Wireless Project Report

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Title: To understand the performance difference between IPv4 and IPv6 and also their respective latency for the concerned websites while using different network carriers like Jio, Airtel and VI, and to see how the geolocation of the pinged servers and network topology impact the performance.

Key Deliverables:

1. Collecting the data for each of the 100 websites which are both IPv4 and IPv6 enabled through the ping module of the Linux, using different network carriers (Airtel, Vi and Jio) for over a week.
2. Obtaining the geolocation of the servers using its IP address (both IPv4 and IPv6).
3. Obtaining traceroute data and information about the number of hops using the traceroute command.
4. Analysis of the performance of IPv4 and IPv6 over various parameters.

Procedure:

Phase I: Collecting Data

1) First top 130 websites were chosen (top websites listed and Alexa and some government and Institute websites)
2) An automated script was created using multi-threading concept to capture the following details (for each day, for each website, for both IPv4 and IPv6)
   i. Get the ISP name using whatismyisp.com
   ii. Ping each website 40 times with packet size 10 and collect the RTTs for each ping.
   iii. Collect geolocation of the IP address using ipinfo.io
   iv. Send traceroute request to the IP address and collect the data
   v. Use multithreading to send pings requests to 10 websites simultaneously to reduce the collection time.
   vi. After multi threading, our time for each session was around 2.5 hrs.
   vii. The data is stored in mongo db containers in json format. One example for the json format:

```
{
```

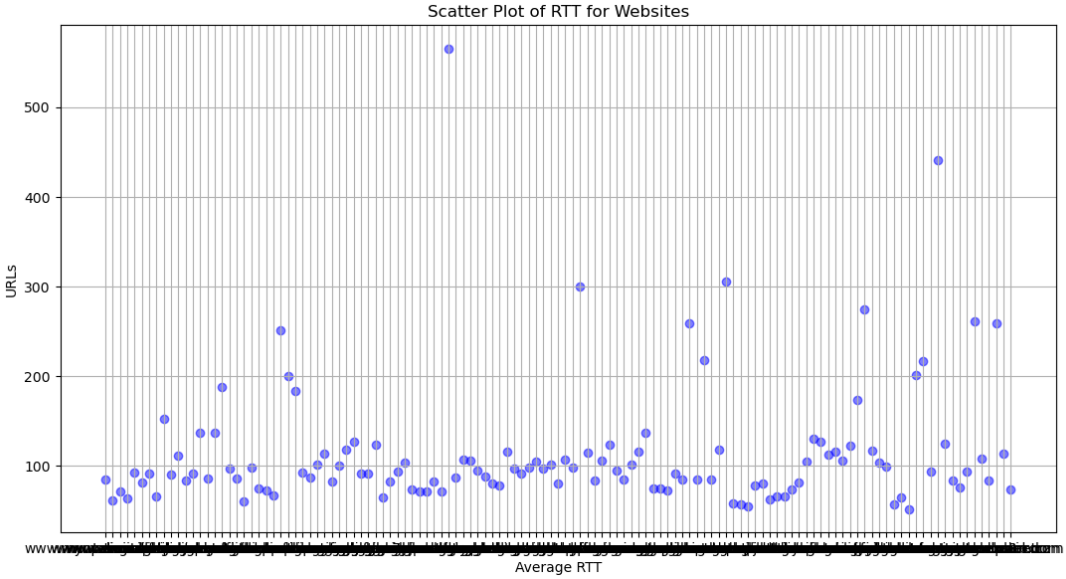
_id: ObjectId("6550ac1a71c8ab4f1bc9727b"),
Date: ISODate("2023-11-12T00:00:00.000Z"),
'Network Service Provider': 'Idea Cellular Limited',
URL: 'www.facebook.com',
'IPv4 Address': '31.13.79.35',
'IPv4 City': 'Mumbai',
'IPv4 County': 'IN',
'IPv4 Organisation': 'AS32934 Facebook, Inc.',
'IPv4 RTT': [
[32.9, 138.44, 492],
[32, 45.72, 60.8],
[33.5, 41.1, 45],
[34.2, 40.7, 51.9],
[23.2, 35.22, 48.8],
[22, 32.82000000000001, 42.7],
[35.5, 44.86, 59.5],
[23.2, 58.86, 141],
[29.7, 38.04, 50.3],
[36, 42.779999999999994, 49.7],
[28.4, 36.7, 44.4],
[28.4, 35.7, 44.3],
[25.6, 31.96, 44.2],
[28.6, 38.959999999999994, 53.4],
[26.1, 36.92, 64.1],
[29.9, 43.14, 59.9],
[32.9, 36.480000000000004, 41.3],
[36.3, 54.3, 76.5],
[21.3, 30.619999999999997, 54.8],
[31.7, 37.7, 41.7],
[22.6, 30.339999999999996, 40.7],
[18.5, 97.66, 319],
[37, 40.22, 49.6],
[21.1, 36.760000000000005, 50.3],
[19.4, 32.58, 55],
[22.3, 34.28, 43.9],
[32.1, 35.92, 41.7],
[28.4, 38.220000000000006, 47.4],
[30.3, 39.779999999999994, 50.2],
[24.3, 34.540000000000006, 45.5],
[24.9, 36.08, 51.9],
[26.9, 43.1, 66.9],
[34.5, 45.34, 60.7],
[24.7, 48.54, 90.1],
[30.3, 42.1, 62.5],
[23.6, 32.06, 37.2],
[32, 142.23999999999998, 337],
[30.2, 35.779999999999994, 42.4],
[31.4, 33.46, 39.3],
[23, 35.7, 45.3]

```
        ],
        'Traceroute Data IPv4': [
        {
        hop_number: 1,
        ip_address: '172.20.10.1',
        round_trip_times: '3.947 ms 3.916 ms 3.902 ms'
        },
        {
        hop_number: 2,
        ip_address: '192.168.31.240',
        round_trip_times: '224.255 ms 224.241 ms 224.226 ms'
        },
        { hop_number: 3, ip_address: 'Unknown', round_trip_times: '' },
        {
        hop_number: 4,
        ip_address: '192.168.32.2',
        round_trip_times: ' 35.201 ms'
        },
        { hop_number: 5, ip_address: 'Unknown', round_trip_times: '' },
        {
        hop_number: 6,
        ip_address: '223.196.21.212',
        round_trip_times: '37.336 ms 38.219 ms 41.906 ms'
        },
        {
        hop_number: 7,
        ip_address: '182.19.125.15',
        round_trip_times: '45.215 ms 45.166 ms 43.875 ms'
        },
        {
        hop_number: 8,
        ip_address: '223.196.40.9',
        round_trip_times: '37.225 ms 36.513 ms 34.491 ms'
        },
        {
        hop_number: 9,
        ip_address: '223.196.6.238',
        round_trip_times: '33.236 ms   33.205 ms   29.708 ms'
        },
}
```


Phase II: Data Refinement

1. The Data was exported from mongodb for all 3 isps, to csv files.
2. First, all the csv files were merged together for both IPv4 and IPv6.
3. All the empty values were replaced by NaN in the sheet.
4. The date column was formatted (Current format: YYYY-MM-DD)

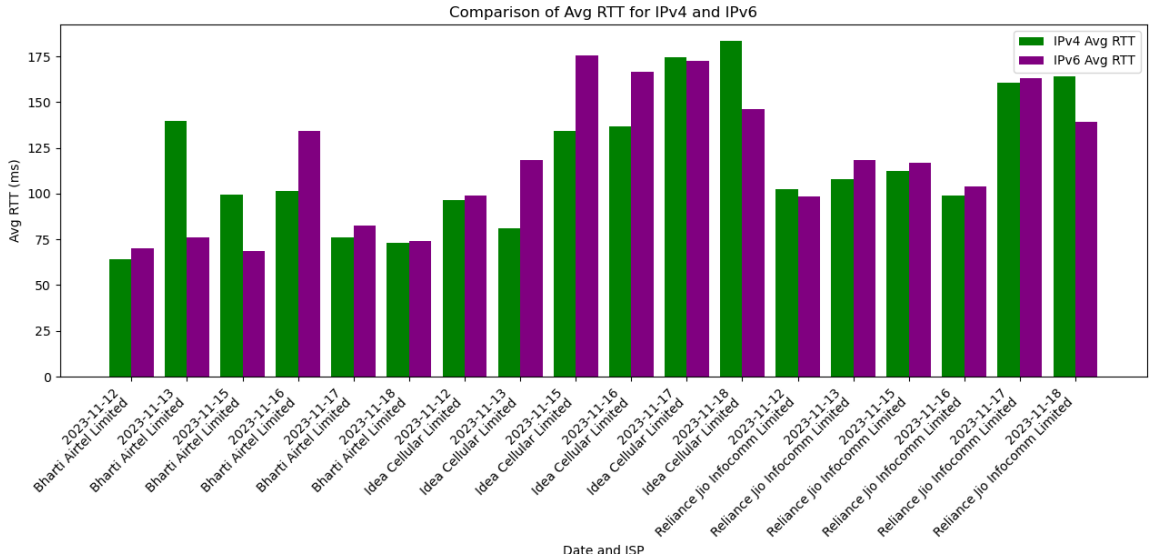
5. Since there were some websites which were lossy, we found all those websites which were common in both IPv4 and IPv6 for all days and all ISPs.
6. For all those websites whose ping didn't work even for one time, they were removed from both the files.
7. To the find the top 100 optimal websites to proceed with, following steps were used:
   i. Average of MAX RTTs was calculated for each website in IPv4 and IPv6 combined.
   ii. Scatter plot was created to find the outliers.
   iii. The ones in the optimal range were chosen.
   Scatter plot:



Phase III: Analysis

Various plots have been created to analyze the IPv4 and IPv6 performance.

I. <u>Based on Latency:</u>
   1. For both IPv4 and IPv6, Avg RTT is calculated by taking the mean of all 40 pings for each day and each ISP.
      The following plot shows the distribution for the same.



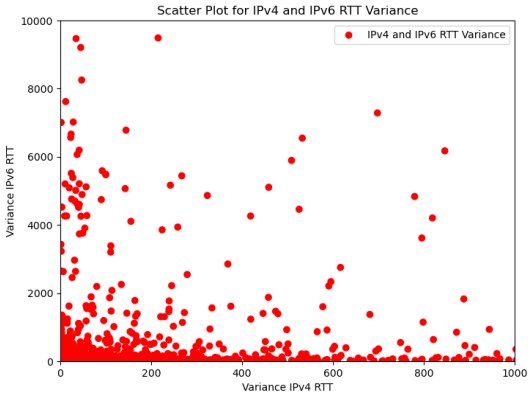
It can be observed from the plot that

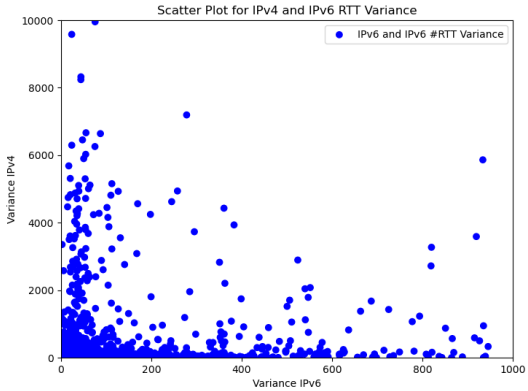
1. There is not clear distinction between the latencies of IPv4 and IPv6
2. According to ISP, For Airtel, on an avg, IPv6 has more or almost the same latency as IPv4.
3. For VI as well, IPv6 has slightly more latency or almost the same as IPv4.
4. For Jio (5G), IPv6 has more latency than IPv4.

```
Average RTT IPv4: 117.02952480687797
Average RTT IPv6: 117.99392020507759
```

The total Average latency for IPv4 and IPv6 across all days and ISPs is almost the same.

For finding the variability and correlation between IPv4 and IPv6, scatter plot for their variance was created as follows:





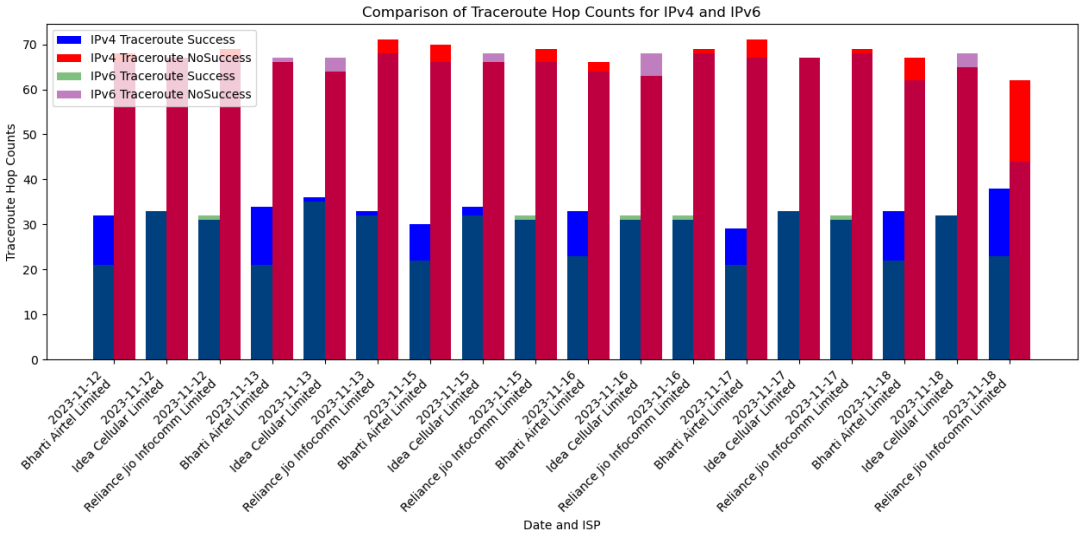
From the above scatter plots, it can be observed that the variance distribution of IPv4 and IPv6 is almost the same. But yes, if we check precisely, From 0 to 200 (in blue figure), the plot is

slightly more dense than the first one, which means that IPv6 has slightly more variability than IPv4.
Also, by viewing the plot, it is inferred that IPv4 and IPv6 are negatively correlated.
Inference: In terms of latency, IPv6 is slightly less or almost same efficient as IPv4.

II. Based on Number of Hops(Traceroute):

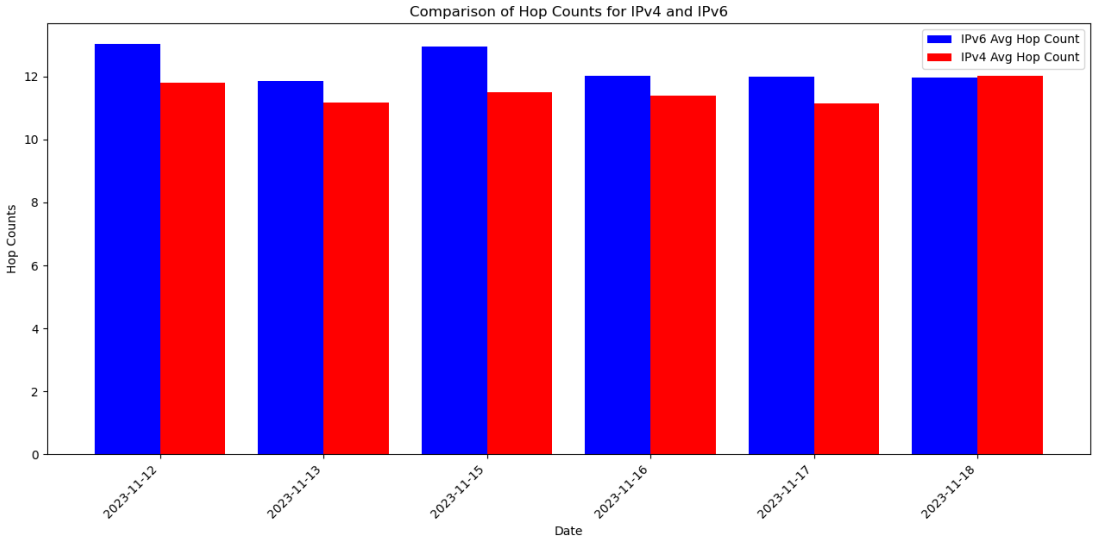
Now we analyze IPv4 and IPv6 based on the hop data we found.

First we analyze the lossiness of IPv4 and IPv6 based on whether it was able to reach the server or whether the ICMP packet TTL expired even before reaching the server.
For this we plot the data between successful and unsuccessful traceroute requests for both IPv4 and IPv6



From the above plot, we can infer that IPv4 has more successful traceroute successes as compared to IPv6 across all the ISPs.
While for unsuccessful traceroutes, Both IPv4 and IPv6 perform the same.

Then we plot to count the average number of hops required by IPv4 and IPv6.



We can clearly infer from the above plot that IPv6 has more or at least as much as IPv4 hop counts as compared to IPv4.
Inference: We can infer from above plots that IPv6's slightly more latency is due to the fact that it has more Hop counts than IPv4. Also, IPv4 is more slightly more reliable than IPv4 in terms of getting response from the server.

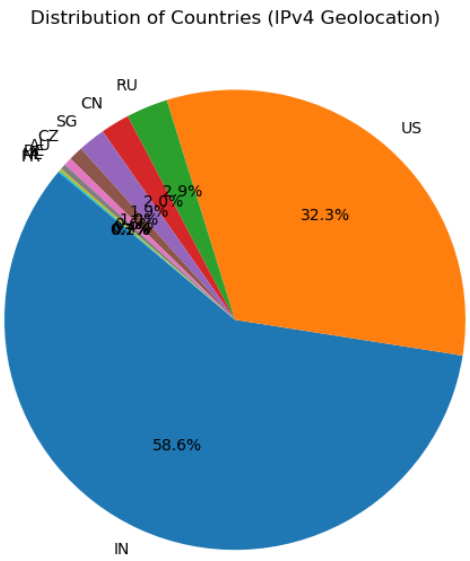
III. **Based on Geolocation:**

1. Which has more accurate geolocation:

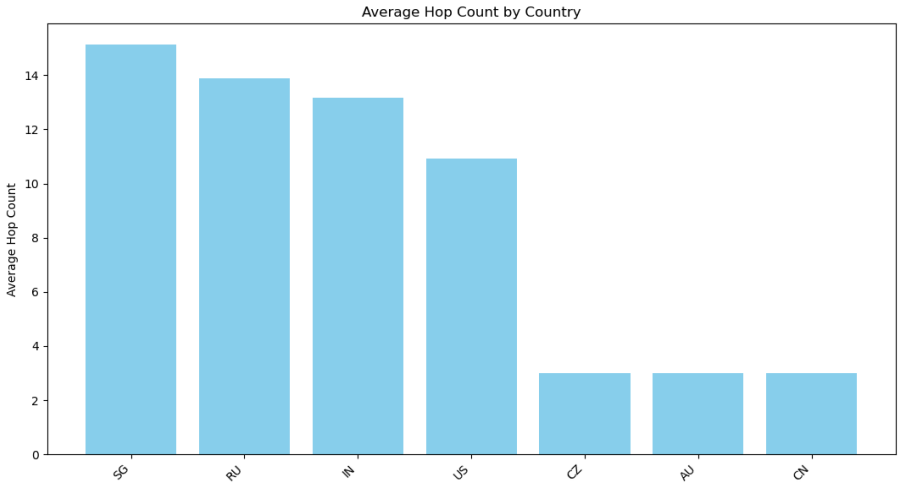
```
IPv4 Location: 15
IPv6 Location: 155
```

This is the count for all those websites whose geolocation cannot be obtained from an IP address.
Clearly, geolocation accuracy of IPv6 is way less than IPv4.

2. Number of unique countries distribution:

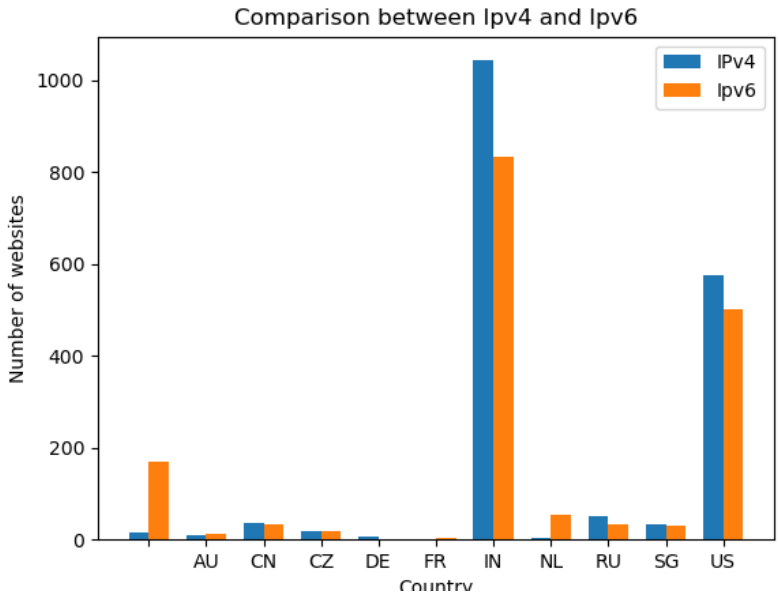


3. Average Number of Hops among all geolocations.



Singapore has ranked 1 in terms of highest average number of hops.

4. IPv6 and IPv4 comparison based on successful pings and traceroutes based on geolocation.



Inference: It can be inferred that almost for all countries, the reliability of IPv4 is more than IPv6.

We conclude our analysis by stating that

1. IPv6 has almost the same or slightly more latency than IPv4.
2. IPv6 is slightly less reliable than IPv4 in terms of getting a response from the server and for various geolocations.

Since IPv6 is still in the building phase, we can say that it is also a good option to use IPv6.