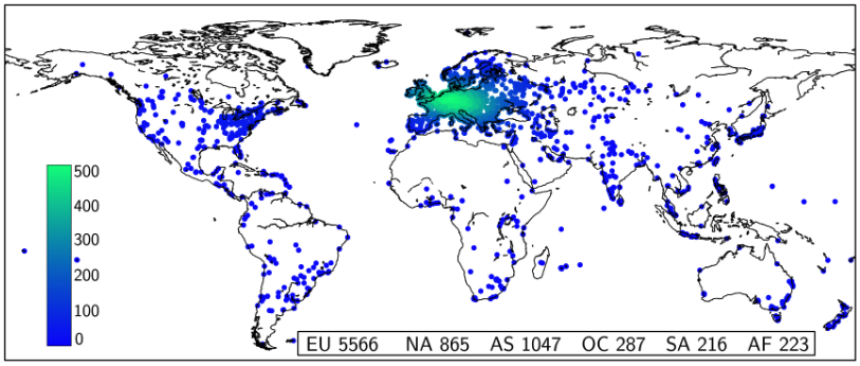
Assignment 3 (CMB - WS 2022/23)

Global Mobile Network Measurements

Introduction

In this assignment, we will use a combination of targeted measurements from the global measurement platform RIPE Atlas.

RIPE Atlas is a global measurement platform that allows users to measure Internet connectivity and reachability from various locations around the world. The platform uses a network of probes, which are small devices that are placed at different locations. Traditionally, the platform was composed of thousands of small hardware probes connected to the Internet, but recently, the platform also included support for software probes. RIPE Atlas probes are based in more than 200 countries and are operated by volunteer hosts. They are strategically placed in various locations, including homes, offices, data centers, and universities, providing a comprehensive view of the Internet from diverse locations.



You can access the platform through a web interface (https://atlas.ripe.net/) which allows you to create new measurements and view real-time and historical performance data. Note that RIPE Atlas is completely open-source, and you can view not just data from your measurements but from measurements conducted by any Atlas user (https://atlas.ripe.net/measurements/). Organizations frequently rely on RIPE Atlas to troubleshoot connectivity issues, identify bottlenecks, and monitor the performance of their own networks. Additionally, the platform provides APIs that allow users to automate their measurements and integrate the data into their own tools and systems (https://atlas.ripe.net/docs/apis/rest-api-manual/).

Assignment Objective

The assignment aims to understand the diversity of mobile and fixed Internet access across the globe, the impact of last-mile access on overall Internet performance, routing paths from ISP clients to cloud providers, and the potential for offloading computations to compute devices closer to the users. We will also examine how LEO satellite connections are operationally different/similar to traditional WiFi and mobile connectivity.

NOTE: This is a group assignment, and every group is expected to perform the measurement tasks collectively and submit the final report.

Pre-requisite Checklist

Please make sure before Friday 20th Jan that:

1. You have created a RIPE NCC account and can access https://atlas.ripe.net/my/ webpage.
2. You have received 1 million credits in your RIPE account. If not, please ensure that you have correctly posted your RIPE NCC account details in the following sheet. Please send an email to mohan@in.tum.de with the subject line "[CMB-Assignment-3] RIPE Atlas credits" if you have completed the steps but haven't received the credits.

HELPFUL NOTES:

1. The 1 million credits provided to you is a hard limit for this assignment and no extra credits will be provided. Please keep in mind the credit cost of your measurements https://atlas.ripe.net/docs/getting-started/credits.html.
    a. A helpful resource on what you can do as RIPE Atlas millionaire: https://labs.ripe.net/author/becha/what-can-you-do-with-one-million-ripe-atlas-credits/
2. You are advised to read the publications in the reference section before attempting the assignment. The publications highlight many best practices for conducting Internet-wide measurements to maximize the correctness of analysis/results.

Measurement Tasks

*** Please see the analysis tasks section before finalizing your probe and datacenter endpoint selection.**

1. Download the latest list of probes from RIPE archive: https://ftp.ripe.net/ripe/atlas/probes/archive/
2. Do probe selection:
    a. Filter 100 probes that are "connected" and
        b. Connected via cellular networks*
        c. Connected via home WiFi networks*

* Use “user-defined tags” for each probe to estimate this connectivity (e.g. “home”, “lte”, “wlan”, etc.). Read [5] for pointers on RIPE Atlas tags. Also document the tags you used for your selection.

   d. Filter another set of RIPE Atlas probes that are connected via Starlink (you can filter them through their IPv4 ASN – Starlink ASN is ASN14593)
   e. Filter another set of 100 connected probes connected in residential networks using ethernet that are located nearby to wireless probes filtered in step 2 and 3.
3. Create ICMP Pings and Traceroute measurements from the filtered probe sets to cloud datacenters
   a. You can find the list of cloud datacenters and their locations here.
   b. Ping measurements must be periodic (with one measurement every few hours), so you can track the change in latency from the probes over multiple days.
   c. Traceroute measurements can be one-off.
   Note: Please keep in mind your estimated credit spend before scheduling the measurements (https://atlas.ripe.net/docs/getting-started/credits.html)

Analysis Tasks/Questions

*** Your analysis must be based on at least one week of measurements.**

1. Which probes did you select and where are they located? Justify how you made sure your probe selection represents the global mobile connectivity.
2. Analyze connectivity of wireless vs wired networks globally
   a. Are there significant latency differences between probes using different access technologies i.e. wired vs WiFi vs LTE vs Starlink? How does the latencies vary over time/day?
   b. Compare the state of different last-mile access technology in different continents. Is there an obviously better-performing wireless technology in every continent? Which and by how much?
   c. Which wireless technology is most stable? Is it dependent on the network provider of the probe?
3. What is the impact of the distance between the probe and cloud datacenter to end-to-end latency?
   a. Which organizations host the routers on-path between probes and cloud datacenters? Do you observe different Internet routes for different cloud providers? If yes, why?
   b. What are the latency variations for probes connecting to datacenters in neighboring continents via under-sea cables (e.g. from EU to NA). Do you observe similar variations for wired and satellite probes? Why/why not?
   c. If you imagine the wireless RIPE Atlas probes to be mobile clients running a next-generation application requiring 30 ms end-to-end operational latency, is there a potential benefit in offloading to an organization on path instead of offloading to the cloud datacenter deployed (i) in the same country as the probe

(ii) in the neighboring country in the same continent and (iii) in the neighboring continent?

Deliverables

1. Documentation that must include:
    a. all your measurement steps, including the measurement parameters and tags
    b. descriptive answer to questions, including plots
2. Step-by-step code and collected dataset (e.g. hosted in Git repo). You will be graded on the reproducibility of your results. Please make sure to document your code so that it is easy for us to follow.

Deadline

Please send your report (with a link to your code and dataset) to mohan@in.tum.de with the subject line “[CMB-Assignment-3] Final submission” before **19 Feb 2023, 23:59**

References

[1] The Khang Dang, Nitinder Mohan, Lorenzo Corneo, Aleksandr Zavodovski, Jörg Ott, and Jussi Kangasharju. 2021. Cloudy with a chance of short RTTs: analyzing cloud connectivity in the internet. In Proceedings of the 21st ACM Internet Measurement Conference (IMC '21). Association for Computing Machinery, New York, NY, USA, 62–79. https://doi.org/10.1145/3487552.3487854

[2] Lorenzo Corneo, Maximilian Eder, Nitinder Mohan, Aleksandr Zavodovski, Suzan Bayhan, Walter Wong, Per Gunningberg, Jussi Kangasharju, and Jörg Ott. 2021. Surrounded by the Clouds: A Comprehensive Cloud Reachability Study. In Proceedings of the Web Conference 2021 (WWW '21). Association for Computing Machinery, New York, NY, USA, 295–304. https://doi.org/10.1145/3442381.3449854

[3] L. Corneo et al., "(How Much) Can Edge Computing Change Network Latency?," 2021 IFIP Networking Conference (IFIP Networking), Espoo and Helsinki, Finland, 2021, pp. 1-9, doi: 10.23919/IFIPNetworking52078.2021.9472847.

[4] Vaibhav Bajpai, Steffie Jacob Eravuchira, and Jürgen Schönwälder. 2015. Lessons Learned From Using the RIPE Atlas Platform for Measurement Research. SIGCOMM Comput. Commun. Rev. 45, 3 (July 2015), 35–42. https://doi.org/10.1145/2805789.2805796

[5] V. Bajpai, S. J. Eravuchira, J. Schönwälder, R. Kisteleki and E. Aben, "Vantage point selection for IPv6 measurements: Benefits and limitations of RIPE Atlas tags," 2017 IFIP/IEEE Symposium on Integrated Network and Service Management (IM), Lisbon, Portugal, 2017, pp. 37-44, doi: 10.23919/INM.2017.7987262.

[6] Nitinder Mohan, Lorenzo Corneo, Aleksandr Zavodovski, Suzan Bayhan, Walter Wong, and Jussi Kangasharju. 2020. Pruning Edge Research with Latency Shears. In Proceedings of the 19th ACM Workshop on Hot Topics in Networks (HotNets '20). Association for Computing Machinery, New York, NY, USA, 182–189. https://doi.org/10.1145/3422604.3425943