Making a tool to unravel Starlinks network routing

Author: Christiaan Baraya - c.baraya@student.tudelft.nl
Supervisor: Tanya Shreedhar
Responsible Professor: Nitinder Mohan

1. Goal

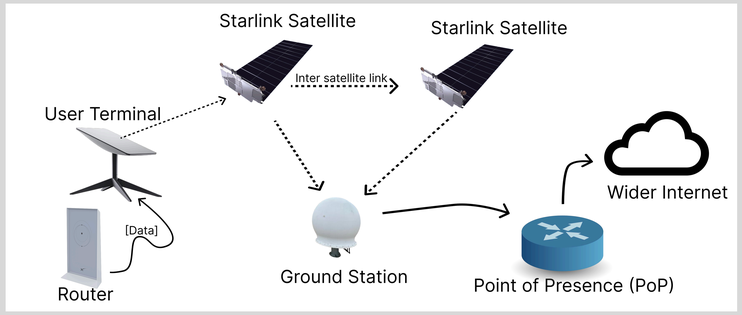
Display Starlink's network routing on a web-tool, to gain insight into the relation between ground infrastructure proximity and latency.

2. Motivation

There used to be no reliable tool or method that told Starlink users which path their data took. Constructing this functionality could help researchers gain more insight into Starlink and help Starlink consumers with understanding network delays.

3. Background: workings of Starlink

Point of Presence (PoP): a data centre that connects Starlink users with the internet.



4. Method to identify associated PoP

Part A:

1. For a user, issue multiple traceroutes over the Starlink Network to retrieve PoPs' IPs.
2. Perform IP geolocation on these addresses using IPinfo.
3. This should return the city that houses the PoP. However, this may return incorrect results.

Part B:

1. Use Starlink's GeoIP Feed. This document assigns subnets to each country.
2. Perform reverse DNS lookups on all addresses belonging to a country. This gives, for example, the domain "customer.**sfiabgr1**.pop.starlinkisp.net" = **S**o**fia, b**u**lg**a**r**ia.
3. Now we have a list of PoPs relating to a country.

Part C:
From the result of part A, discard all PoP not appearing in the result of part B. Now a single PoP remains, which is concluded to be the associated PoP of that user.

Hop	Address	Description
1	192.168.1.1	User Terminal
2	100.64.0.1	Ground Station
3	172.16.251.62	PoP
4	**206.224.67.96**	**PoP**
5	**206.224.67.78**	**PoP**

IPinfo

{Chicago; London}
It cannot be both

```
209.198.128.0/24,GB,GB-EN,London,
209.198.129.0/24,GB,GB-EN,London,
209.198.136.0/24,FR,FR-IDF,Paris,
209.198.137.0/24,FR,FR-IDF,Paris,
209.198.138.0/24,BG,BG-22,Sofia,
209.198.139.0/24,BG,BG-22,Sofia,
209.198.140.0/24,NL,NL-NH,Amsterdam,
209.198.141.0/24,NL,NL-NH,Amsterdam,
```

Starlink GeoIP Feed

{Frankfurt; Madrid; London; Milan; Doha}

⇒ **PoP is in London (lndngbr1)**

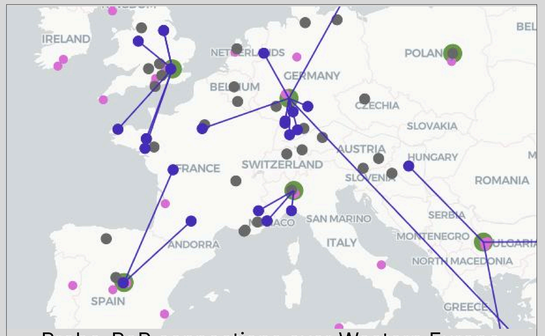
The Only city which appears in both parts.

5. Web-tool

RIPE Atlas is a platform with devices (probes) that perform continuous measurements (under which traceroutes). Probes also measure latencies to the PoP.

I built a web-tool which, for all active probes ●, determines their associated PoPs. These connections are shown on an interactive map. This calculation can be done in real-time or historically, with the time-slider.
The map also displays PoPs ●, ground stations ●, inactive probes ●, and satellites (not shown).

This tool can give insight into Starlinks routing and different routing patterns can be discovered. Using the time-slider the evolution of a route can be examined.



Probe-PoP connections over Western Europe

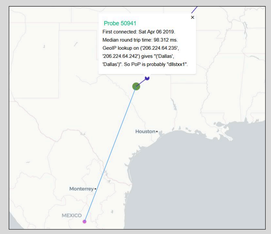
6. Analysis

Top graph (just PoPs):
Each blue dot represents a probe.

- The y-axis shows the median round-trip time to the PoP between 1 and 7 June 2025.
- The x-axis shows the geodesic distance to this PoP.

The graph shows a strong correlation, but has some outliers that can be explained by ground station proximity.

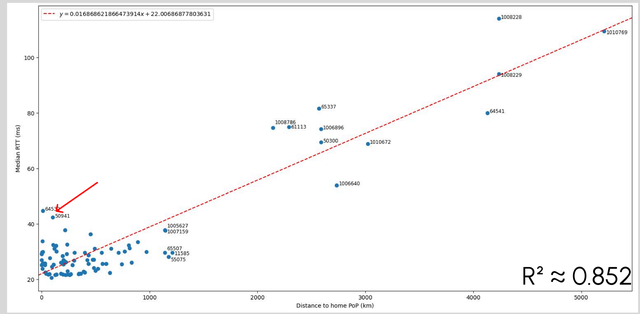
Probe 50941 (red arrow) is connected to the PoP in Dallas, Texas.
This probe is very close to the PoP, but no ground station is near. The signal has to travel to central Mexico and back. Only considering PoPs gave optimistic results.

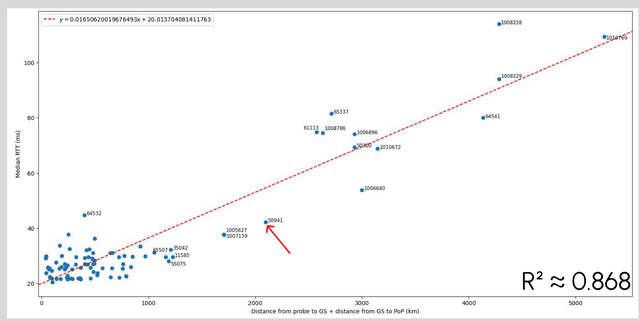


Bottom graph (PoPs + ground stations):

- The x-axis instead shows distance from probe to ground station + distance from ground station to PoP.
- The ground station nearest to the associated PoP is used.

Correlation is stronger. 50941 instead appears to the right.





7. Discussion

- The method to identify PoPs seems promising, but it is difficult to assess its accuracy. Doing this would require an objective way to already know the PoP for some users.
- There are a limited number of Starlink probes (95) and most probes are located in Europe or the United States. This leaves many unrepresented regions. Future work could use more diverse data.

8. Key Takeaways

- Using the method described, the PoP to which a Starlink user is connected can be determined.
- Proximity to ground stations and points of presence has a strong correlation with latency.

Image References
1. A Multifaceted Look at Starlink Performance (Mohan e.a.)
2. https://stock.adobe.com/nl/551556433
3. https://www.youtube.com/watch?v=giQ8xEWjnBs

Date submitted: 23 June 2025