

95th Percentile Billing

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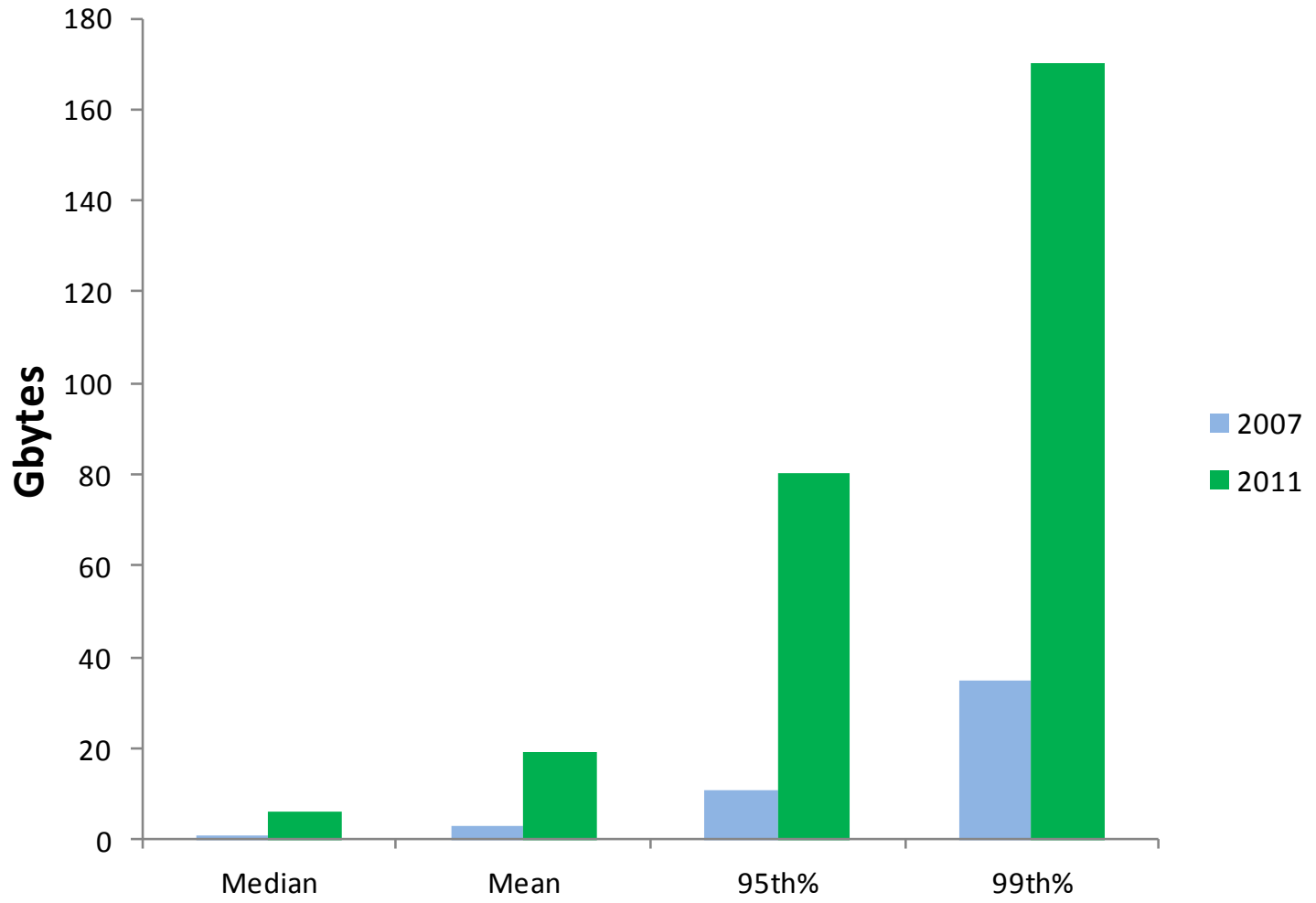
Nanog53 Philadelphia, PA

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Outline

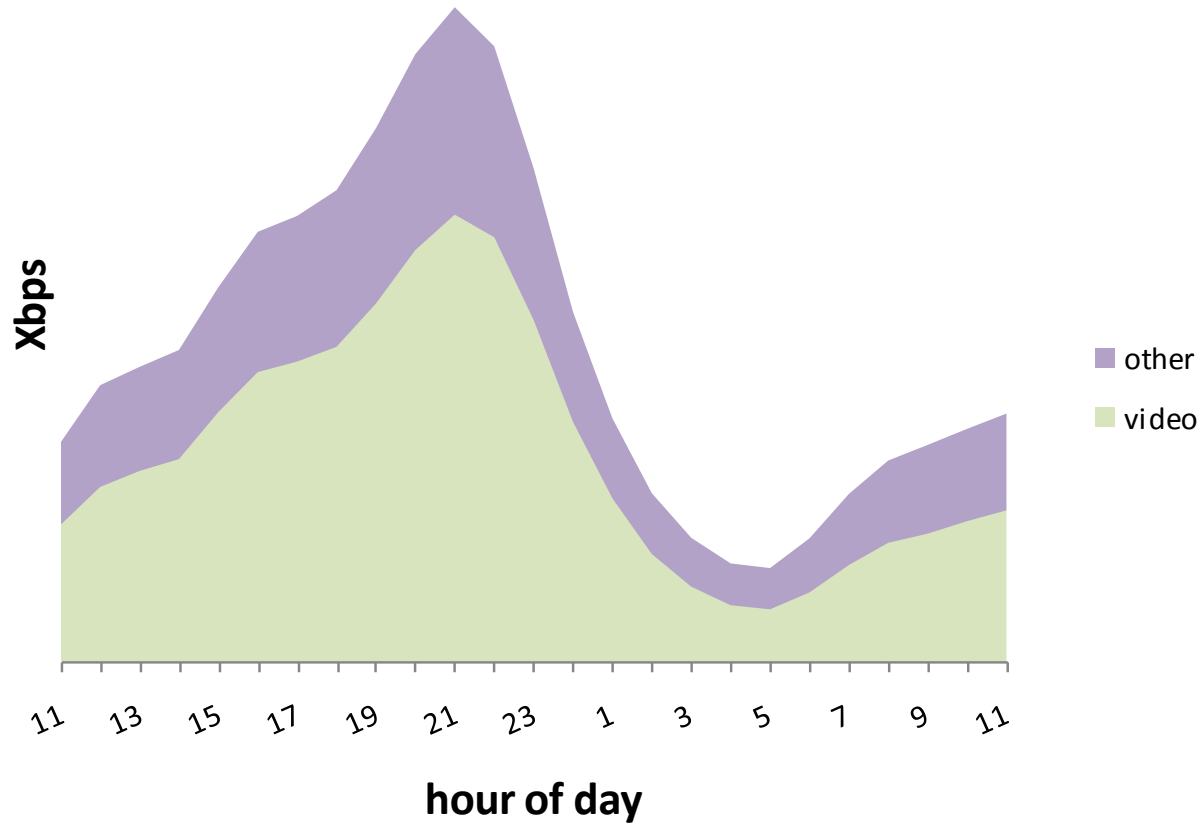
- Internet access usage trends and consumption based pricing
- Background on 95th percentile billing
- Conversion from monthly 95th % Mbps to volume
- Traffic 'peakedness' and impact on cost per unit volume
- Consequences of billing policy
- Two sided market

Monthly Broadband Consumer Usage



What is causing intra-day peakedness in traffic?

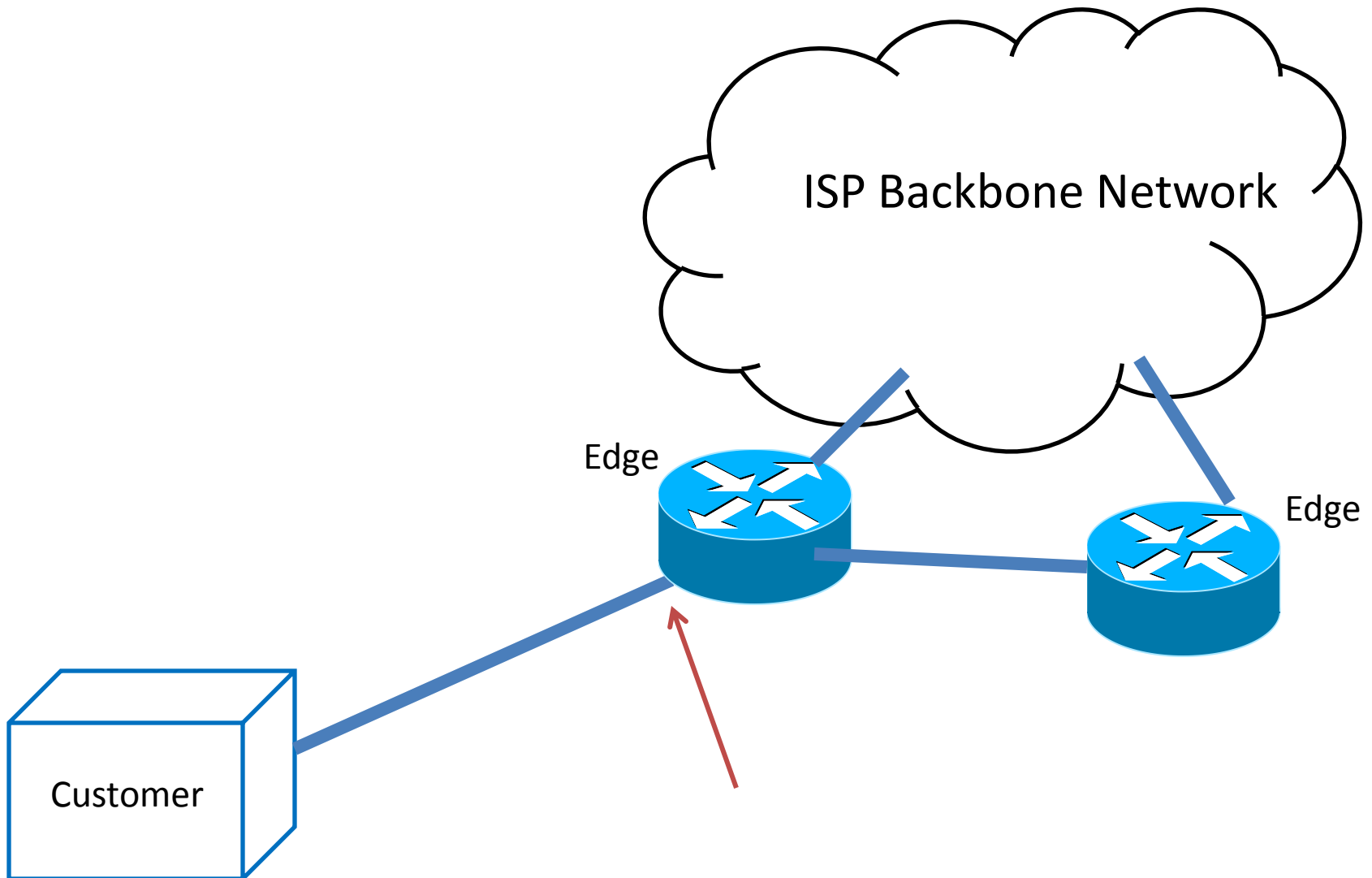
OTT Video Over 70% of Peak Period Bandwidth



95th% Billing Explained

- What is the 95th % billing? How is it computed?
 - Measure interface bandwidth every 5 minutes for the month (12 per hour, 288 per day, 8640 for 30 days)
 - Sort measurements from largest to smallest
 - Throw away top 5% of values (432)
 - 36 hours per month or 1.2 hours per day for which there is no billing
 - Remaining value is the 95th % in Mbps. Customer charged based on this value

Location of Measurements



original measurements

16.45
16.37
16.67
16.34
16.59
16.52
16.61
16.55
17.02
17.51
17.84
18.18
18.42
18.89
18.97
19.16
19.27
19.61
19.60
19.60
19.02
19.73
19.60
19.67
19.40
18.91
19.09
19.18
19.31
19.42

8640 values



sorted measurements

30.97
30.88
30.72
30.70
30.66
30.65
30.64
30.48
30.37
30.05
29.94
29.93
29.89
29.87
29.81
29.70
29.69
29.59
29.57
29.36
29.33
29.28
29.28
29.24
29.24
29.21
29.19
29.03
29.03
28.95

8640 values

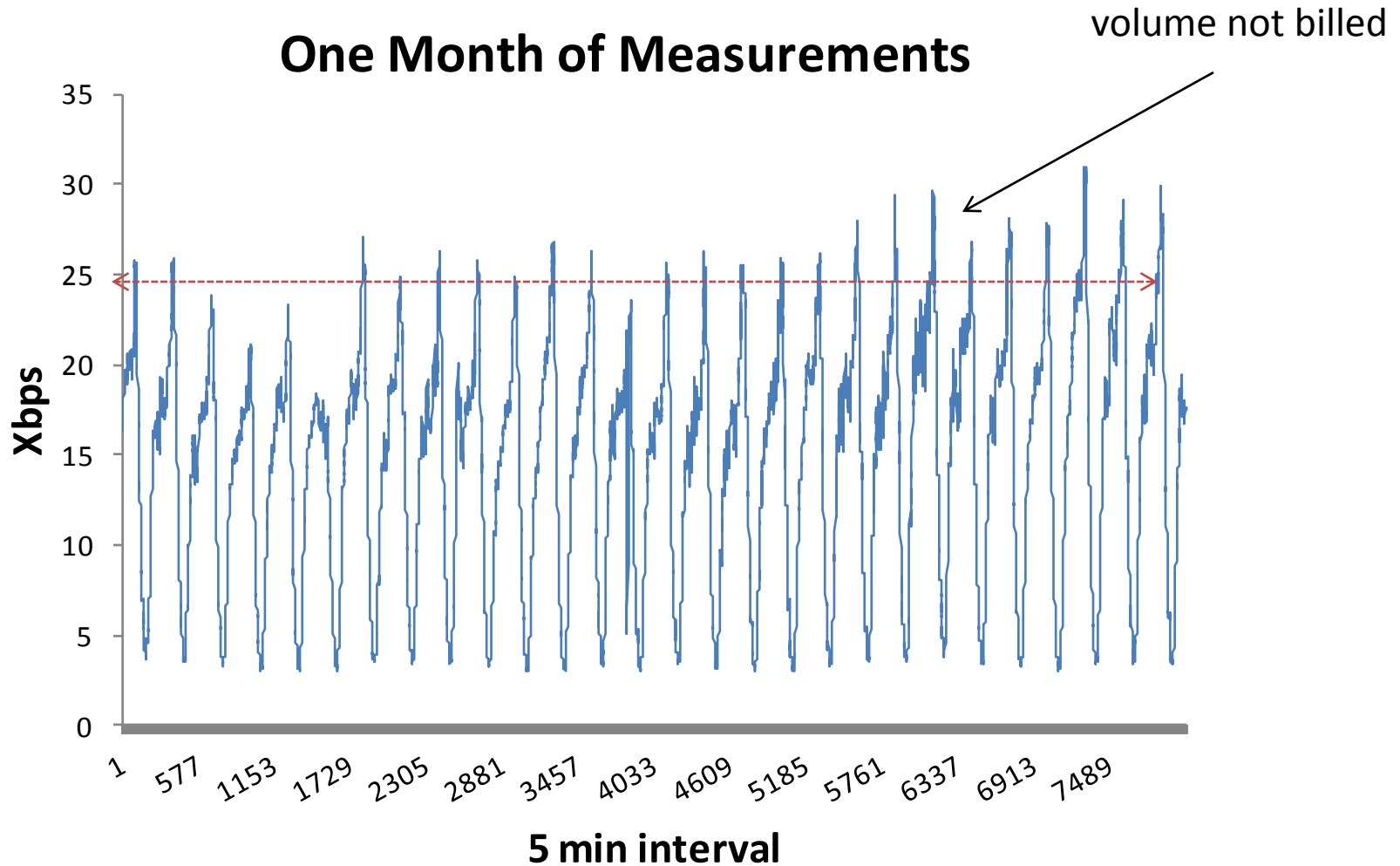


bottom 95th% measurements

24.90
24.89
24.88
24.88
24.88
24.88
24.87
24.87
24.86
24.86
24.86
24.86
24.83
24.83
24.83
24.83
24.83
24.82
24.82
24.82
24.82
24.82
24.82
24.82
24.80
24.78
24.78
24.78
24.78
24.76
24.76
24.75
24.75

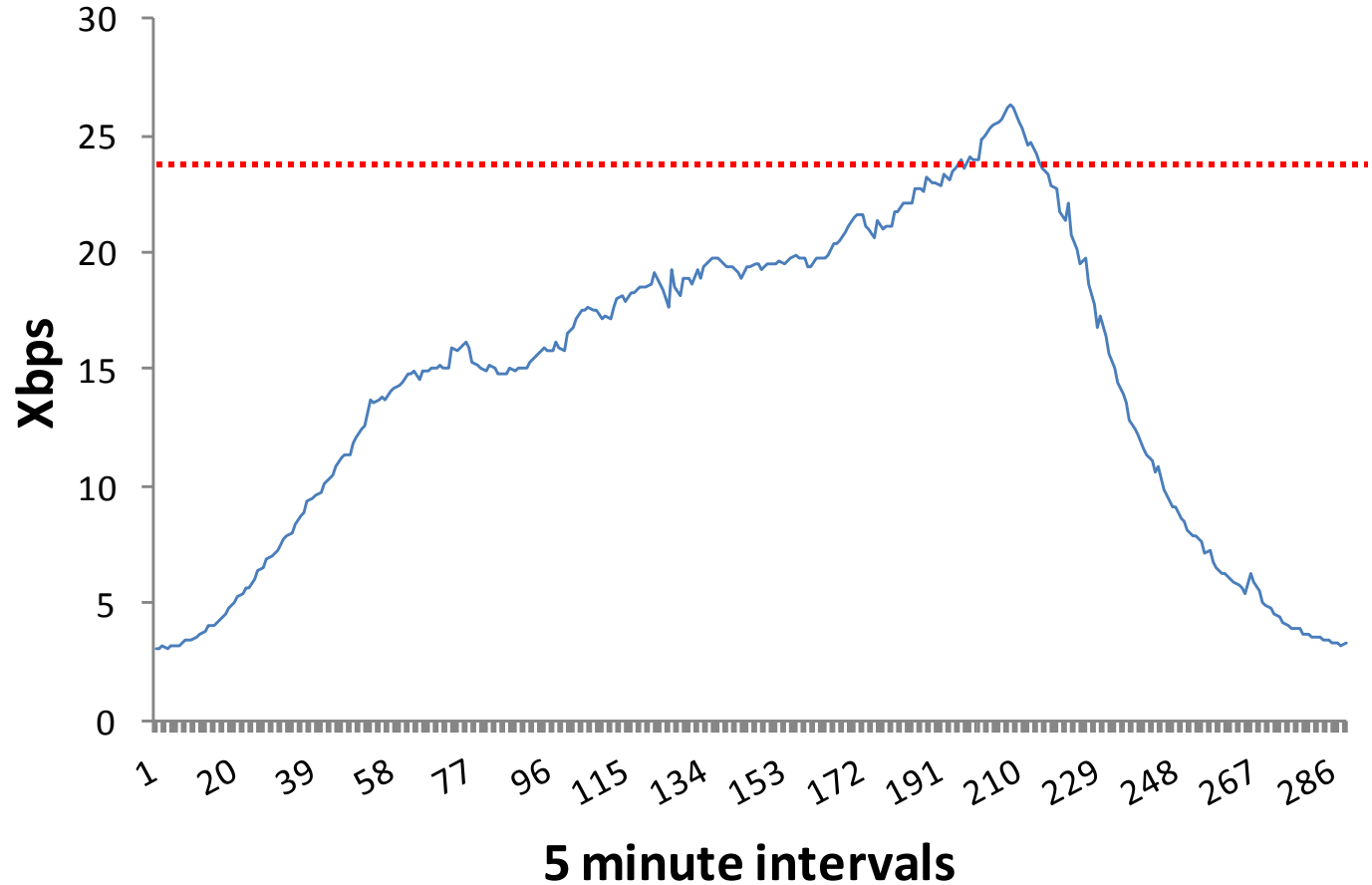
8208 values

One Month of Measurements



95th % is 25, max of 31, average of 15

Closer Look at One Day



Max = 26.3

Mean = 14.6

95th % = 24.1

Ratio of 95th % to mean = 1.6

Max is 1.10% of 95th % value

Estimate Monthly Volume from 95th % Mbps (Reconcile Bandwidth and Volume Measurements)

- Start with 95th % measurement of X Mbps
- Divide by 95th%/mean ratio for that interface, suppose 1.8
- $X/1.8$ is the *average* Mbps for entire month
- Divide by 8 (bits per byte), $X/1.8/8$ is average Mbytes per second
- Multiply by seconds in a month ($3600*24*30$) 2.592 M
- Volume is $(X/1.8/8)*2.592M$ Mbytes
- Divide by 1024 to compute Gbytes or $1024*1024$ for Tbytes

Price Conversion Example

- Calculate price paid / volume
- Start with 100 Mbps 95th%
- Average is = $100/1.8 = 55.6$ Mbps
- $55.6/8 = 6.9$ Mbytes per second
- $6.9 * 2.592M = 18000000$ Mbytes =
 $18000000/1024 = 17578$ Gbytes = 17.2 Tbytes
- Suppose billed price is \$3 per Mbps
- Price charged is $100 * \$3 = \300
- Price per Gbyte = $\$300/17578$ Gbytes = 1.7 cents

Monthly * Volume and Price per Gbyte

The price paid per Gbyte (in cents) depends on the ratio of the 95th % to mean and the price paid per monthly 95th% Mbps.

Ratio of 95th% to mean

		1	1.25	1.5	1.75	2	2.25
Price Per Meg	\$1	0.32	0.40	0.47	0.55	0.63	0.71
	\$2	0.63	0.79	0.95	1.11	1.26	1.42
	\$3	0.95	1.19	1.42	1.66	1.90	2.13
	\$4	1.26	1.58	1.90	2.21	2.53	2.84
	\$5	1.58	1.98	2.37	2.77	3.16	3.56

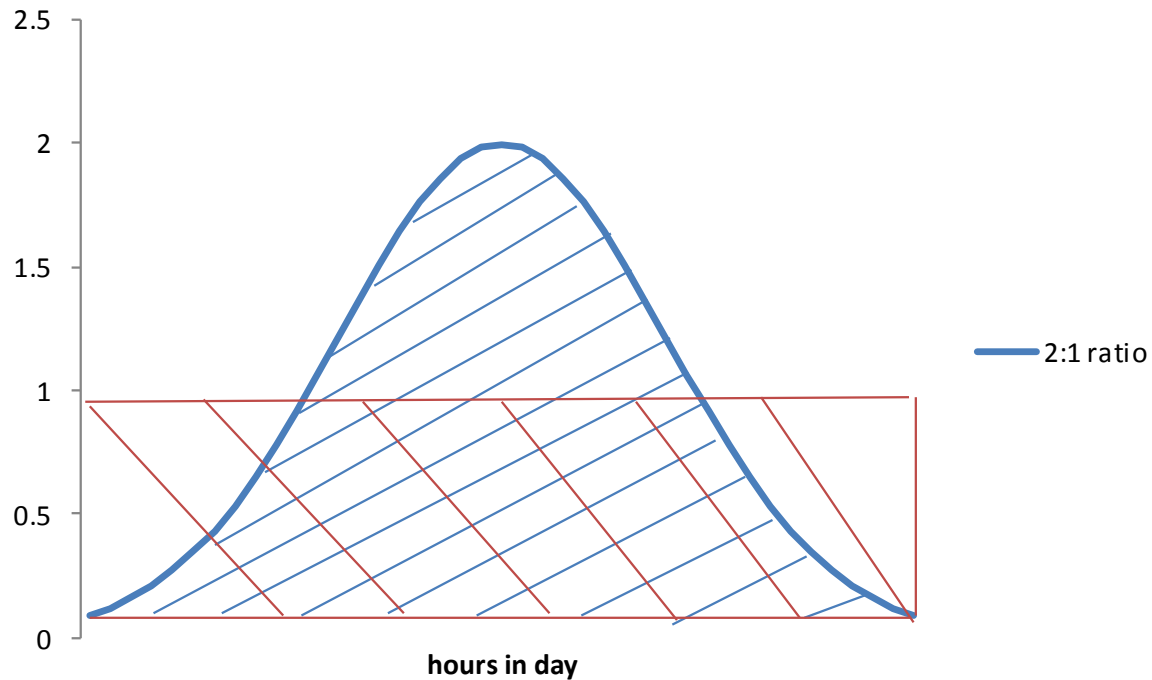
Gbytes delivered per month for 95th % of 1 Mbps. Varies with peakedness.

		1	1.25	1.5	1.75	2	2.25
Gbytes		316	253	211	181	158	141
Efficiency		100%	80%	67%	57%	50%	44%

best you can do

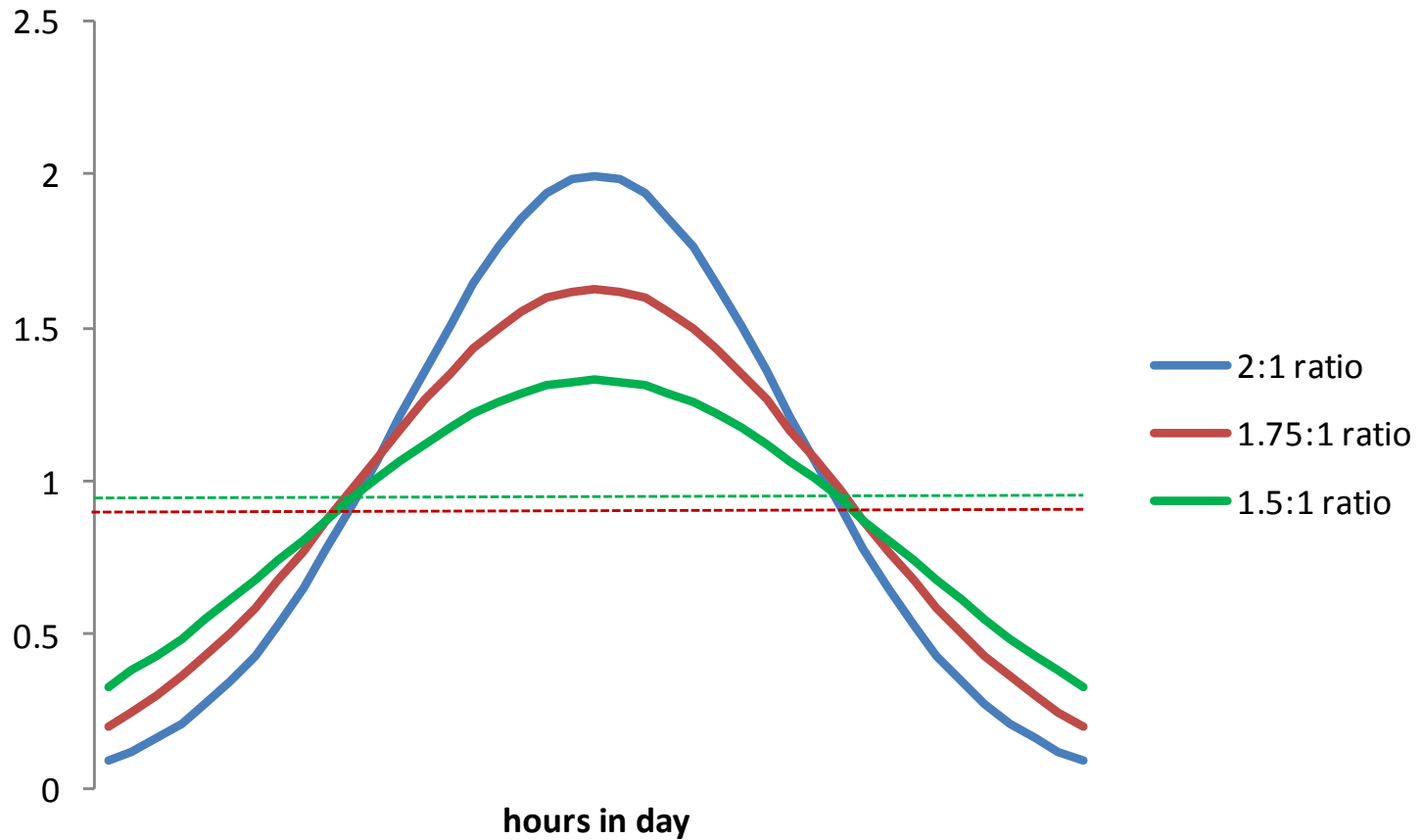
more typical, less efficient

Same Daily Volume Varying 'Efficiency' due to Peakedness

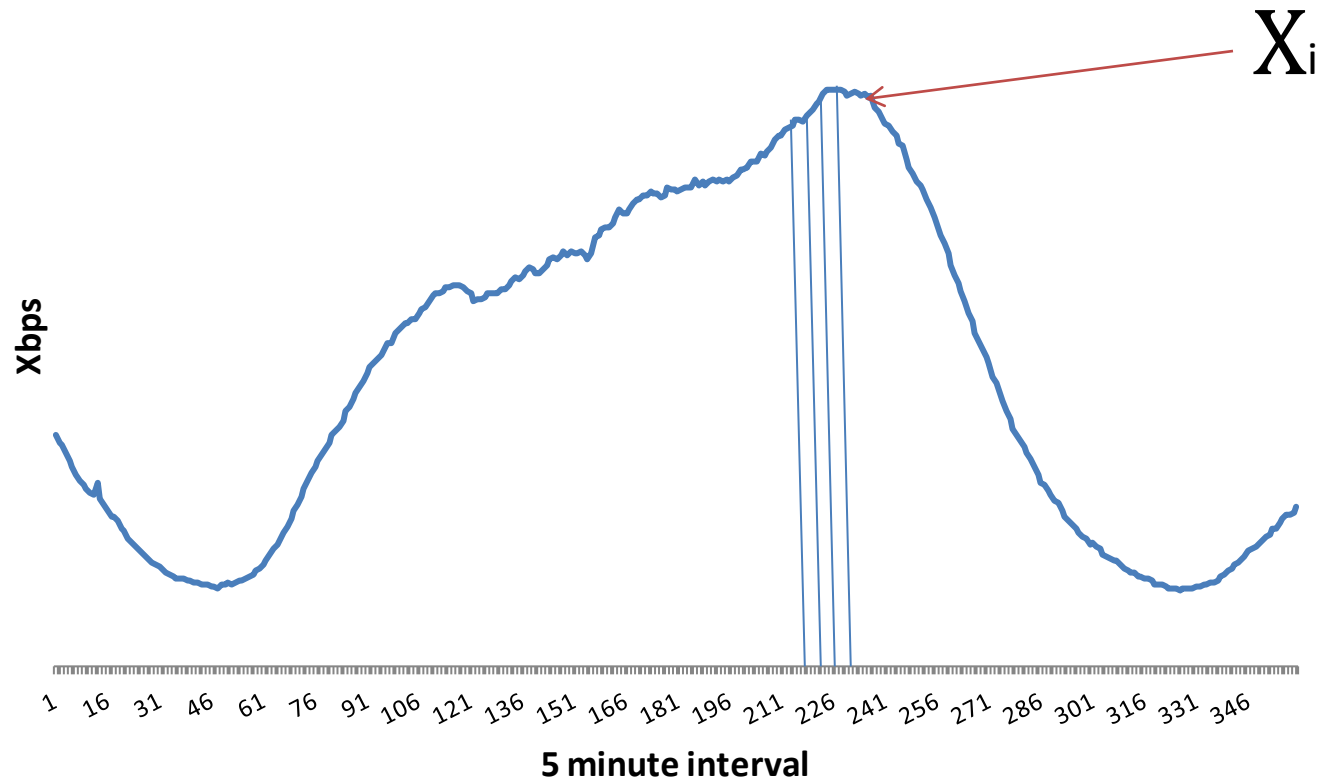


Area (proportional to volume of data transferred in bytes) under blue curve = area of red rectangle

Approximately Same Daily Volume Varying Peakedness (Price Paid)



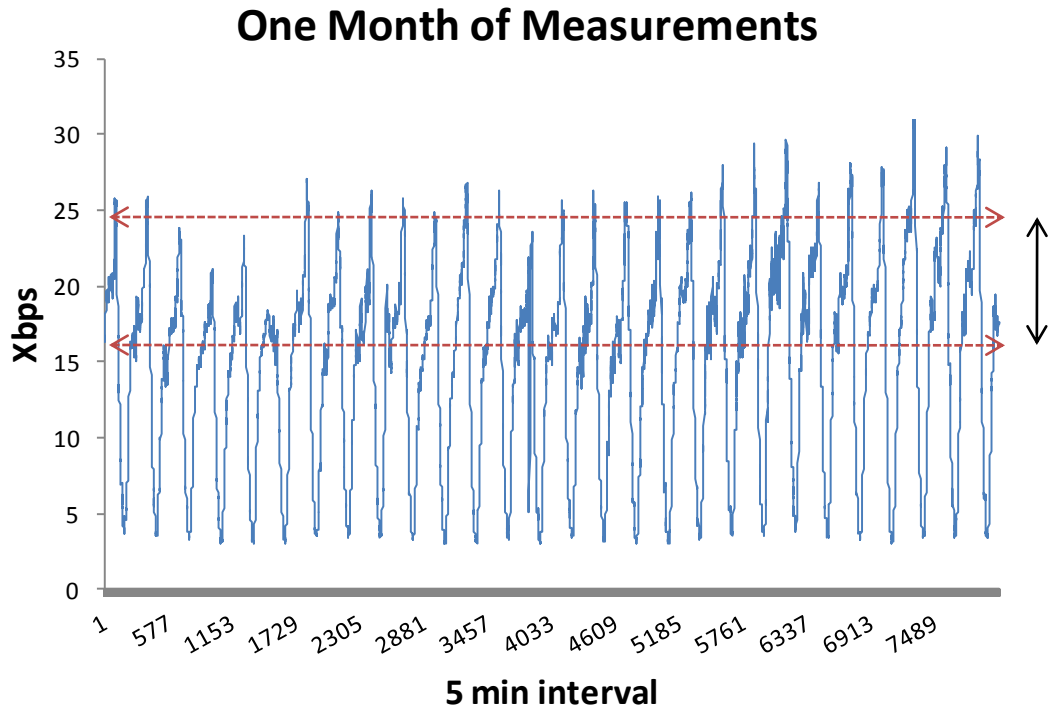
Monthly Volume



$$n * \left(\underbrace{\left(\sum_{i=1}^n (X_i / 8) * 300 \right) / n}_{\text{average}} \right)$$

average

Reduction in Variability Reduces Costs



The closer the 95th % is to the mean, the lower the cost per volume. Objective for customer of 95th% billing is to mitigate peakedness.

95th % = 24.9

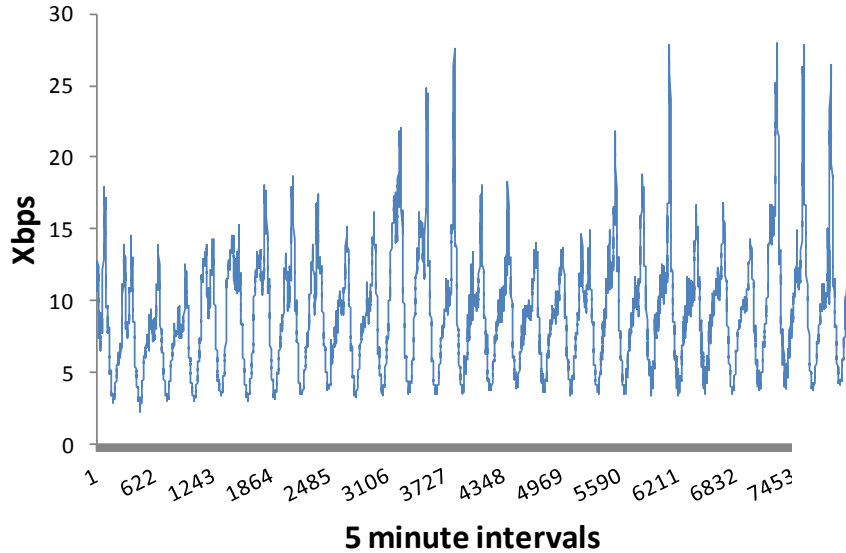
Mean = 14.8

Ratio of 95th to mean = 1.7

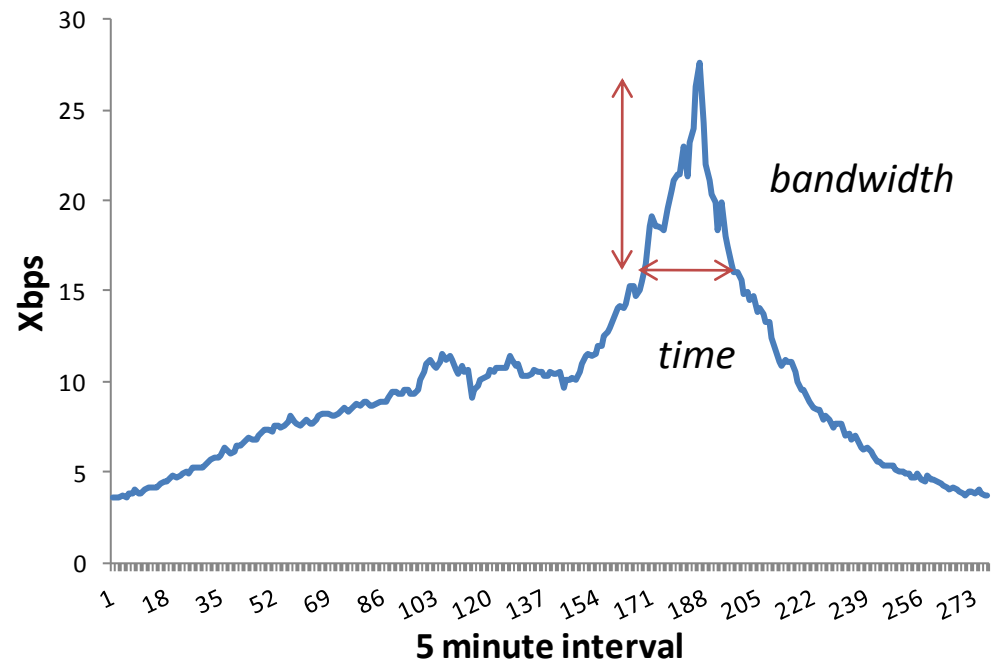
Volume not billed for is 9% of total volume (percentage above 95th % line).

Consequences of 95th % Billing Policy

Example Bandwidth



One month of data – closer
Look at one day. Peak to mean
3:1, typically closer to 2:1
for natural traffic.



$$\text{time} * \text{average bandwidth} / 8 = \text{volume}$$

Two Sided Market

- Assume a moderately fast internet service at 6-20 Mbps.
- Current pricing (non-promotional) @ \$50 per month.
- For a heavy video user customer downloading 150 Gbytes per month, the price paid per consumed Gbyte is 33 cents ($5000/150$)
- Content provider pays $\frac{1}{2}$ to 3 cents per Gbyte (\$1 - \$5 per 95th % Mbps)
- Residential internet consumer paying over 95%+ of the price per delivered Gbyte

Summary

- Content delivery providers must accommodate bandwidth intensive video with a distinct time of day pattern
- Objective of content provider is to minimize cost per Gbyte delivered
- Objective of internet service and transit providers is to recover costs, maintain profitable service, and maintain predictability in traffic patterns to ensure capacity and performance
- The combination of peaked traffic and billing practices presents a challenge to both content and transit providers
- Is 95th % billing transparent enough and reconcilable with the trend towards per unit volume billing for consumers?