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Implementation of Multi-Room Computer Laboratory Network Infrastructure Based on Star Topology in an Educational Environment

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A B S T R A C T

Reliable network infrastructure is essential to support digital-based learning activities in educational institutions, particularly in computer laboratories that require stable and simultaneous internet access for a large number of devices. This study aims to implement a multi-room computer laboratory network infrastructure consisting of 160 PCs distributed across four laboratory rooms, each containing 40 computers. The network architecture is designed using a star topology, where each PC connects to an access switch within its respective room, and all switches are connected to a central modem acting as the primary gateway and Dynamic Host Configuration Protocol (DHCP) server. The infrastructure follows a peer-to-peer model without centralized server deployment or bandwidth management configuration. The implementation process includes physical network installation, structured cabling, automatic IP configuration through DHCP, and connectivity testing to ensure proper communication and internet accessibility. The results show that all 160 PCs successfully obtained IP addresses without conflicts and were able to access the internet simultaneously under normal operating conditions. The star topology provided ease of installation, simplified troubleshooting, and effective fault isolation. These findings indicate that the implemented infrastructure operates reliably as a foundational network system and provides a baseline for future development, including network segmentation, bandwidth management, and centralized service integration.

INTRODUCTION

The rapid development of information technology has significantly transformed learning systems in educational environments, particularly through the utilization of computer laboratories as facilities for digital-based practical activities. The availability of stable and integrated network infrastructure is a crucial factor in supporting academic activities such as programming practicum sessions, network simulations, e-learning access, and computer-based examinations. Therefore, the design and implementation of computer networks in educational laboratories must be carried out systematically to accommodate high connectivity demands and simultaneous multi-user access [1,2].

In educational institutions with a large number of devices distributed across multiple laboratory rooms, network deployment presents specific challenges. Common issues include equitable connectivity distribution, management of numerous devices, internet access stability, and ease of network maintenance. Without proper infrastructure planning, networks may experience performance degradation, IP address conflicts, and difficulties in troubleshooting [3].

The star topology is one of the most widely used network models in Local Area Network (LAN) implementation due to its advantages in installation simplicity, fault isolation, and scalability. In this topology, each device is connected to a central device (switch), ensuring that a failure in one device does not directly affect others[4,5]. This model is considered suitable for computer laboratory environments that require stability and ease of physical network management.

This study discusses the implementation of network infrastructure across four computer laboratory rooms with a total of 160 PCs, where each room consists of 40 computers. All devices are connected to the internet using dynamic IP addressing through the Dynamic Host Configuration Protocol (DHCP) provided by a modem acting as the main gateway[6,7]. The implemented infrastructure follows a peer-to-peer model without centralized server deployment or bandwidth management, thus focusing on the fundamental stage of network infrastructure implementation.

The objective of this study is to describe the process of implementing a multi-room computer laboratory network infrastructure based on a star topology and to identify the resulting network characteristics and operational conditions. The findings are expected to serve as a baseline reference for future development toward a more structured network system, including network segmentation, bandwidth management, and the integration of local server services.

Thus, this study not only documents the technical implementation but also provides an evaluative foundation for developing a more scalable and well-managed educational network infrastructure.

METHOD

This study employed a network engineering approach to implement the computer laboratory network infrastructure. The methodology consisted of five main stages: requirement analysis, network design, physical installation, configuration, and testing.

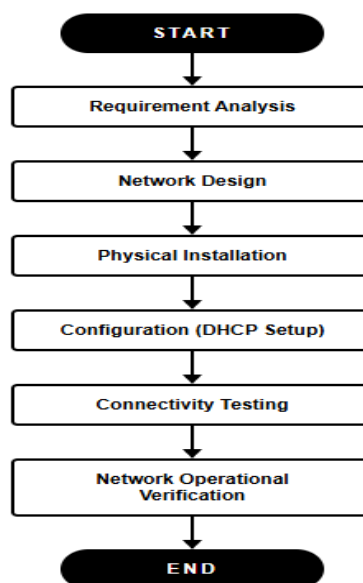


Figure 1. Flowchart of Implementation Process

Requirement Analysis

The initial stage involved identifying the operational requirements of the laboratory environment. The infrastructure was designed to support 160 PCs distributed across four laboratory rooms, with 40 computers in each room. All devices required simultaneous internet connectivity. The network was planned using a peer-to-peer model without centralized server deployment, bandwidth management, or network segmentation. IP address allocation was configured to be automatic using Dynamic Host Configuration Protocol (DHCP) provided by the central modem.

Table 1. Network Infrastructure Components

Component	Quantity	Function
PCs	160	Client devices
Access Switches	4	Room-level network distribution
Modem/Router	1	Gateway and DHCP server
UTP Cables	160+	Device interconnection

Network Design

The network architecture was designed using a star topology. In each laboratory room, all PCs were connected to an access switch serving as the central connection point. Each access switch was then connected to a central modem functioning as the main gateway and DHCP server. The design followed a flat network structure without VLAN implementation or subnet division. The modem handled IP address distribution and internet routing for all connected devices.

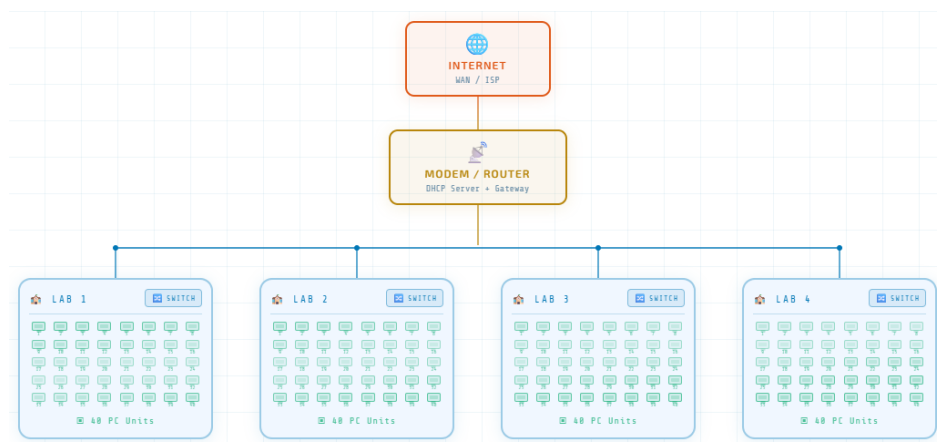


Figure 2. Network Topology of the Multi-Room Computer Laboratory

Physical Installation

The physical installation phase included structured cabling using Unshielded Twisted Pair (UTP) cables to connect each PC to the access switch in its respective room. Switches were positioned centrally within each laboratory to optimize cable management and reduce signal attenuation. All switches were interconnected to the modem through uplink ports to establish internet access.

Configuration

Network configuration was performed by enabling DHCP services on the modem and setting all PCs to obtain IP addresses automatically. No manual IP configuration was applied. The modem acted as the gateway and DNS forwarder for all connected devices.

Testing and Verification

Testing procedures were conducted to ensure proper network functionality. Connectivity tests included verifying IP address assignment, ping tests between devices within and across rooms, and internet access validation. The network was also observed under simultaneous usage conditions to assess operational stability.

RESULTS AND DISCUSSION

The implementation of the multi-room computer laboratory network infrastructure was successfully completed according to the planned design. The network consists of 160 PCs distributed across four laboratory rooms, with 40 computers in each room. Each room is connected using a star topology in which all PCs are linked to an access switch, and all switches are connected to a central modem functioning as the main gateway and DHCP server. Following the configuration phase, all devices were set to obtain IP addresses automatically through DHCP. Testing results showed that all 160 PCs

successfully received IP addresses without duplication or conflict. The DHCP service provided stable IP distribution across the entire network without requiring manual configuration.

Table 2. Comparison of Network Performance Conditions

Laboratory	Avg Latency (Normal)	Avg Latency (Simultaneous)	Latency Increase (ms)	Packet Loss
Lab 1	20 ms	28 ms	+8 ms	0%
Lab 2	19 ms	27 ms	+8 ms	0%
Lab 3	21 ms	29 ms	+8 ms	0%
Lab 4	21 ms	30 ms	+9 ms	0%

Connectivity testing was conducted within individual laboratory rooms and across different rooms. Ping tests confirmed successful communication between devices within the same room as well as between rooms. Internet access testing demonstrated that all computers were able to access external websites simultaneously under normal operating conditions. During simultaneous usage, the network maintained stable connectivity without disconnections. The star topology allowed isolated fault detection, meaning that when a single device was disconnected, it did not affect other connected devices. Overall, the implemented infrastructure functioned properly as a foundational network system supporting practical learning activities.

Table 3. Internet Connectivity Test Results from Each Laboratory Room

Laboratory Room	Test Destination	Packets Sent	Packets Received	Packet Loss	Minimum Latency (ms)	Maximum Latency (ms)	Average Latency (ms)	Status
Lab 1	google.com	4	4	0%	18	22	20	Stable
Lab 2	google.com	4	4	0%	17	21	19	Stable
Lab 3	google.com	4	4	0%	19	23	21	Stable
Lab 4	google.com	4	4	0%	18	24	21	Stable

Internet connectivity testing was performed from each laboratory room using ICMP echo requests to a public domain. The results indicate 0% packet loss across all laboratories, with average latency ranging between 18–21 ms. These findings confirm stable external connectivity and consistent internet performance under normal operating conditions.

The implementation results demonstrate that the star-topology-based infrastructure is capable of supporting 160 PCs distributed across four laboratory rooms with stable connectivity under normal operating conditions. The absence of packet loss during both single-device and simultaneous usage testing indicates that the physical infrastructure and switching capacity are sufficient to handle the current traffic load. This confirms that star topology remains an effective and practical solution for medium-scale educational laboratory environments.

However, performance analysis reveals a measurable increase in average latency during simultaneous usage conditions. The observed latency increase of approximately 8–9 ms across all laboratories indicates the impact of aggregated traffic on the shared gateway and internet link. Although the increase remains within acceptable limits for general academic activities such as web browsing, e-learning access, and online assessments, it highlights the limitations of a flat network architecture without traffic management mechanisms.

The reliance on a single modem functioning as both gateway and DHCP server introduces a centralized dependency point. While this simplifies configuration and reduces administrative complexity, it also creates potential scalability and reliability concerns. As the number of users or bandwidth-intensive applications increases, the absence of bandwidth management and traffic prioritization may result in congestion and uneven resource distribution.

Furthermore, since all devices operate within the same broadcast domain, the current design does not provide traffic isolation between laboratory rooms. In larger deployments, this could lead to increased broadcast traffic and potential performance degradation. Implementing logical segmentation mechanisms such as VLANs could improve traffic control, enhance security, and optimize performance distribution across rooms.

Despite these limitations, the implemented infrastructure successfully fulfills its primary objective as a foundational network system for educational laboratory activities. The results establish a clear performance baseline that can be used for future comparative studies involving network segmentation, bandwidth control implementation, or centralized service integration. Thus, while the current design is operationally adequate, its long-term scalability would benefit from structured network management enhancements.

CONCLUSION

This study successfully implemented a multi-room computer laboratory network infrastructure based on a star topology in an educational environment, supporting 160 client devices across four laboratories with stable connectivity and zero packet loss under both normal and simultaneous usage conditions. Although a moderate increase in latency was observed during peak simultaneous access, the delay remained within acceptable limits for academic activities, indicating that the proposed design is reliable and operationally adequate for medium-scale deployments. Nevertheless, the centralized gateway architecture and lack of traffic segmentation may limit scalability in future expansions; therefore, enhancements such as VLAN implementation and bandwidth management are recommended. Overall, the study provides a practical implementation reference and performance baseline for structured laboratory network development in educational institutions.

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