Simulation And Analysis Of Star Topology Using NS2 And Cisco Packet Tracer

AMRITHA P[1], SURANYA DAS M S[2]
[1, 2] Dept of Computer Science and Engineering
[1, 2] Government Engineering College, Wayanad Kerala, India
A. P. J. Abdul Kalam Technological University

Abstract- *The star topology is a fundamental network architecture widely adopted for its simplicity, centralized management, and ease of troubleshooting. In this paper, we present a comprehensive simulation and analysis of the star topology using NS2 (Network Simulator 2) and Cisco Packet Tracer to evaluate its performance, reliability, and scalability in modern networks. The implementation involves connecting multiple nodes (PCs, servers) to a central hub or switch, forming a star-shaped structure. Using NS2, we analyze critical performance metrics such as latency, throughput, packet delivery ratio (PDR), and jitter under varying traffic loads. Additionally, Cisco Packet Tracer is employed to model real-world scenarios, including link failures, congestion control, and dynamic routing protocols (e.g., RIP, OSPF), providing a hands-on understanding of fault tolerance and network recovery. Challenges like single point failure (hub dependency) are also examined, with proposed mitigation strategies, such as redundant hubs or hybrid topologies. This study serves as a practical guide for network designers and educators, using NS2 for quantitative analysis and Packet Tracer for visual experimentation to optimize star-based networks for diverse applications.*

Keywords- Star topology, NS2, Cisco Packet Tracer, network simulation, latency, throughput, fault tolerance.

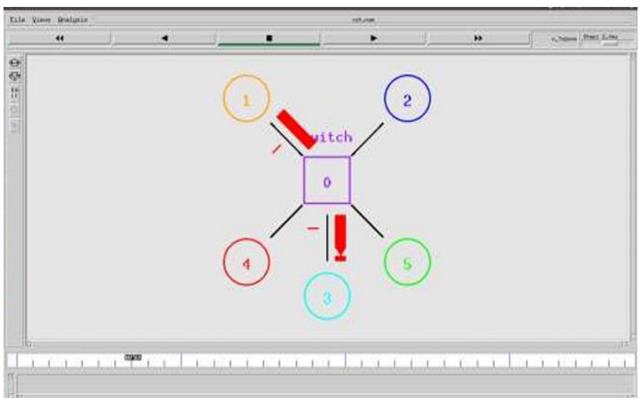
I. INTRODUCTION

Computer networks have become an indispensable part of modern communication systems, enabling seamless interaction, data transfer, and resource sharing among devices across different geographical locations. They support a wide range of applications, from business operations and education to health care, research, and social interaction, thereby forming the backbone of today’s digital world. The design of a computer network largely depends on its topology, which determines the structure of connections and the flow of data between nodes. Commonly used topologies include bus, ring, mesh, star, and hybrid. The bus topology, while simple and cost effective, suffers from single-point failures and limited scalability. The ring topology provides equal access but is highly vulnerable to link failures. Mesh topology offers robustness and fault tolerance but is expensive and complex due to the high number of connections required. Hybrid topology, as a combination of different designs, provides flexibility andscalability but may be difficult to manage. Among these, the star topology has emerged as one of the most widely adopted due to its simplicity, efficiency, and adaptability. In a star network, all nodes are connected to a central hub or switch, which manages communication, making it easier to isolate faults, scale the network, and maintain overall efficiency. The failure of a single device does not affect the rest of the network, and additional devices can be added without disrupting the system. These features make star topology the preferred choice for both small and large-scale networks, especially in environments relying on Ethernet and wireless technologies. However, to truly understand the performance of such topologies beyond theoretical analysis, simulationbased approaches are essential. Network simulation tools such as NS2 and Cisco Packet Tracer provide a cost-effective and controlled platform to model, analyze, and evaluate network behavior under different conditions. They enable researchers to study parameters such as latency, throughput, packet loss, and fault tolerance, which are critical for real-world deployment. Motivated by this, the present study focuses on simulating and analyzing star topology using NS2 and Cisco Packet Tracer, with the objective of evaluating its communication efficiency, scalability, and reliability. The insights gained from this work aim to highlight the strengths and limitations of star topology, thereby contributing to improved network design and practical implementation strategies.

II. IMPLEMENTATION OF STARTOPOLOGY

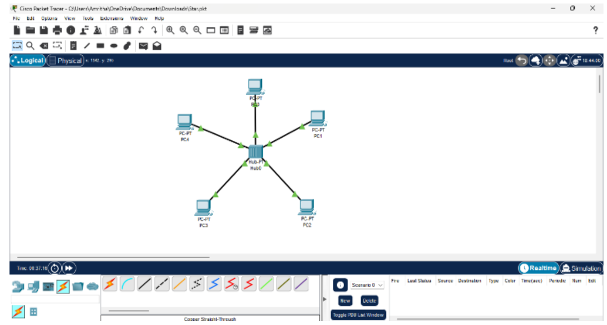
A. NS2

In order to study the performance of star topology, the network was implemented and simulated using the NS2 (Network Simulator 2) environment. The topology consists of a central switch node connected to multiple end devices (nodes 1, 2, 3, 4, and 5), as illustrated in Figure 1. The central node (labeled as node 0) functions as the switch, managing all communication between devices in the network. Each end device is connected directly to the switch, ensuring that data transmission between any two nodes passes through the central hub. This configuration highlights the core principle of startopology, where the switch plays a vital role in controlling traffic flow and isolating faults. In the simulation, red markers are used to indicate active communication paths, while nodes are shown exchanging data packets through the switch. The implementation in NS2 enables observation of packet flow, throughput, and fault handling, thereby providing valuable insights into the efficiency and reliability of star topology. By simulating such a setup, it becomes possible to analyze how star topology performs under different network conditions without the need for physical hardware, thus validating its suitability for practical applications.



B. CISCO-PACKET TRACER

The star topology was also implemented using Cisco Packet Tracer, a widely used network simulation tool for designing and testing computer networks. In this setup, a central hub (Hub0) acts as the core device, with five end systems (PC0, PC1, PC2, PC3, and PC4) connected to it using copper straight-through cables, as shown in Figure 2. The hub ensures that all communication between devices passes through the central node, thereby demonstrating the fundamental principle of star topology. Each PC can communicate with any other PC in the network, but the transmission is always routed via the hub, which broadcasts the signals to all connected devices. This setup makes it easier to visualize how data travels across the network and highlights the importance of the central hub in controlling communication. Cisco Packet Tracer provides both real-time and simulation modes, which allow observation of packet flow, testing of connectivity, and analysis of fault tolerance within the star configuration. By using Packet Tracer, the reliability, scalability, and efficiency of the star topology can be examined in a virtual environment, providing practical insights into its suitability for real-world networking applications.



III. LITERATURE REVIEW

Early work on local-area network design established how physical topologies shape reliability, latency, and manage ability, with the star layout consistently favored for small to-medium LANs due to centralized control and straightforward fault isolation. Research comparing canonical topologies Fig. 2. Star Topology Implementation in packet tracer (bus, ring, mesh, star, and hybrids) reports that star deployments simplify address learning and traffic concentration at a hub/switch, reducing collision domains in modern Ethernet and easing incremental growth. Studies also note the tradeoff: the central device is a potential bottleneck or single point of failure unless redundancy is introduced. Subsequent analyses investigate quality-of-service (QoS) under varying loads, showing that in switched stars, per-link contention is minimized and end-to-end delay remains predictable at moderate utilization, while saturation first appears at the uplinks to the switch rather than at edge links. Energy-aware networking work further highlights that port-level power management on switches can lower consumption without materially impacting throughput in lightly loaded star LANs. A substantial body of research uses NS2 to study topology dependent performance because it allows fine-grained control of protocol stacks, traffic models, and queueing disciplines. Typical NS2 studies model star topologies with CBR/UDP and FTP/TCP sources to measure throughput, packet delivery ratio (PDR), delay, and jitter under controlled variations of link rates, buffer sizes, and active queue management (e.g., DropTail vs. RED). These works consistently show that (i) increasing switch buffer capacity lowers loss but can inflate delay; (ii) TCP goodput in a star benefits from per-flow isolation on separate access links; and (iii) bursty traffic patterns stress the central queue, making queue policy a dominant factor in delay/jitter. Extensions include star-based WLANs (AP centered stars) where NS2 modules demonstrate how MAC contention and hidden nodes alter delay distribution compared with wired stars, and resilience studies where link/node failures are injected to quantify recovery behavior and the impact of rerouting timers. In parallel, Cisco Packet Tracer has been widely adopted in education and pre-deployment simulation for star networks because it provides a device-centric graphical environment, protocol wizards, and step-through packet animation. The literature in computing education reports that Packet Tracer improves conceptual understanding of addressing, VLANs on access switches, and inter-VLAN routing in star-like campus segments. Classroom studies show gains in students' diagnostic skills—particularly around cable selection, portconfiguration, and interpreting ARP/ICMP flows—when star labs are performed in both real-time and event-driven simulation modes. Applied case studies use Packet Tracer to prototype small enterprise stars with DHCP, DNS, and ACLs, emphasizing configuration correctness, fault localization (e.g., shut/no shutdown, speed/duplex mismatches), and visual tracing of end-to-end paths before hardware purchase. Comparative investigations across topologies within a single tool (either NS2 or Packet Tracer) are common: they contrast star with bus/ring/mesh for metrics like delay, loss, and scalability under node churn. However, comparisons across tools are rare. NS2 studies excel at protocol-level fidelity (custom queueing, stochastic traffic, scripted failures) but offer less emphasis on vendor-style configuration workflows. Packet Tracer studies, conversely, foreground operational realism (device CLIs, interface states, cabling choices) and learner outcomes but typically report fewer low-level performance statistics or stochastic repetitions. As a result, the community lacks systematic evidence about how conclusions drawn in one simulator translate to the other for the same star scenario. A smaller stream of work evaluates pedagogical outcomes rather than packet-level metrics. These papers argue that star topology is an ideal scaffold for novices because it externalizes core concepts—default gateways, L2/L3 demarcation, and centralized forwarding—while keeping path reasoning simple ("host → switch → host"). When Packet Tracer is paired with formal measurement (e.g., ping/iperf timing) or with scripted NS2 runs, students demonstrate better transfer from simulation to physical labs. Yet these studies typically treat the tools as complementary without quantifying where they agree or diverge on performance outputs. Gap and motivation. Across the surveyed work, there is no focused, side-by-side comparative analysis of a star topology implemented in both NS2 and Cisco Packet Tracer using identical scenarios, traffic profiles, and evaluation metrics, nor is there a reconciliation of differences in reported throughput, delay, jitter, and loss attributable to simulator assumptions (e.g., queue models, timing granularity, or device behavior abstractions). This gap matters because educators and practitioners routinely move between high-fidelity research simulators and vendor-centric teaching tools. Positioning of this study. To address this, the present work implements the same star topology in NS2 and Packet Tracer, standardizes link rates, buffer sizes, and traffic pat terns (TCP/UDP, CBR/Poisson), and evaluates a shared metric suite (throughput, end-to-end delay, jitter, and PDR) under controlled load and failure injections. By aligning scenarios and reporting effect sizes for cross-tool differences, the study provides (i) validated insights into star-topology performance, (ii) guidance on when each simulator is appropriate, and (iii) a reproducible benchmark others can extend.

IV. METHODOLOGY

To evaluate the performance of star topology, two widely used network simulation platforms were employed: NS2 (Net • NS2 is an open-source, discrete event-driven simulator designed for networking research. It supports simulation of wired and wireless networks, TCP/UDP traffic, queueing models, and routing protocols. In this study, NS2 was used along with TCL (Tool Command Language) scripting to define the network configuration, generate traffic, and set performance parameters. Simulation outputs were stored in trace files, which were later analyzed to calculate metrics such as throughput, packet delivery ratio, and end-to-end delay. The Network Animator (NAM) tool was also utilized to visualize the star topology setup and observe the packet flow dynamically. • Cisco Packet Tracer is a GUI-based network simulation tool developed by Cisco. It provides an interactive environment for building and configuring networks using virtual devices such as PCs, switches, hubs, and routers. In this study, Packet Tracer was used to design the star topology by connecting multiple end devices to a central hub/switch using copper straight-through cables. The tool's real-time mode allowed configuration and immediate testing of connectivity, while the simulation mode enabled step-by-step observation of packet transfer and error checking. This combination made Packet Tracer suitable for evaluating configuration aspects and device level behavior in the star topology. The star topology in this study was designed with a central hub or switch serving as the core device, while multiple end systems were connected to it via point-to-point links. All communication between nodes was routed through the central device, reflecting the fundamental nature of star networks. The system design included a central node for managing traffic flow, end devices functioning as hosts, and defined network parameters such as standard Ethernet bandwidths of 10 Mbps and 100 Mbps, traffic types including CBR over UDP, FTP over TCP, and VoIP streams, packet sizes ranging between 512 bytes and 1024 bytes, and routing protocols where Packet Tracer employed static routing while NS2 used default routing behavior. Topology visualization was achieved using NAM in NS2 and the logical workspace in Packet Tracer. To analyze performance, multiple simulation scenarios were conducted by varying node counts (5, 10, and 15) to study scalability, and by generating diverse traffic patterns to emulate real-world conditions. The performance metrics considered were throughput, end-to-end delay, packet delivery ratio (PDR), jitter, and fault tolerance under node or link failures. Through systematic variation of nodes, traffic, and packet sizes, the study enabled a comparative evaluation of star topology performance in NS2, which emphasizes research focused trace-based analysis, and Cisco Packet Tracer, which highlights GUI-based configuration and visualization.

V. RESULTS AND ANALYSIS

The simulation results for the star topology were collected and analyzed using both NS2 and Cisco Packet Tracer under varying scenarios of node count, traffic type, and packet size. Performance metrics such as throughput, end-to-end delay, packet delivery ratio (PDR), jitter, and fault tolerance were considered for comparison. Throughput: In both simulators, throughput initially increased as the number of nodes increased from 5 to 10, since more data flows were generated. However, beyond a certain point (15 nodes), throughput began to saturate due to congestion at the central switch. NS2 reported more precise throughput fluctuations, as it models queue sizes and packet drops in greater detail, while Packet Tracer showed smoother throughput values due to abstraction in traffic generation. Delay: End-to-end delay remained relatively low and stable with 5 and 10 nodes in both simulators, but it increased significantly at 15 nodes, particularly in NS2 where queuing delays and congestion effects were more prominent. Packet Tracer, on the other hand, reported less variation in delay because it emphasizes logical connectivity rather than packet level timing precision. Packet Delivery Ratio (PDR): Both simulators demonstrated high PDR values (close to 100%) under light and moderate loads. In NS2, PDR slightly dropped with heavier traffic loads and larger packet sizes due to queue overflow at the switch, whereas Packet Tracer maintained almost constant delivery, reflecting its simplified traffic handling. Jitter: For VoIP traffic, NS2 showed noticeable jitter when the number of nodes increased, as packet timing variations became more significant under congestion. Packet Tracer showed minimal jitter values, since it does not simulate stochastic packet inter-arrival variations as accurately as NS2. Fault Tolerance: In both simulators, the failure of a single node or link did not affect the overall functioning of the network, confirming the robustness of star topology. However, when the central switch failed, the entire network communication was disrupted, highlighting the inherent limitation of star networks. In general, the comparative results demonstrated that while NS2 provides more accurate and detailed performance insights into packet-level behavior, Cisco Packet Tracer excels in configuration testing and visual demonstration of communication f lows.

VI. DISCUSSION

The results reveal important trends in the behavior of the star topology under different conditions. The increase in through put with an increase in the number of nodes to a threshold can be explained by the higher number of active flows that efficiently utilize the available bandwidth. However, as the number of nodes grows beyond this threshold, congestion at the central switch becomes the bottleneck, leading to increased delays and reduced efficiency. This is particularly evident in NS2 due to its fine-grained modeling of queues, buffers, and traffic randomness. The pros of star topology highlighted in the simulations include simplicity in design, ease of scalability, and effective fault isolation, since failure of a single node does not disrupt the entire network. However, the main drawback remains the single point of failure in the central hub or switch, which, if compromised, leads to total network breakdown. This tradeoff between ease of management and vulnerability is consistent with the observations in both simulators. When comparing the tools, the differences in the results arise from the level of abstraction each tool provides. NS2, which is research-oriented, captures detailed aspects such as queueing, jitter, and stochastic delays, making it more suitable for protocol-level analysis and academic research. Cisco Packet Tracer, on the other hand, abstracts level details to provide a practical and educational perspective, emphasizing device configuration, logical connectivity, and visualization. This makes it particularly effective for teaching and training in networking fundamentals. From a practical point of view, the findings imply that the star topology remains a reliable and efficient design for small to medium-scale networks, such as office LANs,classrooms, and home networks. The comparative study further suggests that NS2 is better suited for researchers analyzing performance in complex traffic models, while Packet Tracer is ideal for students and practitioners who focus on device-level configuration and troubleshooting.

VII. CONCLUSION

This study presented a comparative analysis of star topology performance using NS2 and Cisco Packet Tracer. The simulations demonstrated that throughput increases with node count up to a certain limit, after which congestion at the central hub causes performance degradation. Delay and jitter were more accurately captured in NS2 due to its detailed modeling, while Packet Tracer provided consistent but less precise values due to its abstraction. Both simulators confirmed the robustness of star topology against individual node or link failures, though they also highlighted its vulnerability to central hub failure. The findings indicate that NS2 provides more accurate insights into the dynamic behavior of networks, making it highly suitable for research and protocol-level evaluation. Conversely, Cisco Packet Tracer is more effective as an educational tool, enabling learners to design, configure, and visualize networks in a user-friendly environment. Star topology, given its simplicity, scalability, and fault isolation, is particularly suitable for LAN environments, educational institutions, and small businesses, although larger deployments must mitigate the risk of central hub failure through redundancy.

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