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"ANALYZING THROUGHPUT AND PACKET LOSS IN PERFECT DIFFERENCE NETWORKS AND MESH ARCHITECTURES"

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ABSTRACT

Network performance analysis plays a crucial role in the design and evaluation of communication systems. The Perfect Difference Network is a novel network topology characterized by a regular, fully connected structure with an inherent property that minimizes the difference between the maximum and minimum node degrees. In contrast, the N Complete Network represents a fully connected network where each node is directly connected to all other nodes, forming a complete graph. This study aims to evaluate and compare the performance of PDN architecture and mesh architecture across several parameters. The findings of this research will provide insights into the advantages of replacing mesh design with PDN architecture. The major factors for comparison in this context are throughput and packet loss, while supplementary characteristics include changes in traffic rates and connection failure. Under some circumstances, the use of mesh networks may provide superior performance compared to traditional packet data networks (PDN). However, this advantage is counterbalanced by the cost savings achieved by PDN, as it reduces the number of required links.

Keywords: - Nodes, Networks, Simulation, Complete Network, Difference Network.

I. INTRODUCTION

In the ever-evolving world of computer networks, the performance and efficiency of data transmission are of paramount importance. Two architectural paradigms that have gained significant attention are Perfect Difference Networks and Mesh Architectures. These two approaches offer unique solutions to the challenges of data transmission and communication. In this 1000-word introduction, we will explore the fundamental concepts, principles, and characteristics of Perfect Difference Networks and Mesh Architectures, with a specific focus on their impact on throughput and packet loss. By examining these two network architectures, we aim to provide a comprehensive understanding of their strengths and weaknesses in handling data throughput and mitigating packet loss, shedding light on their real-world applications and implications.

Perfect Difference Networks, often referred to as PDNs, represent a novel and innovative approach to network architecture. These networks are designed to maximize the efficiency of data transfer by exploiting mathematical concepts like perfect differences and orthogonal arrays. Unlike traditional network topologies that rely on hierarchies and centralized routing, PDNs distribute data in a manner that optimizes throughput and minimizes the risk of packet loss. The concept of a perfect difference is based on the mathematical principles of finite fields, where each node in the network communicates with a unique set of other nodes. This uniqueness minimizes the chances of collisions and congestion, resulting in improved throughput and reduced packet loss.

In a Perfect Difference Network, every node is assigned a distinct identity, allowing for parallel data transmission. Unlike other architectures where nodes often share communication paths, the orthogonal nature of PDNs means that each node operates independently. This independence ensures that data can be transmitted concurrently without interference, significantly boosting the overall throughput of the network. Moreover, the unique communication paths reduce the likelihood of packet collisions and subsequent loss, making PDNs an intriguing solution for applications requiring high reliability and low packet loss.

Mesh Architectures, on the other hand, offer a different approach to network design. In a mesh network, every node is interconnected with multiple neighbors, forming a complex web of communication paths. Unlike Perfect Difference Networks, mesh architectures are characterized by their redundancy and interconnectedness. This redundancy is a key feature that contributes to their fault tolerance and resilience. Mesh networks are often used in scenarios where reliability is of utmost importance, such as military communications and emergency response systems.

One of the notable features of mesh architectures is their adaptability and self-healing capabilities. If a link or node in a mesh network fails, data can automatically reroute through alternative paths, minimizing the impact on throughput and reducing the chances of packet loss. This self-healing property is particularly valuable in scenarios where network continuity is critical. Mesh networks excel in scenarios where the environment is dynamic and unpredictable, making them suitable for applications such as IoT (Internet of Things), smart cities, and wireless sensor networks.

The choice between Perfect Difference Networks and Mesh Architectures depends on the specific requirements and constraints of a given application. Perfect Difference Networks are well-suited for scenarios where maximizing throughput and minimizing packet loss are the primary objectives. These networks are particularly efficient in applications like scientific simulations, financial trading, and data centers, where large volumes of data need to be transmitted quickly and reliably. The inherent design of PDNs minimizes interference, resulting in high throughput and low packet loss, making them an ideal choice for data-intensive tasks.

Mesh Architectures, on the other hand, shine in situations where fault tolerance and adaptability are paramount. In environments where network nodes may fail or the topology is constantly changing, mesh networks provide a robust solution. Their self-healing capabilities ensure that data transmission remains intact even in the face of node failures or network disruptions. This makes mesh architectures the preferred choice for applications such as disaster recovery, military communications, and wireless sensor networks.

To better understand the impact of these network architectures on throughput and packet loss, let's delve deeper into their characteristics and performance metrics.

Perfect Difference Networks are distinguished by their efficiency in handling high-throughput data transfer. The perfect difference concept, grounded in mathematical principles, ensures that each node communicates with a unique set of other nodes. This uniqueness minimizes the chances of collisions and congestion, allowing data to be transmitted concurrently without interference. Consequently, PDNs offer impressive throughput capabilities, making them ideal for applications that demand rapid data transfer. For example, in a high-frequency trading environment, where split-second decisions and actions are crucial, the low-latency and high-throughput nature of PDNs can provide a significant advantage.

Furthermore, PDNs are highly resistant to packet loss. The orthogonal communication paths and minimal chance of collision ensure that data packets are transmitted and received reliably. In scenarios where even a single lost packet can result in significant consequences, such as in medical telemetry or autonomous vehicles, the reliability of Perfect Difference Networks becomes a clear asset. Packet loss can lead to data corruption or delays, which may not be tolerable in such critical applications.

On the other hand, Mesh Architectures exhibit a different set of characteristics. While they may not offer the same level of raw throughput as PDNs, they are designed with redundancy and fault tolerance in mind. In a mesh network, every node is interconnected with multiple neighbors, ensuring that data can take alternative routes if a link or node fails. This redundancy reduces the risk of data loss and maintains network connectivity, even in adverse conditions. Consequently, mesh architectures excel in applications where reliability and fault tolerance are paramount.

In addition to fault tolerance, Mesh Architectures are highly adaptable. They can dynamically adjust to changes in the network topology, making them suitable for environments with mobile or transient nodes. In a smart city, for example, where sensor nodes may be constantly on the move, mesh networks can autonomously adapt to maintain communication, ensuring that data continues to flow without significant disruptions. This adaptability and self-healing capability contribute to lower packet loss in scenarios where network conditions are unpredictable.

Perfect Difference Networks and Mesh Architectures each have their strengths and weaknesses when it comes to throughput and packet loss. PDNs excel in applications where high throughput and low packet loss are the top priorities, making them suitable for data-intensive, time-critical tasks. Mesh Architectures, on the other hand, shine in environments where fault tolerance and adaptability are crucial, providing robust network solutions that minimize packet loss in dynamic and unpredictable scenarios.

As technology continues to advance, the choice between these two network architectures will depend on the specific requirements of the applications they serve. In some cases, a hybrid approach may be the most effective solution, combining the strengths of both architectures to create a network that maximizes throughput while minimizing packet loss.

II. REVIEW OF LITERATURE

Anad, Maan et al., (2018) The NS-2 program is extensively used in the research domain for simulating networks and sequentially modeling packet-based events depending on time. The NS-2 software package includes the Network Animator (NAM), which generates a visual depiction of network simulations. Additionally, NS-2 provides support for many simulation protocols. The end-to-end testing of the network is possible. The examination encompasses several aspects such as data transmission, latency, jitter, packet-loss ratio, and throughput. The Performance Analysis involves the simulation of a virtual network and the concurrent evaluation of transport layer protocols. This is achieved by using variable data and analyzing the simulation outcomes using the NS-2 network simulator.

Abd, Mt et al., (2016) A Mobile Ad Hoc Network (MANET) refers to a collection of mobile devices that form a network without relying on a fixed infrastructure or architecture. In this network, each node fulfills a dual role, functioning both as a router and as a host simultaneously. In addition, The network's capacity for nodes to join or disconnect with ease. In order to build effective connectivity inside the network, routing protocols were used to investigate pathways between nodes. The basic objective of the routing protocol is to ensure the discovery of the most efficient route between pairs of nodes. The routing of Mobile Ad hoc Networks (MANETs) is a complex task that necessitates the enhancement of several routing protocols inside the MANET environment. The primary objective of this research is to analyze and distinguish the efficacy of two reactive routing protocols, namely Ad-hoc on demand Distance Vector (AODV) and Dynamic Source Routing (DSR), within the context of Mobile Ad hoc Networks (MANETs). We used two performance indicators, namely average throughput and average end-to-end latency. A simulation research was conducted using Network Simulator (NS) version 2.35 to evaluate the performance metrics of the routing protocols. The study included altering the packet size and number of nodes. Based on the conclusive study of practical results, it is evident that AODV exhibits superior performance in terms of throughput when compared to DSR. Conversely, DSR demonstrates a more favorable performance in the context of low average end-to-end latency.

Ramesh, Chithrupa et al., (2014) In this study, we examine a hypothetical situation in which several event-driven systems rely on a wireless network for communication with their respective controllers. These systems use a conflict resolution mechanism (CRM) in order to mediate access to the network. In this study, we introduce a Markov model to analyze the network interactions across event-based systems. By using this particular model, we are able to derive an analytical equation that represents the dependability of the network, which refers to the chance of successfully delivering a packet. Our model has two significant components. Our model effectively depicts the concurrent interactions between the event-triggering policy and the customer relationship management (CRM) system. The need of this requirement arises from the fact that event-triggering rules often exhibit adaptability in response to the result of customer relationship management (CRM) activities. Additionally, the model is derived by disentangling the interconnections among the various systems inside the network, taking cues from Bianchi's examination of IEEE 802.11. The need of this requirement arises from the fact that network interactions establish a correlation among the variables of the system. In this study, we use Monte-Carlo simulations to evaluate our proposed model across diverse network topologies and to verify the accuracy of our performance analysis.

Ikeda, Makoto et al., (2012) An Ad-hoc Network refers to a group of wireless terminals that has the capability to autonomously establish a temporary network without relying on any assistance from fixed infrastructure or centralized management. This research aims to assess the throughput and received packet rate of wireless ad-hoc networks via the use of simulations. The network simulators ns-2 and ns-3 were used in our study, specifically focusing on the Optimized Link State Routing (OLSR) protocol. In this study, we assess the performance of ns-2 and ns-3 with regard to memory use and runtime metrics. In addition, we conduct a comparative analysis of the mean throughput, mean received rate, and quantity of received packets across varying area dimensions and node quantities. The simulation findings indicate that as the network size rises, ns-3 exhibits superior performance compared to ns-2.

Yadav, Rakesh et al., (2011) Mobile Ad hoc networks (MANET) are intricate distributed systems that consist of wireless ad hoc networks, which operate without the need for a fixed infrastructure. These networks have a dynamic topology and are sometimes referred to as short-lived networks. A Mobile Ad hoc Network (MANET) is a kind of network that is characterized by its self-organizing and self-configuring capabilities, allowing mobile nodes to move in an arbitrary manner. The mobile nodes has the capability to receive and then transmit packets in a manner similar to that of a router. The problem of routing in Mobile Ad hoc Networks (MANETs) is of utmost importance, since the effectiveness of routing protocols directly impacts the reliability of the routing process. AODV, DSDV, and DSR are widely recognized as the most prevalent routing protocols in the field. The performance measures are derived using a range of performance indicators, including packet delivery percentage and average end-to-end latency. This research also examines the performance of using execution time while modifying various parameters in MANET simulations.

III. RESEARCH METHODOLOGY

The NS simulator is a discrete event simulator that follows the principles of object-oriented programming. The simulator keeps a list of events and sequentially performs each event. It operates on a single thread of control, ensuring the absence of locking or race conditions. The back end used in NS-2 is a C++ event scheduler that is mostly employed in protocols. Once again, the speed at which it operates is very efficient, so affording greater levels of control. The front end used in NS-2 is OTCL, which facilitates the creation of scenarios and modifications to C++ protocols. The act of writing and making revisions is facilitated by its inherent simplicity. This research presents a comparative analysis of the throughput and packet loss characteristics of two network topologies: PDN (Partial Directed Network) and N Complete Network. The study focuses on two scenarios involving 7 nodes and 13 nodes, respectively. Initially, two distinct networks are established with Network Simulation version 2.

IV. DATA ANALYSIS AND INTERPRETATION

This study aims to analyze and evaluate the performance metrics, namely throughput and packet loss, of PDN (Partial Directed Network) and N Complete Network for two different network sizes, namely 7 nodes and 13 nodes. Table 1 presents the communication parameters for the Perfect Difference Network and the N Complete Network.

Table 1 Communication Parameter

Nodes	7 and 13
Topologies	PDN and N complete
Traffic Rate	FTP
Network Protocol	TCP
Network Parameter	Throughput, Packet Loss
Bandwidth	1MBPS
Packet Size	500 bytes
Routing Protocol	Distance Vector
Queue Management Mechanism	Drop Trail
Source Node	Node 0
Destination Node	Node 5
Routing Strategic	Dynamic

- **Throughput result for 7 nodes**

The analysis of throughput for a PDN with a network size of 7 is conducted using the PDS values of {0, 1, 3} and a complete network. The comparison between the throughput of the Partially Disjoint Network (PDN) and the N Complete Network (NCN) in the event of link failures, as seen in Figures 1 and 2, reveals that the PDN exhibits superior performance. As seen in Figure 2, it can be observed that when there are 5 broken connections, the related network's throughput performance of the Public Data Network (PDN) is higher.

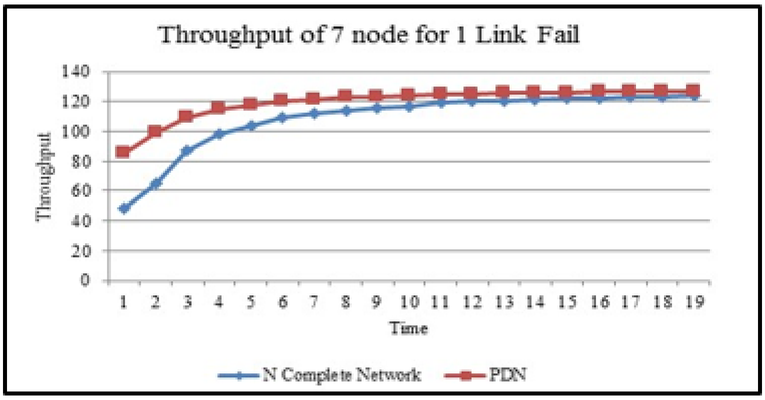

Figure 1: Result of throughput for 7 nodes of 1 link Fail

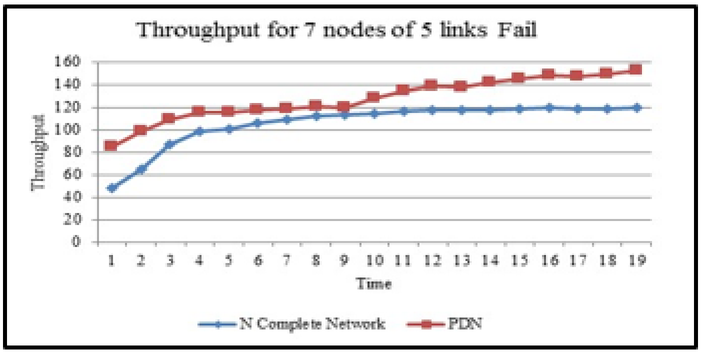

Figure 2: Result of throughput for 7 Node of 5 links Fail

- **Throughput result for 13 Nodes**

The figure 3 demonstrates that the throughput for PND (Path Network Design) with a size of 13, as determined by the Power Spectral Density (PSD) values of {0, 1, 4}, remains constant in the presence of a single link failure in the whole network N. Figure 4 illustrates the variation in throughput for both the N Complete Network and PDN as a result of link failures. The degradation of throughput in the N Complete Network is more pronounced when a greater number of connections break, in comparison to the Partially Degraded Network (PDN).

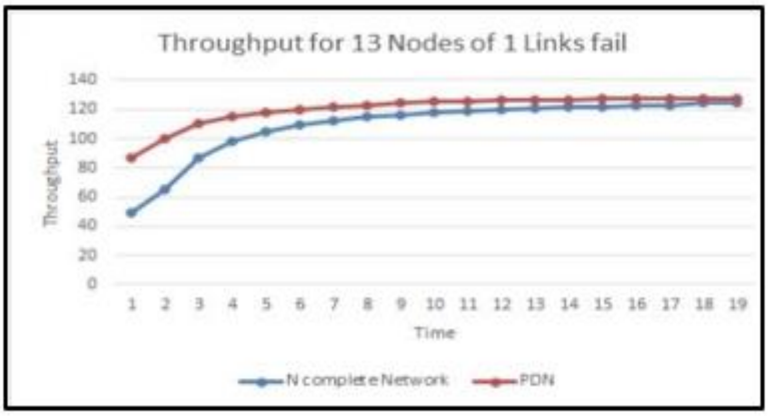

Figure 3: Result of Throughput for 13 Nodes of 1 Link fail

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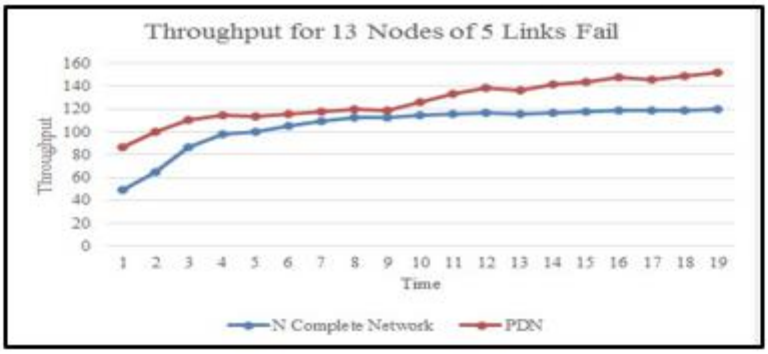

Figure 4: Result of Throughput for 13 Nodes of 5 Link fail

- **Packet Loss**

The observed data in Table 2 indicates that the N Complete Network has a higher proportion of packet loss compared to the Perfect Difference Network as the number of failed connections increases. The packet loss percentage for a single link failure in PDN with 7 and 13 nodes is minimal, about 0.03%.

Table 2 No of Packet Loss for PDN and N Complete Network

Percentages of Packet Loss				
	7 Nodes		13 Nodes	
	1 Link Fail	5 Links Fail	1 Link Fail	5 Links Fail
N Complete Network	0.10%	0.20%	0.12%	0.24%
PDN	0.02%	0.10%	0.01%	0.15%

V. CONCLUSION

In conclusion, Perfect Difference Networks and Mesh Architectures represent two distinct approaches to network design, each offering unique advantages when it comes to throughput and packet loss. Perfect Difference Networks excel in applications where high throughput and low packet loss are paramount, making them ideal for data-intensive and time-critical tasks. In contrast, Mesh Architectures prioritize fault tolerance and adaptability, minimizing packet loss in dynamic and unpredictable scenarios.

The choice between these architectures ultimately depends on the specific requirements of the application, and in some cases, a hybrid approach may be the most effective solution. As technology continues to advance, ongoing research and development will further optimize these network paradigms to meet the evolving demands of our interconnected world. By understanding the strengths and weaknesses of both Perfect Difference Networks and Mesh Architectures, we can make informed decisions on how best to harness their capabilities to shape the future of networking technology across various industries and applications.

REFERENCES

1. Abd, Mt & Fareed, Hamza & Alsaqour, Raed. (2016). Performance analysis of reactive routing protocols in mobile ad hoc network using NS2. 11. 4267-4271.

2. Accha, Venu & hak gupta, Sindhu. (2018). Performance analysis of Wireless Sensor Network MAC protocols using NS-2. 859-862. 10.1109/GUCON.2018.8674996.

3. Anad, Maan & Alsaleem, Naors & Zakar, Nawfal. (2018). Network Performance Analysis Based on Network Simulator NS-2.. Ibn AL- Haitham Journal For Pure and Applied Science. 31. 222. 10.30526/31.2.1951.

4. D., Diana & A., Rajeswari. (2020). Simulation and Performance Analysis of CIT College Campus Network for Realistic Traffic Scenarios using NETSIM. Procedia Computer Science. 171. 2635-2644. 10.1016/j.procs.2020.04.286.

5. Ikeda, Makoto & Kulla, Elis & Hiyama, Masahiro & Barolli, Leonard & Ikeda, M & Barolli, Admir & Barolli, L & Kulla, Elis & Hiyama, Á. (2012). Simulation and Performance Analysis of Ad-hoc Networks Using NS-2 and NS-3 Simulators. 114. 10.1007/978-94-007-2792-2_61.

6. Jaiswal, Rupesh & Lokhande, Shashikant & S.V., Mitkari. (2023). Performance Evaluation of Wireless Networks. 7. PP. 1237-1242.

7. Ramesh, Chithrupa & Sandberg, Henrik & Johansson, Karl. (2014). Performance Analysis of a Network of Event-Based Systems. IEEE Transactions on Automatic Control. 61. 10.1109/TAC.2016.2523422.

8. S M, Dilip Kumar & J, Shilpa & S, Shruthi & Kumar, Hemanth & Kumar, Vijaya. (2009). Performance Analysis and Comparison of MANET Routing Protocols with NS-2.

9. Yadav, Rakesh & Bhardwaj, Manish & Pandey, Sachi. (2011). Performance Analysis of Routing Protocols Using Different Environment in MANET. International Journal of Scientific and Engineering Research. 42-45.

10. Yeh, P.-C & Stark, Wayne & Zummo, Salam. (2008). Performance Analysis of Wireless Networks With Directional Antennas. Vehicular Technology, IEEE Transactions on. 57. 3187 - 3199. 10.1109/TVT.2008.917223.