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ORIGINAL ARTICLE

Measuring Global Internet Speed by Using Complex Network

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ABSTRACT

Today is the 21st advent the era of modern digital world, the digital world where internet and speed of internet is the main concern for individuals and organizations by using computer networks. Therefore, in this research we formalize and analyze the average usage of worldwide countries by using complex network and model the dataset of worldwide internet speed. Furthermore, using this data set we observe the complex network with global internet speed by average (Degree Distribution, Betweenness, and Closeness) by using weighted directed graph while the edge merge strategy is sum.

Keywords: *Worldwide, internet, degree, edge, Betweenness, closeness global, average and sum*

Author`s Contribution
[1,2] Data analysis, interpretation, and manuscript writing, Active participation in data collection
[1,2] Conception, synthesis, planning of research. Interpretation and discussion

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INTRODUCTION

The study of network representations of physical, biological, and social phenomena leading to predictive models of these phenomena [1]. There are multiple networks some are one node networks and some are two mode networks while some are simple networks and some are complex networks in the networks science. According the [2] networks are everywhere, from the Internet, to social networks, and the genetic networks that determine our biological existence [3].

COMPLEX NETWORKS:

The complex network is connected with many nodes and to interact with multiple ways or different ways. The nodes in a network are frequently referred to as vertices or elements, and they are formally represented by the symbols$v_1, v_2, \cdots v_N$, where N denotes the total number of nodes in the network [4].

Many scientific domains that use network research to evaluate a variety of better network and understanding of how networks organize their connections (structure) and how information moves through their nodes (dynamics). As an alternative to conventional methodologies, information theory techniques have recently come into the spotlight thanks to their capacity to characterize complicated networks in a more precise and reliable manner. [5]

LITERATURE REVIEW

This paper [6] the author conducted the research on two ways network modeled and analysis on dengue data set. The author mainly focused on data modeled and analysis on two mode complex networks on dengue epidemic behavior the data given by health ministry Malaysia. In this research, they conducted data analysis and modeling on complex network system on dengue effected cases and find Closeness, Betweenness and Short path-length through Degree and Clustering coefficient structure views. Furthermore, they conducted analysis on two mode to one mode network using there different projections techniques to found the high dengue cases, most affected localities and lest effected area with global perspective. Therefore, the paper discussed and gets result of complex analyzed model with three different projection methods and found Newman method is most suitable for projection and data analysis on given data set. The result shows that few localities are vital for Closeness and Betweenness significances perspectives. In nutshell after analysis that few localities need to attention for hygiene and effective treatment. Further, they will work on scale-free and random network in future.

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In the paper [7] the researchers focused on analysis of political corruption through network structure. The author suggested that the corruption is very dangerous for society in which the society affected much more through financially and economically that the reason that they take data set of corruption scandal of past 27 years and focused on dynamic network and wanted to found two similar scandals people thorough network analysis. Furthermore, they done analysis on 400 peoples who involved in different corruption scandals in Brazil, the unique dataset on corruption.

Thus they predicated corrupt people or individual and groups with help systematic algorithm. They also predicated scandals of future concluded with network system. Therefore, they discuss the important role of network science in detecting and mitigating political corruption.

This article [8] motivated that how to combat corruption and financial irregularities through complex network system. United Nations (UN) emphasis the countries must develop the systematic mechanism and preventive approach to combat corruption scandals in large scale. This article focused on major corruption of Mexico involving a network of hundreds of shell companies used to misappropriate billions of dollars. They describe that with the help of complex network system, they have measured the global parameter of density, diameter, average path length, and average degree in order to provide systematic evidence. This system analysis provided to oversee the legal and illegal deeds. The complex system science provided new paradigm to measure systematic framework from which easy to understand the social systems. Political, economic, ecological and social systems the great impact on our lives. Furthermore, Public policy based on rigorous scientific research, with complexity science as a multidisciplinary bridge, is a first step towards a new way of addressing the major issues of this century.

They focused on dark [9] (covert) networks which is also important for researcher who's focused on dark analysis network side. This paper is mainly focused on two basic network analysis metrics, betweenness and degree uniqueness. In this research, they analyze the behavior of nodes in dark networks based on betweenness and degree centrality measures by using 9/11 terrorist network as dataset. The researcher analyzed weighted and un-weighted links to prove that weighted networks are very closer to scale-free phenomenon as compared to un-weighted networks the author mentioned in this paper. Furthermore, the result shows that the above network stand its robustness by including weight of links also weighted liks point of view identify accurately major nodes in the network. They also observed that metrics degree and Betweenness illustrations are also true. The researchers done experiments on "r-project" for graphs and charts which shown satisfactory results.

This paper focused [10] in computer networking the routers, protocols and internetworking algorithms are highly important for computer networks. The researchers focused on robust dissemination approach which can be used in one dynamical Autonomous System (AS) to know the appearance and disappearance of nodes, and speedily propagate the information to all nodes in the routers network. (AW Mahesar 2014). In this article they found heterogeneous topology is efficient for data transmission to many nodes once. However, Link detection algorithm helped to disconnected and newly added nodes in the network. In nutshell ad hoc and wireless networks to better devise powerful and robust algorithms and this may constitute future work.

The researchers [11] investigated the number of weighted networks affording their capacity and strength. In this paper they mainly focused on originally defined unweighted network with global clustering coefficient, they also proposed to generalize of coefficient with encoded information in the wights of ties. (Tore Opsahl et al. 2009). The authors done comparative study by applying the number of coefficients to a many networks' dataset. On the other hand, they measured and compared the standard and generalized clustering coefficients on several network datasets where the weights of ties are recorded (Tore Opsahl et al. 2009). Moreover, in the first phase they found cut-off increases when standard coefficient generally decreases. It's very much difficult to understand the result. However, in the second phase minimum method given highest value while maximum method given the lowest outcome. In the way, third phase of result indicated that social networking is strong ties. The Network dataset that is richer in information, more robust against potential inaccuracies emanating from subjective judgments, and more suitable to investigations that rely on generalized measures, such as our proposed clustering coefficient.

In this paper [12] the author observed flavor networking with food paring with different variety of regional cuisines. Increasingly availability of food variety the authors investigated the food preparation methods systematically data driven. In the way, the researchers identified the series of food ingredients and its pattern through network based investigations. However, the pattern of flavor and food verity varying degree in different geographic regions likes North American and Western European dishes tend to combine ingredients that share flavor compounds East Asian cuisine avoids them. This work helps to understand the data driven network analysis method and much useful for food sciences.

In this paper [13] the article conducted the study about network of community dogs on a university campus inThailand. The researchers mainly focused on the dataset of rabies dogs from the University Campus in Nakhon Pathom, Thailand, analysis was done three one mode and two mode networks to found degree and betweenness free-roaming dog network. Furthermore, the authors find the high betweenness and degree to found the dogs that have higher transmitting disease. The author also perceived there are no different between urban and rural areas dogs by food or areas. The studies was conducted on cross-sectional design by using computer networks.

This paper [14] according to the author that pollination and seed distribution network is known as bimodal, two sets plant and animal are linkage with

them. However, bimodal network will be transformed into unimodals. Thus the study focused on unweighted and weighted bimodal network into unmodals for plants and animals. In this study they have done comparative methods unimodal projections from bimodal mutualistic networks using original network and link network. Moreover, they found that by avoiding the loss of weighted information in the projection, they obtain a different degree centrality for the species, i.e., the most central species are not the same considering link weight or not. The role of a species as a network connector, however, appeared to be little influenced by link weight.

This paper [15] most networks working on one-mode network and two-mode networks frequently one-mode network to be examined in this study. The researchers proposed such a redefinition for both the global and local clustering coefficients. Both the redefinitions only ponder the network structures that are not closed by definition for example three nodes that are connected to a common node in the two-mode structure. However, the projected coefficients characterize only the first analyzed process of transform one-mode network ratio for two-mode network.

RESEARCH METHODOLOGY

CRITICAL EVALUATION:

Table 1 –Organization Research Papers

S. No	Tasks
1	Summary of Research Articles/ Literature Review more than 10 articles
2	Critical Evaluation
3	Analysis of Real Network Data
4	Applied Analysis Network Metrics
5	Future Work
6	Conclusion

Before you start to prepare our paper, first write and save we have many research papers related with computer networks and complex networks. In some papers have models and tools are proposed to address complex network issues, one and two mode is discussed. Our review have to be summarized in the fallowing compare and contrastable

Table 2 - Critical Analysis of Research Papers

Lit. Ref	Context of Research	Problem Discussed	Technique Used	Model/ Tool/ Proposed
1	Network Science / health data analysis	Two-mode network modeling and analysis of dengue epidemic behavior in Gombak, Malaysia	Dengue epidemic behavior	Yes
2	Network science for corruption	The dynamical structure of political corruption networks	Corruption Dataset algorithms	Yes
3	Network science to combat corruption	Corruption and complexity: a scientific framework for the analysis of corruption Networks	Network metrics for the integrated network decomposed	Yes
4	Dark networks	Analyzing the Weighted Dark Networks using Scale-Free Network Approach	degree and betweenness as well as 9-11 as dataset	Yes
5	Computer Networking	Node Status Detection and Information Diffusion in Router	Autonomous System (AS)	Yes

		Network using Scale-Free Network		
6	Social Networking	Clustering in weighted networks	Comparison between the generalized and the standard clustering coefficients.	No
7	Networking for Food Sciences	Flavor network and the principles of food pairing	Data driven network analysis methods/ Food dataset	No
8	Networking for animals	Analyses of Contact Networks of Community Dogs on a University Campus in Nakhon Pathom, Thailand	Cross-sectional design	No
9	Networking on biomedical	Alternative approaches of transformin g bimodal into unimodal mutualistic networks. The usefulness of preserving weighted information	Unweighted and weighted bimodal network	No
10	Social Networking	Triadic closure in two-mode networks: Redefining the global and local clustering coefficients	one-mode & two-mode networks	Yes

MEASURING AND ANALYSIS OF REAL NETWORK DATA:

This dataset gives to find the average speed of worldwide internet speed country wise to find the connection between them as directed complex network. We have two sets of node one is “country name” and second is “average usage “the edge is connected between the two nodes. We have 285 nodes and 144 edges it’s a weighted directed graph to measure edge merge strategy is sum.

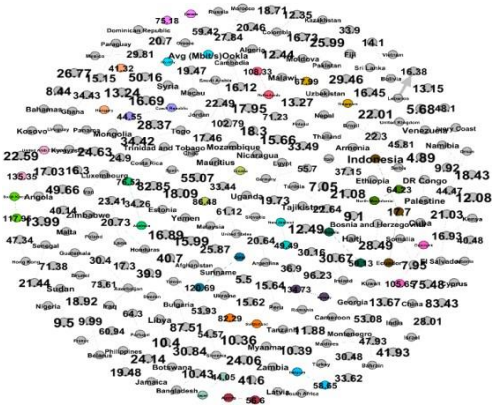

Figure. 1. Graphical representation of directed graph

APPLIED ANALYSIS NETWORK METRICS:

Modularity is a measure of the structure of networks or graphs which measures the strength of division of a network into modules.

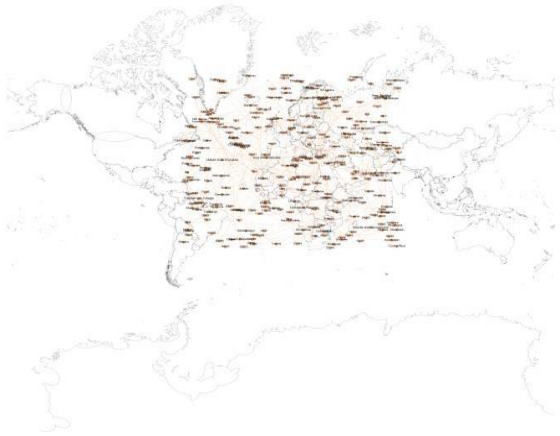

Figure 2. Connection of network with worldwide internet

Degree Distribution: in the degree distribution we find in degree, out degree and w degree.

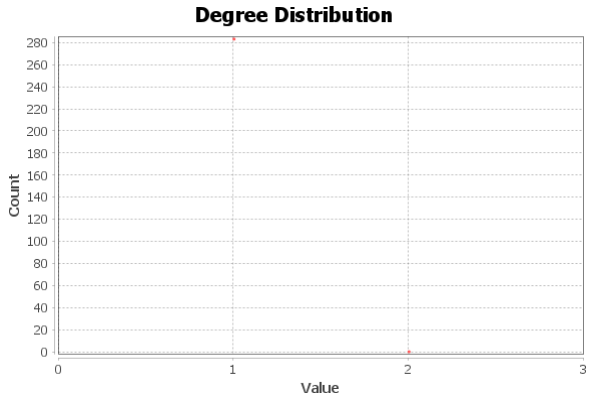

Figure . Degree Result

Betweenness Distribution: in this we find the harmonic closeness and eccentricity.

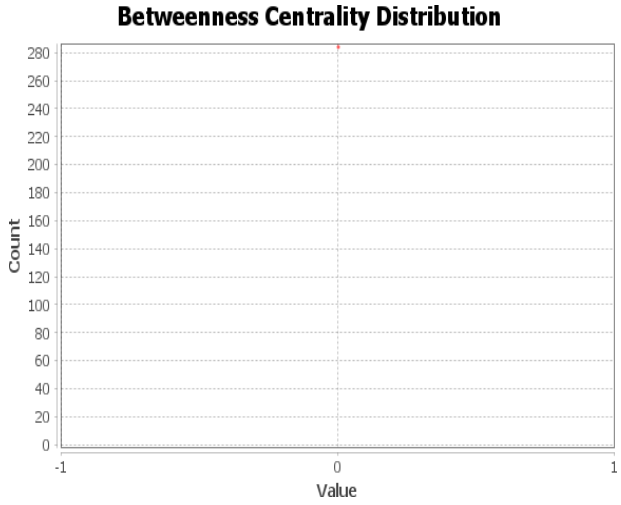

Figure. 4. Betweenness Result

Closeness Distribution:

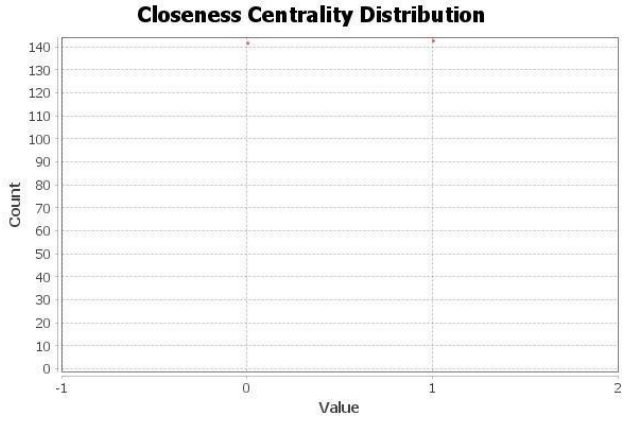

Figure. 5. Closeness

Communities Size Distribution: weakly connected component are 142 and strongly connected component are 285

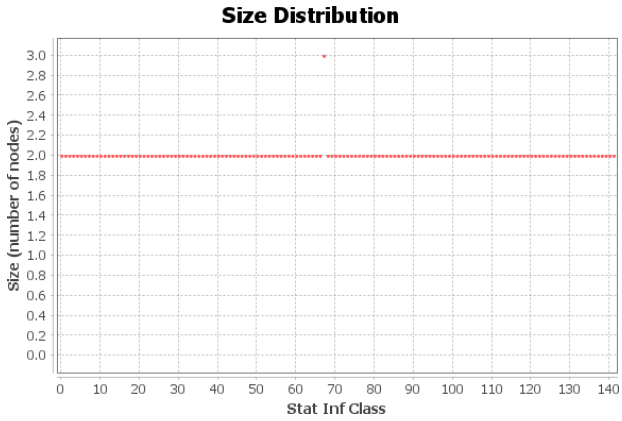

Figure.6. Communities Size Distribution

RESULTS AND DISCUSSION

The analysis of the global internet speed network provides important insights into the underlying structural properties of complex networks. The presence of 142 weakly connected components and 285 strongly connected components indicates a highly fragmented network topology, suggesting that many nodes operate in small, isolated clusters. This fragmentation reflects significant variability in global internet infrastructure, where regions with limited connectivity create isolated subnetworks that reduce overall cohesion.

The centrality measures—degree, closeness, and betweenness offer an in-depth understanding of the influence and importance of individual nodes within the network. Nodes with high degree centrality act as major hubs that facilitate information exchange, while nodes with high closeness centrality demonstrate efficient access to other nodes in the network. Betweenness centrality highlights bridging nodes that connect different clusters and are critical for maintaining communication flow. Variations in these measures demonstrate how inequalities in infrastructure shape global internet performance.

This study also highlights broader research paradigms associated with complex network analysis. Understanding how networks behave, break, and reorganize is essential for fields such as computer science, engineering, medicine, and data science. Insights from this research can guide future work on building more resilient, stable, and adaptive networks. For instance, identifying components with poor connectivity can help policymakers and engineers prioritize infrastructure improvements. Similarly, recognizing high-betweenness nodes enables the design of more robust routing strategies that avoid potential bottlenecks or vulnerabilities. Overall, the findings emphasize the need for continued research into complex network dynamics, particularly in environments affected by heterogeneity and rapid technological changes. By analyzing real-world datasets such as global internet performance, this study lays the foundation for developing next-generation complex network models that are more scalable, reliable, and capable of supporting critical scientific and medical applications.

CONCLUSION

The objective of this study was to review and analyze a complex network by examining key centrality measures including degree, closeness, and betweenness derived from the average global internet speed network. Our findings indicate that the network contains 142 weakly connected components and 285 strongly connected components, reflecting its highly fragmented and intricate structure. This study contributes to identifying various research paradigms related to complex networks and provides insights into how such networks can be effectively analyzed and managed. In essence, this research will support scientists, engineers, and medical professionals in developing more robust and resilient complex network models in the future.

FUTURE WORK

During our work we have analyzed the issues associated with complex networks and one and two mode networks has analyzed In our future work we will propose a model for complex networking while using one mode to two mode network on healthcare to deal with emergency pandemics. Our work will contribute in Network Science

REFERENCE

[1] Liu, L., Essam, D., & Lynar, T. (2022). Complexity measures for IoT network traffic. *IEEE Internet of Things Journal*, *9*(24), 25715-25735.

[2] Rubinov, M., & Sporns, O. (2010). Complex network measures of brain connectivity: uses and interpretations. *Neuroimage*, *52*(3), 1059-1069.

[3] Park, J. S., Lee, J. Y., & Lee, S. B. (2000). Internet traffic measurement and analysis in a high speed network environment: Workload and flow characteristics. *Journal of Communications and Networks*, *2*(3), 287-296.

[4] Esfandiari, S., & Fakhrahmad, S. M. (2025). The collaborative role of K-Shell and PageRank for identifying influential nodes in complex networks. *Physica A: Statistical Mechanics and itsApplications*, *658*, 130256.

[5] Saura, J. R., Palacios-Marqués, D., & Ribeiro-Soriano, D. (2025). Privacy concerns in social media UGC communities: Understanding user behavior sentiments in complex networks. *Information Systems and e-Business Management*, *23*(1), 125-145.

[6] Wandelt, S., Zhang, A., & Sun, X. (2025). Global Airport Resilience Index: Towards a comprehensive understanding of air transportation resilience. *Transportation Research Part D: Transport and Environment*, *138*, 104522.

[7] Lu, C., Li, S., Xu, N., Zhang, Y., & Qin, Y. (2025). Research on AI-driven complex network and management system of coal and gas outburst accident. *Journal of Safety and Sustainability*, *2*(1), 32-44.

[8] Panahi, P. H. S., Jalilvand, A. H., & Diyanat, A. (2025). An efficient network-based QoE assessment framework for multimedia networks using a machine learning approach. *IEEE Open Journal of the Communications Society*.

[9] Boeing, G. (2025). Modeling and analyzing urban networks and amenities with OSMnx. *Geographical Analysis*.

[10] Zhang, Z., Ghavasieh, A., Zhang, J., & De Domenico, M. (2025). Coarse-graining network flow through statistical physics and machine learning. *Nature Communications*, *16*(1), 1605.

[11] Bhola, B., Kumar, R., Rani, P., Sharma, R., Mohammed, M. A., Yadav, K., ... & Alkwai, L. M. (2025). Quality-enabled decentralized dynamic IoT

platform with scalable resources integration. *IET Communications*, *19*(1), e12514.

[12] Gao, P., Jia, C., & Zhou, A. (2024). Encryption–decryption-based state estimation for nonlinear complex networks subject to coupled perturbation. *Systems Science & Control Engineering*, *12*(1), 2357796.

[13] Wadho, S. A., Meghji, A. F., Yichiet, A., Kumar, R., & Shaikh, F. B. (2023). Encryption Techniques and Algorithms to Combat Cybersecurity Attacks: A Review. *VAWKUM Transactions on Computer Sciences*, *11*(1), 295-305.

[14] Ali, S., Wadho, S. A., Talpur, K. R., Talpur, B. A., Alshudukhi, K. S., Humayun, M., ... & Shah, A. (2025). Next-Generation Quantum Security: The Impact of Quantum Computing on Cybersecurity—Threats, Mitigations, and Solutions. *Computers and Electrical Engineering*, *128*, 110649.

[15] Ji, G., Zhong, H., Nzudie, H. L. F., Wang, P., & Tian, P. (2024). The structure, dynamics, and vulnerability of the global food trade network. *Journal of Cleaner Production*, *434*, 140439.

[16] Wadho, S. A., Yichiet, A., Gan, M. L., Lee, C. K., Ali, S., & Akbar, R. (2024, January). Ransomware detection techniques using machine learning methods. In *2024 IEEE 1st Karachi Section Humanitarian Technology Conference (KHI-HTC)* (pp. 1-6). IEEE.

[17] Zhao, L., Sun, P., Zhang, J., Peng, M., Zhong, Y., & Liang, W. (2023). A complex network important node identification based on the KPDN method. *Applied Sciences*, *13*(14), 8303.

[18] Ghoshal, A. K., Das, N., & Das, S. (2021). Disjoint and overlapping community detection in small-world networks leveraging mean path length. *IEEE Transactions on Computational Social Systems*, *9*(2),40

[19] Wadho, S. A., Ali, S., & Mohammed, A. A. A. (2024). Secret Sharing as a Defense Mechanism for Ransomware in Cloud Storage Systems. *International Journal of Advanced Computer Science & Applications*, *15*(10).

[20] Kumar, R., Meghji, A. F., Wadho, S. A., Shaikh, F. B., Shaikh, U., & Ayyasamy, R. K. (2023). Implementation and Challenges in Cloud Computing. *JOURNAL OF INFORMATION & COMMUNICATION TECHNOLOGY*, *17*(2), 81-88.