Name: Rajat Rajesh Shetty Assignment 2
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P14] Consider the queuing delay in a router buffer. Let I denote traffic intensity. that is, $I = La/R$. suppose that the queuing delay takes the form $IL/R(1-I)$ for $I<1$.

a) provide a formula for the total delay, that is, the queuing delay plus the transmission delay.

b) Plot the total delay as a function of L/R.

⇒ W.K.T,

total Delay: Queuing delay + Transmission delay.

a) propogation delay & switching delay in a queue is ignored.

∴ total Delay = $d_{queue} + d_{trans}$

$$= \frac{IL}{R(1-I)} + L/R$$

$$= \frac{L}{R}\left[\frac{I}{1-I} + 1\right]$$

$$= \frac{L}{R}\left[\frac{I+1-I}{1-I}\right]$$

$$\Rightarrow \frac{L}{R}\left[\frac{1}{1-I}\right] \text{ sec}$$

b) Let us assume that the transmission is represented by x. so, the transmission delay $x = L/R$.

traffic intensity, $I = \frac{La}{R} = xa$

Hence, the total delay: $\frac{x}{1-xa}$

P18] Perform a traceroute between source & destination on the same continent at 3 different hours of the day.

a. Find the average & SD of the round trip delays at each of the 3 hours.

b. Find the no. of routers in the path at each of the 3 hours. Did the paths change during any of the hours?

c. Try to identify the no. of ISP networks that the traceroute packets pass through source to destination.

d) Repeat the above for a source & destination on different continents. compare the intra-continent & inter-continent results

⇒ a) From the cmd results

$D_1 = 18.67$ ms $D_2 = 17.67$ ms $D_3 = 18$ ms

The average of the 3 round-trip delays:

$$\bar{D} = \frac{D_1 + D_2 + D_3}{3} \Rightarrow \frac{(18.67 + 17.67 + 18)}{3}$$

$$\Rightarrow 18.11 \text{ msec}$$

∴ The average = 18.11 msec

& S.D = 0.416

18
19
19.
56

= 18.67

The S.D of 3 round trip delays:

$$\sigma = \sqrt{1/N \left[(D_1 - \bar{D})^2 + (D_2 - \bar{D})^2 + (D_3 - \bar{D})^2 \right]}$$

$$\Rightarrow \sqrt{\frac{1}{3}\left[(18.67 - 18.11)^2 + (17.67 - 18.11)^2 + (18 - 18.11)^2 \right]}$$

$$= 0.416$$

b). The no. of routers in the path at each of the 3 hours is 11

No, the paths didnot change during any of the hours.

c) In this example, the traceroutes have passed through 3 ISP Networks the Traceroute packets passed through From source to destination. Yes in this experiment the largest delays occured at peering interfaces between adjacent ISP.

Traceroute From mumbai to US (www.sterens.edu)

d) The average round trip delay at each of the 3 hours are 10.792 ms, 10.624 ms. & 10.786 ms. ∴ The average delay is = 10.71 3 round trip

& S.D = 0.066

b) The no of routers in the path at each of 3 hours is 6. No the path didnot change.

a)
c) Traceroute packet passed through 1 ISP network. From source to destination.

d) To check for Inter & Intra continents, iam using Mumbai → US & Canada → U.S. trace routes.

Comparing the 2, it seems that the only difference i see is an increase in time for different continents. The Intra-continent results are used to make faster reach to the DNS.

The inter continent result are used to the server that is essential to the user.

P19] a) Visit the site http://www.traceroute.org & perform traceroutes from 2 different cities in France to same destination host in the United States. How many links are the same in the 2 traceroutes? Is the transatlantic link the same?

(b) Repeat (a) but this time choose one city in France & another city in Germany.

(c) Pick a city in US, & perform traceroutes to 2 hosts, each in a different city in China. How many links are common in the 2 traceroutes? Do the 2 traceroutes diverge before reaching China?

=) a) Marseille & Montpellier.

It seems that there are only 4 links that are the same. The first 3 usual uswest1, & then neotel-pairpao-neotel.net is the 4th one that is same. I think this is because they use 2 seperate transatlantic links. Marsellie takes the xe1-0-0 & Montpellier takes xe-2-0-0. These are thought to be translatic link mainly due to latency of over 150 ms.

b) Munich & Montpellier.

These 2 cities actually have more in common than the 2 french cities. Both have the first 3 west 1. But then they shared 2 more ip addresses. Both used 72.21.222.21 & 205.251.229.15. Neither appears to be on the same translatic link, but they are very close. Both are on the xe-20-0 but the routers diverge from there

c) Beijing & Qingdao. (City in chia)

These 2 cities are the most different. They only share beginning 3 routers & dont use the same transatlantic link. However some of the IP address are incredibly close to each other in physical locat^n, probably in the same room.

P20

Consider the throughout example corresponding to figure 1.20(b). Now suppose there are M client-server pairs rather than 10. Defn R_s, R_c & R for the rates of the server links, client links & Netwo link. Derive a general expression for throughput in terms of R_s, R_c, R, & M.

⇒ Given data

R_s = server link rate

R_c = client link rate

R = Network link rate

M = client-server pair.

Instantaneous throughput & average throughput are 2 types of throughput. The server throughput R_c faster than R_s.

Network always depends on client-server links.

∴ general expression for throughput in terms of R_c, R_s, R & M is $\min\{R_s, R_c, R/M\}$

P25] suppose 2 hosts, A & B, are seperated by 20 kms and are connected by a direct link of R = 2Mbps. suppose prop. speed over link is 2.5×10^8 m/s.

a) Calculate bandwidth delay product, R. delay.

b) Consider sending a file of 800,000 bits from A to B. suppose the file is sent continously as one message. what is the max no of bits that will be in the link at given time?

c) provide an interpretation of bandwidth-delay product.

d) what is the width (mts) of a bit in the link?

e) Derive a general expression for the width of a bit in terms of propogation speed S, the transmission rate R, and the length of link M

⇒ The distance between 2 hosts A & B = 20,000 km.

a) $= 2 \times 10^7$ m,

Transmission rate of direct link between A & B = 2Mbps

$= 2 \times 10^6$ bps

propagation speed of link between A & B $= 2.5 \times 10^8$ m/s

$\therefore$ propogation delay $= \frac{\text{Distance}}{\text{speed}} = \frac{2 \times 10^7}{2.5 \times 10^8} = 0.08$ sec

$\therefore$ bandwidth delay $=$

$R \times d_{prog} = 2 \times 10^6 \times 0.08 = 16 \times 10^4$ bits.

$\therefore$ bandwith delay product is 160000 bits

b) size of file $= 80{,}000$ bits $= 8 \times 10^5$ bits

T.R(R) of direct link between A & B $= 2$ Mbps

$= 2 \times 10^6$ bps

The bandwidth delay:

$R \times d_{prog} = 2 \times 10^6 \times 0.08 = 16 \times 10^4$ bits

$\therefore$ the max no. of bits at a given time will be 160,000 bits

c) The product of bandwidth delay = to the max no of bits on transmission line.

d) $R = 2$ Mbps $= 2 \times 10^6$ bps

$S = 2.5 \times 10^8$ m/sec

$\therefore$ length of 1 bit of transmission one $= \frac{\text{speed (S)}}{\text{Transmission rate (R)}}$

$= \frac{2.5 \times 10^8}{2 \times 10^6} = 125$ m/bit

$\therefore$ it is longer than a football field.

e) A general expression for the width $= \frac{\text{(Transmission rate (R) * speed (S))}}{\text{length of link (m)}}$

$= \frac{R * S}{m}$

18a.b.c

```
C:\Users\rajat>tracert www.stevens.edu

Tracing route to www.stevens.edu [104.18.130.28]
over a maximum of 30 hops:

  1     3 ms     4 ms     2 ms  10.0.0.1
  2    39 ms    60 ms    46 ms  96.120.75.5
  3    31 ms    29 ms    26 ms  24.124.225.69
  4    57 ms    18 ms    12 ms  68.86.210.205
  5    68 ms    52 ms   108 ms  162.151.210.53
  6    30 ms    27 ms    40 ms  be-98-ar03.plainfield.nj.panjde.comcast.net [68.85.35.37]
  7    16 ms    20 ms    18 ms  be-31133-cs03.newark.nj.ibone.comcast.net [96.110.42.41]
  8    62 ms    31 ms    17 ms  be-2303-pe03.newark.nj.ibone.comcast.net [96.110.37.74]
  9    37 ms    37 ms    27 ms  173.167.58.38
 10    41 ms    43 ms    68 ms  172.70.112.2
 11    18 ms    19 ms    19 ms  104.18.130.28

Trace complete.
```

```
C:\Users\rajat>tracert www.stevens.edu

Tracing route to www.stevens.edu [104.18.130.28]
over a maximum of 30 hops:

  1     3 ms     3 ms     2 ms  10.0.0.1
  2    12 ms    13 ms    15 ms  96.120.75.5
  3    48 ms    36 ms     9 ms  24.124.225.69
  4    69 ms    92 ms    61 ms  68.86.210.205
  5    22 ms    17 ms    15 ms  162.151.210.53
  6    45 ms    55 ms    32 ms  be-98-ar03.plainfield.nj.panjde.comcast.net [68.85.35.37]
  7    77 ms    71 ms    50 ms  be-31133-cs03.newark.nj.ibone.comcast.net [96.110.42.41]
  8    13 ms    17 ms    13 ms  be-2303-pe03.newark.nj.ibone.comcast.net [96.110.37.74]
  9    49 ms    89 ms    48 ms  173.167.58.38
 10    16 ms    16 ms    16 ms  172.70.112.2
 11    16 ms    18 ms    19 ms  104.18.130.28

Trace complete.
```

```
C:\Users\rajat>tracert www.stevens.edu

Tracing route to www.stevens.edu [104.18.130.28]
over a maximum of 30 hops:

  1     4 ms     4 ms     5 ms  10.0.0.1
  2    16 ms    14 ms    14 ms  96.120.75.5
  3    14 ms    15 ms    17 ms  24.124.225.69
  4    23 ms    14 ms    16 ms  68.86.210.205
  5    17 ms    11 ms    17 ms  162.151.210.53
  6    13 ms    13 ms    21 ms  be-98-ar03.plainfield.nj.panjde.comcast.net [68.85.35.37]
  7    14 ms    13 ms    20 ms  be-31133-cs03.newark.nj.ibone.comcast.net [96.110.42.41]
  8    13 ms    14 ms    20 ms  be-2303-pe03.newark.nj.ibone.comcast.net [96.110.37.74]
  9    26 ms    84 ms    66 ms  173.167.58.38
 10    23 ms    14 ms    30 ms  172.70.112.2
 11    19 ms    17 ms    18 ms  104.18.130.28

Trace complete.
```

18.d (first half)

File Edit Format View Help

```
traceroute to www.stevens.edu (104.18.130.28), 30 hops max, 40 byte packets
 1  gateway (103.13.112.1)  0.540 ms *  0.699 ms
 2  103.149.113.69 (103.149.113.69)  2.635 ms  2.526 ms  2.441 ms
 3  nsg-static-117.9.76.182-airtel.com (182.76.9.117)  5.698 ms  5.712 ms  5.716 ms
 4  182.79.134.158 (182.79.134.158)  10.365 ms  10.452 ms  10.497 ms
 5  182.79.161.173 (182.79.161.173)  12.051 ms  12.061 ms  12.179 ms
 6  104.18.130.28 (104.18.130.28)  11.093 ms  10.538 ms  10.534 ms

traceroute to www.stevens.edu (104.18.130.28), 30 hops max, 40 byte packets
 1  gateway (103.13.112.1)  0.694 ms *  0.912 ms
 2  103.149.113.69 (103.149.113.69)  2.138 ms  2.390 ms  2.325 ms
 3  nsg-static-117.9.76.182-airtel.com (182.76.9.117)  6.440 ms  6.502 ms  6.524 ms
 4  182.79.134.158 (182.79.134.158)  6.856 ms  6.901 ms  6.925 ms
 5  182.79.161.173 (182.79.161.173)  12.980 ms  12.38 ms  12.014 ms
 6  104.18.130.28 (104.18.130.28)  11.528 ms  10.336 ms  10.328 ms
```

```
traceroute to www.stevens.edu (104.18.130.28), 30 hops max, 40 byte packets
 1  gateway (103.13.112.1)  0.694 ms *  0.912 ms
 2  103.149.113.69 (103.149.113.69)  2.438 ms  2.390 ms  2.325 ms
 3  nsg-static-117.9.76.182-airtel.com (182.76.9.117)  5.440 ms  5.502 ms  5.524 ms
 4  182.79.134.158 (182.79.134.158)  5.856 ms  5.901 ms  5.925 ms
 5  182.79.161.173 (182.79.161.173)  11.980 ms  12.038 ms  12.064 ms
 6  104.18.130.28 (104.18.130.28)  10.578 ms  10.666 ms  10.628 ms
```

18.d (Second half)

Traceroute to http://www.stevens.edu from Toronto - CA

traceroute to www.stevens.edu (104.18.130.28), 30 hops max, 40 byte packets(Download traceroute)

Hop	Node	Response Time(ms)
1	*	-
2	Internal (Internal)	1.345
3	Internal (Internal)	2.731
4	Internal (Internal)	9.189
5	cloudflare.ip4.torontointernetxchange.net (206.108.34.208)	1.343
6	104.18.130.28 (104.18.130.28)	1.839

Traceroute to http://www.stevens.edu from Mumbai - IN

traceroute to www.stevens.edu (104.18.130.28), 30 hops max, 40 byte packets(Download traceroute)

Hop	Node	Response Time(ms)
1	*	-
2	*	-
3	Internal (Internal)	0.896
4	Internal (Internal)	0.530
5	ae0-100.gw2.mum1.in.linode.com (172.105.32.9)	0.531
6	103.27.170.48 (103.27.170.48)	1.466
7	104.18.130.28 (104.18.130.28)	0.464

19.a

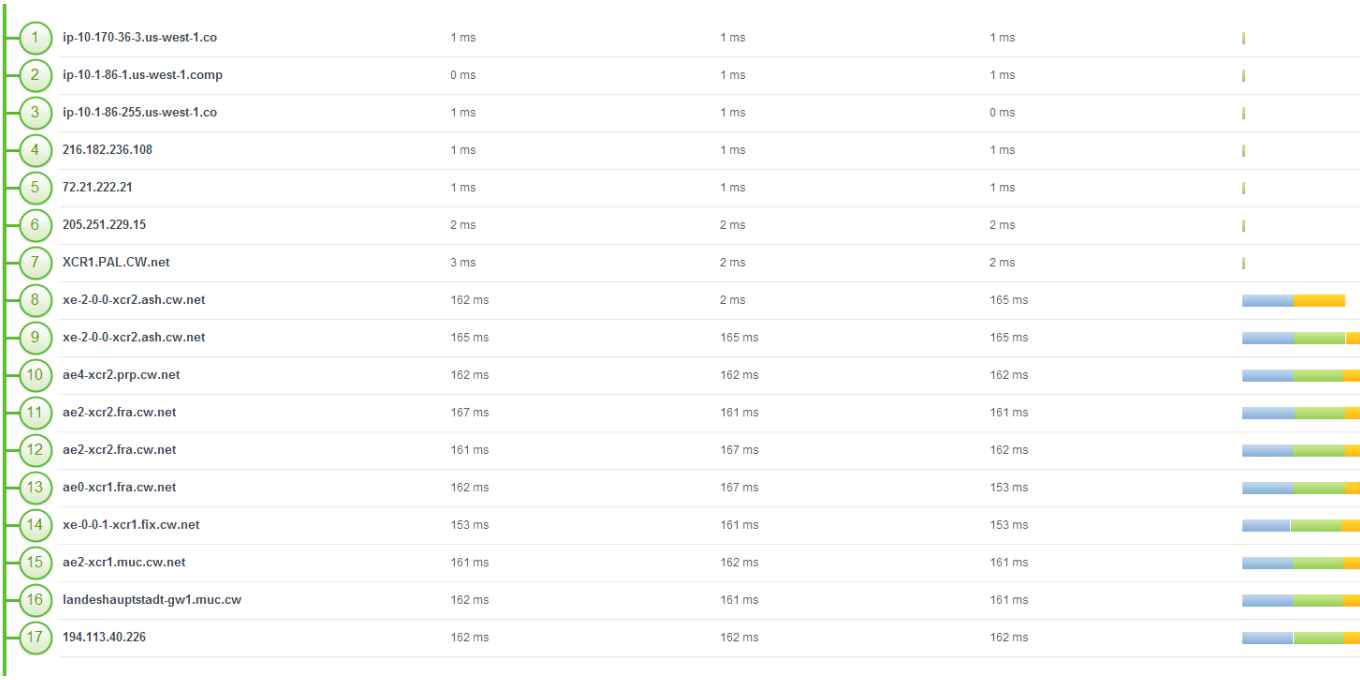
1	ip-10-170-36-3.us-west-1.co	0 ms	1 ms	1 ms	
2	ip-10-1-86-1.us-west-1.comp	1 ms	0 ms	1 ms	
3	ip-10-1-78-255.us-west-1.co	1 ms	1 ms	1 ms	
4	216.182.236.106	1 ms	1 ms	1 ms	
5	72.21.222.18	2 ms	68 ms	12 ms	
6	72.21.222.18	2 ms	2 ms	2 ms	
7	205.251.229.15	2 ms	2 ms	2 ms	
8	neotel1-paixpao-neotel.net	2 ms	2 ms	2 ms	
9	xe1-0-0.tcr1.telx.nyc.as821	74 ms	74 ms	151 ms	
10	xe2-1-0.ter1.eqx2.par.as821	155 ms	155 ms	146 ms	
11	xe2-2-0.ter2.eqx2.par.as821	179 ms	146 ms	155 ms	
12	xe2-1-0.ter1.eqx2.par.as821	151 ms	151 ms	151 ms	
13	nexto-prs.ix-customers-rese	155 ms	146 ms	146 ms	
14	nexto-prs.ix-customers-rese	155 ms	146 ms	154 ms	
15	N/A	0 ms	162 ms	162 ms	
16	nexto-prs.ix-customers-rese	151 ms	0 ms	0 ms	

City of Marseille

1	ip-10-170-36-3.us-west-1.co	0 ms	0 ms	1 ms	
2	ip-10-1-76-1.us-west-1.comp	2 ms	0 ms	0 ms	
3	ip-10-1-88-255.us-west-1.co	1 ms	1 ms	0 ms	
4	216.182.236.112	1 ms	1 ms	1 ms	
5	72.21.222.21	1 ms	1 ms	1 ms	
6	205.251.229.15	2 ms	2 ms	2 ms	
7	neotel1-paixpao-neotel.net	3 ms	2 ms	2 ms	
8	xe11-2-0.tcr1.eqx.chi.as821	53 ms	2 ms	2 ms	
9	xe11-2-0.tcr1.eqx.chi.as821	53 ms	74 ms	77 ms	
10	N/A	0 ms	74 ms	0 ms	
11	xe2-0-0.tcr1.rb.par.as8218.	146 ms	164 ms	165 ms	
12	ma-ab04-rtbb-005.eolas-serv	165 ms	165 ms	164 ms	
13	eif-qos-ma-01.eolas-service	164 ms	0 ms	164 ms	
14	178.237.109.142	169 ms	160 ms	160 ms	
15	eif-qos-ma-01.eolas-service	160 ms	160 ms	192 ms	
16	178.237.109.142	164 ms	164 ms	192 ms	

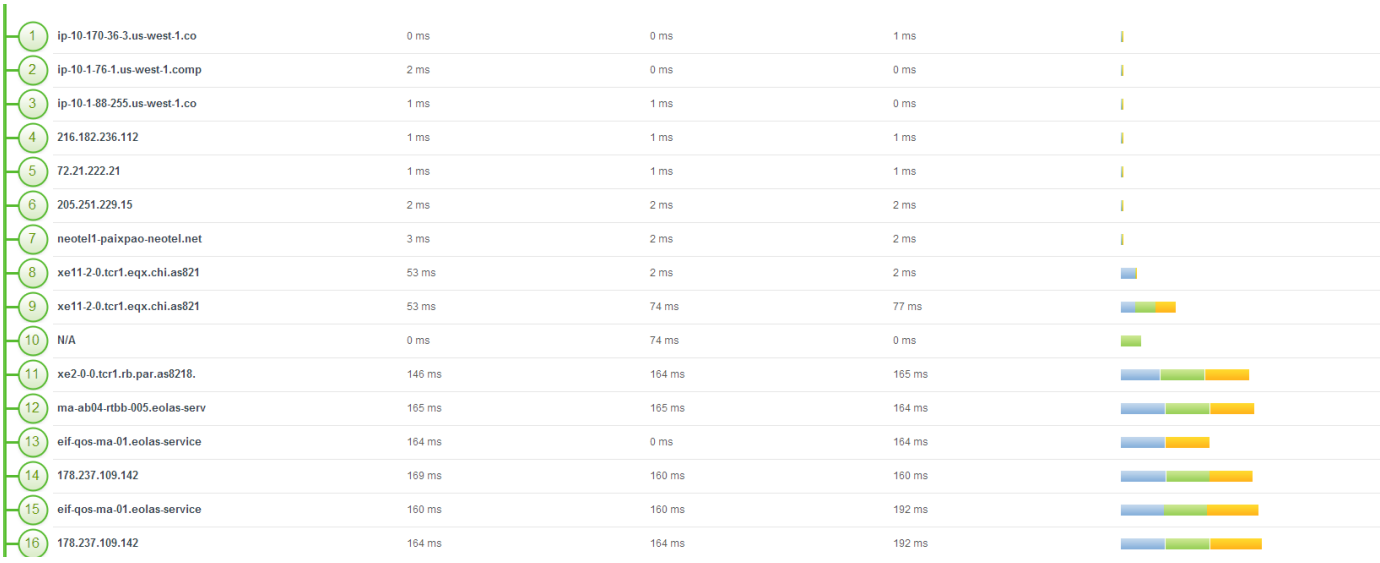
City of Montepellier

19.b



1	ip-10-170-36-3.us-west-1.co	1 ms	1 ms	1 ms
2	ip-10-1-86-1.us-west-1.comp	0 ms	1 ms	1 ms
3	ip-10-1-86-255.us-west-1.co	1 ms	1 ms	0 ms
4	216.182.236.108	1 ms	1 ms	1 ms
5	72.21.222.21	1 ms	1 ms	1 ms
6	205.251.229.15	2 ms	2 ms	2 ms
7	XCR1.PAL.CW.net	3 ms	2 ms	2 ms
8	xe-2-0-0-xcr2.ash.cw.net	162 ms	2 ms	165 ms
9	xe-2-0-0-xcr2.ash.cw.net	165 ms	165 ms	165 ms
10	ae4-xcr2.prp.cw.net	162 ms	162 ms	162 ms
11	ae2-xcr2.fra.cw.net	167 ms	161 ms	161 ms
12	ae2-xcr2.fra.cw.net	161 ms	167 ms	162 ms
13	ae0-xcr1.fra.cw.net	162 ms	167 ms	153 ms
14	xe-0-0-1-xcr1.fix.cw.net	153 ms	161 ms	153 ms
15	ae2-xcr1.muc.cw.net	161 ms	162 ms	161 ms
16	landeshauptstadt-gw1.muc.cw	162 ms	161 ms	161 ms
17	194.113.40.226	162 ms	162 ms	162 ms

City of Munich



1	ip-10-170-36-3.us-west-1.co	0 ms	0 ms	1 ms
2	ip-10-1-76-1.us-west-1.comp	2 ms	0 ms	0 ms
3	ip-10-1-88-255.us-west-1.co	1 ms	1 ms	0 ms
4	216.182.236.112	1 ms	1 ms	1 ms
5	72.21.222.21	1 ms	1 ms	1 ms
6	205.251.229.15	2 ms	2 ms	2 ms
7	neotel1-paixpao-neotel.net	3 ms	2 ms	2 ms
8	xe11-2-0.tcr1.eqx.chi.as821	53 ms	2 ms	2 ms
9	xe11-2-0.tcr1.eqx.chi.as821	53 ms	74 ms	77 ms
10	N/A	0 ms	74 ms	0 ms
11	xe2-0-0.tcr1.rb.par.as8218.	146 ms	164 ms	165 ms
12	ma-ab04-rtbb-005.eolas-serv	165 ms	165 ms	164 ms
13	eif-qos-ma-01.eolas-service	164 ms	0 ms	164 ms
14	178.237.109.142	169 ms	160 ms	160 ms
15	eif-qos-ma-01.eolas-service	160 ms	160 ms	192 ms
16	178.237.109.142	164 ms	164 ms	192 ms

City of Montpellier

19.c

1	ip-10-170-36-3.us-west-1.co	0 ms	0 ms	1 ms	
2	ip-10-1-76-1.us-west-1.comp	0 ms	3 ms	0 ms	
3	ip-10-1-76-255.us-west-1.co	0 ms	1 ms	1 ms	
4	216.182.236.106	2 ms	2 ms	57 ms	
5	72.21.222.18	2 ms	2 ms	2 ms	
6	205.251.229.15	2 ms	2 ms	2 ms	
7	snj-edge-04.inet.qwest.net	67 ms	2 ms	2 ms	
8	sjp-brdr-04.inet.qwest.net	2 ms	4 ms	4 ms	
9	63.146.27.134	5 ms	3 ms	6 ms	
10	202.97.50.61	5 ms	5 ms	3 ms	
11	202.97.52.157	440 ms	440 ms	440 ms	
12	202.97.58.117	442 ms	443 ms	442 ms	
13	202.97.53.33	447 ms	443 ms	447 ms	
14	N/A	0 ms	447 ms	0 ms	
15	22.254.120.106.static.bjtel	309 ms	0 ms	308 ms	
16	50.95.247.60.static.bjtelec	166 ms	166 ms	166 ms	
17	50.95.247.60.static.bjtelec	166 ms	0 ms	166 ms	

City of Beijing

1	ip-10-170-36-2.us-west-1.co	0 ms	0 ms	1 ms	
2	ip-10-1-68-1.us-west-1.comp	0 ms	0 ms	1 ms	
3	ip-10-1-88-255.us-west-1.co	0 ms	1 ms	1 ms	
4	216.182.236.100	25 ms	1 ms	1 ms	
5	72.21.222.16	6 ms	25 ms	2 ms	
6	205.251.229.168	2 ms	2 ms	2 ms	
7	ae7.sjc10.ip4.tinet.net	2 ms	2 ms	62 ms	
8	as4837.ip4.tinet.net	2 ms	2 ms	62 ms	
9	219.158.33.201	168 ms	152 ms	2 ms	
10	as4837.ip4.tinet.net	2 ms	152 ms	167 ms	
11	219.158.97.229	153 ms	178 ms	153 ms	
12	219.158.97.53	178 ms	197 ms	195 ms	
13	219.158.4.165	195 ms	205 ms	204 ms	
14	119.167.86.78	206 ms	169 ms	169 ms	
15	119.167.86.78	205 ms	205 ms	1281 ms	
16	124.129.250.254	1280 ms	1380 ms	193 ms	
17	124.129.250.254	1381 ms	198 ms	1380 ms	
18	218.58.80.75	169 ms	169 ms	193 ms	
19	N/A	0 ms	0 ms	170 ms	

City of Qingdao