Simulation on Internet Speed Around the World

Abstract

Due to the need for quick access to information and data, internet speed is receiving a lot of attention these days. However, internet data speeds vary around the world. The majority of the world's poorer nations lack high speed internet. By examining the internet speeds of various places around the world, several academics are able to identify the causes and potential remedies. Additionally, they demonstrate the value of high-speed internet in all aspects of modern life, including farming, education, commerce, and industry. Due to this reason, simulating internet speed around the world is important. Thus in this project internet speed has been simulated around the world using different libraries of python including pandas, geopandas, folium, plotly, matplotlib, and mapclassify. In the project, broadband and mobile internet speed all over the world has been shown in the map. Besides, in the map broadband and mobile speed rank as well as broadband and mobile Mbps has been shown by hovering.

1 Introduction

Internet speed is subpar when signal intensity is between 110 and 120 dBm. To maintain a good internet speed of 5-20 Mbps for necessary applications in the Internet of Things (IoT) era and given the significance of transmitting massive data to the receiver side, both the transmit and receive sides should have internet signal strength of at least 50 to 65 dBm[1]. However, since we are aware that no internet measurement tool is 100% accurate, we can move closer to standardized measurement tools by looking at internet speed statistics[2]. For this study, the ookla internet speed dataset was used. After simulating the data, we may contrast the results with simulations of different datasets. Therefore, simulating internet speed around the globe will enable us to have a general understanding of the internet speed in other nations. Additionally, it will make it simple for us to locate underdeveloped locations around the world in terms of internet speed.

2 Literature Review

Internet speed gains a uttermost attention now-a-days due to necessity of world information and data fast. But all over the world the internet data speed is not same. Mainly the developing countries around the world lack of high speed internet. Many researchers find the reasons and the solutions from surveying internet speed of different regions across the world. They also show the importance of the high speed internet in our day-to-day life including farming, education, business, and industry. To resolve the issue regarding slow internet, they showed the simulation for good antenna design.

The simulation of internet behavior around the world is quite tough due to network's heterogeneity and rapid changes [3]. To cope up with the issue researchers discussed two key strategies. They searched for invariants and explored the simulation parameter space. Here, they proved that heterogeneity and fast changes in the internet restricts the existence of single suite of simulation scenarios. To generate the decision they showed the traffic volume per day of USENET from 1986 to 1994 and LBNL data from 1997 to 2001. Their result proves that due to heterogeneity and fast changes of internet it is quite tough to prove the internet speed in a single simulation.

To improve the internet speed S. Saravanan et al. [1] showed the FMDH antenna design simulation as mobile wi-fi internet speed is important for numerous applications. According to them, signal strength should be between -30 to -65 dBm to maintain proper high speed. To resolve the issue they combined an FM radio receiver antenna and parabolic dish antenna with a winding helical coil for designing FMDH antenna. With their redesigned FMDH antenna they proved that the signal strength of Airtel internet speed is far more better. With the FMDH antenna the average download speed was 20.92 Mbps while without the antenna it was only 9.00 Mbps and the upload speed was 8.06 Mbps and 1.69 Mbps respectively. The outcome of the research proves that the internet speed is gained by the redesigned antenna architecture.

Besides, the different simulation processes many researchers work on the importance of internet speed in different fields and regions and the effect due to slow internet speed. Following the process Atxutegi et al. [2] showed the technical constraints regarding standardized internet speed measurements for end users. According to them, online speed measurement tools are not accurate that are provided to the end users. They also checked other factors including involved network nodes and TCP/IP implementations which generate reliability issue of the measurement methods. They proposed a mechanism to find a full understanding of cross-layer effects during a speed test targeting end users. To solve this problem they showed static constraints using operating system (OS)-dependent factors that affect flow control including the sizes of the transmission buffers , and windows scale (WS). For dynamic constraints, they used a hybrid simulation/emulation framework

based on the NS-3 network simulator. They showed network dump for static constraints analysis, NS-3 dumbbell scenario for dynamic constraints study, and live tests for real world comparisons. In this article they clearly proved the constraints that affect a proper Internet speed measurement, paving the way to a standardized methodology in which end users are the main target.

Grimpes et al. [4] showed the impacts of internet connectivity on firm productivity in New Zealand. Firm productivity has been enhanced for higher internet speed. To ascertain the effect that various types of internet connectivity have on firm productivity, researchers employed a sizable New Zealand micro-survey of businesses connected to unit record firm financial data. To account for variables that affect how businesses choose their internet connectivity, such as firm productivity, propensity score matching was utilized. After pairing up the companies, they looked at how adopting various internet connectivity types (speeds) might affect productivity. Although they discover no variations in productivity across broadband types, adoption of broadband is found to increase productivity. The findings offer the first firm-level estimates of the extent of productivity improvements attributable to improved internet access on a global scale. From this work it is clear that high speed internet can help to increase productivity of firm which leads to reduce famine all around the world.

Ivwighreghweta et al. [5] showed the impact of the internet on academic performance of students in tertiary institutions in Nigeria. The study used a survey research design as its methodology. The instrument used to gather the data was a questionnaire. To analyze the data, frequency counts and straightforward percentages were utilized. Six thousand (6000) students from the University of Benin in Benin City, the Delta State University in Abraka, the Western Delta University in Oghara, and the Delta State Polytechnic in Otefe make up the study population. The study found that pupils are better prepared for their exams while using the internet. It was also discovered that some of the issues preventing effective internet access in tertiary institutions in Nigeria were power outages, slow internet speeds, a shortage of computer terminals, too many hits or information overload, and inadequate computers. According to the study, the importance of internet speed in education sector is higher than any other field.

The contributing factors for growth of broadband internet connections in South Korea are investigated by Yun et al. [6]. From three perspectives—public sector, private sector, and social—they investigated the behaviors and circumstances causing the dispersion. They said that the key to Korea's rapid adoption of broadband was the alignment of supply and demand. Strong infrastructure competition in particular has produced high-quality services at a cheap fixed cost. They also took into account the necessity to close the digital gap and the use of retail e-commerce applications.They showed the actions and factors contributing to the rapid development of broadband Internet in Korea. They compared the usage of

internet for different fields including games, e-commerce with Koreans and other developed countries. From their research it is obvious that Koreans are mostly dependant on high internet speed.

Farrington et al. [7] showed the importance of rural internet use in Britain. According to them in Britain, there is a digital divide that separates urban from rural locations. Geographical differences in Internet connection quality result in many rural locations receiving only a portion of the service that metropolitan areas do. The research is on finding challenges of rural communities regarding usage of internet, and the impact of a divide that is not only stark, but likely to widen as broadband speeds in well-connected areas increase at a faster rate than in rural Britain. It does this by methodically analyzing data produced by the RCUK Digital Economy Research Hub at the University of Aberdeen and the Oxford Internet Institute. From the research the lack of proper internet speed is completely visible in rural area in Britain.

In 2016, Salac et al. [8] did a study on the internet connectivity in the Philippines. They looked closely at the poor Internet access and the steep price that consumers must pay. According to the report, this inefficiency reduces users' incentives to innovate in a way that may support inclusive growth and the creation of an inclusive information society. The report also shown that the Philippines' Internet infrastructure lags behind that of other modern emerging countries in Asia, notably in terms of Internet connectivity, through a comparison of the worldwide ICT scenario with the country's current state. They also found that the main reason behind slow internet speed in the Philippines is the lack of competition in the Internet market. In the research the researchers able to prove the importance of high-speed internet in the Philippines and find the reason behind the slow internet speed.

Furthermore, there are many repositories which also provide different simulation procedures on internet speed. Among them there are three repositories that are internet speed simulator [9], starter: Ookla internet speed dataset [10], and internet speed visualization [11]. In internet speed simulator [9], they worked using HTML, CSS, and javascript to simulate. They have taken two inputs: image size and update interval. For different internet speeds, they showed the total time taken and progress in percentage using animation. To prove the internet speed and the importance of the internet speed in research the work is valuable as it can help to simulate the result for upload and download image in different internet speed.

In starter: Ookla internet speed dataset [10] they used python libraries: folium, geopandas, and pandas are used to simulate the dataset. Dataset used in this project is in shapeFile format which can be read by pandas and geapandas. This dataset contains the average download speed, average upload speed, average latency, etc of the corresponding location. They simulate average latency on an explorable World map using folium. Color

mapping has been used as the deeper intensity of color means the more average latency. This project is helpful for finding internet speed for different countries that can help us to do further research on usage of internet all around the world.

The project internet speed visualization [11] is also from a public repository from Kaggle. In this project two libraries of R: tidyverse and ggpubr are used. The project shows a comparative barplot of the top 20 countries' broadband internet speed. The project also represents a z-score comparison that reveals the low and high broadband internet speeds among the countries. This project also can be used in research work for the statistical analysis.

3 Methodology

In this project, two different datasets have been used which are collected from kaggle, that is an open source platform. The dataset has been analyzed and plotted to understand the pattern and distribution of data.

Besides, Python 3.10.5 has been used to implement the simulation project. In this project, different libraries of Python programming language has been used. A comparative bar plot, a heat map on a world map, and an explorable world map are utilized to analyze and simulate the dataset.

3.1 Libraries

Libraries used to simulate 'internet speed dataset' are mentioned below.

- pandas
- geopandas
- folium
- plotly
- matplotlib
- mapclassify

3.1.1 pandas

Pandas is an open-source library that is made mainly for working with relational or labeled data both easily and intuitively. It provides various data structures and operations for manipulating numerical data and time series. This library is built on top of the NumPy library. Pandas is fast, and it has high performance and productivity for users.

3.1.2 geopandas

Working with geographical data in Python is made simpler with the help of the open source project GeoPandas. GeoPandas expands the datatypes that pandas uses to include geometric types for spatial operations. Shapely performs geometric operations.

3.1.3 folium

Data that has been altered in Python can be easily viewed with Folium on an interactive Leaflet map. It permits sending Vincent/Vega visualizations as map markers as well as the tying of data to a map for choropleth visualizations. The library supports custom tilesets with Mapbox or Cloudmade API keys and includes a number of built-in tilesets from OpenStreetMap, MapQuest Open, MapQuest Open Aerial, Mapbox, and Stamen. Folium allows the coupling of data to TopoJSON and GeoJSON overlays in order to produce choropleth maps with color-brewer color schemes.

3.1.4 plotly

The interactive, graph-publishing-ready graphs are created by Plotly's Python graphing package. Line plots, scatter plots, area charts, bar charts, error bars, box plots, histograms, heatmaps, subplots, multiple-axes, polar charts, and bubble charts are a few examples of how to build them.

3.1.5 matplotlib

Python's Matplotlib is a fantastic visualization package that is simple to use. It is constructed using NumPy arrays, intended to operate with the larger SciPy stack, and includes a number of graphs, including line, bar, scatter, histogram, and others.

3.1.6 mapclassify

A group of choropleth map categorization schemes are implemented by mapclassify. The selection of the number of classes and the categorization of the data are its main concerns. It is designed to work with upstream map-rendering and geovisualization software (such as Geopandas and Geoplot).

3.2 Dataset

The 'internet speed dataset' contains columns which are Country, Broadband Speed Rank, Broadband Mbps, Mobile Speed Rank, Mobile Mbps. Ten samples are shown in Fig. 1. Besides, world countries' "GIS" data has been used in the project. "GIS" stands for Geographical Information

	Country	Broadband Speed Rank	Broadband Mbps	Mobile Speed Rank	Mobile Mbps
1	Singapore	2.0	192.01	19.0	64.92
2	Chile	3.0	189.36	109.0	15.50
3	Thailand	4.0	184.03	56.0	32.38
4	Hong Kong (SAR)	5.0	173.42	38.0	45.86
5	Denmark	6.0	163.60	8.0	87.11
6	Macau (SAR)	7.0	156.73	35.0	47.56
7	China	8.0	155.79	9.0	85.83
8	United States	9.0	143.76	21.0	62.47
9	Spain	10.0	134.19	49.0	35.59
10	Romania	11.0	127.07	52.0	33.80

Figure 1: Samples of internet speed dataset

System. ShapeFile data has been used to plot and separate countries on the world map. The sample on this dataset looks like the table in Fig. 2.

	FID	COUNTRY	ISO	COUNTRYAFF	AFF_ISO	SHAPE_Leng	SHAPE_Area	geometry
1	2	United States Minor Outlying Islands	UM	United States	US	0.480216	0.003216	MULTIPOLYGON (((-160.02114 -0.39805, -160.0281...
2	3	Cook Islands	CK	New Zealand	NZ	0.980664	0.013073	MULTIPOLYGON (((-159.74698 -21.25667, -159.793...
3	4	French Polynesia	PF	France	FR	3.930211	0.175332	MULTIPOLYGON (((-149.17920 -17.87084, -149.258...
4	5	Niue	NU	New Zealand	NZ	0.541413	0.021414	POLYGON ((-169.89389 -19.14556, -169.93088 -19...
5	6	Pitcairn	PN	United Kingdom	GB	0.338167	0.004286	MULTIPOLYGON (((-128.33222 -24.32726, -128.326...
6	7	Samoa	WS	Samoa	WS	3.019662	0.245519	MULTIPOLYGON (((-172.59650 -13.50911, -172.551...
7	8	Tokelau	TK	New Zealand	NZ	0.108696	0.000606	POLYGON ((-171.84806 -9.21889, -171.85886 -9.2...
8	9	Tonga	TO	Tonga	TO	1.309124	0.040018	MULTIPOLYGON (((-175.14529 -21.26806, -175.186...
9	10	Wallis and Futuna	WF	France	FR	0.700608	0.013414	MULTIPOLYGON (((-178.06082 -14.32389, -178.137...

Figure 2: ShapeFile sample data for countries

4 Experimental Results and Discussions

In this project, the internet speed around the world has been simulated. Here, the comparative bar-plot of broadband and mobile Mbps for different countries has been shown. Fig. 3 is showing the comparative bar-plot of top 10 countries on the basis of Broadband Mbps. From the bar plot we can observe that many countries with high broadband internet speed do not have a high mobile internet speed.

The internet speed dataset and GIS dataset for countries are merged so that we can plot internet speeds for corresponding countries. Two different heat-maps of the world map are simulated, one is based on broadband internet speed and the other is mobile internet speed. Fig. 4 and 5 illustrate the

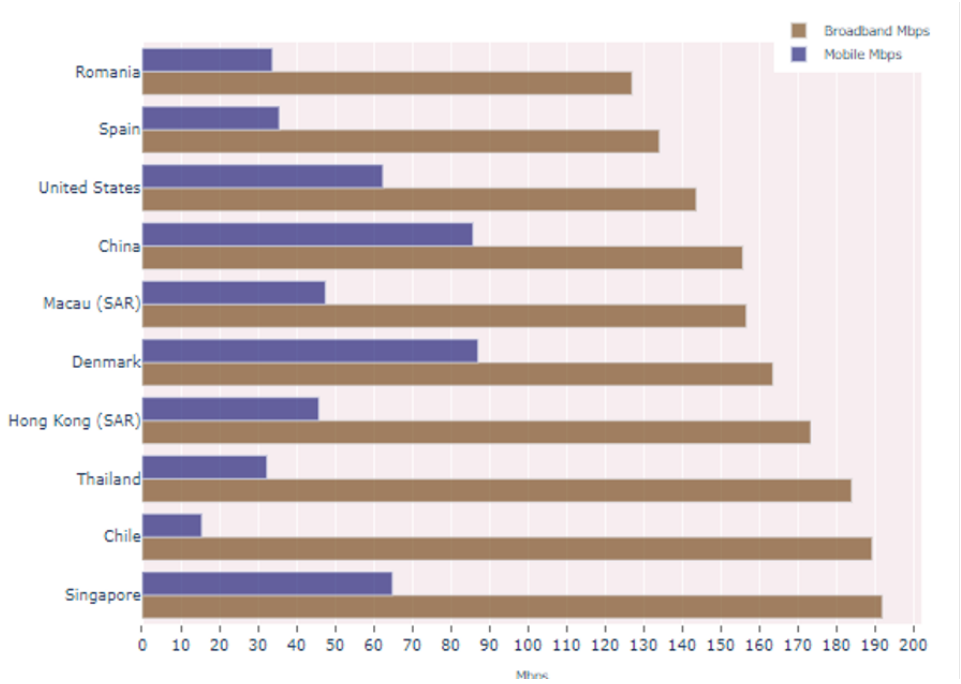

Figure 3: Comparative bar-plot of top 10 countries

heat-map simulation on the basis of broadband internet speed and mobile internet speed, respectively.

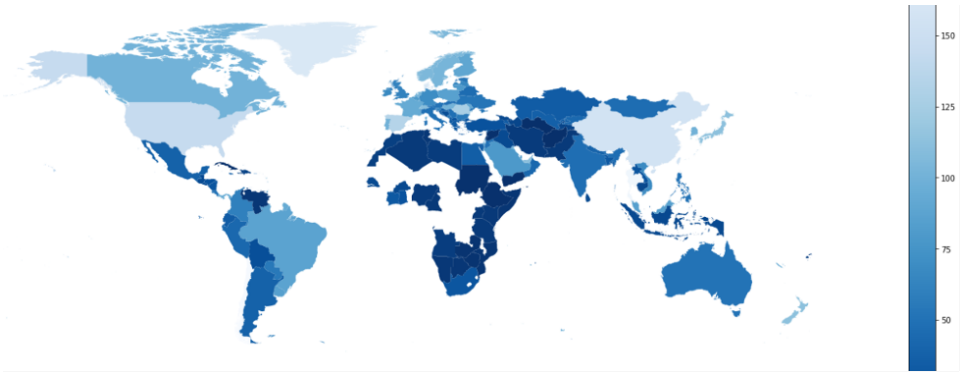

Figure 4: Broadband Internet Speed All Over the World

Data from the merged dataset has been simulated on an explorable world map. In this simulation, we can hover over the countries on the map. When we hover over a particular country, we can see the rank and speed in mbps for both broadband and mobile internet speed like in Fig. 6.

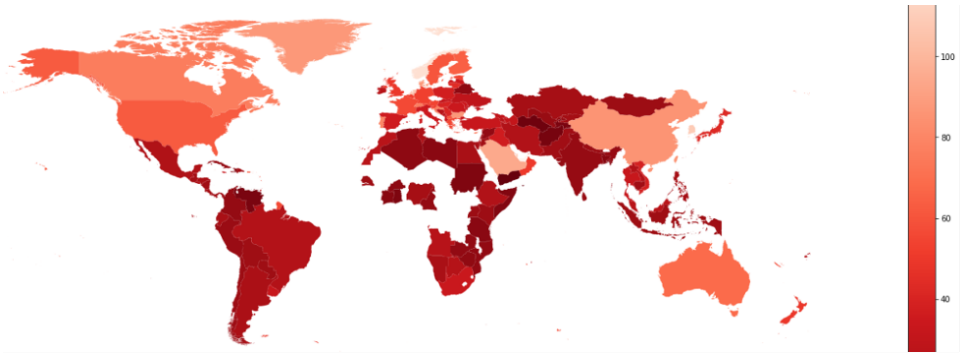

Figure 5: Mobile Internet Speed All Over the World

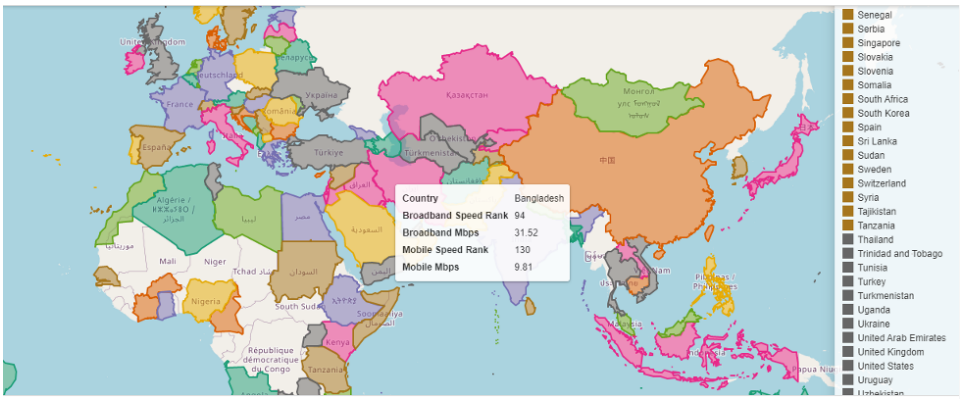

Figure 6: Hovering on the Explorable World Map

5 Conclusion

High internet speed has numerous effects for obtaining information and data fast. It also helps to produce better performance in different fields including farming, education, business, and industry. In this project, internet speed all around the world is simulated to obtain the outcome of internet speed data. The project shows different regions of various internet speed for both broadband internet speed and mobile internet speed. Besides it also shows the comparative bar-chart for different countries. From the outcome it can be concluded that, the project can help to further research regarding internet speed.

References

[1] S. Saravanan and P. Sudhakar, "Analysis of mobile internet speed, signal strength and fmdh antenna design for improved internet speed," *The Journal of Supercomputing*, vol. 76, no. 6, pp. 4449–4475, 2020.

[2] E. Atxutegi, F. Liberal, E. Saiz, and E. Ibarrola, "Toward standardized internet speed measurements for end users: Current technical constraints," *IEEE Communications Magazine*, vol. 54, no. 9, pp. 50–57, 2016.

[3] S. Floyd and V. Paxson, "Difficulties in simulating the internet," *IEEE/ACm Transactions on Networking*, vol. 9, no. 4, pp. 392–403, 2001.

[4] A. Grimes, C. Ren, and P. Stevens, "The need for speed: Impacts of internet connectivity on firm productivity," *Journal of Productivity Analysis*, vol. 37, no. 2, pp. 187–201, 2012.

[5] O. Ivwighreghweta and M. A. Igere, "Impact of the internet on academic performance of students in tertiary institutions in nigeria," *Information Impact: Journal of Information and Knowledge Management*, vol. 5, no. 2, pp. 47–56, 2014.

[6] K. Yun, H. Lee, and S.-H. Lim, "The growth of broadband internet connections in south korea: Contributing factors," *Asia-Pacific Research Center, Stanford Institute for International Studies*, 2002.

[7] J. Farrington, L. Philip, C. Cottrill, P. Abbott, G. Blank, and W. H. Dutton, "Two-speed britain: Rural internet use," *Available at SSRN 2645771*, 2015.

[8] R. A. Salac and Y. S. Kim, "A study on the internet connectivity in the philippines," *Asia Pacific Journal of Business Review*, vol. 1, no. 1, pp. 67–88, 2016.

[9] Bryonf, *Internet-speed-simulator*, https://github.com/bryonf/internet-speed-simulator, accessed on 14 August 2021.

[10] Dhruvildave, *Starter: Ookla internet speed dataset*, https://www.kaggle.com/code/dhruvildave/starter-ookla-internet-speed-dataset, accessed on 14 August 2021.

[11] yulindexterliu, *Internet speed visualization*, https://www.kaggle.com/code/yulindexterliu/internet-speed-visualization, accessed on 14 August 2021.