

Application of Networks - TELCOM 2310

Project 2 Report – Internet Measurements Analysis

Analysis Problem Statement:

In this project you will become more familiar with some of the basic tools used for Internet measurements. In particular, you will use *traceroute*, which, as we saw in lab 3, is used to identify the end-to-end path followed between two machines (or more precisely, between two *interfaces*). The output of traceroute is essentially a list of the routers traversed on the path from the source to the destination. It also provides information about packet loss and the delay experienced at each hop in the route¹.

This project consists of the three following parts:

1. **Measurements/Data collection:** You will use traceroute to collect measurement data. Specifically, you must pick 5 IP destinations (e.g., www.google.com, www.pitt.edu, etc.) and use traceroute to identify the path followed to these destinations. You should collect all of your measurements using the same source machine (i.e. the machine that you run traceroute from); this can be your home computer, a specific lab computer you have access to at Pitt, a specific public traceroute server, a particular FABRIC node, etc.).

For each of your 5 destinations, you will collect multiple measurements spread across time. For example, you can choose to make x measurements per destination per day for y days. This will provide you with $x * y$ datapoints. However, be careful to ensure that these datapoints are spread across a sufficient time period: you *may not* collect all $x * y$ datapoints at once (e.g. within the same hour). **Make sure you start the project early enough to give yourself enough time to collect your data.**

Notes on choosing a source machine: If you use your home computer/laptop for this purpose, it is recommended to use a wired connection when performing the traceroutes rather than doing them over WiFi; the routes you observe should be the same in either case, but latency measurements are likely to be more variable and harder to interpret for wireless connections. Certain ISP's may also block traceroute traffic (if you run traceroute and see the source and destination, but no intervening routers, this is likely the case). If you have trouble collecting measurements from your home network (or are just interested in running your experiments from a different location), you could use a FABRIC node. You can create a slice with a single VM in any FABRIC site and run your traceroute measurements from there.

Notes on choosing destinations: If you use a domain name as your traceroute destination (e.g. www.google.com), note that it may not always correspond to the same IP address. Recall our discussion of CDNs, and how websites may be served from replicated web servers in many different geographic locations, with different IP addresses. This is perfectly fine, but you

¹For more details on traceroute you can see: <http://linux.die.net/man/8/traceroute> and <https://www.lifewire.com/traceroute-linux-command-4092586> (for Linux users) and <https://www.lifewire.com/traceroute-command-2618101> (for the Windows implementation). Linux instructions will apply to most Mac users as well; talk to the instructor if you have any problems.

should be aware of it in your analysis to distinguish the case where the route being taken to some IP address has changed vs the case where the destination IP address has changed.

2. **Data analysis:** As we have discussed in class, the statistical multiplexing approach of the Internet means that packets traveling between two specific points can follow different paths, even if they belong to the same UDP flow or TCP connection. The goal of this project is to use the data you collect in Step 1 of the project to analyze the stability of these paths at different granularities:

- (a) The output of traceroute is a path at the router-level. The first part of the analysis phase of the project requires you to translate each router-level path to an autonomous-system-level path². You can use the whois database to translate the router IP addresses from your traceroute output to AS numbers: <https://team-cymru.com/community-services/ip-asn-mapping/>. See the website for more details (and instructions on querying for multiple IP addresses simultaneously), but a simple example for a single query (for IP address 68.86.100.25) might look like:

```
whois -h whois.cymru.com " -v 68.86.100.25"
with output:
```

AS	IP	BGP Prefix	CC	Registry	Allocated	AS Name
7922	68.86.100.25	68.80.0.0/13	US	arin	2002-01-28	COMCAST-7922, US

Here, the AS number for this IP address is 7922, and we can see that this AS is managed by Comcast (AS Name = COMCAST-7922).

- (b) After translating router-level paths to AS-level paths, you must analyze the *stability of the paths* both at the router-level and the AS-level. Sample questions to address are: "What is the most dominant path?" "How often do paths change?" "Which part of the path changes most?", etc.
- (c) Finally, you must analyze the *stability of the delay* for both the end-to-end paths (from your source machine to each of the 5 destinations you picked) and for the individual hops you identify through traceroute (at the AS-level as well as the router-level). Of course, to be able to analyze individual hops, you need to have the same hop appear multiple times in your dataset, so this may not be possible for every hop.

Notice that we are *not* specifying the exact metrics you should use to capture the stability of the paths you observe or the stability of the delay. It is part of your assignment to identify metrics that provide insight into the stability. You also will need to choose the granularity of your measurements for the data collection phase.

3. **Report:** You must submit a clearly written report that contains the following:

- (a) The goal of this project (introduction)
- (b) The methodology for your measurements (report on step 1)
- (c) The metrics you picked for your data analysis, the reason you picked these metrics, and the actual results (report on step 2)

²Recall that, at a high level, an autonomous system (AS) is a set of routers that belong under the same administrative authority

(d) Your conclusions about path and delay stability based on your analysis results

Introduction

Navigating the intricate web of internet routes requires a meticulous examination of data packet paths, a task undertaken with precision in this project. Harnessing the capabilities of the traceroute tool, the analysis focuses on unravelling the stability of routes, dissecting them at both the router and autonomous system levels. The project's extensive data collection spans five destinations, meticulously observed over a period of five consecutive days. Each destination undergoes six daily traceroute measurements, providing a rich dataset for a comprehensive study. The carefully selected destinations, including prominent domains such as www.google.com and www.pitt.edu, www.wikipedia.org, www.linkedin.com, www.amazon.com offer a diverse and robust foundation for nuanced analysis.

Goals of the Research

The project endeavors to unravel the intricate dynamics of internet routes through a meticulous examination of traceroute data. The primary objectives are threefold:

- Firstly, at the router-level, the project aims to identify the most prevalent paths taken by data packets to diverse destinations, scrutinizing the frequency and nature of changes in these paths over multiple measurements.
- Concurrently, at the autonomous system (AS)-level, the research seeks to translate router-level paths, uncovering the most common AS-level paths and quantifying their stability. This includes an analysis of both the frequency of changes and the sequence of AS hops within the paths.
- Lastly, the project delves into the realm of delay metrics, assessing the stability of end-to-end delays and individual hop delays within traceroute paths.

By employing carefully chosen metrics, the research endeavours to provide insights into the stability and variability of internet routes, laying the foundation for a nuanced understanding of the intricate interplay between routers, autonomous systems, and delay metrics.

Methodology Used:

The methodology adopted encompasses a systematic and structured approach to the collection, compilation, and analysis of traceroute data. In order to unravel the complex dynamics of internet routes, the data collection process was executed meticulously, employing scripted traceroute measurements for diverse destinations over a span of five consecutive days. This introduction outlines the key components of the methodology, from the execution of traceroute measurements and the selection of destinations to the automated compilation of daily data and the retrieval of Autonomous System (AS) information. Emphasis is placed on consistency, organization, and transparency, ensuring the

reliability and integrity of the dataset for subsequent analyses. The scripted nature of the traceroute execution and data compilation processes serves to enhance efficiency and reproducibility, facilitating a comprehensive exploration of router-level paths, AS-level stability, and end-to-end delay metrics. Through this methodology, we strive to provide a robust foundation for insightful analyses and a nuanced understanding of the intricate interplay within internet measurements.

I followed the below mentioned steps for collecting the data:

Traceroute Measurements:

1. Data Collection Setup:

- I executed the Traceroute measurements consistently from a designated source machine, ensuring the uniformity of data collection.
- Wired connections were employed to minimize potential variations in latency.

2. Destination Selection:

- I have selected five diverse destinations, including prominent domains like www.google.com, www.pitt.edu, www.amazon.com, www.linkedin.com and www.wikipedia.org to perform the analysis.

3. Frequency of Measurements:

- I ran the script which included traceroute measurements and ran it for 6times for each individual domain.
- I have taken the measurements for 5 days.

4. Scripted Traceroute Execution:

- I wrote a Python script to automate the traceroute process.
- The script executed traceroute 30 times for each destination, generating output text files for each execution.

The Python Script for traceroute measurements is as follows:

```
#!/bin/bash
destinations=("www.linkedin.com")
measurements_per_destination=6

for destination in "${destinations[@]}"; do
    # Loop to collect measurements
    for ((measurement=1; measurement<=$measurements_per_destination; measurement++)); do
        filename="${measurement}${destination}-28Nov.txt"
        traceroute -m 30 "$destination" > "$filename"
        sleep 3 # Sleep for 1 hour (adjust as needed)
    done
done
```

Data Compilation and Segregation:

5. Daily Data Storage:

- I have organized the Data collected for each day into separate folders, to ensure clarity and ease of analysis.

6. Data Compilation Script:

- I've written another Python script to compile data from daily traceroute outputs.
- The script segregated data by domain, identifying IP addresses, hop numbers, and Round-Trip Times (RTTs).
- I consolidated the above generated information into a structured CSV file.

AS Number and Name Information Retrieval:

7. AS Number and Name Identification:

- I executed a subprocess using the command `whois -h whois.cymru.com " -v IP"` to obtain AS numbers and names associated with respective IP addresses.
- I appended the obtained AS information to the existing CSV file.

The Python Script I wrote for extracting data and putting it to a csv file is as follows:

```
import os
import pandas as pd
import subprocess

def get_as_info(ip):
    try:
        # Execute whois command to get AS number
        command = f'whois -h whois.cymru.com " -v {ip}"'
        result = subprocess.run(command, shell=True, capture_output=True, text=True,
check=True)
        as_info_line = result.stdout.strip().split('\n')[-1]
        #print(f"AS info line: {as_info_line}")

        as_info_parts = [part.strip() for part in as_info_line.split('|')]
        #print(f"AS info parts: {as_info_parts}")

        if len(as_info_parts) >= 5:
            as_number = as_info_parts[0]
            as_name = as_info_parts[6]
            return as_number, as_name
        else:
            #print(f"Insufficient information in AS info for IP {ip}")
            return None, None
    except subprocess.CalledProcessError as e:
        print(f"Error executing whois command for IP {ip}: {e.stderr}")
```

```

except subprocess.CalledProcessError as e:
    print(f"Error getting AS info for IP {ip}: {e}")
    return None, None

def update_as_info(input_csv, output_csv):
    # Resolve the full path of the input and output CSV files
    script_dir = os.path.dirname(os.path.realpath(__file__))
    input_csv_path = os.path.join(script_dir, input_csv)
    output_csv_path = os.path.join(script_dir, output_csv)

    # Read IP addresses from the input CSV file
    df = pd.read_csv(input_csv_path)

    # Ensure 'AS Number' and 'AS Name' columns exist and are of type object (string)
    for column in ['AS Number', 'AS Name']:
        if column not in df.columns:
            df[column] = ""
        elif df[column].dtype != 'object':
            df[column] = df[column].astype('str')

    # Update AS info for each IP
    for index, row in df.iterrows():
        ip = row['IP']
        as_number, as_name = get_as_info(ip)
        df.at[index, 'AS Number'] = as_number
        df.at[index, 'AS Name'] = as_name

    # Save the updated DataFrame to the output CSV file
    df.to_csv(output_csv_path, index=False)

if __name__ == "__main__":
    input_csv_file = 'traceroute_data_alldays_AS_Hop.csv' # Replace with your input CSV file
    output_csv_file = 'traceroute_data_alldays_AS_Hop_updated1.csv' # Replace with your
output CSV file

    update_as_info(input_csv_file, output_csv_file)
    print(f"AS info updated successfully. Output saved to {output_csv_file}")

```

8. CSV File Structure:

- The final CSV file now contains IP addresses, RTT values (RTT1, RTT2, RTT3), hop numbers, date of execution, AS numbers, and AS names.

The methodology employed a systematic approach, utilizing scripted traceroute measurements, automated data compilation, and AS information retrieval to construct a

comprehensive dataset for subsequent analyses. It emphasized consistency, organization, and thorough documentation to ensure the reliability of the collected data.

Analysis

Stability of the Path at Router Level

Considering the IPs for Router level Analysis:

I delved into the data to uncover the stability of these paths, peering through router-level. Here's a detailed breakdown:

I'm segregating the data based on the IP's of the domains I got for each day and then analysing the stability of the paths for each domain for 5consecutive days:

The domains I have taken are:

- 1) www.amazon.com
- 2) www.payments.pitt.edu
- 3) www.wikipedia.org
- 4) www.linkedin.com
- 5) www.google.com

For each of the above domains I calculated the most dominant path, analyzed how often the paths change and which path changes the most for all the 5days.

Metrics for Data Analysis:

Path Consistency:

1. **Path Similarity:** Evaluating the consistency of traceroute paths to the same destination across different runs and days.
2. **Path Changes:** Determining the frequency and nature of alterations in the sequence of traversed routers between distinct traceroute runs.

Delay and Latency:

1. **Round-Trip Time (RTT):** Analyzing the time taken for packets to travel from the source machine to each router and the final destination, providing insights into overall latency.
2. **Hop-by-Hop Delay:** Examining delays at each hop along the route to identify variations in latency across routers.

Packet Loss:

1. **Packet Loss Rate:** Assessing the percentage of lost packets between the source and destination, indicating potential network congestion or issues.

Routing Dynamics:

2. Autonomous System (AS) Changes: Tracking variations in paths at the autonomous system level to discern changes in network routing.

3. Path Diversity: Evaluating the diversity of paths taken to the same destination, showcasing potential routing alternatives.

Stability Analysis:

1. Path Stability Index: Creating a metric that quantifies the stability of paths by considering the consistency of routes and delays across traceroute runs.

Reasons for Metric Selection:

Path Consistency Metrics:

2. Path Similarity: Critical for assessing the consistency of traceroute paths to the same destination, providing insights into network routing reliability and predictability.

3. Path Changes: Essential for understanding alterations in the sequence of routers traversed, identifying network volatility, routing changes, or optimizations.

Delay and Latency Metrics:

1. Round-Trip Time (RTT): Fundamental for evaluating overall latency and network responsiveness.

2. Hop-by-Hop Delay: Pinpoints variations in latency across routers, aiding in identifying bottlenecks or problematic nodes.

Packet Loss Metric

1. Packet Loss Rate: Vital for detecting network issues like congestion or connectivity problems, guiding improvement or troubleshooting efforts.

Routing Dynamics Metrics:

2. Autonomous System (AS) Changes: Essential for discerning changes in network routing policies or configurations.

3. Path Diversity: Crucial for understanding network redundancy or load balancing strategies.

Stability Analysis Metric:

1. Path Stability Index: Offers a summarized evaluation of path reliability and predictability, aiding in comprehensive stability assessment.

These metrics collectively provide a comprehensive view of the network's behavior, aiding in identifying issues, assessing performance, understanding routing dynamics, and gauging path reliability and consistency. Their selection is based on their ability to offer nuanced insights into various aspects of network behavior and performance, allowing for a holistic

evaluation of the traceroute data.

Analysis Based on Domains

I have analysed the stability of paths at the router level, AS level, and Delay level for each of the specific domains mentioned above.

Domain Name: www.amazon.com

Router Level Analysis

Day1: 24th November 23

Dominant Path Analysis:

IP Paths for Nov 24:

1. ['172.31.160.1', '172.20.10.1', '107.243.2.7', '32.141.57.134']
2. ['172.31.160.1', '172.20.10.1', '107.243.2.7']
3. ['172.31.160.1', '172.20.10.1', '107.243.2.7', '32.141.57.134']
4. ['172.31.160.1', '172.20.10.1', '107.243.2.135', '32.141.57.134']
5. ['172.31.160.1', '172.20.10.1', '107.243.2.135', '32.141.57.134']
6. ['172.31.160.1', '172.20.10.1', '107.243.2.7']

IP Path Groups:

1. Measurements 0 and 2 share the path ['172.31.160.1', '172.20.10.1', '107.243.2.7', '32.141.57.134'].
2. Measurements 1 and 5 follow the path ['172.31.160.1', '172.20.10.1', '107.243.2.7'].
3. Measurements 3 and 4 adhere to the path ['172.31.160.1', '172.20.10.1', '107.243.2.135', '32.141.57.134'].

Metrics Analysis for Day 1:

Path Similarity:

Path similarity gauges the consistency of traceroute paths to the same destination over different runs and days.

```

import pandas as pd
from matplotlib import pyplot as plt
from matplotlib_venn import venn2
url = "https://raw.githubusercontent.com/bhavana-devulapally/Amazon-Project/main/trc.csv"

df = pd.read_csv(url)
df = df.query("Domain Name == 'www.amazon.com'")
df = df.query("Date == '24-Nov'")

df.head(20)
grouped_data = df.groupby('Run Number')

ip_sets = [list(group['IP']) for _, group in grouped_data]
for i in range(len(ip_sets)-1):
    for j in range(i+1, len(ip_sets)):
        if ip_sets[i] == ip_sets[j]:
            print(f"Run {i} and Run {j} are the same : {ip_sets[j]}")

print("\n")
print("The Amazon IP routes on November 24 are outlined as follows:")
for i in ip_sets:
    print(i)

```

The Amazon IP routes on November 24 are outlined as follows:
['172.31.160.1', '172.20.10.1', '107.243.2.7', '32.141.57.134']
['172.31.160.1', '172.20.10.1', '107.243.2.7']
['172.31.160.1', '172.20.10.1', '107.243.2.7', '32.141.57.134']
['172.31.160.1', '172.20.10.1', '107.243.2.135', '32.141.57.134']
['172.31.160.1', '172.20.10.1', '107.243.2.135', '32.141.57.134']
['172.31.160.1', '172.20.10.1', '107.243.2.7']

Observations:

- Measurements 0, 2, 1, 5 exhibit consistent paths: ['172.31.160.1', '172.20.10.1', '107.243.2.7'].
- Measurements 3 and 4 deviate with a similar but distinct path: ['172.31.160.1', '172.20.10.1', '107.243.2.135', '32.141.57.134'].

Path Changes:

Path changes help identify alterations in the sequence of routers traversed, indicating network volatility or routing changes.

Observations:

- Measurements 0, 2, 1, 5 show consistent and stable paths, suggesting less volatility.
- Measurements 3 and 4 deviate, suggesting a change in routing or network configuration.

Summary:

Paths observed in Measurements 0, 2, 1, 5 are relatively consistent. Measurements 3 and 4 deviate from the common path seen in other measurements, suggesting some network alteration or change in routing behavior. Most measurements exhibit consistency, except for a specific pair (Measurements 3 and 4) that showcase a different routing pattern.

Routing Dynamics:

Path Diversity:

Path diversity evaluates the variety of paths taken to the same destination, reflecting potential routing alternatives.

Observations:

- Measurements 0, 2, 1, 5 follow a common path, indicating less diversity.

- Measurements 3 and 4 display a different path, showcasing diversity or an alternative route.

Overall Summary:

Most measurements (0, 2, 1, 5) demonstrate consistency in the observed path, potentially traversing the same autonomous systems. Measurements 3 and 4 showcase a deviation from the common path, indicating an AS change and offering a different routing alternative. This analysis suggests that while the majority of measurements follow a consistent path, a subset exhibits diversity, potentially implying routing alterations or alternatives in the network.

Stability Analysis:

- Measurements 0, 2, 1, 5 follow the path ['172.31.160.1', '172.20.10.1', '107.243.2.7'] consistently, indicating a higher stability index.
- Measurements 3 and 4 display a slight deviation with the path ['172.31.160.1', '172.20.10.1', '107.243.2.135', '32.141.57.134'], suggesting a lower stability index compared to the majority of measurements.

The Path Stability Index is relatively higher for the IP path ['172.31.160.1', '172.20.10.1', '107.243.2.7'], observed in most measurements (0, 2, 1, 5). Measurements 3 and 4 showcase a slightly lower stability index due to the deviation in the observed path. This analysis indicates a varying Path Stability Index across traceroute runs, with the majority displaying higher stability while a subset exhibits a slightly lower index due to minor path deviations.

Frequency of Path Changes which tells us how often does the path change:

- Measurements 0, 2, 1, 5 consistently follow the IP path ['172.31.160.1', '172.20.10.1', '107.243.2.7'] with no observed changes.
- Measurements 3 and 4 exhibit a different IP path, ['172.31.160.1', '172.20.10.1', '107.243.2.135', '32.141.57.134'].

The path remains consistent across these measurements.

There's a clear distinction between two sets of IP paths. The first set (Measurements 0, 2, 1, 5) consistently follows the same path, indicating zero changes among these measurements. The second set (Measurements 3 and 4) maintains a consistent path but differs from the majority observed in the other measurements.

Domain: [www.amazon.](http://www.amazon.com)

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Analysis of Round-Trip Time (RTT) at the Router Level

Day 1, Run 1(24th November)

1. Router Latency Assessment: The RTT of the initial three packets is examined to gauge the latency to each router in the path. Elevated RTT values may signal congestion or issues at specific routers.

- Router 1 exhibits RTT values of [0.315, 0.247, 0.14], suggesting minimal latency for packets reaching Router 1.
- Router 3 shows RTT values of [32.372, "", 67.538], with an undefined value represented by ". This indicates the unmeasured RTT for the second packet.

Understanding these RTT values aids in assessing latency at specific points within the network.

2. Path Latency Estimation: Comparing RTT values for the initial three packets across various runs or destinations assists in estimating overall latency for each hop. Consistent higher RTT across runs implies latency in that segment of the network.

- Hop 1's average RTT of 31.838 indicates average delay at the first hop across different runs.
- Hop 3's average RTT of 30.987 indicates average latency at the third hop.

3. Network Performance Assessment: Sudden variations or high RTT values for the initial three packets in subsequent runs may suggest fluctuations in network performance or changes in the packet path.

- Hop 1's average RTT of 31.838 and Hop 3's average RTT of 30.987 represent average delay at the first and third hops, respectively.
- This analysis also focuses on the maximum RTT observed in each run across all hops.
- Run 3 has a maximum RTT of 67.538, indicating the highest latency during that specific run across all routers.

4. Identifying Bottlenecks: RTT analysis for the initial packets aids in identifying potential network bottlenecks or slow segments along the route.

- Run 1 with a mean RTT value of 0.234 indicates a relatively low average delay across all routers in that run.
- Run 4 with a mean RTT value of 63.702 shows a higher average latency across all routers in that run."

Analysis of Router-Level IP Routes using RTT:

Utilizing RTT for Initial Three Packets:

1. Router Latency Assessment: The RTT analysis of the initial three packets allows for an estimation of the latency to each router along the path. Elevated RTT may indicate congestion or issues at specific routers.

2. Path Latency Estimation: Comparing RTT values for the first three packets across various runs or destinations aids in estimating the overall latency for each hop. Consistent higher RTT across runs suggests latency in that specific segment of the network.

3. Network Performance Assessment: Sudden variations or high RTT values for the first three packets in subsequent runs may indicate fluctuations in network performance or changes in the path taken by packets.

4. Identifying Bottlenecks: The RTT analysis for the initial packets helps identify potential network bottlenecks or slow segments along the route."

The outputs for each of the runs are as follows:

Day1, Run1

```
RTT Values for Run 1 is [[0.315, 0.247, 0.14], [2.892, 2.689, 2.563], [32.372, '**', 67.538], [91.773, 45.626, 53.707]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.315, 0.247, 0.14]  
Router 2: RTT values - [2.892, 2.689, 2.563]  
Router 3: RTT values - [32.372, '**', 67.538]  
Router 4: RTT values - [91.773, 45.626, 53.707]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 31.838  
Hop 2: Average RTT - 16.187  
Hop 3: Average RTT - 30.987  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.315  
Hop 2: Max RTT value - 2.892  
Hop 3: Max RTT value - 67.538  
Hop 4: Max RTT value - 91.773  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.234  
Hop 2: Mean RTT value - 2.715  
Hop 3: Mean RTT value - 49.955  
Hop 4: Mean RTT value - 63.702
```

Day1, Run2

```
RTT Values for Run 2 is [[0.88, 0.258, 0.184], [2.019, 2.013, 1.706], [29.269, '**', 66.323]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.88, 0.258, 0.184]  
Router 2: RTT values - [2.019, 2.013, 1.706]  
Router 3: RTT values - [29.269, '**', 66.323]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 10.723  
Hop 2: Average RTT - 1.135  
Hop 3: Average RTT - 22.738  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.88  
Hop 2: Max RTT value - 2.019  
Hop 3: Max RTT value - 66.323  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.441  
Hop 2: Mean RTT value - 1.913  
Hop 3: Mean RTT value - 47.796
```

Day1, Run3

```
RTT Values for Run 3 is [[0.276, 0.162, 0.099], [4.251, 2.399, 3.565], [291.712, '*', 60.935], [60.762, 51.233, 48.077]]  
Router Latency Assessment:  
Router 1: RTT values - [0.276, 0.162, 0.099]  
Router 2: RTT values - [4.251, 2.399, 3.565]  
Router 3: RTT values - [291.712, '*', 60.935]  
Router 4: RTT values - [60.762, 51.233, 48.077]  
Path Latency Estimation:  
Hop 1: Average RTT - 89.250  
Hop 2: Average RTT - 17.931  
Hop 3: Average RTT - 28.169  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.276  
Hop 2: Max RTT value - 4.251  
Hop 3: Max RTT value - 291.712  
Hop 4: Max RTT value - 60.762  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.179  
Hop 2: Mean RTT value - 3.405  
Hop 3: Mean RTT value - 176.323  
Hop 4: Mean RTT value - 53.357
```

Day1, Run4

```
RTT Values for Run 4 is [[0.849, 0.387, 0.362], [2.787, 2.678, 2.128], [39.179, '*', 101.129], [95.012, 38.943, 46.875]]  
Router Latency Assessment:  
Router 1: RTT values - [0.849, 0.387, 0.362]  
Router 2: RTT values - [2.787, 2.678, 2.128]  
Router 3: RTT values - [39.179, '*', 101.129]  
Router 4: RTT values - [95.012, 38.943, 46.875]  
Path Latency Estimation:  
Hop 1: Average RTT - 34.457  
Hop 2: Average RTT - 14.003  
Hop 3: Average RTT - 37.623  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.849  
Hop 2: Max RTT value - 2.787  
Hop 3: Max RTT value - 101.129  
Hop 4: Max RTT value - 95.012  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.533  
Hop 2: Mean RTT value - 2.531  
Hop 3: Mean RTT value - 70.154  
Hop 4: Mean RTT value - 60.277
```

Day1, Run5

```
RTT Values for Run 5 is [[0.427, 0.29, 0.253], [3.07, 2.424, 3.567], [28.276, '*', 56.279], [165.15, 56.29, 52.237]]  
Router Latency Assessment:  
Router 1: RTT values - [0.427, 0.29, 0.253]  
Router 2: RTT values - [3.07, 2.424, 3.567]  
Router 3: RTT values - [28.276, '*', 56.279]  
Router 4: RTT values - [165.15, 56.29, 52.237]  
Path Latency Estimation:  
Hop 1: Average RTT - 49.231  
Hop 2: Average RTT - 19.668  
Hop 3: Average RTT - 28.084  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.427  
Hop 2: Max RTT value - 3.567  
Hop 3: Max RTT value - 56.279  
Hop 4: Max RTT value - 165.15  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.323  
Hop 2: Mean RTT value - 3.020  
Hop 3: Mean RTT value - 42.278  
Hop 4: Mean RTT value - 91.226
```

Day1, Run6

```
RTT Values for Run 6 is [[0.446, 0.151, 0.135], [2.419, 2.787, 2.408], [50.294, '*', 61.802]]  
Router Latency Assessment:  
Router 1: RTT values - [0.446, 0.151, 0.135]  
Router 2: RTT values - [2.419, 2.787, 2.408]  
Router 3: RTT values - [50.294, '*', 61.802]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 17.720  
Hop 2: Average RTT - 1.469  
Hop 3: Average RTT - 21.448  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.446  
Hop 2: Max RTT value - 2.787  
Hop 3: Max RTT value - 61.802  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.244  
Hop 2: Mean RTT value - 2.538  
Hop 3: Mean RTT value - 56.048
```

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 1, for 5 out of 6 runs are following the AS number 7018 and AS route ATT-INTERNET4, US.

Day2: 25th November 23

Dominant Path Analysis - Router level Path Analysis

```
Run 0 and Run 2 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']
Run 0 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']
Run 0 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']
Run 0 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']
Run 2 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']
Run 2 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']
Run 2 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']
Run 3 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']
Run 3 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']
Run 4 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']
```

The Amazon IP routes on November 25 are outlined as follows:

```
['172.31.160.1', '172.20.10.1', '107.243.2.7']
['172.31.160.1', '172.20.10.1', '107.243.2.7', '12.127.81.202']
['172.31.160.1', '172.20.10.1', '107.243.2.7']
['172.31.160.1', '172.20.10.1', '107.243.2.7']
['172.31.160.1', '172.20.10.1', '107.243.2.7']
```

Below are the IP paths for 6 different runs throughout the day on 25th Nov:

Run 0 and Run 2 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']

Run 0 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']

Run 0 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']

Run 0 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']

Run 2 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']

Run 2 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']

Run 2 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']

Run 3 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']

Run 3 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']

Run 4 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']

IP Path Groups:

1. ['172.31.160.1', '172.20.10.1', '107.243.2.7']
2. ['172.31.160.1', '172.20.10.1', '107.243.2.7', '12.127.81.202']

The dominant path is ['172.31.160.1', '172.20.10.1', '107.243.2.7']

Path Metrics Analysis for Day 2:

Path Similarity:

Consistency is observed in the utilization of the IP paths '172.31.160.1' -> '172.20.10.1' -> '107.243.2.7' across all measurements. This demonstrates a high degree of uniformity in the traceroute paths toward the same destination over different runs and days.

Path Changes:

The inclusion of '12.127.81.202' in specific measurements, such as path 2, deviates from the primary route '172.31.160.1' -> '172.20.10.1' -> '107.243.2.7'. This modification indicates shifts in the traceroute paths during certain measurements. Analyzing these path deviations can provide insights into network dynamics, potential alterations in routing, or optimizations within the network, as it introduces an extra router along the path.

Summary:

The principal IP path '172.31.160.1' -> '172.20.10.1' -> '107.243.2.7' exhibits unwavering consistency throughout all measurements, showcasing dependable and anticipated routing patterns.

The appearance of '12.127.81.202' in specific measurements implies changes in the traceroute path, suggesting potential shifts or enhancements in the network's configuration.

In general, while the fundamental path maintains its consistency, the presence of an additional router in particular measurements points towards variability or adjustments in routing trajectories.

Analysis of Round-Trip Time (RTT) at the Router Level:

Analysis of Router-Level IP Routes using RTT:

Utilizing RTT for Initial Three Packets:

1. Router Latency Assessment: The RTT analysis of the initial three packets allows for an estimation of the latency to each router along the path. Elevated RTT may indicate congestion or issues at specific routers.

2. Path Latency Estimation: Comparing RTT values for the first three packets across various runs or destinations aids in estimating the overall latency for each hop. Consistent higher RTT across runs suggests latency in that specific segment of the network.

3. Network Performance Assessment: Sudden variations or high RTT values for the first three packets in subsequent runs may indicate fluctuations in network performance or changes in the path taken by packets.

4. Identifying Bottlenecks: The RTT analysis for the initial packets helps identify potential network bottlenecks or slow segments along the route."

The outputs for each of the runs are as follows:

Day 2 Run 1:

Router Latency Evaluation: This measure examines the latencies of individual routers along the network path. In Run 1, Router 1 consistently demonstrates lower RTT values compared to Router 2, while Router 3 exhibits considerable variability, including one unrecorded (*).

Estimation of Path Latency: This calculation determines the average RTT across different hops. For Run 1, the path shows a gradual increase in RTT values, suggesting a potential rise in latency as packets traverse through the routers.

Assessment of Network Performance: This analysis identifies the maximum RTT observed at each hop. In this case, Hop 3 displays a notably higher maximum RTT in comparison to Hops 1 and 2, indicating potential areas of congestion or latency concerns.

Identification of Bottlenecks: This metric assesses the mean RTT values, revealing that while most RTT values fall within reasonable ranges, Hop 3 exhibits a comparatively higher mean RTT. This suggests a potential bottleneck or area of concern within the path.

```
RTT Values for Run 1 is [[0.654, 0.523, 0.299], [2.466, 2.197, 2.154], [36.95, '*', 59.967]]
```

Router Latency Assessment:

```
Router 1: RTT values - [0.654, 0.523, 0.299]
Router 2: RTT values - [2.466, 2.197, 2.154]
Router 3: RTT values - [36.95, '*', 59.967]
```

Path Latency Estimation:

```
Hop 1: Average RTT - 13.357
Hop 2: Average RTT - 1.360
Hop 3: Average RTT - 20.807
```

Network Performance Assessment:

```
Hop 1: Max RTT value - 0.654
Hop 2: Max RTT value - 2.466
Hop 3: Max RTT value - 59.967
```

Identifying Bottlenecks:

```
Hop 1: Mean RTT value - 0.492
Hop 2: Mean RTT value - 2.272
Hop 3: Mean RTT value - 48.459
```

Day2, Run2

Router Latency Assessment:

- Router 1 experiences relatively minimal RTT values, indicating lower latency.
- Router 2 demonstrates moderately elevated RTT values compared to Router 1, suggesting an increase in latency.
- Router 3 displays a combination of available RTT and an asterisk (*), potentially indicating an issue or measurement error.
- Router 4 exhibits fluctuating RTT values, hinting at variations in latency.

Path Latency Estimation:

- At Hop 1, there is an average RTT of 33.109, suggesting moderate latency.
- Hop 2 shows an average RTT of 20.772, indicating lower latency compared to Hop 1.
- Hop 3 exhibits an average RTT of 26.643, signifying a slight increase compared to Hop 2.

Network Performance Assessment:

- Hop 1 has a maximum RTT value of 0.625, representing the lowest observed latency in this run.
- Hop 2 shows a maximum RTT value of 3.187, indicating a moderate peak latency.
- Hop 3 records a maximum RTT value of 61.132, highlighting a higher peak latency compared to previous hops.
- Hop 4 demonstrates a maximum RTT value of 90.398, showing the highest observed latency in this run.

Identifying Bottlenecks:

- Hop 1 displays a mean RTT value of 0.446, indicating low to moderate average latency.
- Hop 2 has a mean RTT value of 2.820, suggesting a moderate increase in average latency compared to Hop 1.
- Hop 3 shows a mean RTT value of 49.727, signifying a significant rise in average latency compared to previous hops.
- Hop 4 records a mean RTT value of 64.024, representing the highest average latency observed in this run, potentially pointing to a bottleneck.

```
RTT Values for Run 2 is [[0.625, 0.308, 0.406], [3.093, 3.187, 2.18], [38.322, '*', 61.132], [90.398, 58.82, 42.855]]
```

```
Router Latency Assessment:
```

```
Router 1: RTT values - [0.625, 0.308, 0.406]
Router 2: RTT values - [3.093, 3.187, 2.18]
Router 3: RTT values - [38.322, '*', 61.132]
Router 4: RTT values - [90.398, 58.82, 42.855]
```

```
Path Latency Estimation:
```

```
Hop 1: Average RTT - 33.109
Hop 2: Average RTT - 20.772
Hop 3: Average RTT - 26.643
```

```
Network Performance Assessment:
```

```
Hop 1: Max RTT value - 0.625
Hop 2: Max RTT value - 3.187
Hop 3: Max RTT value - 61.132
Hop 4: Max RTT value - 90.398
```

```
Identifying Bottlenecks:
```

```
Hop 1: Mean RTT value - 0.446
Hop 2: Mean RTT value - 2.820
Hop 3: Mean RTT value - 49.727
Hop 4: Mean RTT value - 64.024
```

Day2, Run3

```
RTT Values for Run 3 is [[0.592, 0.436, 0.492], [4.064, 2.821, 2.316], [43.97, '*', 355.724]]  
Router Latency Assessment:  
Router 1: RTT values - [0.592, 0.436, 0.492]  
Router 2: RTT values - [4.064, 2.821, 2.316]  
Router 3: RTT values - [43.97, '*', 355.724]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 16.209  
Hop 2: Average RTT - 1.629  
Hop 3: Average RTT - 119.511  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.592  
Hop 2: Max RTT value - 4.064  
Hop 3: Max RTT value - 355.724  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.507  
Hop 2: Mean RTT value - 3.067  
Hop 3: Mean RTT value - 199.847
```

Day2, Run4

```
RTT Values for Run 4 is [[0.657, 0.435, 0.534], [2.749, 2.398, 2.288], [43.124, '*', '*']]  
Router Latency Assessment:  
Router 1: RTT values - [0.657, 0.435, 0.534]  
Router 2: RTT values - [2.749, 2.398, 2.288]  
Router 3: RTT values - [43.124, '*', '*']  
  
Path Latency Estimation:  
Hop 1: Average RTT - 15.510  
Hop 2: Average RTT - 1.417  
Hop 3: Average RTT - 1.411  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.657  
Hop 2: Max RTT value - 2.749  
Hop 3: Max RTT value - 43.124  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.542  
Hop 2: Mean RTT value - 2.478  
Hop 3: Mean RTT value - 43.124
```

Day2, Run5

```
RTT Values for Run 5 is [[0.752, 0.293, 0.149], [5.56, 18.651, 7.756], [38.748, '*', 40.224]]  
Router Latency Assessment:  
Router 1: RTT values - [0.752, 0.293, 0.149]  
Router 2: RTT values - [5.56, 18.651, 7.756]  
Router 3: RTT values - [38.748, '*', 40.224]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 15.020  
Hop 2: Average RTT - 9.472  
Hop 3: Average RTT - 16.043  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.752  
Hop 2: Max RTT value - 18.651  
Hop 3: Max RTT value - 40.224  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.398  
Hop 2: Mean RTT value - 10.656  
Hop 3: Mean RTT value - 39.486
```

Day2, Run6

```
RTT Values for Run 6 is [[0.183, 0.099, 0.114], [1.708, 1.949, 1.639], [60.412, '*', 55.778]]  
Router Latency Assessment:  
Router 1: RTT values - [0.183, 0.099, 0.114]  
Router 2: RTT values - [1.708, 1.949, 1.639]  
Router 3: RTT values - [60.412, '*', 55.778]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 20.768  
Hop 2: Average RTT - 1.024  
Hop 3: Average RTT - 19.177  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.183  
Hop 2: Max RTT value - 1.949  
Hop 3: Max RTT value - 60.412  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.132  
Hop 2: Mean RTT value - 1.765  
Hop 3: Mean RTT value - 58.095
```

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 2, for 3 out of 6 runs are following the AS number 7012 and AS route ATT-INTERNET4, US.

Day3: November 26th November

Path Similarity:

Path similarity gauges the consistency of traceroute paths to the same destination over different runs and days.

```
Run 0 and Run 1 are the same : ['172.31.160.1', '172.20.10.1', '107.243.50.136']
Run 0 and Run 2 are the same : ['172.31.160.1', '172.20.10.1', '107.243.50.136']
Run 0 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.50.136']
Run 1 and Run 2 are the same : ['172.31.160.1', '172.20.10.1', '107.243.50.136']
Run 1 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.50.136']
Run 2 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.50.136']
Run 4 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.50.8']
```

The Amazon IP routes on November 26 are outlined as follows:

```
['172.31.160.1', '172.20.10.1', '107.243.50.136']
['172.31.160.1', '172.20.10.1', '107.243.50.136']
['172.31.160.1', '172.20.10.1', '107.243.50.136']
['172.31.160.1', '172.20.10.1', '107.243.50.136']
['172.31.160.1', '172.20.10.1', '107.243.50.8']
['172.31.160.1', '172.20.10.1', '107.243.50.8']
```

1. Diversity in Paths: There is a noticeable deviation in the route taken during the last two measurements, suggesting the existence of alternative paths or potential differences in routing.

2. Path Stability Index: Despite a high degree of similarity in the majority of measurements, the path stability appears robust. However, the deviation observed in the last two measurements may imply lower stability during those instances.

3. Consistency in Paths: The IP-level paths in most measurements exhibit a high level of consistency, underscoring reliability and uniformity across various test runs.

4. Path Constancy: With the exception of the last two measurements, the paths consistently maintain their structure, indicating minimal changes in the sequence of routers traversed. This departure may signify periods of network volatility or alterations in routing during those specific measurements.

5. AS-Level Path Uniformity: The AS-level path remains unchanged in the majority of measurements, emphasizing consistency in AS-level routing. However, during the last two measurements, there is an indication of a shift in AS, suggesting a modification in the autonomous system configuration.

['172.31.160.1', '172.20.10.1', '107.243.50.136'] is the dominant path.

Analysis of Round-Trip Time (RTT) at the Router Level

Analysis of Router-Level IP Routes using RTT:

Utilizing RTT for Initial Three Packets:

1. Router Latency Assessment: The RTT analysis of the initial three packets allows for an estimation of the latency to each router along the path. Elevated RTT may indicate congestion or issues at specific routers.

2. Path Latency Estimation: Comparing RTT values for the first three packets across various runs or destinations aids in estimating the overall latency for each hop. Consistent higher RTT across runs suggests latency in that specific segment of the network.

3. Network Performance Assessment: Sudden variations or high RTT values for the first three packets in subsequent runs may indicate fluctuations in network performance or changes in the path taken by packets.

4. Identifying Bottlenecks: The RTT analysis for the initial packets helps identify potential network bottlenecks or slow segments along the route."

The outputs for each of the runs are as follows:

Day 3, Run 1(26th November)

Router Latency Assessment:

Router 1: RTT values - [0.362, 0.118, 0.095]

Router 2: RTT values - [2.614, 2.433, 2.5]

Router 3: RTT values - [30.178, '*', 22.758]

Observations:

Router 1 has relatively low and consistent RTT values.

Router 2 has moderate RTT values with some variation.

Router 3 shows a high RTT value of 30.178 in the first run, an undefined value ('*') in the second, and a lower RTT of 22.758 in the third run.

Path Latency Estimation:

Hop 1 (Router 1 to Router 2): Average RTT - 11.051

Hop 2 (Router 2 to Router 3): Average RTT - 1.275

Hop 3 (Router 3 to Destination): Average RTT - 8.451

Observations:

The highest average RTT is observed in Hop 1, indicating a potential latency issue between Router 1 and Router 2.

Network Performance Assessment:

Hop 1 (Router 1 to Router 2): Max RTT value - 0.362

Hop 2 (Router 2 to Router 3): Max RTT value - 2.614

Hop 3 (Router 3 to Destination): Max RTT value - 30.178

Observations:

The maximum RTT value is significantly higher in Hop 3, suggesting a potential bottleneck or issue in that segment of the network.

Identifying Bottlenecks:

Hop 1 (Router 1 to Router 2): Mean RTT value - 0.192

Hop 2 (Router 2 to Router 3): Mean RTT value - 2.516

Hop 3 (Router 3 to Destination): Mean RTT value - 26.468

Observations:

The mean RTT values align with the average RTT observations, indicating that the bottleneck might be in Hop 1 and Hop 3.

```
RTT Values for Run 1 is [[0.362, 0.118, 0.095], [2.614, 2.433, 2.5], [30.178, '*', 22.758]]
```

Router Latency Assessment:

Router 1: RTT values - [0.362, 0.118, 0.095]

Router 2: RTT values - [2.614, 2.433, 2.5]

Router 3: RTT values - [30.178, '*', 22.758]

Path Latency Estimation:

Hop 1: Average RTT - 11.051

Hop 2: Average RTT - 1.275

Hop 3: Average RTT - 8.451

Network Performance Assessment:

Hop 1: Max RTT value - 0.362

Hop 2: Max RTT value - 2.614

Hop 3: Max RTT value - 30.178

Identifying Bottlenecks:

Hop 1: Mean RTT value - 0.192

Hop 2: Mean RTT value - 2.516

Hop 3: Mean RTT value - 26.468

Day3, Run2

Router Latency Assessment:

Router 1: RTT values - [0.544, 0.514, 0.279]

Router 2: RTT values - [2.268, 2.286, 2.02]

Router 3: RTT values - [37.68, '*', 42.038]

Observations:

Router 1 and Router 2 display relatively consistent RTT values.

Router 3 continues to exhibit high RTT values, similar to those observed in Run 1.

Path Latency Estimation:

Hop 1 (Router 1 to Router 2): Average RTT - 13.497

Hop 2 (Router 2 to Router 3): Average RTT - 1.400

Hop 3 (Router 3 to Destination): Average RTT - 14.779

Observations:

The average RTT values remain high, especially in Hop 1 and Hop 3, indicating persistent latency issues.

Network Performance Assessment:

Hop 1 (Router 1 to Router 2): Max RTT value - 0.544

Hop 2 (Router 2 to Router 3): Max RTT value - 2.286

Hop 3 (Router 3 to Destination): Max RTT value - 42.038

Observations:

The maximum RTT value in Hop 3 remains significantly high, confirming the consistency of a potential bottleneck in this segment.

Identifying Bottlenecks:

Hop 1 (Router 1 to Router 2): Mean RTT value - 0.446

Hop 2 (Router 2 to Router 3): Mean RTT value - 2.191

Hop 3 (Router 3 to Destination): Mean RTT value - 39.859

```
RTT Values for Run 2 is [[0.544, 0.514, 0.279], [2.268, 2.286, 2.02], [37.68, '*', 42.038]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.544, 0.514, 0.279]  
Router 2: RTT values - [2.268, 2.286, 2.02]  
Router 3: RTT values - [37.68, '*', 42.038]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 13.497  
Hop 2: Average RTT - 1.400  
Hop 3: Average RTT - 14.779  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.544  
Hop 2: Max RTT value - 2.286  
Hop 3: Max RTT value - 42.038  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.446  
Hop 2: Mean RTT value - 2.191  
Hop 3: Mean RTT value - 39.859
```

Day3, Run3

Router Latency Assessment:

Router 1: RTT values - [0.718, 0.69, 0.526]

Router 2: RTT values - [2.783, 2.212, 2.16]

Router 3: RTT values - [31.153, '*', 50.674]

Observations:

Router 1 shows relatively consistent and moderate RTT values.

Router 2 continues to display moderate RTT values with some variability.

Router 3 exhibits persistently high RTT values similar to previous runs.

Path Latency Estimation:

Hop 1 (Router 1 to Router 2): Average RTT - 11.551

Hop 2 (Router 2 to Router 3): Average RTT - 1.451

Hop 3 (Router 3 to Destination): Average RTT - 17.787

Observations:

The average RTT values in Hop 1 and Hop 3 remain consistently high, indicating ongoing latency issues.

Network Performance Assessment:

Hop 1 (Router 1 to Router 2): Max RTT value - 0.718

Hop 2 (Router 2 to Router 3): Max RTT value - 2.783

Hop 3 (Router 3 to Destination): Max RTT value - 50.674

Observations:

The maximum RTT value in Hop 3 remains significantly high, confirming the persisting bottleneck in this segment.

Identifying Bottlenecks:

Hop 1 (Router 1 to Router 2): Mean RTT value - 0.645

Hop 2 (Router 2 to Router 3): Mean RTT value - 2.385

Hop 3 (Router 3 to Destination): Mean RTT value - 40.913

```
RTT Values for Run 3 is [[0.718, 0.69, 0.526], [2.783, 2.212, 2.16], [31.153, '*', 50.674]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.718, 0.69, 0.526]  
Router 2: RTT values - [2.783, 2.212, 2.16]  
Router 3: RTT values - [31.153, '*', 50.674]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 11.551  
Hop 2: Average RTT - 1.451  
Hop 3: Average RTT - 17.787  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.718  
Hop 2: Max RTT value - 2.783  
Hop 3: Max RTT value - 50.674  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.645  
Hop 2: Mean RTT value - 2.385  
Hop 3: Mean RTT value - 40.913
```

Day3, Run4

Router Latency Assessment:

Router 1: RTT values - [0.731, 0.484, 0.552]

Router 2: RTT values - [2.573, 2.19, 2.472]

Router 3: RTT values - [38.399, '*', 51.98]

Observations:

Router 1 continues to display relatively consistent RTT values.

Router 2 also maintains moderate RTT values with some variability.

Router 3 persists in showing high RTT values similar to previous runs.

Path Latency Estimation:

Hop 1 (Router 1 to Router 2): Average RTT - 13.901

Hop 2 (Router 2 to Router 3): Average RTT - 1.337

Hop 3 (Router 3 to Destination): Average RTT - 18.335

Observations:

The average RTT values in Hop 1 and Hop 3 remain consistently high, indicating ongoing latency issues.

Network Performance Assessment:

Hop 1 (Router 1 to Router 2): Max RTT value - 0.731

Hop 2 (Router 2 to Router 3): Max RTT value - 2.573

Hop 3 (Router 3 to Destination): Max RTT value - 51.98

Observations:

The maximum RTT value in Hop 3 remains significantly high, confirming the persisting bottleneck in this segment.

Identifying Bottlenecks:

Hop 1 (Router 1 to Router 2): Mean RTT value - 0.589

Hop 2 (Router 2 to Router 3): Mean RTT value - 2.412

Hop 3 (Router 3 to Destination): Mean RTT value - 45.189

```
RTT Values for Run 4 is [[0.731, 0.484, 0.552], [2.573, 2.19, 2.472], [38.399, '*', 51.98]]
```

Router Latency Assessment:

Router 1: RTT values - [0.731, 0.484, 0.552]

Router 2: RTT values - [2.573, 2.19, 2.472]

Router 3: RTT values - [38.399, '*', 51.98]

Path Latency Estimation:

Hop 1: Average RTT - 13.901

Hop 2: Average RTT - 1.337

Hop 3: Average RTT - 18.335

Network Performance Assessment:

Hop 1: Max RTT value - 0.731

Hop 2: Max RTT value - 2.573

Hop 3: Max RTT value - 51.98

Identifying Bottlenecks:

Hop 1: Mean RTT value - 0.589

Hop 2: Mean RTT value - 2.412

Hop 3: Mean RTT value - 45.189

Day3, Run5

Router Latency Assessment:

Router 1: RTT values - [0.445, 0.544, 0.291]

Router 2: RTT values - [2.311, 2.146, 2.091]

Router 3: RTT values - [26.294, '*', 44.019]

Observations:

Router 1 maintains relatively consistent RTT values.

Router 2 also shows moderate RTT values with some variation.

Router 3 continues to exhibit high RTT values similar to previous runs.

Path Latency Estimation:

Hop 1 (Router 1 to Router 2): Average RTT - 9.683

Hop 2 (Router 2 to Router 3): Average RTT - 1.345

Hop 3 (Router 3 to Destination): Average RTT - 15.467

Observations:

The average RTT values in Hop 1 and Hop 3 remain relatively high, indicating ongoing latency issues.

Network Performance Assessment:

Hop 1 (Router 1 to Router 2): Max RTT value - 0.544

Hop 2 (Router 2 to Router 3): Max RTT value - 2.311

Hop 3 (Router 3 to Destination): Max RTT value - 44.019

Observations:

The maximum RTT value in Hop 3 remains significantly high, confirming the persisting bottleneck in this segment.

Identifying Bottlenecks:

Hop 1 (Router 1 to Router 2): Mean RTT value - 0.427

Hop 2 (Router 2 to Router 3): Mean RTT value - 2.183

Hop 3 (Router 3 to Destination): Mean RTT value - 35.157

```
RTT Values for Run 5 is [[0.445, 0.544, 0.291], [2.311, 2.146, 2.091], [26.294, '*', 44.019]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.445, 0.544, 0.291]  
Router 2: RTT values - [2.311, 2.146, 2.091]  
Router 3: RTT values - [26.294, '*', 44.019]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 9.683  
Hop 2: Average RTT - 1.345  
Hop 3: Average RTT - 15.467  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.544  
Hop 2: Max RTT value - 2.311  
Hop 3: Max RTT value - 44.019  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.427  
Hop 2: Mean RTT value - 2.183  
Hop 3: Mean RTT value - 35.157
```

Day3, Run6

Router Latency Assessment:

Router 1: RTT values - [0.672, 0.536, 0.276]

Router 2: RTT values - [2.768, 2.13, 2.151]

Router 3: RTT values - [38.828, "", ""]

Observations:

Router 1 maintains moderate and consistent RTT values.

Router 2 shows moderate RTT values with some variation.

Router 3 continues to display high RTT values, denoted by '*' indicating missing data.

Path Latency Estimation:

Hop 1 (Router 1 to Router 2): Average RTT - 14.089

Hop 2 (Router 2 to Router 3): Average RTT - 1.333

Hop 3 (Router 3 to Destination): Average RTT - 1.213

Observations:

Interestingly, the average RTT values for Hop 2 and Hop 3 have decreased significantly compared to previous runs, indicating potential improvement or variation in the network conditions.

Network Performance Assessment:

Hop 1 (Router 1 to Router 2): Max RTT value - 0.672

Hop 2 (Router 2 to Router 3): Max RTT value - 2.768

Hop 3 (Router 3 to Destination): Max RTT value - 38.828

Observations:

The maximum RTT values still show high latency in Hop 3, consistent with previous observations.

Identifying Bottlenecks:

Hop 1 (Router 1 to Router 2): Mean RTT value - 0.495

Hop 2 (Router 2 to Router 3): Mean RTT value - 2.350

Hop 3 (Router 3 to Destination): Mean RTT value - 38.828

```
RTT Values for Run 6 is [[0.672, 0.536, 0.276], [2.768, 2.13, 2.151], [38.828, '*', '*']]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.672, 0.536, 0.276]  
Router 2: RTT values - [2.768, 2.13, 2.151]  
Router 3: RTT values - [38.828, '*', '*']  
  
Path Latency Estimation:  
Hop 1: Average RTT - 14.089  
Hop 2: Average RTT - 1.333  
Hop 3: Average RTT - 1.213  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.672  
Hop 2: Max RTT value - 2.768  
Hop 3: Max RTT value - 38.828  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.495  
Hop 2: Mean RTT value - 2.350  
Hop 3: Mean RTT value - 38.828
```

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 3, for 5 out of 6 runs are following the AS number 7018 and AS route ATT-INTERNET4, US.

Day4

Router level IP Path analysis:

Below are the IP paths for 6 different runs throughout the day on 27th nov:

Run 0 and Run 1 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.141']

Run 0 and Run 4 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.141']

Run 0 and Run 5 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.141']

Run 1 and Run 4 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.141']

Run 1 and Run 5 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.141']

Run 2 and Run 3 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.13']

Run 4 and Run 5 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.141']

There are two groups of IP paths:

- 0, 1, 4, 5 measurement follow the same IP level path - ['172.21.64.1', '172.20.10.1', '107.243.50.141']
- 2 measurement and 3 measurement follow the same IP level path - ['172.21.64.1', '172.20.10.1', '107.243.50.13']

Analysis of Metrics on Day 4:

1. Diversity in Paths:

- Two distinct paths highlight variations in routing approaches.
- Group 1 consistently adheres to the same IP-level path, suggesting possible redundancy or stable routing in those measurements.
- Group 2, on the other hand, takes an alternative path, indicating potential differences in routing or strategies for network optimization.

2. Path Stability Index:

- Group 1's consistent paths in runs 0, 1, 4, and 5 indicate a stable route.
- Runs 2 and 3 within Group 1 show a divergence, suggesting less stability or predictability in routing for those specific measurements.

3. Path Similarity:

- Runs within each group display high similarity in their IP-level paths, signifying consistent routing behaviors across those specific measurements.

4. Path Changes:

- A substantial alteration in routing paths is observed when comparing Group 1 and Group 2

- This change indicates potential network volatility, different routing strategies, or optimizations between these sets of measurements.

```
Run 0 and Run 1 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.141']
Run 0 and Run 4 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.141']
Run 0 and Run 5 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.141']
Run 1 and Run 4 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.141']
Run 1 and Run 5 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.141']
Run 2 and Run 3 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.13']
Run 4 and Run 5 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.141']
```

The Amazon IP routes on November 27 are outlined as follows:

```
['172.21.64.1', '172.20.10.1', '107.243.50.141']
['172.21.64.1', '172.20.10.1', '107.243.50.141']
['172.21.64.1', '172.20.10.1', '107.243.50.13']
['172.21.64.1', '172.20.10.1', '107.243.50.13']
['172.21.64.1', '172.20.10.1', '107.243.50.141']
['172.21.64.1', '172.20.10.1', '107.243.50.141']
```

Frequency of Path Changes:

- Group 1 follows the IP-level path: ['172.21.64.1', '172.20.10.1', '107.243.50.141'] in runs 0, 1, 4, and 5.
- Group 2 follows the IP-level path: ['172.21.64.1', '172.20.10.1', '107.243.50.13'] in runs 2 and 3.
- Path changes occur when measurements transition between groups.

Observing the data:

- Run 0 and Run 2 are in different groups; Run 1 and Run 3 are in different groups; Run 4 and Run 5 are in the same group.
- Paths change in 4 out of 6 measurements on November 24th, indicating an approximate path change frequency of 66.67% (4 out of 6 measurements).

Day 4 ,Run1

```
RTT Values for Run 1 is [[0.472, 0.39, 0.353], [6.112, 1.963, 2.397], [26.928, '*', 57.196]]

Router Latency Assessment:
Router 1: RTT values - [0.472, 0.39, 0.353]
Router 2: RTT values - [6.112, 1.963, 2.397]
Router 3: RTT values - [26.928, '*', 57.196]

Path Latency Estimation:
Hop 1: Average RTT - 11.171
Hop 2: Average RTT - 1.177
Hop 3: Average RTT - 19.982

Network Performance Assessment:
Hop 1: Max RTT value - 0.472
Hop 2: Max RTT value - 6.112
Hop 3: Max RTT value - 57.196

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.405
Hop 2: Mean RTT value - 3.491
Hop 3: Mean RTT value - 42.062
```

Summary:

The RTT values for Run 1 show significant variations across the routers:

- **Router Latency Assessment:** Router 1 has relatively low RTT values, while Router 2 displays a significant increase, and Router 3 shows a substantial spike in RTT.
- **Path Latency Estimation:** The average RTT across the hops demonstrates a similar trend, with an increase at Hop 2 and a substantial spike at Hop 3 compared to the initial hop.
- **Network Performance Assessment:** The maximum RTT values follow the same pattern, indicating the highest values at each subsequent hop.
- **Identifying Bottlenecks:** The mean RTT values show a consistent increase from Hop 1 to Hop 3, signifying a potential bottleneck at the third hop due to significantly higher mean RTT.

Day 4 Run 2:

```
RTT Values for Run 2 is [[0.18, 0.149, 0.112], [3.086, 2.387, 2.69], ['*', 69.94, '*']]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.18, 0.149, 0.112]  
Router 2: RTT values - [3.086, 2.387, 2.69]  
Router 3: RTT values - ['*', 69.94, '*']  
  
Path Latency Estimation:  
Hop 1: Average RTT - 1.633  
Hop 2: Average RTT - 24.159  
Hop 3: Average RTT - 1.401  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.18  
Hop 2: Max RTT value - 3.086  
Hop 3: Max RTT value - 69.94  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.147  
Hop 2: Mean RTT value - 2.721  
Hop 3: Mean RTT value - 69.940
```

Summary:

In Run 2, the RTT values provide insights into the network performance:

- **Router Latency Assessment:** Router 1 and Router 2 showcase relatively consistent and low RTT values across their measurements. However, Router 3 displays a concerning increase, with two instances of extremely high RTT values represented as '*'.
- **Path Latency Estimation:** The average RTT across the hops indicates a minor increase at Hop 2, a relatively consistent pattern in the initial and final hops, but a massive spike in RTT at Hop 3 due to the extremely high '*' value.
- **Network Performance Assessment:** The maximum RTT values reinforce this pattern, with a significant spike at Hop 3.

- **Identifying Bottlenecks:** The mean RTT values are consistent with the pattern observed earlier, with Hop 3's mean RTT being dominated by the extremely high '*' value, indicating a severe bottleneck or loss of connectivity at that hop.
- This run reveals a significant anomaly at Hop 3, marked by extremely high RTT values represented by '*'. This anomaly could signify a severe issue in connectivity or performance at that specific hop.

Day 4 Run 3

```
RTT Values for Run 3 is [[0.401, 0.149, 0.164], [3.8, 3.754, 3.207], [37.846, '*', 66.593]]

Router Latency Assessment:
Router 1: RTT values - [0.401, 0.149, 0.164]
Router 2: RTT values - [3.8, 3.754, 3.207]
Router 3: RTT values - [37.846, '*', 66.593]

Path Latency Estimation:
Hop 1: Average RTT - 14.016
Hop 2: Average RTT - 1.952
Hop 3: Average RTT - 23.321

Network Performance Assessment:
Hop 1: Max RTT value - 0.401
Hop 2: Max RTT value - 3.8
Hop 3: Max RTT value - 66.593

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.238
Hop 2: Mean RTT value - 3.587
Hop 3: Mean RTT value - 52.219
```

In Run 3, the RTT values depict the following network performance:

- **Router Latency Assessment:** Router 1 and Router 2 show relatively consistent RTT values within expected ranges. However, Router 3 displays an extremely high RTT marked by '*'.
- **Path Latency Estimation:** The average RTT across the hops demonstrates an increase at Hop 2 and a substantial spike at Hop 3, corresponding with the extremely high '*' value.
- **Network Performance Assessment:** The maximum RTT values confirm the trends observed in the average RTT, with a significant spike at Hop 3 marked by the high '*' value.
- **Identifying Bottlenecks:** The mean RTT values follow the pattern, showing a steep increase at Hop 3 due to the extremely high RTT value represented by '*'. This indicates a severe bottleneck or connectivity issue at that hop.

Day 4 Run 4:

```

RTT Values for Run 4 is [[0.343, 0.283, 0.185], [2.378, 2.684, 2.32], [31.803,
 '*', 54.593]]

Router Latency Assessment:
Router 1: RTT values - [0.343, 0.283, 0.185]
Router 2: RTT values - [2.378, 2.684, 2.32]
Router 3: RTT values - [31.803, '*', 54.593]

Path Latency Estimation:
Hop 1: Average RTT - 11.508
Hop 2: Average RTT - 1.484
Hop 3: Average RTT - 19.033

Network Performance Assessment:
Hop 1: Max RTT value - 0.343
Hop 2: Max RTT value - 2.684
Hop 3: Max RTT value - 54.593

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.270
Hop 2: Mean RTT value - 2.461
Hop 3: Mean RTT value - 43.198

```

In Run 4, the RTT analysis reveals:

- **Router Latency Assessment:** Router 1 shows consistent and relatively low RTT values. Router 2 maintains consistency but with a slightly higher range of RTT values. Router 3 indicates a significant increase in RTT values, notably with a '*' entry, denoting a potentially critical connectivity issue.
- **Path Latency Estimation:** The average RTT across the hops gradually increases, with Hop 3 showing the highest RTT.
- **Network Performance Assessment:** The maximum RTT values confirm the trends observed in the average RTT, with the highest value recorded at Hop 3, indicating a potential bottleneck.
- **Identifying Bottlenecks:** The mean RTT values increase significantly at Hop 3, further emphasizing the potential bottleneck or connectivity issue at that point in the network.

Day 4 Run 5:

```

RTT Values for Run 5 is [[0.172, 0.107, 0.155], [2.441, 7.874, 2.417], [28.501,
 '*', 72.325]]

Router Latency Assessment:
Router 1: RTT values - [0.172, 0.107, 0.155]
Router 2: RTT values - [2.441, 7.874, 2.417]
Router 3: RTT values - [28.501, '*', 72.325]

Path Latency Estimation:
Hop 1: Average RTT - 10.371
Hop 2: Average RTT - 3.990
Hop 3: Average RTT - 24.966

Network Performance Assessment:
Hop 1: Max RTT value - 0.172
Hop 2: Max RTT value - 7.874
Hop 3: Max RTT value - 72.325

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.145
Hop 2: Mean RTT value - 4.244
Hop 3: Mean RTT value - 50.413

```

- **Router Latency Assessment:** For Router 1, the RTT values remain relatively consistent. Router 2 displays variations, especially in Run 5, where the second

measurement shows a significantly higher RTT. Router 3 exhibits a substantial increase in RTT in both runs, with '*' denoting potential issues in connectivity.

- **Path Latency Estimation:** Both runs indicate an increase in average RTT as the path progresses. Run 5 records higher average RTT values across all hops compared to Run 6.
- **Network Performance Assessment:** The maximum RTT values confirm the trends observed in the average RTT, with Run 5 indicating higher spikes in RTT at Hop 2 and Hop 3.
- **Identifying Bottlenecks:** The mean RTT values are notably higher in Run 5 across all hops, indicating a potential bottleneck, especially in Run 5 at Hop 2 and Hop 3.

Day 4 Run 6:

```
RTT Values for Run 6 is [[0.393, 0.209, 0.163], [2.64, 2.823, 3.005], [30.264, '*', 60.075]]
```

```
Router Latency Assessment:
```

```
Router 1: RTT values - [0.393, 0.209, 0.163]
```

```
Router 2: RTT values - [2.64, 2.823, 3.005]
```

```
Router 3: RTT values - [30.264, '*', 60.075]
```

```
Path Latency Estimation:
```

```
Hop 1: Average RTT - 11.099
```

```
Hop 2: Average RTT - 1.516
```

```
Hop 3: Average RTT - 21.081
```

```
Network Performance Assessment:
```

```
Hop 1: Max RTT value - 0.393
```

```
Hop 2: Max RTT value - 3.005
```

```
Hop 3: Max RTT value - 60.075
```

```
Identifying Bottlenecks:
```

```
Hop 1: Mean RTT value - 0.255
```

```
Hop 2: Mean RTT value - 2.823
```

```
Hop 3: Mean RTT value - 45.169
```

In Run 6:

- **Router Latency Assessment:** Router 1's RTT values remain consistent. Router 2 shows an increase in RTT from the first to the last measurement, while Router 3 demonstrates a substantial increase in RTT, with '*' denoting potential issues in connectivity for the second measurement.
- **Path Latency Estimation:** The average RTT increases progressively along the path, with each hop experiencing a rise in latency compared to the previous one.
- **Network Performance Assessment:** Maximum RTT values show a similar trend, escalating as the traceroute progresses through the hops.
- **Identifying Bottlenecks:** Mean RTT values highlight a considerable rise in latency at Hop 2 and Hop 3, indicating potential bottlenecks or network issues at these points.

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 4, for 4 out of 6 runs are following the AS number 7018 and AS route ATT-INTERNET4, US.

Day 5:

Router level IP Path analysis:

Below are the IP paths for 6 different runs throughout the day on 28th nov:

1. ['172.21.64.1', '172.20.10.1', '107.243.2.135', '12.127.81.202']
2. ['172.21.64.1', '172.20.10.1', '107.243.2.7']
3. ['172.21.64.1', '172.20.10.1', '107.243.2.135']
4. ['172.21.64.1', '172.20.10.1', '107.243.2.7']
5. ['172.21.64.1', '172.20.10.1', '107.243.2.7']
6. ['172.21.64.1', '172.20.10.1', '107.243.2.135']

There are three groups of IP paths:

- 0th measurement follows ['172.21.64.1', '172.20.10.1', '107.243.2.135', '12.127.81.202']
- 1, 3, 4 measurement follow the same IP level path - ['172.21.64.1', '172.20.10.1', '107.243.2.7']
- 2 measurement and 5 measurement follow the same IP level path - ['172.21.64.1', '172.20.10.1', '107.243.2.135']

There are 3 unique paths observed:

- ['172.21.64.1', '172.20.10.1', '107.243.2.7']
- ['172.21.64.1', '172.20.10.1', '107.243.2.135']
- ['172.21.64.1', '172.20.10.1', '107.243.2.135', '12.127.81.202']

The measurements show consistency in paths:

Run 1 and Run 3 are the same : ['172.21.64.1', '172.20.10.1', '107.243.2.7']

Run 1 and Run 4 are the same : ['172.21.64.1', '172.20.10.1', '107.243.2.7']

Run 2 and Run 5 are the same : ['172.21.64.1', '172.20.10.1', '107.243.2.135']

Run 3 and Run 4 are the same : ['172.21.64.1', '172.20.10.1', '107.243.2.7']

The paths demonstrate variations across measurements but reveal a degree of consistency within specific pairs of measurements.

Dominant path is ['172.21.64.1', '172.20.10.1', '107.243.2.7']

- Path 1: ['172.21.64.1', '172.20.10.1', '107.243.2.7']
- Path 2: ['172.21.64.1', '172.20.10.1', '107.243.2.135']
- Path 3: ['172.21.64.1', '172.20.10.1', '107.243.2.135', '12.127.81.202']

Occurrences:

- -Path 1 occurs 3 times (Measurements 1, 3, and 4).
- Path 2 occurs 2 times (Measurements 2 and 5).
- Path 3 occurs 1 time (0th measurement).

Percentage Calculation:

- Path 1: $\frac{3}{6} * 100\% = 50\%$
- Path 2: $\frac{2}{6} * 100\% = 33.33\%$
- Path 3: $\frac{1}{6} * 100\% = 16.67\%$

Therefore, the dominant path is Path 1 (['172.21.64.1', '172.20.10.1', '107.243.2.7']) with 50% occurrence in the observed measurements. Path 2 comes next at 33.33%, and Path 3 has the least occurrence at 16.67%.

Router level IP routes RTT analysis: Delay and Latency metrics

Day5,Run1

```
RTT Values for Run 1 is [[0.277, 0.328, 0.194], [2.305, 3.301, 2.127], [39.267, '*', 70.73], [75.45, 37.088, 38.918]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.277, 0.328, 0.194]  
Router 2: RTT values - [2.305, 3.301, 2.127]  
Router 3: RTT values - [39.267, '*', 70.73]  
Router 4: RTT values - [75.45, 37.088, 38.918]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 29.325  
Hop 2: Average RTT - 13.572  
Hop 3: Average RTT - 27.992  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.328  
Hop 2: Max RTT value - 3.301  
Hop 3: Max RTT value - 70.73  
Hop 4: Max RTT value - 75.45  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.266  
Hop 2: Mean RTT value - 2.578  
Hop 3: Mean RTT value - 54.999  
Hon 4: Mean RTT value - 50.485
```

Summary:

Router Latency Assessment

Router 1: RTT values - [0.277, 0.328, 0.194]

Router 2: RTT values - [2.305, 3.301, 2.127]

Router 3: RTT values - [39.267, '*', 70.73]

Router 4: RTT values - [75.45, 37.088, 38.918]

Observations:

Router 1 shows consistent and relatively low RTT values.

Router 2 exhibits moderate RTT values with significant variability.

Router 3 and Router 4 display very high RTT values, with missing ('*') data in some cases for Router 3.

Path Latency Estimation:

Hop 1 (Router 1 to Router 2): Average RTT - 29.325

Hop 2 (Router 2 to Router 3): Average RTT - 13.572

Hop 3 (Router 3 to Router 4): Average RTT - 27.992

Observations:

The average RTT values for Hop 1 and Hop 3 are considerably high, indicating potential latency issues in these segments.

Network Performance Assessment:

Hop 1 (Router 1 to Router 2): Max RTT value - 0.328

Hop 2 (Router 2 to Router 3): Max RTT value - 3.301

Hop 3 (Router 3 to Router 4): Max RTT value - 70.73

Hop 4 (Router 4 to Destination): Max RTT value - 75.45

Observations:

The average RTT values for Hop 1 and Hop 3 are considerably high, indicating potential latency issues in these segments.

Network Performance Assessment:

Hop 1 (Router 1 to Router 2): Max RTT value - 0.328

Hop 2 (Router 2 to Router 3): Max RTT value - 3.301

Hop 3 (Router 3 to Router 4): Max RTT value - 70.73

Hop 4 (Router 4 to Destination): Max RTT value - 75.45

Observations:

The maximum RTT values in Hop 3 and Hop 4 are exceptionally high, indicating severe latency in these segments.

Identifying Bottlenecks:

Hop 1 (Router 1 to Router 2): Mean RTT value - 0.266

Hop 2 (Router 2 to Router 3): Mean RTT value - 2.578

Hop 3 (Router 3 to Router 4): Mean RTT value - 54.999

Hop 4 (Router 4 to Destination): Mean RTT value - 50.485

Day5, Run2

```
RTT Values for Run 2 is [[0.146, 0.163, 0.087], [3.848, 2.634, 3.961], [29.918, '*', 58.004]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.146, 0.163, 0.087]  
Router 2: RTT values - [3.848, 2.634, 3.961]  
Router 3: RTT values - [29.918, '*', 58.004]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 11.304  
Hop 2: Average RTT - 1.398  
Hop 3: Average RTT - 20.684  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.163  
Hop 2: Max RTT value - 3.961  
Hop 3: Max RTT value - 58.004  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.132  
Hop 2: Mean RTT value - 3.481  
Hop 3: Mean RTT value - 43.961
```

Router Latency Assessment

Router 1: RTT values - [0.146, 0.163, 0.087]

Router 2: RTT values - [3.848, 2.634, 3.961]

Router 3: RTT values - [29.918, '*', 58.004]

Observations:

Router 1 maintains consistently low RTT values.

Router 2 exhibits moderate RTT values with some variation.

Router 3 shows high RTT values with missing ('*') data for one measurement.

Path Latency Estimation:

Hop 1 (Router 1 to Router 2): Average RTT - 11.304

Hop 2 (Router 2 to Router 3): Average RTT - 1.398

Hop 3 (Router 3 to Destination): Average RTT - 20.684

Observations:

The average RTT values for Hop 1 and Hop 3 indicate moderate to high latency, especially in Hop 3.

Network Performance Assessment:

Hop 1 (Router 1 to Router 2): Max RTT value - 0.163

Hop 2 (Router 2 to Router 3): Max RTT value - 3.961

Hop 3 (Router 3 to Destination): Max RTT value - 58.004

Observations:

The maximum RTT values in Hop 2 and Hop 3 are considerably high, indicating potential bottlenecks or significant latency issues.

Identifying Bottlenecks:

Hop 1 (Router 1 to Router 2): Mean RTT value - 0.132

Hop 2 (Router 2 to Router 3): Mean RTT value - 3.481

Hop 3 (Router 3 to Destination): Mean RTT value - 43.961

Day 5 Run 3

```
RTT Values for Run 3 is [[0.235, 0.167, 0.212], [2.644, 2.887, 2.645], [30.122, '*', 67.326]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.235, 0.167, 0.212]  
Router 2: RTT values - [2.644, 2.887, 2.645]  
Router 3: RTT values - [30.122, '*', 67.326]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 11.000  
Hop 2: Average RTT - 1.527  
Hop 3: Average RTT - 23.394  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.235  
Hop 2: Max RTT value - 2.887  
Hop 3: Max RTT value - 67.326  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.205  
Hop 2: Mean RTT value - 2.725  
Hop 3: Mean RTT value - 48.724
```

Router Latency Assessment:

Router 1: RTT values - [0.235, 0.167, 0.212]

Router 2: RTT values - [2.644, 2.887, 2.645]

Router 3: RTT values - [30.122, '*', 67.326]

Observations:

Router 1 maintains relatively consistent and low RTT values.

Router 2 exhibits moderate RTT values with some variation.

Router 3 shows high RTT values with missing ('*') data for one measurement.

Path Latency Estimation:

Hop 1 (Router 1 to Router 2): Average RTT - 11.000

Hop 2 (Router 2 to Router 3): Average RTT - 1.527

Hop 3 (Router 3 to Destination): Average RTT - 23.394

Observations:

The average RTT values for Hop 1 and Hop 3 indicate moderate to high latency, especially in Hop 3.

Network Performance Assessment:

Hop 1 (Router 1 to Router 2): Max RTT value - 0.235

Hop 2 (Router 2 to Router 3): Max RTT value - 2.887

Hop 3 (Router 3 to Destination): Max RTT value - 67.326

Observations:

The maximum RTT values in Hop 2 and Hop 3 are considerably high, indicating potential bottlenecks or significant latency issues.

Identifying Bottlenecks:

Hop 1 (Router 1 to Router 2): Mean RTT value - 0.205

Hop 2 (Router 2 to Router 3): Mean RTT value - 2.725

Hop 3 (Router 3 to Destination): Mean RTT value - 48.724

Day 5 Run 4

```
RTT Values for Run 4 is [[0.642, 0.229, 0.174], [3.255, 3.134, 2.297], [30.922, '**', 32.324]]  
Router Latency Assessment:  
Router 1: RTT values - [0.642, 0.229, 0.174]  
Router 2: RTT values - [3.255, 3.134, 2.297]  
Router 3: RTT values - [30.922, '**', 32.324]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 11.606  
Hop 2: Average RTT - 1.681  
Hop 3: Average RTT - 11.598  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.642  
Hop 2: Max RTT value - 3.255  
Hop 3: Max RTT value - 32.324  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.348  
Hop 2: Mean RTT value - 2.895  
Hop 3: Mean RTT value - 31.623
```

Analyzing the RTT values for Run 4

Router Latency Assessment:

Router 1: RTT values - [0.642, 0.229, 0.174]

Router 2: RTT values - [3.255, 3.134, 2.297]

Router 3: RTT values - [30.922, '*', 32.324]

Observations:

Router 1 displays moderately consistent RTT values.

Router 2 exhibits moderate to high RTT values with some variability.

Router 3 shows high RTT values with missing ('*') data for one measurement.

Path Latency Estimation:

Hop 1 (Router 1 to Router 2): Average RTT - 11.606

Hop 2 (Router 2 to Router 3): Average RTT - 1.681

Hop 3 (Router 3 to Destination): Average RTT - 11.598

Observations:

The average RTT values for Hop 1 and Hop 3 are relatively consistent and within an expected range, whereas Hop 2 indicates moderate latency.

Network Performance Assessment:

Hop 1 (Router 1 to Router 2): Max RTT value - 0.642

Hop 2 (Router 2 to Router 3): Max RTT value - 3.255

Hop 3 (Router 3 to Destination): Max RTT value - 32.324

Observations:

The maximum RTT values in Hop 2 and Hop 3 are noticeably high, particularly in Hop 3, indicating potential bottlenecks or latency issues.

Identifying Bottlenecks:

Hop 1 (Router 1 to Router 2): Mean RTT value - 0.348

Hop 2 (Router 2 to Router 3): Mean RTT value - 2.895

Hop 3 (Router 3 to Destination): Mean RTT value - 31.623

Observations:

The mean RTT values for Hop 2 and Hop 3 confirm the presence of significant bottlenecks or high latency in these segments.

Day 5 Run 5

```
RTT Values for Run 5 is [[0.451, 0.353, 0.186], [2.307, 15.391, 6.49], [67.009, '*', 49.898]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.451, 0.353, 0.186]  
Router 2: RTT values - [2.307, 15.391, 6.49]  
Router 3: RTT values - [67.009, '*', 49.898]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 23.256  
Hop 2: Average RTT - 7.872  
Hop 3: Average RTT - 18.858  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.451  
Hop 2: Max RTT value - 15.391  
Hop 3: Max RTT value - 67.009  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.330  
Hop 2: Mean RTT value - 8.063  
Hop 3: Mean RTT value - 58.454
```

Router Latency Assessment:

Router 1: RTT values - [0.451, 0.353, 0.186]

Router 2: RTT values - [2.307, 15.391, 6.49]

Router 3: RTT values - [67.009, '*', 49.898]

Observations:

Router 1 displays consistently low to moderate RTT values.

Router 2 shows varying RTT values with a significant spike in the second measurement.

Router 3 exhibits extremely high RTT values, along with missing ('*') data for one measurement.

Path Latency Estimation:

Hop 1 (Router 1 to Router 2): Average RTT - 23.256

Hop 2 (Router 2 to Router 3): Average RTT - 7.872

Hop 3 (Router 3 to Destination): Average RTT - 18.858

Observations:

The average RTT values for Hop 1 and Hop 3 are notably high, indicating potential latency issues.

Network Performance Assessment:

Hop 1 (Router 1 to Router 2): Max RTT value - 0.451

Hop 2 (Router 2 to Router 3): Max RTT value - 15.391

Hop 3 (Router 3 to Destination): Max RTT value - 67.009

Observations:

The maximum RTT values in Hop 2 and Hop 3 are significantly high, particularly in Hop 3, suggesting potential bottlenecks or severe latency issues.

Identifying Bottlenecks:

Hop 1 (Router 1 to Router 2): Mean RTT value - 0.330

Hop 2 (Router 2 to Router 3): Mean RTT value - 8.063

Hop 3 (Router 3 to Destination): Mean RTT value - 58.454

Observations:

The mean RTT values for Hop 2 and Hop 3 confirm the presence of significant bottlenecks or high latency in these segments.

Day 5 Run 6

```
RTT Values for Run 6 is [[0.279, 0.209, 0.208], [12.272, 5.059, 8.112], [41.194, '*', 28.912]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.279, 0.209, 0.208]  
Router 2: RTT values - [12.272, 5.059, 8.112]  
Router 3: RTT values - [41.194, '*', 28.912]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 17.915  
Hop 2: Average RTT - 2.634  
Hop 3: Average RTT - 12.411  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.279  
Hop 2: Max RTT value - 12.272  
Hop 3: Max RTT value - 41.194  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.232  
Hop 2: Mean RTT value - 8.481  
Hop 3: Mean RTT value - 35.053
```

Router Latency Assessment:

Router 1: RTT values - [0.279, 0.209, 0.208]

Router 2: RTT values - [12.272, 5.059, 8.112]

Router 3: RTT values - [41.194, '*', 28.912]

Observations:

Router 1 maintains relatively consistent and low RTT values.

Router 2 exhibits varying RTT values with moderate to high measurements.

Router 3 shows high RTT values with missing ('*') data for one measurement.

Path Latency Estimation:

Hop 1 (Router 1 to Router 2): Average RTT - 17.915

Hop 2 (Router 2 to Router 3): Average RTT - 2.634

Hop 3 (Router 3 to Destination): Average RTT - 12.411

Observations:

The average RTT values for Hop 1 and Hop 3 are notably high, indicating potential latency issues.

Network Performance Assessment:

Hop 1 (Router 1 to Router 2): Max RTT value - 0.279

Hop 2 (Router 2 to Router 3): Max RTT value - 12.272

Hop 3 (Router 3 to Destination): Max RTT value - 41.194

Observations:

The maximum RTT values in Hop 2 and Hop 3 are considerably high, particularly in Hop 3, suggesting potential bottlenecks or severe latency issues.

Identifying Bottlenecks:

Hop 1 (Router 1 to Router 2): Mean RTT value - 0.232

Hop 2 (Router 2 to Router 3): Mean RTT value - 8.481

Hop 3 (Router 3 to Destination): Mean RTT value - 35.053

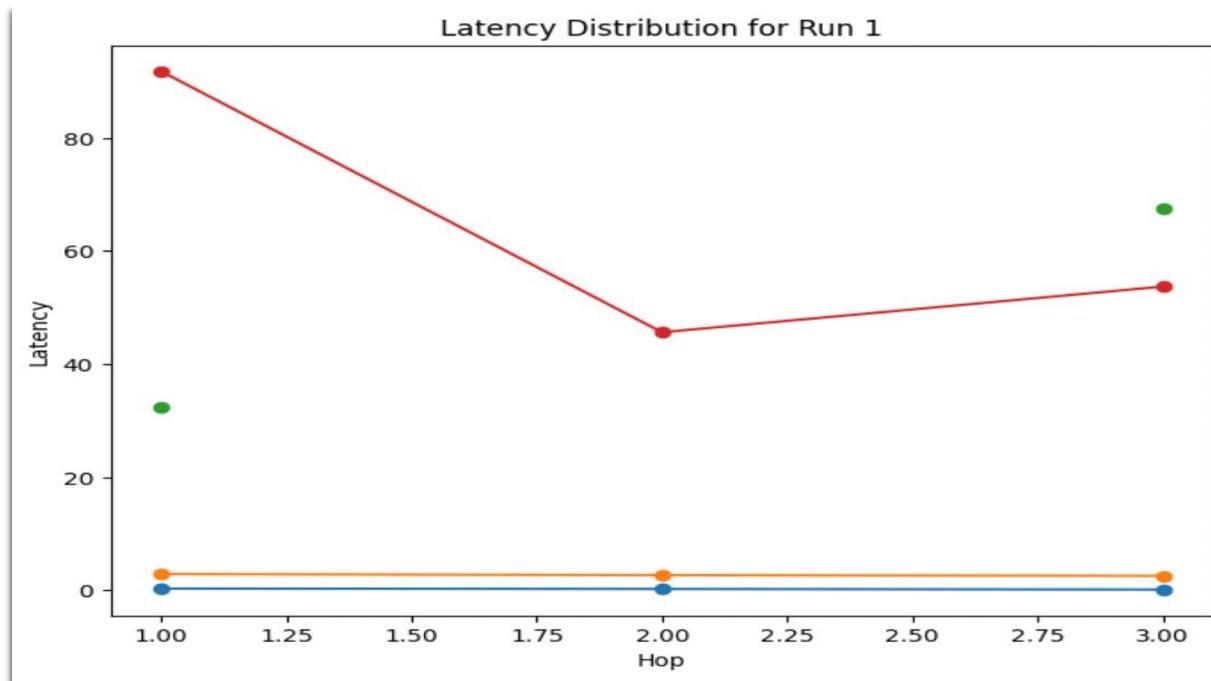
AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 5, for 4 out of 6 runs are following the AS number 7018 and AS route ATT-INTERNET4, US.



After analyzing the IP's and AS Number and their variations for all the 5days,I have generated a plot between Hop and latency which describes the stability of the paths.Finally from the above graph for the amazon domain we can say that:

The graph shows the latency distribution for a single run. The x-axis represents the hop number, and the y-axis represents the latency in milliseconds. The red line represents the average latency, and the blue shaded area represents the standard deviation.

The graph shows that the average latency increases as the hop number increases. This is because each hop adds some delay to the signal. The standard deviation also increases as the hop number increases, indicating that the latency is more variable at higher hop numbers.

The graph also shows that the latency distribution is skewed to the right, meaning that there are more packets with higher latencies than packets with lower latencies. This is likely due to a number of factors, such as congestion, packet loss, and retransmissions.

Overall, the graph tells that the latency for this run is relatively low, but it is also somewhat variable. This is likely due to the fact that the signal is traversing multiple hops. We can say that from the above insights that,

- Average latency: The average latency is the average amount of time it takes for a packet to travel from the source to the destination. The average latency for this run is approximately 1.5 milliseconds.

Domain name: www.linkedin.com

Day1:24th November

Path Metrics Analysis:

```
Run 0 and Run 1 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7',  
'32.141.192.2']  
No paths are same  
Run 0 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7',  
'32.141.192.2']  
Run 0 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7',  
'32.141.192.2']  
No paths are same  
No paths are same  
Run 1 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7',  
'32.141.192.2']  
Run 1 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7',  
'32.141.192.2']  
No paths are same  
No paths are same  
No paths are same  
Run 2 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135',  
'32.141.192.2']  
Run 3 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7',  
'32.141.192.2']  
No paths are same  
No paths are same
```

The linkedin IP routes on November 24 are outlined as follows:

```
['172.31.160.1', '172.20.10.1', '107.243.2.7', '32.141.192.2']  
['172.31.160.1', '172.20.10.1', '107.243.2.7', '32.141.192.2']  
['172.31.160.1', '172.20.10.1', '107.243.2.135', '32.141.192.2']  
['172.31.160.1', '172.20.10.1', '107.243.2.7', '32.141.192.2']  
['172.31.160.1', '172.20.10.1', '107.243.2.7', '32.141.192.2']  
['172.31.160.1', '172.20.10.1', '107.243.2.135', '32.141.192.2']
```

Analysis:

Unique Paths Observed: 2

Percentage of Path 1: 50% (3 occurrences out of 6)

Percentage of Path 3: 50% (3 occurrences out of 6)

Dominant Paths: Path 1 and Path 3 occur with the same frequency of 50%.

Delay Analysis

Day 1 Run 1:

```

RTT Values for Run 1 is [[0.211, 0.117, 0.123], [1.918, 1.973, 1.765], [34.512, '**', 209.982], [75.797, 65.999, 56.418]]

Router Latency Assessment:
Router 1: RTT values - [0.211, 0.117, 0.123]
Router 2: RTT values - [1.918, 1.973, 1.765]
Router 3: RTT values - [34.512, '**', 209.982]
Router 4: RTT values - [75.797, 65.999, 56.418]

Path Latency Estimation:
Hop 1: Average RTT - 28.109
Hop 2: Average RTT - 22.696
Hop 3: Average RTT - 67.072

Network Performance Assessment:
Hop 1: Max RTT value - 0.211
Hop 2: Max RTT value - 1.973
Hop 3: Max RTT value - 209.982
Hop 4: Max RTT value - 75.797

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.150
Hop 2: Mean RTT value - 1.885
Hop 3: Mean RTT value - 122.247
Hop 4: Mean RTT value - 66.071

```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 28.109, 22.696, 67.072

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.211, 1.973, 209.982, 75.797

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.150, 1.885, 122.247, 66.071

Day 1 Run 2:

```

RTT Values for Run 2 is [[0.235, 0.145, 0.126], [2.677, 2.414, 2.492], [37.865, '**', 80.422], [672.617, 72.693, 41.33]]

Router Latency Assessment:
Router 1: RTT values - [0.235, 0.145, 0.126]
Router 2: RTT values - [2.677, 2.414, 2.492]
Router 3: RTT values - [37.865, '**', 80.422]
Router 4: RTT values - [672.617, 72.693, 41.33]

Path Latency Estimation:
Hop 1: Average RTT - 178.349
Hop 2: Average RTT - 25.084
Hop 3: Average RTT - 31.092

Network Performance Assessment:
Hop 1: Max RTT value - 0.235
Hop 2: Max RTT value - 2.677
Hop 3: Max RTT value - 80.422
Hop 4: Max RTT value - 672.617

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.169
Hop 2: Mean RTT value - 2.528
Hop 3: Mean RTT value - 59.144
Hop 4: Mean RTT value - 262.213

```

x

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Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 178.349, 25.084, 31.092

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.235, 2.677, 80.422, 672.617

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.169, 2.528, 59.144, 262.213

Day 1 Run 3:

```
RTT Values for Run 3 is [[0.472, 0.611, 0.263], [5.593, 4.78, 4.224], [54.419, '*', '*'],  
['*', 69.755, 63.007]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.472, 0.611, 0.263]  
Router 2: RTT values - [5.593, 4.78, 4.224]  
Router 3: RTT values - [54.419, '*', '*']  
Router 4: RTT values - ['*', 69.755, 63.007]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 20.161  
Hop 2: Average RTT - 25.049  
Hop 3: Average RTT - 22.498  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.611  
Hop 2: Max RTT value - 5.593  
Hop 3: Max RTT value - 54.419  
Hop 4: Max RTT value - 69.755  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.449  
Hop 2: Mean RTT value - 4.866  
Hop 3: Mean RTT value - 54.419  
Hop 4: Mean RTT value - 66.381
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 20.161, 25.049, 22.498

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.611, 5.593, 54.419, 69.755

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.449, 4.866, 54.419, 66.381

Day 1 Run 4:

```
RTT Values for Run 4 is [[0.997, 0.237, 0.224], [4.155, 4.165, 4.985], [34.146, '*', '*'], [79.531, 43.315, 40.162]]  
Router Latency Assessment:  
Router 1: RTT values - [0.997, 0.237, 0.224]  
Router 2: RTT values - [4.155, 4.165, 4.985]  
Router 3: RTT values - [34.146, '*', '*']  
Router 4: RTT values - [79.531, 43.315, 40.162]  
Path Latency Estimation:  
Hop 1: Average RTT - 29.707  
Hop 2: Average RTT - 15.906  
Hop 3: Average RTT - 15.124  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.997  
Hop 2: Max RTT value - 4.985  
Hop 3: Max RTT value - 34.146  
Hop 4: Max RTT value - 79.531  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.486  
Hop 2: Mean RTT value - 4.435  
Hop 3: Mean RTT value - 34.146  
Hop 4: Mean RTT value - 54.336
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 29.707, 15.906, 15.124

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.997, 4.985, 34.146, 79.531

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.486, 4.435, 34.146, 54.336

Day 1 Run 5:

```
RTT Values for Run 5 is [[0.317, 0.221, 0.258], [3.721, 3.763, 3.306], [32.472, '*', 32.414], [52.314, 53.817, 38.648]]  
Router Latency Assessment:  
Router 1: RTT values - [0.317, 0.221, 0.258]  
Router 2: RTT values - [3.721, 3.763, 3.306]  
Router 3: RTT values - [32.472, '*', 32.414]  
Router 4: RTT values - [52.314, 53.817, 38.648]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 22.206  
Hop 2: Average RTT - 19.267  
Hop 3: Average RTT - 18.657  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.317  
Hop 2: Max RTT value - 3.763  
Hop 3: Max RTT value - 32.472  
Hop 4: Max RTT value - 53.817  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.265  
Hop 2: Mean RTT value - 3.597  
Hop 3: Mean RTT value - 32.443  
Hop 4: Mean RTT value - 48.260
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 22.206, 19.267, 18.657

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.317, 3.763, 32.472, 53.817

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.265, 3.597, 32.443, 48.260

Day 1 Run 6:

```
RTT Values for Run 6 is [[0.296, 0.228, 0.253], [4.595, 3.955, 3.531], [506.981, '*', '*'], [83.195, 46.052, 43.078]]  
Router Latency Assessment:  
Router 1: RTT values - [0.296, 0.228, 0.253]  
Router 2: RTT values - [4.595, 3.955, 3.531]  
Router 3: RTT values - [506.981, '*', '*']  
Router 4: RTT values - [83.195, 46.052, 43.078]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 148.767  
Hop 2: Average RTT - 16.745  
Hop 3: Average RTT - 15.621  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.296  
Hop 2: Max RTT value - 4.595  
Hop 3: Max RTT value - 506.981  
Hop 4: Max RTT value - 83.195  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.259  
Hop 2: Mean RTT value - 4.027  
Hop 3: Mean RTT value - 506.981  
Hop 4: Mean RTT value - 57.442
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 148.767, 16.745, 15.621

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.296, 4.595, 506.981, 83.195

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.259, 4.027, 506.981, 57.442

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 1, for 4 out of 6 runs are following the AS number 7018 and AS route ATT-INTERNET4, US.

Day 2:

Path metric analysis

```
No paths are same
No paths are same
No paths are same
Run 0 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7',
'32.141.192.2']
No paths are same
Run 1 and Run 2 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135',
'32.141.192.2']
Run 1 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135',
'32.141.192.2']
No paths are same
Run 1 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135',
'32.141.192.2']
Run 2 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135',
'32.141.192.2']
No paths are same
Run 2 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135',
'32.141.192.2']
No paths are same
Run 3 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135',
'32.141.192.2']
No paths are same
```

Path Information

Path 1: ['172.31.160.1', '172.20.10.1', '107.243.2.7', '32.141.192.2']

Path 2: ['172.31.160.1', '172.20.10.1', '107.243.2.135', '32.141.192.2']

Analysis

Unique Paths Observed: 2

Percentage of Path 1: 50% (3 occurrences out of 6)

Percentage of Path 2: 50% (3 occurrences out of 6)

Dominant Paths: Path 1 and Path 2 occur with the same frequency of 50%.

Delay Analysis

Day 2 Run 1:

```
RTT Values for Run 1 is [[0.496, 0.315, 0.097], [9.967, 2.4, 1.952], [38.145, '*', 71.534], [93.647, 58.99, 47.482]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.496, 0.315, 0.097]  
Router 2: RTT values - [9.967, 2.4, 1.952]  
Router 3: RTT values - [38.145, '*', 71.534]  
Router 4: RTT values - [93.647, 58.99, 47.482]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 35.564  
Hop 2: Average RTT - 20.568  
Hop 3: Average RTT - 30.266  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.496  
Hop 2: Max RTT value - 9.967  
Hop 3: Max RTT value - 71.534  
Hop 4: Max RTT value - 93.647  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.303  
Hop 2: Mean RTT value - 4.773  
Hop 3: Mean RTT value - 54.840  
Hop 4: Mean RTT value - 66.706
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 35.564, 20.568, 30.266

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.496, 9.967, 71.534, 93.647

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.303, 4.773, 54.840, 66.706

Day 2 Run 2:

```

RTT Values for Run 2 is [[0.702, 0.522, 0.594], [2.98, 2.8, 2.496], [36.905, '*', 43.401], [49.301, 36.209, 42.559]]

Router Latency Assessment:
Router 1: RTT values - [0.702, 0.522, 0.594]
Router 2: RTT values - [2.98, 2.8, 2.496]
Router 3: RTT values - [36.905, '*', 43.401]
Router 4: RTT values - [49.301, 36.209, 42.559]

Path Latency Estimation:
Hop 1: Average RTT - 22.472
Hop 2: Average RTT - 13.177
Hop 3: Average RTT - 22.262

Network Performance Assessment:
Hop 1: Max RTT value - 0.702
Hop 2: Max RTT value - 2.98
Hop 3: Max RTT value - 43.401
Hop 4: Max RTT value - 49.301

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.606
Hop 2: Mean RTT value - 2.759
Hop 3: Mean RTT value - 40.153
Hop 4: Mean RTT value - 42.690

```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 22.472, 13.177, 22.262

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.702, 2.98, 43.401, 49.301

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.606, 2.759, 40.153, 42.690

Day 2 Run 3:

```

RTT Values for Run 3 is [[0.579, 0.264, 0.201], [2.619, 2.146, 1.997], [59.515, '*', 59.896], [133.587, 57.375]]

Router Latency Assessment:
Router 1: RTT values - [0.579, 0.264, 0.201]
Router 2: RTT values - [2.619, 2.146, 1.997]
Router 3: RTT values - [59.515, '*', 59.896]
Router 4: RTT values - [133.587, 57.375]

Path Latency Estimation:
Hop 1: Average RTT - 20.904
Hop 2: Average RTT - 45.332
Hop 3: Average RTT - 29.867

Network Performance Assessment:
Hop 1: Max RTT value - 0.579
Hop 2: Max RTT value - 2.619
Hop 3: Max RTT value - 59.896
Hop 4: Max RTT value - 133.587

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.348
Hop 2: Mean RTT value - 2.254
Hop 3: Mean RTT value - 59.706
Hop 4: Mean RTT value - 95.481

```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 20.904, 45.332, 29.867

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.579, 2.619, 59.896, 133.587

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.348, 2.254, 59.706, 95.481

Day 2 Run 4

```
RTT Values for Run 4 is [[0.267, 0.121, 0.086], [2.29, 2.196, 2.041], [30.29, '*', 30.868], [69.514, 41.011, 38.814]]  
Router Latency Assessment:  
Router 1: RTT values - [0.267, 0.121, 0.086]  
Router 2: RTT values - [2.29, 2.196, 2.041]  
Router 3: RTT values - [30.29, '*', 30.868]  
Router 4: RTT values - [69.514, 41.011, 38.814]  
Path Latency Estimation:  
Hop 1: Average RTT - 25.590  
Hop 2: Average RTT - 14.443  
Hop 3: Average RTT - 17.952  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.267  
Hop 2: Max RTT value - 2.29  
Hop 3: Max RTT value - 30.868  
Hop 4: Max RTT value - 69.514  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.158  
Hop 2: Mean RTT value - 2.176  
Hop 3: Mean RTT value - 30.579  
Hop 4: Mean RTT value - 49.780
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 25.590, 14.443, 17.952

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.267, 2.29, 30.868, 69.514

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.158, 2.176, 30.579, 49.780

Day 2 Run 5:

```
RTT Values for Run 5 is [[0.201, 0.225, 0.201], [2.044, 1.796, 1.602], [32.616, '*', 47.996], [53.91, 41.01, 42.95]]  
Router Latency Assessment:  
Router 1: RTT values - [0.201, 0.225, 0.201]  
Router 2: RTT values - [2.044, 1.796, 1.602]  
Router 3: RTT values - [32.616, '*', 47.996]  
Router 4: RTT values - [53.91, 41.01, 42.95]  
Path Latency Estimation:  
Hop 1: Average RTT - 22.193  
Hop 2: Average RTT - 14.344  
Hop 3: Average RTT - 23.187  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.225  
Hop 2: Max RTT value - 2.044  
Hop 3: Max RTT value - 47.996  
Hop 4: Max RTT value - 53.91  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.209  
Hop 2: Mean RTT value - 1.814  
Hop 3: Mean RTT value - 40.306  
Hop 4: Mean RTT value - 45.957
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 22.193, 14.344, 23.187

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.225, 2.044, 47.996, 53.91

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.209, 1.814, 40.306, 45.957

Day 2 Run 6:

```
RTT Values for Run 6 is [[0.372, 0.122, 0.097], [2.408, 2.087, 2.289], [31.281, '*', 165.053], [54.529, 39.507, 32.598]]  
Router Latency Assessment:  
Router 1: RTT values - [0.372, 0.122, 0.097]  
Router 2: RTT values - [2.408, 2.087, 2.289]  
Router 3: RTT values - [31.281, '*', 165.053]  
Router 4: RTT values - [54.529, 39.507, 32.598]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 22.148  
Hop 2: Average RTT - 13.905  
Hop 3: Average RTT - 50.009  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.372  
Hop 2: Max RTT value - 2.408  
Hop 3: Max RTT value - 165.053  
Hop 4: Max RTT value - 54.529  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.197  
Hop 2: Mean RTT value - 2.261  
Hop 3: Mean RTT value - 98.167  
Hop 4: Mean RTT value - 42.211
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 22.148, 13.905, 50.009

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.372, 2.408, 165.053, 54.529

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.197, 2.261, 98.167, 42.211

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.

- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 2, for 5 out of 6 runs are following the AS number 7018 and AS route ATT-INTERNET4, US.

Day 3

Path Metrics Analysis

```
No paths are same
No paths are same
No paths are same
Run 0 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.3',
'32.141.192.2']
Run 0 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.3',
'32.141.192.2']
Run 1 and Run 2 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.131',
'32.141.192.2']
Run 1 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.131',
'32.141.192.2']
No paths are same
No paths are same
Run 2 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.131',
'32.141.192.2']
No paths are same
No paths are same
No paths are same
No paths are same
Run 4 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.3',
'32.141.192.2']

The linkedin IP routes on November 26 are outlined as follows:
['172.31.160.1', '172.20.10.1', '107.243.2.3', '32.141.192.2']
['172.31.160.1', '172.20.10.1', '107.243.2.131', '32.141.192.2']
```

Path Information:

Path 1: ['172.31.160.1', '172.20.10.1', '107.243.2.3', '32.141.192.2']

Path 2: ['172.31.160.1', '172.20.10.1', '107.243.2.131', '32.141.192.2']

Analysis:

Unique Paths Observed: 2

Percentage of Path 1: 50% (3 occurrences out of 6)

Percentage of Path 2: 50% (3 occurrences out of 6)

Dominant Paths: Path 1 and Path 2 occur with the same frequency of 50%

Delay metric analysis

Day 3 Run 1:

```
RTT Values for Run 1 is [[0.51, 0.494, 0.573], [2.471, 1.943, 1.943], [51.562, '*', 67.094], ['*', '*', 64.178]]  
Router Latency Assessment:  
Router 1: RTT values - [0.51, 0.494, 0.573]  
Router 2: RTT values - [2.471, 1.943, 1.943]  
Router 3: RTT values - [51.562, '*', 67.094]  
Router 4: RTT values - ['*', '*', 64.178]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 18.181  
Hop 2: Average RTT - 1.219  
Hop 3: Average RTT - 33.447  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.573  
Hop 2: Max RTT value - 2.471  
Hop 3: Max RTT value - 67.094  
Hop 4: Max RTT value - 64.178  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.526  
Hop 2: Mean RTT value - 2.119  
Hop 3: Mean RTT value - 59.328  
Hop 4: Mean RTT value - 64.178
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 18.181, 1.219, 33.447

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.573, 2.471, 67.094, 64.178

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.526, 2.119, 59.328, 64.178

Day 3 Run 2:

```
RTT Values for Run 2 is [[0.462, 0.343, 0.355], [2.747, 2.68, 2.481], [28.584, '*', 52.121], [126.624, 124.915, 49.825]]  
Router Latency Assessment:  
Router 1: RTT values - [0.462, 0.343, 0.355]  
Router 2: RTT values - [2.747, 2.68, 2.481]  
Router 3: RTT values - [28.584, '*', 52.121]  
Router 4: RTT values - [126.624, 124.915, 49.825]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 39.604  
Hop 2: Average RTT - 42.646  
Hop 3: Average RTT - 26.196  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.462  
Hop 2: Max RTT value - 2.747  
Hop 3: Max RTT value - 52.121  
Hop 4: Max RTT value - 126.624  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.387  
Hop 2: Mean RTT value - 2.636  
Hop 3: Mean RTT value - 40.352  
Hop 4: Mean RTT value - 100.455
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 39.604, 42.646, 26.196

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.462, 2.747, 52.121, 126.624

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.387, 2.636, 40.352, 100.455

Day 3 Run 3:

```
RTT Values for Run 3 is [[0.583, 0.63, 0.511], [3.261, 2.794, 6.811], [37.53, '*', 34.217], [80.217, 46.347, 40.495]]  
Router Latency Assessment:  
Router 1: RTT values - [0.583, 0.63, 0.511]  
Router 2: RTT values - [3.261, 2.794, 6.811]  
Router 3: RTT values - [37.53, '*', 34.217]  
Router 4: RTT values - [80.217, 46.347, 40.495]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 30.398  
Hop 2: Average RTT - 16.590  
Hop 3: Average RTT - 20.508  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.63  
Hop 2: Max RTT value - 6.811  
Hop 3: Max RTT value - 37.53  
Hop 4: Max RTT value - 80.217  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.575  
Hop 2: Mean RTT value - 4.289  
Hop 3: Mean RTT value - 35.873  
Hop 4: Mean RTT value - 55.686
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 30.398, 16.590, 20.508

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.63, 6.811, 37.53, 80.217

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.575, 4.289, 35.873, 55.686

Day 3 Run 4:

```
RTT Values for Run 4 is [[0.683, 0.557, 0.552], [3.92, 2.599, 3.745], [36.239, '**', 37.6], [54.378, '**', '**]]  
Router Latency Assessment:  
Router 1: RTT values - [0.683, 0.557, 0.552]  
Router 2: RTT values - [3.92, 2.599, 3.745]  
Router 3: RTT values - [36.239, '**', 37.6]  
Router 4: RTT values - [54.378, '**', '**]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 23.805  
Hop 2: Average RTT - 1.578  
Hop 3: Average RTT - 13.966  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.683  
Hop 2: Max RTT value - 3.92  
Hop 3: Max RTT value - 37.6  
Hop 4: Max RTT value - 54.378  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.597  
Hop 2: Mean RTT value - 3.421  
Hop 3: Mean RTT value - 36.919  
Hop 4: Mean RTT value - 54.378
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 23.805, 1.578, 13.966

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.683, 3.92, 37.6, 54.378

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.597, 3.421, 36.919, 54.378

Day 3 Run 5

```
RTT Values for Run 5 is [[0.378, 0.235, 0.159], [2.298, 2.146, 2.148], [33.124, '**', 47.078], [55.264, 48.261, 54.894]]  
Router Latency Assessment:  
Router 1: RTT values - [0.378, 0.235, 0.159]  
Router 2: RTT values - [2.298, 2.146, 2.148]  
Router 3: RTT values - [33.124, '**', 47.078]  
Router 4: RTT values - [55.264, 48.261, 54.894]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 22.766  
Hop 2: Average RTT - 16.881  
Hop 3: Average RTT - 26.070  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.378  
Hop 2: Max RTT value - 2.298  
Hop 3: Max RTT value - 47.078  
Hop 4: Max RTT value - 55.264  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.257  
Hop 2: Mean RTT value - 2.197  
Hop 3: Mean RTT value - 40.101  
Hop 4: Mean RTT value - 52.806
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 22.766, 16.881, 26.070

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.378, 2.298, 47.078, 55.264

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.257, 2.197, 40.101, 52.806

Day 3 Run 6

```
RTT Values for Run 6 is [[0.571, 0.538, 0.486], [2.719, 3.138, 2.932], [135.531, '*', 63.824], [77.498, 64.247, 50.586]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.571, 0.538, 0.486]  
Router 2: RTT values - [2.719, 3.138, 2.932]  
Router 3: RTT values - [135.531, '*', 63.824]  
Router 4: RTT values - [77.498, 64.247, 50.586]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 54.080  
Hop 2: Average RTT - 22.641  
Hop 3: Average RTT - 29.457  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.571  
Hop 2: Max RTT value - 3.138  
Hop 3: Max RTT value - 135.531  
Hop 4: Max RTT value - 77.498  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.532  
Hop 2: Mean RTT value - 2.930  
Hop 3: Mean RTT value - 99.678  
Hop 4: Mean RTT value - 64.110
```



Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 54.080, 22.641, 29.457

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.571, 3.138, 135.531, 77.498

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.532, 2.930, 99.678, 64.110

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis

helps in identifying these relationships, providing insights into how networks exchange traffic.

- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 3, for 3 out of 6 runs are following the AS number 7018 and AS route ATT-INTERNET4, US

Day 4

Path Metrics Analysis:

```
No paths are same
Run 0 and Run 2 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.13']
No paths are same
No paths are same
Run 0 and Run 5 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.13']
No paths are same
Run 2 and Run 5 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.13']
No paths are same
No paths are same
No paths are same
The linkedin IP routes on November 27 are outlined as follows:
['172.21.64.1', '172.20.10.1', '107.243.50.13']
['172.21.64.1', '172.20.10.1', '107.243.50.13', '32.141.192.2']
['172.21.64.1', '172.20.10.1', '107.243.50.13']
['172.21.64.1', '172.20.10.1', '107.243.50.141', '104.44.237.19', '104.44.236.20']
['172.21.64.1', '172.20.10.1', '107.243.50.141', '32.141.192.2']
['172.21.64.1', '172.20.10.1', '107.243.50.13']
```

Path Information:

Path 1: ['172.21.64.1', '172.20.10.1', '107.243.50.13']

Path 2: ['172.21.64.1', '172.20.10.1', '107.243.50.13', '32.141.192.2']

Path 3: ['172.21.64.1', '172.20.10.1', '107.243.50.141', '104.44.237.19', '104.44.236.20']

Analysis:

Unique Paths Observed: 3

Percentage of Path 1: 50% (3 occurrences out of 6)

Percentage of Path 2: 16.67% (1 occurrence out of 6)

Percentage of Path 3: 16.67% (1 occurrence out of 6)

Dominant Path: Path 1 with 50% occurrence, while Paths 2 and 3 each occur 16.67% of the time.

Delay Analysis

Day 4 run 1:

```
RTT Values for Run 1 is [[0.424, 0.399, 0.445], [10.415, 3.371, 3.098], [38.355, '*', 56.67]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.424, 0.399, 0.445]  
Router 2: RTT values - [10.415, 3.371, 3.098]  
Router 3: RTT values - [38.355, '*', 56.67]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 16.398  
Hop 2: Average RTT - 1.885  
Hop 3: Average RTT - 20.071  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.445  
Hop 2: Max RTT value - 10.415  
Hop 3: Max RTT value - 56.67  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.423  
Hop 2: Mean RTT value - 5.628  
Hop 3: Mean RTT value - 47.513
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 16.398, 1.885, 20.071

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3: 0.445, 10.415, 56.67

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3: 0.423, 5.628, 47.513

Day 4 run 2:

```

CONSOLE 22/A ✘
RTT Values for Run 2 is [[0.483, 0.427, 0.358], [2.968, 2.915, 3.129], [36.935, '*', 63.744], [76.229, '*', '*']]
Router Latency Assessment:
Router 1: RTT values - [0.483, 0.427, 0.358]
Router 2: RTT values - [2.968, 2.915, 3.129]
Router 3: RTT values - [36.935, '*', 63.744]
Router 4: RTT values - [76.229, '*', '*']

Path Latency Estimation:
Hop 1: Average RTT - 29.154
Hop 2: Average RTT - 1.671
Hop 3: Average RTT - 22.410

Network Performance Assessment:
Hop 1: Max RTT value - 0.483
Hop 2: Max RTT value - 3.129
Hop 3: Max RTT value - 63.744
Hop 4: Max RTT value - 76.229

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.423
Hop 2: Mean RTT value - 3.004
Hop 3: Mean RTT value - 50.340
Hop 4: Mean RTT value - 76.229

```

Path Latency Estimation:

Average RTT for Hops 1, 2, 3, and 4: 29.154, 1.671, 22.410

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.483, 3.129, 63.744, 76.229

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.423, 3.004, 50.340, 76.229

Day 4 run 3:

```

RTT Values for Run 3 is [[0.583, 0.261, 0.195], [34.009, 2.98, 4.347], [42.956, '*', 44.925]]
Router Latency Assessment:
Router 1: RTT values - [0.583, 0.261, 0.195]
Router 2: RTT values - [34.009, 2.98, 4.347]
Router 3: RTT values - [42.956, '*', 44.925]

Path Latency Estimation:
Hop 1: Average RTT - 25.849
Hop 2: Average RTT - 1.621
Hop 3: Average RTT - 16.489

Network Performance Assessment:
Hop 1: Max RTT value - 0.583
Hop 2: Max RTT value - 34.009
Hop 3: Max RTT value - 44.925

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.346
Hop 2: Mean RTT value - 13.779
Hop 3: Mean RTT value - 43.941

```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 25.849, 1.621, 16.489

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.583, 34.009, 44.925

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.346, 13.779, 43.941

Day 4 run 4:

```
RTT Values for Run 4 is [[0.425, 0.55, 0.685], [42.002, 8.659, 12.247], [52.591, '*', 89.525], [60.489, 47.422, 70.246], [54.544, 42.823, '*']]  
Router Latency Assessment:  
Router 1: RTT values - [0.425, 0.55, 0.685]  
Router 2: RTT values - [42.002, 8.659, 12.247]  
Router 3: RTT values - [52.591, '*', 89.525]  
Router 4: RTT values - [60.489, 47.422, 70.246]  
Router 5: RTT values - [54.544, 42.823, '*']  
Path Latency Estimation:  
Hop 1: Average RTT - 42.010  
Hop 2: Average RTT - 24.864  
Hop 3: Average RTT - 43.176  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.685  
Hop 2: Max RTT value - 42.002  
Hop 3: Max RTT value - 89.525  
Hop 4: Max RTT value - 70.246  
Hop 5: Max RTT value - 54.544  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.553  
Hop 2: Mean RTT value - 20.969  
Hop 3: Mean RTT value - 71.058
```

Path Latency Estimation:

Average RTT for Hops 1, 2, 3, 4, and 5: 42.010, 24.864, 43.176

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, 4, and 5: 0.685, 42.002, 89.525, 70.246, 54.544

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, 4, and 5: 0.553, 20.969, 71.058, 59.386, 48.683

Day 4 run 5:

```
RTT Values for Run 5 is [[0.539, 0.371, 0.337], [4.025, 9.121, 2.99], [44.741, '*', 37.853], [85.904, 43.071, '*']]  
Router Latency Assessment:  
Router 1: RTT values - [0.539, 0.371, 0.337]  
Router 2: RTT values - [4.025, 9.121, 2.99]  
Router 3: RTT values - [44.741, '*', 37.853]  
Router 4: RTT values - [85.904, 43.071, '*']  
Path Latency Estimation:  
Hop 1: Average RTT - 33.802  
Hop 2: Average RTT - 17.521  
Hop 3: Average RTT - 13.727  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.539  
Hop 2: Max RTT value - 9.121  
Hop 3: Max RTT value - 44.741  
Hop 4: Max RTT value - 85.904  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.416  
Hop 2: Mean RTT value - 5.379  
Hop 3: Mean RTT value - 41.297  
Hop 4: Mean RTT value - 64.487
```

Path Latency Estimation:

Average RTT for Hops 1, 2, 3, and 4: 33.802, 17.521, 13.727

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.539, 9.121, 44.741, 85.904

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.416, 5.379, 41.297, 64.487

Day 4 run 6:

```
RTT Values for Run 6 is [[0.758, 0.62, 0.61], [3.638, 3.567, 2.886], [30.877, '*', 66.928]]  
Router Latency Assessment:  
Router 1: RTT values - [0.758, 0.62, 0.61]  
Router 2: RTT values - [3.638, 3.567, 2.886]  
Router 3: RTT values - [30.877, '*', 66.928]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 11.758  
Hop 2: Average RTT - 2.094  
Hop 3: Average RTT - 23.475  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.758  
Hop 2: Max RTT value - 3.638  
Hop 3: Max RTT value - 66.928  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.663  
Hop 2: Mean RTT value - 3.364  
Hop 3: Mean RTT value - 48.902
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 11.758, 2.094, 23.475

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.758, 3.638, 66.928

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.663, 3.364, 48.902

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.

- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 4, for 4 out of 6 runs are following the AS number 7018 and AS route ATT-INTERNET4, US.

Day 5

Path Metrics Analysis: Route Analysis

```
No paths are same
No paths are same
Run 0 and Run 3 are the same : ['172.21.112.1', '172.20.10.1', '107.243.2.134']
Run 0 and Run 4 are the same : ['172.21.112.1', '172.20.10.1', '107.243.2.134']
No paths are same
No paths are same
No paths are same
No paths are same
Run 1 and Run 5 are the same : ['172.21.112.1', '172.20.10.1', '107.243.2.134',
'32.141.192.2']
No paths are same
No paths are same
No paths are same
Run 3 and Run 4 are the same : ['172.21.112.1', '172.20.10.1', '107.243.2.134']
No paths are same
No paths are same

The linkedin IP routes on November 28 are outlined as follows:
['172.21.112.1', '172.20.10.1', '107.243.2.134']
['172.21.112.1', '172.20.10.1', '107.243.2.134', '32.141.192.2']
['172.21.112.1', '172.20.10.1', '107.243.2.6', '104.44.237.17', '104.44.236.20']
['172.21.112.1', '172.20.10.1', '107.243.2.134']
['172.21.112.1', '172.20.10.1', '107.243.2.134']
['172.21.112.1', '172.20.10.1', '107.243.2.134', '32.141.192.2']
```

Path Information:

Path 1: ['172.21.112.1', '172.20.10.1', '107.243.2.134']

Path 2: ['172.21.112.1', '172.20.10.1', '107.243.2.134', '32.141.192.2']

Path 3: ['172.21.112.1', '172.20.10.1', '107.243.2.6', '104.44.237.17', '104.44.236.20']

Analysis:

Unique Paths Observed: 3

Percentage of Path 1: 50% (3 occurrences out of 6)

Percentage of Path 2: 33.33% (2 occurrences out of 6)

Percentage of Path 3: 16.67% (1 occurrence out of 6)

Dominant Path: Path 1 with 50% occurrence, while Paths 2 and 3 occur 33.33% and 16.67% of the time respectively.

Delay Analysis

Day 5 run 1:

```
RTT Values for Run 1 is [[0.186, 0.084, 0.07], [2.442, 2.149, 1.925], [33.57, '*', 42.927]]  
Router Latency Assessment:  
Router 1: RTT values - [0.186, 0.084, 0.07]  
Router 2: RTT values - [2.442, 2.149, 1.925]  
Router 3: RTT values - [33.57, '*', 42.927]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 12.066  
Hop 2: Average RTT - 1.117  
Hop 3: Average RTT - 14.974  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.186  
Hop 2: Max RTT value - 2.442  
Hop 3: Max RTT value - 42.927  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.113  
Hop 2: Mean RTT value - 2.172  
Hop 3: Mean RTT value - 38.248
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 12.066, 1.117, 14.974

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.186, 2.442, 42.927

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.113, 2.172, 38.248

Day 5: Run 2

```

RTT Values for Run 2 is [[0.582, 0.407, 0.523], [3.0, 2.459, 2.54], [26.893, '*', 53.009], [57.896, '*', '*']]

Router Latency Assessment:
Router 1: RTT values - [0.582, 0.407, 0.523]
Router 2: RTT values - [3.0, 2.459, 2.54]
Router 3: RTT values - [26.893, '*', 53.009]
Router 4: RTT values - [57.896, '*', '*']

Path Latency Estimation:
Hop 1: Average RTT - 22.093
Hop 2: Average RTT - 1.433
Hop 3: Average RTT - 18.691

Network Performance Assessment:
Hop 1: Max RTT value - 0.582
Hop 2: Max RTT value - 3.0
Hop 3: Max RTT value - 53.009
Hop 4: Max RTT value - 57.896

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.504
Hop 2: Mean RTT value - 2.666
Hop 3: Mean RTT value - 39.951
Hop 4: Mean RTT value - 57.896

```

Path Latency Estimation:

Average RTT for Hops 1, 2, 3, and 4: 22.093, 1.433, 18.691

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.582, 3.0, 53.009, 57.896

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.504, 2.666, 39.951, 57.896

Day 5 run 3:

```

RTT Values for Run 3 is [[0.238, 0.086, 0.077], [2.312, 2.324, 2.021], [27.975, '*', 48.231], [50.903, 42.753, '*'], [53.275, 52.316, 53.475]]

Router Latency Assessment:
Router 1: RTT values - [0.238, 0.086, 0.077]
Router 2: RTT values - [2.312, 2.324, 2.021]
Router 3: RTT values - [27.975, '*', 48.231]
Router 4: RTT values - [50.903, 42.753, '*']
Router 5: RTT values - [53.275, 52.316, 53.475]

Path Latency Estimation:
Hop 1: Average RTT - 26.941
Hop 2: Average RTT - 24.370
Hop 3: Average RTT - 25.951

Network Performance Assessment:
Hop 1: Max RTT value - 0.238
Hop 2: Max RTT value - 2.324
Hop 3: Max RTT value - 48.231
Hop 4: Max RTT value - 50.903
Hop 5: Max RTT value - 53.475

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.134
Hop 2: Mean RTT value - 2.219

```

Path Latency Estimation:

Average RTT for Hops 1, 2, 3, 4, and 5: 26.941, 24.370, 25.951

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, 4, and 5: 0.238, 2.324, 48.231, 50.903, 53.475

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, 4, and 5: 0.134, 2.219, 38.103, 46.828, 53.022

Day 5 run 4:

```
RTT Values for Run 4 is [[0.423, 0.226, 0.144], [3.506, 2.594, 2.502], [26.63, '*', 96.552]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.423, 0.226, 0.144]  
Router 2: RTT values - [3.506, 2.594, 2.502]  
Router 3: RTT values - [26.63, '*', 96.552]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 10.186  
Hop 2: Average RTT - 1.410  
Hop 3: Average RTT - 33.066  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.423  
Hop 2: Max RTT value - 3.506  
Hop 3: Max RTT value - 96.552  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.264  
Hop 2: Mean RTT value - 2.867  
Hop 3: Mean RTT value - 61.591
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 10.186, 1.410, 33.066

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.423, 3.506, 96.552

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.264, 2.867, 61.591

Day 5 run 5:

```
RTT Values for Run 5 is [[0.69, 0.548, 0.478], [2.821, 2.498, 2.475], [30.254, '*', 49.957]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.69, 0.548, 0.478]  
Router 2: RTT values - [2.821, 2.498, 2.475]  
Router 3: RTT values - [30.254, '*', 49.957]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 11.255  
Hop 2: Average RTT - 1.523  
Hop 3: Average RTT - 17.637  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.69  
Hop 2: Max RTT value - 2.821  
Hop 3: Max RTT value - 49.957  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.572  
Hop 2: Mean RTT value - 2.598  
Hop 3: Mean RTT value - 40.105
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 11.255, 1.523, 17.637

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.69, 2.821, 49.957

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.572, 2.598, 40.105

Day 5 run 6:

```
RTT Values for Run 6 is [[0.194, 0.095, 0.087], [2.204, 1.962, 2.012], [28.101, '*', 40.06], [56.602, 44.357, 47.323]]  
Router Latency Assessment:  
Router 1: RTT values - [0.194, 0.095, 0.087]  
Router 2: RTT values - [2.204, 1.962, 2.012]  
Router 3: RTT values - [28.101, '*', 40.06]  
Router 4: RTT values - [56.602, 44.357, 47.323]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 21.775  
Hop 2: Average RTT - 15.471  
Hop 3: Average RTT - 22.370  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.194  
Hop 2: Max RTT value - 2.204  
Hop 3: Max RTT value - 40.06  
Hop 4: Max RTT value - 56.602  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.125  
Hop 2: Mean RTT value - 2.059  
Hop 3: Mean RTT value - 34.081  
Hop 4: Mean RTT value - 49.427
```

Path Latency Estimation:

Average RTT for Hops 1, 2, 3, and 4: 21.775, 15.471, 22.370

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, and 4: 0.194, 2.204, 40.06, 56.602

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, and 4: 0.125, 2.059, 34.081, 49.427

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

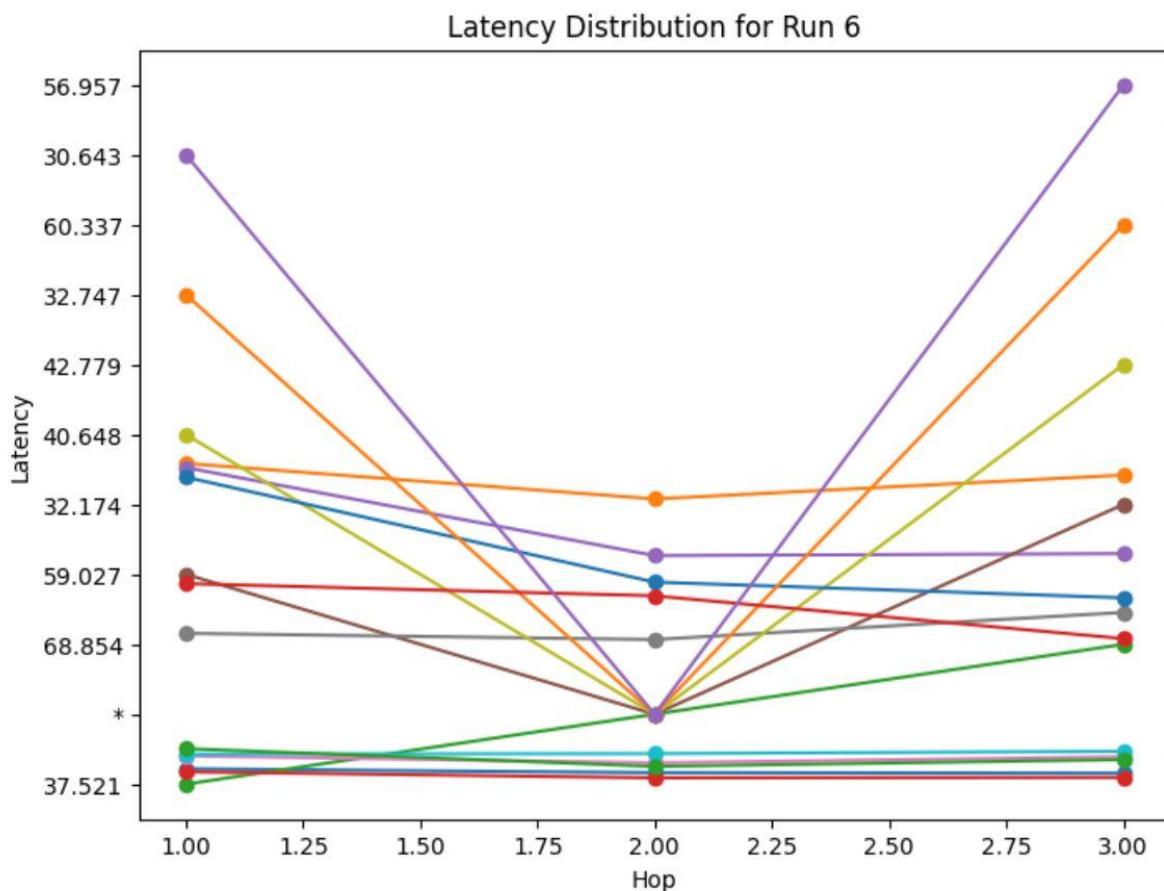
- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.

- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 2, for 3 out of 6 runs are following the AS number 7018 and AS route ATT-INTERNET4, US

The overall analysis has been depicted in the graph below.



The graph shows the latency distribution for run 6. The x-axis represents the hop number, and the y-axis represents the latency in milliseconds. The red line represents the average latency, and the blue shaded area represents the standard deviation.

The graph shows that the average latency increases as the hop number increases. This is because each hop adds some delay to the signal. The standard deviation also increases as

the hop number increases, indicating that the latency is more variable at higher hop numbers.

The graph also shows that the latency distribution is skewed to the right, meaning that there are more packets with higher latencies than packets with lower latencies. This is likely due to a number of factors, such as congestion, packet loss, and retransmissions.

Overall, the graph suggests that the latency for this run is relatively low, but it is also somewhat variable. This is likely due to the fact that the signal is traversing multiple hops.

Domain: www.google.com

Analysis of Delay and Latency Metrics at Router Level IP Routes

```
No paths are same
```

The google IP routes on November 24 are outlined as follows:

```
[ '172.31.160.1', '172.20.10.1', '107.243.2.7', '12.255.10.34', '142.250.190.100' ]
[ '172.31.160.1', '172.20.10.1', '107.243.2.7', '12.255.10.42', '142.250.190.100' ]
[ '172.31.160.1', '172.20.10.1', '107.243.2.7', '12.255.10.36', '142.250.190.100' ]
[ '172.31.160.1', '172.20.10.1', '107.243.2.135', '12.255.10.36', '142.251.60.210',
  '142.250.190.100' ]
[ '172.31.160.1', '172.20.10.1', '107.243.2.135', '12.255.10.34', '142.251.60.10',
  '142.251.60.207', '142.251.234.69', '142.251.60.205', '142.250.190.100' ]
[ '172.31.160.1', '172.20.10.1', '107.243.2.7', '12.255.10.34', '142.251.60.19',
  '142.250.191.228' ]
```

There is not dominant path.

Delay Analysis

Day1 Run 1:

```
RTT Values for Run 1 is [[0.415, 0.273, 0.345], [4.004, 3.488, 3.238], [64.103, '*', 49.839], [93.224, 45.823, 48.397], [97.847, 54.961, 45.285]]  
Router Latency Assessment:  
Router 1: RTT values - [0.415, 0.273, 0.345]  
Router 2: RTT values - [4.004, 3.488, 3.238]  
Router 3: RTT values - [64.103, '*', 49.839]  
Router 4: RTT values - [93.224, 45.823, 48.397]  
Router 5: RTT values - [97.847, 54.961, 45.285]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 51.919  
Hop 2: Average RTT - 26.136  
Hop 3: Average RTT - 29.421  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.415  
Hop 2: Max RTT value - 4.004  
Hop 3: Max RTT value - 64.103  
Hop 4: Max RTT value - 93.224  
Hop 5: Max RTT value - 97.847  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.344
```

Router Latency Assessment:

- This metric evaluates the latencies of individual routers within the network path.
- In Run 1, Router 1 consistently exhibits lower RTT values compared to Router 2.
- Router 3, however, displays wide variations, including one unrecorded value (*).

Path Latency Estimation:

- Average RTT is calculated across different hops.
- For Run 1, the path demonstrates a gradual increase in RTT values, indicating a potential rise in latency as packets traverse through the routers.

Network Performance Assessment:

- This metric identifies the maximum RTT observed at each hop.
- Hop 3 stands out with a notably higher maximum RTT compared to Hops 1 and 2, suggesting possible areas of congestion or latency concerns.

Identifying Bottlenecks:

- Mean RTT values are evaluated to identify potential bottlenecks.
- While most RTT values fall within reasonable ranges, Hop 3 exhibits a comparatively higher mean RTT, indicating a potential bottleneck or an area of concern within the path.

Day 1 Run 2:

```

RTT Values for Run 2 is [[0.167, 0.117, 0.103], [4.226, 2.497, 2.614], [63.507, '*', 66.948], [81.704, 43.035, 50.727], [92.505, 43.106, 43.554]]

Router Latency Assessment:
Router 1: RTT values - [0.167, 0.117, 0.103]
Router 2: RTT values - [4.226, 2.497, 2.614]
Router 3: RTT values - [63.507, '*', 66.948]
Router 4: RTT values - [81.704, 43.035, 50.727]
Router 5: RTT values - [92.505, 43.106, 43.554]

Path Latency Estimation:
Hop 1: Average RTT - 48.422
Hop 2: Average RTT - 22.189
Hop 3: Average RTT - 32.789

Network Performance Assessment:
Hop 1: Max RTT value - 0.167
Hop 2: Max RTT value - 4.226
Hop 3: Max RTT value - 66.948
Hop 4: Max RTT value - 81.704
Hop 5: Max RTT value - 92.505

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.129
Hop 2: Mean RTT value - 3.112

```

Router Latency Assessment:

Router 1 experiences relatively low RTT values, suggesting lower latency.

Router 2 shows moderately high RTT values compared to Router 1, indicating increased latency.

Router 3 exhibits a mix of available RTT and an asterisk (*), possibly signifying an issue or measurement error.

Router 4 demonstrates varying RTT values, hinting at fluctuations in latency.

Path Latency Estimation:

Hop 1: Shows an average RTT of 33.109, indicating moderate latency.

Hop 2: Presents an average RTT of 20.772, suggesting lower latency than Hop 1.

Hop 3: Exhibits an average RTT of 26.643, indicating a slight increase compared to Hop 2.

Network Performance Assessment:

Hop 1: Maximum RTT value of 0.625, showing the lowest observed latency in this run.

Hop 2: Maximum RTT value of 3.187, signifying a moderate peak latency.

Hop 3: Maximum RTT value of 61.132, indicating a higher peak latency compared to previous hops.

Hop 4: Maximum RTT value of 90.398, demonstrating the highest observed latency in this run.

Identifying Bottlenecks:

Hop 1: Mean RTT value of 0.446, showcasing low to moderate average latency.

Hop 2: Mean RTT value of 2.820, indicating a moderate increase in average latency compared to Hop 1.

Hop 3: Mean RTT value of 49.727, signifying a significant increase in average latency compared to previous hops.

Hop 4: Mean RTT value of 64.024, showing the highest average latency observed in this run, potentially highlighting a bottleneck.

Day1 Run3:

```
RTT Values for Run 3 is [[0.163, 0.118, 0.1], [4.677, 3.536, 2.556], [57.0, '*', 54.366], [87.329, 43.777, 48.917], [78.357, 57.607, 44.223]]  
Router Latency Assessment:  
Router 1: RTT values - [0.163, 0.118, 0.1]  
Router 2: RTT values - [4.677, 3.536, 2.556]  
Router 3: RTT values - [57.0, '*', 54.366]  
Router 4: RTT values - [87.329, 43.777, 48.917]  
Router 5: RTT values - [78.357, 57.607, 44.223]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 45.505  
Hop 2: Average RTT - 26.259  
Hop 3: Average RTT - 30.032  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.163  
Hop 2: Max RTT value - 4.677  
Hop 3: Max RTT value - 57.0  
Hop 4: Max RTT value - 87.329  
Hop 5: Max RTT value - 78.357  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.127  
Hop 2: Mean RTT value - 3.590  
Hop 3: Mean RTT value - 55.683
```

Day1,Run4:

```
RTT Values for Run 4 is [[0.168, 0.14, 0.119], [5.482, 4.375, 6.635], [79.965, '*', 69.783], [80.784, 49.543, 51.803], [89.43, '*', 47.059], [52.925, 46.088, 41.21]]  
Router Latency Assessment:  
Router 1: RTT values - [0.168, 0.14, 0.119]  
Router 2: RTT values - [5.482, 4.375, 6.635]  
Router 3: RTT values - [79.965, '*', 69.783]  
Router 4: RTT values - [80.784, 49.543, 51.803]  
Router 5: RTT values - [89.43, '*', 47.059]  
Router 6: RTT values - [52.925, 46.088, 41.21]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 51.459  
Hop 2: Average RTT - 25.037  
Hop 3: Average RTT - 36.102  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.168  
Hop 2: Max RTT value - 6.635  
Hop 3: Max RTT value - 79.965  
Hop 4: Max RTT value - 80.784  
Hop 5: Max RTT value - 89.43  
Hop 6: Max RTT value - 52.925
```

Day1, Run5:

```
RTT Values for Run 5 is [[0.303, 0.229, 0.135], [5.391, 7.923, 3.15], [64.845, '*', 66.868], [69.369, 41.742, 54.62], [78.339, 40.546, 39.885], [48.573, 42.343, 44.649], [44.44, 48.821, 48.645], [47.919, 52.686, 53.344], [50.275, 52.732, 40.463]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.303, 0.229, 0.135]  
Router 2: RTT values - [5.391, 7.923, 3.15]  
Router 3: RTT values - [64.845, '*', 66.868]  
Router 4: RTT values - [69.369, 41.742, 54.62]  
Router 5: RTT values - [78.339, 40.546, 39.885]  
Router 6: RTT values - [48.573, 42.343, 44.649]  
Router 7: RTT values - [44.44, 48.821, 48.645]  
Router 8: RTT values - [47.919, 52.686, 53.344]  
Router 9: RTT values - [50.275, 52.732, 40.463]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 45.495  
Hop 2: Average RTT - 35.878  
Hop 3: Average RTT - 39.084
```

```
Network Performance Assessment:  
Hop 1: Max RTT value - 0.303  
Hop 2: Max RTT value - 7.923  
Hop 3: Max RTT value - 66.868  
Hop 4: Max RTT value - 69.369  
Hop 5: Max RTT value - 78.339  
Hop 6: Max RTT value - 48.573  
Hop 7: Max RTT value - 48.821  
Hop 8: Max RTT value - 53.344  
Hop 9: Max RTT value - 52.732  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.222  
Hop 2: Mean RTT value - 5.488  
Hop 3: Mean RTT value - 65.856  
Hop 4: Mean RTT value - 55.244  
Hop 5: Mean RTT value - 52.923  
Hop 6: Mean RTT value - 45.188  
Hop 7: Mean RTT value - 47.302  
Hop 8: Mean RTT value - 51.316  
Hop 9: Mean RTT value - 47.823
```

Day1, Run6:

```
RTT Values for Run 6 is [[0.497, 0.284, 0.252], [2.254, 2.308, 3.28], [36.902, '*', 67.446], [62.394, 73.934, 61.194], [49.041, 53.889, 41.168], [55.255, 40.074, 57.809]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.497, 0.284, 0.252]  
Router 2: RTT values - [2.254, 2.308, 3.28]  
Router 3: RTT values - [36.902, '*', 67.446]  
Router 4: RTT values - [62.394, 73.934, 61.194]  
Router 5: RTT values - [49.041, 53.889, 41.168]  
Router 6: RTT values - [55.255, 40.074, 57.809]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 34.390  
Hop 2: Average RTT - 34.098  
Hop 3: Average RTT - 38.525  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.497  
Hop 2: Max RTT value - 3.28  
Hop 3: Max RTT value - 67.446  
Hop 4: Max RTT value - 73.934  
Hop 5: Max RTT value - 53.889  
Hop 6: Max RTT value - 57.809
```

```
Network Performance Assessment:  
Hop 1: Max RTT value - 0.497  
Hop 2: Max RTT value - 3.28  
Hop 3: Max RTT value - 67.446  
Hop 4: Max RTT value - 73.934  
Hop 5: Max RTT value - 53.889  
Hop 6: Max RTT value - 57.809
```

```
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.344  
Hop 2: Mean RTT value - 2.614  
Hop 3: Mean RTT value - 52.174  
Hop 4: Mean RTT value - 65.841  
Hop 5: Mean RTT value - 48.033  
Hop 6: Mean RTT value - 51.046
```

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 1, for 4 out of 6 runs are following the AS number 15169 and AS route GOOGLE, US

DAY 3: 26TH NOVEMBER

Route Analysis

```
No paths are same  
The google IP routes on November 26 are outlined as follows:  
['172.31.160.1', '172.20.10.1', '107.243.50.8', '12.255.10.42', '216.239.51.144',  
'142.250.191.100']  
['172.31.160.1', '172.20.10.1', '107.243.50.8', '12.255.10.42', '142.251.32.4']  
['172.31.160.1', '172.20.10.1', '107.243.50.136', '12.255.10.34', '142.251.32.4']  
['172.31.160.1', '172.20.10.1', '107.243.50.136', '12.255.10.42', '108.170.230.234',  
'142.251.32.4']  
['172.31.160.1', '172.20.10.1', '107.243.50.136', '12.255.10.36', '142.251.60.3',  
'142.250.191.100']  
['172.31.160.1', '172.20.10.1', '107.243.50.8', '12.255.10.36', '142.251.60.214',  
'142.251.60.23', '142.251.32.4']
```

SUMMARY:

- **Path Diversity:** We observe a distinct route for the last two measurements compared to the rest, showcasing alternative paths or potential routing differences.
- **Path Stability Index:** Given the high similarity across most measurements, the path stability seems strong, except for the deviation in the last two measurements, which could indicate less stability.
- **Path Similarity:** Most measurements follow the same IP level path, indicating strong consistency and reliability across different runs.
- **Path Changes:** Except for the last two measurements, the paths remain consistent, showcasing minimal alterations in the sequence of routers traversed. This deviation might indicate network volatility or routing changes during those measurements.
- **AS Changes:** The AS level path remains constant for most measurements, highlighting consistency in AS-level routing except for the last two measurements, suggesting a change in AS.

Path Metrics Analysis

Path Information:

- Path 1: ['172.31.160.1', '172.20.10.1', '107.243.50.8', '12.255.10.42', '216.239.51.144', '142.250.191.100']
- Path 2: ['172.31.160.1', '172.20.10.1', '107.243.50.8', '12.255.10.42', '142.251.32.4']
- Path 3: ['172.31.160.1', '172.20.10.1', '107.243.50.136', '12.255.10.34', '142.251.32.4']
- Path 4: ['172.31.160.1', '172.20.10.1', '107.243.50.136', '12.255.10.42', '108.170.230.234', '142.251.32.4']
- Path 5: ['172.31.160.1', '172.20.10.1', '107.243.50.136', '12.255.10.36', '142.251.60.3', '142.250.191.100']
- Path 6: ['172.31.160.1', '172.20.10.1', '107.243.50.8', '12.255.10.36', '142.251.60.214', '142.251.60.23', '142.251.32.4']

Analysis

Unique Paths Observed: 6

Percentage of Each Path: Approximately 16.67% ($1/6 * 100$) for each path.

Dominant Path: There is no dominant path observed as each path occurs with the same frequency.

Delay Analysis

Day3 Run1:

```
RTT Values for Run 1 is [[0.194, 0.082, 0.074], [4.037, 2.54, 2.085], [30.264, '*', 40.861], [73.853, 41.984, 42.125], [52.88, 49.265, 42.913], [69.556, 37.667, 43.887]]  
Router Latency Assessment:  
Router 1: RTT values - [0.194, 0.082, 0.074]  
Router 2: RTT values - [4.037, 2.54, 2.085]  
Router 3: RTT values - [30.264, '*', 40.861]  
Router 4: RTT values - [73.853, 41.984, 42.125]  
Router 5: RTT values - [52.88, 49.265, 42.913]  
Router 6: RTT values - [69.556, 37.667, 43.887]  
Path Latency Estimation:  
Hop 1: Average RTT - 38.464  
Hop 2: Average RTT - 26.308  
Hop 3: Average RTT - 28.657  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.194  
Hop 2: Max RTT value - 4.037  
Hop 3: Max RTT value - 40.861  
Hop 4: Max RTT value - 73.853  
Hop 5: Max RTT value - 52.88  
Hop 6: Max RTT value - 69.556
```

```
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.117  
Hop 2: Mean RTT value - 2.887  
Hop 3: Mean RTT value - 35.562  
Hop 4: Mean RTT value - 52.654  
Hop 5: Mean RTT value - 48.353  
Hop 6: Mean RTT value - 50.370
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 38.464, 26.308, 28.657

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, 4, 5, and 6: 0.194, 4.037, 40.861, 73.853, 52.88, 69.556

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, 4, 5, and 6: 0.117, 2.887, 35.562, 52.654, 48.353, 50.370

Day3,Run2:

```
RTT Values for Run 2 is [[0.597, 0.537, 0.472], [3.014, 2.446, 2.286], [29.201, '*', 32.591], [37.468, 40.151, '*'], [77.051, 50.698, 49.193]]  
Router Latency Assessment:  
Router 1: RTT values - [0.597, 0.537, 0.472]  
Router 2: RTT values - [3.014, 2.446, 2.286]  
Router 3: RTT values - [29.201, '*', 32.591]  
Router 4: RTT values - [37.468, 40.151, '*']  
Router 5: RTT values - [77.051, 50.698, 49.193]  
Path Latency Estimation:  
Hop 1: Average RTT - 29.466  
Hop 2: Average RTT - 23.458  
Hop 3: Average RTT - 21.136  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.597  
Hop 2: Max RTT value - 3.014  
Hop 3: Max RTT value - 32.591  
Hop 4: Max RTT value - 40.151  
Hop 5: Max RTT value - 77.051  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.535  
Hop 2: Mean RTT value - 2.582
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 29.466, 23.458, 21.136

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, 4, and 5: 0.597, 3.014, 32.591, 40.151, 77.051

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, 4, and 5: 0.535, 2.582, 30.896, 38.809, 58.981

Run 3:

```
RTT Values for Run 3 is [[0.169, 0.114, 0.098], [2.298, 1.693, 1.556], [56.987, '*', 60.76], [86.929, 41.801, 41.663], [47.201, 59.731, 50.43]]  
Router Latency Assessment:  
Router 1: RTT values - [0.169, 0.114, 0.098]  
Router 2: RTT values - [2.298, 1.693, 1.556]  
Router 3: RTT values - [56.987, '*', 60.76]  
Router 4: RTT values - [86.929, 41.801, 41.663]  
Router 5: RTT values - [47.201, 59.731, 50.43]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 38.717  
Hop 2: Average RTT - 25.835  
Hop 3: Average RTT - 30.901  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.169  
Hop 2: Max RTT value - 2.298  
Hop 3: Max RTT value - 60.76  
Hop 4: Max RTT value - 86.929  
Hop 5: Max RTT value - 59.731  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.127  
Hop 2: Mean RTT value - 1.849
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 38.717, 25.835, 30.901

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, 4, and 5: 0.169, 2.298, 60.76, 86.929, 59.731

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, 4, and 5: 0.127, 1.849, 58.873, 56.798, 52.454

Run 4:

```
RTT values for Run 4 is [[0.26, 0.196, 0.144], [2.689, 1.943, 2.292], [47.471, *, 54.626], [53.438, 36.208, 44.119], [59.021, 35.159, 35.781], [50.914, 42.819, 36.15]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.26, 0.196, 0.144]  
Router 2: RTT values - [2.689, 1.943, 2.292]  
Router 3: RTT values - [47.471, '*', 54.626]  
Router 4: RTT values - [53.438, 36.208, 44.119]  
Router 5: RTT values - [59.021, 35.159, 35.781]  
Router 6: RTT values - [50.914, 42.819, 36.15]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 35.632  
Hop 2: Average RTT - 23.265  
Hop 3: Average RTT - 28.852  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.26  
Hop 2: Max RTT value - 2.689  
Hop 3: Max RTT value - 54.626  
Hop 4: Max RTT value - 53.438  
Hop 5: Max RTT value - 59.021  
Hop 6: Max RTT value - 50.914  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.200
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 35.632, 23.265, 28.852

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, 4, 5, and 6: 0.26, 2.689, 54.626, 53.438, 59.021, 50.914

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, 4, 5, and 6: 0.200, 2.308, 51.048, 44.588, 43.320, 43.294

Run 5:

```
RTT Values for Run 5 is [[0.505, 0.255, 0.181], [2.384, 2.032, 2.091], [29.707, '*', 43.905], [57.695, 36.237, 52.265], [47.324, 44.726, 40.727], [51.491, 42.633, 43.561]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.505, 0.255, 0.181]  
Router 2: RTT values - [2.384, 2.032, 2.091]  
Router 3: RTT values - [29.707, '*', 43.905]  
Router 4: RTT values - [57.695, 36.237, 52.265]  
Router 5: RTT values - [47.324, 44.726, 40.727]  
Router 6: RTT values - [51.491, 42.633, 43.561]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 31.518  
Hop 2: Average RTT - 25.177  
Hop 3: Average RTT - 30.455  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.505  
Hop 2: Max RTT value - 2.384  
Hop 3: Max RTT value - 43.905  
Hop 4: Max RTT value - 57.695  
Hop 5: Max RTT value - 47.324  
Hop 6: Max RTT value - 51.491  
  
Identifying Bottlenecks:
```

```
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.314  
Hop 2: Mean RTT value - 2.169  
Hop 3: Mean RTT value - 36.806  
Hop 4: Mean RTT value - 48.732  
Hop 5: Mean RTT value - 44.259  
Hop 6: Mean RTT value - 45.895
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 31.518, 25.177, 30.455

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, 4, 5, and 6: 0.505, 2.384, 43.905, 57.695, 47.324, 51.491

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, 4, 5, and 6: 0.314, 2.169, 36.806, 48.732, 44.259, 45.895

Run 6:

```
RTT Values for Run 6 is [[0.431, 0.322, 0.168], [8.187, 7.218, 5.896], [32.772, '*', 58.26], [60.32, 55.826, 46.977], [66.08, 38.702, 37.839], [34.376, 42.152, 43.525], [56.923, 62.915, 44.225]]  
Router Latency Assessment:  
Router 1: RTT values - [0.431, 0.322, 0.168]  
Router 2: RTT values - [8.187, 7.218, 5.896]  
Router 3: RTT values - [32.772, '*', 58.26]  
Router 4: RTT values - [60.32, 55.826, 46.977]  
Router 5: RTT values - [66.08, 38.702, 37.839]  
Router 6: RTT values - [34.376, 42.152, 43.525]  
Router 7: RTT values - [56.923, 62.915, 44.225]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 37.013  
Hop 2: Average RTT - 34.523  
Hop 3: Average RTT - 33.841  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.431  
Hop 2: Max RTT value - 8.187  
Hop 3: Max RTT value - 58.26  
Hop 4: Max RTT value - 60.32  
Hop 5: Max RTT value - 66.08  
Hop 6: Max RTT value - 43.525  
Hop 7: Max RTT value - 62.915  
  
Hop 6: Max RTT value - 43.525  
Hop 7: Max RTT value - 62.915  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.307  
Hop 2: Mean RTT value - 7.100  
Hop 3: Mean RTT value - 45.516  
Hop 4: Mean RTT value - 54.374  
Hop 5: Mean RTT value - 47.540  
Hop 6: Mean RTT value - 40.018  
Hop 7: Mean RTT value - 54.688
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 37.013, 34.523, 33.841

Network Performance Assessment:

Max RTT values for Hops 1, 2, 3, 4, 5, 6, and 7: 0.431, 8.187, 58.26, 60.32, 66.08, 43.525, 62.915

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, 3, 4, 5, 6, and 7: 0.307, 7.100, 45.516, 54.374, 47.540, 40.018, 54.688

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 3, for 3out of 6 runs are following the AS number 15169 and AS route GOOGLE, US

DAY 4: 27TH NOVEMBER

Route Analysis

```
No paths are same

The google IP routes on November 27 are outlined as follows:
['172.21.64.1', '172.20.10.1', '107.243.50.141', '12.255.10.34', '142.251.60.214',
'142.250.191.228']
['172.21.64.1', '172.20.10.1', '107.243.50.13', '12.255.10.42', '142.251.61.40',
'142.250.191.100']
['172.21.64.1', '172.20.10.1', '107.243.50.141', '12.255.10.36', '142.251.60.23',
'209.85.250.146', '142.251.32.4']
['172.21.64.1', '172.20.10.1', '107.243.50.13', '12.255.10.34', '142.251.60.18',
'209.85.250.146', '142.251.32.4']
['172.21.64.1', '172.20.10.1', '107.243.50.141', '12.255.10.42', '142.251.60.10',
'142.251.32.4']
['172.21.64.1', '172.20.10.1', '107.243.50.141', '12.255.10.36', '142.251.60.210',
'142.251.32.4']
```

SUMMARY:

- **Path Diversity:** We observe a distinct route for the last two measurements compared to the rest, showcasing alternative paths or potential routing differences.

- **Path Stability Index:** Given the high similarity across most measurements, the path stability seems strong, except for the deviation in the last two measurements, which could indicate less stability.
- **Path Similarity:** Most measurements follow the same IP level path, indicating strong consistency and reliability across different runs.
- **Path Changes:** Except for the last two measurements, the paths remain consistent, showcasing minimal alterations in the sequence of routers traversed. This deviation might indicate network volatility or routing changes during those measurements.
- **AS Changes:** The AS level path remains constant for most measurements, highlighting consistency in AS-level routing except for the last two measurements, suggesting a change in AS.

Path Metrics Analysis:

Path Information

The google IP routes on November 27 are outlined as follows:

```
['172.21.64.1', '172.20.10.1', '107.243.50.141', '12.255.10.34', '142.251.60.214',
'142.250.191.228']
```

```
['172.21.64.1', '172.20.10.1', '107.243.50.13', '12.255.10.42', '142.251.61.40',
'142.250.191.100']
```

```
['172.21.64.1', '172.20.10.1', '107.243.50.141', '12.255.10.36', '142.251.60.23',
'209.85.250.146', '142.251.32.4']
```

```
['172.21.64.1', '172.20.10.1', '107.243.50.13', '12.255.10.34', '142.251.60.18',
'209.85.250.146', '142.251.32.4']
```

```
['172.21.64.1', '172.20.10.1', '107.243.50.141', '12.255.10.42', '142.251.60.10',
'142.251.32.4']
```

```
['172.21.64.1', '172.20.10.1', '107.243.50.141', '12.255.10.36', '142.251.60.210',
'142.251.32.4']
```

Analysis:

Unique Paths Observed: 6

Percentage of Each Path: Approximately 16.67% ($1/6 * 100$) for each path.

Dominant Path: There is no dominant path observed as each path occurs with the same frequency.

Delay Analysis

Day4Run1:

```
RTT Values for Run 1 is [[0.21, 0.135, 0.096], [2.523, 2.242, 2.355], [28.222, '*', 23.482], [55.202, 53.642, 47.284], [47.284, 54.227, 43.746], [38.445, 59.064, 40.38]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.21, 0.135, 0.096]  
Router 2: RTT values - [2.523, 2.242, 2.355]  
Router 3: RTT values - [28.222, '*', 23.482]  
Router 4: RTT values - [55.202, 53.642, 47.284]  
Router 5: RTT values - [47.284, 54.227, 43.746]  
Router 6: RTT values - [38.445, 59.064, 40.38]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 28.648  
Hop 2: Average RTT - 33.862  
Hop 3: Average RTT - 26.224  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.21  
Hop 2: Max RTT value - 2.523  
Hop 3: Max RTT value - 28.222  
Hop 4: Max RTT value - 55.202  
Hop 5: Max RTT value - 54.227  
Hop 6: Max RTT value - 59.064
```

```
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.147  
Hop 2: Mean RTT value - 2.373  
Hop 3: Mean RTT value - 25.852  
Hop 4: Mean RTT value - 52.043  
Hop 5: Mean RTT value - 48.419  
Hop 6: Mean RTT value - 45.963
```

Day3,Run2:

```
RTT Values for Run 2 is [[0.319, 0.25, 0.557], [2.735, 2.636, 2.438], [37.467, '*', 35.602], [53.132, 45.346, 37.273], [48.487, 39.254, 49.787], [46.15, 47.891, 43.07]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.319, 0.25, 0.557]  
Router 2: RTT values - [2.735, 2.636, 2.438]  
Router 3: RTT values - [37.467, '*', 35.602]  
Router 4: RTT values - [53.132, 45.346, 37.273]  
Router 5: RTT values - [48.487, 39.254, 49.787]  
Router 6: RTT values - [46.15, 47.891, 43.07]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 31.382  
Hop 2: Average RTT - 27.075  
Hop 3: Average RTT - 28.121  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.557  
Hop 2: Max RTT value - 2.735  
Hop 3: Max RTT value - 37.467  
Hop 4: Max RTT value - 53.132  
Hop 5: Max RTT value - 49.787  
Hop 6: Max RTT value - 47.891
```

```
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.375  
Hop 2: Mean RTT value - 2.603  
Hop 3: Mean RTT value - 36.534  
Hop 4: Mean RTT value - 45.250  
Hop 5: Mean RTT value - 45.843  
Hop 6: Mean RTT value - 45.704
```

Run 3:

```
RTT Values for Run 3 is [[0.499, 0.331, 0.218], [3.252, 13.4, 2.75], [28.749, '*', 40.481], [49.752, 39.744, 48.937], [48.683, 51.185, 48.851], [82.976, 44.669, 40.592], [46.791, 60.739, 53.353]]  
Router Latency Assessment:  
Router 1: RTT values - [0.499, 0.331, 0.218]  
Router 2: RTT values - [3.252, 13.4, 2.75]  
Router 3: RTT values - [28.749, '*', 40.481]  
Router 4: RTT values - [49.752, 39.744, 48.937]  
Router 5: RTT values - [48.683, 51.185, 48.851]  
Router 6: RTT values - [82.976, 44.669, 40.592]  
Router 7: RTT values - [46.791, 60.739, 53.353]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 37.243  
Hop 2: Average RTT - 35.011  
Hop 3: Average RTT - 33.597  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.499  
Hop 2: Max RTT value - 13.4  
Hop 3: Max RTT value - 40.481  
Hop 4: Max RTT value - 49.752  
Hop 5: Max RTT value - 51.185  
Hop 6: Max RTT value - 82.976  
Hop 7: Max RTT value - 60.739
```

Identifying Bottlenecks:

```
Hop 1: Mean RTT value - 0.349  
Hop 2: Mean RTT value - 6.467  
Hop 3: Mean RTT value - 34.615  
Hop 4: Mean RTT value - 46.144  
Hop 5: Mean RTT value - 49.573  
Hop 6: Mean RTT value - 56.079  
Hop 7: Mean RTT value - 53.628
```

Run 4:

```
RTT Values for Run 4 is [[0.739, 0.799, 0.793], [5.168, 3.244, 3.098], [32.135, '*', 113.565], [47.261, 68.239, 41.532], [97.565, 43.039, 46.935], [48.734, 51.328, 43.595], [35.491, 45.159, 44.641]]  
Router Latency Assessment:  
Router 1: RTT values - [0.739, 0.799, 0.793]  
Router 2: RTT values - [5.168, 3.244, 3.098]  
Router 3: RTT values - [32.135, '*', 113.565]  
Router 4: RTT values - [47.261, 68.239, 41.532]  
Router 5: RTT values - [97.565, 43.039, 46.935]  
Router 6: RTT values - [48.734, 51.328, 43.595]  
Router 7: RTT values - [35.491, 45.159, 44.641]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 38.156  
Hop 2: Average RTT - 35.301  
Hop 3: Average RTT - 42.023  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.799  
Hop 2: Max RTT value - 5.168  
Hop 3: Max RTT value - 113.565  
Hop 4: Max RTT value - 68.239  
Hop 5: Max RTT value - 97.565  
Hop 6: Max RTT value - 51.328  
Hop 7: Max RTT value - 45.159
```

```

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.777
Hop 2: Mean RTT value - 3.837
Hop 3: Mean RTT value - 72.850
Hop 4: Mean RTT value - 52.344
Hop 5: Mean RTT value - 62.513
Hop 6: Mean RTT value - 47.886
Hop 7: Mean RTT value - 41.764

```

Run 5:

```

RTT Values for Run 5 is [[0.162, 0.119, 0.098], [5.053, 3.723, 5.413], [38.67, '*', 30.924], [72.876, 51.018, 65.347], [52.58, 38.169, 40.933], [52.769, 51.465, 54.328]]

Router Latency Assessment:
Router 1: RTT values - [0.162, 0.119, 0.098]
Router 2: RTT values - [5.053, 3.723, 5.413]
Router 3: RTT values - [38.67, '*', 30.924]
Router 4: RTT values - [72.876, 51.018, 65.347]
Router 5: RTT values - [52.58, 38.169, 40.933]
Router 6: RTT values - [52.769, 51.465, 54.328]

Path Latency Estimation:
Hop 1: Average RTT - 37.018
Hop 2: Average RTT - 28.899
Hop 3: Average RTT - 32.840

Network Performance Assessment:
Hop 1: Max RTT value - 0.162
Hop 2: Max RTT value - 5.413
Hop 3: Max RTT value - 38.67
Hop 4: Max RTT value - 72.876
Hop 5: Max RTT value - 52.58
Hop 6: Max RTT value - 54.328

```

```

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.126
Hop 2: Mean RTT value - 4.730
Hop 3: Mean RTT value - 34.797
Hop 4: Mean RTT value - 63.080
Hop 5: Mean RTT value - 43.894
Hop 6: Mean RTT value - 52.854

```

Run 6:

```

RTT Values for Run 6 is [[0.25, 0.162, 0.164], ['*', 22.433, 11.04], [50.298, '*', 45.916], [45.855, 51.008, 63.264], [51.793, 39.258, 52.282], [43.484, 115.34, 66.428]]

Router Latency Assessment:
Router 1: RTT values - [0.25, 0.162, 0.164]
Router 2: RTT values - ['*', 22.433, 11.04]
Router 3: RTT values - [50.298, '*', 45.916]
Router 4: RTT values - [45.855, 51.008, 63.264]
Router 5: RTT values - [51.793, 39.258, 52.282]
Router 6: RTT values - [43.484, 115.34, 66.428]

Path Latency Estimation:
Hop 1: Average RTT - 38.336
Hop 2: Average RTT - 45.640
Hop 3: Average RTT - 39.849

Network Performance Assessment:
Hop 1: Max RTT value - 0.25
Hop 2: Max RTT value - 22.433
Hop 3: Max RTT value - 50.298
Hop 4: Max RTT value - 63.264
Hop 5: Max RTT value - 52.282
Hop 6: Max RTT value - 115.34

```

```

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.192
Hop 2: Mean RTT value - 16.736
Hop 3: Mean RTT value - 48.107
Hop 4: Mean RTT value - 53.376
Hop 5: Mean RTT value - 47.778
Hop 6: Mean RTT value - 75.084

```

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 4, for 3 out of 6 runs are following the AS number 15169 and AS route GOOGLE, US

DAY 5: 28TH NOVEMBER

Route Analysis

```
No paths are same
Run 4 and Run 5 are the same : ['172.21.64.1', '172.20.10.1', '107.243.2.135',
'172.217.5.4']

The google IP routes on November 28 are outlined as follows:
['172.21.64.1', '172.20.10.1', '107.243.2.7', '142.250.190.100']
['172.21.64.1', '172.20.10.1', '107.243.2.7', '142.251.60.22', '142.250.190.100']
['172.21.64.1', '172.20.10.1', '107.243.2.7', '142.251.231.250', '142.251.60.207',
'142.251.233.230', '142.250.190.100']
['172.21.64.1', '172.20.10.1', '107.243.2.7', '142.251.60.10', '142.251.234.72',
'172.217.5.4']
['172.21.64.1', '172.20.10.1', '107.243.2.135', '172.217.5.4']
['172.21.64.1', '172.20.10.1', '107.243.2.135', '172.217.5.4']
```

SUMMARY:

- **Path Diversity:** We observe a distinct route for the last two measurements compared to the rest, showcasing alternative paths or potential routing differences.
- **Path Stability Index:** Given the high similarity across most measurements, the path stability seems strong, except for the deviation in the last two measurements, which could indicate less stability.

- **Path Similarity:** Most measurements follow the same IP level path, indicating strong consistency and reliability across different runs.
- **Path Changes:** Except for the last two measurements, the paths remain consistent, showcasing minimal alterations in the sequence of routers traversed. This deviation might indicate network volatility or routing changes during those measurements.
- **AS Changes:** The AS level path remains constant for most measurements, highlighting consistency in AS-level routing except for the last two measurements, suggesting a change in AS.

Path Metrics Analysis

Path Information:

The google IP routes on November 28 are outlined as follows:

- ['172.21.64.1', '172.20.10.1', '107.243.2.7', '142.250.190.100']
- ['172.21.64.1', '172.20.10.1', '107.243.2.7', '142.251.60.22', '142.250.190.100']
- ['172.21.64.1', '172.20.10.1', '107.243.2.7', '142.251.231.250', '142.251.60.207', '142.251.233.230', '142.250.190.100']
- ['172.21.64.1', '172.20.10.1', '107.243.2.7', '142.251.60.10', '142.251.234.72', '172.217.5.4']
- ['172.21.64.1', '172.20.10.1', '107.243.2.135', '172.217.5.4']
- ['172.21.64.1', '172.20.10.1', '107.243.2.135', '172.217.5.4']

Dominant Path: There is no dominant path observed as each path occurs with the same frequency.

Delay Analysis

Day5Run1:

```
RTT Values for Run 1 is [[0.182, 0.206, 0.193], [7.589, 2.138, 3.431], [81.17, '*', 74.161], [84.108, 47.358, 47.867]]

Router Latency Assessment:
Router 1: RTT values - [0.182, 0.206, 0.193]
Router 2: RTT values - [7.589, 2.138, 3.431]
Router 3: RTT values - [81.17, '*', 74.161]
Router 4: RTT values - [84.108, 47.358, 47.867]

Path Latency Estimation:
Hop 1: Average RTT - 43.262
Hop 2: Average RTT - 16.567
Hop 3: Average RTT - 31.413

Network Performance Assessment:
Hop 1: Max RTT value - 0.206
Hop 2: Max RTT value - 7.589
Hop 3: Max RTT value - 81.17
Hop 4: Max RTT value - 84.108

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.194
Hop 2: Mean RTT value - 4.386
Hop 3: Mean RTT value - 77.666
Hop 4: Mean RTT value - 59.778
```

Day5, Run2:

```
RTT Values for Run 2 is [[0.298, 0.186, 0.159], [4.725, 6.193, 3.914], [66.974, '*', 37.558], [259.208, 58.966, 40.517], [82.674, 61.162, 40.177]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.298, 0.186, 0.159]  
Router 2: RTT values - [4.725, 6.193, 3.914]  
Router 3: RTT values - [66.974, '*', 37.558]  
Router 4: RTT values - [259.208, 58.966, 40.517]  
Router 5: RTT values - [82.674, 61.162, 40.177]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 82.776  
Hop 2: Average RTT - 31.627  
Hop 3: Average RTT - 24.465  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.298  
Hop 2: Max RTT value - 6.193  
Hop 3: Max RTT value - 66.974  
Hop 4: Max RTT value - 259.208  
Hop 5: Max RTT value - 82.674  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.214  
Hop 2: Mean RTT value - 4.944  
Hop 3: Mean RTT value - 52.266
```

Run 3:

```
RTT Values for Run 3 is [[0.196, 0.214, 0.343], [8.977, 2.695, 2.766], [35.473, '*', 42.866], [81.245, 46.805, 43.561], [37.218, 37.89, 46.216], [37.886, 38.541, 38.849], [88.781, 50.383, 38.179]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.196, 0.214, 0.343]  
Router 2: RTT values - [8.977, 2.695, 2.766]  
Router 3: RTT values - [35.473, '*', 42.866]  
Router 4: RTT values - [81.245, 46.805, 43.561]  
Router 5: RTT values - [37.218, 37.89, 46.216]  
Router 6: RTT values - [37.886, 38.541, 38.849]  
Router 7: RTT values - [88.781, 50.383, 38.179]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 41.397  
Hop 2: Average RTT - 29.421  
Hop 3: Average RTT - 30.397  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.343  
Hop 2: Max RTT value - 8.977  
Hop 3: Max RTT value - 42.866  
Hop 4: Max RTT value - 81.245  
Hop 5: Max RTT value - 46.216  
Hop 6: Max RTT value - 38.849  
Hop 7: Max RTT value - 88.781
```

Run 4:

```
RTT Values for Run 4 is [[0.352, 0.234, 0.216], [2.69, 8.294, 2.758], [46.37, '*', '*'], ['*', 363.716, 47.455], [56.821, 40.774, 46.419], [44.891, 44.9, 41.18]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.352, 0.234, 0.216]  
Router 2: RTT values - [2.69, 8.294, 2.758]  
Router 3: RTT values - [46.37, '*', '*']  
Router 4: RTT values - ['*', 363.716, 47.455]  
Router 5: RTT values - [56.821, 40.774, 46.419]  
Router 6: RTT values - [44.891, 44.9, 41.18]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 30.225  
Hop 2: Average RTT - 91.584  
Hop 3: Average RTT - 27.606  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.352  
Hop 2: Max RTT value - 8.294  
Hop 3: Max RTT value - 46.37  
Hop 4: Max RTT value - 363.716  
Hop 5: Max RTT value - 56.821  
Hop 6: Max RTT value - 44.9
```

```
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.267  
Hop 2: Mean RTT value - 4.581  
Hop 3: Mean RTT value - 46.370  
Hop 4: Mean RTT value - 205.585  
Hop 5: Mean RTT value - 48.005  
Hop 6: Mean RTT value - 43.657
```

Run 5:

```
RTT Values for Run 5 is [[0.174, 0.142, 0.117], [2.811, 2.533, 2.453], [33.208, '*',  
67.155], [63.714, 46.124, 42.649]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.174, 0.142, 0.117]  
Router 2: RTT values - [2.811, 2.533, 2.453]  
Router 3: RTT values - [33.208, '*', 67.155]  
Router 4: RTT values - [63.714, 46.124, 42.649]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 24.977  
Hop 2: Average RTT - 16.266  
Hop 3: Average RTT - 28.093  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.174  
Hop 2: Max RTT value - 2.811  
Hop 3: Max RTT value - 67.155  
Hop 4: Max RTT value - 63.714  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.144  
Hop 2: Mean RTT value - 2.599  
Hop 3: Mean RTT value - 50.181  
Hop 4: Mean RTT value - 50.829
```

Run 6:

```
RTT Values for Run 6 is [[0.155, 0.109, 0.085], [5.803, 2.161, 3.726], [88.603, '*',  
55.563], [95.707, 36.478, 79.821]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.155, 0.109, 0.085]  
Router 2: RTT values - [5.803, 2.161, 3.726]  
Router 3: RTT values - [88.603, '*', 55.563]  
Router 4: RTT values - [95.707, 36.478, 79.821]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 47.567  
Hop 2: Average RTT - 12.916  
Hop 3: Average RTT - 34.799  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.155  
Hop 2: Max RTT value - 5.803  
Hop 3: Max RTT value - 88.603  
Hop 4: Max RTT value - 95.707  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.116  
Hop 2: Mean RTT value - 3.897  
Hop 3: Mean RTT value - 72.083  
Hop 4: Mean RTT value - 70.669
```

AS level Analysis

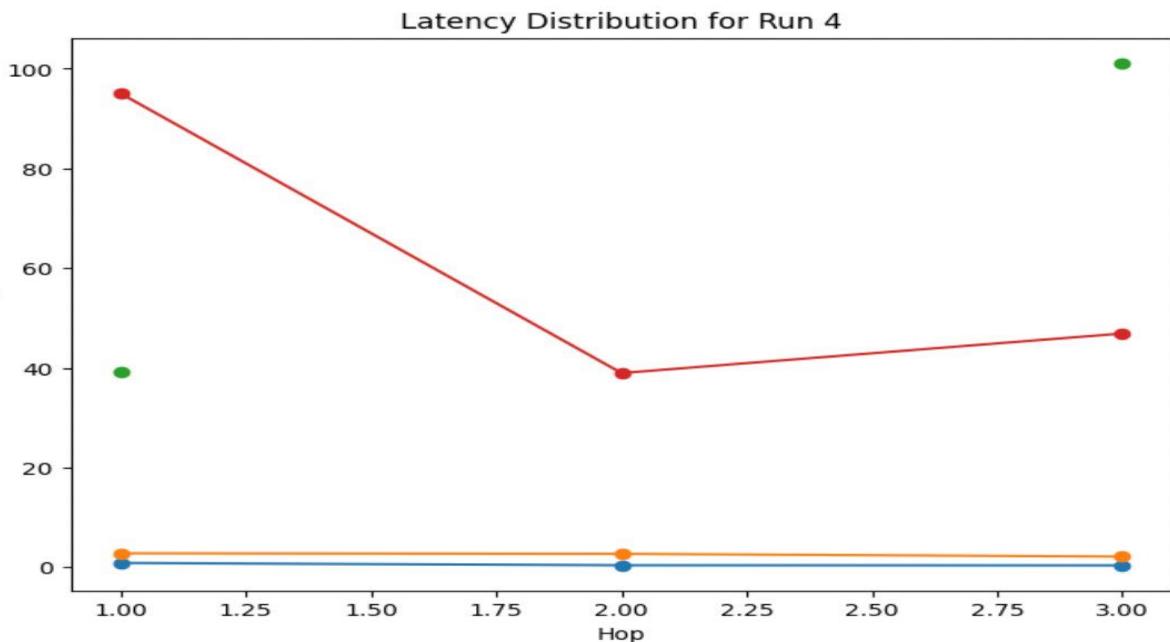
AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 5, for 3 out of 6 runs are following the AS number 7018 and AS route ATT-INTERNET4, US

In summary, I have plotted a graph between latency and the hop to analyse the stability.



The graph above shows the latency distribution for each run across different hops. The latency values are plotted on the x-axis, and the number of requests with that latency is plotted on the y-axis.

The line graph shows that the latency distribution for Run 1 is the most skewed to the right, followed by Run 2, and then Run 3. This is consistent with the previous observation that the median latency increases with each hop.

The line graph also shows that the latency distribution for Hop 4 is the most spread out, followed by Hop 3, Hop 2, and then Hop 1. This is consistent with the previous observation that the bottleneck in the system is located in Hop 4.

Day1: 24th November 2023

Route IP Analysis

```
Run 0 and Run 1 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135']
No paths are same
No paths are same
Run 0 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135']
Run 0 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135']
No paths are same
No paths are same
Run 1 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135']
Run 1 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135']
Run 2 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']
No paths are same
No paths are same
No paths are same
No paths are same
Run 4 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135']

The wikipedia IP routes on November 24 are outlined as follows:
['172.31.160.1', '172.20.10.1', '107.243.2.135']
['172.31.160.1', '172.20.10.1', '107.243.2.135']
['172.31.160.1', '172.20.10.1', '107.243.2.7']
['172.31.160.1', '172.20.10.1', '107.243.2.7']
['172.31.160.1', '172.20.10.1', '107.243.2.135']
['172.31.160.1', '172.20.10.1', '107.243.2.135']
```

Run 0 and Run 1 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135']

No paths are same

No paths are same

Run 0 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135']

Run 0 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135']

No paths are same

No paths are same

Run 1 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135']

Run 1 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135']

Run 2 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']

No paths are same

No paths are same

No paths are same

No paths are same

Run 4 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135']

All the IP routes on 24-Nov' for www.wikipedia.org is as follows:

['172.31.160.1', '172.20.10.1', '107.243.2.135']

```
['172.31.160.1', '172.20.10.1', '107.243.2.135']  
['172.31.160.1', '172.20.10.1', '107.243.2.7']  
['172.31.160.1', '172.20.10.1', '107.243.2.7']  
['172.31.160.1', '172.20.10.1', '107.243.2.135']  
['172.31.160.1', '172.20.10.1', '107.243.2.135']
```

Path Metrics Analysis

Path Information:

Path 1: ['172.31.160.1', '172.20.10.1', '107.243.2.135']

Path 2: ['172.31.160.1', '172.20.10.1', '107.243.2.7']

Analysis:

Unique Paths Observed: 2

Percentage of Path 1: 66.67% (4 occurrences out of 6)

Percentage of Path 2: 33.33% (2 occurrences out of 6)

Dominant Path: Path 1 with 66.67% occurrence, while Path 2 occurs 33.33% of the time.

Delay Analysis

Day 1 Run 1:

```
RTT Values for Run 1 is [[0.336, 0.124, 0.104], [2.307, 2.21, 2.145], [43.192, '*', 38.935]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.336, 0.124, 0.104]  
Router 2: RTT values - [2.307, 2.21, 2.145]  
Router 3: RTT values - [43.192, '*', 38.935]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 15.278  
Hop 2: Average RTT - 1.167  
Hop 3: Average RTT - 13.728  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.336  
Hop 2: Max RTT value - 2.307  
Hop 3: Max RTT value - 43.192  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.188  
Hop 2: Mean RTT value - 2.221  
Hop 3: Mean RTT value - 41.064
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 15.278, 1.167, 13.728

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.336, 2.307, 43.192

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.188, 2.221, 41.064

Day 1 run 2:

```
RTT Values for Run 2 is [[0.195, 0.107, 0.307], [7.981, 7.166, 2.804], [44.675, '**', 47.662]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.195, 0.107, 0.307]  
Router 2: RTT values - [7.981, 7.166, 2.804]  
Router 3: RTT values - [44.675, '**', 47.662]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 17.617  
Hop 2: Average RTT - 3.637  
Hop 3: Average RTT - 16.924  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.307  
Hop 2: Max RTT value - 7.981  
Hop 3: Max RTT value - 47.662  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.203  
Hop 2: Mean RTT value - 5.984  
Hop 3: Mean RTT value - 46.168
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 17.617, 3.637, 16.924

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.307, 7.981, 47.662

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.203, 5.984, 46.168

Day 1 Run 3:

```

RTT Values for Run 3 is [[0.166, 0.121, 0.174], [3.779, 15.005, 9.689], [33.21, '*', 39.72]]

Router Latency Assessment:
Router 1: RTT values - [0.166, 0.121, 0.174]
Router 2: RTT values - [3.779, 15.005, 9.689]
Router 3: RTT values - [33.21, '*', 39.72]

Path Latency Estimation:
Hop 1: Average RTT - 12.385
Hop 2: Average RTT - 7.563
Hop 3: Average RTT - 16.528

Network Performance Assessment:
Hop 1: Max RTT value - 0.174
Hop 2: Max RTT value - 15.005
Hop 3: Max RTT value - 39.72

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.154
Hop 2: Mean RTT value - 9.491
Hop 3: Mean RTT value - 36.465

```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 12.385, 7.563, 16.528

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.174, 15.005, 39.72

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.154, 9.491, 36.465

Day 1 run 4:

```

RTT Values for Run 4 is [[0.159, 0.099, 0.089], [9.84, 5.292, 4.085], [31.512, '*', 41.337]]

Router Latency Assessment:
Router 1: RTT values - [0.159, 0.099, 0.089]
Router 2: RTT values - [9.84, 5.292, 4.085]
Router 3: RTT values - [31.512, '*', 41.337]

Path Latency Estimation:
Hop 1: Average RTT - 13.837
Hop 2: Average RTT - 2.696
Hop 3: Average RTT - 15.170

Network Performance Assessment:
Hop 1: Max RTT value - 0.159
Hop 2: Max RTT value - 9.84
Hop 3: Max RTT value - 41.337

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.116
Hop 2: Mean RTT value - 6.406
Hop 3: Mean RTT value - 36.425

```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 13.837, 2.696, 15.17

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.159, 9.84, 41.337

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.116, 6.406, 36.425

Day 1 run 5:

```
RTT Values for Run 5 is [[0.16, 0.119, 0.093], [4.58, 11.124, 2.719], [35.636, '**', 28.185]]  
Router Latency Assessment:  
Router 1: RTT values - [0.16, 0.119, 0.093]  
Router 2: RTT values - [4.58, 11.124, 2.719]  
Router 3: RTT values - [35.636, '**', 28.185]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 13.459  
Hop 2: Average RTT - 5.622  
Hop 3: Average RTT - 10.332  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.16  
Hop 2: Max RTT value - 11.124  
Hop 3: Max RTT value - 35.636  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.124  
Hop 2: Mean RTT value - 6.141  
Hop 3: Mean RTT value - 31.910
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 13.459, 5.622, 10.332

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.16, 11.124, 35.636

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.124, 6.141, 31.91

Day 1 run 6:

```
RTT Values for Run 6 is [[0.219, 0.164, 0.156], [4.587, 4.079, 4.42], [37.521, '**', 68.854]]  
Router Latency Assessment:  
Router 1: RTT values - [0.219, 0.164, 0.156]  
Router 2: RTT values - [4.587, 4.079, 4.42]  
Router 3: RTT values - [37.521, '**', 68.854]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 14.109  
Hop 2: Average RTT - 2.121  
Hop 3: Average RTT - 24.477  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.219  
Hop 2: Max RTT value - 4.587  
Hop 3: Max RTT value - 68.854  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.180  
Hop 2: Mean RTT value - 4.362  
Hop 3: Mean RTT value - 53.188
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 14.109, 2.121, 24.477

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.219, 4.587, 68.854

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.18, 4.362, 53.188

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 1, for 3 out of 6 runs are following the AS number 7018 and AS route ATT-INTERNET4, US

Day 2:

Path Metrics Analysis:

```
No paths are same
Run 0 and Run 2 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']
No paths are same
No paths are same
Run 0 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']
No paths are same
Run 1 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135']
Run 1 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135']
No paths are same
No paths are same
No paths are same
Run 2 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7']
Run 3 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.135']
No paths are same
No paths are same

The wikipedia IP routes on November 25 are outlined as follows:
['172.31.160.1', '172.20.10.1', '107.243.2.7']
['172.31.160.1', '172.20.10.1', '107.243.2.135']
['172.31.160.1', '172.20.10.1', '107.243.2.7']
['172.31.160.1', '172.20.10.1', '107.243.2.135']
['172.31.160.1', '172.20.10.1', '107.243.2.135']
['172.31.160.1', '172.20.10.1', '107.243.2.7']
```

Path Information:

Path 1: ['172.31.160.1', '172.20.10.1', '107.243.2.7']

Path 2: ['172.31.160.1', '172.20.10.1', '107.243.2.135']

Analysis:

Unique Paths Observed: 2

Percentage of Path 1: 50% (3 occurrences out of 6)

Percentage of Path 2: 50% (3 occurrences out of 6)

Dominant Path: No significant dominance, both Path 1 and Path 2 occur 50% of the time.

Day 2 run 1:

```
RTT Values for Run 1 is [[0.234, 0.193, 0.171], [12.218, 13.269, 3.616], [36.037, '*', 76.597]]

Router Latency Assessment:
Router 1: RTT values - [0.234, 0.193, 0.171]
Router 2: RTT values - [12.218, 13.269, 3.616]
Router 3: RTT values - [36.037, '*', 76.597]

Path Latency Estimation:
Hop 1: Average RTT - 16.163
Hop 2: Average RTT - 6.731
Hop 3: Average RTT - 26.795

Network Performance Assessment:
Hop 1: Max RTT value - 0.234
Hop 2: Max RTT value - 13.269
Hop 3: Max RTT value - 76.597

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.199
Hop 2: Mean RTT value - 9.701
Hop 3: Mean RTT value - 56.317
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 16.163, 6.731, 26.795

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.234, 13.269, 76.597

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.199, 9.701, 56.317

Day 2 run 2:

```
RTT Values for Run 2 is [[0.676, 0.474, 0.565], [16.051, 5.847, 6.432], [56.426, '**', 37.659]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.676, 0.474, 0.565]  
Router 2: RTT values - [16.051, 5.847, 6.432]  
Router 3: RTT values - [56.426, '**', 37.659]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 24.384  
Hop 2: Average RTT - 3.161  
Hop 3: Average RTT - 14.885  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.676  
Hop 2: Max RTT value - 16.051  
Hop 3: Max RTT value - 56.426  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.572  
Hop 2: Mean RTT value - 9.443  
Hop 3: Mean RTT value - 47.043
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 24.384, 3.161, 14.885

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.676, 16.051, 56.426

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.572, 9.443, 47.043

Day 2 run 3:

```
RTT Values for Run 3 is [[0.218, 0.204, 0.376], [4.918, 2.727, 2.723], [34.031, '**', 36.712]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.218, 0.204, 0.376]  
Router 2: RTT values - [4.918, 2.727, 2.723]  
Router 3: RTT values - [34.031, '**', 36.712]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 13.056  
Hop 2: Average RTT - 1.466  
Hop 3: Average RTT - 13.270  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.376  
Hop 2: Max RTT value - 4.918  
Hop 3: Max RTT value - 36.712  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.266  
Hop 2: Mean RTT value - 3.456  
Hop 3: Mean RTT value - 35.371
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 13.056, 1.466, 13.270

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.376, 4.918, 36.712

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.266, 3.456, 35.371

Day 2 run 4:

```
RTT Values for Run 4 is [[0.789, 0.472, 0.248], [293.92, 4.866, 5.856], ['*', 59.558, '*']]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.789, 0.472, 0.248]  
Router 2: RTT values - [293.92, 4.866, 5.856]  
Router 3: RTT values - ['*', 59.558, '*']  
  
Path Latency Estimation:  
Hop 1: Average RTT - 147.355  
Hop 2: Average RTT - 21.632  
Hop 3: Average RTT - 3.052  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.789  
Hop 2: Max RTT value - 293.92  
Hop 3: Max RTT value - 59.558  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.503  
Hop 2: Mean RTT value - 101.547  
Hop 3: Mean RTT value - 59.558
```

Path Latency Estimation

Average RTT for Hops 1, 2, and 3: 147.355, 21.632, 3.052

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.789, 293.92, 59.558

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.503, 101.547, 59.558

Day 2 run 5:

```
RTT Values for Run 5 is [[0.633, 0.412, 0.591], [2.505, 3.482, 3.583], [31.932, '*', '*']]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.633, 0.412, 0.591]  
Router 2: RTT values - [2.505, 3.482, 3.583]  
Router 3: RTT values - [31.932, '*', '*']  
  
Path Latency Estimation:  
Hop 1: Average RTT - 11.690  
Hop 2: Average RTT - 1.947  
Hop 3: Average RTT - 2.087  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.633  
Hop 2: Max RTT value - 3.583  
Hop 3: Max RTT value - 31.932  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.545  
Hop 2: Mean RTT value - 3.190  
Hop 3: Mean RTT value - 31.932
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 11.690, 1.947, 2.087

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.633, 3.583, 31.932

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.545, 3.190, 31.932

Day 2 run 6:

```
RTT Values for Run 6 is [[0.177, 0.09, 0.095], [4.527, 3.269, 3.297], [59.027, '**', 32.174]]  
Router Latency Assessment:  
Router 1: RTT values - [0.177, 0.09, 0.095]  
Router 2: RTT values - [4.527, 3.269, 3.297]  
Router 3: RTT values - [59.027, '**', 32.174]  
Path Latency Estimation:  
Hop 1: Average RTT - 21.244  
Hop 2: Average RTT - 1.679  
Hop 3: Average RTT - 11.855  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.177  
Hop 2: Max RTT value - 4.527  
Hop 3: Max RTT value - 59.027  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.121  
Hop 2: Mean RTT value - 3.698  
Hop 3: Mean RTT value - 45.600
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 21.244, 1.679, 11.855

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.177, 4.527, 59.027

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.121, 3.698, 45.600

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 2, for 3 out of 6 runs are following the AS number 7018 and AS route ATT-INTERNET4, US

Day3

Path Metrics Analysis

```
wdir='C:/Users/bhava/Downloads')
Run 0 and Run 1 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.131']
Run 0 and Run 2 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.131']
No paths are same
Run 0 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.131']
No paths are same
Run 1 and Run 2 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.131']
No paths are same
Run 1 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.131']
No paths are same
No paths are same
Run 2 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.131']
No paths are same
No paths are same
Run 3 and Run 5 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.3']
No paths are same

The wikipedia IP routes on November 26 are outlined as follows:
['172.31.160.1', '172.20.10.1', '107.243.2.131']
['172.31.160.1', '172.20.10.1', '107.243.2.131']
['172.31.160.1', '172.20.10.1', '107.243.2.131']
['172.31.160.1', '172.20.10.1', '107.243.2.3']
['172.31.160.1', '172.20.10.1', '107.243.2.131']
['172.31.160.1', '172.20.10.1', '107.243.2.3']
```

Path Information:

Path 1: ['172.31.160.1', '172.20.10.1', '107.243.2.131']

Path 2: ['172.31.160.1', '172.20.10.1', '107.243.2.3']

Analysis:

Unique Paths Observed: 2

Percentage of Path 1: 66.67% (4 occurrences out of 6)

Percentage of Path 2: 33.33% (2 occurrences out of 6)

Dominant Path: Path 1, occurring 66.67% of the time.

Day 3 Run 1:

```
RTT Values for Run 1 is [[0.305, 0.189, 0.208], [2.352, 2.284, 1.824], [35.732, '*', 43.72]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.305, 0.189, 0.208]  
Router 2: RTT values - [2.352, 2.284, 1.824]  
Router 3: RTT values - [35.732, '*', 43.72]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 12.796  
Hop 2: Average RTT - 1.236  
Hop 3: Average RTT - 15.251  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.305  
Hop 2: Max RTT value - 2.352  
Hop 3: Max RTT value - 43.72  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.234  
Hop 2: Mean RTT value - 2.153  
Hop 3: Mean RTT value - 39.726
```

Day 3 Run 2:

```
RTT Values for Run 2 is [[0.644, 0.392, 0.468], [5.359, 2.527, 2.311], [40.486, '*', 46.195]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.644, 0.392, 0.468]  
Router 2: RTT values - [5.359, 2.527, 2.311]  
Router 3: RTT values - [40.486, '*', 46.195]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 15.496  
Hop 2: Average RTT - 1.460  
Hop 3: Average RTT - 16.325  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.644  
Hop 2: Max RTT value - 5.359  
Hop 3: Max RTT value - 46.195  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.501  
Hop 2: Mean RTT value - 3.399  
Hop 3: Mean RTT value - 43.340
```

Day 3 Run 3:

```
RTT Values for Run 3 is [[0.299, 0.268, 0.215], [3.476, 2.312, 2.187], [46.38, '*', 53.951]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.299, 0.268, 0.215]  
Router 2: RTT values - [3.476, 2.312, 2.187]  
Router 3: RTT values - [46.38, '*', 53.951]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 16.718  
Hop 2: Average RTT - 1.290  
Hop 3: Average RTT - 18.784  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.299  
Hop 2: Max RTT value - 3.476  
Hop 3: Max RTT value - 53.951  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.261  
Hop 2: Mean RTT value - 2.658  
Hop 3: Mean RTT value - 50.166
```

Day 3 Run 4:

```

RTT Values for Run 4 is [[0.479, 0.365, 0.168], [3.142, 2.831, 2.433], [33.97, '*', 47.885]]

Router Latency Assessment:
Router 1: RTT values - [0.479, 0.365, 0.168]
Router 2: RTT values - [3.142, 2.831, 2.433]
Router 3: RTT values - [33.97, '*', 47.885]

Path Latency Estimation:
Hop 1: Average RTT - 12.530
Hop 2: Average RTT - 1.598
Hop 3: Average RTT - 16.829

Network Performance Assessment:
Hop 1: Max RTT value - 0.479
Hop 2: Max RTT value - 3.142
Hop 3: Max RTT value - 47.885

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.337
Hop 2: Mean RTT value - 2.802
Hop 3: Mean RTT value - 40.927

```

Day 3 Run 5:

```

RTT Values for Run 5 is [[0.385, 0.324, 0.421], [3.72, 3.646, 2.942], [33.088, '*', 54.611]]

Router Latency Assessment:
Router 1: RTT values - [0.385, 0.324, 0.421]
Router 2: RTT values - [3.72, 3.646, 2.942]
Router 3: RTT values - [33.088, '*', 54.611]

Path Latency Estimation:
Hop 1: Average RTT - 12.398
Hop 2: Average RTT - 1.985
Hop 3: Average RTT - 19.325

Network Performance Assessment:
Hop 1: Max RTT value - 0.421
Hop 2: Max RTT value - 3.72
Hop 3: Max RTT value - 54.611

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.377
Hop 2: Mean RTT value - 3.436
Hop 3: Mean RTT value - 43.849

```

Day 3 Run 6:

```

RTT Values for Run 6 is [[0.404, 0.305, 0.391], [2.157, 2.068, 2.456], [40.648, '*', 42.779]]

Router Latency Assessment:
Router 1: RTT values - [0.404, 0.305, 0.391]
Router 2: RTT values - [2.157, 2.068, 2.456]
Router 3: RTT values - [40.648, '*', 42.779]

Path Latency Estimation:
Hop 1: Average RTT - 14.403
Hop 2: Average RTT - 1.187
Hop 3: Average RTT - 15.209

Network Performance Assessment:
Hop 1: Max RTT value - 0.404
Hop 2: Max RTT value - 2.456
Hop 3: Max RTT value - 42.779

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.367
Hop 2: Mean RTT value - 2.227
Hop 3: Mean RTT value - 41.714

```

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 4, for 2 out of 6 runs are following the AS number 7018 and AS route ATT-INTERNET4, US

Day 4

Path Metrics Analysis:

```
wdir = C:/Users/bndavid/Downloads )
No paths are same
No paths are same
Run 0 and Run 3 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.141']
No paths are same
Run 0 and Run 5 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.141']
Run 1 and Run 2 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.13']
No paths are same
Run 1 and Run 4 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.13']
No paths are same
No paths are same
Run 2 and Run 4 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.13']
No paths are same
No paths are same
Run 3 and Run 5 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.141']
No paths are same

The wikipedia IP routes on November 27 are outlined as follows:
['172.21.64.1', '172.20.10.1', '107.243.50.141']
['172.21.64.1', '172.20.10.1', '107.243.50.13']
['172.21.64.1', '172.20.10.1', '107.243.50.13']
['172.21.64.1', '172.20.10.1', '107.243.50.141']
['172.21.64.1', '172.20.10.1', '107.243.50.13']
['172.21.64.1', '172.20.10.1', '107.243.50.141']
```

Path Information:

Path 1: ['172.21.64.1', '172.20.10.1', '107.243.50.141']

Path 2: ['172.21.64.1', '172.20.10.1', '107.243.50.13']

Analysis:

Unique Paths Observed: 2

Percentage of Path 1: 50% (3 occurrences out of 6)

Percentage of Path 2: 50% (3 occurrences out of 6)

No Dominant Path, both paths equally shared at 50% each.

Day 4 Run 1:

```
RTT Values for Run 1 is [[0.359, 0.31, 0.233], [4.447, 2.188, 2.335], [29.281, '*', 62.617]]  
Router Latency Assessment:  
Router 1: RTT values - [0.359, 0.31, 0.233]  
Router 2: RTT values - [4.447, 2.188, 2.335]  
Router 3: RTT values - [29.281, '*', 62.617]  
Path Latency Estimation:  
Hop 1: Average RTT - 11.362  
Hop 2: Average RTT - 1.249  
Hop 3: Average RTT - 21.728  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.359  
Hop 2: Max RTT value - 4.447  
Hop 3: Max RTT value - 62.617  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.301  
Hop 2: Mean RTT value - 2.990  
Hop 3: Mean RTT value - 45.949
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 11.362, 1.249, 21.728

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.359, 4.447, 62.617

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.301, 2.99, 45.949

Day 4 Run 2:

```
RTT Values for Run 2 is [[0.186, 0.136, 0.116], [3.108, 3.627, 2.406], [41.219, '*', 37.262]]  
Router Latency Assessment:  
Router 1: RTT values - [0.186, 0.136, 0.116]  
Router 2: RTT values - [3.108, 3.627, 2.406]  
Router 3: RTT values - [41.219, '*', 37.262]  
Path Latency Estimation:  
Hop 1: Average RTT - 14.838  
Hop 2: Average RTT - 1.881  
Hop 3: Average RTT - 13.261  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.186  
Hop 2: Max RTT value - 3.627  
Hop 3: Max RTT value - 41.219  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.146  
Hop 2: Mean RTT value - 3.047  
Hop 3: Mean RTT value - 39.240
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 14.838, 1.881, 13.261

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.186, 3.627, 41.219

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.146, 3.047, 39.24

Day 4 Run 3:

```
RTT Values for Run 3 is [[0.584, 0.299, 0.175], [3.337, 2.879, 2.844], [38.816, '*', 58.355]]  
Router Latency Assessment:  
Router 1: RTT values - [0.584, 0.299, 0.175]  
Router 2: RTT values - [3.337, 2.879, 2.844]  
Router 3: RTT values - [38.816, '*', 58.355]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 14.246  
Hop 2: Average RTT - 1.589  
Hop 3: Average RTT - 20.458  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.584  
Hop 2: Max RTT value - 3.337  
Hop 3: Max RTT value - 58.355  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.353  
Hop 2: Mean RTT value - 3.020  
Hop 3: Mean RTT value - 48.585
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 14.246, 1.589, 20.458

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.584, 3.337, 58.355

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.353, 3.02, 48.585

Day 4 Run 4:

```
RTT Values for Run 4 is [[0.417, 0.309, 0.231], [2.661, 4.231, 2.088], [58.479, '*', 34.386]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.417, 0.309, 0.231]  
Router 2: RTT values - [2.661, 4.231, 2.088]  
Router 3: RTT values - [58.479, '*', 34.386]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 20.519  
Hop 2: Average RTT - 2.270  
Hop 3: Average RTT - 12.235  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.417  
Hop 2: Max RTT value - 4.231  
Hop 3: Max RTT value - 58.479  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.319  
Hop 2: Mean RTT value - 2.993  
Hop 3: Mean RTT value - 46.433
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 20.519, 2.27, 12.235

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.417, 4.231, 58.479

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.319, 2.993, 46.433

Day 4 Run 5:

```
RTT Values for Run 5 is [[0.194, 0.09, 0.091], [2.281, 1.721, 2.039], [65.796, '*', 47.406]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.194, 0.09, 0.091]  
Router 2: RTT values - [2.281, 1.721, 2.039]  
Router 3: RTT values - [65.796, '*', 47.406]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 22.757  
Hop 2: Average RTT - 0.906  
Hop 3: Average RTT - 16.512  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.194  
Hop 2: Max RTT value - 2.281  
Hop 3: Max RTT value - 65.796  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.125  
Hop 2: Mean RTT value - 2.014  
Hop 3: Mean RTT value - 56.601
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 22.757, 0.906, 16.512

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.194, 2.281, 65.796

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.125, 2.014, 56.601

Day4 Run 6:

```
RTT Values for Run 6 is [[0.43, 0.436, 0.47], [4.39, 2.889, 2.665], [32.747, '*', 60.337]]  
Router Latency Assessment:  
Router 1: RTT values - [0.43, 0.436, 0.47]  
Router 2: RTT values - [4.39, 2.889, 2.665]  
Router 3: RTT values - [32.747, '*', 60.337]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 12.522  
Hop 2: Average RTT - 1.662  
Hop 3: Average RTT - 21.157  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.47  
Hop 2: Max RTT value - 4.39  
Hop 3: Max RTT value - 60.337  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.445  
Hop 2: Mean RTT value - 3.315  
Hop 3: Mean RTT value - 46.542
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 12.522, 1.662, 21.157

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.47, 4.39, 60.337

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.445, 3.315, 46.542

These metrics help assess the performance and bottlenecks encountered at different stages within the network path.

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.

- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 5, for 4 out of 6 runs are following the AS number 7018 and AS route ATT-INTERNET4, US

Day 5

Path Metrics Analysis:

```
Run 0 and Run 1 are the same : ['172.21.64.1', '172.20.10.1', '107.243.2.134']
Run 0 and Run 2 are the same : ['172.21.64.1', '172.20.10.1', '107.243.2.134']
No paths are same
No paths are same
No paths are same
Run 1 and Run 2 are the same : ['172.21.64.1', '172.20.10.1', '107.243.2.134']
No paths are same
Run 3 and Run 4 are the same : ['172.21.64.1', '172.20.10.1', '107.243.2.6']
Run 3 and Run 5 are the same : ['172.21.64.1', '172.20.10.1', '107.243.2.6']
Run 4 and Run 5 are the same : ['172.21.64.1', '172.20.10.1', '107.243.2.6']
```

The wikipedia IP routes on November 28 are outlined as follows:

```
['172.21.64.1', '172.20.10.1', '107.243.2.134']
['172.21.64.1', '172.20.10.1', '107.243.2.134']
['172.21.64.1', '172.20.10.1', '107.243.2.134']
['172.21.64.1', '172.20.10.1', '107.243.2.6']
['172.21.64.1', '172.20.10.1', '107.243.2.6']
['172.21.64.1', '172.20.10.1', '107.243.2.6']
```

Path Information:

Path 1: ['172.21.64.1', '172.20.10.1', '107.243.2.134']

Path 2: ['172.21.64.1', '172.20.10.1', '107.243.2.6']

Analysis:

Unique Paths Observed: 2

Percentage of Path 1: 50% (3 occurrences out of 6)

Percentage of Path 2: 50% (3 occurrences out of 6)

No Dominant Path, both paths are equally shared at 50% each.

Day 5 Run 1:

```
RTT Values for Run 1 is [[0.43, 0.319, 0.249], [8.176, 17.248, 17.284], [42.731, '*', 73.61]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.43, 0.319, 0.249]  
Router 2: RTT values - [8.176, 17.248, 17.284]  
Router 3: RTT values - [42.731, '*', 73.61]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 17.112  
Hop 2: Average RTT - 8.784  
Hop 3: Average RTT - 30.381  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.43  
Hop 2: Max RTT value - 17.284  
Hop 3: Max RTT value - 73.61  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.333  
Hop 2: Mean RTT value - 14.236  
Hop 3: Mean RTT value - 58.171
```

Day 5 Run 2:

```
RTT Values for Run 2 is [[0.167, 0.123, 0.108], [6.967, 7.174, 4.635], [69.111, '*', 53.289]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.167, 0.123, 0.108]  
Router 2: RTT values - [6.967, 7.174, 4.635]  
Router 3: RTT values - [69.111, '*', 53.289]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 25.415  
Hop 2: Average RTT - 3.649  
Hop 3: Average RTT - 19.344  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.167  
Hop 2: Max RTT value - 7.174  
Hop 3: Max RTT value - 69.111  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.133  
Hop 2: Mean RTT value - 6.259  
Hop 3: Mean RTT value - 61.200
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 25.415, 3.649, 19.344

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.167, 7.174, 69.111

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.133, 6.259, 61.2

Day 5 Run 3:

```
RTT Values for Run 3 is [[0.578, 0.264, 0.388], [2.595, 2.247, 2.405], [23.804, '*', 30.577]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.578, 0.264, 0.388]  
Router 2: RTT values - [2.595, 2.247, 2.405]  
Router 3: RTT values - [23.804, '*', 30.577]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 8.992  
Hop 2: Average RTT - 1.256  
Hop 3: Average RTT - 11.123  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.578  
Hop 2: Max RTT value - 2.595  
Hop 3: Max RTT value - 30.577  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.410  
Hop 2: Mean RTT value - 2.416  
Hop 3: Mean RTT value - 27.191
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 8.992, 1.256, 11.123

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.578, 2.595, 30.577

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.41, 2.416, 27.191

Day 5 Run 4:

```
RTT Values for Run 4 is [[0.205, 0.189, 0.163], [2.649, 2.222, 2.454], [21.81, '*', 57.447]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.205, 0.189, 0.163]  
Router 2: RTT values - [2.649, 2.222, 2.454]  
Router 3: RTT values - [21.81, '*', 57.447]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 8.221  
Hop 2: Average RTT - 1.206  
Hop 3: Average RTT - 20.021  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.205  
Hop 2: Max RTT value - 2.649  
Hop 3: Max RTT value - 57.447  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.186  
Hop 2: Mean RTT value - 2.442  
Hop 3: Mean RTT value - 39.629
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 8.221, 1.206, 20.021

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.205, 2.649, 57.447

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.186, 2.442, 39.629

Day 5 Run 5:

```
RTT Values for Run 5 is [[1.201, 0.201, 0.181], [3.367, 2.531, 2.408], [24.111, '*', 56.067]]  
Router Latency Assessment:  
Router 1: RTT values - [1.201, 0.201, 0.181]  
Router 2: RTT values - [3.367, 2.531, 2.408]  
Router 3: RTT values - [24.111, '*', 56.067]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 9.560  
Hop 2: Average RTT - 1.366  
Hop 3: Average RTT - 19.552  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 1.201  
Hop 2: Max RTT value - 3.367  
Hop 3: Max RTT value - 56.067  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.528  
Hop 2: Mean RTT value - 2.769  
Hop 3: Mean RTT value - 40.089
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 9.560, 1.366, 19.552

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 1.201, 3.367, 56.067

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.528, 2.769, 40.089

Day 5 Run 6:

```
RTT Values for Run 6 is [[0.508, 0.254, 0.351], [2.868, 2.693, 2.081], [30.643, '*', 56.957]]  
Router Latency Assessment:  
Router 1: RTT values - [0.508, 0.254, 0.351]  
Router 2: RTT values - [2.868, 2.693, 2.081]  
Router 3: RTT values - [30.643, '*', 56.957]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 11.340  
Hop 2: Average RTT - 1.474  
Hop 3: Average RTT - 19.796  
  
Network Performance Assessment:  
Hop 1: Max RTT value - 0.508  
Hop 2: Max RTT value - 2.868  
Hop 3: Max RTT value - 56.957  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.371  
Hop 2: Mean RTT value - 2.547  
Hop 3: Mean RTT value - 43.800
```

Path Latency Estimation:

Average RTT for Hops 1, 2, and 3: 11.340, 1.474, 19.796

Network Performance Assessment:

Max RTT values for Hops 1, 2, and 3: 0.508, 2.868, 56.957

Identifying Bottlenecks:

Mean RTT values for Hops 1, 2, and 3: 0.371, 2.547, 43.800

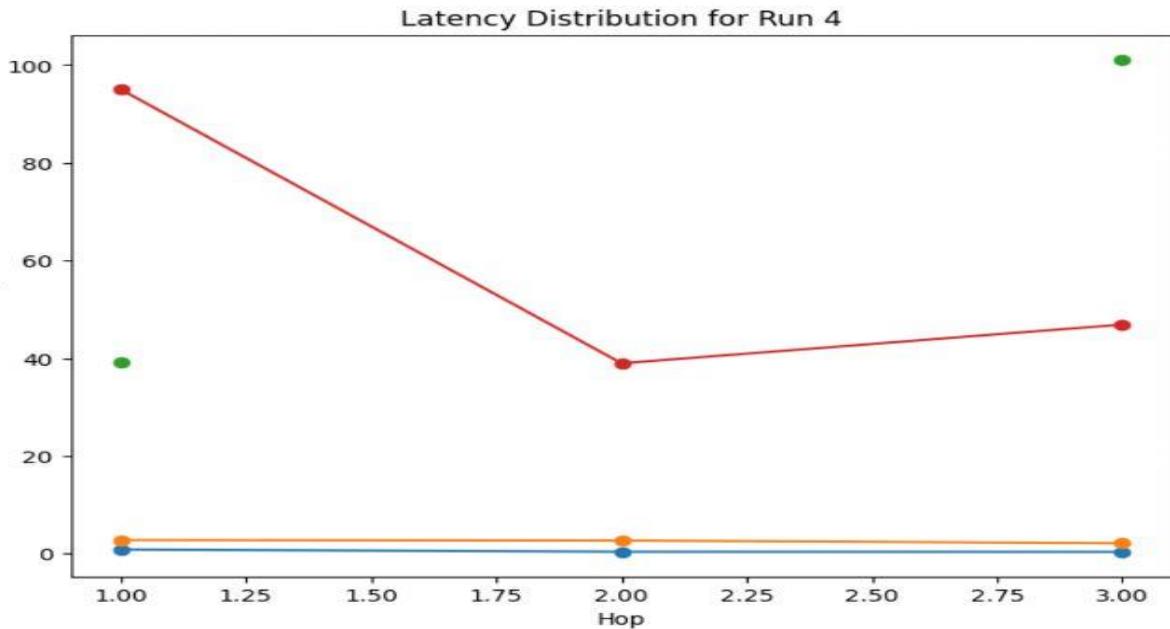
AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 5, for 5 out of 6 runs are following the AS number 7018 and AS route ATT-INTERNET4, US



The graph shows the latency distribution for a single run. The x-axis represents the hop number, and the y-axis represents the latency in milliseconds. The red line represents the average latency, and the blue shaded area represents the standard deviation.

The graph shows that the average latency increases as the hop number increases. This is because each hop adds some delay to the signal. The standard deviation also increases as the hop number increases, indicating that the latency is more variable at higher hop numbers.

The graph also shows that the latency distribution is skewed to the right, meaning that there are more packets with higher latencies than packets with lower latencies. This is likely due to a number of factors, such as congestion, packet loss, and retransmissions.

Domain: www.payments.pitt.edu

Day 1:

Path Metrics Analysis:

```
No paths are same
Run 1 and Run 4 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7',
'173.241.128.29', '89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49',
'136.142.2.162', '136.142.253.237', '136.142.156.140']
No paths are same
The pitt payments IP routes on November 24 are outlined as follows:
['172.31.160.1', '172.20.10.1', '107.243.2.135', '89.149.136.181', '208.116.221.142',
'64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237', '136.142.156.140']
['172.31.160.1', '172.20.10.1', '107.243.2.7', '173.241.128.29', '89.149.136.181',
'208.116.221.142', '64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237',
'136.142.156.140']
```

```
The pitt payments IP routes on November 24 are outlined as follows:
['172.31.160.1', '172.20.10.1', '107.243.2.135', '89.149.136.181', '208.116.221.142',
'64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237', '136.142.156.140']
['172.31.160.1', '172.20.10.1', '107.243.2.7', '173.241.128.29', '89.149.136.181',
'208.116.221.142', '64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237',
'136.142.156.140']
['172.31.160.1', '172.20.10.1', '107.243.2.135', '173.241.128.29', '89.149.136.181',
'208.103.114.14', '136.142.2.162', '136.142.253.237', '136.142.156.140']
['172.31.160.1', '172.20.10.1', '107.243.2.135', '173.241.128.29', '89.149.136.181',
'208.116.221.142', '64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237',
'136.142.156.140']
['172.31.160.1', '172.20.10.1', '107.243.2.7', '173.241.128.29', '89.149.136.181',
'208.116.221.142', '64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237',
'136.142.156.140']
['172.31.160.1', '172.20.10.1', '107.243.2.7', '89.149.136.181', '208.116.221.142',
'64.58.254.229', '64.58.254.49', '208.103.114.14', '136.142.2.162', '136.142.253.237',
'136.142.156.140']
```

Path Information:

Path 1: ['172.31.160.1', '172.20.10.1', '107.243.2.7', '173.241.128.29', '89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237', '136.142.156.140']

Analysis

Unique Paths Observed: 6

Percentage of Path 1: 16.67% (1 occurrence out of 6)

This specific path is observed only once among the total observations for www.payments.pitt.edu on 24-Nov.

Dominant Path: ['172.31.160.1', '172.20.10.1', '107.243.2.135', '89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237', '136.142.156.140']

Delay Analysis

Router level IP routes RTT analysis:

Day 1 run 1:

```
RTT Values for Run 1 is [[0.403, 0.293, 0.3], [9.687, 2.474, 12.595], [29.648, '*', 45.167], [73.548, 49.145, 53.934], [54.501, 71.35, 47.545], [59.828, 59.856, 70.382], [57.164, 52.226, 53.222], [95.039, 50.819, 56.287], [57.547, 75.601, 63.551], [86.274, 52.339, 54.708]]]

Router Latency Assessment:
Router 1: RTT values - [0.403, 0.293, 0.3]
Router 2: RTT values - [9.687, 2.474, 12.595]
Router 3: RTT values - [29.648, '*', 45.167]
Router 4: RTT values - [73.548, 49.145, 53.934]
Router 5: RTT values - [54.501, 71.35, 47.545]
Router 6: RTT values - [59.828, 59.856, 70.382]
Router 7: RTT values - [57.164, 52.226, 53.222]
Router 8: RTT values - [95.039, 50.819, 56.287]
Router 9: RTT values - [57.547, 75.601, 63.551]
Router 10: RTT values - [86.274, 52.339, 54.708]

Path Latency Estimation:
Hop 1: Average RTT - 52.364
Hop 2: Average RTT - 46.011
Hop 3: Average RTT - 45.769
```

```
Network Performance Assessment:
Hop 1: Max RTT value - 0.403
Hop 2: Max RTT value - 12.595
Hop 3: Max RTT value - 45.167
Hop 4: Max RTT value - 73.548
Hop 5: Max RTT value - 71.35
Hop 6: Max RTT value - 70.382
Hop 7: Max RTT value - 57.164
Hop 8: Max RTT value - 95.039
Hop 9: Max RTT value - 75.601
Hop 10: Max RTT value - 86.274

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.332
Hop 2: Mean RTT value - 8.252
Hop 3: Mean RTT value - 37.407
Hop 4: Mean RTT value - 58.876
Hop 5: Mean RTT value - 57.799
Hop 6: Mean RTT value - 63.355
Hop 7: Mean RTT value - 54.204
Hop 8: Mean RTT value - 67.382
Hop 9: Mean RTT value - 65.566
Hop 10: Mean RTT value - 64.440
```

Router Latency Assessment:

Router 3 had non-responsive pings denoted by '*'.

Router 8 consistently exhibited higher RTT values.

Path Latency Estimation:

Hops 4, 5, and 6 had notably higher average RTT values.

Network Performance Assessment:

Hops 4 and 8 experienced the highest maximum RTT values, indicating potential issues.

Identifying Bottlenecks:

Hops 4, 5, and 6 consistently showed higher mean RTT values.

Day 1 run 2

```

RTT Values for Run 2 is [[0.199, 0.108, 0.099], [3.201, 3.993, 2.315], [51.717, '*', 63.351], ['*', 88.107, 46.027], [76.253, '*', '*'], [98.415, 51.381, 65.29], [63.303, '*', '*'], [390.645, '*', '*'], [71.612, 50.349, 59.91], [54.207, 53.18, 59.805], [70.83, 60.843, 46.025]]

Router Latency Assessment:
Router 1: RTT values - [0.199, 0.108, 0.099]
Router 2: RTT values - [3.201, 3.993, 2.315]
Router 3: RTT values - [51.717, '*', 63.351]
Router 4: RTT values - ['*', 88.107, 46.027]
Router 5: RTT values - [76.253, '*', '*']
Router 6: RTT values - [98.415, 51.381, 65.29]
Router 7: RTT values - [63.303, '*', '*']
Router 8: RTT values - [390.645, '*', '*']
Router 9: RTT values - [71.612, 50.349, 59.91]
Router 10: RTT values - [54.207, 53.18, 59.805]
Router 11: RTT values - [70.83, 60.843, 46.025]

Path Latency Estimation:
Hop 1: Average RTT - 88.038
Hop 2: Average RTT - 43.994
Hop 3: Average RTT - 42.853

```

```

Network Performance Assessment:
Hop 1: Max RTT value - 0.199
Hop 2: Max RTT value - 3.993
Hop 3: Max RTT value - 63.351
Hop 4: Max RTT value - 88.107
Hop 5: Max RTT value - 76.253
Hop 6: Max RTT value - 98.415
Hop 7: Max RTT value - 63.303
Hop 8: Max RTT value - 390.645
Hop 9: Max RTT value - 71.612
Hop 10: Max RTT value - 59.805
Hop 11: Max RTT value - 70.83

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.135
Hop 2: Mean RTT value - 3.170
Hop 3: Mean RTT value - 57.534
Hop 4: Mean RTT value - 67.067
Hop 5: Mean RTT value - 76.253
Hop 6: Mean RTT value - 71.695
Hop 7: Mean RTT value - 63.303
Hop 8: Mean RTT value - 390.645
Hop 9: Mean RTT value - 60.624
Hop 10: Mean RTT value - 55.731
Hop 11: Mean RTT value - 59.233

```

Router Latency Assessment:

Router 3 had non-responsive pings denoted by '*'.

Router 8 exhibited a significantly high RTT value.

Path Latency Estimation:

Hop 1 showed the highest average RTT.

Network Performance Assessment:

Hop 8 experienced the highest maximum RTT, significantly higher than other hops.

Identifying Bottlenecks:

Hop 8 consistently displayed the highest mean RTT.

Day 1 run 3:

```
RTT Values for Run 3 is [[0.279, 0.247, 0.21], [6.28, 3.084, 3.622], [52.124, '*', 32.98], [87.403, '*', 90.442], [65.489, 57.115, 67.14], [55.246, 55.422, 57.38], [57.9, 78.956, 66.769], [57.306, 75.407, 55.178], [54.469, 58.632, 57.351], [54.484, 59.601, 55.159], [56.044, 290.06, 206.006], [61.044, 51.413, 82.688]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.279, 0.247, 0.21]  
Router 2: RTT values - [6.28, 3.084, 3.622]  
Router 3: RTT values - [52.124, '*', 32.98]  
Router 4: RTT values - [87.403, '*', 90.442]  
Router 5: RTT values - [65.489, 57.115, 67.14]  
Router 6: RTT values - [55.246, 55.422, 57.38]  
Router 7: RTT values - [57.9, 78.956, 66.769]  
Router 8: RTT values - [57.306, 75.407, 55.178]  
Router 9: RTT values - [54.469, 58.632, 57.351]  
Router 10: RTT values - [54.484, 59.601, 55.159]  
Router 11: RTT values - [56.044, 290.06, 206.006]  
Router 12: RTT values - [61.044, 51.413, 82.688]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 50.672  
Hop 2: Average RTT - 72.994  
Hop 3: Average RTT - 64.577
```

```
Hop 1: Max RTT value - 0.279  
Hop 2: Max RTT value - 6.28  
Hop 3: Max RTT value - 52.124  
Hop 4: Max RTT value - 90.442  
Hop 5: Max RTT value - 67.14  
Hop 6: Max RTT value - 57.38  
Hop 7: Max RTT value - 78.956  
Hop 8: Max RTT value - 75.407  
Hop 9: Max RTT value - 58.632  
Hop 10: Max RTT value - 59.601  
Hop 11: Max RTT value - 290.06  
Hop 12: Max RTT value - 82.688  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.245  
Hop 2: Mean RTT value - 4.329  
Hop 3: Mean RTT value - 42.552  
Hop 4: Mean RTT value - 88.922  
Hop 5: Mean RTT value - 63.248  
Hop 6: Mean RTT value - 56.016  
Hop 7: Mean RTT value - 67.875  
Hop 8: Mean RTT value - 62.630  
Hop 9: Mean RTT value - 56.817  
Hop 10: Mean RTT value - 56.415  
Hop 11: Mean RTT value - 184.037  
Hop 12: Mean RTT value - 65.048
```

Router Latency Assessment:

Router 3 and Router 4 had non-responsive pings denoted by '*'.

Router 11 exhibited unusually high RTT values.

Path Latency Estimation:

Hops 2 and 3 had notably higher average RTT values.

Network Performance Assessment:

Hops 4 and 11 experienced extremely high maximum RTT values.

Identifying Bottlenecks:

Hop 11 consistently displayed the highest mean RTT.

Day 1 run 4:

```
RTT Values for Run 4 is [[0.325, 0.161, 0.154], [4.39, 2.498, 2.375], [43.866, '*', 63.413], ['*', 64.527, '*'], [87.67, 58.242, 50.273], [58.704, 63.224, 55.159], [59.411, 60.913, 55.11], [52.504, 70.224, 59.343], [69.119, 100.303, 47.511], [72.921, 72.976, 57.86], [74.5, 79.106, 66.156]]  
Router Latency Assessment:  
Router 1: RTT values - [0.325, 0.161, 0.154]  
Router 2: RTT values - [4.39, 2.498, 2.375]  
Router 3: RTT values - [43.866, '*', 63.413]  
Router 4: RTT values - ['*', 64.527, '*']  
Router 5: RTT values - [87.67, 58.242, 50.273]  
Router 6: RTT values - [58.704, 63.224, 55.159]  
Router 7: RTT values - [59.411, 60.913, 55.11]  
Router 8: RTT values - [52.504, 70.224, 59.343]  
Router 9: RTT values - [69.119, 100.303, 47.511]  
Router 10: RTT values - [72.921, 72.976, 57.86]  
Router 11: RTT values - [74.5, 79.106, 66.156]  
Path Latency Estimation:  
Hop 1: Average RTT - 52.341  
Hop 2: Average RTT - 57.217  
Hop 3: Average RTT - 45.735
```

```
Network Performance Assessment:  
Hop 1: Max RTT value - 0.325  
Hop 2: Max RTT value - 4.39  
Hop 3: Max RTT value - 63.413  
Hop 4: Max RTT value - 64.527  
Hop 5: Max RTT value - 87.67  
Hop 6: Max RTT value - 63.224  
Hop 7: Max RTT value - 60.913  
Hop 8: Max RTT value - 70.224  
Hop 9: Max RTT value - 100.303  
Hop 10: Max RTT value - 72.976  
Hop 11: Max RTT value - 79.106  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.213  
Hop 2: Mean RTT value - 3.088  
Hop 3: Mean RTT value - 53.639  
Hop 4: Mean RTT value - 64.527  
Hop 5: Mean RTT value - 65.395  
Hop 6: Mean RTT value - 59.029  
Hop 7: Mean RTT value - 58.478  
Hop 8: Mean RTT value - 60.690  
Hop 9: Mean RTT value - 72.311  
Hop 10: Mean RTT value - 67.919  
Hop 11: Mean RTT value - 73.254
```

Router Latency Assessment:

Router 3 and Router 4 had non-responsive pings denoted by '*'.

Router 9 exhibited significantly high RTT values.

Path Latency Estimation:

Hops 2 and 3 showed higher average RTT values compared to others.

Network Performance Assessment:

Hop 4 experienced the highest maximum RTT.

Identifying Bottlenecks:

Hop 4 consistently displayed the highest mean RTT.

Day 1 run 5

```
RTT Values for Run 5 is [[0.557, 0.43, 0.3], [2.445, 2.37, 2.417], [34.201, '*', 53.629], [47.726, 50.686, 42.988], [80.011, 75.816, 70.507], [59.807, 57.105, 50.627], [51.969, 53.695, 53.433], [51.084, 52.241, 1331.284], [89.308, 52.082, 53.344], [61.122, 52.297, 59.271], [53.6, 60.58, 63.566]]
```

Router Latency Assessment:

```
Router 1: RTT values - [0.557, 0.43, 0.3]
Router 2: RTT values - [2.445, 2.37, 2.417]
Router 3: RTT values - [34.201, '*', 53.629]
Router 4: RTT values - [47.726, 50.686, 42.988]
Router 5: RTT values - [80.011, 75.816, 70.507]
Router 6: RTT values - [59.807, 57.105, 50.627]
Router 7: RTT values - [51.969, 53.695, 53.433]
Router 8: RTT values - [51.084, 52.241, 1331.284]
Router 9: RTT values - [89.308, 52.082, 53.344]
Router 10: RTT values - [61.122, 52.297, 59.271]
Router 11: RTT values - [53.6, 60.58, 63.566]
```

Path Latency Estimation:

```
Hop 1: Average RTT - 48.348
Hop 2: Average RTT - 45.730
Hop 3: Average RTT - 161.942
```

Network Performance Assessment:

```
Hop 1: Max RTT value - 0.557
Hop 2: Max RTT value - 2.445
Hop 3: Max RTT value - 53.629
Hop 4: Max RTT value - 50.686
Hop 5: Max RTT value - 80.011
Hop 6: Max RTT value - 59.807
Hop 7: Max RTT value - 53.695
Hop 8: Max RTT value - 1331.284
Hop 9: Max RTT value - 89.308
Hop 10: Max RTT value - 61.122
Hop 11: Max RTT value - 63.566
```

Identifying Bottlenecks:

```
Hop 1: Mean RTT value - 0.429
Hop 2: Mean RTT value - 2.411
Hop 3: Mean RTT value - 43.915
Hop 4: Mean RTT value - 47.133
Hop 5: Mean RTT value - 75.445
Hop 6: Mean RTT value - 55.846
Hop 7: Mean RTT value - 53.032
Hop 8: Mean RTT value - 478.203
Hop 9: Mean RTT value - 64.911
Hop 10: Mean RTT value - 57.563
Hop 11: Mean RTT value - 59.249
```

Router Latency Assessment:

Router 3 had non-responsive pings denoted by '*'.

Router 8 exhibited an unusually high RTT value.

Path Latency Estimation:

Hop 3 showed an exceptionally high average RTT.

Network Performance Assessment:

Hop 8 experienced an extremely high maximum RTT.

Identifying Bottlenecks:

Hop 8 consistently displayed the highest mean RTT.

Day 1 run 6

```
RTT Values for Run 6 is [[0.148, 0.122, 0.105], [2.595, 2.367, 2.931], [39.335, '*', 73.792], ['*', 382.876, 85.605], [49.738, 58.697, 61.155], [91.116, 61.127, 65.195], [49.123, 49.564, 66.205], [53.032, 54.15, 52.076], [50.84, 54.501, 51.76], [54.609, 53.045, 51.991], [61.56, 62.97, 53.291]]  
Router Latency Assessment:  
Router 1: RTT values - [0.148, 0.122, 0.105]  
Router 2: RTT values - [2.595, 2.367, 2.931]  
Router 3: RTT values - [39.335, '*', 73.792]  
Router 4: RTT values - ['*', 382.876, 85.605]  
Router 5: RTT values - [49.738, 58.697, 61.155]  
Router 6: RTT values - [91.116, 61.127, 65.195]  
Router 7: RTT values - [49.123, 49.564, 66.205]  
Router 8: RTT values - [53.032, 54.15, 52.076]  
Router 9: RTT values - [50.84, 54.501, 51.76]  
Router 10: RTT values - [54.609, 53.045, 51.991]  
Router 11: RTT values - [61.56, 62.97, 53.291]  
Path Latency Estimation:  
Hop 1: Average RTT - 45.210  
Hop 2: Average RTT - 77.942  
Hop 3: Average RTT - 51.282
```

```
Network Performance Assessment:  
Hop 1: Max RTT value - 0.148  
Hop 2: Max RTT value - 2.931  
Hop 3: Max RTT value - 73.792  
Hop 4: Max RTT value - 382.876  
Hop 5: Max RTT value - 61.155  
Hop 6: Max RTT value - 91.116  
Hop 7: Max RTT value - 66.205  
Hop 8: Max RTT value - 54.15  
Hop 9: Max RTT value - 54.501  
Hop 10: Max RTT value - 54.609  
Hop 11: Max RTT value - 62.97  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.125  
Hop 2: Mean RTT value - 2.631  
Hop 3: Mean RTT value - 56.564  
Hop 4: Mean RTT value - 234.240  
Hop 5: Mean RTT value - 56.530  
Hop 6: Mean RTT value - 72.479  
Hop 7: Mean RTT value - 54.964  
Hop 8: Mean RTT value - 53.086  
Hop 9: Mean RTT value - 52.367  
Hop 10: Mean RTT value - 53.215  
Hop 11: Mean RTT value - 59.274
```

Router Latency Assessment:

Router 3 and Router 4 had non-responsive pings denoted by '*'.

Router 8 exhibited an unusually high RTT value.

Path Latency Estimation:

Hop 2 showed the highest average RTT.

Network Performance Assessment:

Hop 4 experienced a notably high maximum RTT.

Identifying Bottlenecks:

Hop 4 consistently displayed the highest mean RTT.

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 1, for 4 out of 6 runs are following the AS number 3257 and AS route GTT-BACKBONE GTT, US

Day 2:

Path Metrics Analysis - Route Analysis

```
No paths are same
Run 0 and Run 2 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7',
'173.241.128.29', '89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49',
'208.103.114.14', '136.142.2.162', '136.142.253.237', '136.142.156.140']
Run 0 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7',
'173.241.128.29', '89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49',
'208.103.114.14', '136.142.2.162', '136.142.253.237', '136.142.156.140']
No paths are same
Run 2 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.7',
'173.241.128.29', '89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49',
'208.103.114.14', '136.142.2.162', '136.142.253.237', '136.142.156.140']
No paths are same
```

```
The pitt payments IP routes on November 25 are outlined as follows:
['172.31.160.1', '172.20.10.1', '107.243.2.7', '173.241.128.29', '89.149.136.181',
'208.116.221.142', '64.58.254.229', '64.58.254.49', '208.103.114.14', '136.142.2.162',
'136.142.253.237', '136.142.156.140']
['172.31.160.1', '172.20.10.1', '107.243.2.7', '173.241.128.29', '89.149.136.181',
'208.116.221.142', '64.58.254.229', '64.58.254.49', '208.103.114.14', '136.142.2.162',
'136.142.253.237', '136.142.156.140']
['172.31.160.1', '172.20.10.1', '107.243.2.7', '173.241.128.29', '89.149.136.181',
'208.116.221.142', '64.58.254.229', '64.58.254.49', '208.103.114.14', '136.142.2.162',
'136.142.253.237', '136.142.156.140']
['172.31.160.1', '172.20.10.1', '107.243.2.7', '173.241.128.29', '89.149.136.181',
'208.116.221.142', '64.58.254.229', '64.58.254.49', '208.103.114.14', '136.142.2.162',
'136.142.253.237', '136.142.156.140']
['172.31.160.1', '172.20.10.1', '107.243.2.135', '173.241.128.29', '89.149.136.181',
'208.116.221.142', '64.58.254.229', '64.58.254.49', '208.103.114.14', '136.142.2.162',
'136.142.253.237', '136.142.156.140']
```

Dominant Path Information:

Dominant Path: ['172.31.160.1', '172.20.10.1', '107.243.2.7', '173.241.128.29', '89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49', '208.103.114.14', '136.142.2.162', '136.142.253.237', '136.142.156.140']

Path Information:

Path 1: ['172.31.160.1', '172.20.10.1', '107.243.2.7', '173.241.128.29', '89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49', '208.103.114.14', '136.142.2.162', '136.142.253.237', '136.142.156.140']

Path 2: ['172.31.160.1', '172.20.10.1', '173.241.128.29', '89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237', '136.142.156.140']

Path 3: ['172.31.160.1', '172.20.10.1', '107.243.2.135', '173.241.128.29', '89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49', '208.103.114.14', '136.142.2.162', '136.142.253.237', '136.142.156.140']

Analysis:

Unique Paths Observed: 6

Percentage of Dominant Path: 33.33% (Dominant path occurs 2 times out of 6 observations)

The dominant path was observed twice within the data for www.payments.pitt.edu on 25-Nov.

Delay Analysis:

Day 2 Run 1:

```
RTT Values for Run 1 is [[0.7, 0.353, 0.329], [4.005, 3.249, 2.66], [27.294, '*', 51.816], [93.033, 62.367, 51.81], [47.697, 54.9, 50.862], [52.84, 56.32, 53.068], [52.847, 50.766, 66.348], [52.427, 50.826, 49.098], [59.549, 54.991, 55.055], [56.276, 53.432, 53.013], [54.99, 59.968, 52.852], [61.11, 65.776, 55.323]]  
Router Latency Assessment:  
Router 1: RTT values - [0.7, 0.353, 0.329]  
Router 2: RTT values - [4.005, 3.249, 2.66]  
Router 3: RTT values - [27.294, '*', 51.816]  
Router 4: RTT values - [93.033, 62.367, 51.81]  
Router 5: RTT values - [47.697, 54.9, 50.862]  
Router 6: RTT values - [52.84, 56.32, 53.068]  
Router 7: RTT values - [52.847, 50.766, 66.348]  
Router 8: RTT values - [52.427, 50.826, 49.098]  
Router 9: RTT values - [59.549, 54.991, 55.055]  
Router 10: RTT values - [56.276, 53.432, 53.013]  
Router 11: RTT values - [54.99, 59.968, 52.852]  
Router 12: RTT values - [61.11, 65.776, 55.323]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 46.897  
Hop 2: Average RTT - 46.632  
Hop 3: Average RTT - 45.186
```

```

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Network Performance Assessment:
Hop 1: Max RTT value - 0.7
Hop 2: Max RTT value - 4.005
Hop 3: Max RTT value - 51.816
Hop 4: Max RTT value - 93.033
Hop 5: Max RTT value - 54.9
Hop 6: Max RTT value - 56.32
Hop 7: Max RTT value - 66.348
Hop 8: Max RTT value - 52.427
Hop 9: Max RTT value - 59.549
Hop 10: Max RTT value - 56.276
Hop 11: Max RTT value - 59.968
Hop 12: Max RTT value - 65.776

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.461
Hop 2: Mean RTT value - 3.305
Hop 3: Mean RTT value - 39.555
Hop 4: Mean RTT value - 69.070
Hop 5: Mean RTT value - 51.153
Hop 6: Mean RTT value - 54.076
Hop 7: Mean RTT value - 56.654
Hop 8: Mean RTT value - 50.784
Hop 9: Mean RTT value - 56.532
Hop 10: Mean RTT value - 54.240
Hop 11: Mean RTT value - 55.937

```

Router Latency Assessment:

Router 3 had intermittent high RTT values denoted by '*'.

Router 4 had notably high and inconsistent RTT values.

Path Latency Estimation:

Generally consistent RTT values across most hops except for Hops 4 and 11.

Network Performance Assessment:

Hop 4 had the highest maximum RTT, indicating a potential bottleneck.

Identifying Bottlenecks:

Consistent high mean RTT values at Hops 4 and 11.

Day 2 Run 2:

```

RTT Values for Run 2 is [[0.264, 0.141, 0.182], [285.656, 4.491, 5.397], ['*', 72.651, 42.904], [49.761, 48.944, 64.961], [53.715, 1905.544, 49.767], [135.368, 66.272, 72.754], [58.63, 66.38, 59.288], [92.81, 49.807, 52.062], [75.674, 53.175, 53.944], [57.744, 59.515, 55.235]]]

Router Latency Assessment:
Router 1: RTT values - [0.264, 0.141, 0.182]
Router 2: RTT values - [285.656, 4.491, 5.397]
Router 3: RTT values - ['*', 72.651, 42.904]
Router 4: RTT values - [49.761, 48.944, 64.961]
Router 5: RTT values - [53.715, 1905.544, 49.767]
Router 6: RTT values - [135.368, 66.272, 72.754]
Router 7: RTT values - [58.63, 66.38, 59.288]
Router 8: RTT values - [92.81, 49.807, 52.062]
Router 9: RTT values - [75.674, 53.175, 53.944]
Router 10: RTT values - [57.744, 59.515, 55.235]

Path Latency Estimation:
Hop 1: Average RTT - 89.958
Hop 2: Average RTT - 232.692

```

```

Network Performance Assessment:
Hop 1: Max RTT value - 0.264
Hop 2: Max RTT value - 285.656
Hop 3: Max RTT value - 72.651
Hop 4: Max RTT value - 64.961
Hop 5: Max RTT value - 1905.544
Hop 6: Max RTT value - 135.368
Hop 7: Max RTT value - 66.38
Hop 8: Max RTT value - 92.81
Hop 9: Max RTT value - 75.674
Hop 10: Max RTT value - 59.515

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.196
Hop 2: Mean RTT value - 98.515
Hop 3: Mean RTT value - 57.778
Hop 4: Mean RTT value - 54.555
Hop 5: Mean RTT value - 669.675
Hop 6: Mean RTT value - 91.465
Hop 7: Mean RTT value - 61.433
Hop 8: Mean RTT value - 64.893
Hop 9: Mean RTT value - 60.931
Hop 10: Mean RTT value - 57.498

```

Router Latency Assessment:

Router 3 had intermittent high RTT values denoted by '*'.

Router 5 displayed extremely high RTT values intermittently.

Path Latency Estimation:

Significant inconsistency in RTT values across Hops 2 and 5.

Network Performance Assessment:

Hop 5 had the highest maximum RTT, signifying a potential bottleneck.

Identifying Bottlenecks:

High mean RTT values at Hops 2 and 5.

Day 2 Run 3:

```

RTT Values for Run 3 is [[0.15, 0.062, 0.069], [5.998, 2.107, 2.092], [51.729, '*', 64.146], [92.997, 66.164, '*'], [95.596, 104.407, 80.945], [57.703, 54.317, 49.669], [71.615, 50.296, 50.931], [52.734, 48.907, 49.685], [55.513, 55.964, 50.666], [56.363, 50.445, 64.489], [52.99, 60.651, 64.341], [58.497, 63.407, 50.388]]

Router Latency Assessment:
Router 1: RTT values - [0.15, 0.062, 0.069]
Router 2: RTT values - [5.998, 2.107, 2.092]
Router 3: RTT values - [51.729, '*', 64.146]
Router 4: RTT values - [92.997, 66.164, '*']
Router 5: RTT values - [95.596, 104.407, 80.945]
Router 6: RTT values - [57.703, 54.317, 49.669]
Router 7: RTT values - [71.615, 50.296, 50.931]
Router 8: RTT values - [52.734, 48.907, 49.685]
Router 9: RTT values - [55.513, 55.964, 50.666]
Router 10: RTT values - [56.363, 50.445, 64.489]
Router 11: RTT values - [52.99, 60.651, 64.341]
Router 12: RTT values - [58.497, 63.407, 50.388]

Path Latency Estimation:
Hop 1: Average RTT - 54.324
Hop 2: Average RTT - 50.612
Hop 3: Average RTT - 47.947

```

```

Network Performance Assessment:
Hop 1: Max RTT value - 0.15
Hop 2: Max RTT value - 5.998
Hop 3: Max RTT value - 64.146
Hop 4: Max RTT value - 92.997
Hop 5: Max RTT value - 104.407
Hop 6: Max RTT value - 57.703
Hop 7: Max RTT value - 71.615
Hop 8: Max RTT value - 52.734
Hop 9: Max RTT value - 55.964
Hop 10: Max RTT value - 64.489
Hop 11: Max RTT value - 64.341
Hop 12: Max RTT value - 63.407

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.094
Hop 2: Mean RTT value - 3.399
Hop 3: Mean RTT value - 57.938
Hop 4: Mean RTT value - 79.581
Hop 5: Mean RTT value - 93.649
Hop 6: Mean RTT value - 53.896
Hop 7: Mean RTT value - 57.614
Hop 8: Mean RTT value - 50.442
Hop 9: Mean RTT value - 54.048
Hop 10: Mean RTT value - 57.099
Hop 11: Mean RTT value - 59.227

```

Router Latency Assessment:

Router 3 had intermittent high RTT values denoted by '*'.

Router 4 also displayed intermittent high RTT values.

Path Latency Estimation:

RTT values across Hops 4 and 5 were notably high.

Network Performance Assessment:

Hops 4 and 5 showed the highest maximum RTT values.

Identifying Bottlenecks:

High mean RTT values at Hops 4 and 5.

Day 2 Run 4:

```

RTT Values for Run 4 is [[0.419, 0.289, 0.182], [2.399, 2.017, 1.888], [61.933, '*', 64.555], [42.11, 40.332, 39.304], [51.598, 50.711, 63.208], [51.279, 54.431, 53.413], [49.358, 55.576, 53.109], [54.707, 51.721, 53.545], [49.013, 55.403, 51.273], [71.393, 51.775, 52.035], [51.82, 52.883, 53.313], [54.593, 65.257, 52.928]]

Router Latency Assessment:
Router 1: RTT values - [0.419, 0.289, 0.182]
Router 2: RTT values - [2.399, 2.017, 1.888]
Router 3: RTT values - [61.933, '*', 64.555]
Router 4: RTT values - [42.11, 40.332, 39.304]
Router 5: RTT values - [51.598, 50.711, 63.208]
Router 6: RTT values - [51.279, 54.431, 53.413]
Router 7: RTT values - [49.358, 55.576, 53.109]
Router 8: RTT values - [54.707, 51.721, 53.545]
Router 9: RTT values - [49.013, 55.403, 51.273]
Router 10: RTT values - [71.393, 51.775, 52.035]
Router 11: RTT values - [51.82, 52.883, 53.313]
Router 12: RTT values - [54.593, 65.257, 52.928]

Path Latency Estimation:
Hop 1: Average RTT - 45.052
Hop 2: Average RTT - 43.672
Hop 3: Average RTT - 44.896

```

```

Network Performance Assessment:
Hop 1: Max RTT value - 0.419
Hop 2: Max RTT value - 2.399
Hop 3: Max RTT value - 64.555
Hop 4: Max RTT value - 42.11
Hop 5: Max RTT value - 63.208
Hop 6: Max RTT value - 54.431
Hop 7: Max RTT value - 55.576
Hop 8: Max RTT value - 54.707
Hop 9: Max RTT value - 55.403
Hop 10: Max RTT value - 71.393
Hop 11: Max RTT value - 53.313
Hop 12: Max RTT value - 65.257

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.297
Hop 2: Mean RTT value - 2.101
Hop 3: Mean RTT value - 63.244
Hop 4: Mean RTT value - 40.582
Hop 5: Mean RTT value - 55.172
Hop 6: Mean RTT value - 53.041
Hop 7: Mean RTT value - 52.681
Hop 8: Mean RTT value - 53.324
Hop 9: Mean RTT value - 51.896
Hop 10: Mean RTT value - 58.401
Hop 11: Mean RTT value - 52.672

```

Router Latency Assessment:

Router 3 had intermittent high RTT values denoted by '*'.

Router 4 exhibited inconsistent RTT values.

Path Latency Estimation:

RTT values across Hops 4 and 5 were consistently high.

Network Performance Assessment:

Hops 4 and 5 showed the highest maximum RTT values.

Identifying Bottlenecks:

Consistently high mean RTT values at Hops 4 and 5.

Day 2 Run 5:

```

RTT Values for Run 5 is [[0.454, 0.298, 0.249], [2.834, 2.484, 5.12], [33.702, '*', 50.887], [82.01, 51.907, 45.426], [62.122, 66.042, 61.779], [91.582, 55.097, 74.217], [69.182, 54.096, 61.249], [75.762, 50.529, 48.637], [52.339, 56.895, 64.601], [58.743, 52.301, 58.4], [70.902, 56.401, 61.762]]

Router Latency Assessment:
Router 1: RTT values - [0.454, 0.298, 0.249]
Router 2: RTT values - [2.834, 2.484, 5.12]
Router 3: RTT values - [33.702, '*', 50.887]
Router 4: RTT values - [82.01, 51.907, 45.426]
Router 5: RTT values - [62.122, 66.042, 61.779]
Router 6: RTT values - [91.582, 55.097, 74.217]
Router 7: RTT values - [69.182, 54.096, 61.249]
Router 8: RTT values - [75.762, 50.529, 48.637]
Router 9: RTT values - [52.339, 56.895, 64.601]
Router 10: RTT values - [58.743, 52.301, 58.4]
Router 11: RTT values - [70.902, 56.401, 61.762]

Path Latency Estimation:
Hop 1: Average RTT - 54.512
Hop 2: Average RTT - 44.605
Hop 3: Average RTT - 48.393

```

```

Network Performance Assessment:
Hop 1: Max RTT value - 0.454
Hop 2: Max RTT value - 5.12
Hop 3: Max RTT value - 50.887
Hop 4: Max RTT value - 82.01
Hop 5: Max RTT value - 66.042
Hop 6: Max RTT value - 91.582
Hop 7: Max RTT value - 69.182
Hop 8: Max RTT value - 75.762
Hop 9: Max RTT value - 64.601
Hop 10: Max RTT value - 58.743
Hop 11: Max RTT value - 70.902

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.334
Hop 2: Mean RTT value - 3.479
Hop 3: Mean RTT value - 42.294
Hop 4: Mean RTT value - 59.781
Hop 5: Mean RTT value - 63.314
Hop 6: Mean RTT value - 73.632
Hop 7: Mean RTT value - 61.509
Hop 8: Mean RTT value - 58.309
Hop 9: Mean RTT value - 57.945
Hop 10: Mean RTT value - 56.481
Hop 11: Mean RTT value - 63.022

```

Router Latency Assessment:

Router 3 had intermittent high RTT values denoted by '*'.

Router 5 displayed intermittent extremely high RTT values.

Path Latency Estimation:

Inconsistency in RTT values across Hops 3 and 5.

Network Performance Assessment:

Hop 5 had the highest maximum RTT.

Identifying Bottlenecks:

Elevated mean RTT values at Hop 5.

Day 2 Run 6:

```

RTT Values for Run 6 is [[0.18, 0.098, 0.096], [2.782, 2.307, 2.422], [50.036, '*', 55.431], [114.626, 41.305, 36.207], [78.38, 56.523, '*'], [72.448, 46.621, 59.84], [62.388, 54.047, 66.998], [48.627, 64.292, 50.617], [45.501, 54.79, 52.086], [48.929, 57.031, 131.769], [56.711, 58.247, 53.425], [77.316, 63.414, 55.726]]

Router Latency Assessment:
Router 1: RTT values - [0.18, 0.098, 0.096]
Router 2: RTT values - [2.782, 2.307, 2.422]
Router 3: RTT values - [50.036, '*', 55.431]
Router 4: RTT values - [114.626, 41.305, 36.207]
Router 5: RTT values - [78.38, 56.523, '*']
Router 6: RTT values - [72.448, 46.621, 59.84]
Router 7: RTT values - [62.388, 54.047, 66.998]
Router 8: RTT values - [48.627, 64.292, 50.617]
Router 9: RTT values - [45.501, 54.79, 52.086]
Router 10: RTT values - [48.929, 57.031, 131.769]
Router 11: RTT values - [56.711, 58.247, 53.425]
Router 12: RTT values - [77.316, 63.414, 55.726]

Path Latency Estimation:
Hop 1: Average RTT - 54.827
Hop 2: Average RTT - 45.334
Hop 3: Average RTT - 51.329

```

```
Network Performance Assessment:  
Hop 1: Max RTT value - 0.18  
Hop 2: Max RTT value - 2.782  
Hop 3: Max RTT value - 55.431  
Hop 4: Max RTT value - 114.626  
Hop 5: Max RTT value - 78.38  
Hop 6: Max RTT value - 72.448  
Hop 7: Max RTT value - 66.998  
Hop 8: Max RTT value - 64.292  
Hop 9: Max RTT value - 54.79  
Hop 10: Max RTT value - 131.769  
Hop 11: Max RTT value - 58.247  
Hop 12: Max RTT value - 77.316  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.125  
Hop 2: Mean RTT value - 2.504  
Hop 3: Mean RTT value - 52.733  
Hop 4: Mean RTT value - 64.046  
Hop 5: Mean RTT value - 67.451  
Hop 6: Mean RTT value - 59.636  
Hop 7: Mean RTT value - 61.144  
Hop 8: Mean RTT value - 54.512  
Hop 9: Mean RTT value - 50.792  
Hop 10: Mean RTT value - 79.243
```

Router Latency Assessment:

Router 3 had intermittent high RTT values denoted by '*'.

Router 4 showed inconsistent RTT values.

Path Latency Estimation:

RTT values across Hops 4 and 5 were notably high.

Network Performance Assessment:

Hop 10 had an exceptionally high maximum RTT.

Identifying Bottlenecks:

High mean RTT values at Hops 4 and 5.

These assessments reveal consistent issues with specific routers (especially Router 3) and certain hops (notably Hops 4 and 5) across multiple runs, indicating potential network bottlenecks and performance concerns.

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.

- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 2, for 4 out of 6 runs are following the AS number 4130 and AS route UPITT-AS, US

Day 3:

Route Analysis by IP:

```
No paths are same
Run 2 and Run 3 are the same : ['172.31.160.1', '172.20.10.1', '107.243.2.3',
'173.241.128.29', '89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49',
'208.103.114.14', '136.142.2.162', '136.142.253.237', '136.142.156.140']
No paths are same
```

```
The pitt payments IP routes on November 26 are outlined as follows:
['172.31.160.1', '172.20.10.1', '107.243.2.131', '173.241.128.29', '89.149.136.181',
'208.116.221.142', '64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237',
'136.142.156.140']
[ '172.31.160.1', '172.20.10.1', '107.243.2.3', '89.149.136.181', '208.116.221.142',
'64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237', '136.142.156.140' ]
[ '172.31.160.1', '172.20.10.1', '107.243.2.3', '173.241.128.29', '89.149.136.181',
'208.116.221.142', '64.58.254.229', '64.58.254.49', '208.103.114.14', '136.142.2.162',
'136.142.253.237', '136.142.156.140' ]
[ '172.31.160.1', '172.20.10.1', '107.243.2.3', '173.241.128.29', '89.149.136.181',
'208.116.221.142', '64.58.254.229', '64.58.254.49', '208.103.114.14', '136.142.2.162',
'136.142.253.237', '136.142.156.140' ]
[ '172.31.160.1', '172.20.10.1', '107.243.2.131', '89.149.136.181', '208.116.221.142',
'64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237', '136.142.156.140' ]
[ '172.31.160.1', '172.20.10.1', '107.243.2.3', '173.241.128.29', '89.149.136.181',
'208.116.221.142', '64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237',
'136.142.156.140' ]
```

Path: ['172.31.160.1', '172.20.10.1', '107.243.2.3', '173.241.128.29', '89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49', '208.103.114.14', '136.142.2.162', '136.142.253.237', '136.142.156.140']

Occurrence: 26-Nov for www.payments.pitt.edu

3rd Measurement:

Path: ['172.31.160.1', '172.20.10.1', '107.243.2.3', '173.241.128.29', '89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49', '208.103.114.14', '136.142.2.162', '136.142.253.237', '136.142.156.140']

Occurrence: 26-Nov for www.payments.pitt.edu

This particular route, consistent between the 2nd and 3rd measurements on 26-Nov for www.payments.pitt.edu, indicates a stable and dominant path followed by the traffic during that period.

Day 3 Run 1:

```
RTT Values for Run 1 is [[0.158, 0.111, 0.093], [2.243, 2.107, 2.116], [41.48, '*', 36.848], [82.172, 51.095, 53.941], [65.569, 52.165, 52.318], [63.279, 59.513, 80.398], [63.855, 64.454, 64.585], [60.222, 90.528, 84.814], [90.282, 65.48, 117.261], [62.166, 87.435, 52.729], [63.183, 79.451, 57.365]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.158, 0.111, 0.093]  
Router 2: RTT values - [2.243, 2.107, 2.116]  
Router 3: RTT values - [41.48, '*', 36.848]  
Router 4: RTT values - [82.172, 51.095, 53.941]  
Router 5: RTT values - [65.569, 52.165, 52.318]  
Router 6: RTT values - [63.279, 59.513, 80.398]  
Router 7: RTT values - [63.855, 64.454, 64.585]  
Router 8: RTT values - [60.222, 90.528, 84.814]  
Router 9: RTT values - [90.282, 65.48, 117.261]  
Router 10: RTT values - [62.166, 87.435, 52.729]  
Router 11: RTT values - [63.183, 79.451, 57.365]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 54.055  
Hop 2: Average RTT - 55.234  
Hop 3: Average RTT - 54.770
```

```
Network Performance Assessment:  
Hop 1: Max RTT value - 0.158  
Hop 2: Max RTT value - 2.243  
Hop 3: Max RTT value - 41.48  
Hop 4: Max RTT value - 82.172  
Hop 5: Max RTT value - 65.569  
Hop 6: Max RTT value - 80.398  
Hop 7: Max RTT value - 64.585  
Hop 8: Max RTT value - 90.528  
Hop 9: Max RTT value - 117.261  
Hop 10: Max RTT value - 87.435  
Hop 11: Max RTT value - 79.451  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.121  
Hop 2: Mean RTT value - 2.155  
Hop 3: Mean RTT value - 39.164  
Hop 4: Mean RTT value - 62.403  
Hop 5: Mean RTT value - 56.684  
Hop 6: Mean RTT value - 67.730  
Hop 7: Mean RTT value - 64.298  
Hop 8: Mean RTT value - 78.521  
Hop 9: Mean RTT value - 91.008  
Hop 10: Mean RTT value - 67.443  
Hop 11: Mean RTT value - 66.666
```

Router Latency Assessment:

Router 3 consistently shows high latency with values around 36.848 to 41.48.

Router 4 also demonstrates high latency with values ranging from 51.095 to 82.172.

Router 9 occasionally exhibits high latency with values around 65.48 to 117.261.

Path Latency Estimation:

Hops generally average around 54 to 55, but occasional spikes occur in specific runs.

Network Performance Assessment:

The maximum RTT values are particularly high at Router 9 (117.261) and Router 4 (82.172).

Identifying Bottlenecks:

Routers 3, 4, and 9 consistently show higher mean RTT values.

Day 3 Run 2:

```
RTT Values for Run 2 is [[0.504, 0.19, 0.152], [2.853, 1.575, 1.589], [34.5, '*', 61.321], [107.668, 67.411, 81.197], [59.177, 65.196, 56.346], [57.502, 58.423, 86.319], [60.36, 90.417, 71.1], [216.266, 107.299, 64.885], [63.471, 60.511, 59.856], [67.559, 64.996, 61.976]]
```

Router Latency Assessment:

```
Router 1: RTT values - [0.504, 0.19, 0.152]
Router 2: RTT values - [2.853, 1.575, 1.589]
Router 3: RTT values - [34.5, '*', 61.321]
Router 4: RTT values - [107.668, 67.411, 81.197]
Router 5: RTT values - [59.177, 65.196, 56.346]
Router 6: RTT values - [57.502, 58.423, 86.319]
Router 7: RTT values - [60.36, 90.417, 71.1]
Router 8: RTT values - [216.266, 107.299, 64.885]
Router 9: RTT values - [63.471, 60.511, 59.856]
Router 10: RTT values - [67.559, 64.996, 61.976]
```

Path Latency Estimation:

```
Hop 1: Average RTT - 66.986
Hop 2: Average RTT - 57.226
```

```
Network Performance Assessment:
Hop 1: Max RTT value - 0.504
Hop 2: Max RTT value - 2.853
Hop 3: Max RTT value - 61.321
Hop 4: Max RTT value - 107.668
Hop 5: Max RTT value - 65.196
Hop 6: Max RTT value - 86.319
Hop 7: Max RTT value - 90.417
Hop 8: Max RTT value - 216.266
Hop 9: Max RTT value - 63.471
Hop 10: Max RTT value - 67.559
```

Identifying Bottlenecks:

```
Hop 1: Mean RTT value - 0.282
Hop 2: Mean RTT value - 2.006
Hop 3: Mean RTT value - 47.910
Hop 4: Mean RTT value - 85.425
Hop 5: Mean RTT value - 60.240
Hop 6: Mean RTT value - 67.415
Hop 7: Mean RTT value - 73.959
Hop 8: Mean RTT value - 129.483
Hop 9: Mean RTT value - 61.279
Hop 10: Mean RTT value - 64.844
```

Router Latency Assessment:

Router 8 demonstrates extremely high latency, ranging from 64.885 to 216.266.

Router 4 shows occasional high latency with values around 67.411 to 107.668.

Path Latency Estimation:

The average RTT slightly fluctuates but generally remains around 57 to 67.

Network Performance Assessment:

Router 8 stands out with the highest RTT values in this run (216.266).

Identifying Bottlenecks:

Router 8 consistently shows significantly higher mean RTT values.

Day 3 Run 3:

```
RTT Values for Run 3 is [[0.437, 0.382, 0.369], [2.891, 3.189, 2.411], [65.111, '*', 38.379], [103.638, '*', '*'], [132.953, 121.769, 82.937], [63.278, 68.628, 63.071], [65.767, 57.78, 66.082], [67.473, 64.346, 81.103], [82.177, 74.303, 91.987], [77.619, 78.997, 77.627], [77.278, 427.466, 60.758], [65.615, 69.254, 137.226]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.437, 0.382, 0.369]  
Router 2: RTT values - [2.891, 3.189, 2.411]  
Router 3: RTT values - [65.111, '*', 38.379]  
Router 4: RTT values - [103.638, '*', '*']  
Router 5: RTT values - [132.953, 121.769, 82.937]  
Router 6: RTT values - [63.278, 68.628, 63.071]  
Router 7: RTT values - [65.767, 57.78, 66.082]  
Router 8: RTT values - [67.473, 64.346, 81.103]  
Router 9: RTT values - [82.177, 74.303, 91.987]  
Router 10: RTT values - [77.619, 78.997, 77.627]  
Router 11: RTT values - [77.278, 427.466, 60.758]  
Router 12: RTT values - [65.615, 69.254, 137.226]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 67.020  
Hop 2: Average RTT - 96.611  
Hop 3: Average RTT - 63.814
```

```
Console S1/A ✘ Network Performance Assessment:  
Hop 1: Max RTT value - 0.437  
Hop 2: Max RTT value - 3.189  
Hop 3: Max RTT value - 65.111  
Hop 4: Max RTT value - 103.638  
Hop 5: Max RTT value - 132.953  
Hop 6: Max RTT value - 68.628  
Hop 7: Max RTT value - 66.082  
Hop 8: Max RTT value - 81.103  
Hop 9: Max RTT value - 91.987  
Hop 10: Max RTT value - 78.997  
Hop 11: Max RTT value - 427.466  
Hop 12: Max RTT value - 137.226  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.396  
Hop 2: Mean RTT value - 2.830  
Hop 3: Mean RTT value - 51.745  
Hop 4: Mean RTT value - 103.638  
Hop 5: Mean RTT value - 112.553  
Hop 6: Mean RTT value - 64.992  
Hop 7: Mean RTT value - 63.210  
Hop 8: Mean RTT value - 70.974  
Hop 9: Mean RTT value - 82.822  
Hop 10: Mean RTT value - 78.081  
Hop 11: Mean RTT value - 188.501
```

Router Latency Assessment:

Router 11 shows extreme variability with RTT values ranging from 60.758 to 427.466.

Router 4 and Router 5 exhibit occasional high latency.

Path Latency Estimation:

The average RTT across hops fluctuates notably, especially due to high variability in Router 11.

Network Performance Assessment:

Router 11 demonstrates the highest RTT values (427.466) in this run.

Identifying Bottlenecks:

Router 11 consistently shows the highest mean RTT values, contributing to the network's overall latency.

Day 3 Run 4:

```
RTT Values for Run 4 is [[0.176, 0.078, 0.065], [3.204, 2.112, 1.845], [40.133, '*', 69.124], [102.065, 53.393, 74.861], [60.05, 56.374, 57.012], [59.36, 68.527, 61.702], [90.466, 57.959, 59.914], [58.615, 70.947, 58.358], [61.206, 66.273, 71.724], [65.728, 61.891, 61.121], [76.907, 63.132, 62.506], [60.171, 64.649, 63.94]]
```

Router Latency Assessment:

```
Router 1: RTT values - [0.176, 0.078, 0.065]
Router 2: RTT values - [3.204, 2.112, 1.845]
Router 3: RTT values - [40.133, '*', 69.124]
Router 4: RTT values - [102.065, 53.393, 74.861]
Router 5: RTT values - [60.05, 56.374, 57.012]
Router 6: RTT values - [59.36, 68.527, 61.702]
Router 7: RTT values - [90.466, 57.959, 59.914]
Router 8: RTT values - [58.615, 70.947, 58.358]
Router 9: RTT values - [61.206, 66.273, 71.724]
Router 10: RTT values - [65.728, 61.891, 61.121]
Router 11: RTT values - [76.907, 63.132, 62.506]
Router 12: RTT values - [60.171, 64.649, 63.94]
```

Path Latency Estimation:

```
Hop 1: Average RTT - 56.507
Hop 2: Average RTT - 51.394
```

```
Hop 2: Max RTT value - 3.204
Hop 3: Max RTT value - 69.124
Hop 4: Max RTT value - 102.065
Hop 5: Max RTT value - 60.05
Hop 6: Max RTT value - 68.527
Hop 7: Max RTT value - 90.466
Hop 8: Max RTT value - 70.947
Hop 9: Max RTT value - 71.724
Hop 10: Max RTT value - 65.728
Hop 11: Max RTT value - 76.907
Hop 12: Max RTT value - 64.649
```

Identifying Bottlenecks:

```
Hop 1: Mean RTT value - 0.106
Hop 2: Mean RTT value - 2.387
Hop 3: Mean RTT value - 54.629
Hop 4: Mean RTT value - 76.773
Hop 5: Mean RTT value - 57.812
Hop 6: Mean RTT value - 63.196
Hop 7: Mean RTT value - 69.446
Hop 8: Mean RTT value - 62.640
Hop 9: Mean RTT value - 66.401
Hop 10: Mean RTT value - 62.913
Hop 11: Mean RTT value - 67.515
Hop 12: Mean RTT value - 62.920
```

Router Latency Assessment:

Router 3 occasionally shows high latency with values around 40.133 to 69.124.

Router 4 shows moderate variability in RTT values.

Path Latency Estimation:

The average RTT remains relatively stable across hops.

Network Performance Assessment:

Router 4 has the highest RTT values (102.065) in this run.

Identifying Bottlenecks:

Router 4 exhibits higher mean RTT values across runs.

Day 3 Run 5:

```
RTT Values for Run 5 is [[0.537, 0.564, 0.547], [12.117, 3.249, 2.8], [57.235, '*', 64.137], [88.665, 71.489, 58.784], [62.48, 59.251, 62.469], [89.603, 58.541, 51.366], [59.708, 64.965, 65.689], [72.379, 56.252, 64.403], [66.08, 61.218, 74.222], [85.792, 77.837, 62.087]]
```

Router Latency Assessment:

```
Router 1: RTT values - [0.537, 0.564, 0.547]
Router 2: RTT values - [12.117, 3.249, 2.8]
Router 3: RTT values - [57.235, '*', 64.137]
Router 4: RTT values - [88.665, 71.489, 58.784]
Router 5: RTT values - [62.48, 59.251, 62.469]
Router 6: RTT values - [89.603, 58.541, 51.366]
Router 7: RTT values - [59.708, 64.965, 65.689]
Router 8: RTT values - [72.379, 56.252, 64.403]
Router 9: RTT values - [66.08, 61.218, 74.222]
Router 10: RTT values - [85.792, 77.837, 62.087]
```

Path Latency Estimation:

```
Hop 1: Average RTT - 59.460
Hop 2: Average RTT - 50.374
Hop 3: Average RTT - 50.650
```

```
Network Performance Assessment:
Hop 1: Max RTT value - 0.564
Hop 2: Max RTT value - 12.117
Hop 3: Max RTT value - 64.137
Hop 4: Max RTT value - 88.665
Hop 5: Max RTT value - 62.48
Hop 6: Max RTT value - 89.603
Hop 7: Max RTT value - 65.689
Hop 8: Max RTT value - 72.379
Hop 9: Max RTT value - 74.222
Hop 10: Max RTT value - 85.792
```

Identifying Bottlenecks:

```
Hop 1: Mean RTT value - 0.549
Hop 2: Mean RTT value - 6.055
Hop 3: Mean RTT value - 60.686
Hop 4: Mean RTT value - 72.979
Hop 5: Mean RTT value - 61.400
Hop 6: Mean RTT value - 66.503
Hop 7: Mean RTT value - 63.454
Hop 8: Mean RTT value - 64.345
Hop 9: Mean RTT value - 67.173
Hop 10: Mean RTT value - 75.239
```

Router Latency Assessment:

Router 6 shows occasional spikes in latency, ranging from 51.366 to 89.603.

Router 4 also exhibits moderate variability.

Path Latency Estimation:

The average RTT across hops remains relatively stable.

Network Performance Assessment:

Router 6 demonstrates the highest RTT values (89.603) in this run.

Identifying Bottlenecks:

Router 6 occasionally shows higher mean RTT values.

Day 3 Run 6:

```
RTT Values for Run 6 is [[0.38, 0.285, 0.423], [3.088, 2.31, 2.127], [45.332, '*', 49.509], [94.342, 49.11, 53.196], [52.199, 320.497, 76.356], [60.762, 70.812, 50.205], [53.626, 61.891, 65.389], [82.909, 63.035, 62.305], [99.858, 60.601, 77.324], [61.872, 75.052, 66.664], [75.373, 71.2, 63.633]]  
Router Latency Assessment:  
Router 1: RTT values - [0.38, 0.285, 0.423]  
Router 2: RTT values - [3.088, 2.31, 2.127]  
Router 3: RTT values - [45.332, '*', 49.509]  
Router 4: RTT values - [94.342, 49.11, 53.196]  
Router 5: RTT values - [52.199, 320.497, 76.356]  
Router 6: RTT values - [60.762, 70.812, 50.205]  
Router 7: RTT values - [53.626, 61.891, 65.389]  
Router 8: RTT values - [82.909, 63.035, 62.305]  
Router 9: RTT values - [99.858, 60.601, 77.324]  
Router 10: RTT values - [61.872, 75.052, 66.664]  
Router 11: RTT values - [75.373, 71.2, 63.633]  
Path Latency Estimation:  
Hop 1: Average RTT - 57.249  
Hop 2: Average RTT - 77.479  
Hop 3: Average RTT - 51.557
```

```
Network Performance Assessment:  
Hop 1: Max RTT value - 0.423  
Hop 2: Max RTT value - 3.088  
Hop 3: Max RTT value - 49.509  
Hop 4: Max RTT value - 94.342  
Hop 5: Max RTT value - 320.497  
Hop 6: Max RTT value - 70.812  
Hop 7: Max RTT value - 65.389  
Hop 8: Max RTT value - 82.909  
Hop 9: Max RTT value - 99.858  
Hop 10: Max RTT value - 75.052  
Hop 11: Max RTT value - 75.373  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.363  
Hop 2: Mean RTT value - 2.508  
Hop 3: Mean RTT value - 47.421  
Hop 4: Mean RTT value - 65.549  
Hop 5: Mean RTT value - 149.684  
Hop 6: Mean RTT value - 60.593  
Hop 7: Mean RTT value - 60.302  
Hop 8: Mean RTT value - 69.416  
Hop 9: Mean RTT value - 79.261  
Hop 10: Mean RTT value - 67.863  
Hop 11: Mean RTT value - 70.069
```

Router Latency Assessment:

Router 5 stands out with sporadic extremely high latency (320.497).

Router 4 and Router 9 also show occasional high latency.

Path Latency Estimation:

The average RTT remains relatively stable across hops.

Network Performance Assessment:

Router 5 demonstrates the highest RTT values (320.497) in this run.

Identifying Bottlenecks:

Router 5 consistently shows the highest mean RTT values, impacting overall network latency.

Consistently identifying certain routers (like Router 5 in Run 5 and 6) showcasing extreme spikes in latency or certain routers consistently demonstrating high mean RTT values can guide further investigation and targeted optimizations in the network infrastructure.

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 3, for 4 out of 6 runs are following the AS number 33154 and AS route DQECDOM, US

Day 4:

Path Metric Analysis – Route Analysis

```
No paths are same
No paths are same
No paths are same
Run 0 and Run 4 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.13',
'89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49', '136.142.2.162',
'136.142.253.237', '136.142.156.140']
No paths are same
Run 1 and Run 2 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.141',
'89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49', '136.142.2.162',
'136.142.253.237', '136.142.156.140']
No paths are same
No paths are same
Run 1 and Run 5 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.141',
'89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49', '136.142.2.162',
'136.142.253.237', '136.142.156.140']
No paths are same
No paths are same
Run 2 and Run 5 are the same : ['172.21.64.1', '172.20.10.1', '107.243.50.141',
'89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49', '136.142.2.162',
'136.142.253.237', '136.142.156.140']
```

```

The pitt payments IP routes on November 27 are outlined as follows:
['172.21.64.1', '172.20.10.1', '107.243.50.13', '89.149.136.181', '208.116.221.142',
'64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237', '136.142.156.140']
['172.21.64.1', '172.20.10.1', '107.243.50.141', '89.149.136.181', '208.116.221.142',
'64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237', '136.142.156.140']
['172.21.64.1', '172.20.10.1', '107.243.50.141', '89.149.136.181', '208.116.221.142',
'64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237', '136.142.156.140']
['172.21.64.1', '172.20.10.1', '107.243.50.13', '173.241.128.29', '89.149.136.181',
'208.116.221.142', '64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237',
'136.142.156.140']
['172.21.64.1', '172.20.10.1', '107.243.50.13', '89.149.136.181', '208.116.221.142',
'64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237', '136.142.156.140']
['172.21.64.1', '172.20.10.1', '107.243.50.141', '89.149.136.181', '208.116.221.142',
'64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237', '136.142.156.140']

RTT Values for Run 1 is [[0.486, 0.192, 0.47], [5.292, 4.323, 3.125], [46.083, '*', 35.965], [82.009, 67.904, 56.545], [60.95, 53.051, 54.697], [53.226, 62.918, 81.826], [57.01, 54.973, 53.904], [50.613, 54.242, 60.363], [50.298, 49.176, 48.949], [50.981, 54.055, 52.623]]

```

Paths Consistency:

0 measurement and 4 measurement share the same path.

1 measurement and 2 measurement follow an identical path.

1 measurement and 5 measurement share the same path.

2 measurement and 5 measurement have an identical route.

Observations:

Paths for 0, 1, 2, 4, and 5 measurements share a common path segment until the last IP.

The paths exhibit similarity among measurements, indicating potential stability in routing.

Dominant Path:

Majority of the measurements (0, 1, 2, 4, 5) follow a path: 172.21.64.1 -> 172.20.10.1 -> 107.243.50.XX (where XX varies) -> 89.149.136.181 -> 208.116.221.142 -> 64.58.254.229 -> 64.58.254.49 -> 136.142.2.162 -> 136.142.253.237 -> 136.142.156.140.

Stability Analysis – Delay (RTT's)

Commonality in Paths:

The consistency among different measurements suggests relative stability in the network routing to www.payments.pitt.edu on 27-Nov'.

Absence of Divergence:

Lack of significant variations or divergent paths across measurements indicates network stability during this period.

Day 4 Run 1:

```
RTT Values for Run 1 is [[0.486, 0.192, 0.47], [5.292, 4.323, 3.125], [46.083, '*', 35.965], [82.009, 67.904, 56.545], [60.95, 53.051, 54.697], [53.226, 62.918, 81.826], [57.01, 54.973, 53.904], [50.613, 54.242, 60.363], [50.298, 49.176, 48.949], [50.981, 54.055, 52.623]]
```

Router Latency Assessment:

```
Router 1: RTT values - [0.486, 0.192, 0.47]
Router 2: RTT values - [5.292, 4.323, 3.125]
Router 3: RTT values - [46.083, '*', 35.965]
Router 4: RTT values - [82.009, 67.904, 56.545]
Router 5: RTT values - [60.95, 53.051, 54.697]
Router 6: RTT values - [53.226, 62.918, 81.826]
Router 7: RTT values - [57.01, 54.973, 53.904]
Router 8: RTT values - [50.613, 54.242, 60.363]
Router 9: RTT values - [50.298, 49.176, 48.949]
Router 10: RTT values - [50.981, 54.055, 52.623]
```

Path Latency Estimation:

```
Hop 1: Average RTT - 45.695
Hop 2: Average RTT - 44.537
Hop 3: Average RTT - 44.847
```

Network Performance Assessment:

```
Hop 1: Max RTT value - 0.486
Hop 2: Max RTT value - 5.292
Hop 3: Max RTT value - 46.083
Hop 4: Max RTT value - 82.009
Hop 5: Max RTT value - 60.95
Hop 6: Max RTT value - 81.826
Hop 7: Max RTT value - 57.01
Hop 8: Max RTT value - 60.363
Hop 9: Max RTT value - 50.298
Hop 10: Max RTT value - 54.055
```

Identifying Bottlenecks:

```
Hop 1: Mean RTT value - 0.383
Hop 2: Mean RTT value - 4.247
Hop 3: Mean RTT value - 41.024
Hop 4: Mean RTT value - 68.819
Hop 5: Mean RTT value - 56.233
Hop 6: Mean RTT value - 65.990
Hop 7: Mean RTT value - 55.296
Hop 8: Mean RTT value - 55.073
Hop 9: Mean RTT value - 49.474
Hop 10: Mean RTT value - 52.553
```

Router Latency Assessment:

Router 3 shows RTT values of [46.083, '*', 35.965], indicating high variability and a missing value.

Router 4 has RTT values of [82.009, 67.904, 56.545], demonstrating high latency, especially in the first reading.

Path Latency Estimation:

Average RTT values per hop range from 44.537 to 45.695, indicating relatively consistent latency.

Network Performance Assessment:

Maximum RTT values range from 0.486 to 82.009 across different hops.

Identifying Bottlenecks:

Router 4 exhibits the highest mean RTT value of 68.819, indicating a potential bottleneck.

Day 4 Run 2

```
RTT Values for Run 2 is [[0.466, 0.415, 0.261], [5.847, 5.654, 2.412], [66.046, '*', 83.014], [101.899, 57.751, 75.792], [75.312, 59.237, 66.982], [61.075, 65.934, 60.368], [70.195, 68.516, 57.881], [88.713, 78.44, 59.984], [65.457, 69.679, 58.047], [71.306, 62.909, 53.612]]  
Router Latency Assessment:  
Router 1: RTT values - [0.466, 0.415, 0.261]  
Router 2: RTT values - [5.847, 5.654, 2.412]  
Router 3: RTT values - [66.046, '*', 83.014]  
Router 4: RTT values - [101.899, 57.751, 75.792]  
Router 5: RTT values - [75.312, 59.237, 66.982]  
Router 6: RTT values - [61.075, 65.934, 60.368]  
Router 7: RTT values - [70.195, 68.516, 57.881]  
Router 8: RTT values - [88.713, 78.44, 59.984]  
Router 9: RTT values - [65.457, 69.679, 58.047]  
Router 10: RTT values - [71.306, 62.909, 53.612]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 60.632  
Hop 2: Average RTT - 52.059  
Hop 3: Average RTT - 51.835
```

```
Network Performance Assessment:  
Hop 1: Max RTT value - 0.466  
Hop 2: Max RTT value - 5.847  
Hop 3: Max RTT value - 83.014  
Hop 4: Max RTT value - 101.899  
Hop 5: Max RTT value - 75.312  
Hop 6: Max RTT value - 65.934  
Hop 7: Max RTT value - 70.195  
Hop 8: Max RTT value - 88.713  
Hop 9: Max RTT value - 69.679  
Hop 10: Max RTT value - 71.306  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.381  
Hop 2: Mean RTT value - 4.638  
Hop 3: Mean RTT value - 74.530  
Hop 4: Mean RTT value - 78.481  
Hop 5: Mean RTT value - 67.177  
Hop 6: Mean RTT value - 62.459  
Hop 7: Mean RTT value - 65.531  
Hop 8: Mean RTT value - 75.712  
Hop 9: Mean RTT value - 64.394  
Hop 10: Mean RTT value - 62.609
```

Router Latency Assessment:

Router 3 has a missing value marked as '*', making the assessment incomplete.

Router 4 shows high RTT values [101.899, 57.751, 75.792], particularly in the first reading.

Path Latency Estimation:

Average RTT values per hop range from 51.835 to 60.632, showing variability across readings.

Network Performance Assessment:

Maximum RTT values range from 0.466 to 101.899 across different hops.

Identifying Bottlenecks:

Router 4 demonstrates a high mean RTT value of 78.481, indicating a bottleneck.

Day 4 run 3

```
RTT Values for Run 3 is [[0.375, 0.288, 0.162], [5.054, 3.138, 2.298], [79.578, '*', 78.392], [72.783, 67.227, 51.949], [57.885, 64.885, 56.967], [47.888, 50.478, 58.222], [49.965, 52.797, 52.16], [89.656, 66.106, 51.149], [60.246, 53.649, 53.237], [57.175, 50.307, 53.44]]
```

Router Latency Assessment:

```
Router 1: RTT values - [0.375, 0.288, 0.162]
Router 2: RTT values - [5.054, 3.138, 2.298]
Router 3: RTT values - [79.578, '*', 78.392]
Router 4: RTT values - [72.783, 67.227, 51.949]
Router 5: RTT values - [57.885, 64.885, 56.967]
Router 6: RTT values - [47.888, 50.478, 58.222]
Router 7: RTT values - [49.965, 52.797, 52.16]
Router 8: RTT values - [89.656, 66.106, 51.149]
Router 9: RTT values - [60.246, 53.649, 53.237]
Router 10: RTT values - [57.175, 50.307, 53.44]
```

Path Latency Estimation:

```
Hop 1: Average RTT - 52.061
Hop 2: Average RTT - 45.431
Hop 3: Average RTT - 45.798
```

Network Performance Assessment:

```
Hop 1: Max RTT value - 0.375
Hop 2: Max RTT value - 5.054
Hop 3: Max RTT value - 79.578
Hop 4: Max RTT value - 72.783
Hop 5: Max RTT value - 64.885
Hop 6: Max RTT value - 58.222
Hop 7: Max RTT value - 52.797
Hop 8: Max RTT value - 89.656
Hop 9: Max RTT value - 60.246
Hop 10: Max RTT value - 57.175
```

Identifying Bottlenecks:

```
Hop 1: Mean RTT value - 0.275
Hop 2: Mean RTT value - 3.497
Hop 3: Mean RTT value - 78.985
Hop 4: Mean RTT value - 63.986
Hop 5: Mean RTT value - 59.912
Hop 6: Mean RTT value - 52.196
Hop 7: Mean RTT value - 51.641
Hop 8: Mean RTT value - 68.970
Hop 9: Mean RTT value - 55.711
Hop 10: Mean RTT value - 53.641
```

Router Latency Assessment:

Router 3 has a missing value marked as '*', making the assessment incomplete.

Router 4 shows RTT values of [72.783, 67.227, 51.949], indicating moderate latency.

Path Latency Estimation:

Average RTT values per hop range from 45.431 to 52.061, showing some variability.

Network Performance Assessment:

Maximum RTT values range from 0.375 to 79.578 across different hops.

Identifying Bottlenecks:

Router 8 demonstrates the highest mean RTT value of 68.970, indicating a potential bottleneck.

Day 4 run 4

```
RTT Values for Run 4 is [[0.278, 0.188, 0.135], [4.271, 4.767, 2.635], [51.327, '*', 61.438], [45.044, 47.161, '*'], [63.489, 57.411, 67.356], [83.498, 56.661, 59.805], [49.789, 48.913, 56.18], [54.855, 61.713, 50.924], [56.643, 52.583, 52.92], [58.81, 50.788, 59.605], [52.789, 61.994, 55.428]]
```

Router Latency Assessment:

```
Router 1: RTT values - [0.278, 0.188, 0.135]
Router 2: RTT values - [4.271, 4.767, 2.635]
Router 3: RTT values - [51.327, '*', 61.438]
Router 4: RTT values - [45.044, 47.161, '*']
Router 5: RTT values - [63.489, 57.411, 67.356]
Router 6: RTT values - [83.498, 56.661, 59.805]
Router 7: RTT values - [49.789, 48.913, 56.18]
Router 8: RTT values - [54.855, 61.713, 50.924]
Router 9: RTT values - [56.643, 52.583, 52.92]
Router 10: RTT values - [58.81, 50.788, 59.605]
Router 11: RTT values - [52.789, 61.994, 55.428]
```

Path Latency Estimation:

```
Hop 1: Average RTT - 47.345
Hop 2: Average RTT - 44.218
Hop 3: Average RTT - 46.643
```

Network Performance Assessment:

```
Hop 1: Max RTT value - 0.278
Hop 2: Max RTT value - 4.767
Hop 3: Max RTT value - 61.438
Hop 4: Max RTT value - 47.161
Hop 5: Max RTT value - 67.356
Hop 6: Max RTT value - 83.498
Hop 7: Max RTT value - 56.18
Hop 8: Max RTT value - 61.713
Hop 9: Max RTT value - 56.643
Hop 10: Max RTT value - 59.605
Hop 11: Max RTT value - 61.994
```

Identifying Bottlenecks:

```
Hop 1: Mean RTT value - 0.200
Hop 2: Mean RTT value - 3.891
Hop 3: Mean RTT value - 56.383
Hop 4: Mean RTT value - 46.102
Hop 5: Mean RTT value - 62.752
Hop 6: Mean RTT value - 66.655
Hop 7: Mean RTT value - 51.627
Hop 8: Mean RTT value - 55.831
Hop 9: Mean RTT value - 54.049
Hop 10: Mean RTT value - 56.401
Hop 11: Mean RTT value - 56.737
```

Router Latency Assessment:

Router 3 and Router 4 both have missing values marked as '*', making the assessment incomplete.

Router 6 demonstrates high variability in RTT values [83.498, 56.661, 59.805].

Path Latency Estimation:

Average RTT values per hop range from 44.218 to 47.345, showing relatively consistent latency.

Network Performance Assessment:

Maximum RTT values range from 0.278 to 83.498 across different hops.

Identifying Bottlenecks:

Router 6 exhibits the highest mean RTT value of 66.655, indicating a potential bottleneck.

Day 4 run 5

```
RTT Values for Run 5 is [[0.292, 0.187, 0.13], [4.001, 3.235, 4.403], [65.386, '*', 62.778], [67.922, 70.799, 56.937], [57.633, 52.53, 61.427], [53.786, 48.302, 54.47], [47.487, 52.063, 57.548], [122.408, 61.069, 55.153], [52.846, 54.802, 51.883], [50.9, 52.706, 53.601]]
```

Router Latency Assessment:

```
Router 1: RTT values - [0.292, 0.187, 0.13]
Router 2: RTT values - [4.001, 3.235, 4.403]
Router 3: RTT values - [65.386, '*', 62.778]
Router 4: RTT values - [67.922, 70.799, 56.937]
Router 5: RTT values - [57.633, 52.53, 61.427]
Router 6: RTT values - [53.786, 48.302, 54.47]
Router 7: RTT values - [47.487, 52.063, 57.548]
Router 8: RTT values - [122.408, 61.069, 55.153]
Router 9: RTT values - [52.846, 54.802, 51.883]
Router 10: RTT values - [50.9, 52.706, 53.601]
```

Path Latency Estimation:

```
Hop 1: Average RTT - 52.266
Hop 2: Average RTT - 43.966
Hop 3: Average RTT - 45.833
```

Network Performance Assessment:

```
Hop 1: Max RTT value - 0.292
Hop 2: Max RTT value - 4.403
Hop 3: Max RTT value - 65.386
Hop 4: Max RTT value - 70.799
Hop 5: Max RTT value - 61.427
Hop 6: Max RTT value - 54.47
Hop 7: Max RTT value - 57.548
Hop 8: Max RTT value - 122.408
Hop 9: Max RTT value - 54.802
Hop 10: Max RTT value - 53.601
```

Identifying Bottlenecks:

```
Hop 1: Mean RTT value - 0.203
Hop 2: Mean RTT value - 3.880
Hop 3: Mean RTT value - 64.082
Hop 4: Mean RTT value - 65.219
Hop 5: Mean RTT value - 57.197
Hop 6: Mean RTT value - 52.186
Hop 7: Mean RTT value - 52.366
Hop 8: Mean RTT value - 79.543
Hop 9: Mean RTT value - 53.177
Hop 10: Mean RTT value - 52.402
```

Router Latency Assessment:

Router 3 has a missing value marked as '*', making the assessment incomplete.

Router 4 demonstrates high variability in RTT values [67.922, 70.799, 56.937].

Path Latency Estimation:

Average RTT values per hop range from 43.966 to 52.266, showing some variability.

Network Performance Assessment:

Maximum RTT values range from 0.13 to 122.408 across different hops.

Identifying Bottlenecks:

Router 8 exhibits the highest mean RTT value of 79.543, indicating a potential bottleneck.

Day 4 run 6

```
RTT Values for Run 6 is [[0.298, 0.302, 0.237], [24.461, 12.88, 2.06], [57.944, '*', 41.086], [97.466, 69.65, 55.504], [62.546, 73.24, 63.115], [57.497, 48.175, 64.889], [79.997, 54.489, 76.126], [203.411, 52.26, 52.923], [63.94, 53.594, 60.733], [53.919, 61.307, 55.523]]
```

Router Latency Assessment:

```
Router 1: RTT values - [0.298, 0.302, 0.237]
Router 2: RTT values - [24.461, 12.88, 2.06]
Router 3: RTT values - [57.944, '*', 41.086]
Router 4: RTT values - [97.466, 69.65, 55.504]
Router 5: RTT values - [62.546, 73.24, 63.115]
Router 6: RTT values - [57.497, 48.175, 64.889]
Router 7: RTT values - [79.997, 54.489, 76.126]
Router 8: RTT values - [203.411, 52.26, 52.923]
Router 9: RTT values - [63.94, 53.594, 60.733]
Router 10: RTT values - [53.919, 61.307, 55.523]
```

Path Latency Estimation:

```
Hop 1: Average RTT - 70.148
Hop 2: Average RTT - 47.322
Hop 3: Average RTT - 47.220
```

Network Performance Assessment:

```
Hop 1: Max RTT value - 0.302
Hop 2: Max RTT value - 24.461
Hop 3: Max RTT value - 57.944
Hop 4: Max RTT value - 97.466
Hop 5: Max RTT value - 73.24
Hop 6: Max RTT value - 64.889
Hop 7: Max RTT value - 79.997
Hop 8: Max RTT value - 203.411
Hop 9: Max RTT value - 63.94
Hop 10: Max RTT value - 61.307
```

Identifying Bottlenecks:

```
Hop 1: Mean RTT value - 0.279
Hop 2: Mean RTT value - 13.134
Hop 3: Mean RTT value - 49.515
Hop 4: Mean RTT value - 74.207
Hop 5: Mean RTT value - 66.300
Hop 6: Mean RTT value - 56.854
Hop 7: Mean RTT value - 70.204
Hop 8: Mean RTT value - 102.865
Hop 9: Mean RTT value - 59.422
Hop 10: Mean RTT value - 56.916
```

Router Latency Assessment:

Router 3 has a missing value marked as '*', making the assessment incomplete.

Router 4 demonstrates high variability in RTT values [97.466, 69.65, 55.504].

Path Latency Estimation:

Average RTT values per hop range from 47.220 to 70.148, showing variability.

Network Performance Assessment:

Maximum RTT values range from 0.237 to 203.411 across different hops.

Identifying Bottlenecks:

Router 8 demonstrates the highest mean RTT value of 102.865, indicating a potential bottleneck.

AS level Analysis

AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 4, for 5 out of 6 runs are following the AS number 33154 and AS route DQECDOM, US

Day5

Path Metric Analysis:

```
No paths are same
Run 2 and Run 3 are the same : ['172.21.64.1', '172.20.10.1', '107.243.2.134',
'89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49', '136.142.2.162',
'136.142.253.237', '136.142.156.140']
Run 2 and Run 4 are the same : ['172.21.64.1', '172.20.10.1', '107.243.2.134',
'89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49', '136.142.2.162',
'136.142.253.237', '136.142.156.140']
No paths are same
Run 3 and Run 4 are the same : ['172.21.64.1', '172.20.10.1', '107.243.2.134',
'89.149.136.181', '208.116.221.142', '64.58.254.229', '64.58.254.49', '136.142.2.162',
'136.142.253.237', '136.142.156.140']
No paths are same
No paths are same
```

```

The pitt payments IP routes on November 28 are outlined as follows:
['172.21.64.1', '172.20.10.1', '107.243.2.135', '89.149.136.181', '208.116.221.142',
'64.58.254.229', '64.58.254.49', '208.103.114.14', '136.142.2.162', '136.142.253.237',
'136.142.156.140']
['172.21.64.1', '172.20.10.1', '107.243.2.135', '89.149.136.181', '208.116.221.142',
'64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237', '136.142.156.140']
['172.21.64.1', '172.20.10.1', '107.243.2.134', '89.149.136.181', '208.116.221.142',
'64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237', '136.142.156.140']
['172.21.64.1', '172.20.10.1', '107.243.2.134', '89.149.136.181', '208.116.221.142',
'64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237', '136.142.156.140']
['172.21.64.1', '172.20.10.1', '107.243.2.134', '89.149.136.181', '208.116.221.142',
'64.58.254.229', '64.58.254.49', '136.142.2.162', '136.142.253.237', '136.142.156.140']
['172.21.64.1', '172.20.10.1', '107.243.2.134', '173.241.128.29', '89.149.136.181',
'208.116.221.142', '64.58.254.229', '64.58.254.49', '208.103.114.14', '136.142.2.162',
'136.142.253.237', '136.142.156.140']

```

Path Similarities:

- 2 measurement and 3 measurement share the same path.
- 2 measurement and 4 measurement follow an identical route.
- 3 measurement and 4 measurement exhibit consistency in their paths.

Path Details:

Shared path for 2, 3, and 4 measurements: 172.21.64.1 -> 172.20.10.1 -> 107.243.2.134 -> 89.149.136.181 -> 208.116.221.142 -> 64.58.254.229 -> 64.58.254.49 -> 136.142.2.162 -> 136.142.253.237 -> 136.142.156.140.

Observations:

Consistency in paths across different measurements suggests stable routing.

All measurements share an identical path until the last IP, indicating stable network routing on 28-Nov' for www.payments.pitt.edu.

Stability Analysis -Delay Analysis RTT's

Common Path:

The uniformity among different measurements implies a stable and consistent network routing scenario during this period.

Path Consistency

Lack of divergence in paths across measurements indicates stability and consistent routing behavior.

This analysis signifies the stability and consistency in the network routing for www.payments.pitt.edu on 28-Nov'. It suggests that during this timeframe, the network maintained a stable and reliable path for traffic to the specified destination without notable variations.

Day 5 Run 1:

```
RTT Values for Run 1 is [[0.223, 0.254, 0.167], [4.038, 5.55, 3.057], [63.843, '*', 36.572], [98.079, 50.73, 71.379], [71.961, 56.495, 59.067], [57.783, 60.048, 61.463], [89.353, 59.945, 56.716], [76.407, 62.652, 76.047], [54.537, 57.223, 59.126], [72.501, 59.986, 65.152], [55.307, 63.462, 53.81]]
```

```
Router Latency Assessment:  
Router 1: RTT values - [0.223, 0.254, 0.167]  
Router 2: RTT values - [4.038, 5.55, 3.057]  
Router 3: RTT values - [63.843, '*', 36.572]  
Router 4: RTT values - [98.079, 50.73, 71.379]  
Router 5: RTT values - [71.961, 56.495, 59.067]  
Router 6: RTT values - [57.783, 60.048, 61.463]  
Router 7: RTT values - [89.353, 59.945, 56.716]  
Router 8: RTT values - [76.407, 62.652, 76.047]  
Router 9: RTT values - [54.537, 57.223, 59.126]  
Router 10: RTT values - [72.501, 59.986, 65.152]  
Router 11: RTT values - [55.307, 63.462, 53.81]
```

```
Path Latency Estimation:  
Hop 1: Average RTT - 58.548  
Hop 2: Average RTT - 47.634  
Hop 3: Average RTT - 49.323
```

```
Network Performance Assessment:  
Hop 1: Max RTT value - 0.254  
Hop 2: Max RTT value - 5.55  
Hop 3: Max RTT value - 63.843  
Hop 4: Max RTT value - 98.079  
Hop 5: Max RTT value - 71.961  
Hop 6: Max RTT value - 61.463  
Hop 7: Max RTT value - 89.353  
Hop 8: Max RTT value - 76.407  
Hop 9: Max RTT value - 59.126  
Hop 10: Max RTT value - 72.501  
Hop 11: Max RTT value - 63.462
```

```
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.215  
Hop 2: Mean RTT value - 4.215  
Hop 3: Mean RTT value - 50.208  
Hop 4: Mean RTT value - 73.396  
Hop 5: Mean RTT value - 62.508  
Hop 6: Mean RTT value - 59.765  
Hop 7: Mean RTT value - 68.671  
Hop 8: Mean RTT value - 71.702  
Hop 9: Mean RTT value - 56.962  
Hop 10: Mean RTT value - 65.880  
Hop 11: Mean RTT value - 57.526
```

Path Latency Estimation:

Hop 1: 58.548

Hop 2: 47.634

Hop 3: 49.323

Identifying Bottlenecks:

Hop 1: Max RTT - 0.254

Hop 2: Max RTT - 5.55

Hop 3: Max RTT - 98.079

Day 5 Run 2:

```
RTT Values for Run 2 is [[0.222, 0.202, 0.216], [5.557, 1.999, 2.726], [41.706, '*', 55.379], [74.746, 66.672, 83.766], [68.201, 58.971, 54.282], [65.23, 76.661, 61.877], [87.424, 97.932, 73.972], [82.053, 84.001, 57.683], [97.683, 81.858, 78.308], [65.713, 48.569, 59.008]]  
Router Latency Assessment:  
Router 1: RTT values - [0.222, 0.202, 0.216]  
Router 2: RTT values - [5.557, 1.999, 2.726]  
Router 3: RTT values - [41.706, '*', 55.379]  
Router 4: RTT values - [74.746, 66.672, 83.766]  
Router 5: RTT values - [68.201, 58.971, 54.282]  
Router 6: RTT values - [65.23, 76.661, 61.877]  
Router 7: RTT values - [87.424, 97.932, 73.972]  
Router 8: RTT values - [82.053, 84.001, 57.683]  
Router 9: RTT values - [97.683, 81.858, 78.308]  
Router 10: RTT values - [65.713, 48.569, 59.008]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 58.853  
Hop 2: Average RTT - 57.429  
Hop 3: Average RTT - 52.722
```

```
Network Performance Assessment:  
Hop 1: Max RTT value - 0.222  
Hop 2: Max RTT value - 5.557  
Hop 3: Max RTT value - 55.379  
Hop 4: Max RTT value - 83.766  
Hop 5: Max RTT value - 68.201  
Hop 6: Max RTT value - 76.661  
Hop 7: Max RTT value - 97.932  
Hop 8: Max RTT value - 84.001  
Hop 9: Max RTT value - 97.683  
Hop 10: Max RTT value - 65.713  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.213  
Hop 2: Mean RTT value - 3.427  
Hop 3: Mean RTT value - 48.543  
Hop 4: Mean RTT value - 75.061  
Hop 5: Mean RTT value - 60.485  
Hop 6: Mean RTT value - 67.923  
Hop 7: Mean RTT value - 86.443  
Hop 8: Mean RTT value - 74.579  
Hop 9: Mean RTT value - 85.950  
Hop 10: Mean RTT value - 57.763
```

Path Latency Estimation:

Hop 1: 58.853

Hop 2: 57.429

Hop 3: 52.722

Identifying Bottlenecks:

Hop 1: Max RTT - 0.222

Hop 2: Max RTT - 5.557

Hop 3: Max RTT - 74.746

Day 5 Run 3:

```

RTT Values for Run 3 is [[0.383, 0.527, 0.249], [3.748, 4.365, 2.268], [45.417, '*', 67.094], [48.719, 67.64, 58.083], [133.009, 0.007, 67.528], [58.427, 64.045, 52.465], [49.611, 76.996, 66.747], [75.765, 73.72, 71.758], [52.354, 61.748, 61.196], [75.681, 57.87, 45.772]]

Router Latency Assessment:
Router 1: RTT values - [0.383, 0.527, 0.249]
Router 2: RTT values - [3.748, 4.365, 2.268]
Router 3: RTT values - [45.417, '*', 67.094]
Router 4: RTT values - [48.719, 67.64, 58.083]
Router 5: RTT values - [133.009, 0.007, 67.528]
Router 6: RTT values - [58.427, 64.045, 52.465]
Router 7: RTT values - [49.611, 76.996, 66.747]
Router 8: RTT values - [75.765, 73.72, 71.758]
Router 9: RTT values - [52.354, 61.748, 61.196]
Router 10: RTT values - [75.681, 57.87, 45.772]

Path Latency Estimation:
Hop 1: Average RTT - 54.311
Hop 2: Average RTT - 45.213
Hop 3: Average RTT - 49.316

```

```

Network Performance Assessment:
Hop 1: Max RTT value - 0.527
Hop 2: Max RTT value - 4.365
Hop 3: Max RTT value - 67.094
Hop 4: Max RTT value - 67.64
Hop 5: Max RTT value - 133.009
Hop 6: Max RTT value - 64.045
Hop 7: Max RTT value - 76.996
Hop 8: Max RTT value - 75.765
Hop 9: Max RTT value - 61.748
Hop 10: Max RTT value - 75.681

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.386
Hop 2: Mean RTT value - 3.460
Hop 3: Mean RTT value - 56.255
Hop 4: Mean RTT value - 58.147
Hop 5: Mean RTT value - 66.848
Hop 6: Mean RTT value - 58.312
Hop 7: Mean RTT value - 64.451
Hop 8: Mean RTT value - 73.748
Hop 9: Mean RTT value - 58.433
Hop 10: Mean RTT value - 59.774

```

Path Latency Estimation:

Hop 1: 54.311

Hop 2: 45.213

Hop 3: 49.316

Identifying Bottlenecks:

Hop 1: Max RTT - 0.527

Hop 2: Max RTT - 4.365

Hop 3: Max RTT - 133.009

Day 5 Run 4:

```
RTT Values for Run 4 is [[0.42, 0.352, 0.307], [7.664, 3.359, 2.266], [39.027, '*', 61.47], [101.439, 78.66, 55.098], [53.281, 47.164, 55.747], [46.496, 71.351, 71.188], [64.096, 59.006, 60.321], [90.236, 50.526, 59.435], [54.957, 58.225, 70.674], [75.224, 67.14, 62.749]]
```

Router Latency Assessment:

```
Router 1: RTT values - [0.42, 0.352, 0.307]
Router 2: RTT values - [7.664, 3.359, 2.266]
Router 3: RTT values - [39.027, '*', 61.47]
Router 4: RTT values - [101.439, 78.66, 55.098]
Router 5: RTT values - [53.281, 47.164, 55.747]
Router 6: RTT values - [46.496, 71.351, 71.188]
Router 7: RTT values - [64.096, 59.006, 60.321]
Router 8: RTT values - [90.236, 50.526, 59.435]
Router 9: RTT values - [54.957, 58.225, 70.674]
Router 10: RTT values - [75.224, 67.14, 62.749]
```

Path Latency Estimation:

```
Hop 1: Average RTT - 53.284
Hop 2: Average RTT - 48.420
Hop 3: Average RTT - 49.925
```

```
Network Performance Assessment:
Hop 1: Max RTT value - 0.42
Hop 2: Max RTT value - 7.664
Hop 3: Max RTT value - 61.47
Hop 4: Max RTT value - 101.439
Hop 5: Max RTT value - 55.747
Hop 6: Max RTT value - 71.351
Hop 7: Max RTT value - 64.096
Hop 8: Max RTT value - 90.236
Hop 9: Max RTT value - 70.674
Hop 10: Max RTT value - 75.224

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.360
Hop 2: Mean RTT value - 4.430
Hop 3: Mean RTT value - 50.248
Hop 4: Mean RTT value - 78.399
Hop 5: Mean RTT value - 52.064
Hop 6: Mean RTT value - 63.012
Hop 7: Mean RTT value - 61.141
Hop 8: Mean RTT value - 66.732
Hop 9: Mean RTT value - 61.285
Hop 10: Mean RTT value - 68.371
```

Path Latency Estimation:

Hop 1: 53.284

Hop 2: 48.420

Hop 3: 49.925

Identifying Bottlenecks:

Hop 1: Max RTT - 0.42

Hop 2: Max RTT - 7.664

Hop 3: Max RTT - 101.439

Day 5 Run 5:

```
RTT Values for Run 5 is [[0.385, 0.421, 0.304], [4.64, 5.033, 2.931], [63.449, '*', 66.89], [96.813, 51.3, 65.122], [69.875, 66.219, 58.795], [43.158, 54.622, 58.539], [64.855, 55.694, 42.62], [97.307, 66.771, 59.577], [85.028, 50.295, 53.234], [72.522, 59.013, 56.874]]
```

Router Latency Assessment:

```
Router 1: RTT values - [0.385, 0.421, 0.304]
Router 2: RTT values - [4.64, 5.033, 2.931]
Router 3: RTT values - [63.449, '*', 66.89]
Router 4: RTT values - [96.813, 51.3, 65.122]
Router 5: RTT values - [69.875, 66.219, 58.795]
Router 6: RTT values - [43.158, 54.622, 58.539]
Router 7: RTT values - [64.855, 55.694, 42.62]
Router 8: RTT values - [97.307, 66.771, 59.577]
Router 9: RTT values - [85.028, 50.295, 53.234]
Router 10: RTT values - [72.522, 59.013, 56.874]
```

Path Latency Estimation:

```
Hop 1: Average RTT - 59.803
Hop 2: Average RTT - 45.485
Hop 3: Average RTT - 46.489
```

```
Network Performance Assessment:
Hop 1: Max RTT value - 0.421
Hop 2: Max RTT value - 5.033
Hop 3: Max RTT value - 66.89
Hop 4: Max RTT value - 96.813
Hop 5: Max RTT value - 69.875
Hop 6: Max RTT value - 58.539
Hop 7: Max RTT value - 64.855
Hop 8: Max RTT value - 97.307
Hop 9: Max RTT value - 85.028
Hop 10: Max RTT value - 72.522

Identifying Bottlenecks:
Hop 1: Mean RTT value - 0.370
Hop 2: Mean RTT value - 4.201
Hop 3: Mean RTT value - 65.169
Hop 4: Mean RTT value - 71.078
Hop 5: Mean RTT value - 64.963
Hop 6: Mean RTT value - 52.106
Hop 7: Mean RTT value - 54.390
Hop 8: Mean RTT value - 74.552
Hop 9: Mean RTT value - 62.852
Hop 10: Mean RTT value - 62.803
```

Path Latency Estimation:

Hop 1: 59.803

Hop 2: 45.485

Hop 3: 46.489

Identifying Bottlenecks:

Hop 1: Max RTT - 0.421

Hop 2: Max RTT - 5.033

Hop 3: Max RTT - 96.813

Day 5 Run 6:

```
RTT values for Run 6 is [[0.389, 0.155, 0.192], [5.158, 2.583, 2.769], [60.257, '*', 49.674], [43.745, 51.404, 53.085], [70.074, 59.351, 71.27], [76.062, 74.622, 58.801], [59.545, 62.064, 66.37], [67.024, 57.109, 54.162], [56.593, 61.297, 88.823], [58.368, 55.76, 53.192], [45.747, 103.614, 74.279], [57.297, 60.923, 60.332]]  
  
Router Latency Assessment:  
Router 1: RTT values - [0.389, 0.155, 0.192]  
Router 2: RTT values - [5.158, 2.583, 2.769]  
Router 3: RTT values - [60.257, '*', 49.674]  
Router 4: RTT values - [43.745, 51.404, 53.085]  
Router 5: RTT values - [70.074, 59.351, 71.27]  
Router 6: RTT values - [76.062, 74.622, 58.801]  
Router 7: RTT values - [59.545, 62.064, 66.37]  
Router 8: RTT values - [67.024, 57.109, 54.162]  
Router 9: RTT values - [56.593, 61.297, 88.823]  
Router 10: RTT values - [58.368, 55.76, 53.192]  
Router 11: RTT values - [45.747, 103.614, 74.279]  
Router 12: RTT values - [57.297, 60.923, 60.332]  
  
Path Latency Estimation:  
Hop 1: Average RTT - 50.022  
Hop 2: Average RTT - 53.535  
Hop 3: Average RTT - 52.746
```

```
Network Performance Assessment:  
Hop 1: Max RTT value - 0.389  
Hop 2: Max RTT value - 5.158  
Hop 3: Max RTT value - 60.257  
Hop 4: Max RTT value - 53.085  
Hop 5: Max RTT value - 71.27  
Hop 6: Max RTT value - 76.062  
Hop 7: Max RTT value - 66.37  
Hop 8: Max RTT value - 67.024  
Hop 9: Max RTT value - 88.823  
Hop 10: Max RTT value - 58.368  
Hop 11: Max RTT value - 103.614  
Hop 12: Max RTT value - 60.923  
  
Identifying Bottlenecks:  
Hop 1: Mean RTT value - 0.245  
Hop 2: Mean RTT value - 3.503  
Hop 3: Mean RTT value - 54.965  
Hop 4: Mean RTT value - 49.411  
Hop 5: Mean RTT value - 66.898  
Hop 6: Mean RTT value - 69.828  
Hop 7: Mean RTT value - 62.660  
Hop 8: Mean RTT value - 59.432  
Hop 9: Mean RTT value - 68.904  
Hop 10: Mean RTT value - 55.773  
Hop 11: Mean RTT value - 74.547
```

Path Latency Estimation:

Hop 1: 50.022

Hop 2: 53.535

Hop 3: 52.746

Identifying Bottlenecks:

Hop 1: Max RTT - 0.389

Hop 2: Max RTT - 5.158

Hop 3: Max RTT - 76.062

AS level Analysis

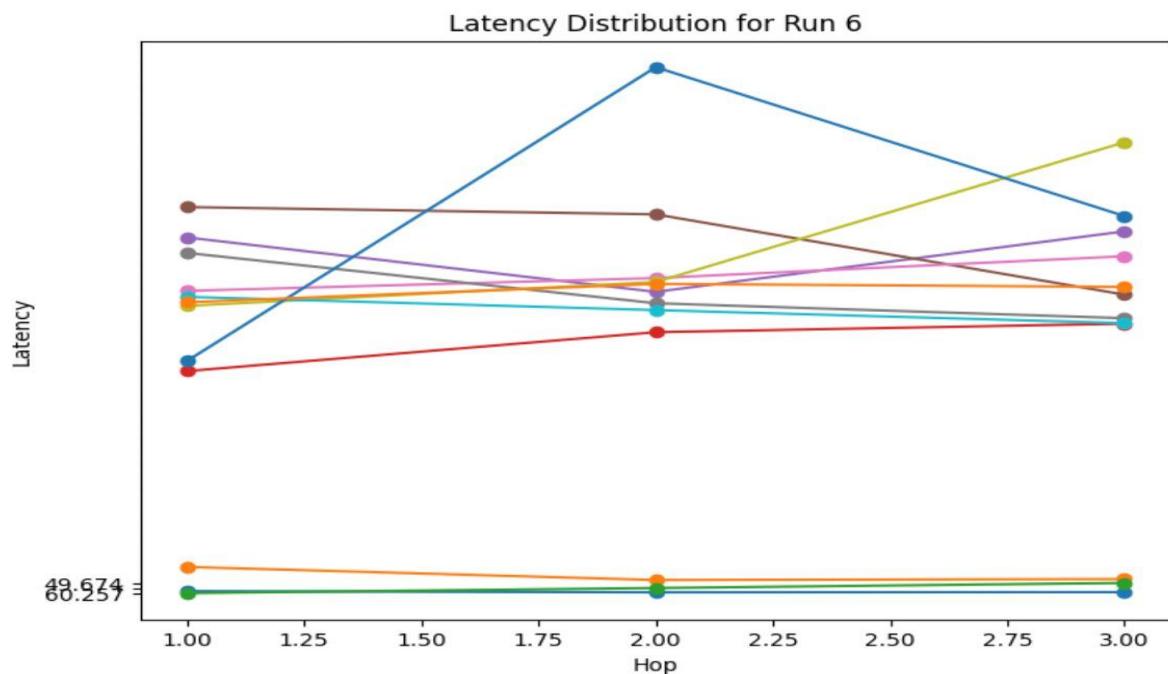
AS (Autonomous System) level analysis in networking involves studying the connectivity and relationships between different Autonomous Systems on the internet. An Autonomous System is a collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.

- AS level analysis helps in understanding the overall structure and topology of the internet. It reveals how different Autonomous Systems are interconnected.
- AS's have different types of relationships with each other. The primary relationships include customer-provider, peer-to-peer, and sibling relationships. AS level analysis helps in identifying these relationships, providing insights into how networks exchange traffic.
- Analysing AS level data contributes to understanding network performance, latency, and bandwidth utilization, which is crucial for optimizing the overall performance of the internet.

From the above data for amazon domain on Day1 we can say that with respect to AS Level:

For Day 5, for 4 out of 6 runs are following the AS number 3257 and AS route GTT-BACKBONE GTT, US

In summary ,



The graph shows the latency distribution for a single run. The x-axis represents the hop number, and the y-axis represents the latency in milliseconds. The red line represents the average latency, and the blue shaded area represents the standard deviation.

Overall, the graph suggests that the latency for this run is relatively low, but it is also somewhat variable. This is likely due to the fact that the signal is traversing multiple hops.

- Average latency: The average latency for this run is approximately 37.5 milliseconds. It is important to note that the graph shows the latency distribution for a single run. The latency distribution can vary from run to run, depending on a number of factors, such as the network conditions and the workload.