Fanny Hermanson: 19980415-8500
Richard Götherström: 19990731-2673

We have discussed a lot with group A3, Erik Lif och Leo Arnholm Söderberg.

1. What path will a message sent from a computer in Uppsala take to reach a computer located in Kiruna?

Traceroute a tool made for following a sent signal to its destination, and show all the stops it makes on the way. It also shows how long it takes in every node, which can be a guideline for how long it really takes, but should not be taken with 100% accuracy.

By doing the traceroute command to ifk.kiruna.se we got a path with 12 hops. Every hop made is by passing a switch or router or different network related machine. Since traceroute gives us response times for every node passed, and these are real time answers, we will get different results every time. This is because our signal will be affected by all other signals sent to the same places at the same time.

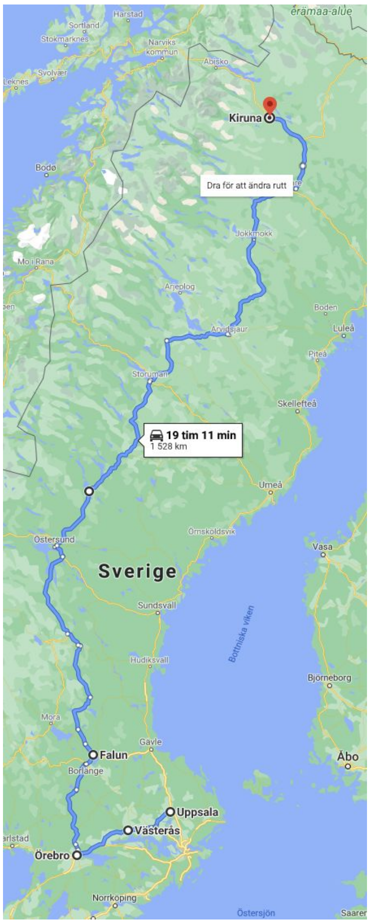
Here we can see the exact hops when we ran traceroute:

```
traceroute to kyla.kiruna.se (192.71.13.83), 64 hops max, 52 byte packets
 1  dsldevice (192.168.10.1)  2.957 ms  2.519 ms  2.857 ms
 2  ti3179a430.ti.telenor.net (146.172.70.251)  9.503 ms  7.593 ms  7.126 m¢s
 3  ti3001c360-ae60-0.ti.telenor.net (146.172.20.2)  7.539 ms  6.506 ms  6.650 ms
 4  ti3001b400-ae4-0.ti.telenor.net (146.172.105.29)  5.705 ms  5.923 ms  5.837 ms
 5  netnod-ix-ge-b-sth-4470.sunet.se (195.69.119.19)  5.388 ms  5.649 ms  5.610 ms
 6  vasteras-fsn2-r1.sunet.se (130.242.4.37)  8.025 ms  8.170 ms  8.007 ms
 7  orebro-lba-r1.sunet.se (130.242.4.31)  15.068 ms  15.138 ms  15.311 ms
 8  falun-fln4-r1.sunet.se (130.242.4.22)  15.251 ms  14.137 ms  14.003 ms
 9  kiruna-kir3-r2.sunet.se (130.242.4.7)  28.339 ms  28.083 ms  28.071 ms
10  irf2.sunet.se (130.242.6.169)  28.572 ms  28.318 ms  28.242 ms
11  irf-gw-link-trk4.irf.se (192.71.152.65)  31.392 ms  31.124 ms  30.426 ms
12  kyla.kiruna.irf.se (192.71.13.83)  28.149 ms  28.303 ms  28.314 ms
```

2. Make sure you are logged in on a computer within UU. When checking the path in the previous question, you may not always get the same answer. Find two different paths from two different networks to a computer in Kiruna. If you measure one path from within the UU network, the other must be measured from outside UU.

Below is one path from a computer in Uppsala University:

```
 1?: [LOCALHOST]                      pmtu 1500
 1:  r1.n.polacksbacken.uu.se                   9.563ms
 1:  r1.n.polacksbacken.uu.se                   2.671ms
 2:  172.16.1.62                        0.181ms
 3:  172.16.1.1                         1.401ms
 4:  l-uu-1-b1.uu.se                    0.522ms
 5:  uu-r1.sunet.se                     0.691ms
 6:  uppsala-upa-r1.sunet.se                 0.843ms
 7:  gavle-sbo-r1.sunet.se                 2.193ms
 8:  sundsvall-sva-r1.sunet.se               4.711ms
 9:  falun-fln4-r1.sunet.se              12.281ms
10:  kiruna-kir3-r2.sunet.se               26.278ms
11:  irf2.sunet.se                     26.458ms
12:  irf-gw-link-trk4.irf.se               29.340ms asymm 13
13:  kyla.kiruna.irf.se                  26.644ms reached
     Resume: pmtu 1500 hops 13 back 14
```

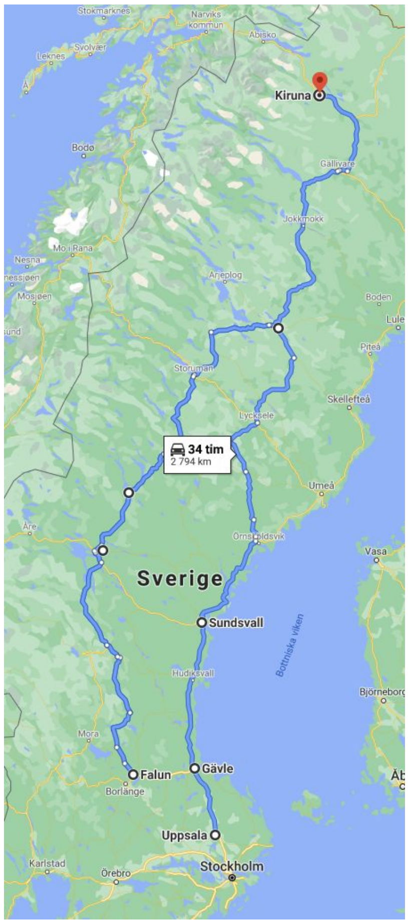


To the left we can see the route chosen by our first computer, and to the right by the computer at UU.

We have looked at Sunets grid of networks and guessed that these paths are the ones used.

We can see a clear difference in how effective the two routes are if just distance matters, with a total of 3056km in total in our first picture, and almost the double of 5588km in the second picture.

The thing making this interesting is the fact that the right one is faster by almost 2ms.



3. What do you think is the reason for your observation in the previous question?

One observation we did is that both our computers are using the sunet grid. They are using different routes to different cities, and that is possibly due to how loaded the different nodes on the way are. The biggest difference between the two routes is what's happening before we get to the sunet grid.

We can see clearly in the first case that after just one hop the package is out on the telenor grid. This would mean that it has left the local network that my computer used when running traceroute. In the second we can see that at least the first three probably are nodes inside the university network. We would also guess that number 4 is in the network, but we don't know, since it could also be a first step of Sunet.

The response time is surprisingly similar in both runs. This is because the distance traveled is not always the biggest cause of delay. In this case it is the nodes between the cables that causes the biggest delay.

4. Measure the response time (sometimes called the round-trip time (RTT)) from a computer in Kiruna. Compute the theoretical RTT from the actual physical distances between the cities the message passed through. How large is the difference between the theoretical and the measured RTT?

The distance is measured using google maps and using the car route from all cities listed with the names.

These distances are measured using our assumptions from how the Sunet grid i layed. We use the formula 2(s*t)=d where s in this case is c.
To get the correct RTT we need to double the distance since we're going both to and from, in this case, Kiruna.

This gives us the following:

Computer	Distance: km	speed: c in ms	actual speed	Difference in speed
Fanny Uppsala	1528*2 = 3056	10.194	28.149	17.955
UU Uppsala	2793*2 = 5588	18.640	26.644	8.004

We are quite surprised by the fact that the second one is less than double the speed of light. This seems wrong and we are not sure how we got so good results with the route given from the traceroute run.

5. How do you explain the differences between theoretical and measured RTT presented in the previous question?

The theoretical RTT is in our case just the distance times the speed of light, which does not really reflect reality. There are mainly three reasons to the differ:

- The route is not straight up optical fiber cables. Every switch and other device the signal has to pass causes a delay in time.
- In every device there will be a queue and some processing time causing delay. This is so that the device can handle all different signals in their time.
- Given that we have the right formula for how our signal passes through the optical fiber, we can't calculate a perfect formula since very many things along the way can affect it.

6. It is possible to observe RTT from intermediate nodes between you and the computer in Kiruna. In some cases, the RTT is not strictly increasing. I.e., you can have a larger RTT to a node closer to you than to another which is further from you. Explain how this can happen.

This can seem impossible at first, but when you think about it it makes sense. Most of the nodes along the way are built for quickly passing through data. For example a regular switch is not usually doing anything itself, but passing through signals and possibly strengthening them. This could be a reason for it to be slow when returning packages.

We can see an example of when it takes longer for a later node here:
(from question 2)

2:	172.16.1.62	0.181ms
3:	172.16.1.1	1.401ms
4:	l-uu-1-b1.uu.se	0.522ms
5:	uu-r1.sunet.se	0.691ms

In this examaple the response time from node 3 is almost triple the time from node 4.
This may be a misleading example since all the nodes are close to each other, but it's a very clear example of how it can be.

The main reason for this is probably that different devices have a different priority for returning packages like these. It can also be due to queues and other stuff like that, but that would also affect the rest of the signals sent. This makes us believe that the main reason is different handling of priorities.

7. Try to find a path from your computer to another with at least 28 intermediate nodes. Where is that computer located?

220.110.210.114 - 26 hops from UU in Uppsala.
It passes through Germany, the United Kingdoms, the USA and ends up in Japan.

8. Try to find a path from your computer to another with as high RTT as possible. Where is that computer located?

The previous IP address gave us a RTT of 294ms.

9. A path with a high RTT does not necessarily mean that there are many intermediate nodes. Explain why.

This is because it's not only the amount of nodes that counts for the increased time. It is as well the process and queue in the router or switch that the node is currently at. If the node is currently at an old bad device with a not very efficient queue system, the measured RTT will increase. If it instead currently is at a more efficient node it will probably go faster.

The requests priority in the nodes can also affect the time it takes for the request, as well as many other reasons.