Kieran McCauley, Taylor McManus, Nate Bielanski, Yujiani Wang, Graham Asam

Repo URL: https://github.com/cs536-hw-group/cs536-assignment1 (to be make public 3 days after due day per: https://piazza.com/class/mkaxd6e8trh43p/post/34) Timestamp: 4:24 pm on 1/29/2026

Documentation: We used AI in the creation and debugging of various files in our code.

Instructions on how to run the code and possible libraries to install are included in the README.md file.

1(c) Explain whether and how distance relates to rtt. What do min and max rtt convey about the distance, and the network state?

The Distance v. RTT plot illustrates that RTT increases with the distance that the ping must travel to reach the server. This confirms that a longer distance correlates with a longer RTT. The plot shows this correlation in a mostly linear relationship.

The minimum RTT, which is zero, came in the instance where we pinged our own computer. This has a distance of zero, indicating that the lowest RTTs have the smallest distance to travel. Regarding the maximum RTT, the scatter plot shows that the point has one of the longest distances at about 10,000 miles. However, it does not have the absolute longest distance. This indicates that the longest distances cause the longest RTTs, but due to possible congestion along the different paths, the longest distance does not correlate to the longest RTT.

One thing to notice about the scatter plot is that there are outliers of longer RTTs that are separate from the main clusters of RTTs for that average distance. These points give us information about the network state at the time that all these pings were run. It indicates a higher level of congestion in the network for that ping, which slowed its overall RTT. The pings that have a lower RTT most likely experienced low-to-normal congestion levels that allowed them to return within the average RTT for that distance.

2(d) Explain your observations from these plots. How does hop count relate to rtt?

The plots show that RTT generally increases with hop count, indicating a positive correlation between the number of hops and total round-trip time. However, the relationship is not strictly linear.

There are several observations from the plots:

1. Certain hops contribute disproportionately to total latency.

The stacked bar chart shows that some intermediate hops introduce large incremental delays, possibly due to congestion, ISP boundary crossings, or lower-capacity routers. These hops could be the bottleneck of RTT.

2. Paths with similar hop counts may have significantly different RTTs.

Paths with similar hop counts may still exhibit significantly different RTTs. This indicates that network routing policies, link quality, and congestion levels play important roles beyond simple hop count.

3. Geographic distance has a stronger impact than hop count.

Some destinations with moderate hop counts exhibit very large RTTs due to long physical distances (e.g., cross-continent or intercontinental links). For example, in the scatter plot, destination 185.76.9.135(Europe) has a larger RTT than destination 185.152.66.67(North America) although it has a smaller hop count. This suggests that geographic distance is the dominant factor in some cases.

In conclusion, while hop count is positively correlated with RTT, it is not a reliable predictor of latency by itself. Other factors such as geographic distance, congestion, and routing policies significantly affect total round-trip time.