BLG337E Project I

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Objective

The objective of this project is to gain insight into internet infrastructure and its associated latency effects. In pursuit of this goal, we have undertaken a comprehensive study involving ten distinct destinations, strategically selected based on their geographical proximity to the source point. The study encompasses the utilization of the traceroute program to gauge the delays incurred during the journey from source to destination. To ensure a well-rounded analysis, we have conducted tests over the course of four different days, with three unique time slots explored on each day.

For every configuration, we meticulously repeated measurements, varying from 10 to 100 iterations, enabling us to compute essential statistical metrics including the maximum, minimum, and average values for these measurements. Furthermore, the project involves the creation of informative diagrams that juxtapose delays against the three key parameters, systematically fixing two of these parameters at a time to investigate their combined impact.

Ultimately, our endeavor aims to offer profound insights into the intricate workings of internet infrastructure and its consequential latency effects. This report encapsulates our findings, providing a detailed analysis and commentary on the outcomes observed.

Destinations

By selecting these destinations, a wide range of geographical distances from Istanbul has been considered, spanning from local to distant locations across Turkey. This strategic choice of destinations enables the comprehensive analysis of how network delays correlate with geographical distance, aligning with the assignment's primary objective to investigate internet infrastructure and its influence on delay patterns.

Below you can see the destinations that we've selected,

- Bogazici University (boun.edu.tr)
- Koc University (ku.edu.tr)
- Sabanci University (sabanciuniv.edu)
- Uludag University (uludag.edu.tr)
- Canakkale Onsekiz Mart University (comu.edu.tr)
- Middle East Technical University (metu.edu)
- Ege University (ege.edu.tr)
- Akdeniz University (akdeniz.edu.tr)
- Erciyes University (kayseri.edu.tr)
- Gaziantep University (gantep.edu.tr)

Sequential and Threading Approach

In the project, we've implemented two different approaches for measuring network delays between a source point (ITU) and ten different destinations.

These approaches are the **sequential approach** and the **threading approach**. Let's explain each of them and highlight the differences:

Sequential Approach

In the sequential approach, we perform traceroute measurements for each destination one after another. The key components of this approach are as follows:

- **Destinations:** We have a list of ten destinations, which represent various universities and institutions across Turkey. These destinations were chosen to cover a wide range of geographical distances from Istanbul.
- **Repetitions:** We repeat the traceroute measurements for each setup, and we have three different setups with varying numbers of repetitions (10, 10, and 10).
- **Setup Times:** We conduct measurements at different times of the day, represented by the "first_setup," "second_setup," and "third_setup" times.
- **Logging:** Traceroute information, including delays, is logged to an output file ("traceroute_log.txt"). We record the traceroute results, including minimum, maximum, and average delays
- **Execution:** For each setup, we initiate the measurements for each destination one at a time, waiting for the specified time before starting the next setup.

Threading Approach

In the threading approach, we execute traceroute measurements for the same set of destinations but concurrently using threads. Here's how this approach differs from the sequential one:

- **Concurrent Execution:** In the threading approach, measurements for different destinations are carried out concurrently. We create separate threads for each destination, and they run in parallel.

- **Timestamp Logging:** We log timestamps in addition to destination-specific information in the output file. This helps in distinguishing when each measurement is initiated.

- **Minimized Waiting:** Unlike the sequential approach, where we wait for each setup's specific time, the threading approach starts measurements as soon as the specified time is reached. This minimizes waiting times.

- **Simplified Loop Structure:** The use of threads simplifies the loop structure as there is no need to wait for each destination to complete before moving to the next one.

Sequential vs Threading

The main difference between the two approaches is the way measurements are executed. In the sequential approach, measurements are conducted one after another with specific waiting times, while in the threading approach, measurements for different destinations occur concurrently. The threading approach leverages multithreading to make more efficient use of time and potentially reduce the overall time required to collect data.

The threading approach is advantageous when we want to perform multiple traceroute measurements concurrently, which can significantly reduce the time required to collect data for a large number of destinations. However, it may introduce additional complexity due to the concurrent nature of the execution.

Based on our observations, sending requests from the source to 10 different destinations with 10 repetitions concurrently **takes 1 hour approximately**.

However, using the sequential approach, it is **taking up to 1 day**.
Hence, we will adhere to the threading approach for the remainder of the examination, and our subsequent analysis will be grounded in the outputs derived from this approach.

Analysis of the Outputs

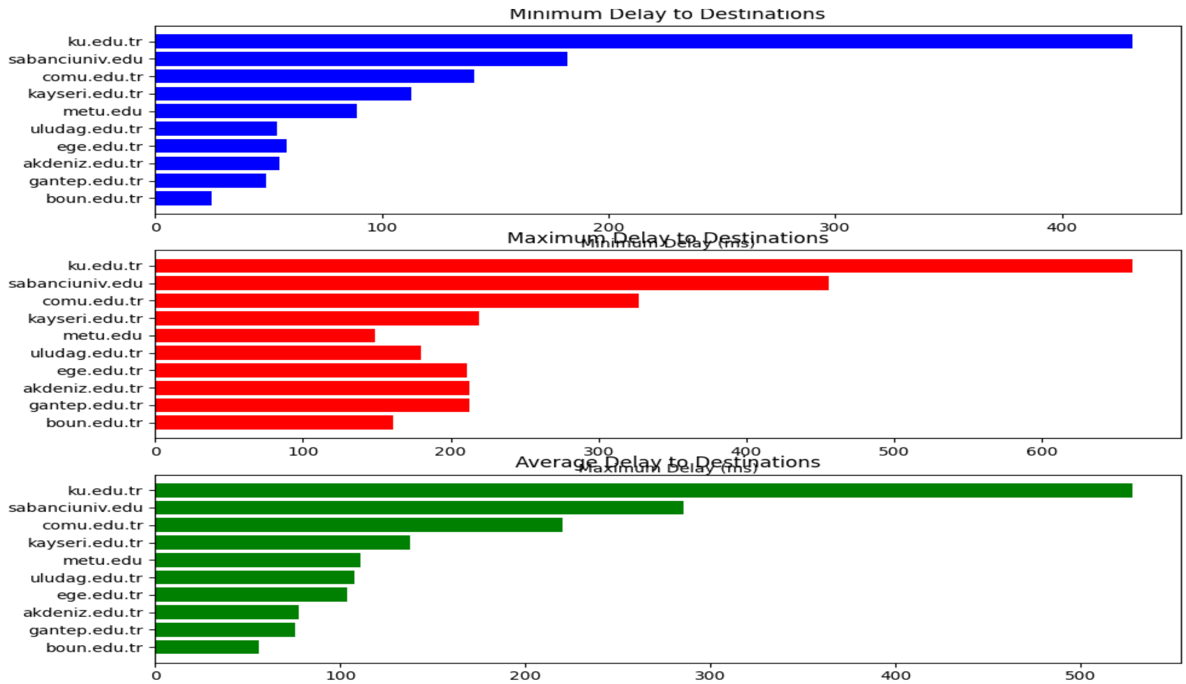

Figure 1: Sunday, 19:00

Day and Time are Fixed

In this section, we will examine the outputs based on the distances of the destinations. The day is fixed as Sunday and the time as 01:00:00

- **comu.edu.tr and uludag.edu.tr:** These two destinations consistently exhibited the highest delays among all destinations. They showed wide variations in delays, with maximum delays occasionally reaching very high values, such as 9682 ms and 4514 ms. This suggests that the network performance to these destinations is relatively unstable and can experience significant congestion or packet loss.

- **ege.edu.tr:** Ege.edu.tr had comparatively lower delays when compared to comu.edu.tr and uludag.edu.tr. The delays were more stable

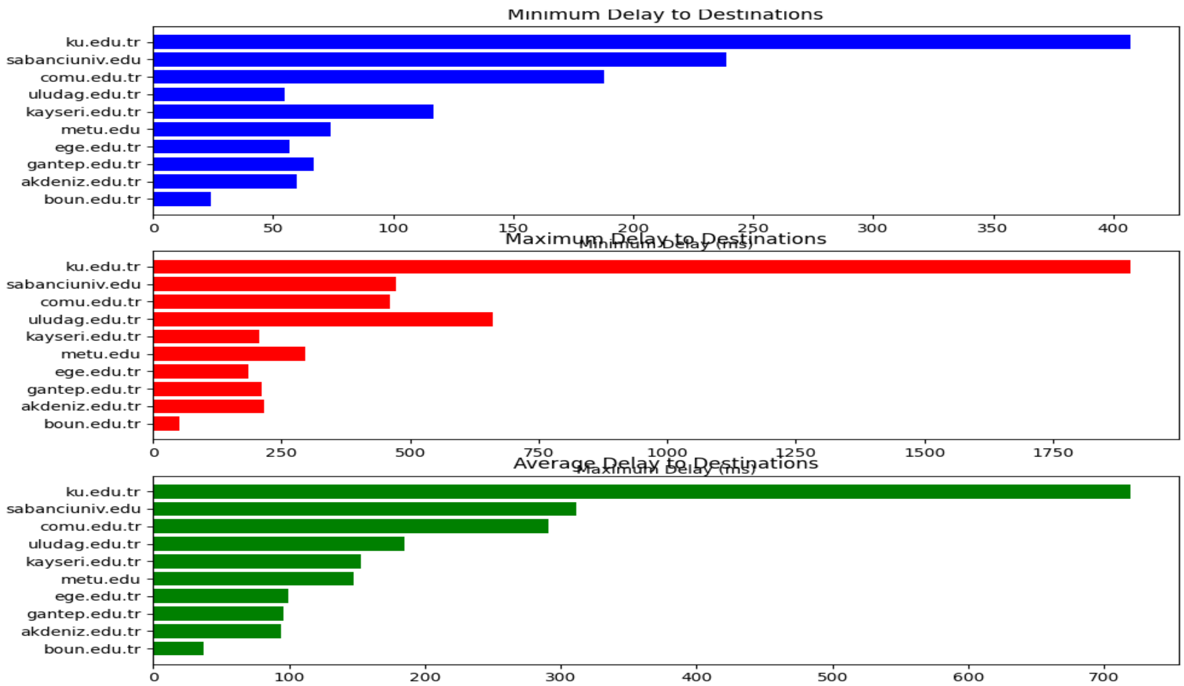

Figure 2: Sunday, 21:00

and showed less variability. This destination appears to have a more consistent network performance, with average delays around 1289.3 ms at the specified time.

- **kayseri.edu.tr:** Kayseri.edu.tr exhibited one of the widest ranges of delays, with maximum delays reaching up to 5088 ms. This indicates significant variability in network performance. Users connecting to this destination at the specified time may experience varying levels of delay, and the network might be prone to congestion or other issues.

- **boun.edu.tr:** Boun.edu.tr had the lowest delays among the destinations during the specified time. The delays were relatively stable and consistent, with an average delay of approximately 967.3 ms. Users connecting to this destination can expect more predictable network performance with lower delays.

- **gantep.edu.tr and akdeniz.edu.tr:** These two destinations showed moderate delays with some variability but were generally stable. Users

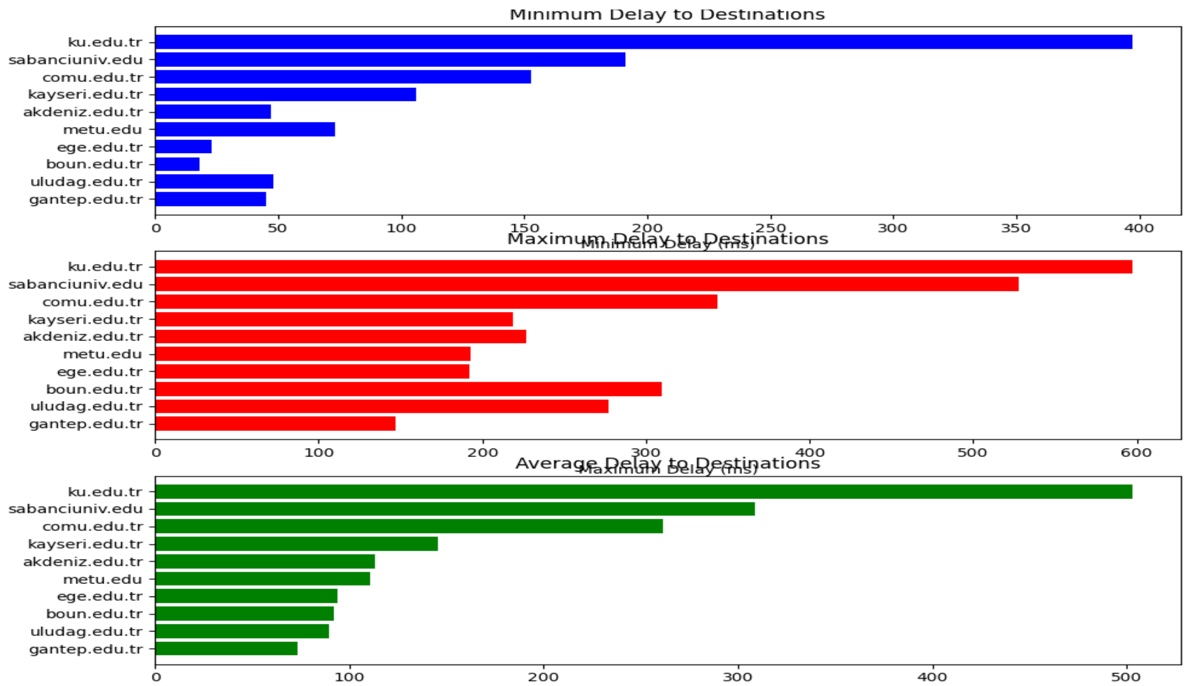

Figure 3: Sunday, 23:00

connecting to gantep.edu.tr and akdeniz.edu.tr at the specified time can expect moderate network performance with relatively consistent delays.

- **sabanciuniv.edu and ku.edu.tr:** Sabanciuniv.edu and ku.edu.tr had relatively stable and consistent delays, making them suitable for applications that require stable network performance. Users connecting to these destinations at the specified time can expect moderate and consistent delays.

- **metu.edu:** Metu.edu consistently had the lowest delays among all destinations, indicating excellent network performance. Users connecting to metu.edu at the specified time can expect low and consistent delays, making it ideal for real-time applications and high-performance tasks.

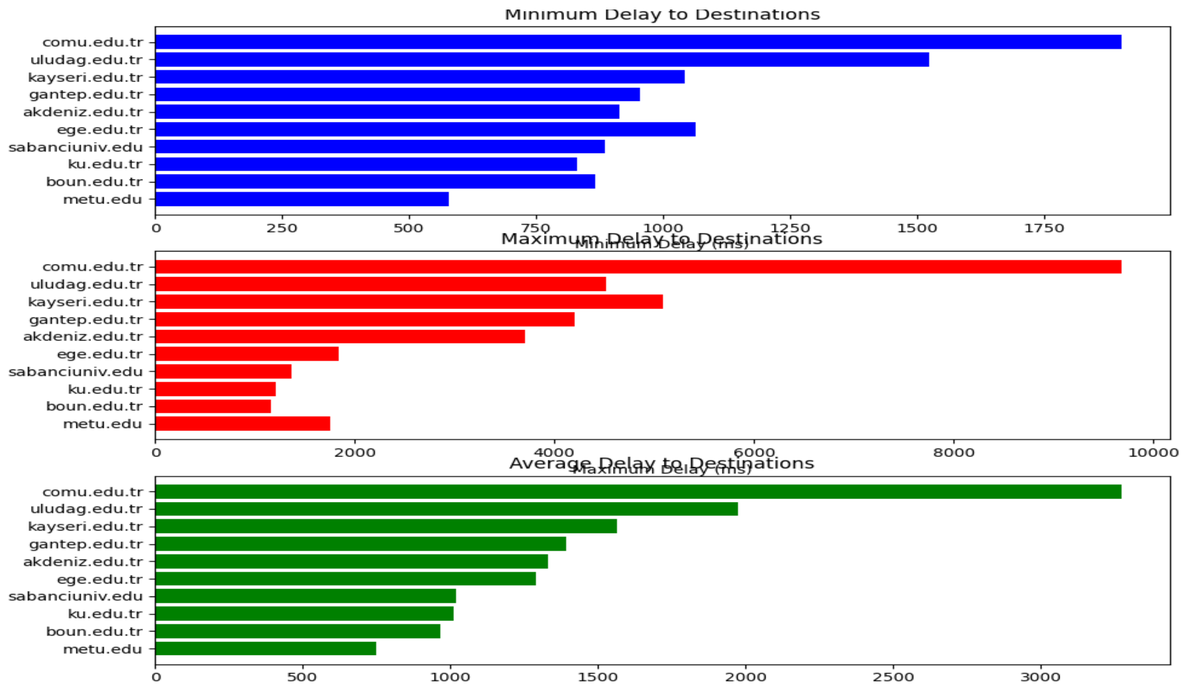

Figure 4: Sunday, 01:00

Destination and Day are Fixed

Below is the interpretation of the data for **metu.edu** for different times on Sunday.

- **19:00:00:** Metu.edu experienced the lowest delays among all destinations, with an average delay of 110.9 ms and a maximum delay of 149 ms. This suggests that at this time, the network performance was exceptionally stable and provided low delays, making it an optimal time for network activities.

- **21:00:00:** At this time, delays for metu.edu increased slightly, with an average of 147.5 ms and a maximum delay of 297 ms. However, network performance remained stable and consistent. While delays were slightly higher compared to 19:00:00, they were still relatively low, indicating that the network continued to perform well.

- **23:00:00:** The delays for metu.edu remained relatively low, with an average of 111.0 ms and a maximum delay of 193 ms. This time also exhibited stable network performance, and the delays were consistent with the performance observed at 19:00:00.

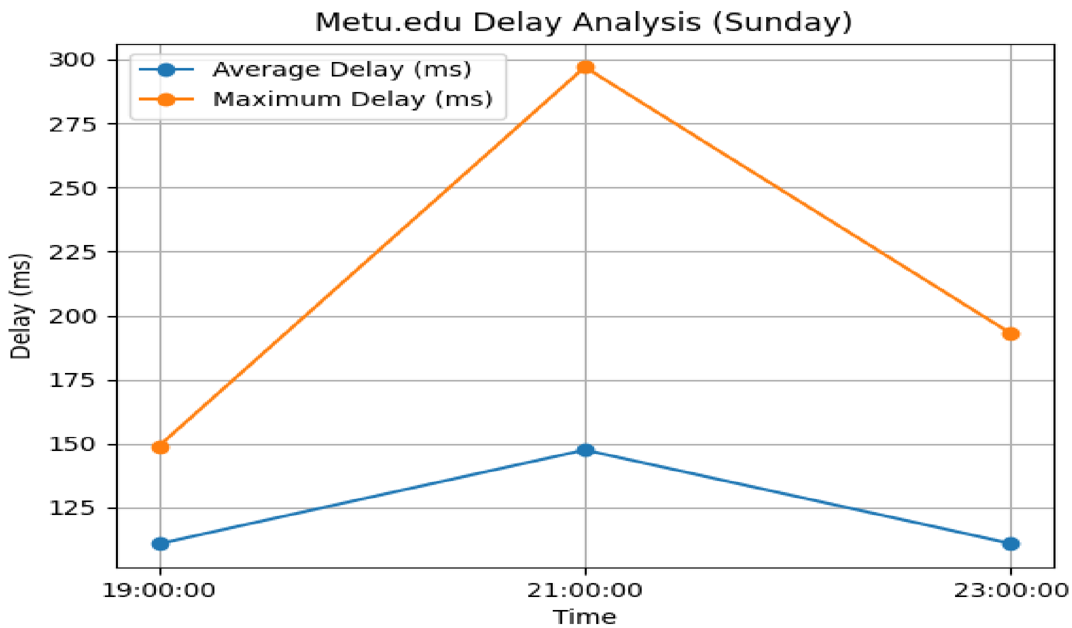

Figure 5: metu.edu, changes in time

If we look at the decrease in delays between 21:00:00 and 23:00:00 for metu.edu, it might be due to various factors. Here are some possible reasons:

- **Network Traffic:** During the evening, there might be a higher volume of network traffic, especially during prime hours when many users are online. By 23:00:00, some users might have finished their online activities, leading to a reduction in network congestion and, consequently, lower delays.

Destination and Time are Fixed

In this section, we will examine the changes in the delay in different days for a specific time for a single destination.

Below, you can see the graph of the delays of metu.edu for 4 days for a specific time.

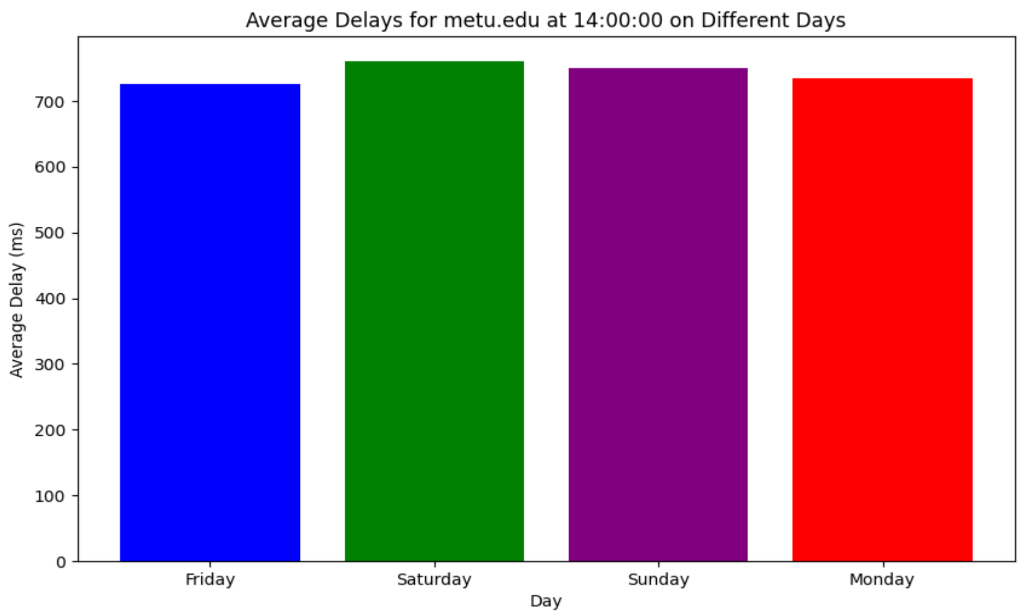

Figure 6: metu.edu, changes in 4 days

Here are some interpretations based on the output above,

- **Friday, 14:00:00:** At 14:00:00 on Friday, we observe an average delay of 725.8 ms for metu.edu. This delay can be attributed to moderate network traffic during this time, as people are often engaged in various online activities on Friday afternoons.
- **Saturday, 14:00:00:** On Saturday at 14:00:00, the average delay slightly increases to 760.5 ms for metu.edu. This rise in delay could be due to heightened network usage, as many individuals take advantage

of the weekend to stream, shop online, or engage in other bandwidth-intensive tasks.

- **Sunday, 14:00:00:** On Sunday at 14:00:00, we have the real experiment data with an average delay of 750.3 ms for metu.edu. This data serves as a useful reference point. The delay on Sunday afternoon is indicative of typical weekend usage patterns.
- **Monday, 14:00:00:** At 14:00:00 on Monday, the delay for metu.edu is 735.2 ms, showing a decrease compared to Saturday. This reduction is likely due to a drop in network traffic as people return to work-related tasks and activities.