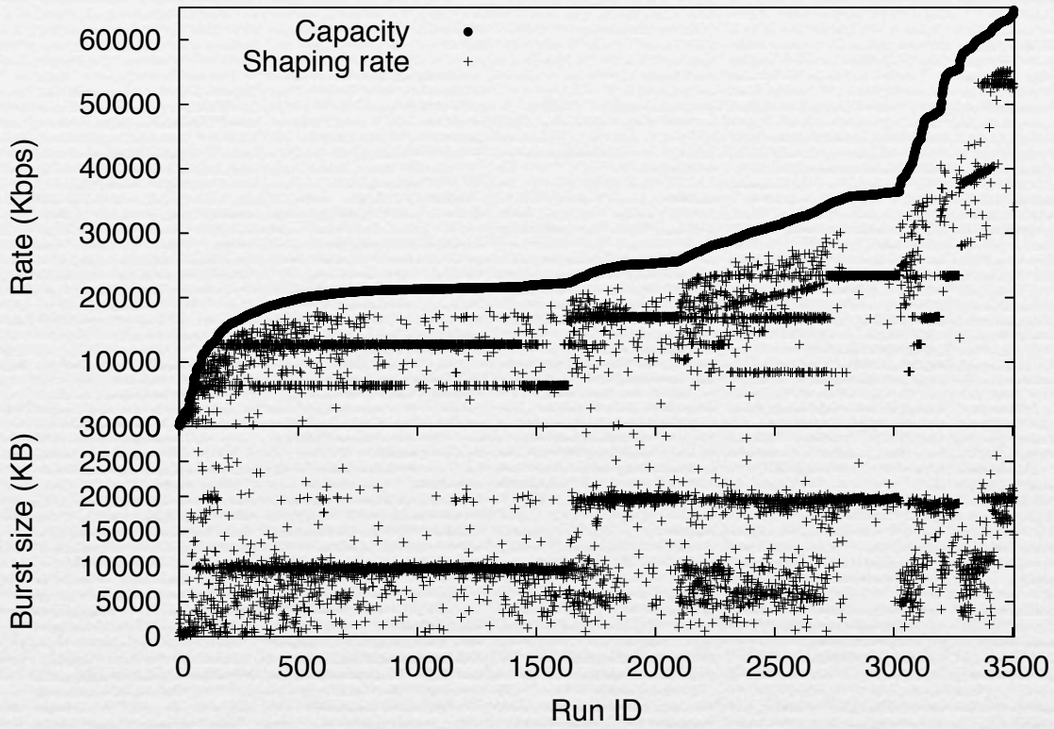
Comcast High Speed Internet FAQ: PowerBoost. `http://customer.comcast.com/Pages/FAQListViewer.aspx?topic=Internet&folder=8b2fc392-4cde-4750-ba34-051cd5feacf0`.

Comcast High-Speed Internet (residential; May 12 2010). `http://www.comcast.com/Corporate/Learn/HighSpeedInternet/speedcomparison.html`.

Case study: Comcast



(a) Upstream.



(b) Downstream.

C (Mbps)	ρ (Mbps)	σ (MB)	Burst duration (s)
3.5	1	5	16.7
4.8	2	5, 10	15.2, 30.5
8.8	5.5	10	25.8
14.5	10	10	18.8

(a) Upstream.

C (Mbps)	ρ (Mbps)	σ (MB)	Burst duration (s)
19.4	6.4	10	6.4
21.1	12.8	10	10.1
28.2	17	20	14.9
34.4	23.4	20	15.3

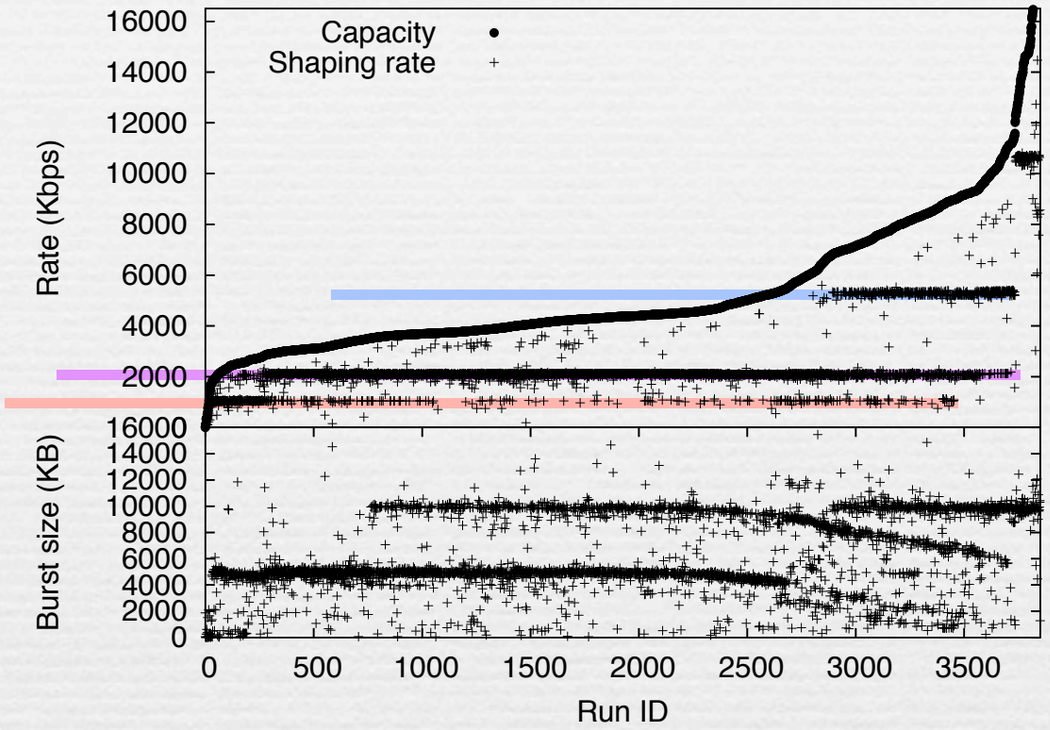
(b) Downstream.

Comcast Business Class Internet (May 12, 2010). `http://business.comcast.com/internet/details.aspx`.

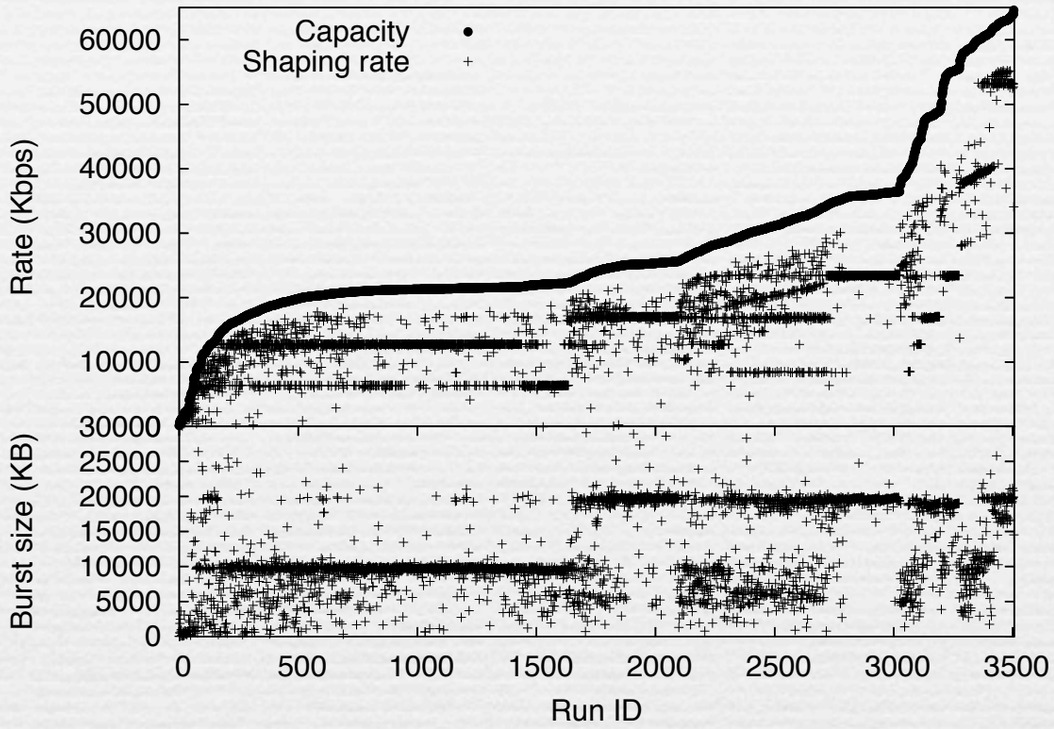
Comcast High Speed Internet FAQ: PowerBoost. `http://customer.comcast.com/Pages/FAQListViewer.aspx?topic=Internet&folder=8b2fc392-4cde-4750-ba34-051cd5feacf0`.

Comcast High-Speed Internet (residential; May 12 2010). `http://www.comcast.com/Corporate/Learn/HighSpeedInternet/speedcomparison.html`.

Case study: Comcast



(a) Upstream.



(b) Downstream.

C (Mbps)	ρ (Mbps)	σ (MB)	Burst duration (s)
3.5	1	5	16.7
4.8	2	5, 10	15.2, 30.5
8.8	5.5	10	25.8
14.5	10	10	18.8

(a) Upstream.

C (Mbps)	ρ (Mbps)	σ (MB)	Burst duration (s)
19.4	6.4	10	6.4
21.1	12.8	10	10.1
28.2	17	20	14.9
34.4	23.4	20	15.3

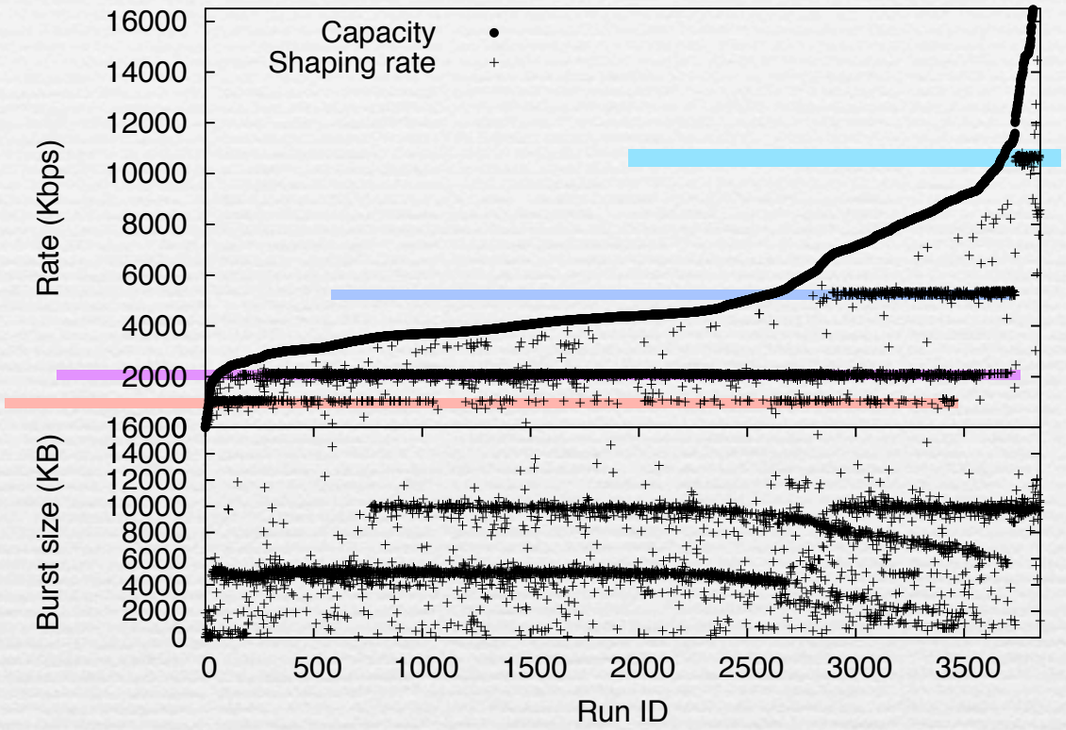
(b) Downstream.

Comcast Business Class Internet (May 12, 2010). `http://business.comcast.com/internet/details.aspx`.

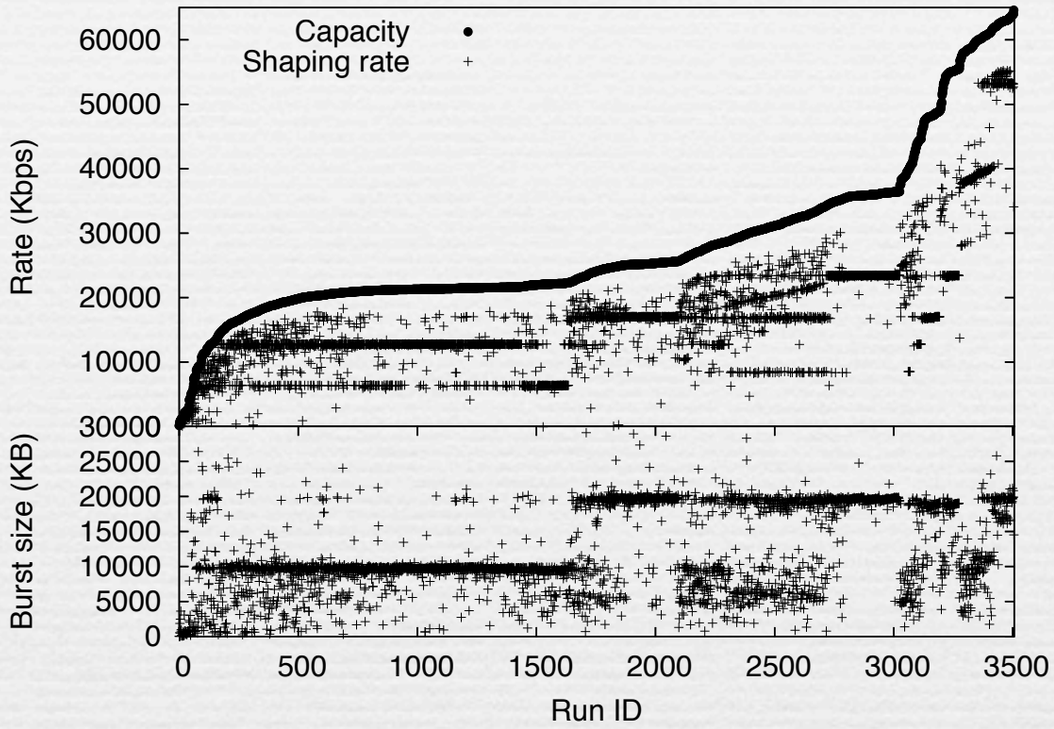
Comcast High Speed Internet FAQ: PowerBoost. `http://customer.comcast.com/Pages/FAQListViewer.aspx?topic=Internet&folder=8b2fc392-4cde-4750-ba34-051cd5feacf0`.

Comcast High-Speed Internet (residential; May 12 2010). `http://www.comcast.com/Corporate/Learn/HighSpeedInternet/speedcomparison.html`.

Case study: Comcast



(a) Upstream.



(b) Downstream.

C (Mbps)	ρ (Mbps)	σ (MB)	Burst duration (s)
3.5	1	5	16.7
4.8	2	5, 10	15.2, 30.5
8.8	5.5	10	25.8
14.5	10	10	18.8

(a) Upstream.

C (Mbps)	ρ (Mbps)	σ (MB)	Burst duration (s)
19.4	6.4	10	6.4
21.1	12.8	10	10.1
28.2	17	20	14.9
34.4	23.4	20	15.3

(b) Downstream.

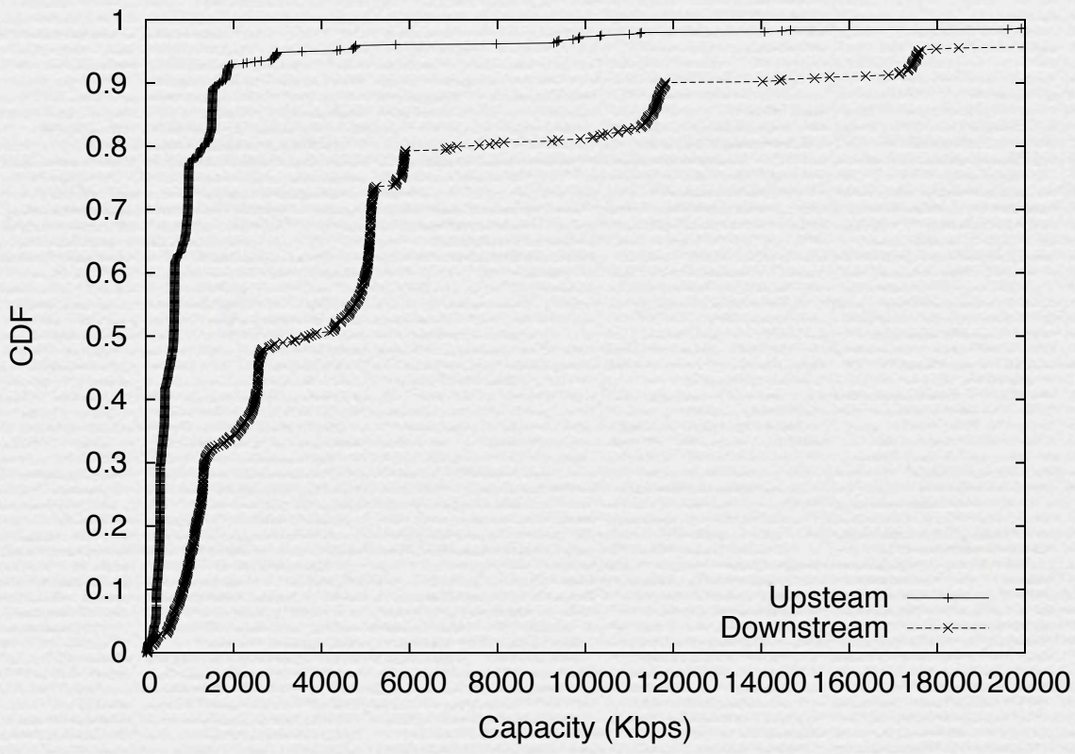
Comcast Business Class Internet (May 12, 2010). `http://business.comcast.com/internet/details.aspx`.

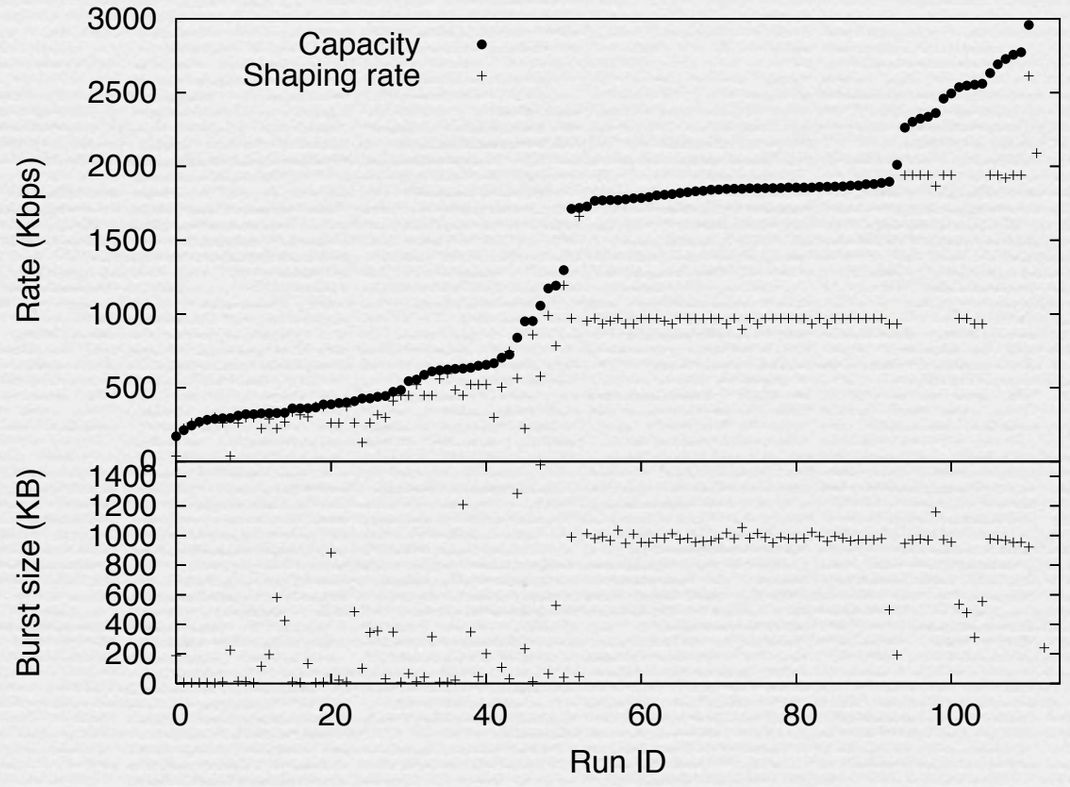
Comcast High Speed Internet FAQ: PowerBoost. `http://customer.comcast.com/Pages/FAQListViewer.aspx?topic=Internet&folder=8b2fc392-4cde-4750-ba34-051cd5feacf0`.

Comcast High-Speed Internet (residential; May 12 2010). `http://www.comcast.com/Corporate/Learn/HighSpeedInternet/speedcomparison.html`.

Case study: AT&T

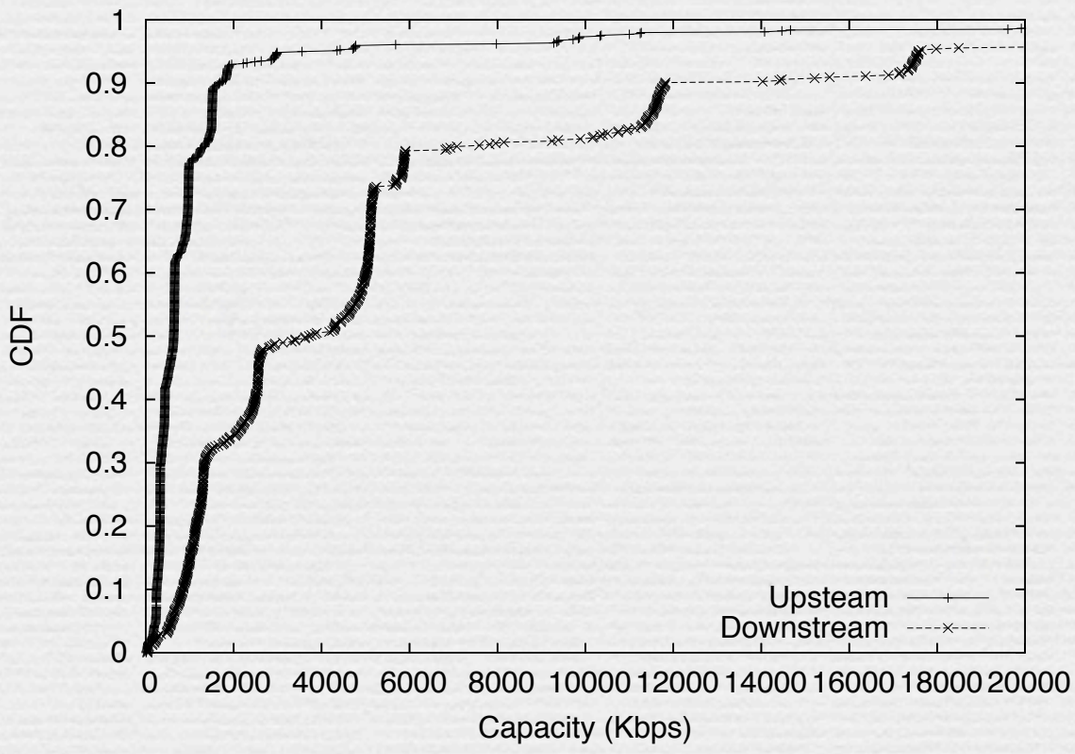
- Few shaping observations: 13-18% runs
- ~60 runs show shaping modes => from Mediacom (domain `mchsi.com`)

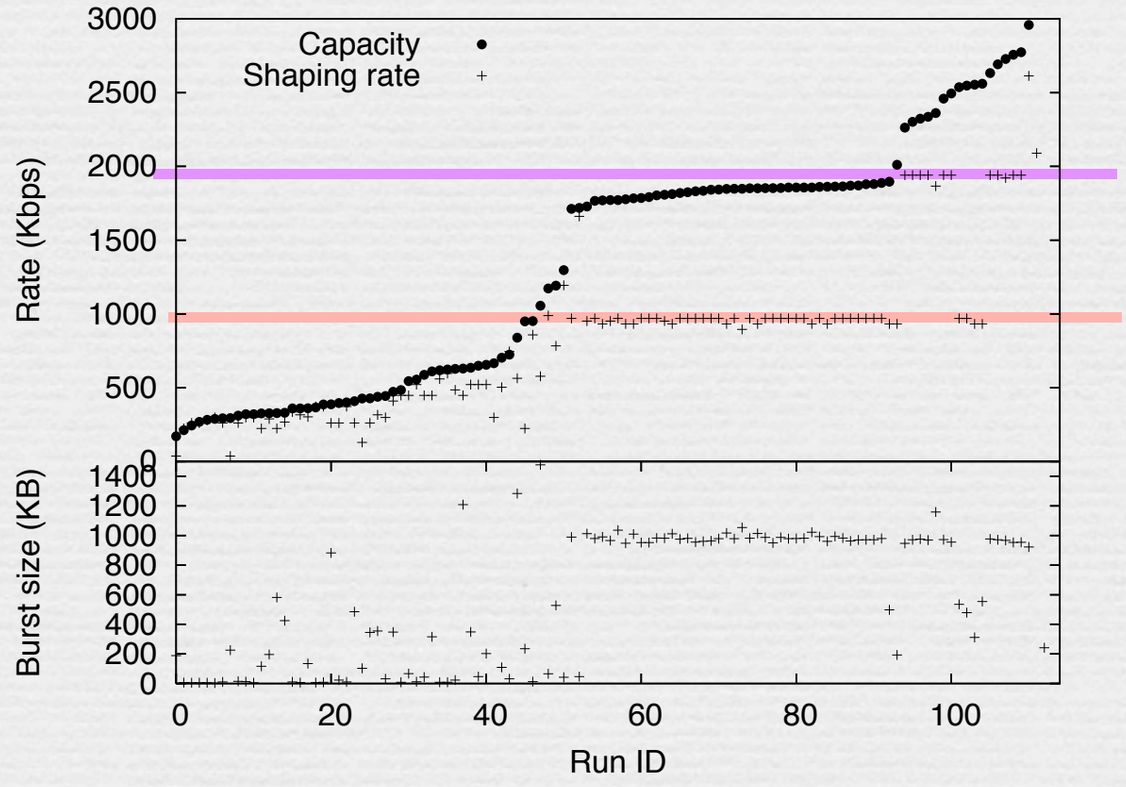




Case study: AT&T

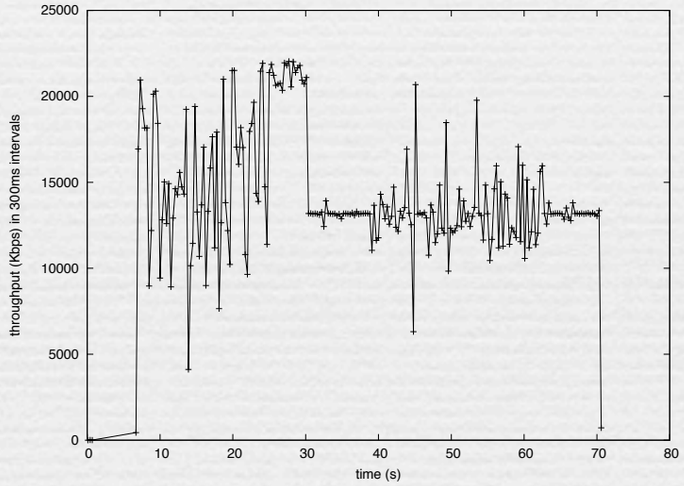
- Few shaping observations: 13-18% runs
- ~60 runs show shaping modes => from Mediacom (domain `mchsi.com`)

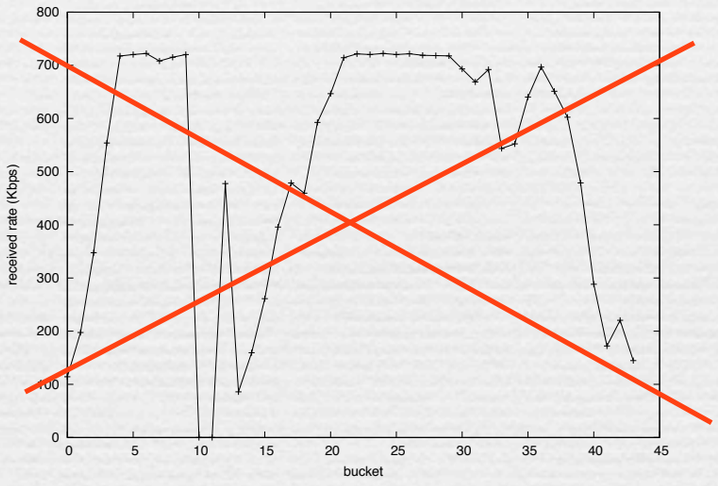




et cetera

- Designed end-to-end shaping detection methods using passive observation





comcast

TCP recovery

- Looking into app-performance optimization using estimates: plug-in for vuze (150m+ users)

Pythia:
Detection, Localization and Diagnosis of performance problems

Joint work with Constantine Dovrolis, Sajjad Zarifzadeh and Madhwaraj G.

Pythia

- Distributed monitoring system for wide-area performance problems
  - not failures (boolean)
- Monitoring: e2e active probing measurements from perfSONAR (Internet2, ESnet, ...):
  - topology (data plane): traceroutes
  - one-way delays, losses, bandwidth (capacity, throughput) ...
- Funded by DoE

Detection

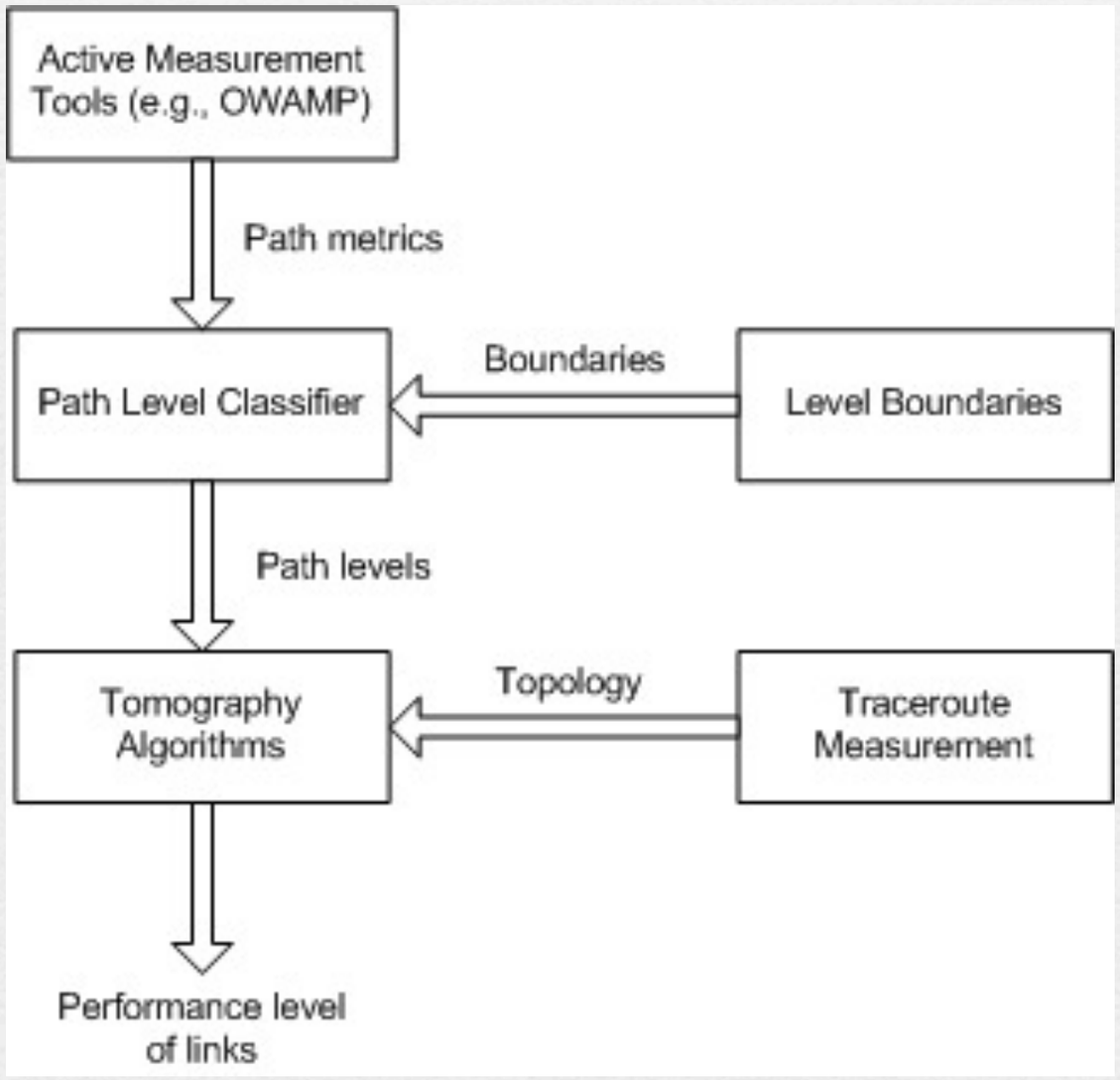
- "Is there a problem on path X right now?"
  - noticeable loss rate, increase in delays, ...
  - look for primitives: level shifts, outliers, etc.
  - algorithms being developed

Localization

- "Which link(s) caused the performance problem?"
- Find smallest set of **bad** link(s) that caused the problem
- Quantify performance into multiple **levels:** {good, ..., moderate, ..., bad}
- Account for case of multiple bottlenecks on path

Localization

- Tech report available: "Localization of Network Performance Problems with Multi-level Discrete Tomography," Sajjad Zarifzadeh, Constantine Dovrolis, 2011.



Diagnosis

- "What is the problem?"
- e.g., insufficient/excessive buffer, routing configuration, faulty devices, duplex mismatch, ...
- approach: machine learning
- work in progress

Troubleshooting Home Wireless Networks

Joint work with Constantine Dovrolis (GATech) ,Dina Papagiannaki (Intel Labs), Peter Steenkiste and Srini Seshan (CMU)

Home Wireless Networks

- Focus on performance problems in 802.11 networks

802.11 pathologies:
- Low signal strength
- Cross traffic
- Hidden terminals
- Non-802.11 interference

Userlevel Diagnosis

- Goal: design a tool that allows home users to do root-cause diagnosis (potentially suggest solutions)
- We operate at the application layer (layer-3)
  - no administrative/root access requirements
  - no NIC/vendor-specific requirements
- Work in progress: in collaboration with Intel Research Pittsburgh and CMU

Approach

- Understand how different packet probing structures interact with 802.11
  - packet pairs, trains, etc.
- Probing structures allow us to distinguish between pathologies
- Cooperative diagnosis localizes the problem

Thank You!

partha @ cc . gatech . edu

End-to-end Methods for

Traffic Shaping Detection, Performance Problem Diagnosis, Home Wireless Troubleshooting

Georgia Institute of Technology

MeasurementLab.org

Carnegie Mellon

Implementing ShaperProbe

- **Non-intrusiveness**: abort probing if we see losses
- Probing **stability**: send small trains if we cannot sleep for short periods (e.g., <15ms on Win32)
- 802.11 **wireless**: extended capacity estimation phase using a longer train
- **Noise** in received rate: we "smooth" measurements

Accuracy

- Wide-area experiments: Comcast to/from GT
- Emulate traffic shaping in front of the modem