DYNAMIC DECISION MAKING IN MULTIPLAYER GAMES

How to improve Player Experience using Edge Computing

EDGEGAP

GAMING AT THE EDGE

by Bastien Roy-Mazoyer

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Preface

Online multiplayer gaming has been plagued with a major problem called lag for the last 20 years. While some tricks and workaround emerged in the last few years, none of them really addressed the root cause of the problem. Those solutions have always been around optimizing the netcode of the game, hiding elements from the gamer so network communication has time to happen in the background, or tweak the network path like a VPN. While not being bad, none of those solutions addressed the lag problem which is mainly due to distance.

The goal of this report is to show that by dynamically selecting the location for each match through real-time telemetry, we can improve player's experience and drastically reduce lag. The studio's match-maker was not modified whatsoever for this study. Results here were achieve only by measuring telemetry and decide the best location based on whatever group/match is created already. It is fair to say that as more locations will become available, and a tighter integration with a matchmaker is completed, we could improve player's experience even more.

Data used in this report is real data gathered in production environment. None of the data have been modified. Studio, game and players identity have been removed to anonymize the report.

Definitions

Definitions to help reading this report:

- **Latency**: *the delay before a transfer of data begins following an instruction for its transfer.*
- **Jitter**: t*he variation in the latency on a packet flow between two systems.*
- **Happiness**: *Metric created by us to calculate accurately the satisfaction of a user experience.*
- **Request ID:** *Our internal Unique Request ID to track a transaction made into our system, associated with a match and its set of players.*
- **Provider:** *The Site Infrastructure where the telemetry probe has been deployed on.*
- **Region:** *The Region of the site where the telemetry has been deployed on.*

Section 1.0

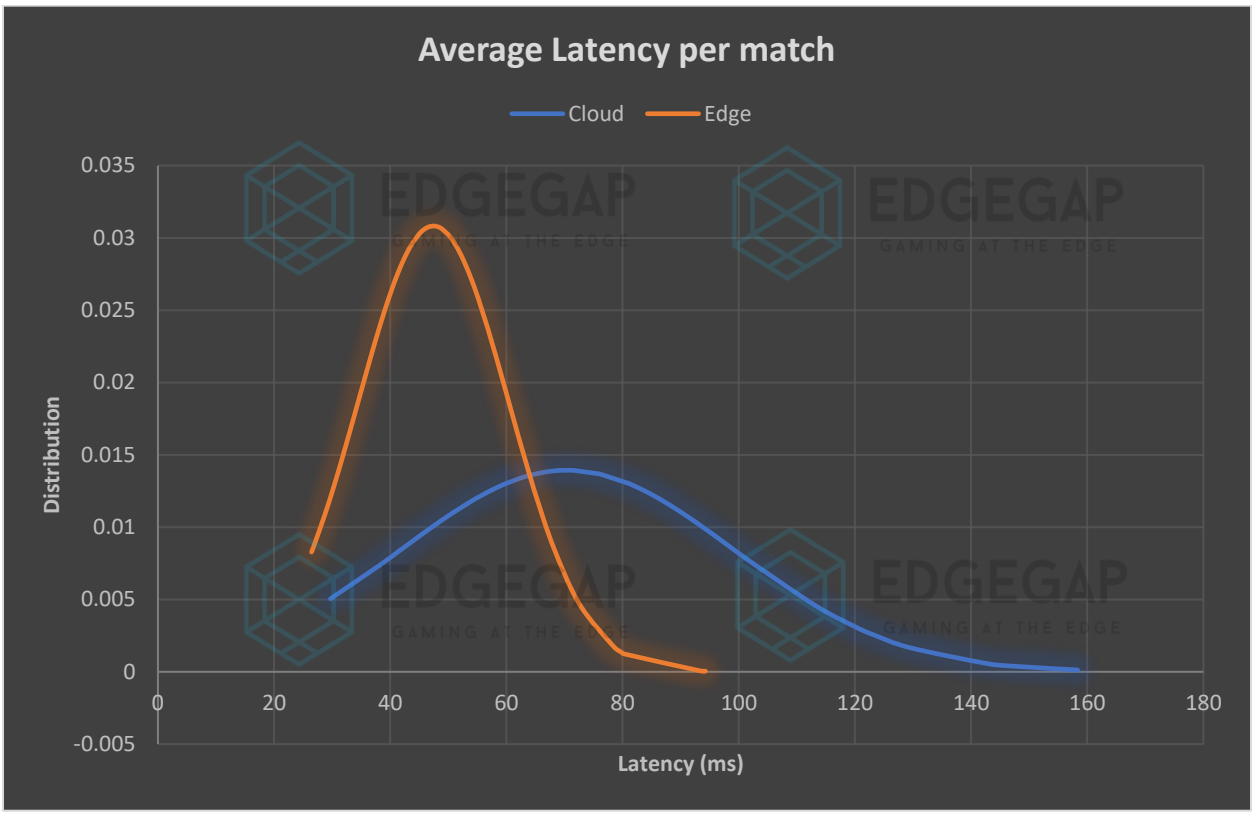
Summary

Using 1000 live players from 100 matches, we re-played those matches through our software and measured multiple locations both in various public clouds and edge infrastructures.

As seen in the graph below, using this data, we can conclude that by using our dynamic game orchestrator, the video game studio would have improved their player experiences by:

- **33%** lower average latency per match
- **45%** reduced standard deviation (closer latency within a match)
- **77%** reduced jitter
- **96%** players with latency below 80ms
- Edge was better over cloud **84%** of the time
- **109%** service quality improvement

Note that we only have access to a limited amount of Edge locations. As infrastructure providers are adding locations, you can expect those improvements to be even better. Cloud locations were although still selected 16% of the time. It is to be expected that cloud will be better for certain group of players based on their locations, time of day, state of network, etc.



Section 2.0

Methodology

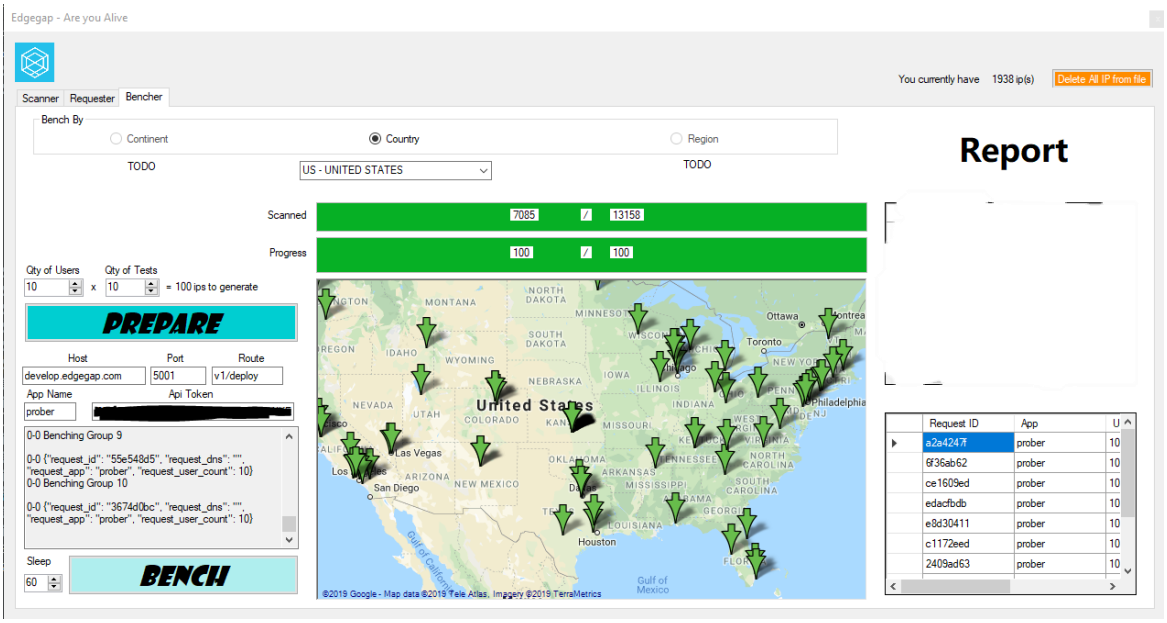
To build this report, we first had to be able to replay a set of matches as provided by a studio. To do so, we used a home-made workload bench tester. This internal tool took in input data provided by a gaming studio. We used the list of IP (players) pooled together as “match”. Our tool made sure each player was reachable by ICMP first. This game was pooling players in group of 10. Those players were most likely pooled together based on the game attributes.

For each match, we deployed our telemetry probes in multiple potential locations. Those locations were a mix of cloud and edge computing infrastructures. Multiple infrastructure providers were used. We are breaking them up in 2 groups, “Cloud” for public cloud and “Edge” for edge infrastructures.

Our data set was made of 1000 players, grouped in 100 matches. Each match had 10 players. We measured around 20 potential locations per match. The measurements taken are described in the section below about happiness level.

Benching

Our testing tool generated a request to Arbitrium, our decision-making software, with the data gathered from the source log provided by the studio. Server responses were also logged in a report.



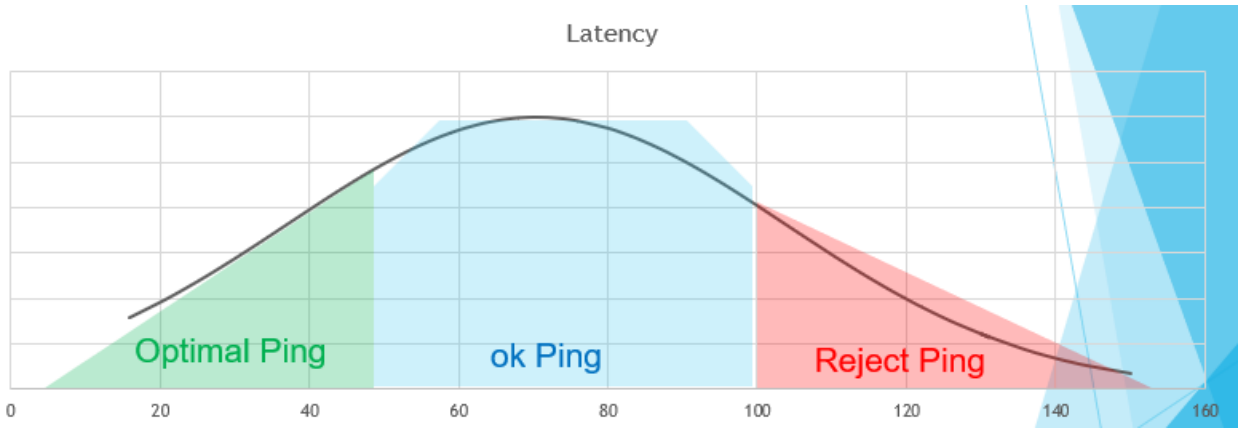
Measurements

To make sure we would always make the best decision, and to compare locations among themselves, we created a measurement called the “happiness level”. This measurement combines multiple data points together to get a unique value per location. Among those data points, we have pure latency (multiple requests), jitter, interval, best and worst scores, rejected ping, optimal ping, drop rates and a few others.

The goal is to get a unique score, per location which we can compare. This method is part of our patent (along the whole decision process) and helps define the best locations per match. The happiness level is the quality of service as measured by removing expectations from the performance. Reach out to us if you’d like to know more about the happiness level and how we make those calculus.

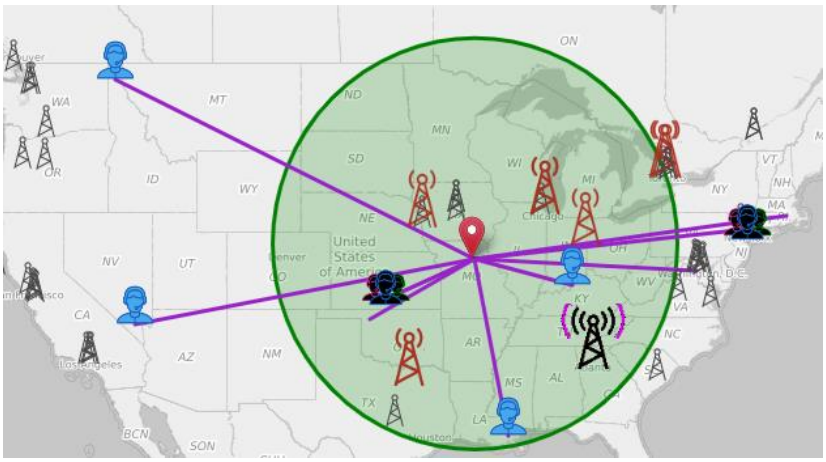
Note that while we logged the happiness level, we also kept every value thus allowing us to build diagrams for each specific metric.

Service Quality = Performance – Expectation

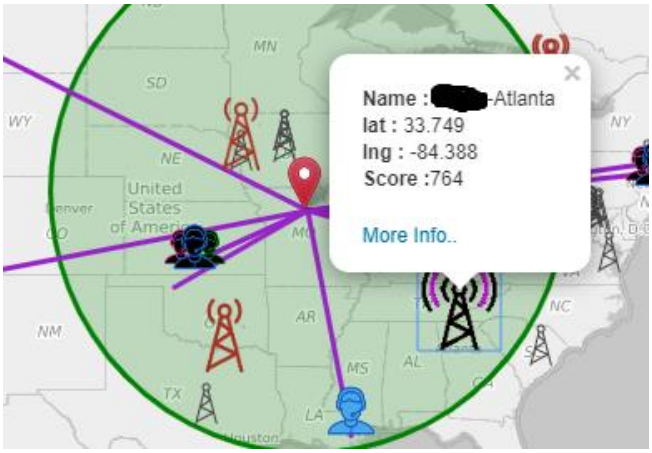


Decision Making

Using our decision-making software Arbitrium, we took every match in the data set provided by the studio and generated a request as if their own match-maker had requested those instances. Below is a single match shown where players are in blue/black. Based on their locations we came up with the green circle to find potential locations (in orange). Those locations were the one running our telemetry probes. After a few seconds the results were sent back to Arbitrium which decided to go with the black/pink antenna and requested for a game to be deployed in this specific location. It is critical to understand that probes were run within each location, for each match. This way we have a preview of what would a match with those players would look like at this specific location.



As seen below, the score, known as our “happiness level”, was of 764. This was the best score of all the potential locations for this specific group of players.



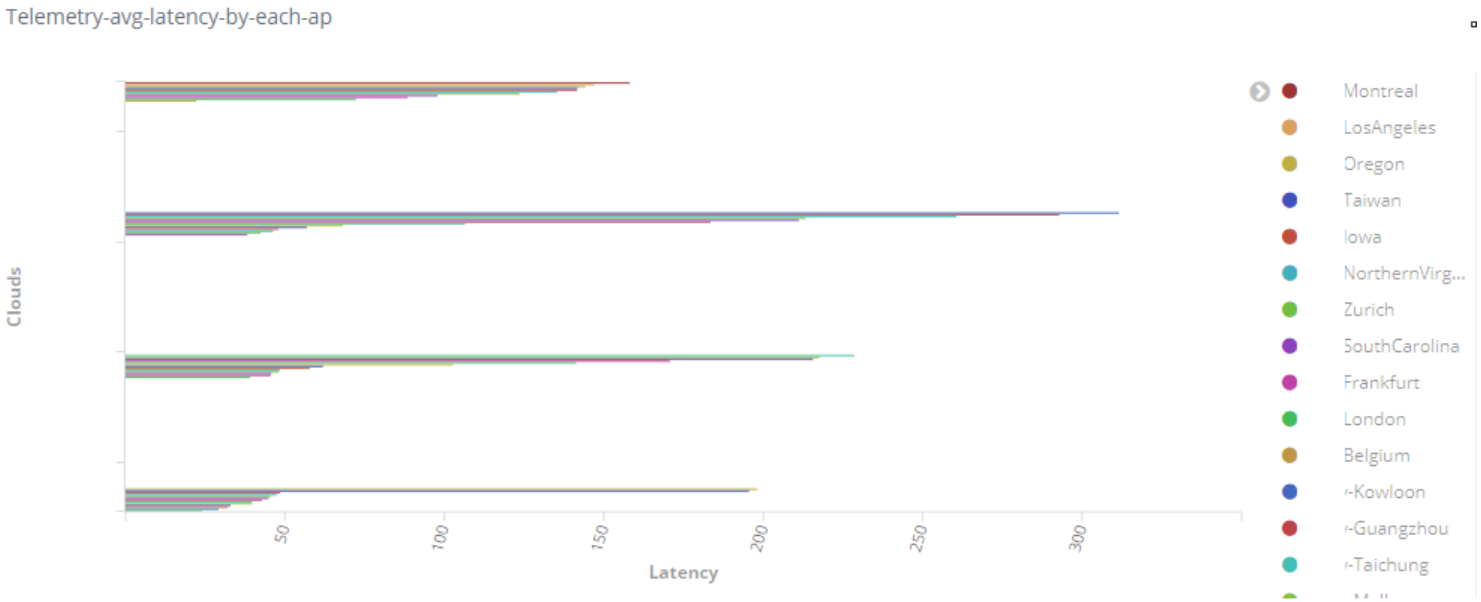
Section 2.1

compiling

Every probe gathering telemetry sent their data to our big data system. The same system was used to compile results and generate this report. A dataset sample can be found in this document, Annexe B.

The full dataset contains too many lines to put it in this report but can be provided per request. For each match, the metrics gathered by each probe were listed. Standard deviation, averages and such were calculated and allowed us to pull the conclusions as seen in the summary.

Using our big data interface, we were able to create multiple reports and graph to narrow down the important data and show metrics at various edge locations. Below is a sample of such graph where locations were compared.



Section 3.0

Probe Results

All the data made by our system was stored into our Big Data system, based on ELK stack (Elasticsearch, Logstash and Kibana). This sample of Probe results shows how we handle the data. Only one example is shown here since it would be too big to show. This data is kept among other metrics not included in this sample.


```
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"position": [0.0, 0.0]}, {"user_id": 4, "ip": "***.34.232.***", "position": [0.0, 0.0]}, {"user_id": 5, "ip":
"***.88.86.*", "position": [0.0, 0.0]}, {"user_id": 6, "ip": "***.59.0.***", "position": [0.0, 0.0]}, {"user_id":
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```

Section 3.1

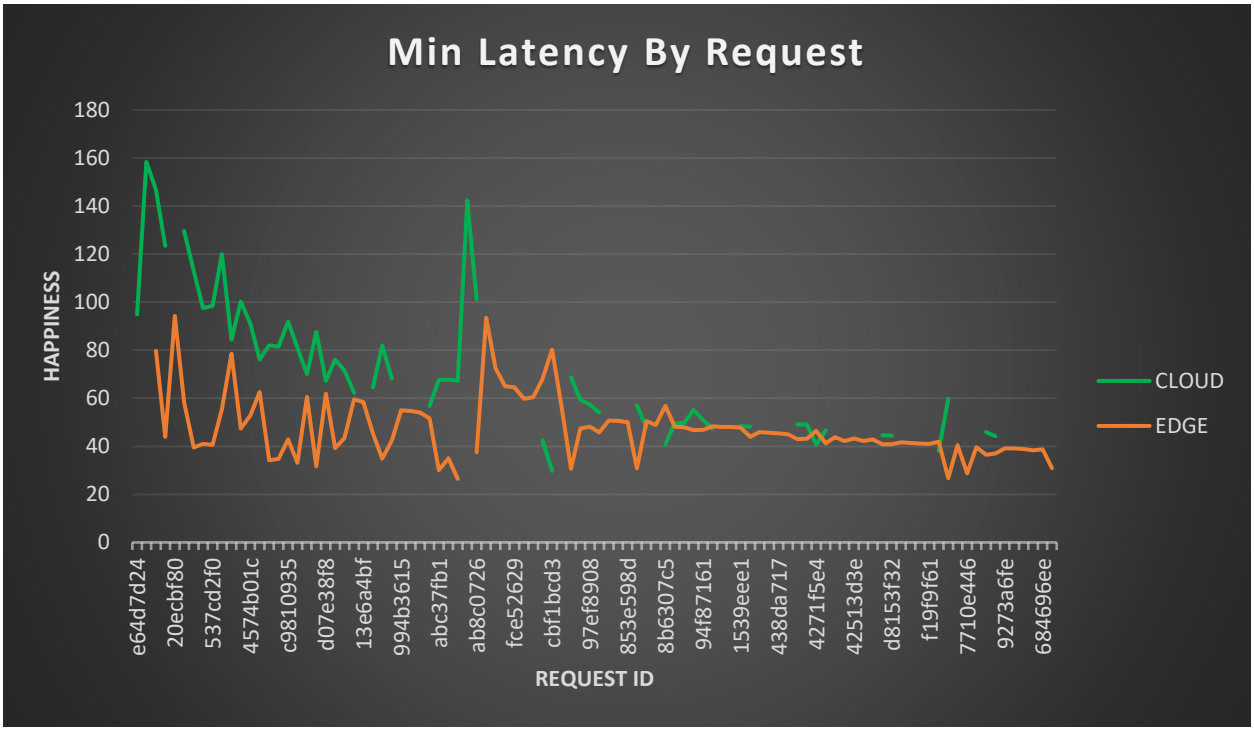
Compiling

The data was grouped by site, provider and request. The data used to compare was the average, per player per match.

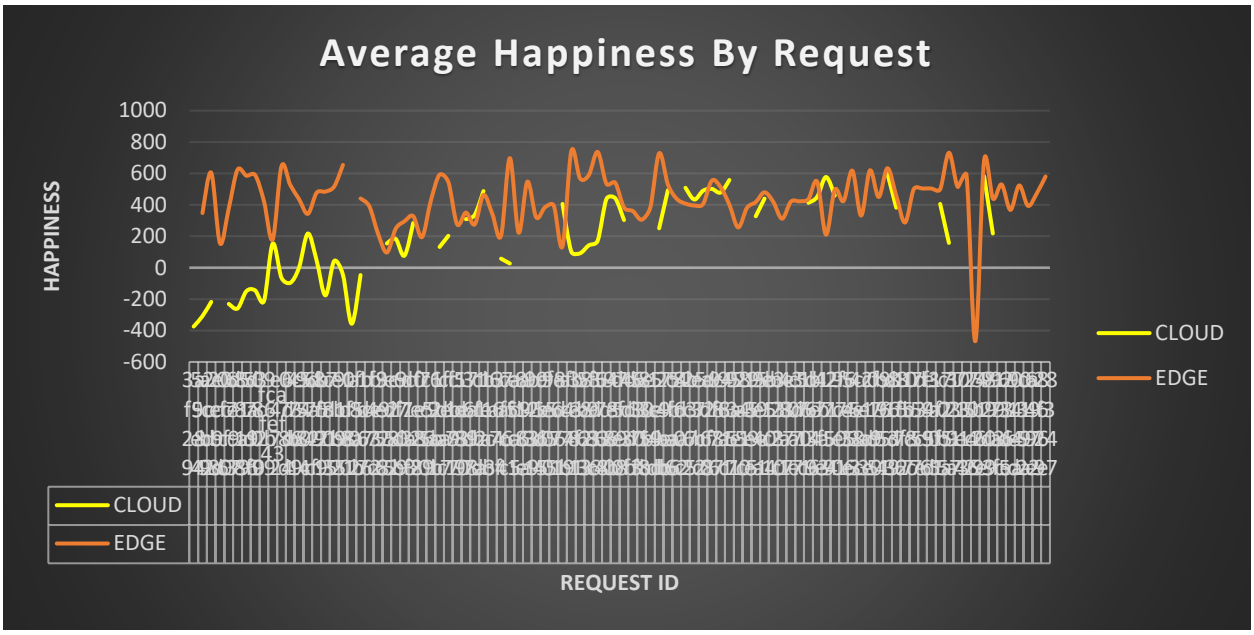
The first table below compares edge locations, against cloud locations. Note that while edge locations were clearly providing better experience overall, in some cases a public cloud location was selected since it had yielded the best metrics from the telemetry.

Edgegap	CLOUD	EDGE	Improvement in %
Avg Happiness	208.6367188	436.3803819	109%
Max Happiness	598.5	741.6666667	24%
% Latency < 40ms	17%	31%	78%
% Latency < 60ms	59%	85%	45%
% Latency < 80ms	70%	96%	36%
Avg Jitter (ms)	13.02122813	2.953110069	77%
Max Jitter (ms)	39.30425	34.031	13%
Avg Latency (ms)	70.49734036	47.43383299	33%
Max Latency (ms)	158.3375	94.2585	40%

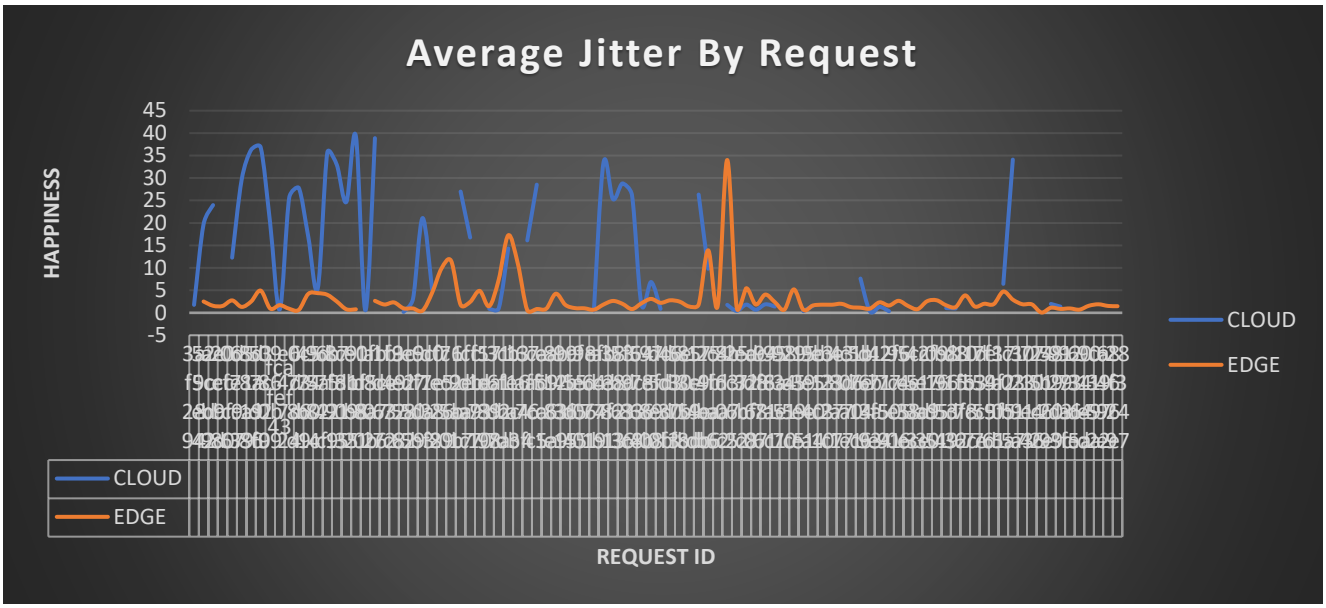
The following graph shows the smallest average latency, per match, for both the best edge location and the best cloud location. While the edge was not always the best option, as expected, we can clearly see that it was providing much lower latency most of the time.



The next graph represents our service quality metric, “happiness level”. Scores can be below 0 due to the nature of the calculus done. In average, edge infrastructure were providing an improvement of 81% versus the cloud.



Surprisingly, the improvement on the jitter front was much higher than expected. We have seen a drastic 88% improvement (or reduction) in jitter with the telemetry coming from the edge versus the one from the cloud.



See Annexe C for raw data sample.

Annexe

Annexe A

Sample data from the main dataset. Each Request ID represents a match of 10 players, and the latency represents the average of those players for a given location (edge or cloud infrastructure).

Comparison	Latency		Standard Deviation	
Request ID	Cloud	EDGE	Cloud	EDGE
e64d7d24	94.8762	41.79133	0.007350246	0.0332
ccdba9c7	71.5685	43.40833	0.01361353	0.033
38e88213	67.79333333	35.05167	0.014083677	0.0281
53bd6336	67.186	26.451	0.014136551	0.0144
5478664b	59.36	47.435	0.014218246	0.03
25c76c22	49.49	48.206	0.012797625	0.0291
b8965d49	44.57	40.93	0.011587215	0.0331
58b92099	45.9	36.54	0.011939324	0.03
9e730703	34.99	36.509	0.008731509	0.0299
5daeb286	31.57333333	32.6565	0.007670714	0.0245
3af52894	158.3375		3.95088E-05	7E-05
529ced42	146.7225	79.78	0.000151563	0.0002
aeccb99d	123.39925	43.9	0.00133372	0.0328
20ecbf80		94.2585	0.001137286	3E-06
0dfec967	129.5185	58.266	0.000806723	0.0133
6571ca39	113.0325	39.514	0.00279986	0.0325
8d8a1986	97.53833333	41.044	0.006552157	0.0331
537cd2f0	98.3965	40.59333	0.006301552	0.033
09860b99	119.975	55.325	0.001730217	0.018
fcafef43	84.48	78.505	0.010550022	0.0003
0c7386d9	100.2486667	47.44	0.005774155	0.03
4574b01c	91.11666667	52.8635	0.008512188	0.0221
9d5a824f	76.2	62.525	0.012734616	0.0077
6b7542c9	81.96066667	34.268	0.011276722	0.027
87fd9115	81.54266667	34.67633	0.01139303	0.0276
c9810935	91.93433333	42.82233	0.008257556	0.0332
e0bfb821	81.071	33.21	0.011522595	0.0254
e9d75059	70.0545	60.55	0.013830637	0.0101
6cf1dab3	87.65166667	31.70667	0.0095892	0.023

d07e38f8	67.275	61.95	0.01412921	0.0083
6f9eaa17	76.0012	39.33267	0.012778403	0.0324
57da8998	62.275	59.5625	0.014319229	0.0114
13e6a4bf		58.452	0.001137286	0.013
67aff764	64.5575	45.34	0.014289162	0.032
caadcac5	82.059	34.915	0.011249166	0.0279
8b1283e9	68.13	42.38	0.014051575	0.0332
994b3615		54.925	0.001137286	0.0186
cf55d545		54.7	0.001137286	0.019
98ed0601		54.025	0.001137286	0.0201
ef647419	56.822	51.64	0.014005459	0.0241
abc37fb1	67.59433333	30.062	0.014101719	0.0203
f69c83c8	68.63866667	30.57333	0.013999332	0.0211
97ef8908	57.44	48.243	0.014067728	0.029
46d330f3		50.675	0.001137286	0.0256
5e307bfb	50.4	50.6145	0.012990501	0.0257
17c94edb	57.0395	30.92	0.01402813	0.0217
254bbab6	47.981	50.3955	0.012454754	0.026
8b6307c5	40.7	56.8	0.010483808	0.0155
ed32bfc8	49.85	47.91025	0.012875225	0.0295
acd86807	55.06	46.75325	0.013792115	0.0307
94f87161	50.83	46.83575	0.013077793	0.0307
956aaec1	47.43	48.3538	0.012322844	0.0289
1539eee1	48.5225	47.735	0.012580968	0.0297
9be540a4	48.175	43.9	0.012500368	0.0328
e313c310		45.95	0.001137286	0.0315
be2327c7		45.6	0.001137286	0.0318
438da717		45.45	0.001137286	0.0319
c106a0e1		45.055	0.001137286	0.0322
d16b3a93	49.13	43.129	0.012718368	0.0331
4271f5e4	40.75	46.408	0.010498663	0.0311
2f775091	46.6	41.275	0.012117822	0.0332
5cee38ec	44.98666667	42.22	0.011699262	0.0332
42513d3e		43.2575	0.001137286	0.0331
cfe7a930	44.42	42.17325	0.011546509	0.0333
d8153f32	44.45	40.8125	0.011554666	0.0331
10fb786c		41.666	0.001137286	0.0332

f19f9f61			41.0125	0.001137286	0.0331
37a2055a		38.1	41.908	0.009696477	0.0333
c103b157		59.75333333	26.7775	0.014240928	0.0149
302391a3			40.525	0.001137286	0.033
7710e446		62.425	28.775	0.014320202	0.0181
2451c62e			39.7	0.001137286	0.0326
9273a6fe			39.1625	0.001137286	0.0323
28f32497		45.925	30.925	0.011945783	0.0217
d8093de9		52.21675	22.821	0.013341652	0.0093
c6e7335c		37.83333333	37.4	0.00961441	0.0309
633ffcb5		39.775	35.6325	0.010206814	0.0289
2b66f51d		35.83	37.956	0.008993297	0.0314
4a6369a3		36.924	36.97167	0.009333315	0.0305
faf6ad0c		37.523	35.19	0.00951868	0.0283
1cbb386d		40.56	34.295	0.010442146	0.0271
27ee0d4a			36.25	0.001137286	0.0296
151e38bc		43.473	23.18667	0.011285245	0.0097
4bbc83b5		39.65	34.0625	0.010169088	0.0267
7270899c			35.8	0.001137286	0.0291
b98adf15		36.85	35.265	0.009310368	0.0284
2fbcaa98		31.55	37.675	0.007663535	0.0312
9d571f81			35.11	0.001137286	0.0282
24e323c6			34.825	0.001137286	0.0278
91184f8c			34.662	0.001137286	0.0276
a4e7df2d		48.544	15.705	0.012585907	0.003
0148f668		33.82666667	33.43933	0.008368915	0.0258
614ba4fb		35.5	32.075	0.008890492	0.0236
6b46b7cc		34.676	30.14	0.008633603	0.0204
dd6cbb07			32.3875	0.001137286	0.0241
d411d4ee			32.0375	0.001137286	0.0235
df0a36b5			31.8545	0.001137286	0.0232
61604a52		35.48	29.878	0.008884259	0.02
	9249438	38.6	24.025	0.009849813	0.0108
230f1320			30.7875	0.001137286	0.0215
Average		62.70160089	42.00438		
Deviation		27.8573315	11.99668		

Annexe B

Data sample from the main data set. Those are the list of player per match and their physical location.

2019-05-16 9:40:19 AM

List of IP by Group of Testing

Country: US - UNITED STATES

# of Users: 10

# of Tests: 10

Group 1

User ***.74.5.*** - 37.751, -97.822

User ***.25.***39.*** - 42.6058, -87.8762

User ***.***72.68. *** - 37.751, -97.822

User ***.***75.***76. *** - 35.0813, -106.6387

User ***.***33.***92. *** - 34.***027, -118.2231

User ***.***97.88. *** - 40.5454, -112.3002

User ***.220.38. *** - 39.7501, -104.9957

User ***.33.76. *** - 42.2084, -83.***616

User ***.253.225. *** - 37.751, -97.822

User ***.7.0. *** - 25.7873, -80.***564

Group 2

User ***.87.***31. *** - 32.6085, -96.8655

User ***.***78.***41.*** - 34.2666, -118.7643

User ***.***81.***40.*** - 37.751, -97.822

User ***.***91.***92.*** - 47.7146, -95.3752

User ***.34.232.*** - 45.7551, -121.4795

User ***.88.86.*** - 34.9441, -89.8544

User ***.59.0.*** - 40.8, -73.9763

User ***.85.48.*** - 37.7852, -122.3874

User ***.3.***.*** - 33.7499, -117.9071

User ***.248.216.*** - 37.751, -97.822

Group 3

User ***.***74.***60.*** - 42.2826, -71.8277

User ***.***38.0.*** - 26.2729, -80.26

User ***.92.***.*** - 43.0475, -87.8964

User **.22.68.*** - 40.05, -105.217

User ***.244.28.*** - 37.751, -97.822

User ***.49.***40.*** - 33.2289, -97.***314

User ***.***39.0.*** - 35.***349, -106.6402

User ***.231.***40.*** - 34.***97, -118.8199

User ***.218.***.*** - 39.9388, -83.0463

User ***.77.9.*** - 37.751, -97.822

Group 4

User ***.***24.0.*** - 40.05, -105.217

User ***.27.74.*** - 47.6092, -122.3314

User ***.27.246.*** - 37.751, -97.822

User ***.45.32.*** - 37.3773, -122.0194

User ***.40.***33.*** - 37.751, -97.822

User ***.253.48.*** - 37.751, -97.822

User ***.249.248.*** - 48.578, -117.8645

User ***.31.203.*** - 39.8498, -75.3747

User ***.***53.***57.*** - 37.751, -97.822

User ***.249.***61.*** - 37.751, -97.822

Group 5

User ***.206.34.*** - 36.5779, -79.4411

User ***.***51.***45.*** - 37.751, -97.822

User ***.37.***20.*** - 37.751, -97.822

User ***.80.29.*** - 37.751, -97.822

User ***.***87.***2.*** - 37.751, -97.822

User ***.***84.227.*** - 37.751, -97.822

User ***.239.96.*** - 39.6327, -75.6998

User ***.245.229.*** - 37.9986, -77.8781

User ***.***24.***8.*** - 37.751, -97.822

User ***.32.80.*** - 37.751, -97.822

Group 6

User ***.***31.73.*** - 37.751, -97.822

User ***.***24.***.*** - 42.0598, -87.6842

User ***.58.***13.*** - 34.4528, -83.***13

User ***.219.208.*** - 37.751, -97.822

User ***.249.232.*** - 41.4245, -89.3693

User ***.***89.***58.*** - 37.751, -97.822

User ***.75.***68.*** - 20.7441, -156.4475

User ***.86.240.*** - 36.539, -86.0242

User ***.***07.252.*** - 37.751, -97.822

User ***.49.64.*** - 41.79, -72.7457

Group 7

User ***.71.32.*** - 40.3371, -79.9901

User ***.225.***80.*** - 43.8125, -111.7855

User ***.***94.80.*** - 40.09, -75.0363

User ***.49.4.*** - 37.751, -97.822

User ***.20.0.*** - 40.822, -73.86

User ***.***92.92.*** - 43.6825, -86.4533

User ***.50.37.*** - 32.69, -96.9177

User ***.6.***3.*** - 37.751, -97.822

User ***.223.25.*** - 37.751, -97.822

User ***.8.81.*** - 37.3881, -121.8756

Group 8

User ***.93.***46.*** - 44.4829, -73.2253

User ***.***1.96.*** - 37.751, -97.822

User ***.***97.***4.*** - 34.0544, -117.2555

User ***.232.48.*** - 36.4162, -83.0108

User ***.62.68.*** - 35.3935, -119.***205

User ***.86.240.*** - 36.539, -86.0242

User ***.28.7.*** - 44.7814, -91.4866

User ***.81.***64.*** - 37.9845, -122.***355

User ***.26.5.*** - 30.3587, -95.6857

User ***.88.***.*** - 40.7416, -84.***522

Group 9

User ***.219.240.*** - 37.751, -97.822

User ***.9.98.*** - 29.7388, -95.8309

User ***.***14.70.*** - 29.2219, -81.0095

User ***.33.90.*** - 30.5012, -87.8795

User ***.203.***.*** - 36.***236, -115.2757

User ***.***93.236.*** - 37.751, -97.822

User ***.223.240.*** - 37.751, -97.822

User ***.34.57.*** - 37.751, -97.822

User ***.95.***82.*** - 37.751, -97.822

User ***.***16.***24.*** - 34.2602, -118.5787

Group 10

User ***.***99.***89.*** - 37.751, -97.822

User ***.***30.***.*** - 36.***214, -115.***41

User ***.***11.5.*** - 29.5584, -98.7435

User ***.***44.36.*** - 37.751, -97.822

User ***.***97.***49.*** - 37.751, -97.822

User ***.44.33.*** - 43.0828, -88.0269

User ***.92.96.*** - 27.893, -82.5074

User ***.62.***57.*** - 37.751, -97.822

User ***.***73.27.*** - 37.751, -97.822

User ***.21.***20.*** - 21.3571, -157.9258

Request ID: a2a4247f - Requested App: prober - User Count: 10

Request ID: 6f36ab62 - Requested App: prober - User Count: 10

Request ID: ce1609ed - Requested App: prober - User Count: 10

Request ID: edacfbdb - Requested App: prober - User Count: 10

Request ID: e8d30411 - Requested App: prober - User Count: 10

Request ID: c1172eed - Requested App: prober - User Count: 10

Request ID: 2409ad63 - Requested App: prober - User Count: 10

Request ID: d24ef118 - Requested App: prober - User Count: 10

Request ID: 55e548d5 - Requested App: prober - User Count: 10

Request ID: 3674d0bc - Requested App: prober - User Count: 10

Annexe C

Below is a sample of the data set for some metrics per location. We did not use every location for our report, we only used the best one both for edge and location. Other metrics were discarded.

Request ID	Provider	Region	Latency	Jitter	Happiness
ce1609ed	Cloud	Cloud-Oregon	297.444	26.558	322
ce1609ed	Cloud	Cloud-LosAngeles	264.538	83.93	-896
ce1609ed	Cloud	Cloud-Montreal	236.914	81.486	-1,000
ce1609ed	Cloud	Cloud-Iowa	180.8	83.2	-898
ce1609ed	Cloud	Cloud-NorthernVirginia	180.327	140.503	-1,000
ce1609ed	Cloud	Cloud-SouthCarolina	132.08	5	306
ce1609ed	Cloud	Cloud-canada	135.385	3.458	493
ce1609ed	Cloud	Cloud-ohio	103.78	3.675	524
ce1609ed	Cloud	Cloud-north-virginia	100.78	1.775	561
ce1609ed	Edge	Edge-Toronto	138.288	5.65	502
ce1609ed	Edge	Edge-NewYork	111.02	6.825	480
ce1609ed	Edge	Edge-Chicago	102.38	4.675	521
ce1609ed	Edge	Edge-Atlanta	31.889	0.775	548
ce1609ed	Edge	Edge-Dallas	27.844	1.05	584
ce1609ed	Edge	Edge-Portland		-0.25	-1,000
a2a4247f	Cloud	Cloud-LosAngeles	185.672	64.982	-801
a2a4247f	Cloud	Cloud-NorthernVirginia	178.339	48.15	-684
a2a4247f	Cloud	Cloud-Iowa	173.254	63.253	-873
a2a4247f	Cloud	Cloud-SouthCarolina	149.813	16.747	-673
a2a4247f	Cloud	Cloud-Oregon	111.75	28.917	-653
a2a4247f	Cloud	Cloud-canada	77.08	0.5	236
a2a4247f	Cloud	Cloud-north-virginia	76.1	4.775	268
a2a4247f	Cloud	Cloud-ohio	70.64	1.15	288
2409ad63	Cloud	Cloud-LosAngeles	180.771	51.288	-895
2409ad63	Cloud	Cloud-Montreal	173.133	36.969	-898
2409ad63	Cloud	Cloud-Iowa	146.298	91.642	-1,000
2409ad63	Cloud	Cloud-NorthernVirginia	132.482	72.693	-759
2409ad63	Cloud	Cloud-SouthCarolina	120.714	43.275	-1,000
2409ad63	Cloud	Cloud-canada	60.2	0.075	308
2409ad63	Cloud	Cloud-ohio	59.244	0.175	329

2409ad63	Cloud	Cloud-north-virginia	55.2	0.425	344
2409ad63	Edge	Edge-Atlanta	59.4	0.775	344
2409ad63	Edge	Edge-Dallas	57.733	0.65	367
2409ad63	Edge	Edge-NewYork	56	1.15	316
2409ad63	Edge	Edge-Toronto	55.82	1.025	498
2409ad63	Edge	Edge-Chicago	49.422	0.5	400
2409ad63	Edge	Edge-Edmonton		-0.25	-1,000
3674d0bc	Cloud	Cloud-LosAngeles	181.492	74.509	-898
3674d0bc	Cloud	Cloud-Iowa	158.525	46.277	-896
3674d0bc	Cloud	Cloud-SouthCarolina	94.852	2.6	143
3674d0bc	Cloud	Cloud-Oregon	68.46	0.35	373
3674d0bc	Cloud	Cloud-sydney	222.063	1.375	-1,000
3674d0bc	Cloud	Cloud-oregon	76.413	0.25	278
3674d0bc	Cloud	Cloud-ohio	67.32	1.375	319
3674d0bc	Cloud	Cloud-north-california	62.8	0.225	457
3674d0bc	Edge	Edge-Toronto	72.04	0.95	326
3674d0bc	Edge	Edge-SanJose	68.152	1.125	390
3674d0bc	Edge	Edge-Atlanta	63.196	3.425	368
3674d0bc	Edge	Edge-Chicago	60.277	1.975	348
3674d0bc	Edge	Edge-Dallas	56.936	0.725	490
3674d0bc	Edge	Edge-Portland		-0.25	-1,000
3674d0bc	Edge	Edge-Seattle		-0.25	-1,000
e8d30411	Cloud	Cloud-LosAngeles	204.048	37.013	-1,000
e8d30411	Cloud	Cloud-Montreal	177.47	51.831	-1,000
e8d30411	Cloud	Cloud-Iowa	174.525	61.478	-1,000
e8d30411	Cloud	Cloud-NorthernVirginia	159.825	54.72	-796
e8d30411	Cloud	Cloud-SouthCarolina	72.3	67.5	-1,000
e8d30411	Edge	Edge-Atlanta	50.51	4.265	481
e8d30411	Edge	Edge-Toronto	43.48	1.1	610
e8d30411	Edge	Edge-NewYork	40.64	1.3	628
e8d30411	Edge	Edge-Chicago	40.6	1.175	644
e8d30411	Edge	Edge-Dallas	36.82	2.625	660
e8d30411	Cloud	Cloud-canada	43.42	0.4	618
e8d30411	Cloud	Cloud-north-virginia	38.444	0.325	498
e8d30411	Cloud	Cloud-ohio	37.92	0.65	670
e8d30411	Edge	Edge-Edmonton		-0.25	-1,000
e8d30411	Edge	Edge-Portland		-0.25	-1,000
d24ef118	Cloud	Cloud-Montreal	191.951	51.284	-1,000
d24ef118	Cloud	Cloud-Oregon	163.14	59.177	-806

d24ef118	Cloud	Cloud-LosAngeles	146.661	56.81	-510
d24ef118	Cloud	Cloud-Iowa	143.9	91.975	-1,000
d24ef118	Cloud	Cloud-NorthernVirginia	102.857	53.863	-285
d24ef118	Cloud	Cloud-SouthCarolina	72.14	7.675	75
d24ef118	Cloud	Cloud-canada	58.6	0.525	459
d24ef118	Cloud	Cloud-ohio	53.22	1.325	514
d24ef118	Cloud	Cloud-north-virginia	49.5	0.425	554
d24ef118	Edge	Edge-NewYork	55.2	3.1	378
d24ef118	Edge	Edge-Toronto	54.38	0.775	505
d24ef118	Edge	Edge-Atlanta	49.94	5.3	447
d24ef118	Edge	Edge-Dallas	44.6	0.675	630
d24ef118	Edge	Edge-Chicago	42.54	0.6	634
d24ef118	Edge	Edge-Portland		-0.25	-1,000
edacfbdb	Cloud	Cloud-LosAngeles	171.771	49.731	-802
edacfbdb	Cloud	Cloud-Iowa	154.648	75.025	-899
edacfbdb	Cloud	Cloud-Oregon	108.981	46.66	-513
edacfbdb	Cloud	Cloud-sydney	213.8	2.325	-1,000
edacfbdb	Cloud	Cloud-ohio	61.34	0.55	420
edacfbdb	Cloud	Cloud-oregon	50.2	1.15	534
edacfbdb	Cloud	Cloud-north-california	42.74	0.65	625
edacfbdb	Edge	Edge-Toronto	63.56	1.225	293
edacfbdb	Edge	Edge-Dallas	58.18	2.175	266
edacfbdb	Edge	Edge-Atlanta	54.961	1.855	387
edacfbdb	Edge	Edge-Chicago	54.96	0.7	390
edacfbdb	Edge	Edge-SanJose	46.54	1.3	572
edacfbdb	Edge	Edge-SanFrancisco	54.462	1.075	533
edacfbdb	Edge	Edge-Portland		-0.25	-1,000
6f36ab62	Cloud	Cloud-LosAngeles	181.53	42.071	-789
6f36ab62	Cloud	Cloud-Iowa	141.1	74.95	-1,000
6f36ab62	Cloud	Cloud-Oregon	119.94	63.978	-811
6f36ab62	Cloud	Cloud-sydney	223.42	0.8	-1,000
6f36ab62	Cloud	Cloud-oregon	60.86	2.475	317
6f36ab62	Cloud	Cloud-ohio	52.34	4.425	481
6f36ab62	Cloud	Cloud-north-california	45.78	1.2	582
6f36ab62	Edge	Edge-Toronto	50.6	1.175	533
6f36ab62	Edge	Edge-SanJose	48.52	1.375	545
6f36ab62	Edge	Edge-Chicago	46.9	4.225	466
6f36ab62	Edge	Edge-Atlanta	44.98	3.65	574
6f36ab62	Edge	Edge-Dallas	38.6	0.8	676

6f36ab62	Edge	Edge-Dallas	39.849	2.48	704
6f36ab62	Edge	Edge-Edmonton		-0.25	-1,000
c1172eed	Cloud	Cloud-LosAngeles	206.7	40.337	-1,000
c1172eed	Cloud	Cloud-Oregon	183.036	66.513	-888
c1172eed	Cloud	Cloud-Montreal	169.35	48.533	-1,000
c1172eed	Cloud	Cloud-Iowa	131.164	108.065	-1,000
c1172eed	Cloud	Cloud-NorthernVirginia	93.857	60.95	-440
c1172eed	Cloud	Cloud-SouthCarolina	70.111	3.55	432
c1172eed	Cloud	Cloud-ohio	45.28	10.45	396
c1172eed	Cloud	Cloud-canada	39.48	0.35	566
c1172eed	Cloud	Cloud-north-virginia	36.74	0.6	592
c1172eed	Edge	Edge-Dallas	37.58	0.4	674
c1172eed	Edge	Edge-Portland		-0.25	-1,000
c1172eed	Edge	Edge-Toronto	40.7	0.875	554
c1172eed	Edge	Edge-Dallas	38.66	0.925	664
c1172eed	Edge	Edge-Atlanta	38.1	0.625	558
c1172eed	Edge	Edge-NewYork	35.76	0.8	590
c1172eed	Edge	Edge-Chicago	30.76	0.725	625
55e548d5	Cloud	Cloud-Oregon	159.733	42.75	-1,000
55e548d5	Cloud	Cloud-LosAngeles	158.549	11.1	-417
55e548d5	Cloud	Cloud-SouthCarolina	124.556	51.95	-1,000
55e548d5	Cloud	Cloud-NorthernVirginia	83.06	114.385	-783
55e548d5	Cloud	Cloud-Iowa	69.333	57.1	-1,000
55e548d5	Cloud	Cloud-canada	48.98	0.75	548
55e548d5	Cloud	Cloud-ohio	46.88	0.45	575
55e548d5	Cloud	Cloud-north-virginia	40.956	1.475	449
55e548d5	Edge	Edge-SanJose	50.956	2.075	357
55e548d5	Edge	Edge-Toronto	44.422	0.925	439
55e548d5	Edge	Edge-Atlanta	41.92	1.475	531
55e548d5	Edge	Edge-Chicago	39.733	2.35	462
55e548d5	Edge	Edge-Dallas	32.867	1.1	550
55e548d5	Edge	Edge-Portland		-0.25	-1,000