

Network Topology

Computer Networks

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Websites & Network Diversity

```
root@194-67-116-72:~# traceroute google.com
traceroute to google.com (172.217.16.110), 30 hops max, 60 byte packets
 1 node82-msk1.cloudvps.reg.ru (89.108.69.216)  0.150 ms  0.126 ms  0.115 ms
 2 kiae-r1.hosting.reg.ru (31.31.194.4)  0.466 ms  0.456 ms  0.446 ms
 3 * * *
 4 150-192-212-88.host.exepo.ru (88.212.192.150)  0.241 ms  0.230 ms  0.268 ms
 5 msk-m9-b1-ae30-vlan342.fiord.net (62.140.239.222)  1.079 ms  1.052 ms  1.039 ms
 6 * * *
 7 * * *
 8 72.14.222.198 (72.14.222.198)  1.478 ms  1.285 ms  1.356 ms
 9 108.170.250.113 (108.170.250.113)  1.435 ms  108.170.250.146 (108.170.250.146)  1.467 ms  108.170.250.130 (108.170.250.130)  2.035 ms
10 216.239.50.44 (216.239.50.44)  17.193 ms  216.239.50.132 (216.239.50.132)  15.801 ms  209.85.255.136 (209.85.255.136)  18.984 ms
11 142.250.227.25 (142.250.227.25)  34.555 ms  142.250.227.7 (142.250.227.7)  33.099 ms  142.250.227.131 (142.250.227.131)  35.104 ms
12 64.233.175.142 (64.233.175.142)  44.503 ms  66.249.94.20 (66.249.94.20)  46.843 ms  72.14.237.108 (72.14.237.108)  46.849 ms
13 74.125.242.241 (74.125.242.241)  45.134 ms  74.125.242.225 (74.125.242.225)  47.957 ms  49.450 ms
14 72.14.239.201 (72.14.239.201)  44.523 ms  45.201 ms  72.14.239.195 (72.14.239.195)  48.765 ms
15 prg02s12-in-f14.1e100.net (172.217.16.110)  46.698 ms  48.458 ms  46.712 ms
root@194-67-116-72:~#
```

Figure 1: Traceroutes were from

- Small Websites: cs.rin.ru, regex101.com
- Universities: Weizmann Institute , Stanford
- Large Corporations: Deutsche Bank, baidu.com

Network Map



Submarine Cables

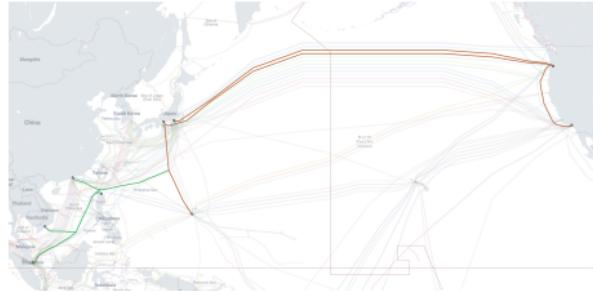


Figure 3: Pacific cables to Hong Kong

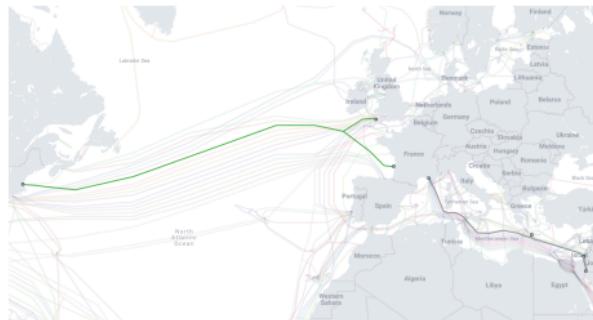


Figure 4: Atlantic Cables to Israel

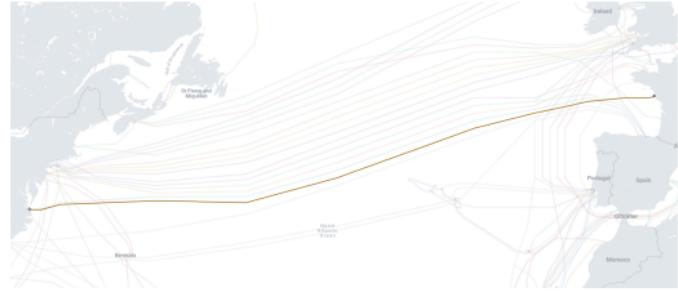


Figure 5: Atlantic Cables to cs.rin.ru

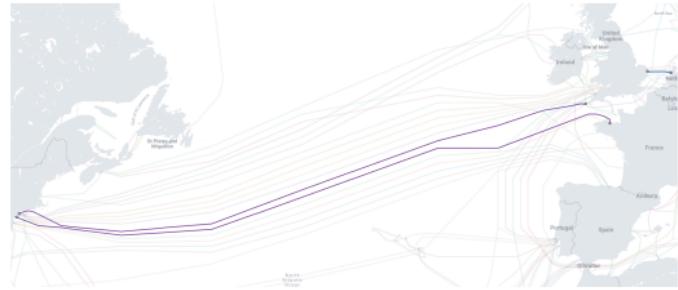


Figure 6: Atlantic Cables to Amsterdam



Map Analysis

Carleton connects directly to at least 2 networks:

- ▶ **Northern Lights GigaPoP**: mainly for US academic/research traffic
- ▶ **Hurricane Electric**: big commercial ISP, often for global/commercial sites
- First hop is always Carleton's gateway, second is Carleton's public IP.
- Third hop changes based on destination: either Northern Lights or Hurricane Electric.
- Domestic sites stick with Northern Lights as long as possible (fast, direct), while international sites shift over to Hurricane Electric to get better global peering.

US & Western Europe:

- Much better connected (e.g. Stanford 60ms, regex101.com/Germany 113ms)
- Fewer hops, low consistent latency
- Academic and carrier networks are well-peered, with direct and fast routes

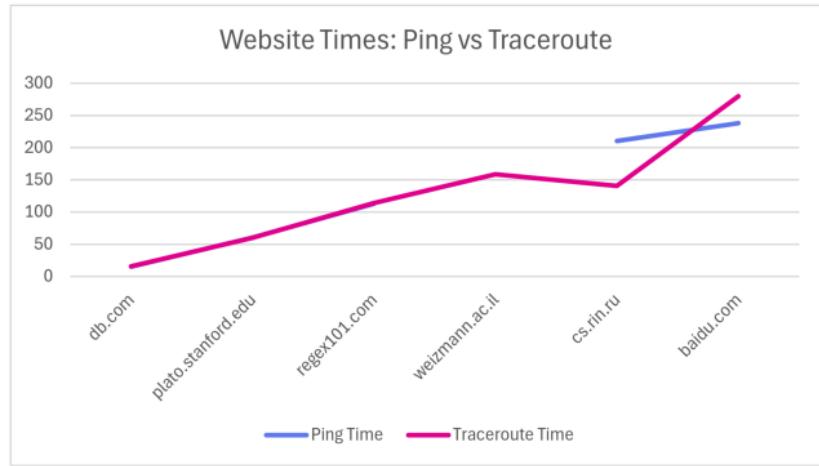
China & Russia:

- Higher ping, more hops, lots of (baidu.com 238ms, cs.rin.ru 210ms)
- More filters/firewalls, less peering, more missing data
- Baidu's path had a large amount of hops inside of China most likely due to traffic engineering



Times & Analysis

- For the first three sites on the graph ping and traceroute are identical
- ▶ **cs.rin.ru**: ping avg 210ms, traceroute 140ms
baidu.com: ping avg 238ms, traceroute 279.8ms
- Differences might be because ping and traceroute don't always hit the exact same IPs (sometimes ping a different server or interface), or maybe traceroute gets blocked/throttled on last hops. Also, heavy filtering or firewalls can inflate traceroute times.
- RTTs mostly confirm the topology graph, but if the final traceroute hop's RTT is much less than the ping RTT, it probably means the traceroute gets filtered at the end



- A barrier, when collecting this data, was finding a website hosted in the middle east where the country didn't firewall the traceroute once it arrived.