Broadband Benchmarking: On the FCC Issues for Inquiry

Paper #0, 5 Pages

Abstract

The Federal Communications Commission (FCC) has recently taken major decisions in an attempt to regulate broadband usage and deployment in the US. One such policy is setting the broadband speed threshold to 25 Mbps/3 Mbps, based on aggregate measurements performed throughout the country. Furthermore, the Commission also requests comments on issues pertaining to defining "advanced telecommunication capabilities" to design benchmarks based on metrics other than broadband speed.

In this work, we provide a much required input to the FCC's open questions, supported by measurements and analysis of usage patterns rather than just speed benchmarks. We analyse users with high tier access links and motivate the need of multiple speed benchmarks based on peak usage of different types of users. We also show that beyond a certain speed, user behavior is not significantly impacted by further increases in broadband capacity, thus motivating the need to define benchmarks based on metrics other than broadband speed to truly offer "advanced" capabilities.

1 Introduction

With the large impact of broadband Internet in daily lives, the high speed of its evolution and capabilities, and the exponential increase in services, it is imperative that all interested parties, such as the transit and content providers, collaborate to satisfy the broadband demands of the user. The Federal Communications Commission (henceforth FCC) holds the important responsibility of overlooking public and private sector initiatives to ensure advanced broadband deployment throughout the US. As part of this responsibility, the FCC has been reporting results of its annual inquiry regarding the availability and timely deployment of "advanced telecommunications capability" to all Americans, since the amendment to the Telecommunications Act of 1996 (section 706 [2]) [1].

If the FCC determines that *"advanced telecommunications capability"* is not being deployed to all Americans in a reasonable and timely fashion, the Commission is required to "take immediate action to accelerate deployment of such capability by removing barriers to infrastructure investment and by promoting competition in the telecommunications market." [2]. Thus, the FCC follows a three step program: (a) *define the benchmark* of "advanced telecommunications capability", (b) *audit the capability* of services offered by Internet Service Providers (henceforth ISPs), and (c) *spend the federal budget* on increasing ISP capabilities, to accomplish their defined standards.

As independent researchers in the measurement community, it is our responsibility to ensure that the FCC defines broadband benchmarks and standards in a sensible manner. Until recently, efforts to define such benchmarks were based on aggregated data analysis by the FCC , where all users were treated similarly without studying their actual usage requirements [**?**]. This resulted in a sudden increase of the benchmark standard from 1 Mbps/200 kbps to 4 Mbps/1 Mbps in 2010 [], and to 25 Mbps/3 Mbps in 2015 [] TODO: check years and standards . Although we support the move to a higher broadband standard based on the increasing share of high quality entertainment traffic in home broadband consumption [3] [4], as well as possibility of offering advanced capability such as telemedicine, we disagree with the methodology followed by the Commission in reaching these standards. By declaring fixed broadband a regulated commodity, it is necessary that in the future, broadband pricing policy take into account usage characteristics.

In particular, we believe that there is a need to: (a) define benchmarks based on standards other than broadband speed, such as usage, (b) define multiple benchmarks rather than aggregates based on type of usage, and (c) re-examine peak time usage with recent changes in usage patterns, to estimate for capacity planning. We also realize that the FCC requests comments on the issues of broadband benchmarking [section 2], and this work presents a first attempt in the direction of supplementing FCC policy with measured usage data from home users.

To analyze usage characteristics we study byte counter data collected by Comcast home gateways for their customers in Salt Lake City, Utah, with a high capacity access link (105 Mbps) [section 3]. Although we limit our analysis to a particular high access link ISP and a single city, this avoids any biases in usage patterns especially during peak time, as well as different pricing models. We proceed by analyzing spacio-temporal usage patterns for from the usage data collected from multiple home gateways, as well as peak usage (during prime-time) [section 4]. Our analysis indicates that for high capacity access links, increasing capacity does not result in higher utilization, and motivate the need of multiple benchmarks based on varying usage within the same tier [section 5]. Finally, we comment on the issues raised by FCC to investigate a better benchmarking solution for the US [section 6].

[1] **Issue #1.** [1]

[2] **Issue #12.** [1]

Based on our dataset analysis, our major contributions in this work are as follows:

- Need for price regulation: Users buy high bandwidth but don't use it, even max usage per user is low. Some users in high bandwidth set can even survive with DSL usage.
- Comment on importance of peak usage: comment of FCC issue, capacity planning needs to be based on peak hours not 24 hour averages.
- no dips by median/mean in usage pattern of a day (or a week). Shows a peak at 8-12, different from FCC. Peak timings are getting late (8-12pm) and this may be a trend of high bandwidth tiers that use loads of entertainment traffic during this time. We come up with a "peak usage" parameter to show the variance per day and compare it with prime time. (in discussion)
- Asymmetry of data in high tier
- Show that there is no major change in usage with increasing tier capacity, but there might be subtle changes (short flows)
- Discuss segregating users (business, average, high peak + load, low peak + load) to motivate multiple benchmarks even in the same tier!

2 Issues for Inquiry

In the FCC report No. 14-113, on Aug 5, 2014 [1], the FCC asks some relevant questions about broadband usage, and requests comments from the community to improve its decision making process. We summarize their comments and hypothesis as follows:

Issue #12. *Household Bandwidth Scenarios* (Table 2, [1]). The typical bandwidth a household may need today varies between 4 to 10 Mbps for low to high usage households during peak period. Is this still valid with continuous introduction of new services and connected devices?

Issue #13. *Peak Usage Time.* Should bandwidth requirements for a typical household be assessed during peak Internet usage periods, from 7 pm to 11 pm on weeknights? Is the "peak usage time" an efficient metric, or should the average usage of a household over a day be considered instead? Does establishing a reasonable household usage scenario during peak periods assist the Commission to identify a benchmark?

Issue #14. *Broadband Speed Benchmarks.* SG: make this another subsection with following points 14-...? What is the right benchmark to represent moderate use for a mid-range needed by a 3 user household? Even though the commission has recently decided to set the benchmark to 25/3 [], anticipating future usage, the growth in Internet usage with Netflix super HD [] and our analysis 5 show that setting such limits is not cool. 15: How should the Commission forecast future household broadband uses to justify such a benchmark?

Issue #16. emphAdoption Based Benchmarks. Similarly for uplink, the benchmark is based on 70% adoption rate - does it even make sense? 17. Symmetrical usage like video calls - does it impact aggregate usage at all?

Issue #19. Does it make sense to base the benchmark on the fastest speed tier for which a substantial portion of the consumers subscribe. How should the Commission define "substantial portion" and how should we interpret such demand?

Issue #22. *Other Speed Benchmarks* Broadband requirements are not uniform throughout the nation. Some users will have significantly greater needs. Should FCC opt for multiple benchmarks depending on user scenario, usage, occupation, and different benchmarks for schools, libraries, etc.? TODO: characterize differing usage even in 100 Mbps/250 tier – a user taxonomy, include Sandvine report taxonomy and show of variance in aggregate users – we will show extreme variance in the same band of users and motivate a need of new benchmarks instead of speed. Note: does this end up motivating a case for non-net neutrality based on low usage vs high usage? did FCC take the wrong decision – if we could show our data set uses completely different set of sites etc...

Issue #28. *Data Usage.*

SG: price of tier increases but comcast usage is same here?

What we don't do: latency, application usage, mobile speed benchmarks.

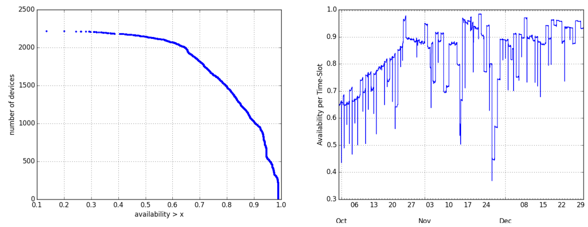
3 Data Source

Our dataset consists of network usage byte counters reported by Comcast gateways every 15 minutes from October 1, 2014 to December 29, 2014. There are two sets of broadband tiers that were used to collect this data: control set, consisting of homes and businesses with a 105 Mbps access link, and the test set, consisting of homes and businesses that were paying for a 105 Mbps access link, yet were receiving 250 Mbps instead. Users in the test set were selected randomly and were not told that their access bandwidth has been increased. There were more than 15000 gateway devices in the control set, with varying usage over the three months, and about 2200 gateway devices in the test set. TODO: confirm - these were reported by Comcast gateways right?

Both the test and control sets were collected from users in Salt Lake City, Utah, to avoid any biases in behavior based on location. Although this dataset corresponds to just one ISP, we believe that it is broadly representative of urban users in the US in the same, or higher broadband bandwidth tier (100 Mbps). Thus, we use this data to draw general conclusions about behavioral change with link capacity TODO: (add more here...)

SG: Supplement the data with bismark?

SG: My Speed Test Usage Patterns data - Any chance?



(a) *Availability by device* **(b)** *Availability by date*

Figure 1: *Availability, based on gateway device responsiveness. (Make common eps plot of availability – 8 control sets (half filtered) + test sets vs availability.)*

3.1 Data Description

Comcast splits the control set into 8 separate pools on different date ranges and gateways TODO: confirm if there is repeated device IDs in control1-8. . Each dataset contains the following relevant fields: Device ID, sample period time, service class, service direction, IP address, and the bytes transferred in the 15 minute sample slot, as described in table 1. TODO: find out more about service class name, and IP addresses being the same across all sets

Field	Description
Device_number	Arbitrarily assigned CM device identifier
end_time	Fifteen minute sample period end time
cmts_inet	Cmts identifier (derived from ip address)
service_direction	1-downstream, 2-upstream
octets_passed	Byte count

Table 1: *Field Descriptions for Comcast Dataset by Comcast*

3.2 Data Sanitization

Our initial analysis of data transferred per time slot showed that certain gateway devices were responsive only for brief periods. We also noticed that certain time slots had a very low response rate throughout the dataset. TODO: Why? asked comcast - waiting for response .

We evaluate the fraction of responsiveness of a gateway throughout the dataset, as well as the fraction of responsiveness per time slot, and call this the **availability**. Figure 1 shows how the number of devices decreases for a higher availability requirement. Based on the common trend of this plot throughout the test and control datasets, we decided to only choose gateway devices with an availability of at least 0.8.

Finally, we sliced the sanitized test set based on the date range of each individual control set for comparison. We compared each of these tests individually to ensure that there are no outliers. We refer to the test and control sets in this case simply as datasets $set_1 - set_8$, where *set* is test or control . We also sliced and combined the sanitized data to give us control and test data for each month, referred to as set_{oct}, set_{nov}, set_{dec}. Finally, we combine all control sets to form a large concatenated dataset over the same date range as the complete test dataset, and we refer to this simply as set_{full}.

4 Methodology

4.1 Relevance of the Dataset

not telling users that the connection was upgraded lets us study correlation between usage and capacity without the bias of user changing his behavior due to external factors (buying a device, being more aggressive as they bought a new plan)

DASU supports correlation by measuring usage on each ISP tier, even for those who changed tiers, but that is biased by user buying a higher tier when they feel unsatisfied. It does not have a good representation of the case when the ISP offers extra bandwidth without charging. Even if it does, the user knows about the capacity bump inducing a change in behavior. Our dataset is unbiased in that manner, we don't expect users to know they have a higher capacity and still study if there is change in behavior

explain that due to no bias in city, and large number of users, this can be interpreted as change or no change in behavior due to increase in capacity of the link. We expect the baseline behavior of these users to be exactly the same. Thus we will put our questions as "change in behavior due to increase in capacity" rather than analysis of two different datasets as we have attempted to eliminate all biases.

Both the test and control sets were collected from users in Salt Lake City, Utah, to avoid any biases in behavior based on location. Although this dataset corresponds to just one ISP, we believe that it is broadly representative of urban users in the US in the same, or higher broadband bandwidth tier (100 Mbps). Thus, we use this data to draw general conclusions about behavioral change with link capacity TODO: (add more here...)

Note that 15 minute time slots were synchronized to the same time stamp. They were off only by a few seconds (under 30, as claimed by Comcast). As our analysis deals with aggregated patterns on a granularity of 15 minutes, we believe this time synchronization to be irrelevant.

4.2 Evaluation Criteria

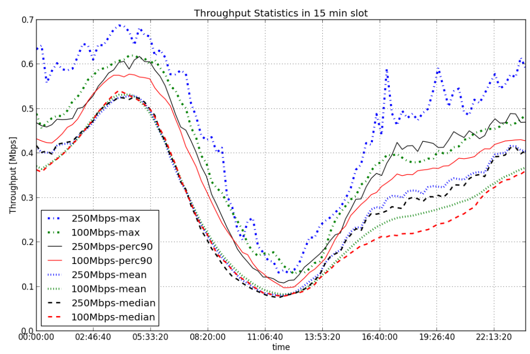
we analyze based on three criteria
usage patterns
peak utilization
prime time ratio
asymmetry in data
user taxonomy

The Importance of Measuring Peak Usage: importance of measuring peak

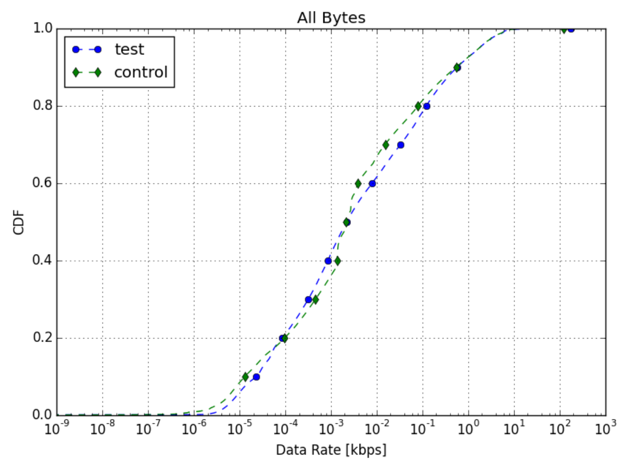
Prime-Time Ratio definition of prime time definition of peak-ratio based on our results we propose a metric peak ratio to segregate users

4.3 Limitations

shortcomings of data + advantages (user end instead of sandvine which is core internet?? so we can comment on per user patterns??)



(a) *agg (days) over means (devices)*



(b) *CDF of data rate per time slot for all devices (agg view of data)*

Figure 2: *User Behavior: Overall not much change due to capacity increase*

5 Results

TODO: This is the results section

We present a comparison between the usage characteristics of the control[3] and test[4]. We interpret the results as change in usage behavior due to increase in access link bandwidth.

5.1 User Behavior

Issue #1.. Does aggregate user behavior differ?

no dip pattern

usage is similar

5.2 Peak Utilization

Issue #2.. Does the maximum (or 90-%ile) data transferred by the device differ?

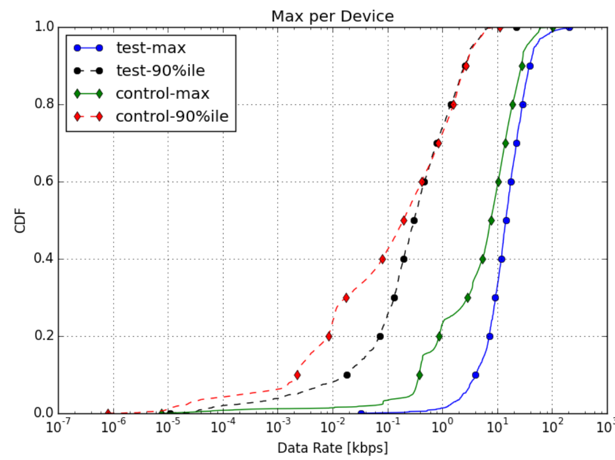
copy reasons from ppt

5.3 Prime Time Ratio

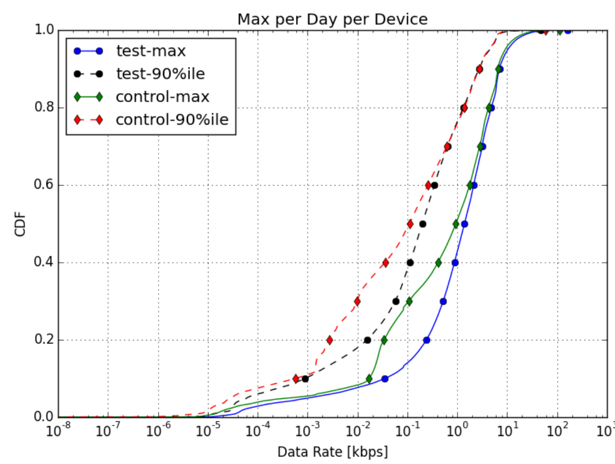
Issue #3.. Does the prime-time ratio differ?

[3]gateway byte counters from users with a 105 Mbps access link

[4]gateway byte counters from users with a 105 Mbps access link



(a) *CDF of max per device*



(b) *CDF of max per device daily*

Figure 3: *Peak Utilization: The maximum data rate varies for test and control set for low data rates, and this variation is present daily.*

Measure PT = avg data rate during a peak hour period : off-peak period

updated to 8-12 PM as seen from 2a.

SG: can also include PT table from ppt if worth it – table shows the "no dip" pattern similar to time series in first subsection.

5.4 Peak Ratio

Issue #4.. How much does the traffic vary in a single day?

implies that ISPs should condition their networks to 50 times median usage per user

5.5 Traffic Asymmetry

TODO: maybe this doesn't need a separate section, just comment on asymmetry in each of the above - plot uplink also

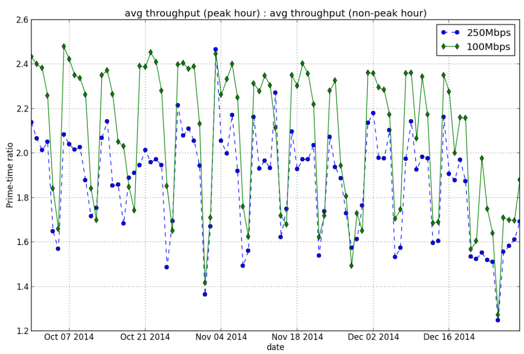


Figure 4: *Prime Time ratio showing weekly pattern + differences during holiday periods (Thanksgiving, Christmas)*

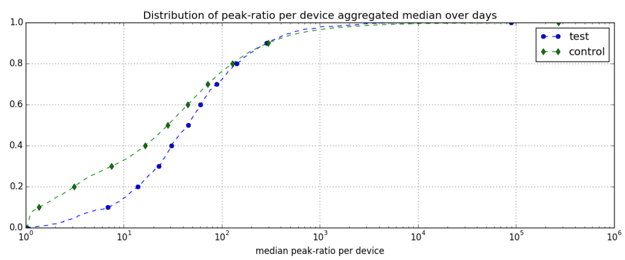


Figure 5: *Median peak ratio per device showing that test set has higher daily variance, which goes upto 50 times)*

6 Discussion

results that are contradictory
results that data suggests that is wrong
- suggest that this may be due to representation
a better way to measure and offer broadband based on utilization?

6.1 User Taxonomy

TODO: This splitting needs to be done

user taxonomy the segregation splits business and casual users based on usage and motivates our discussion on multiple benchmarks

7 Related Work

fcc reports + sandvine on usage patterns
papers studying broadband vs utilization: DASU, Peeking, Broadband measurement, Policy papers
Note: this can go in the intro if lack of space

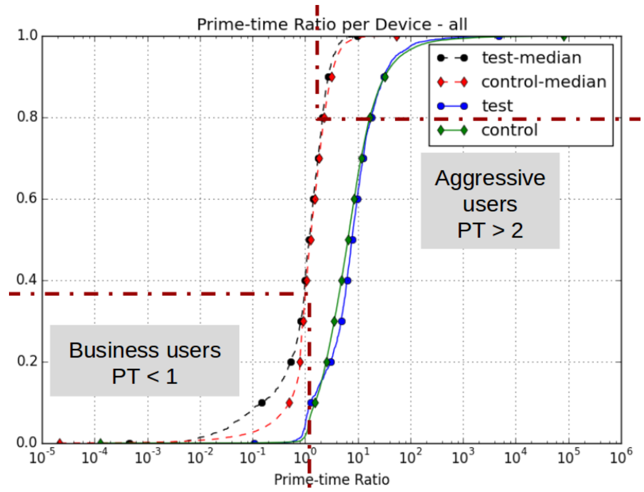


Figure 6: *(old) Prime Time ratio + usage can be used to divide users into four sets: aggressive all time + non aggressive all time, aggressive peak time, aggressive non-peak time (business hours))*

References

[1] Federal Communications Commission. Eleventh Broadband Progress Report No 15-10A1, February 2015. (Cited on pages 1 and 2.)

[2] Federal Communications Commission. Telecommunications Act of 1996, February 2015. (Cited on page 1.)

[3] Sandvine. Global Internet Phenomena Report - 1H, April 2014. (Cited on page 1.)

[4] Sandvine. Global Internet Phenomena Report - 2H, November 2014. (Cited on page 1.)