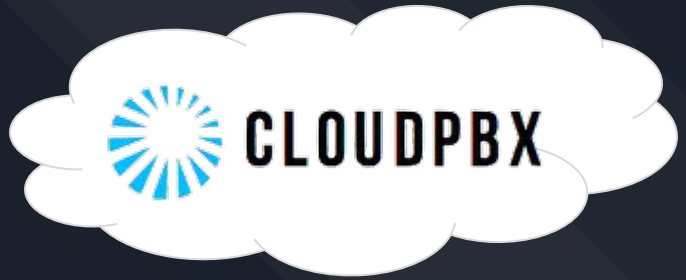
Quality Analysis of CloudPBX VoIP Calls



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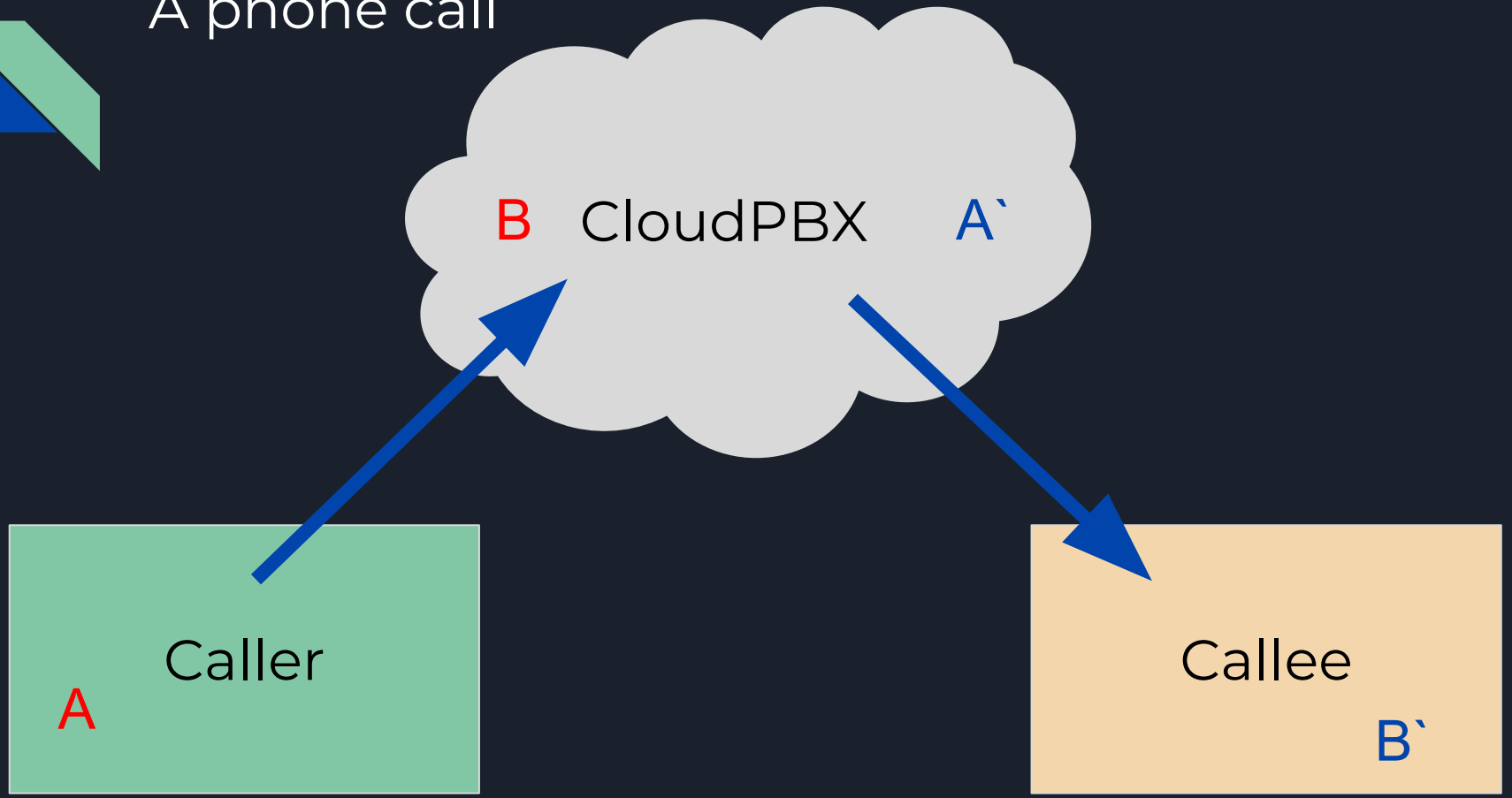
Stefan Hannie, Mohamed Laradji, Michelle Liu,
Eric Lam, Idalia Machuca, Julian Mentasti

A phone call



The dataset - a call metadata log
From May 1, 2018 to present

- Each record represents one leg of a phone call.
- Relevant statistics for each call:
  - RTP (Real-time Transit Protocol) IP address for A & B
  - Total call delay
  - Total call jitter
  - Total packet loss
  - MOS (Mean Opinion Score)
  - Call duration
  - Phone type

Reduce the dataset - When does a record correspond to a real phone call?

- Call duration > 0 ms
- Valid RTP IP address for A
- Valid RTP IP address for B

This reduced our data set by ~ 40%.

~140M records

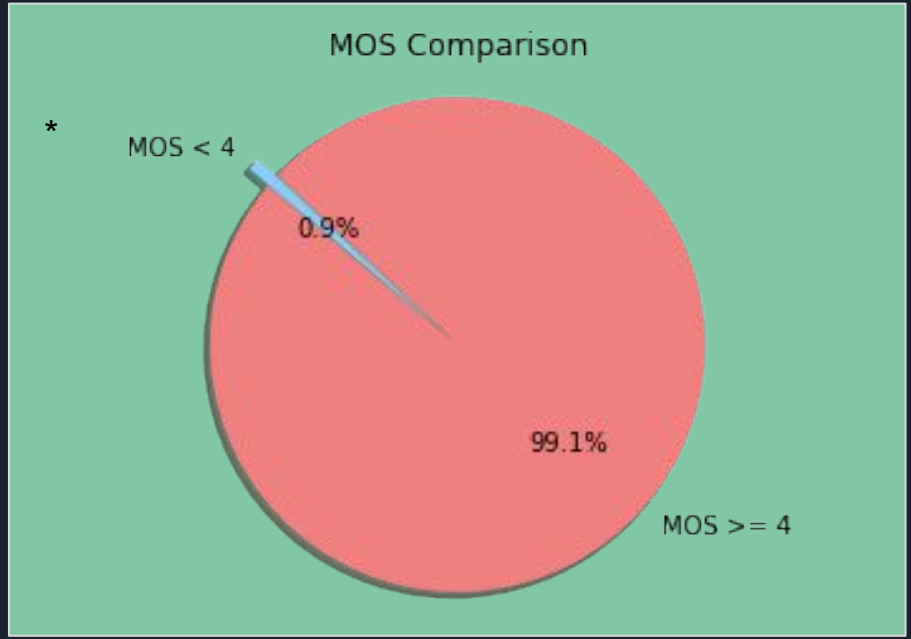
~1GB

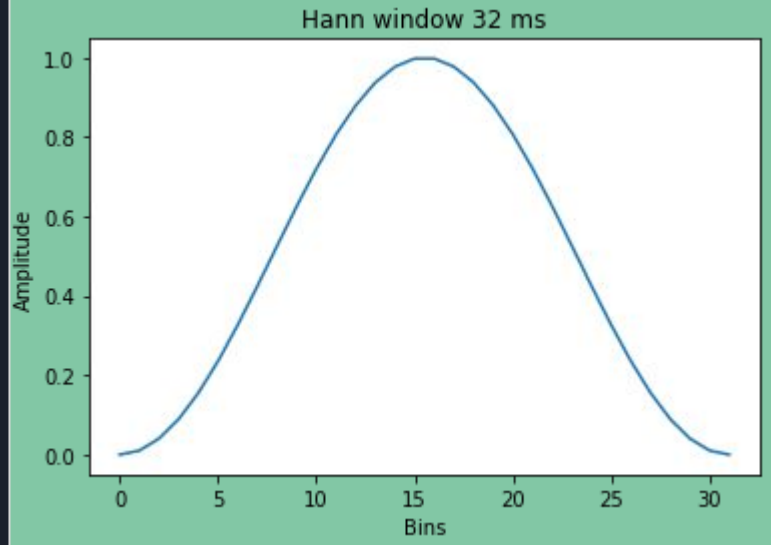
MOS (Mean Opinion Score)

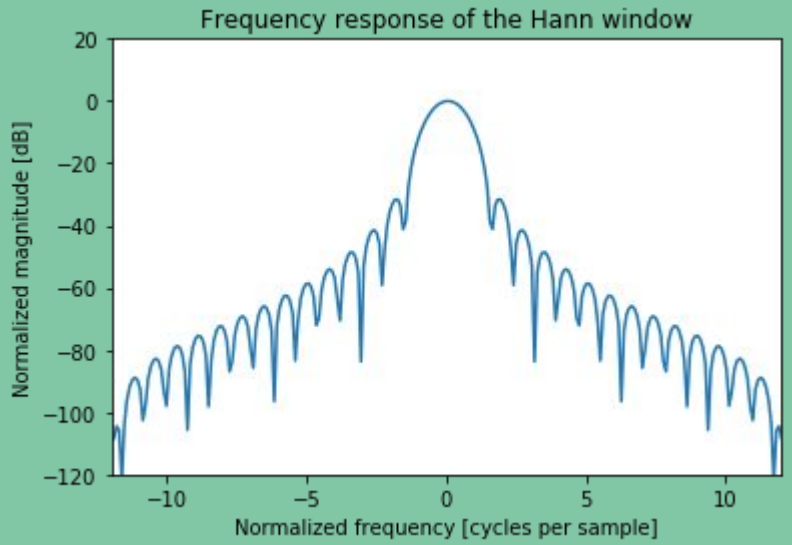
- MOS gives numerical indication of perceived quality of the media received
- value of 4.0 to 4.5 referred to as toll-quality
  - normal value of PSTN and many VoIP services

Limitations of MOS

- Any jitter below 35ms is disregarded
- longer the distance of a call, higher the tolerance of signal disturbances
- “Bad call events” (i.e. dense periods of high jitter) get lost when averaged over the time duration of the call

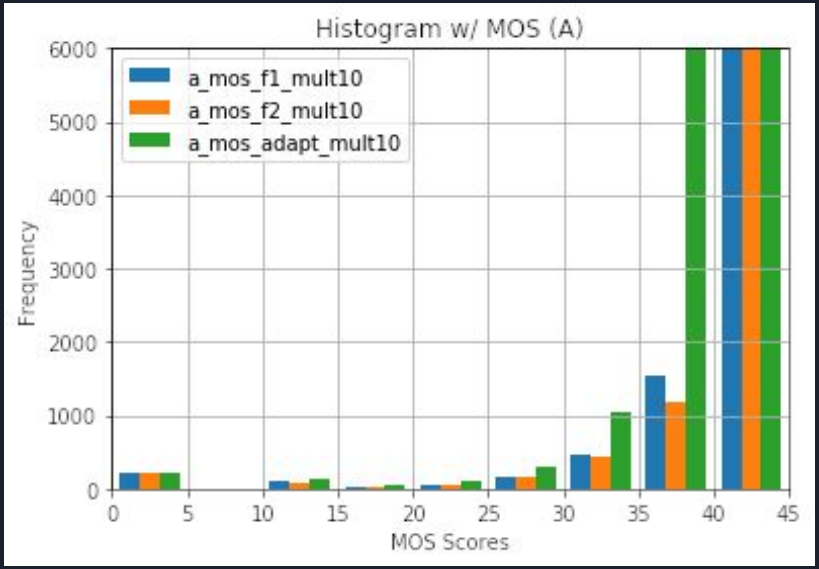


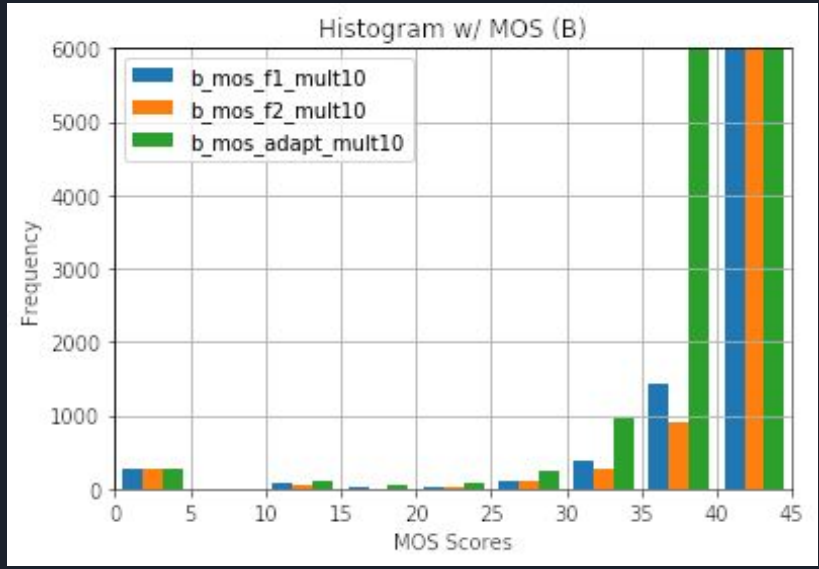




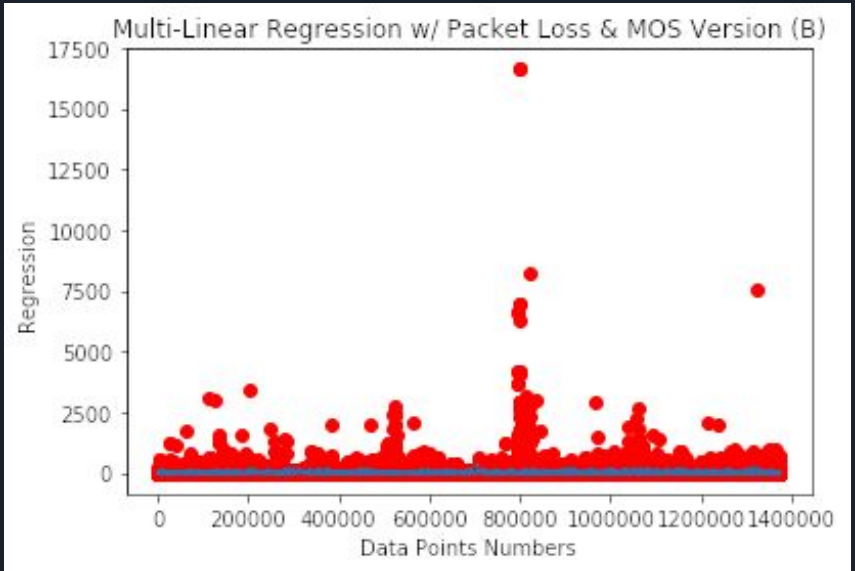
Source: ITU-T P.862

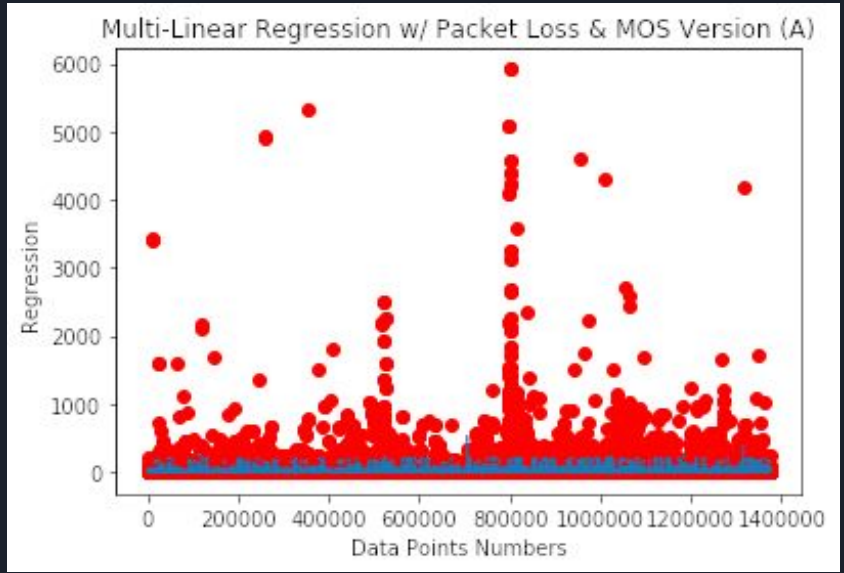
Inaccuracies of MOS





Limitations of MOS





Qual-Fun (Quality Function)

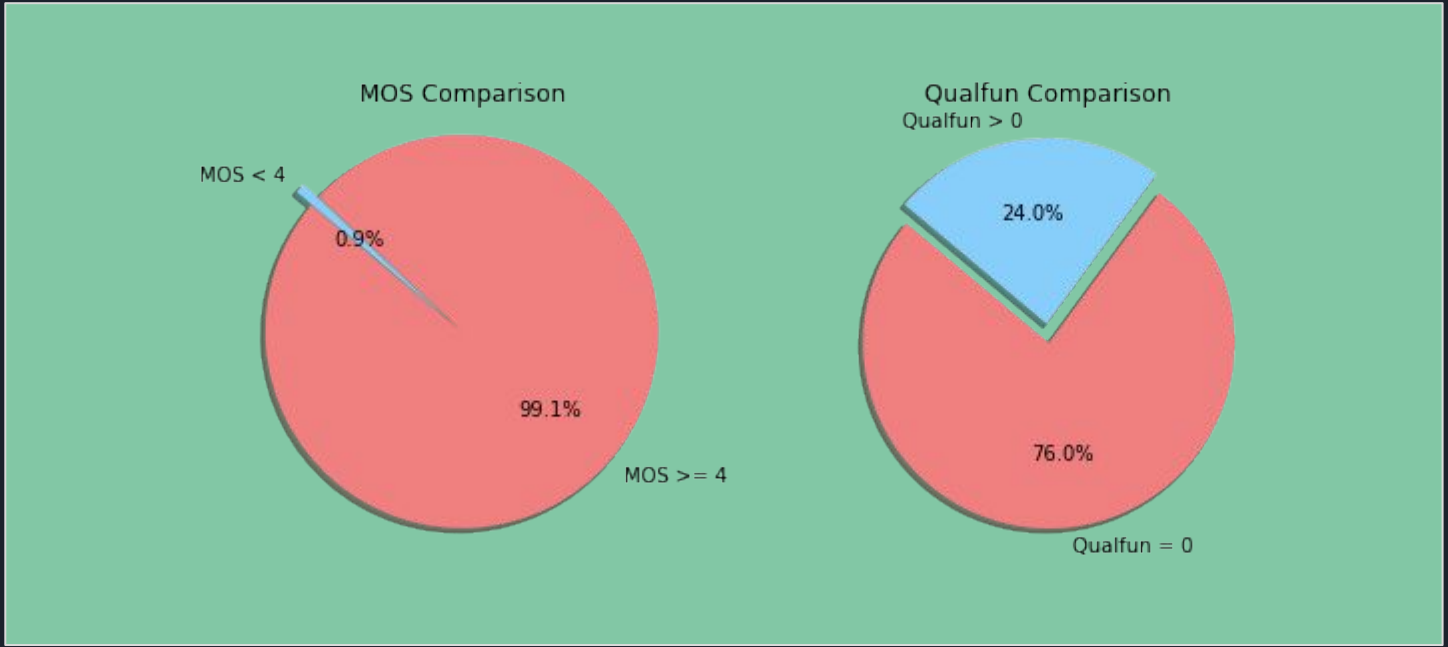
$$s = \frac{\text{net packet delays} + \sum_{n=1}^{10} 20n(\text{weight})_n(\text{sequentially lost packets})_n}{\text{call time}}$$

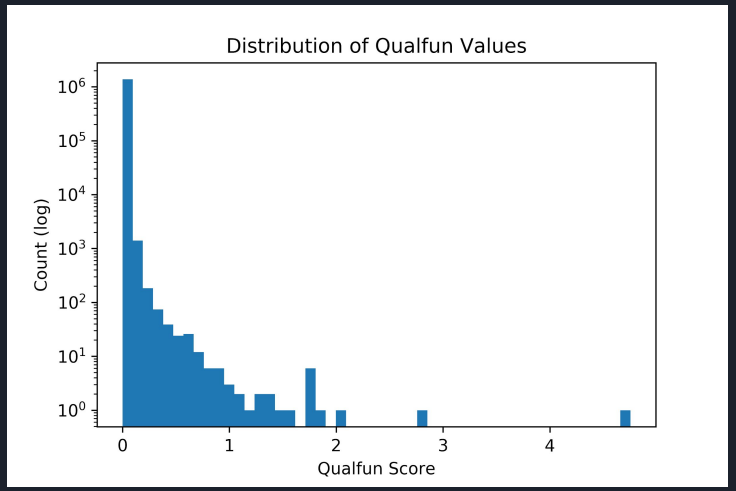
Current approach (MOS): essentially dividing delay time (jitter) by the call duration.

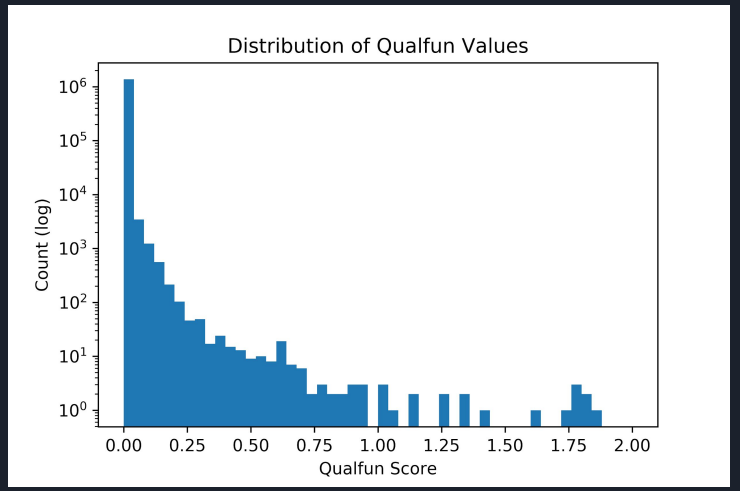
Improvements made (Qual-Fun): added sensitivity to the *density* of jitter.

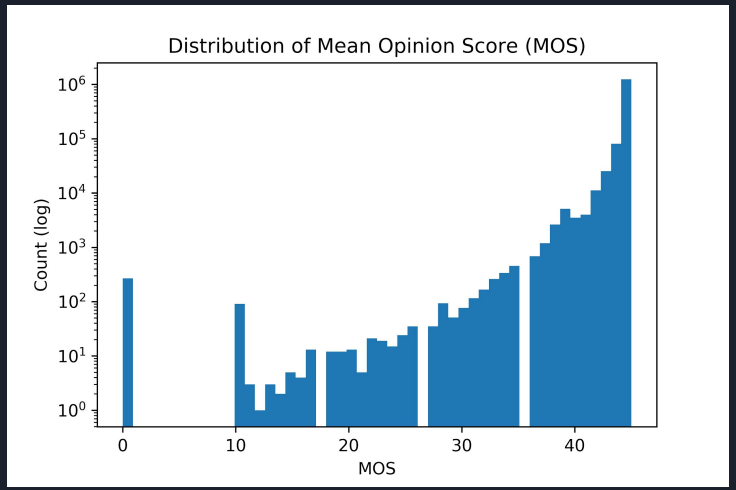

Detailed Information for Calls at Two IPs
max jitter
average jitter
max packet loss
average packet loss
MOS
time
call 1
call 2
avg mos = 4.5
avg qual-fun = 1.7
avg mos = 4.5
avg qual-fun = 1.5

Increased Sensitivity



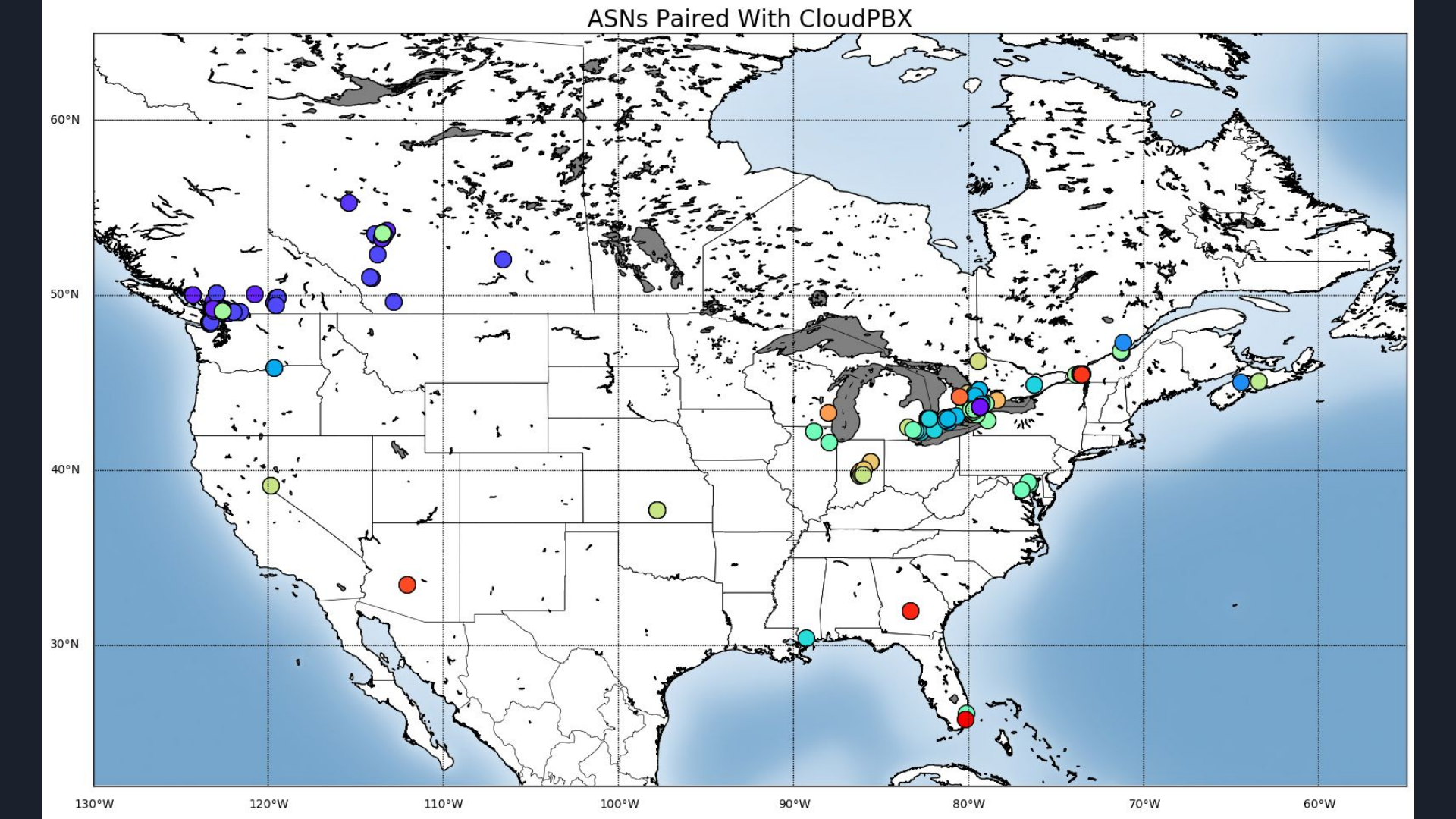

Distribution of Qualfun Values
Count (log)
Qualfun Score

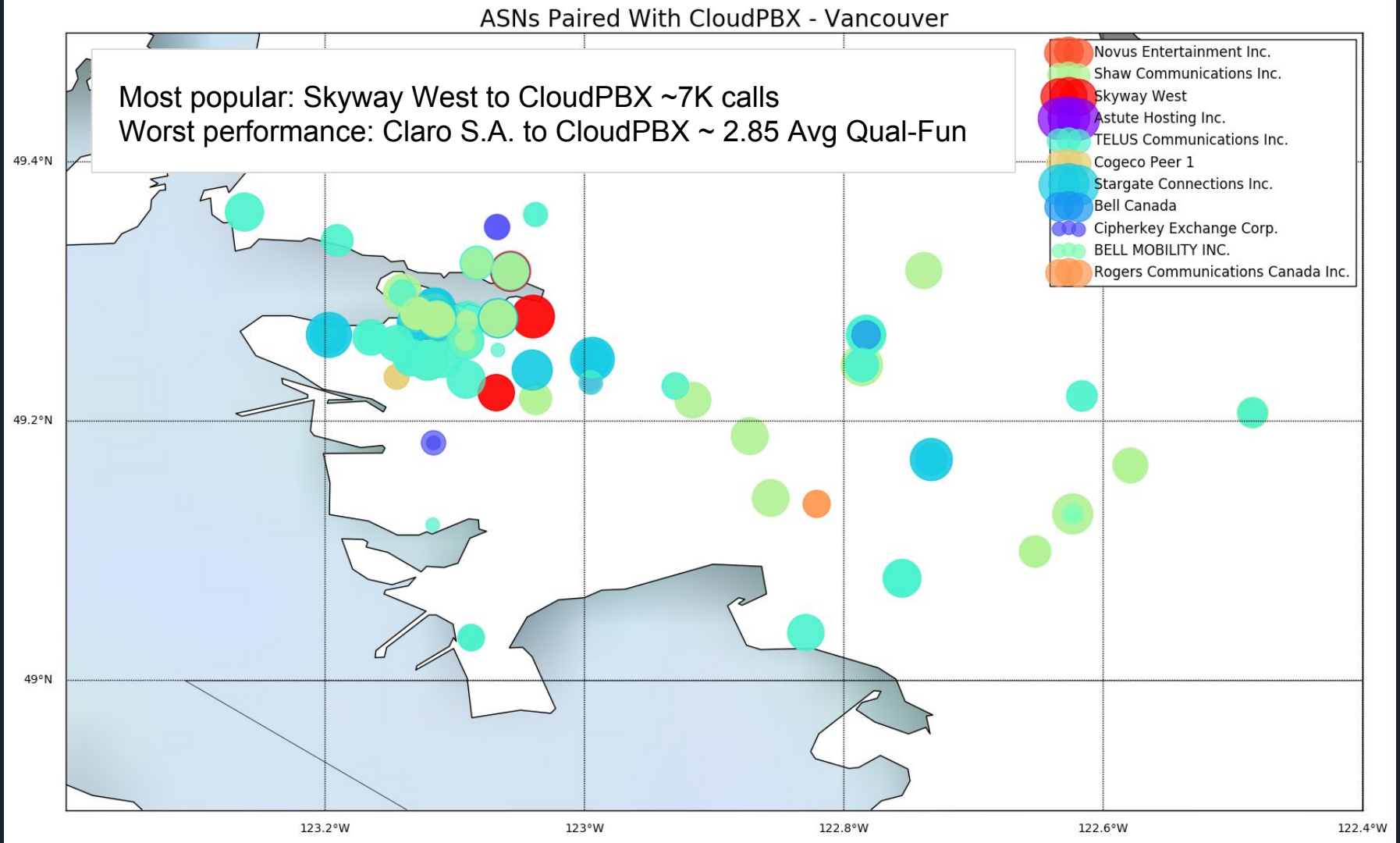

Distribution of Qualfun Values
Count (log)
Qualfun Score

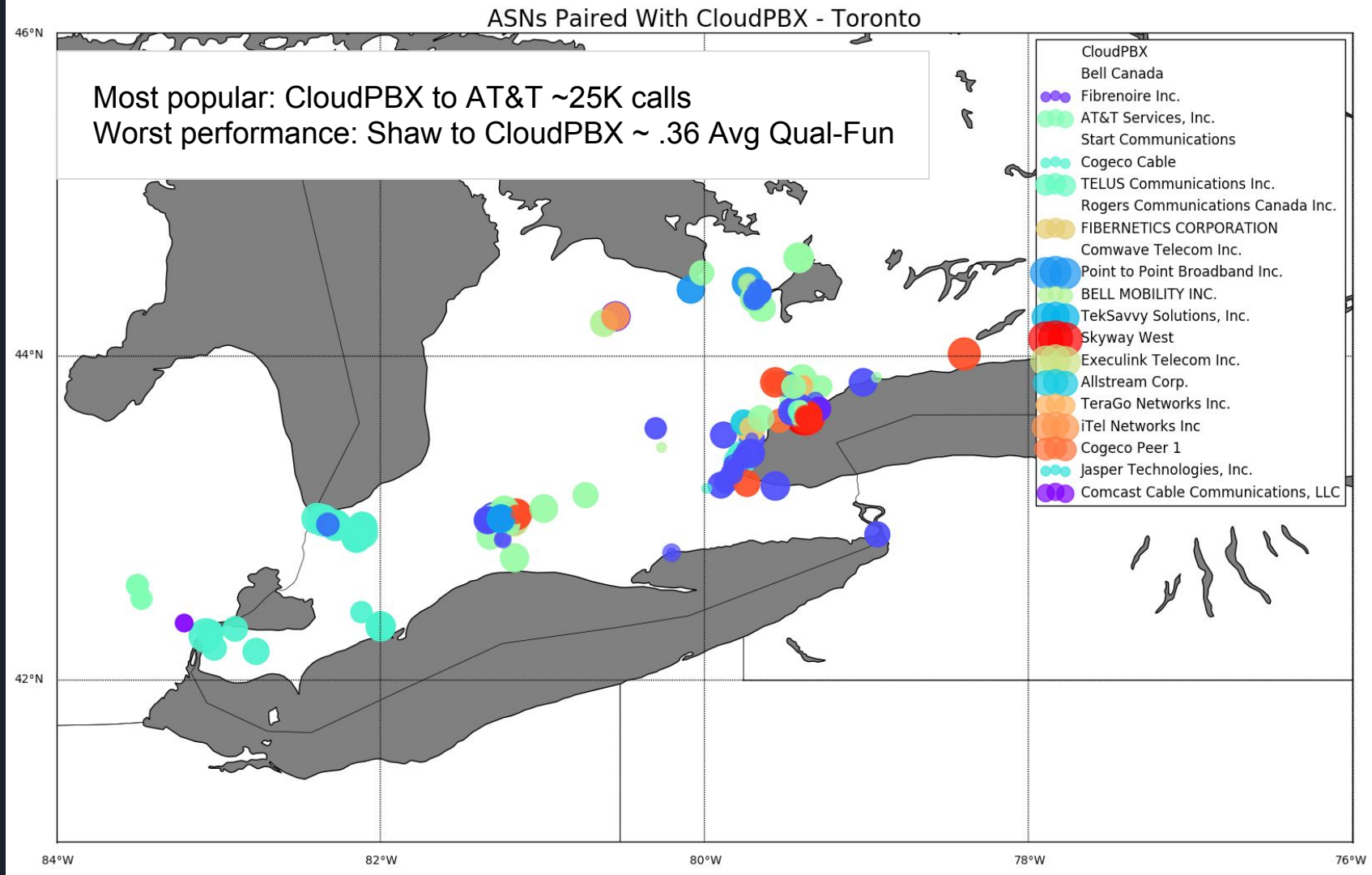

Distribution of Mean Opinion Score (MOS)
Count (log)
MOS

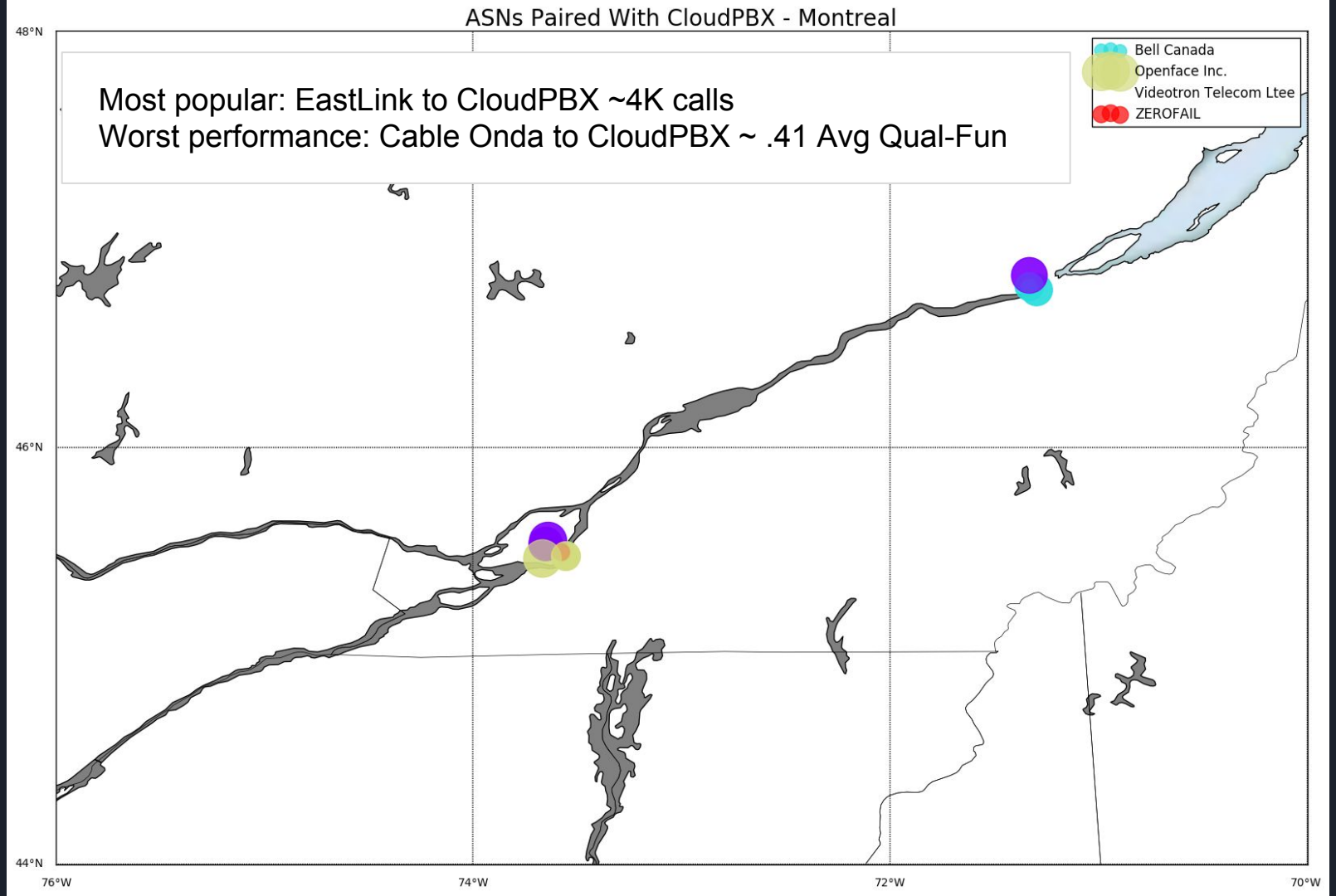
CloudPBX Network Topology

- ~1.8K unique subscriber IP addresses
- ~ 4K unique IP address pairs
- ~ 1.3K unique IP address pairs in each city
  - Vancouver - VAN
  - Toronto - TOR
  - Montreal - MTL
- How popular is each IP address pair?
- What's the average call quality of each IP address pair?


ASNs Paired With CloudPBX
60°N
50°N
40°N
30°N
130°W
120°W
110°W
100°W
90°W
80°W
70°W
60°W


ASNs Paired With CloudPBX - Vancouver
Most popular: Skyway West to CloudPBX ~7K calls
Worst performance: Claro S.A. to CloudPBX ~ 2.85 Avg Qual-Fun
Novus Entertainment Inc.
Shaw Communications Inc.
Skyway West
Astute Hosting Inc.
TELUS Communications Inc.
Cogeco Peer 1
Stargate Connections Inc.
Bell Canada
Cipherkey Exchange Corp.
BELL MOBILITY INC.
Rogers Communications Canada Inc.
49.4°N
49.2°N
49°N
123.2°W
123°W
122.8°W
122.6°W
122.4°W

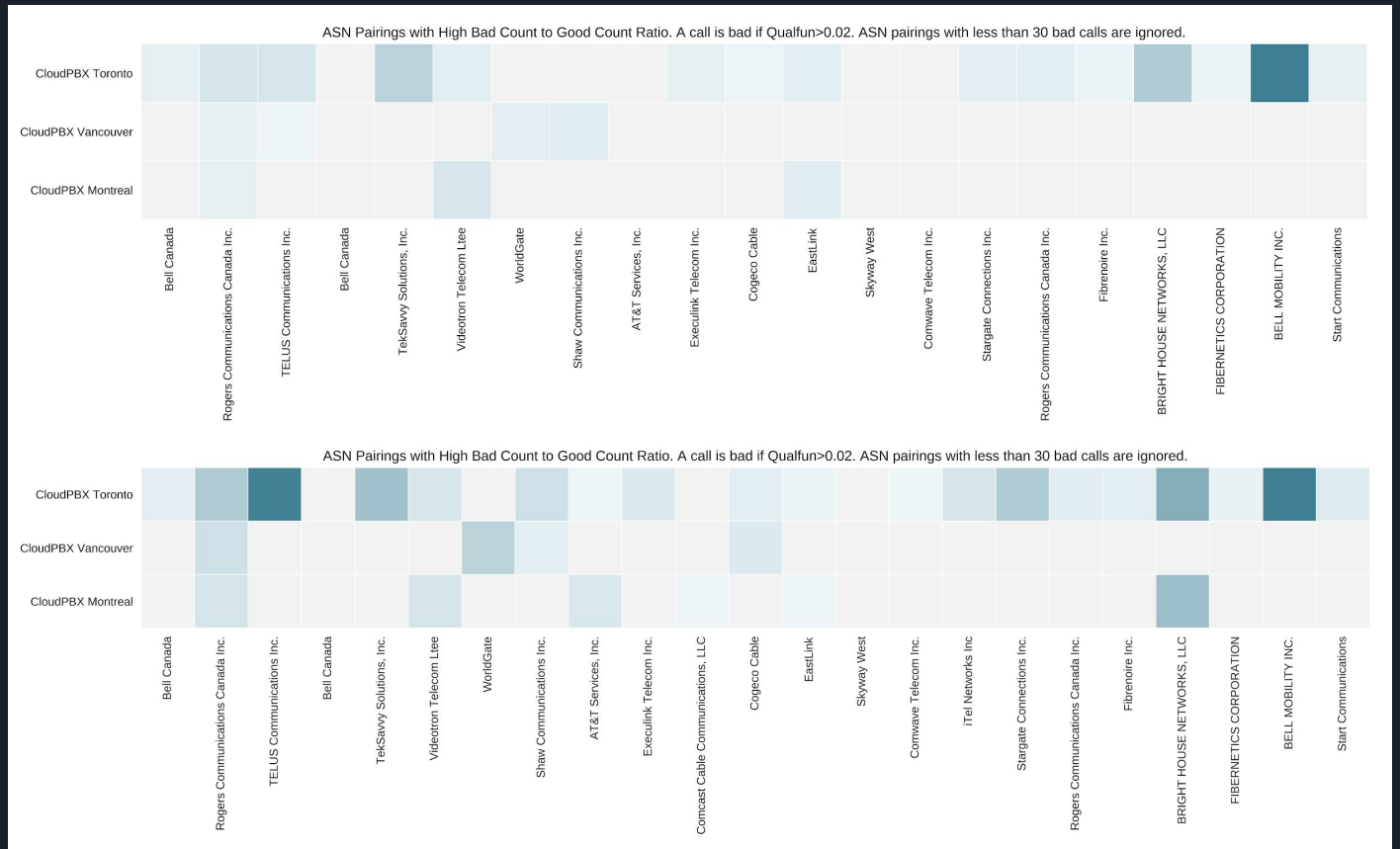

ASNs Paired With CloudPBX - Toronto
Most popular: CloudPBX to AT&T ~25K calls
Worst performance: Shaw to CloudPBX ~ .36 Avg Qual-Fun
CloudPBX
Bell Canada
Fibrenoire Inc.
AT&T Services, Inc.
Start Communications
Cogeco Cable
TELUS Communications Inc.
Rogers Communications Canada Inc.
FIBERNETICS CORPORATION
Comwave Telecom Inc.
Point to Point Broadband Inc.
BELL MOBILITY INC.
TekSavvy Solutions, Inc.
Skyway West
Execulink Telecom Inc.
Allstream Corp.
TeraGo Networks Inc.
iTel Networks Inc
Cogeco Peer 1
Jasper Technologies, Inc.
Comcast Cable Communications, LLC
46°N
44°N
42°N
84°W
82°W
80°W
78°W
76°W


ASNs Paired With CloudPBX - Montreal
Most popular: EastLink to CloudPBX ~4K calls
Worst performance: Cable Onda to CloudPBX ~ .41 Avg Qual-Fun
Bell Canada
Openface Inc.
Videotron Telecom Ltee
ZEROFAIL
48°N
46°N
44°N
76°W
74°W
72°W
70°W

Heatmap of Bad Call ASN Distribution

Calls from CloudPBX:

Calls to CloudPBX:

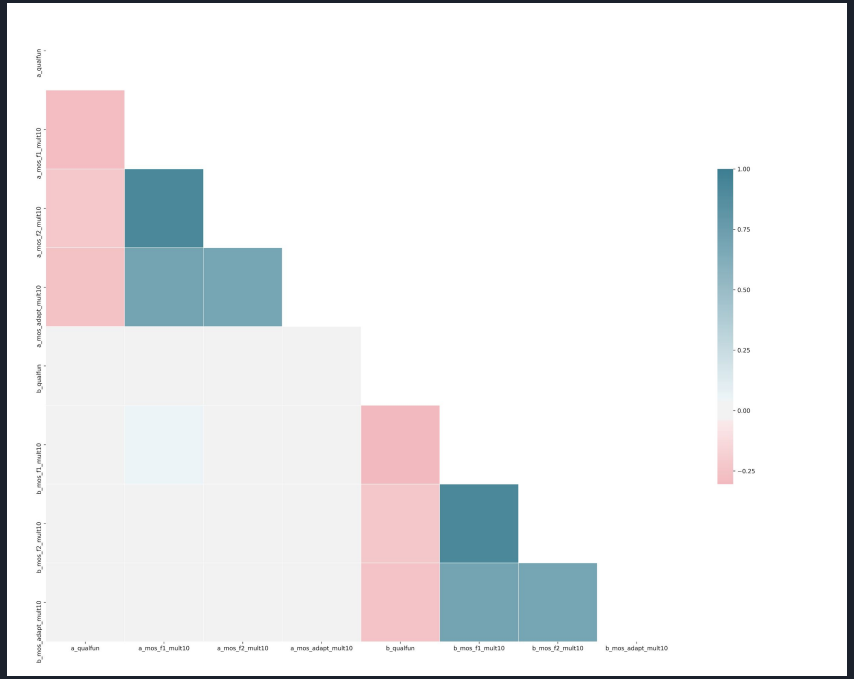


Some Correlations

There are three different MOS's, which differ in jitter buffer size, for each leg of the phone call.

As expected, MOS's of the same leg have strong correlations with each other, and MOS's of different legs have no correlation.

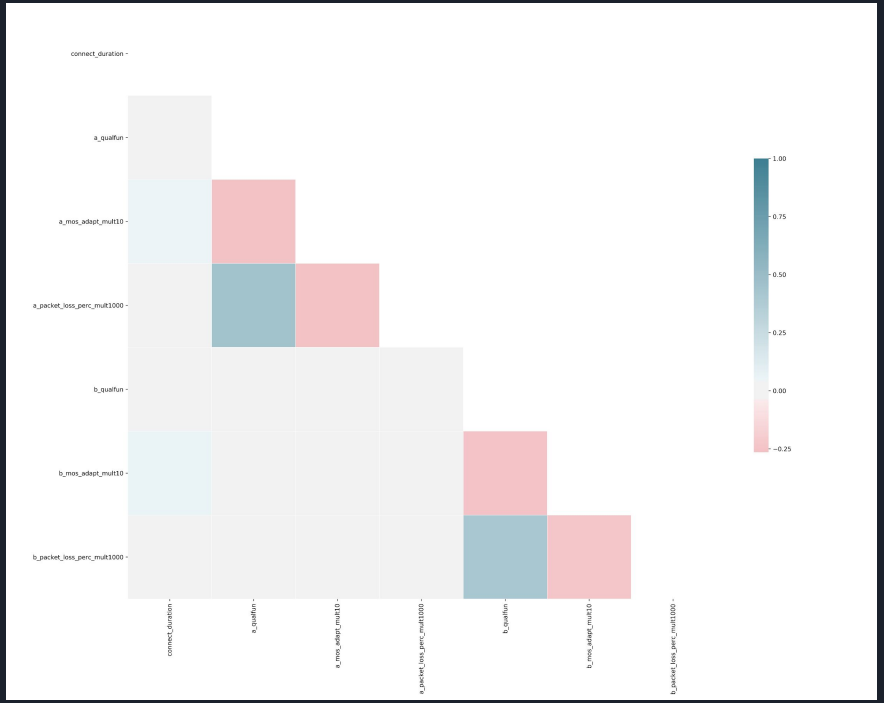
Qualfun weakly correlates with MOS. This partly validates Qualfun.



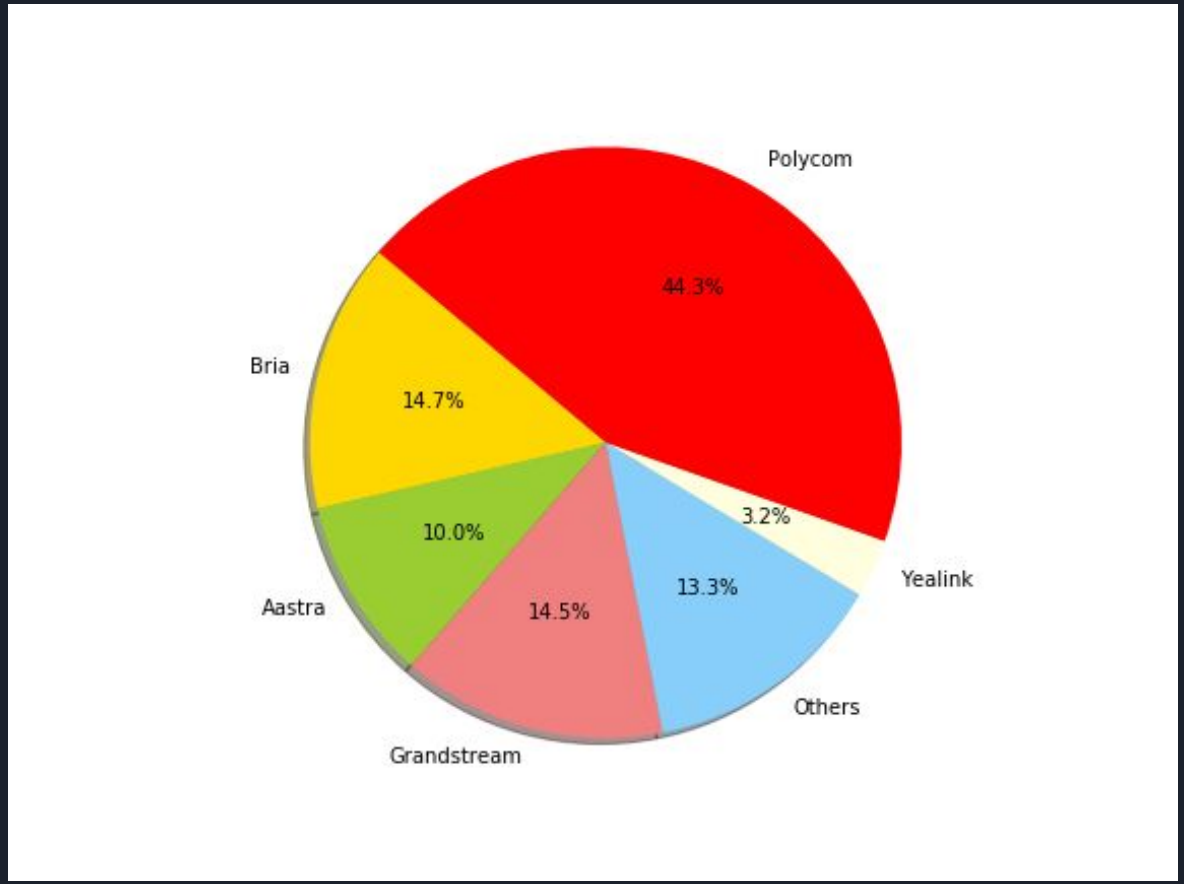
Some Correlations

Percentage Packet Loss (PPL) is another useful measure of call quality.

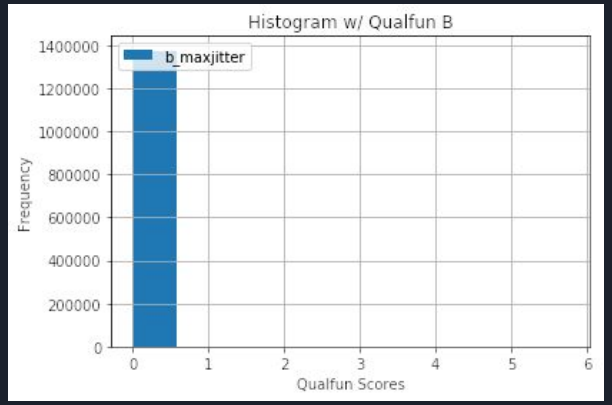
PPL weakly correlates with Qualfun, and does not correlate with MOS.

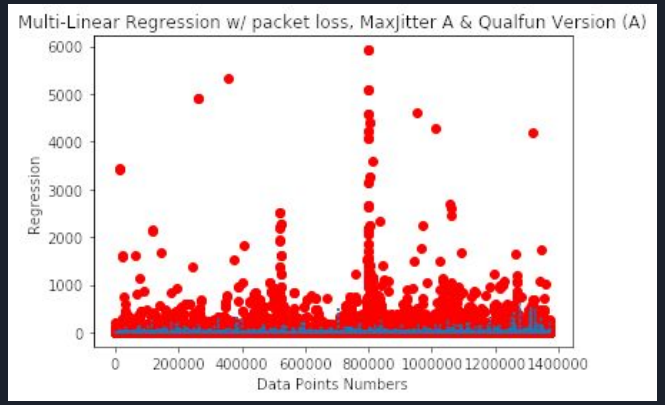


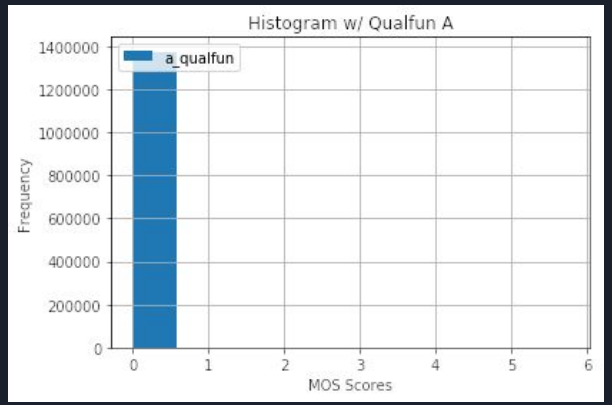
Phone Model Analysis

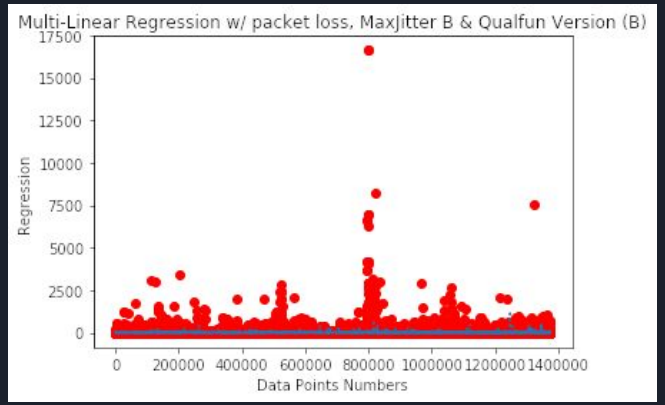


Qual-fun's Shortcomings

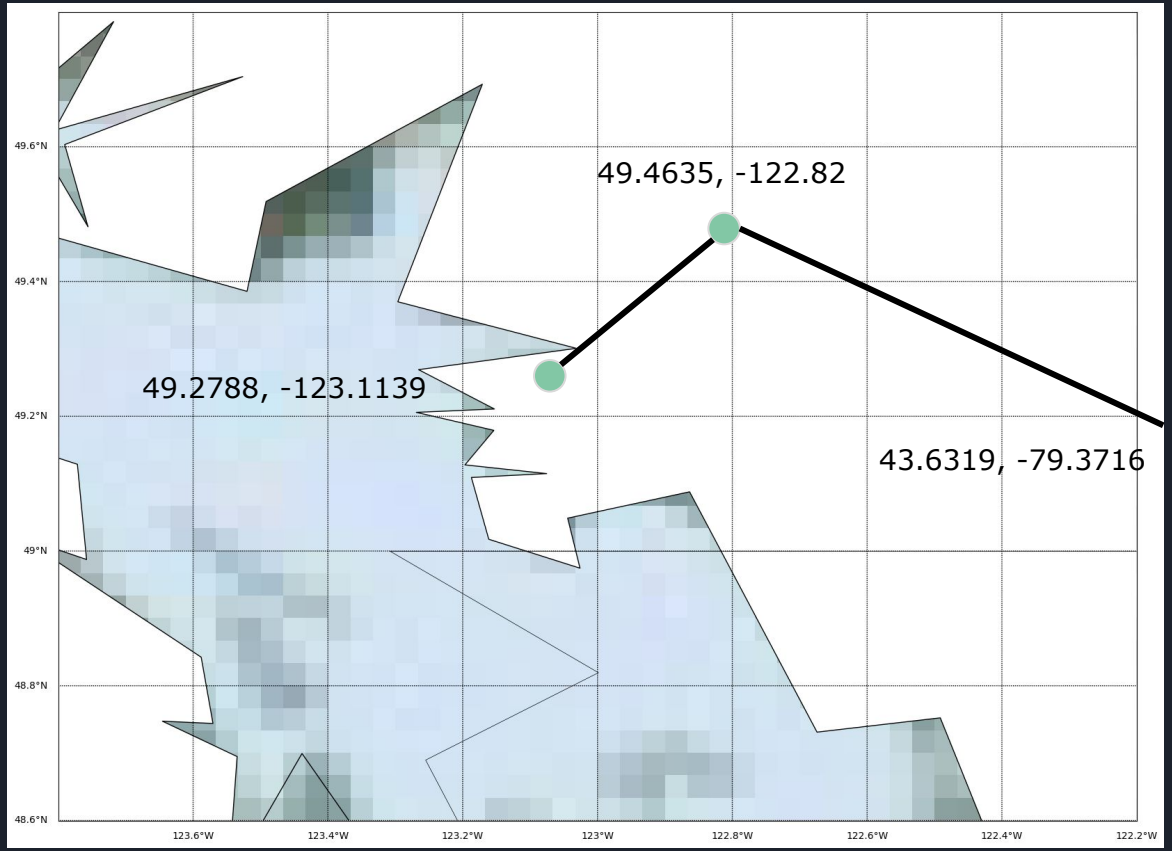




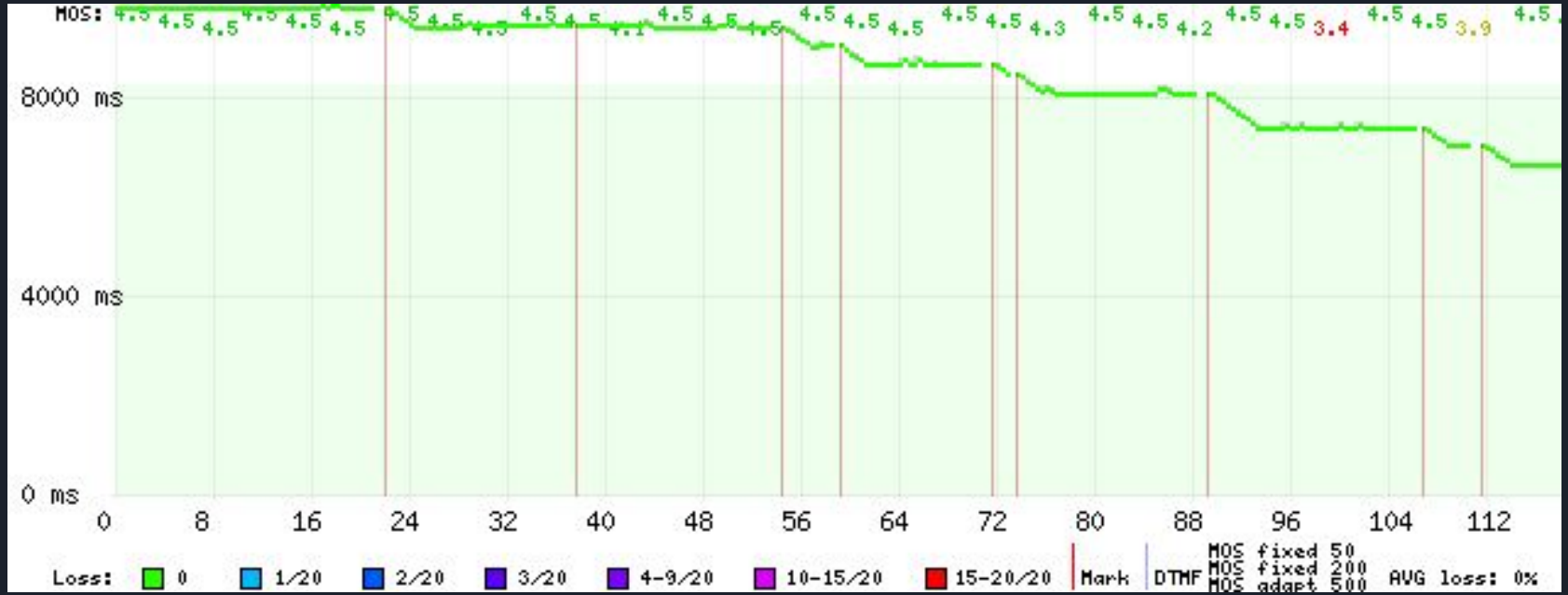




Traceroute


49.6°N
49.4°N
49.2°N
49°N
48.8°N
48.6°N
123.6°W
123.4°W
123.2°W
123°W
122.8°W
122.6°W
122.4°W
122.2°W
49.4635, -122.82
49.2788, -123.1139
43.6319, -79.3716

Developing Prognostic Model



Challenges and Future Questions

- What is the statistical significance of the correlation findings (p-value)?
- What is the distribution of phone calls, grouped by ASN, over different time periods?
- What data structure and data analysis tools will be beneficial for the company's big data analysis needs (Dask)?

Any Questions?