Project Starlink Report

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CCS Concepts: • **Computer systems organization** → **Embedded systems**; *Redundancy*; Robotics; • **Networks** → Network reliability.

Additional Key Words and Phrases: datasets, neural networks, gaze detection, text tagging

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1 INTRODUCTION

Starlink satellites are a network of low Earth orbit satellites designed and operated by SpaceX, a private space exploration company founded by Elon Musk. The aim of Starlink is to provide high-speed, low-latency broadband internet to areas of the world that currently lack reliable internet access. As of April 2023, there are over 1,600 Starlink satellites in orbit, with plans to eventually launch tens of thousands more. The satellites are relatively small and weigh around 260 kg each. They operate in a constellation formation, with each satellite communicating with four others in orbit and with ground stations on Earth.

The Starlink satellites use advanced technology, such as ion thrusters and autonomous collision avoidance systems, to maintain their position in orbit and avoid collisions with other space objects. They are also equipped with advanced lasers to enable communication between satellites and with ground stations, allowing for faster data transfer and lower latency. Moreover, Starlink is a network of low Earth orbit (LEO) satellites designed to provide high-speed, low-latency network connectivity between end hosts on the ground. LEO satellites orbit the Earth at a few hundred kilometers altitude, which allows them to transmit data wirelessly using radio waves between hosts on the ground. This eliminates the need for long-haul fiber connections for transmitting data between hosts in different parts of the world.

The Starlink network has three components: a set of LEO satellites, user terminals, and ground stations. User terminals are purchased and deployed by end-users and wirelessly communicate with the orbiting satellites. Each terminal can only contact a subset of all satellites in orbit, with the satellite map showing which geographical region is within reach of an orbiting satellite. The

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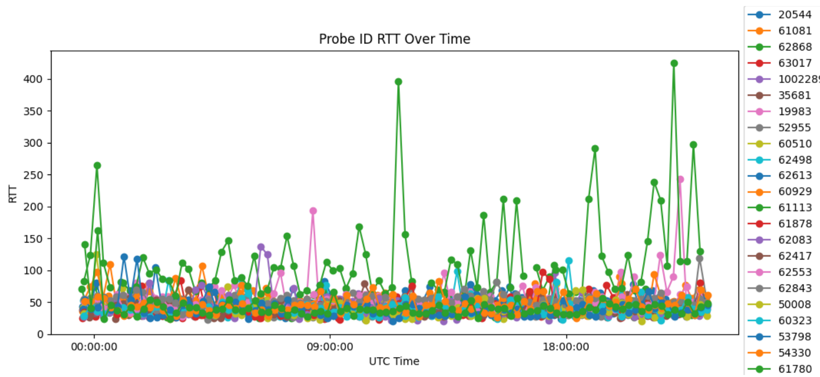

Fig. 1. Plot of each probe over time

ground stations act as the other end of the communication and connect user terminals to the fiber infrastructure of the Internet, allowing users to reach the internet infrastructure on the ground.

The project aims to measure latency and network paths between Starlink user terminals and selected Internet destinations over time, capturing variations in latency and comparing profiles of different user terminals.

2 METHODOLOGY

RIPE Atlas Cousteau is a tool used for conducting measurements on the Internet, such as measuring latency, traceroutes, and DNS queries. The tool is part of the RIPE Atlas project, which is a large-scale, globally distributed network measurement infrastructure operated by the RIPE NCC. To use RIPE Atlas Cousteau for conducting measurements, we first need to register an account with the RIPE NCC and obtain an API key. The API key is required to access the RIPE Atlas API, which allows us to submit measurement requests and retrieve measurement results. Once we have obtained the API key, we can use Python programming language and the Cousteau library to interact with the RIPE Atlas API. We can then write Python scripts that use the Cousteau library to submit measurement requests, retrieve measurement results, and perform data analysis.

To conduct measurements using RIPE Atlas Cousteau, we first need to define the measurement parameters, such as the target IP address, the measurement type (e.g., ping, traceroute), and the measurement interval (whether it's one-off or in an appropriate start and stop time interval). We can then submit the measurement request to the RIPE Atlas API using the Cousteau library. After the measurement is completed, we can retrieve the measurement results from the RIPE Atlas API using the Cousteau library. We can then analyze the results using Python libraries such as Pandas and Matplotlib to visualize the data and draw conclusions.

Overall, we used the RIPE Atlas Cousteau for conducting Internet measurements which involved registering an account, obtaining an API key, writing Python scripts using the Cousteau library, submitting measurement requests, retrieving measurement results, and performing data analysis.

3 DATA AND RESULTS

Once we have gotten the proper spawning pings, we make a create measurement request to collect the data over the span of a day.

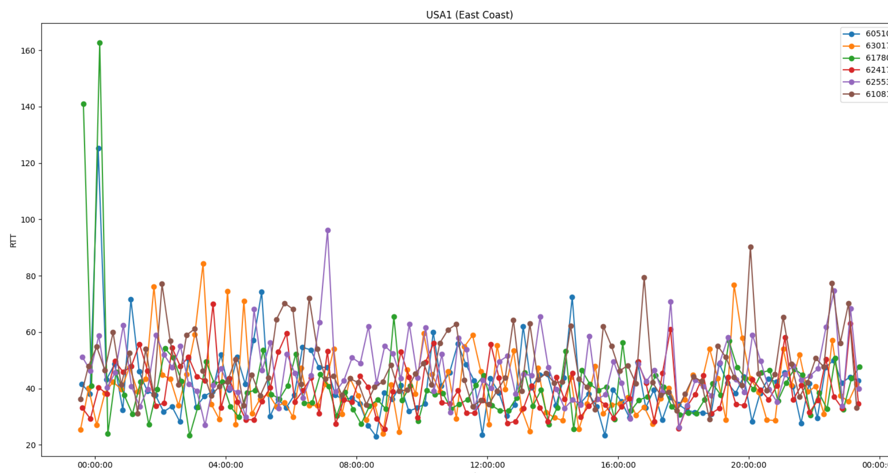

Fig. 2. Graph of RTT vs. UTC Time for the East Coast

3.1 General

Our measurement returned 23 international probes from three distinct geographical regions: North America, Europe, and Oceania. The majority of these probes emanated from the United States of America, totaling thirteen in number, followed by Germany with three probes, and Australia with two probes. The remaining probes originated from Poland, the United Kingdom, France, Canada, and Austria, with a solitary representation each. In general, our measurements were a success. All probes were able to respond to the measurement request with the exception of probe ID 61113 (from USA) which was unreachable and had 100 percent packet loss. Interestingly, the remainder of the probes had 0 percent packet loss. Finally, due to the rate-limiting of the RIPE Atlas API (there cannot be more than 25 concurrent requests), we decided to use a number of probe IDs that were close to the threshold but would not too close as it might have impacted the data collection during mid-execution.

Our analysis of the acquired probes did not reveal any discernible patterns or trends across all probes. However, we did observe periodic and cyclic changes in the Round Trip Time (RTT) metric. Specifically, we detected fluctuations in RTT measurements, where the RTT time experienced peak highs followed by lows in a cyclical manner over the span of a day. This observation suggests that the underlying network infrastructure may be subject to intermittent congestion or routing issues, which can result in fluctuations in the latency of network traffic. Further analysis is required to ascertain the root cause of these RTT variations and their potential impact on network performance. As such, we decided to dig deeper into the regional patterns of latency across the probes.

3.2 Regional

We looked at the locations of our probes and split them geographically to see if there are any trends.

3.2.1 USA1. TODO: describe east coast data

3.2.2 USA2. TODO: describe east coast data

3.2.3 Europe. TODO: describe europe data

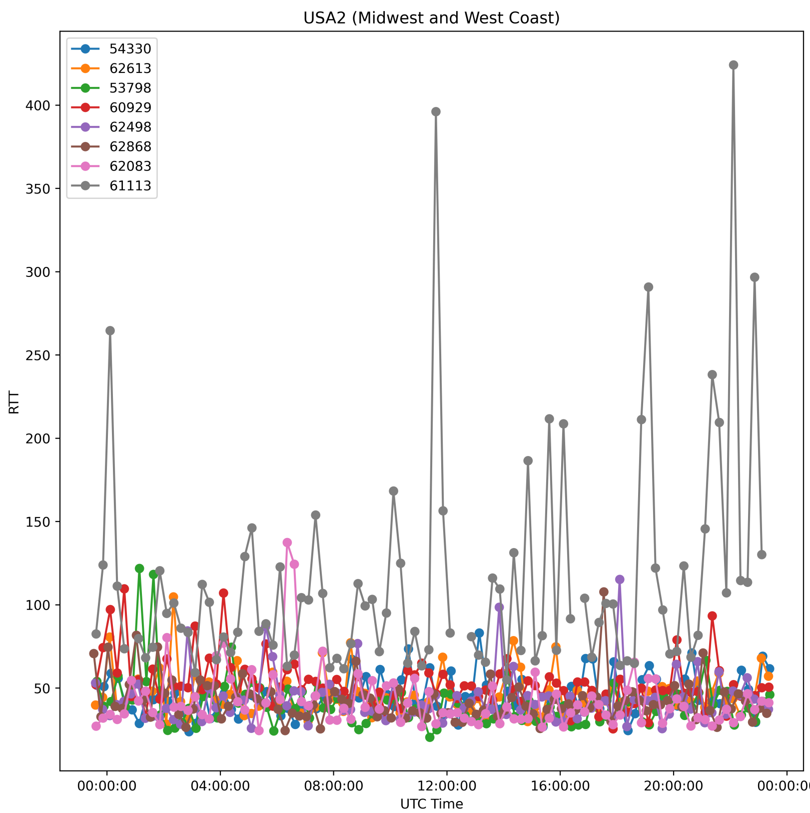

Fig. 3. Graph of RTT vs. UTC Time for the Midwest, West Coast, and Canada

3.2.4 *Oceania.* TODO: describe oceania

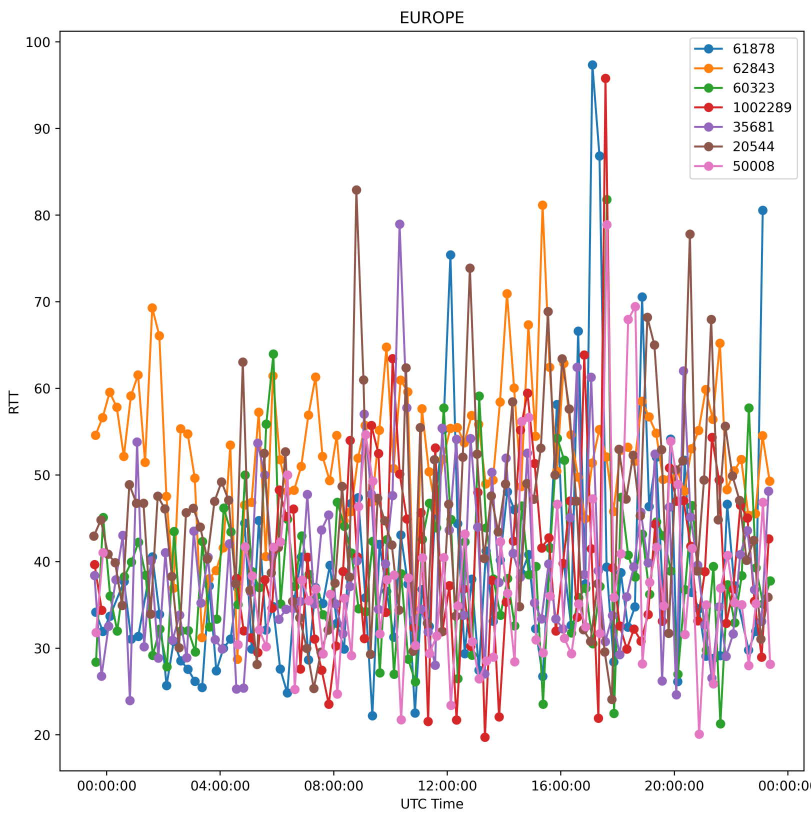

Fig. 4. Graph of RTT vs. UTC Time for Europe

4 ANALYSIS

4.1 USA1

4.2 USA2

4.3 Europe

4.4 Oceania

5 CONCLUSION

6 SELECTIVE PROBING (EXTRA CREDIT)

7 FIGURES

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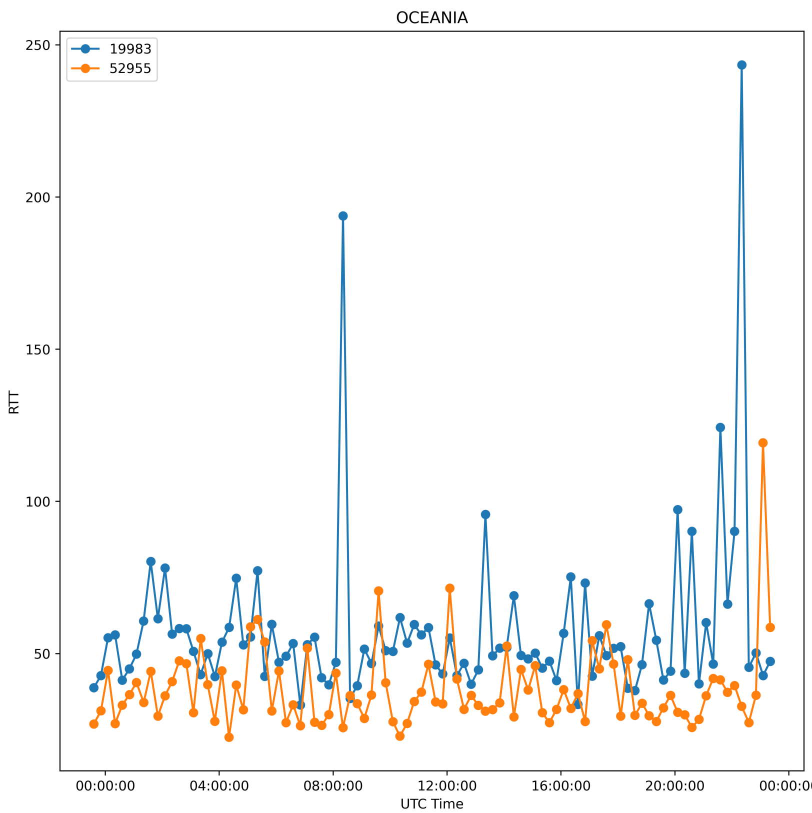

Fig. 5. Graph of RTT vs. UTC Time for Oceania

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Fig. 6. 1907 Franklin Model D roadster. Photograph by Harris & Ewing, Inc. [Public domain], via Wikimedia Commons. (https://goo.gl/VLCRBB).

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9 ACKNOWLEDGMENTS

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```

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