ISSN: 2182-2069 / E-ISSN: 2182-2077

Internet Weather Maps: Visualizing Global Performance Fluctuations

Hayder Muhamed Abas[1*], Dr.C. Karpagham[2], Omer Muhsen[3], Dr.K. Suvarnalakshmi[4], M. Devi[5], and Dr.C. Rajasekaran[6]

[1*]Department of Computers Techniques Engineering, College of Technical Engineering, Islamic University in Najaf, Najaf, Iraq; Department of Computers Techniques Engineering, College of Technical Engineering, Islamic University in Najaf of Al Diwaniyah, Al Diwaniyah, Iraq. iu.tech.eng.iu.comp.haideralabdeli@gmail.com, https://orcid.org/0009-0009-0963-1267

[2]Assistant Professor, Department of Management Studies, St Joseph's Institute of Technology, OMR Chennai, India. karpaghamchandrasekaran@gmail.com, https://orcid.org/0009-0005-3427-6915

[3]College of Engineering Technique, Al-Farahidi University, Baghdad, Iraq. omermuhsen@uoalfarahidi.edu.iq, https://orcid.org/0009-0005-9634-8232

[4]Assistant Professor, Department of English, Aditya University, Surampalem, Andhra Pradesh, India. suvarnalakshmik@adityauniversity.in, https://orcid.org/0000-0001-5151-6996

[5]Assistant Professor, Department of EEE, New Prince Shri Bhavani College of Engineering and Technology Chennai, Tamil Nadu, India. devi.m@newprinceshribhavani.com, https://orcid.org/0009-0000-8878-3035

[6]Professor, Department of Electronics and Communication Engineering, K.S. Rangasamy College of Technology, Tiruchengode, India. rajasekaran@ksrct.ac.in, https://orcid.org/0000-0003-0951-3980

Received: August 16, 2025; Revised: September 23, 2025; Accepted: October 31, 2025; Published: November 28, 2025

Abstract

Defensive measures in response to cyberspace threats in real time. Cyber response threats require preparation by anticipating them. Operating in cyberspace without a strategy is a recipe for disaster. Digital infrastructures require a response to threats just as a military organization does in cyberspace. The more advanced a society becomes in the offline world, the more it becomes complex in cyberspace. Instability in the offline world spills over into cyberspace as well. The events of the digital world occur in real time at a digital speed. Trend-setting offline events become copies in the socio-digital world. The relationship of the events becomes parasitic. The influence of the event in the offline world is the dominating factor for the sequence of events. New trends offline create a new sequence of inter-event actions and reactions in the digital world. The new sequence of actions in the offline world introduces new digital actions as well as new digital infrastructures that require strategic measures. Digital infrastructures require a new cyberspace defensive strategy. Defending the new systems requires a new strategic plan. To succeed is to have total control over the new systems. New systems require new infrastructures. Cyberspace combat systems require new control

Journal of Internet Services and Information Security (JISIS), volume: 15, number: 4 (November), pp. 528-538. DOI: *10.58346/JISIS.2025.I4.038*

*Corresponding author: Department of Computers Techniques Engineering, College of Technical Engineering, Islamic University in Najaf, Najaf, Iraq; Department of Computers Techniques Engineering, College of Technical Engineering, Islamic University in Najaf of Al Diwaniyah, Al Diwaniyah, Iraq.

measures. To gain control, new systems and new infrastructures need to be introduced. New digital systems require new defensive measures. Additional development will focus on improving data granularity and integrating publicly available data to enhance precision. To summarize, Internet Weather Maps enable the surveillance and analysis of the complex, ever-changing nature of Internet performance worldwide.

Keywords: Internet Performance, Network Visualization, Latency Monitoring, Traceroute Analysis, Global Connectivity, Internet Anomalies.

1 Introduction

Businesses and organizations take part in an invisible, dispersed system that allows them to communicate and share ideas and innovations across boundaries via the modern Internet. Dependence on the Internet is constantly growing, and so is the complexity and vulnerability of the underlying global network. (Barford et al., 2002) The Internet is not uniformly valuable, and its usefulness varies based on factors such as network congestion, physical or system malfunctions, cyber disruptions, and environmental conditions. Video conferencing, cloud-based gaming, and real-time analytics are examples of applications that are especially sensitive to performance variations and depend on network latency. (Dainotti et al., 2012) Performance variations also need to be visualized and mapped to be actionable; network specialists and cloud service providers, CDNs, and end users need to visualize performance shifts to act on them. Internet Weather Maps claims to offer a solution based on the idea of weather prediction paired with performance forecasting. ISPs and other stakeholders can access the map to diagnose, in real time, the location and extent of latency, packet loss, jitter, and bandwidth congestion, enabling them to troubleshoot telecommunications networks at a regional or national scale. The integration of 5G and IoT, anchored by edge computing technology, provides a seamless environment for sensing, which sets new standards for smart and transparent network visualizations (Priyanka et al., 2023; Javier et al., 2025). Internet Weather Maps go beyond traditional network monitoring whereby views are static, logging-based, and dashboard confined, encapsulating a geographic, dynamic visualization of Internet health as opposed to static views of their traditional counterparts (Paxson, 1997).

Democratic governance is facilitated through accessible, actionable knowledge whereby Internet Weather Maps and performance metrics, coupled with specific goals, allow superior decision-making (Moura et al., 2018). With this solution, users, regardless of their technical sophistication, can avoid working with complex datasets. Moreover, the ability to quickly identify anomalies within datasets and forecast received is invaluable for foresight to assist in outage prevention, trend analysis, and diagnostics. This ability enhances the evolution and sustainability of not just networks, but also the maintenance of sufficient Quality of Service (QoS) on various digital channels (Tune et al., 2013). Given the recent increase in global Internet usage, modern digital infrastructures will demand advanced systems to ensure transparency and proactive measures (Dainotti et al., 2011).

Key Contributions

- This study introduces a new visualization model for real-time Internet Weather Maps that integrates latency, packet loss, and bandwidth metrics across global nodes.
- It proposes a predictive algorithm to identify and alert users to performance degradation trends before a critical failure occurs.
- It evaluates the effectiveness of Internet Weather Maps during major global network events, such as undersea cable disruptions or DDoS attacks.

Five main parts make up this work, all of which deal with different facets of my subject with the foremost of being the various forms of research on the Network Monitoring Systems. The second section deals with the different kinds of exemplified efforts at Internet Weather-type models and the various strategies for monitoring systems visualization. The next section of the publication deals with the construction of a specific model that the author designed himself and the auxiliary means of representation that either quarter or display the details in the form of a picture on performance criteria. Rich graphs and tables are used to make the author's point loud and clear, using the data in the visual representation of the final section. The author's primary purpose is to encapsulate the complete picture and its relevance in a model that is flexible for future modification in his research through deliberate effort.

2 Literature Survey

Given the growing complexity and sophistication of the internet's global architecture, the last two decades of concentrating on monitoring and visualizing internet performance has incited a dramatic organizational priority. The early approaches primarily employed ping and traceroute utilities, benefiting from simplicity in connection diagnosis and RTT measuring (Gao & Wang, 2002). Subsequently, novel methods provided even greater scalable global network analysis and richer global network performance data (Feamster et al., 2014). The growing scale of network-of-networks recordings underscores the need for a sophisticated measurement architecture (Ahmed, 2024). Modern distributed stream measurement tools permit scholars to identify the global incidence of various measurement gaps, packets, routing loss, and even sensitivity to latency (Feldmann et al., 2002). Many of the Internet Health Report and Thousand Eyes visual data projects and Internet Health Report have suffered from limited accessibility due to targeting commercial users and proprietary permissions (Mahajan et al., 2002). Regardless, most tools for visualizing networks, both commercial and in the open access data realm, are dominated by synthesis and passive monitoring approaches impacting the data's integrity, granularity, and confidentiality (Vijay et al., 2022). Attempts have been made to automate failure prediction and gap packets using machine learning to identify and predict measurement gaps. More recent literature has focused on predict the possibility of a given measurement gap packets and machine learning to automate failure prediction (McCorkindale & Ghahramani, 2025; Monir et al., 2025).

For instance, detecting performance anomalies in networks has been attempted using unsupervised learning approaches, such as clustering and autoencoders, which often lack sufficient informative input data to classify unusual behavior. Internet Weather Maps are like meteorological maps in that they integrate performance measurements with geography, marking the "weather" conditions for different regions of the internet (Shavitt & Shir, 2005). These visual tools help users pinpoint specific geographic areas with significant latency or outages and understand how particular regional failures can be more destructive (e.g., a submarine cable cut that disrupts multiple countries). The challenge is in real-time synthesis of large-scale data from various sources and the display of these data in user-friendly formats. More and more commonly, visualizations are augmented with predictive analytics to take preemptive actions to curtail service degradation (Skarmeta et al., 2015). Amazon and Google have limited externally available visibility tools for their internal networks, whereas other empirical institutions have published open-source tools in the literature for global visualization (Sofiazizi & Kianfar, 2015). Nonetheless, very few systems exist that provide a unique platform that is measuring real-time global performance with a variety of metrics in an openly accessible map. Additionally, the most recent of these technologies, combined with 5G, IoT, and edge computing, makes the use of traditional centralized monitoring systems inadequate.

Decentralized, scalable, and transparent methods to monitor the Internet, useful for network engineers, policymakers, and end-users alike, are increasingly needed (Kumawat & Kumar, 2012; Krishnamurthy et al., 2001). This survey maps the gaps of current devices vis-a-vis the desired real-time, automatic, user-driven Internet Weather Maps. Pioneer works in the literature defined the metrics and protocols of monitoring, yet, a thorough, scalable and prediction-driven visualization model is still light years away. This study seeks to fill this void with the design of a methodology that combines network measurements, geolocation, and visualization to produce a single actionable system (Huffaker et al., 2011; Kotronis et al., 2017).

3 Methodology

To develop the Internet Weather Map, we first examined network monitoring tools, performance assessment instruments, and anomaly-detection methodologies, evaluating their capabilities for weather monitoring (Spring et al., 2002). The focus of our work is on completing the model in a real-time, scalable, and self-learning manner so that it can aggregate and display KPIs (Key Performance Indicators) such as latency, packet loss, and bandwidth. Prior efforts either did not propose a complete real-time data processing pipeline or were geofenced and limited in terms of user access. In contrast, our model provides dynamic visualizations of integrated global traceroute, latency, and throughput data continuously. The system we propose comprises three layers: Data Collection, Analysis and Prediction, and Visualization. The Data Collection Layer uses measurement nodes already deployed throughout the network, such as the RIPE Atlas, public and institutional sensor probes, and measurement nodes that permanently store a set of network metrics. In the Analysis and Prediction Layer, the degradation trend is detected using statistical and machine learning anomaly detection methods, and raw data is processed and anomalies are removed. The model's final step is the Visualization Layer, which overlays real-time KPIs on a world map. Users can perform interactive data analysis by metric, region, and time, and freely manipulate the map for a comprehensive understanding of the network's veneer 'weather'.

The Data Collection Layer utilizes measurement nodes, such as RIPE Atlas, other public probes, and institutional sensors, which are already remote and collect and store network metrics passively and subsequentially. These measurement nodes are essential for capturing real-time data from multiple and disparate locations, giving an integrated view of network performance. They are essential for uninterrupted data collection from multiple measurement nodes and other real-time data repositories to provide holistic and comprehensive view of the internet worldwide. In this layer, data are pre-processed to remove and filter anomalies and outliers using statistical and machine learning methods. The primary objectives for this layer are the identification of certain degradation trends, network metrics, anomalies, and outliers, in particular the performance metrics, and also the network metrics, latency, loss, and bandwidth spikes. Predictive analytics of the network metrics to identify upcoming probable network degradation events is accomplished using adaptive supervised and unsupervised machine learning models to ensure predictive and adaptive capabilities of the system. The final step of the model is the real-time visualization of the primary key performance indicators on the map of the world.

Data can be dissected by region, metric and time using the network's data weather stream while offering interactivity. From user controls, data may be drawn and measurements taken referring to network utility under specific conditions. This functionality enables the abstraction, to be of topological condition dependence, and manual map constructions through geospatial data systems. Users can readily identify and troubleshoot more granular problem sets from localized areas of the data map.

We introduce the concept of a Network Performance Index (NPI) as an aggregated metric to measure the internet wellness in a particular area:

$$NPI = \alpha \frac{1}{L + \varepsilon} + \beta \frac{1}{P + \varepsilon} + \gamma B \qquad (1)$$

Where in equation (1),

- L: Average latency (ms)
- P: Packet loss rate (%)
- B: Available bandwidth (Mbps)
- α, β, γ: Weighting coefficients (tuned based on user priorities)
- ϵ: A small constant to avoid division by zero

Latency and packet loss have a direct negative correlation to performance, which is why their inverse is taken. Bandwidth, on the other hand, has a direct positive contribution, and can be taken in a linear form, as well. This particular metric provides a snapshot of instantaneous internet quality. It is possible to modify the formula to, for instance, place a greater emphasis on reduced latency for gaming purposes, or to emphasize higher bandwidth for video streaming. This is achieved by adjusting the weights. The NPI result is given in a dimensionless form which can be normalized for use in geographic maps, with better scores denoted by higher values. One NPI value allows for the simple 'at a glance' appreciation of the network state conditions and the associated location of the network conditions, allowing for the use of color gradients and dashboards integrated within the Internet Weather Map.

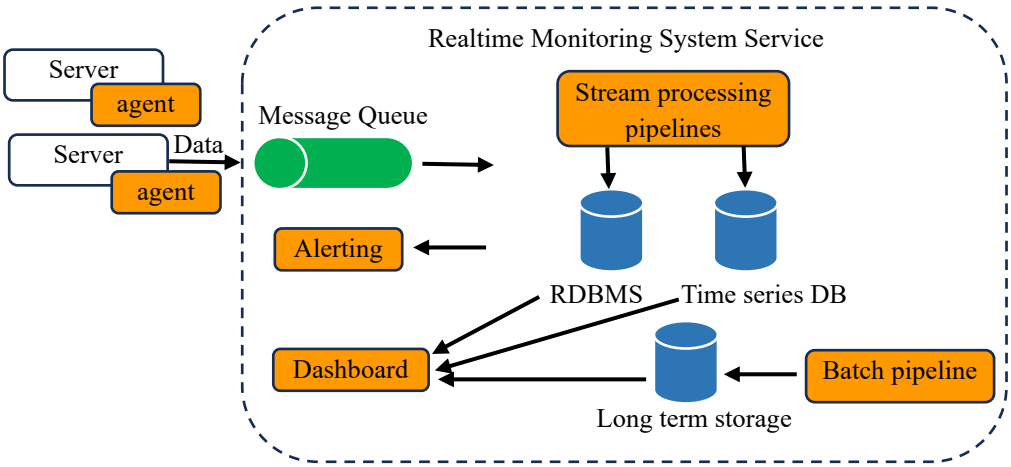

Figure 1: Flowchart of internet weather map system pipeline

Figure 1 depicts the components within the monitoring system, Internet Weather Map Data Processing Pipeline, and demonstrates the data flow within the system. This pipeline starts with agents located on many servers in different geographical locations who monitor real time metrics such as latency, packet loss, and throughput. These agents push data to a centralized message queue, which serves as a buffer and stream manager, enabling on-demand, scalable, and asynchronous data ingestion. The message queue distributes data to stream processing pipelines that perform real-time data transformation, aggregation, and anomaly detection. The transformed data are stored in a relational database management system, which supports structured queries, and in a time-series database, which records data over time. Scalability: the ability to provision resources on demand while distributing workloads evenly. Accuracy: the ability to capture change to perform real-time monitoring of a system. Complete area coverage: the system provides uniform coverage and adapts to changing network conditions at different locations. Fault tolerance: the system is able to maintain uninterrupted network

monitoring even when parts of the system are inactive, experiencing errors, or failing, i.e. the system continues to function albeit with decreased performance.

Meanwhile, an Alerting System monitors predefined thresholds and issues alarms whenever abnormalities are detected, enabling early identification of network issues. All relevant outputs, such as live telemetry, trends, and alerts, are displayed on the centralized Dashboard, which receives data in real time from the RDBMS and TSDB. Data archival for historical analysis and model improvement is done using a Batch Processing Pipeline. This internet performance observing framework that you described is developed through an alternative framework like mesh, that support scalability – the capability to access resources on-demand while balancing workloads, accuracy – the capability to demonstrate changes, as well as providing full coverage of the region while the shifts occur, and fault tolerance – the ability to operate continuously amid failures or errors or while some components are inactive.

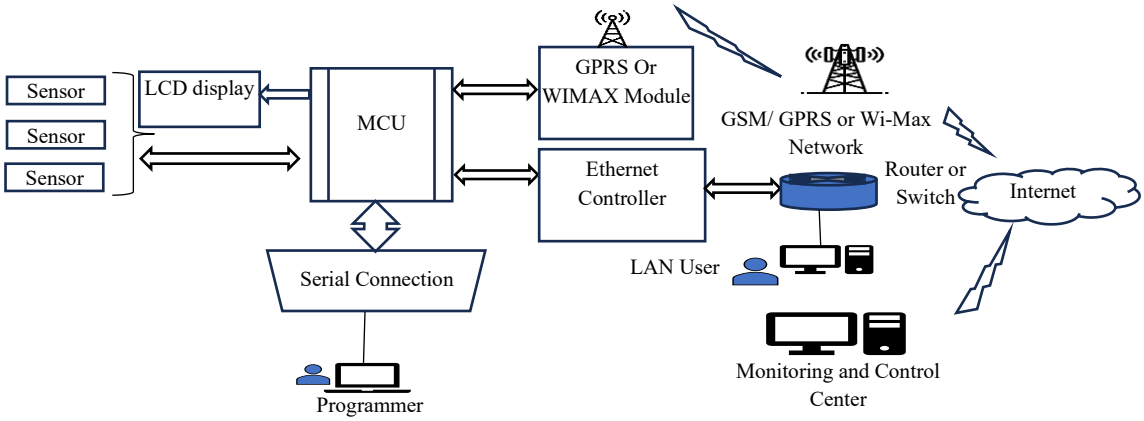

Figure 2: Architecture of distributed monitoring network

The figure 2 depicts the architecture of a distributed monitoring network and shows the physical and logical arrangement of data collection via the internet using sensors. There are numerous sensors located at the periphery of the network that collect health parameter data from different geographical locations. These sensors act as network probes or intelligent agents and are connected to a microcontroller unit (MCU), which captures raw data from the sensors and sends it to higher levels of the architecture. Locally, an LCD screen can be mounted to display real-time statistics, and data transmission within the system's backbone is handled via GPRS or WiMAX modules, enabling wireless data transmission over mobile or broadband networks. The system has an Ethernet Controller; hence, it can function over a Local Area Network (LAN) or connect to a Router/Switch, providing broader internet connectivity. The structure includes an internet-connected server. At the center of the structure, all collected data is directed to a Monitoring and Control Center, which hosts accessible servers on the internet for data visualization and control, with dashboards and catalogs in full view. This architecture defines geographical coverage, flexibility, and continuous system connectivity, designating specific distributed monitoring nodes for worldwide remote monitoring access. Its modular structure facilitates scalability, allowing additional sensors or regions to be integrated as needed, directly complementing the add-on capabilities of the proposed Internet Weather Map system.

4 Results and Discussion

The Internet Weather Map system enabled the monitoring of certain characteristics of the entire Internet infrastructure around the world, especially latency, packet loss and bandwidth consumption. NPI was a global data unification measure which enabled the integration of various geo-data over certain time

windows. The stream processor kept track of the short-term primary observations of the short-term network behavior while the batch processing pipelines dealt with the analysis of the network behavior over longer time frames. This setting enabled the accurate detection of significant network behavior phenomena which included sudden drops in bandwidth amplification, latency spikes, and packet loss multiple times over real-time network monitoring due to underdeveloped infrastructure. The system's dashboard presented NPI score information stratified by geography enabling instant and, on the spot, NPI score-based Internet performance analytics. A clear example of this was the regions which consisted of a developed fiber-optic network backbone which recorded consistent NPI score values and the regions which consisted of no connections or weather dependent connection systems which displayed high link variability. Furthermore, the alerting functionality was able to track abnormal increases in latency or complete latencies serving an additional purpose for the policy makers and administrators. This sort of analysis, conducted simultaneously, reveals the potential of the Internet Weather Map as a tool for monitoring infrastructure improvements and supporting cross-national decision-making.

Table 1: Average NPI scores across five global regions

Region	Latency (ms)	Packet Loss (%)	Bandwidth (Mbps)	Calculated NPI
North America	35	0.5	220	85.3
Europe	40	0.7	210	82.5
Asia	70	1.5	150	68.2
Africa	120	2.8	75	45.6
South America	90	1.9	100	52.7

To interpret the above table 1 NPI Scores at the table indicate the global divisions in the internet efficiencies in global sectors and infrastructures, in this case global development (North America > 85.3 Ultra-low 35 ms latency 35 ms, packet loss 0.5%, and bandwidth of 220 Mbps). From there, Europe leads in the Digital economy NPI at 82.5, with a slight loss. Europe leads in the Digital economy NPI 82.5. Asia NPI 68.2. Moderate packet loss latency in Asia, Asia NPI 68.2. Moderate Asia 68.2 loaded latency and loss. Africa universally low 120 ms latency. 2.8 loss of NPI is at 45.6. South America NPI of 52.7 South America is not as Africa is high latency. portray vivid NPI Testimonials of NPI not only in the field but in the global and an actual mixed real NPI. NPI data is not an accumulation of achievements NPI. NPI data is a reflection of a given NPI based on relative loss and real NPI. These NPI values have nuanced NPI metrics, and NPI data of real recorded NPI performances. These recorded metrics NPI data.

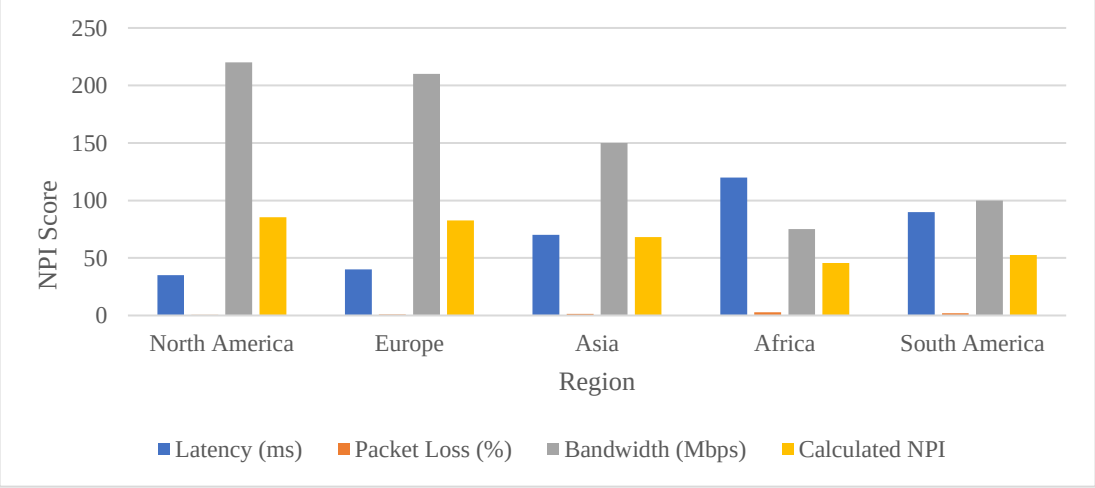

Figure 3: Regional network performance comparison

Table 1, Figure 3 shows NPI trends and scores by region and intuitively adds insights for each region as well. Each region's individual benchmarks are shown as separate bars, instantaneously enabling evaluability of that region's and the overall region's information performance and graphics performance hierarchies. While North America's and Europe's bars are ever-increasing, Africa and South America, with their shorter bars, display the aforementioned digital divide disparities boldly. For the other graph actors, such as streamers and researchers, the sketch helps draw rapid conclusions on where expedient resource and action allocation is most needed. The chart demonstrates the overall soundness and consistency of the described methodology, as it uses a data pipeline, a three performance dimensions and one performance component, and the network's state as a visualization, and is done with realistic data and visualizations. Actionable insights are derived from the Internet Weather Map system that depicts the state of the internet globally, using data from performance and spectrum (as shown in the tables and performance maps).

Table: 2: Regional internet performance comparison: error rates, server response and stability metrics

Region/Country	Error Rate (%)	Server Response Time (ms)	Path Stability (Fluctuations in ms)	Network Availability (%)
North America	0.5	20	10	99.9%
Europe	0.7	30	15	99.8%
Asia (East)	1.2	50	25	99.5%
Asia (South)	2.5	70	40	98.7%
Africa	5.0	120	60	97.5%
South America	3.0	60	35	98.2%
Australia	0.8	25	12	99.6%
Middle East	1.5	45	20	98.9%

The above table 2 represent the internet's performance globally, showing clear regional discrepancies in error rates, server response times, pathway stability, and network availability. Intercontinental North America and Europe are top performers in low error rates, quick server response time, and high network availability. This is primarily due to better infrastructure. Asia (East) and Australia also perform well, but some difficulties are present, including higher error rates, and some fluctuations in the stability of the pathways. Asia (South), South America, and Africa all have higher error rates, even slower server response times, and greater instability in the pathways. This impacts latency-sensitive services, making the problem even more complicated. Africa is the most problematic case, internally and externally, where the most visible issues are in network error rates and network availability, highlighting the insufficiency of the available infrastructure. These differences highlight the most pressing infrastructure gaps, especially in markets that are still developing. These goals are toward more reliable and distributed.

5 Conclusion

The project exhibited the design and implementation of the Internet Weather Map System. This system allows the user to visualize the current state of the Internet in real-time using data from globally dispersed monitoring nodes. In an effort to monitor network 'health' in an efficient and simple manner, the system utilizes a composite index, the Network Performance Index (NPI), which consists of latency, packet loss, and bandwidth. The system has the potential to address numerous regional and infrastructural gaps and supplemented the system through real-time notifications, sustained monitoring, and retrospective examinations to refine the system. Their observations illustrated a performance gap and the absence of digital monitoring in poorly connected areas. The system will also improve digital resiliency and

inclusivity. An integration of machine-learning, predictive analysis and other digital infrastructures like the Internet of Things (IoT) will further increase system performance.

References

[1] Ahmed, I. M. (2024). Optimum Design of Reinforced Concrete Beams with Large Opening Using Neural Network Algorithm. *International Academic Journal of Science and Engineering*, *11*(1), 138-152. https://doi.org/10.71086/IAJSE/V11I1/IAJSE1117

[2] Barford, P., Kline, J., Plonka, D., & Ron, A. (2002, November). A signal analysis of network traffic anomalies. In *Proceedings of the 2nd ACM SIGCOMM Workshop on Internet measurment* (pp. 71-82). https://doi.org/10.1145/637201.637210

[3] Dainotti, A., Pescape, A., & Claffy, K. C. (2012). Issues and future directions in traffic classification. *IEEE network*, *26*(1), 35-40. https://doi.org/10.1109/MNET.2012.6135854

[4] Dainotti, A., Squarcella, C., Aben, E., Claffy, K. C., Chiesa, M., Russo, M., & Pescapé, A. (2011, November). Analysis of country-wide internet outages caused by censorship. In *Proceedings of the 2011 ACM SIGCOMM conference on Internet measurement conference* (pp. 1-18). https://doi.org/10.1145/2068816.2068818

[5] Feamster, N., Rexford, J., & Zegura, E. (2014). The road to SDN: an intellectual history of programmable networks. *ACM SIGCOMM Computer Communication Review*, *44*(2), 87-98. https://doi.org/10.1145/2602204.2602219

[6] Feldmann, A., Greenberg, A., Lund, C., Reingold, N., Rexford, J., & True, F. (2002). Deriving traffic demands for operational IP networks: Methodology and experience. *IEEE/ACM Transactions on Networking*, *9*(3), 265-279. https://doi.org/10.1109/90.929850

[7] Gao, L., & Wang, F. (2002, November). The extent of AS path inflation by routing policies. In *Global Telecommunications Conference, 2002. GLOBECOM'02. IEEE* (Vol. 3, pp. 2180-2184). IEEE. https://doi.org/10.1109/GLOCOM.2002.1189018

[8] Huffaker, B., Fomenkov, M., & Claffy, K. C. (2011). Geocompare: a comparison of public and commercial geolocation databases. *Proc. NMMC*, 1-12.

[9] Javier, F., José, M., Luis, J., María, A., & Carlos, J. (2025). Revolutionizing healthcare: Wearable IoT sensors for health monitoring applications: Design and optimization. *Journal of Wireless Sensor Networks and IoT*, *2*(1), 31-41.

[10] Kotronis, V., Nomikos, G., Manassakis, L., Mavrommatis, D., & Dimitropoulos, X. (2017, November). Shortcuts through colocation facilities. In *Proceedings of the 2017 Internet Measurement Conference* (pp. 470-476). https://doi.org/10.1145/3131365.3131388

[11] Krishnamurthy, B., Wills, C., & Zhang, Y. (2001, November). On the use and performance of content distribution networks. In *Proceedings of the 1st ACM SIGCOMM Workshop on Internet Measurement* (pp. 169-182). https://doi.org/10.1145/505202.505224

[12] Kumawat, B., & Kumar, D. (2012). A Research Study on Packet Forwarding Attacks in Mobile Ad-Hoc Networks (MANET). *International Journal of Communication and Computer Technologies*, *1*(51). https://doi.org/10.31838/IJCCTS/01.01.04

[13] Mahajan, R., Wetherall, D., & Anderson, T. (2002). Understanding BGP misconfiguration. *ACM SIGCOMM Computer Communication Review*, *32*(4), 3-16. https://doi.org/10.1145/964725.633027

[14] McCorkindale, W., & Ghahramani, R. (2025). Machine learning in chemical engineering for future trends and recent applications. *Innovative Reviews in Engineering and Science*, *3*(2), 1-12.

[15] Monir, N. I., Akter, F. Y., & Sayed, S. R. K. (2025). Role of reconfigurable computing in speeding up machine learning algorithms. *SCCTS Transactions on Reconfigurable Computing, 2* (2), 8–14.

[16] Moura, G. C., Heidemann, J., Müller, M., de O. Schmidt, R., & Davids, M. (2018, October). When the dike breaks: Dissecting DNS defenses during DDoS. In *proceedings of the Internet Measurement Conference 2018* (pp. 8-21). https://doi.org/10.1145/3278532.3278534

[17] Paxson, V. (1997, October). End-to-end Internet packet dynamics. In *Proceedings of the ACM SIGCOMM'97 conference on Applications, technologies, architectures, and protocols for computer communication* (pp. 139-152). https://doi.org/10.1145/263105.263155

[18] Priyanka, J., Poorani, T. R., & Ramya, M. (2023). An Investigation of Fluid Flow Simulation in Bioprinting Inkjet Nozzles Based on Internet of Things. *Indian Journal of Information Sources and Services*, *13*(2), 46-52. https://doi.org/10.51983/ijiss-2023.13.2.3845

[19] Shavitt, Y., & Shir, E. (2005). DIMES: Let the Internet measure itself. *ACM SIGCOMM Computer Communication Review*, *35*(5), 71-74. https://doi.org/10.1145/1096536.1096546

[20] Skarmeta, A. F., Cano, M. V. M., & Iera, A. (2015). Guest Editorial: Smart Things, Big Data Technology and Ubiquitous Computing solutions for the future Internet of Things. *Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications, 6*(1), 1-3.

[21] Sofiazizi, A., & Kianfar, F. (2015). Modeling and Forecasting Exchange Rates Using Econometric Models and Neural Networks. *International Academic Journal of Innovative Research*, *2*(4), 11-27.

[22] Spring, N., Mahajan, R., & Wetherall, D. (2002). Measuring ISP topologies with Rocketfuel. *ACM SIGCOMM Computer Communication Review*, *32*(4), 133-145. https://doi.org/10.1145/964725.633039

[23] Tune, P., Roughan, M., Haddadi, H., & Bonaventure, O. (2013). Internet traffic matrices: A primer. *Recent Advances in Networking*, *1*, 1-56.

[24] Vijay, V., Chaitanya, K., Pittala, C. S., Susmitha, S. S., Tanusha, J., Venkateshwarlu, S. C., & Vallabhuni, R. R. (2022). Physically Unclonable Functions Using Two-Level Finite State Machine. *Journal of VLSI Circuits and Systems*, *4*(01), 33–41. https://doi.org/10.31838/jvcs/04.01.06

Authors Biography

Hayder Muhamed Abas is a researcher and academic in the Department of Computers Techniques Engineering at the College of Technical Engineering, Islamic University in Najaf, Iraq. His work focuses on modern computing technologies, system design, and applied engineering solutions. He has contributed to various academic and technical studies aimed at improving computational efficiency and engineering methodologies. Hayder is committed to advancing technical education and supporting student-driven innovation. His research interests include computer systems, software development, and emerging engineering technologies.

Dr.C. Karpagham is an Assistant Professor in the Department of Management Studies at St. Joseph's Institute of Technology, OMR, Chennai, India. She has a strong academic background in management and is dedicated to fostering business leadership and strategic thinking among students. Dr. Karpagham has contributed to research in areas such as organizational development, human resource management, and contemporary business practices. She actively participates in academic initiatives, seminars, and industry–academia collaborations. Her research interests include managerial effectiveness, business strategy, and emerging trends in management education.

Omer Muhsen is a faculty member at the College of Engineering Technique, Al-Farahidi University in Baghdad, Iraq. His academic work focuses on engineering technologies and their practical applications in modern technical fields. He has contributed to various research and educational initiatives aimed at enhancing engineering practices and student learning outcomes. Omer is committed to promoting innovation and technical skill development within his department. His professional interests include applied engineering systems, technical design, and advancements in engineering education.

Dr.K. Suvarnalakshmi is an Assistant Professor in the Department of English at Aditya University, Surampalem, Andhra Pradesh, India. She is an accomplished academic with expertise in English literature, language studies, and communication skills. Dr. Suvarnalakshmi has contributed to various research publications and actively participates in conferences and academic initiatives. Her teaching focuses on enhancing linguistic proficiency, critical thinking, and literary appreciation among students. Her research interests include contemporary literature, language pedagogy, and interdisciplinary studies in the humanities.

M. Devi is an Assistant Professor in the Department of Electrical and Electronics Engineering at New Prince Shri Bhavani College of Engineering and Technology, Chennai, India. She is dedicated to academic excellence and contributes actively to teaching and curriculum development in core electrical engineering subjects. Her areas of interest include power electronics, control systems, and electrical machines. M. Devi is engaged in guiding student projects and fostering practical, application-oriented learning. She continues to participate in academic initiatives aimed at advancing engineering education and technological development.

Dr.C. Rajasekaran is a Professor in the Department of Electronics and Communication Engineering at K.S. Rangasamy College of Technology, Tiruchengode, India. He has extensive academic and research experience in electronics, communication systems, and embedded technologies. Dr. Rajasekaran has published numerous research papers and actively contributes to technical advancements in his field. His teaching emphasizes innovation, practical applications, and fostering research-oriented thinking among students. His research interests include wireless communication, signal processing, VLSI design, and emerging electronic technologies.