**A Laboratory Manual for**

Computer Networks

**(3150710)**

**B.E. Semester 5**

**(Computer Engineering)**

****



**Directorate of Technical Education, Gandhinagar, Gujarat**

**Vishwakarma Government Engineering College Chandkheda**

**Computer Engineering Department**

**Certificate**



***This is to certify that***

***Mr./Ms. Patel Abhi Yogeshkumar of class Computer Engineering Division G, Enrollment No. 220170107079 Has satisfactorily completed his/her term work in Computer Networks Subject for the term ending in 2024-25.***

***Date:-***

**Signature of Teacher Head of Department**

**Preface**

Main motto of any laboratory/practical/field work is for enhancing required skills as well as creating ability amongst students to solve real time problem by developing relevant competencies in psychomotor domain. By keeping in view, GTU has designed competency focused outcome-based curriculum for engineering degree programs where sufficient weightage is given to practical work. It shows importance of enhancement of skills amongst the students and it pays attention to utilize every second of time allotted for practical amongst students, instructors and faculty members to achieve relevant outcomes by performing the experiments rather than having merely study type experiments. It is must for effective implementation of competency focused outcome-based curriculum that every practical is keenly designed to serve as a tool to develop and enhance relevant competency required by the various industry among every student. These psychomotor skills are very difficult to develop through traditional chalk and board content delivery method in the classroom. Accordingly, this lab manual is designed to focus on the industry defined relevant outcomes, rather than old practice of conducting practical to prove concept and theory.

By using this lab manual students can go through the relevant theory and procedure in advance before the actual performance which creates an interest and students can have basic idea prior to performance. This in turn enhances pre-determined outcomes amongst students. Each experiment in this manual begins with competency, industry relevant skills, course outcomes as well as practical outcomes (objectives). The students will also achieve safety and necessary precautions to be taken while performing practical.

This manual also provides guidelines to faculty members to facilitate student centric lab activities through each experiment by arranging and managing necessary resources in order that the students follow the procedures with required safety and necessary precautions to achieve the outcomes. It also gives an idea that how students will be assessed by providing rubrics.

Utmost care has been taken while preparing this lab manual however always there is chances of improvement. Therefore, we welcome constructive suggestions for improvement and removal of errors if any.

**Practical – Course Outcome matrix**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Course Outcomes (COs):**   1. Familiarize with the basic taxonomy - terminologies used in networking and the layered architecture of computer networks. 2. Explain work of layers of OSI and TCP/IP model according to how they can be used to assist in network design and implementation. 3. Examine work of protocols of TCP/IP protocol suite. 4. Design network architecture, assign IP addressing and applyvarious networking algorithms 5. Implement different types of network using different tools and simulators. | | | | | | | |
| **Sr. No.** | **Objective(s) of Experiment** | **Platform to be used** | **CO**  **1** | **CO**  **2** | **CO**  **3** | **CO**  **4** | **CO**  **5** | |
| 1. | Study of different network devices in detail | Network Devices | **√** |  |  |  |  | |
| 2. | Study of different types of network cables and practically implement the cross-wired cable and straight through cable using clamping tool. | Cables, Clamping tool, Connectors | **√** |  |  |  | **√** | |
| 3. | Perform basic network command and Network configuration commands | Computer | **√** |  |  |  |  | |
| 4. | Implement different LAN topologies using Network Simulator | Cisco Packet tracer |  |  |  |  | **√** | |
| 5. | Implement the concept of VLAN using Network Simulator. | Cisco Packet tracer |  |  |  |  | **√** | |
| 6. | Implement the concept of static routing. | Cisco Packet tracer |  |  |  | **√** |  | |
| 7. | Implement the concept of dynamic routing (RIP, OSPF, BGP). | Cisco Packet tracer |  |  |  | **√** |  | |
| 8. | To Simulate Web Server configuration using Cisco Packet tracer emulator. | Cisco Packet tracer |  | **√** |  |  |  | |
| 9. | To Simulate Email Server configuration using Cisco Packet tracer emulator. | Cisco Packet tracer |  | **√** |  |  |  | |
| 10. | Packet capture and header analysis by wire-shark (TCP,UDP,IP) | Wireshark |  |  | **√** |  |  | |

**Industry Relevant Skills**

The following industry relevant competencies are expected to be developed in the student by undertaking the practical work of this laboratory.

1. Identify, connect various network devices.
2. Prepare LAN cable
3. Configuration network and understand protocols behaviors on simulator.

**Guidelines for Faculty members**

1. Teacher should provide the guideline with demonstration of practical to the students with all features.
2. Teacher shall explain basic concepts/theory related to the experiment to the students before starting of each practical
3. Involve all the students in performance of each experiment.
4. Teacher is expected to share the skills and competencies to be developed in the students and ensure that the respective skills and competencies are developed in the students after the completion of the experimentation.
5. Teachers should give opportunity to students for hands-on experience after the demonstration.
6. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected from the students by concerned industry.
7. Give practical assignment and assess the performance of students based on task assigned to check whether it is as per the instructions or not.
8. Teacher is expected to refer complete curriculum of the course and follow the guidelines for implementation.

**Instructions for Students**

1. Students are expected to carefully listen to all the theory classes delivered by the faculty members and understand the COs, content of the course, teaching and examination scheme, skill set to be developed etc.
2. Students shall organize the work in the group and make record of all observations.
3. Students shall develop maintenance skill as expected by industries.
4. Student shall attempt to develop related hand-on skills and build confidence.
5. Student shall develop the habits of evolving more ideas, innovations, skills etc. apart from those included in scope of manual.
6. Student shall refer technical magazines and data books.
7. Student should develop a habit of submitting the experimentation work as per the schedule and s/he should be well prepared for the same.

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**(Progressive Assessment Sheet)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Objective(s) of Experiment** | **Page No.** | **Date of performance** | **Date of submission** | **Assessment**  **Marks** | **Sign. of**  **Teacher with date** | **Remarks** |
| 1. | Study of different network devices in detail |  |  |  |  |  |  |
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| 9. | To Simulate Email Server configuration using Cisco Packet tracer emulator. |  |  |  |  |  |  |
| 10. | Packet capture and header analysis by wire-shark (TCP,UDP,IP) |  |  |  |  |  |  |
| Total | | | | |  |  |  |

**Experiment No: 1**

**AIM:** **Study of different Network devices**

**Date:**

**Competency and Practical Skills:** Identify, connect various network devices.

**Relevant CO: CO1:** Familiarize with the basic taxonomy - terminologies used in networking and the layered architecture of computer networks

**Objectives:** (a) to observe various network devices

(b) Find out usage of each in different case with advantage and disadvantage

(c) Connect devices to establish network of two or more devices

**Equipment/Instruments:** Desktop/laptop, Hub, Switch, Router, Bridge, Gateway, Modem, Repeater, NIC

**Theory:**

Ref: http://swayam.gov.in/

Computer Networking- A Top-Down approach (6th edition), Kurose and Ross, Pearson

**Observations: (Give detailed answer of each question with required figure)**

1. **Hub:** 
   * 1. What is hub?
     2. Features of Hub:
     3. Applications of Hub:
     4. Types of Hub:

A **Hub** is a basic networking device used to connect multiple Ethernet devices in a local area network (LAN). It operates at the physical layer (Layer 1) of the OSI model and is primarily used to transmit data packets to all connected devices, regardless of the intended recipient. Hubs are simplistic devices that do not manage or filter traffic, making them less intelligent compared to switches and routers.

**Features of a Hub:**

1. **Broadcast Transmission:** A hub transmits data packets to all connected devices, which can lead to unnecessary network traffic and potential collisions.
2. **Simple Device:** Hubs are straightforward and easy to use, with no need for configuration.
3. **Operates at Layer 1:** Being a Layer 1 device, hubs do not process any data, ensuring that all packets are simply repeated to other ports.
4. **No Traffic Filtering:** Hubs do not filter traffic, which means that every device connected to the hub receives all the data packets sent over the network.
5. **Half-Duplex Communication:** Hubs typically support half-duplex communication, meaning devices can either send or receive data at one time, but not both simultaneously.
6. **Limited Security:** Due to the broadcast nature of data transmission, hubs do not offer any security features for data filtering or protection.

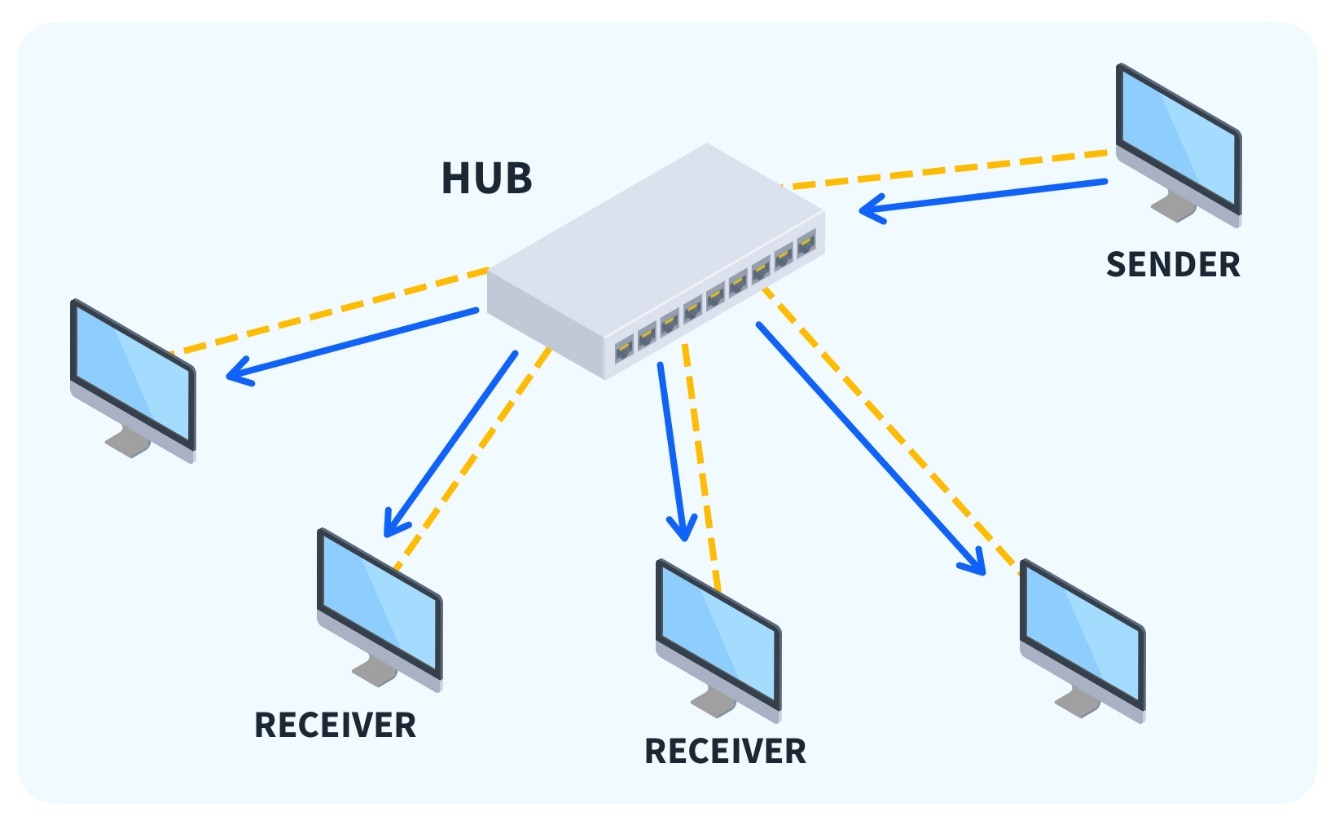
**Applications of a Hub:**

1. **Small Home Networks:** Hubs are suitable for small home or office networks where simplicity and ease of use are prioritized over performance.
2. **Legacy Systems:** In environments where older networking hardware is still in use, hubs may be employed due to compatibility.
3. **Network Monitoring:** Hubs can be used in network monitoring setups where data needs to be captured for analysis since they broadcast all packets to all connected devices.
4. **Device Connectivity:** Hubs can serve as a simple way to connect multiple devices in a local area network when advanced network management is not required.

**Types of Hubs:**

* **Passive Hub:**
  + Functionality: Simply connects the various devices on the network and passes the electrical signals to other devices without any amplification or regeneration.
  + Features: Does not require a power source; does not strengthen or clean the signal.
  + Use Case: Suitable for small networks where the distance between devices is short.
* **Active Hub:**
  + Functionality: Amplifies and regenerates the signal before broadcasting it to the network, ensuring the data can travel longer distances without degradation.
  + Features: Requires a power source; provides better performance than passive hubs.
  + Use Case: Used in larger networks where the signal needs to be strengthened to reach all devices.
* **Intelligent Hub:**
  + Functionality: Includes additional features such as remote management capabilities, diagnostics, and monitoring.
  + Features: Provides some level of network management and can help in troubleshooting network issues.
  + Use Case: Used in more complex networks where monitoring and management of the network is essential.

**Figure:**



1. **Router**

A **router** is a networking device that forwards data packets between computer networks, directing traffic on the Internet. It operates at the network layer (Layer 3) of the OSI model and uses IP addresses to determine the best path for forwarding the packets. Routers connect multiple networks together, such as connecting a local area network (LAN) to the Internet.

**Features of a Router:**

* **Traffic Direction**: Routers analysed incoming data packets and determine the best path for them to reach their destination.
* **Network Layer Operations**: Operates at the network layer, handling IP addresses and routing protocols.
* **Security**: Provides features such as firewalls, VPNs, and filtering to secure the network.
* **Dynamic Routing**: Supports routing protocols like OSPF, BGP, and RIP to dynamically adjust routes based on current network conditions.
* **Static Routing**: Allows manual configuration of routes for predictable and stable network performance.
* **Network Address Translation (NAT)**: Enables multiple devices on a local network to share a single public IP address.
* **Quality of Service (QoS)**: Manages network traffic to ensure performance for critical applications and services.
* **Wireless Connectivity**: Many modern routers include Wi-Fi capabilities to provide wireless network access.

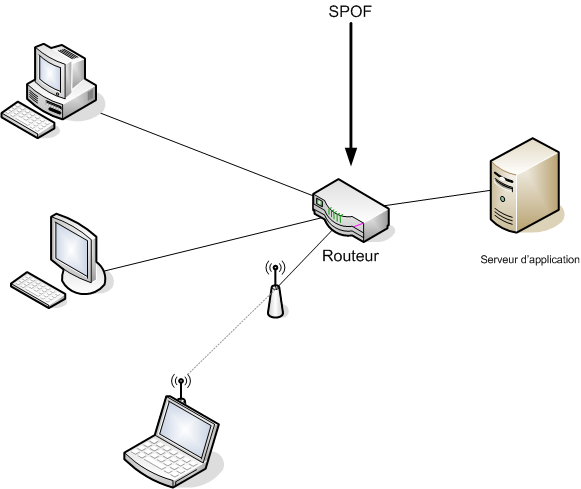
**Applications of a Router:**

* **Internet Connectivity**: Connects home and office networks to the Internet.
* **Inter-Network Communication**: Connects different networks, such as LANs, WANs, and MANs, allowing communication between them.
* **Network Segmentation**: Divides large networks into smaller, more manageable segments, improving performance and security.
* **Remote Access**: Provides VPN services for secure remote access to the network.
* **Load Balancing**: Distributes network traffic across multiple paths or servers to optimize performance.
* **Network Management**: Enables monitoring and management of network traffic, security, and performance.

**Types of Routers:**

* **Core Router**:
  + **Functionality**: Operates within the core of a network, handling large amounts of data and directing traffic within the network backbone.
  + **Features**: High-speed processing, multiple high-bandwidth interfaces, advanced routing protocols.
  + **Use Case**: Used by ISPs and large enterprises to manage the primary network infrastructure.
* **Edge Router**:
  + **Functionality**: Connects an internal network to external networks, such as the Internet or other WANs.
  + **Features**: Supports a variety of WAN technologies, interfaces for external connections, and security features.
  + **Use Case**: Placed at the edge of a network to manage traffic entering and exiting the network.
* **Home Router**:
  + **Functionality**: Provides Internet access to devices within a home or small office network.
  + **Features**: Integrated Wi-Fi, NAT, DHCP server, basic security features.
  + **Use Case**: Commonly used in residential and small business environments to connect devices to the Internet.
* **Wireless Router**:
  + **Functionality**: Combines the features of a router with a wireless access point.
  + **Features**: Wi-Fi connectivity, multiple SSIDs, guest networks, security protocols like WPA3.
  + **Use Case**: Used in homes, offices, and public places to provide wireless Internet access.
* **Virtual Router**:
  + **Functionality**: Runs as software on a server or in a virtualized environment, providing routing functions without dedicated hardware.
  + **Features**: Scalability, flexibility, cost-effectiveness, integration with virtual networks.
  + **Use Case**: Deployed in data centres, cloud environments, and for virtualized network functions.
* **Branch Router**:
  + **Functionality**: Connects branch offices to the main corporate network.
  + **Features**: VPN support, WAN optimization, security features, local breakout for Internet traffic.
  + **Use Case**: Used by enterprises to connect remote or branch offices to the central network.

**Figure**:



1. **Bridge**

A **bridge** is a networking device that connects and filters traffic between two or more network segments, typically within a local area network (LAN). Operating at the data link layer (Layer 2) of the OSI model, bridges use MAC addresses to forward data to the correct destination, reducing network traffic and collisions.

**Features of a Bridge:**

1. **MAC Address Filtering**: Bridges use MAC addresses to determine the destination of frames and forward them to the appropriate segment.
2. **Traffic Reduction**: By dividing a network into segments, bridges reduce overall traffic and minimize collisions.
3. **Transparent Operation**: Bridges operate transparently to connected devices, meaning no special configuration is needed on the end devices.
4. **Learning and Forwarding**: Bridges learn the MAC addresses of devices on each network segment and build a forwarding table to efficiently direct traffic.
5. **Loop Prevention**: Modern bridges use protocols like Spanning Tree Protocol (STP) to prevent network loops, ensuring a loop-free network topology.
6. **Store-and-Forward**: Bridges typically use the store-and-forward method, where they receive the entire frame before forwarding it, allowing error checking.

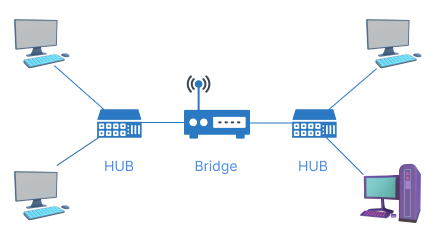
**Applications of a Bridge:**

1. **Network Segmentation**: Bridges are used to divide large networks into smaller, more manageable segments, improving performance and reducing collisions.
2. **Traffic Isolation**: Bridges can isolate network traffic between segments, ensuring that local traffic remains within its segment and does not burden the entire network.
3. **Extending Networks**: Bridges can connect two separate LANs, extending the reach of the network without requiring significant changes to the existing infrastructure.
4. **Legacy Network Integration**: Bridges can connect different types of network segments, such as Ethernet and Token Ring, allowing for the integration of older and newer network technologies.
5. **Improved Security**: By segmenting the network, bridges can help contain broadcast traffic and reduce the spread of network attacks within segments.

**Types of Bridges:**

1. **Transparent Bridge**:
   * **Functionality**: Operates transparently to network devices, learning MAC addresses and building a forwarding table without requiring any configuration.
   * **Features**: Uses MAC addresses to forward frames, operates using the store-and-forward method, and can implement STP.
   * **Use Case**: Commonly used in Ethernet networks to segment and manage traffic without requiring changes to network devices.
2. **Source-Route Bridge**:
   * **Functionality**: Used primarily in Token Ring networks, this bridge uses source routing information contained in frames to determine the path to the destination.
   * **Features**: Relies on the sending device to include routing information in the frame, can handle complex topologies.
   * **Use Case**: Suitable for Token Ring networks and environments where source routing is preferred.
3. **Translational Bridge**:
   * **Functionality**: Connects different types of network segments, such as Ethernet to Token Ring or FDDI to Ethernet.
   * **Features**: Converts frames from one type of network protocol to another, allowing interoperability between different network types.
   * **Use Case**: Used to integrate networks with different architectures, enabling communication between disparate systems.

**Figure**:



1. **Gateway**

A **gateway** is a network node that serves as an access point to another network, often with a different protocol. It acts as a translator between different network protocols, facilitating communication and data transfer between disparate networks. Gateways operate at various layers of the OSI model, but they typically function at the network layer (Layer 3) and above.

**Features of a Gateway:**

1. **Protocol Conversion**: Gateways convert data from one protocol to another, enabling communication between different network architectures.
2. **Network Access Point**: They act as entry and exit points for a network, managing traffic that enters or leaves the network.
3. **Routing Capabilities**: Gateways can route data between different networks, similar to routers.
4. **Security**: They often include security features such as firewalls, VPN support, and intrusion detection/prevention systems.
5. **Traffic Management**: Gateways can prioritize and manage traffic to optimize network performance.
6. **Translation Services**: They provide translation services for different data formats, message formats, and network protocols.
7. **Interoperability**: Ensures different network systems and devices can communicate effectively, despite differences in protocols or architecture.

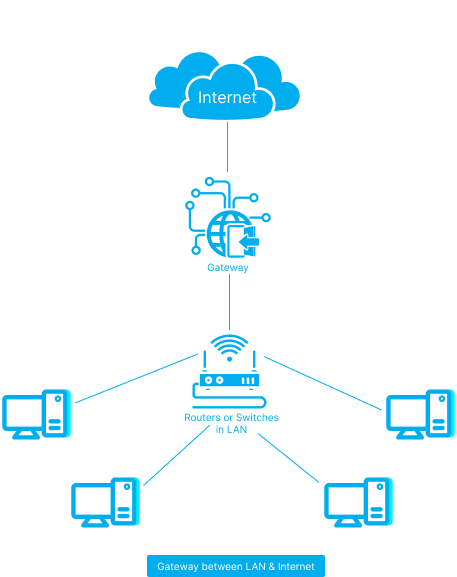
**Applications of a Gateway:**

1. **Internet Access**: Gateways provide access to the Internet for devices within a local network.
2. **Enterprise Networks**: They connect different parts of an enterprise network, such as connecting a corporate LAN to a WAN.
3. **Cloud Services**: Gateways connect local networks to cloud services and platforms, enabling seamless data transfer and communication.
4. **IoT Networks**: Gateways facilitate communication between IoT devices using different protocols.
5. **Unified Communications**: They enable integration of various communication systems like VoIP, email, and instant messaging.
6. **Cross-Protocol Communication**: Gateways allow different systems, such as a mainframe and a client-server network, to communicate and exchange data.

**Types of Gateways:**

1. **Network Gateway**:
   * **Functionality**: Acts as an entry and exit point for a network, providing protocol translation and routing services.
   * **Features**: Protocol conversion, routing capabilities, traffic management, and security features.
   * **Use Case**: Commonly used to connect a local network to the Internet or other external networks.
2. **Application Gateway** (Proxy Server):
   * **Functionality**: Serves as an intermediary between clients and servers, providing application-specific data processing.
   * **Features**: Content filtering, caching, user authentication, and logging.
   * **Use Case**: Used for web traffic management, email filtering, and securing application-level communication.
3. **VoIP Gateway**:
   * **Functionality**: Converts voice and fax calls between the public switched telephone network (PSTN) and an IP network.
   * **Features**: Protocol translation, call routing, compression, and echo cancellation.
   * **Use Case**: Deployed in VoIP systems to enable voice communication over IP networks.
4. **IoT Gateway**:
   * **Functionality**: Facilitates communication between IoT devices and the cloud or other networks.
   * **Features**: Protocol translation, data aggregation, security, and device management.
   * **Use Case**: Used in IoT deployments to connect sensors and devices to cloud services for data analysis and control.
5. **Cloud Storage Gateway**:
   * **Functionality**: Connects local storage systems to cloud storage services, providing seamless integration and data transfer.
   * **Features**: Data compression, encryption, deduplication, and protocol translation.
   * **Use Case**: Used in hybrid cloud environments to enable local applications to access cloud storage transparently.
6. **API Gateway**:
   * **Functionality**: Manages and routes API requests from clients to appropriate microservices or backend services.
   * **Features**: Rate limiting, authentication, load balancing, and logging.
   * **Use Case**: Commonly used in microservices architectures to provide a single-entry point for API consumers.

**Figure**:



1. **Modem**

A **modem** (modulator-demodulator) is a hardware device that converts digital data from a computer or other digital device into an analog signal suitable for a telephone line or other analog medium and vice versa. This allows digital information to be transmitted over analog communication channels, such as telephone lines or cable systems.

**Features of a Modem:**

1. **Modulation and Demodulation**: Converts digital signals to analog signals (modulation) for transmission and converts received analog signals back to digital signals (demodulation).
2. **Data Compression**: Reduces the size of data to increase transmission speed and efficiency.
3. **Error Correction**: Detects and corrects errors in the transmitted data to ensure accurate communication.
4. **Speed**: Measured in bits per second (bps), indicating the rate at which data is transmitted.
5. **Protocol Support**: Supports various communication protocols for data transmission.
6. **Interface**: Provides interfaces such as Ethernet, USB, or serial ports for connecting to computers or routers.
7. **Configuration**: Can be configured through software or firmware settings to optimize performance and compatibility.

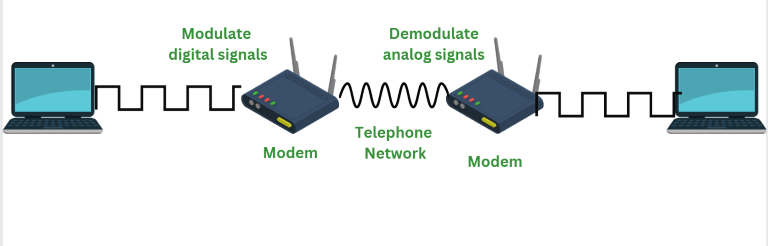
**Applications of a Modem:**

1. **Internet Access**: Provides Internet connectivity by converting digital data from a computer to analog signals for transmission over telephone lines or cable systems.
2. **Remote Access**: Enables remote access to networks or computers via dial-up connections.
3. **Fax Transmission**: Allows computers to send and receive fax messages over telephone lines.
4. **Point-of-Sale Systems**: Used in POS systems to transmit transaction data over phone lines.
5. **Telemetry**: Used in telemetry systems to transmit data from remote sensors or devices to a central location.

**Types of Modems:**

1. **Dial-Up Modem**:
   * **Functionality**: Connects to the Internet via a standard telephone line using the public switched telephone network (PSTN).
   * **Features**: Typically supports speeds up to 56 Kbps, requires dial-up service from an ISP.
   * **Use Case**: Used in areas with limited broadband availability or for specific low-bandwidth applications.
2. **DSL Modem**:
   * **Functionality**: Connects to the Internet using a digital subscriber line (DSL) over existing telephone lines.
   * **Features**: Higher speeds than dial-up (ranging from a few Mbps to hundreds of Mbps), supports simultaneous voice and data transmission.
   * **Use Case**: Common in residential and small business Internet setups where DSL service is available.
3. **Cable Modem**:
   * **Functionality**: Connects to the Internet via a cable television network.
   * **Features**: Supports high-speed Internet access, typically offering speeds from several Mbps to several Gbps.
   * **Use Case**: Widely used in residential areas with cable TV infrastructure for broadband Internet access.
4. **Fiber Optic Modem (ONT)**:
   * **Functionality**: Connects to the Internet using fiber optic cables, also known as an Optical Network Terminal (ONT).
   * **Features**: Provides extremely high-speed Internet access, often in the range of hundreds of Mbps to several Gbps.
   * **Use Case**: Used in areas with fiber optic infrastructure for the fastest Internet speeds available.
5. **Satellite Modem**:
   * **Functionality**: Connects to the Internet via satellite communication.
   * **Features**: Provides Internet access in remote or rural areas where other forms of broadband are unavailable.
   * **Use Case**: Suitable for remote locations, maritime applications, and areas with limited terrestrial Internet infrastructure.
6. **Wireless Modem**:
   * **Functionality**: Connects to the Internet using wireless cellular networks (e.g., 3G, 4G, 5G).
   * **Features**: Portable, often integrated into mobile devices, supports various wireless standards.
   * **Use Case**: Used for mobile Internet access and in areas without wired broadband infrastructure.
7. **ISDN Modem**:
   * **Functionality**: Connects to the Internet using Integrated Services Digital Network (ISDN) lines.
   * **Features**: Supports digital transmission over telephone lines, offering speeds higher than traditional dial-up but lower than DSL.
   * **Use Case**: Used in specific business applications where ISDN infrastructure is available.

**Figure**:



1. **Repeater**

A **repeater** is a network device used to regenerate or amplify signals to extend the distance over which data can travel. It operates at the physical layer (Layer 1) of the OSI model, receiving and retransmitting signals to ensure that they do not degrade or become weak over long distances. Repeaters are essential in maintaining signal integrity across extended lengths of cabling or wireless connections.

**Features of a Repeater:**

1. **Signal Amplification**: Boosts the strength of the incoming signal to overcome the distance limitations of transmission media.
2. **Noise Filtering**: Minimizes noise and distortion in the signal to ensure clear and accurate data transmission.
3. **Bit-Level Regeneration**: Reconstructs the signal at the bit level, ensuring that data integrity is maintained without errors.
4. **Bidirectional**: Capable of amplifying signals in both directions, ensuring communication continuity.
5. **Transparent Operation**: Functions without altering the data content, making it invisible to network protocols and devices.

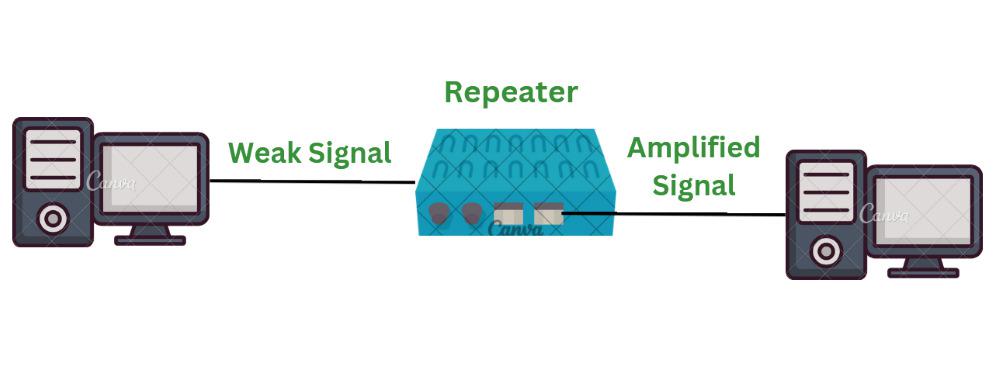
**Applications of a Repeater:**

1. **Extended LANs**: Used to extend the range of local area networks (LANs) by amplifying signals over longer distances.
2. **Long-Distance Communication**: Facilitates communication over long distances in wide area networks (WANs) by maintaining signal strength.
3. **Wireless Networks**: Enhances the range and coverage of wireless networks by boosting weak signals.
4. **Satellite Communication**: Used in satellite communication systems to amplify signals transmitted to and from satellites.
5. **Telecommunication Systems**: Essential in telephone networks to maintain voice signal quality over long distances.

**Types of Repeaters:**

1. **Analog Repeater**:
   * **Functionality**: Amplifies analog signals to extend their range.
   * **Features**: Simple amplification without digital processing, prone to amplifying noise along with the signal.
   * **Use Case**: Used in older telecommunication systems and analog broadcast systems.
2. **Digital Repeater**:
   * **Functionality**: Regenerates digital signals, reconstructing them to their original quality.
   * **Features**: Error detection and correction, bit-level regeneration, better noise immunity.
   * **Use Case**: Commonly used in digital networks, including modern telecommunication systems and data networks.
3. **Wi-Fi Repeater** (Wireless Range Extender):
   * **Functionality**: Extends the range of Wi-Fi networks by receiving and retransmitting wireless signals.
   * **Features**: Can be configured easily, supports various Wi-Fi standards, improves coverage in large areas or buildings.
   * **Use Case**: Used in homes, offices, and public spaces to enhance wireless network coverage.
4. **Optical Repeater**:
   * **Functionality**: Regenerates optical signals in fiber optic communication systems.
   * **Features**: Converts optical signals to electrical signals for amplification and then back to optical signals.
   * **Use Case**: Essential in long-distance fiber optic communication to maintain signal strength and quality.
5. **Telephone Repeater**:
   * **Functionality**: Amplifies voice signals in telephone lines to extend the distance of telecommunication.
   * **Features**: Ensures clear voice communication over long distances, compensates for signal loss.
   * **Use Case**: Used in telecommunication systems, particularly in long-distance and international telephone networks.

**Figure**:



**7. NIC:**

A **Network Interface Card (NIC)** is a hardware component that allows a computer or other devices to connect to a network. It can be integrated into the motherboard or added as an expansion card. NICs facilitate communication between devices on a local area network (LAN) or a larger network by providing the physical interface for data transmission and reception.

**Features of a NIC:**

1. **MAC Address**: Each NIC has a unique Media Access Control (MAC) address, which is used for identifying devices on the network.
2. **Speed**: NICs support various data transfer speeds, such as 10 Mbps, 100 Mbps, 1 Gbps, 10 Gbps, and higher.
3. **Full-Duplex and Half-Duplex**: NICs can operate in full-duplex mode (simultaneous send and receive) or half-duplex mode (send and receive alternately).
4. **Wired and Wireless**: NICs can be wired (Ethernet) or wireless (Wi-Fi), depending on the network infrastructure.
5. **Bus Interface**: NICs connect to the computer via different bus interfaces, such as PCI, PCIe, USB, or integrated directly onto the motherboard.
6. **Protocol Support**: NICs support various network protocols, including TCP/IP, which is fundamental for Internet connectivity.
7. **Wake-on-LAN (WoL)**: Some NICs support Wake-on-LAN, allowing a computer to be powered on remotely.
8. **Quality of Service (QoS)**: Advanced NICs support QoS features to prioritize network traffic for better performance.

**Applications of a NIC:**

1. **Internet Connectivity**: Provides the interface for connecting a computer to the Internet via an Ethernet cable or Wi-Fi.
2. **Local Area Networks (LANs)**: Facilitates communication between devices within a local network, such as in homes, offices, or campus environments.
3. **File Sharing and Printing**: Enables networked devices to share files and access network printers.
4. **Gaming**: Ensures high-speed, low-latency connections for online gaming.
5. **Enterprise Networks**: Used in business environments for connecting workstations, servers, and other network devices.
6. **Virtualization**: Provides network connectivity for virtual machines in virtualized environments.

**Types of NICs:**

1. **Ethernet NIC**:
   * **Functionality**: Connects devices to wired Ethernet networks.
   * **Features**: Supports various Ethernet standards (e.g., 10BASE-T, 100BASE-TX, 1000BASE-T).
   * **Use Case**: Commonly used in desktop computers, servers, and switches for reliable wired network connections.
2. **Wireless NIC (Wi-Fi Adapter)**:
   * **Functionality**: Connects devices to wireless networks.
   * **Features**: Supports various Wi-Fi standards (e.g., 802.11a/b/g/n/ac/ax).
   * **Use Case**: Used in laptops, smartphones, tablets, and desktop computers for wireless connectivity.
3. **Fiber Optic NIC**:
   * **Functionality**: Connects devices to fiber optic networks.
   * **Features**: Supports high-speed data transfer over long distances using fiber optic cables.
   * **Use Case**: Used in data centers, enterprise networks, and high-performance computing environments.
4. **USB NIC**:
   * **Functionality**: Provides network connectivity via a USB interface.
   * **Features**: Portable, plug-and-play, supports both wired (Ethernet) and wireless (Wi-Fi) connections.
   * **Use Case**: Used in laptops, tablets, and other devices that lack built-in NICs or need additional network interfaces.
5. **Virtual NIC**:
   * **Functionality**: Provides network connectivity for virtual machines (VMs) in virtualized environments.
   * **Features**: Software-based, allows VMs to communicate with each other and external networks.
   * **Use Case**: Used in virtualization platforms like VMware, Hyper-V, and KVM.

**Quiz:** (Sufficient space to be provided for the answers)

**Answer:**

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**Answer: Cases Where Network Devices Are Used**

• To understand the cases where the listed network devices are used, let's delve into each device, its features, and specific scenarios where it proves most beneficial. We'll cover Hubs, Routers, Switches, Bridges, Gateways, Modems, Repeaters, and Network Interface Cards (NICs).

**Hub**

• **What is a Hub?** A hub is a basic networking device used to connect multiple Ethernet devices in a local area network (LAN). It operates at the physical layer (Layer 1) of the OSI model and transmits data packets to all connected devices, regardless of the intended recipient.

• **Features of a Hub:**

• Broadcast Transmission: Transmits data packets to all connected devices, leading to unnecessary network traffic and potential collisions.

• Simple Device: Straightforward and easy to use, requiring no configuration.

• Operates at Layer 1: Does not process data, simply repeats packets to other ports.

• No Traffic Filtering: Does not filter traffic, meaning every device receives all data packets.

• Half-Duplex Communication: Supports half-duplex communication, where devices can either send or receive data at one time, but not both simultaneously.

• Limited Security: Offers no specific security features for data filtering or protection.

• **Applications of a Hub:**

• Small Home Networks: Suitable for small home or office networks prioritizing simplicity over performance.

• Legacy Systems: Used in environments with older networking hardware due to compatibility.

• Network Monitoring: Can be used in setups where data needs to be captured for analysis, broadcasting all packets to all connected devices.

• Device Connectivity: Provides a simple way to connect multiple devices in a LAN when advanced network management is not required.

• **Types of Hubs:**

• Passive Hub: Connects devices and passes electrical signals without amplification. Suitable for small networks with short distances.

• Active Hub: Amplifies and regenerates the signal before broadcasting, ensuring data travels longer distances. Used in larger networks.

• Intelligent Hub: Includes remote management, diagnostics, and monitoring features, essential for complex networks.

*[Diagram: Diagram of a Hub connecting multiple devices in a star topology, with data being broadcasted to all devices.]*

**Router**

• A router is a networking device that forwards data packets between computer networks, directing traffic on the Internet. It operates at the network layer (Layer 3) of the OSI model and uses IP addresses to determine the best path for forwarding packets. Routers connect multiple networks together, such as connecting a local area network (LAN) to the Internet.

• **Features of a Router:**

• **Traffic Direction:** Routers analyze incoming data packets and determine the best path for them to reach their destination.

• **Network Layer Operations:** Operates at the network layer, handling IP addresses and routing protocols.

• **Security:** Provides features such as firewalls, VPNs, and filtering to secure the network.

• **Dynamic Routing:** Supports routing protocols like OSPF, BGP, and RIP to dynamically adjust routes based on current network conditions.

• **Static Routing:** Allows manual configuration of routes for predictable and stable network performance.

• **Network Address Translation (NAT):** Enables multiple devices on a local network to share a single public IP address.

• **Quality of Service (QoS):** Prioritizes network traffic based on importance, ensuring critical applications receive adequate bandwidth.

• **Applications of a Router:**

• **Home Networks:** Connects home networks to the Internet, allowing multiple devices to share a single Internet connection.

• **Business Networks:** Manages and directs network traffic within a business, ensuring efficient data transfer and network security.

• **Large Enterprises:** Connects multiple branch offices, enabling communication and data sharing across different locations.

• **Internet Service Providers (ISPs):** Directs and manages Internet traffic, connecting customers to the broader Internet.

• **Cloud Computing:** Routes traffic between virtual machines and services in cloud environments, ensuring efficient and secure data transfer.

*[Diagram: Diagram of a Router connecting a LAN to the Internet, illustrating the flow of data packets and NAT.]*

**Switch**

• A switch is a networking device that connects multiple devices in a local area network (LAN). It operates at the data link layer (Layer 2) of the OSI model and uses MAC addresses to forward data packets only to the intended recipient, improving network efficiency and reducing collisions.

• **Features of a Switch:**

• **Intelligent Forwarding:** Learns the MAC addresses of connected devices and forwards data packets only to the intended recipient.

• **Layer 2 Operations:** Operates at the data link layer, using MAC addresses for forwarding.

• **Full-Duplex Communication:** Supports full-duplex communication, allowing devices to send and receive data simultaneously.

• **VLAN Support:** Allows the creation of virtual LANs to segment the network and improve security and performance.

• **Spanning Tree Protocol (STP):** Prevents loops in the network topology by disabling redundant paths.

• **Quality of Service (QoS):** Prioritizes network traffic based on importance, ensuring critical applications receive adequate bandwidth.

• **Applications of a Switch:**

• **Small Office Networks:** Connects computers, printers, and other devices in a small office, providing efficient network communication.

• **Medium to Large Businesses:** Manages network traffic in larger organizations, supporting a large number of connected devices.

• **Data Centers:** Connects servers and storage devices in data centers, providing high-speed, low-latency communication.

• **Home Networks:** Provides wired connectivity for devices in a home network, offering better performance than hubs.

• **Industrial Networks:** Connects industrial equipment and control systems, ensuring reliable and efficient data transfer.

*[Diagram: Diagram of a Switch connecting multiple devices in a star topology, illustrating the forwarding of data packets based on MAC addresses.]*

**Bridge**

• A bridge is a networking device that connects two or more network segments together. It operates at the data link layer (Layer 2) of the OSI model and uses MAC addresses to filter and forward data packets between segments, reducing traffic and improving network performance.

• **Features of a Bridge:**

• **MAC Address Filtering:** Learns the MAC addresses of devices on each segment and forwards data packets only to the segments where the recipient is located.

• **Layer 2 Operations:** Operates at the data link layer, using MAC addresses for forwarding.

• **Traffic Segmentation:** Reduces network traffic by dividing the network into segments and filtering unnecessary traffic.

• **Loop Prevention:** Some bridges support Spanning Tree Protocol (STP) to prevent loops in the network topology.

• **Applications of a Bridge:**

• **Connecting Network Segments:** Connects two or more network segments with different physical media, such as Ethernet and Wi-Fi.

• **Extending Network Distance:** Extends the physical distance of a network by connecting segments that are too far apart to be directly connected.

• **Reducing Network Congestion:** Reduces network congestion by segmenting the network and filtering unnecessary traffic.

*[Diagram: Diagram of a Bridge connecting two network segments, illustrating the filtering of data packets based on MAC addresses.]*

**Gateway**

• A gateway is a networking device that connects two networks using different protocols. It operates at multiple layers of the OSI model, performing protocol conversion to allow communication between the networks.

• **Features of a Gateway:**

• **Protocol Conversion:** Converts protocols between different networks, allowing devices on different networks to communicate.

• **Layer 3 and Above Operations:** Operates at the network layer and above, handling IP addresses, routing, and application protocols.

• **Security:** Provides security features such as firewalls and access control to protect the network.

• **Address Translation:** Performs network address translation (NAT) to allow multiple devices on a private network to share a single public IP address.

• **Applications of a Gateway:**

• **Connecting LANs to WANs:** Connects a local area network (LAN) to a wide area network (WAN), such as the Internet.

• **Connecting Different Network Architectures:** Connects networks using different architectures, such as Ethernet and Token Ring.

• **Connecting Different Protocol Stacks:** Connects networks using different protocol stacks, such as TCP/IP and IPX/SPX.

• **VoIP Networks:** Media Gateways connect VoIP networks to traditional PSTN.

*[Diagram: Diagram of a Gateway connecting a LAN to the Internet, illustrating protocol conversion and NAT.]*

**Modem**

• A modem (Modulator-Demodulator) is a networking device that converts digital signals from a computer into analog signals for transmission over a communication channel, such as a telephone line or cable. It also converts analog signals back into digital signals for the computer to understand.

• **Features of a Modem:**

• **Signal Conversion:** Converts digital signals into analog signals and vice versa.

• **Data Compression:** Compresses data to increase transmission speed.

• **Error Correction:** Detects and corrects errors in the transmitted data.

• **Dial-Up Access:** Provides dial-up Internet access over telephone lines.

• **Cable Access:** Provides high-speed Internet access over cable TV lines.

• **DSL Access:** Provides high-speed Internet access over digital subscriber lines (DSL).

• **Applications of a Modem:**

• **Dial-Up Internet Access:** Provides Internet access over traditional telephone lines.

• **Cable Internet Access:** Provides high-speed Internet access over cable TV lines.

• **DSL Internet Access:** Provides high-speed Internet access over digital subscriber lines (DSL).

• **Fax Machines:** Used in fax machines to transmit and receive documents over telephone lines.

*[Diagram: Diagram of a Modem connecting a computer to the Internet over a telephone line, illustrating signal modulation and demodulation.]*

**Repeater**

• A repeater is a networking device that amplifies and regenerates a signal to extend the distance it can travel without degradation. It operates at the physical layer (Layer 1) of the OSI model.

• **Features of a Repeater:**

• **Signal Amplification:** Amplifies weak signals to improve signal strength.

• **Signal Regeneration:** Regenerates the signal to remove noise and distortion.

• **Layer 1 Operations:** Operates at the physical layer, dealing with electrical signals.

• **Applications of a Repeater:**

• **Extending Network Distance:** Extends the physical distance of a network by amplifying and regenerating the signal.

• **Overcoming Signal Attenuation:** Overcomes signal attenuation caused by long cable runs or other physical obstacles.

*[Diagram: Diagram of a Repeater amplifying and regenerating a signal to extend its distance.]*

**Network Interface Card (NIC)**

• A network interface card (NIC) is a hardware component that allows a device to connect to a network. It provides the physical interface for connecting to the network and handles the communication between the device and the network.

• **Features of a NIC:**

• **Physical Connection:** Provides a physical interface for connecting to the network, such as an Ethernet port or a Wi-Fi antenna.

• **Data Encapsulation:** Encapsulates data into frames for transmission over the network.

• **MAC Address:** Contains a unique MAC address that identifies the device on the network.

• **Driver Software:** Requires driver software to communicate with the operating system.

• **Applications of a NIC:**

• **Connecting Computers to a Network:** Allows computers to connect to a local area network (LAN) or the Internet.

• **Connecting Servers to a Network:** Allows servers to connect to a network for providing services to clients.

• **Connecting IoT Devices to a Network:** Allows IoT devices to connect to a network for communication and control.

*[Diagram: Diagram of a NIC installed in a computer, showing the Ethernet port and MAC address.]*

<table>Device|Usage Scenario|Advantage|Disadvantage

Hub|Small home networks|Simple and inexpensive|Low performance, high collision risk

Router|Connecting multiple networks (LAN to Internet)|Advanced features, security|More complex configuration

Switch|Medium to large networks|Efficient traffic management, VLANs|More expensive than hubs

Bridge|Connecting network segments|Reduces traffic, extends network distance|Less common in modern networks

Gateway|Connecting different network protocols|Protocol conversion, security|More complex configuration

Modem|Connecting to the Internet over phone lines or cable|Provides Internet access|Limited speed compared to newer technologies

Repeater|Extending network distance|Simple signal amplification|Does not filter traffic

NIC|Connecting devices to a network|Essential for network connectivity|Requires driver software</table>

```

**Answer:**

```docx

## Differentiating Network Devices

This section provides a detailed comparison of various network devices, including hubs, switches, routers, bridges, gateways, modems, repeaters, and NICs (Network Interface Cards). Understanding the differences between these devices is crucial for designing and troubleshooting computer networks.

### Hub

• **What is a Hub?**

• A hub is a basic networking device that connects multiple Ethernet devices in a LAN. It operates at the physical layer (Layer 1) of the OSI model.

• Its primary function is to transmit data packets to all connected devices, regardless of the intended recipient.

• **Features of a Hub:**

• **Broadcast Transmission:** Sends data to all connected devices, leading to potential traffic congestion and collisions.

• **Simple Device:** Easy to use and requires no configuration.

• **Layer 1 Operation:** Operates at the physical layer, simply repeating electrical signals.

• **No Traffic Filtering:** Does not filter traffic, meaning all devices receive all packets.

• **Half-Duplex Communication:** Devices can either send or receive data at one time, but not both simultaneously.

• **Limited Security:** Offers no security features due to its broadcast nature.

• **Applications of a Hub:**

• Small home networks where simplicity is preferred over performance.

• Legacy systems with older networking hardware.

• Network monitoring setups where all data needs to be captured.

• Connecting multiple devices in a LAN when advanced network management isn't needed.

• **Types of Hubs:**

• **Passive Hub:**

• Functionality: Connects devices and passes signals without amplification.

• Features: No power source needed; doesn't strengthen the signal.

• Use Case: Small networks with short distances between devices.

• **Active Hub:**

• Functionality: Amplifies and regenerates the signal.

• Features: Requires a power source; provides better performance.

• Use Case: Larger networks where the signal needs to be strengthened.

• **Intelligent Hub:**

• Functionality: Includes remote management, diagnostics, and monitoring.

• Features: Offers network management capabilities.

• Use Case: Complex networks where monitoring is essential.

*[Diagram: Diagram of a Hub connecting multiple computers. Arrows indicate data being broadcast to all connected devices.]*

### Router

• **What is a Router?**

• A router is a networking device that forwards data packets between computer networks. It operates at the network layer (Layer 3) of the OSI model.

• It directs traffic on the Internet and uses IP addresses to determine the best path for packets.

• **Features of a Router:**

• **Traffic Direction:** Analyzes data packets and determines the best path for them to reach their destination.

• **Network Layer Operations:** Operates at Layer 3, handling IP addresses and routing protocols.

• **Security:** Provides security features such as firewalls and VPNs.

• **Dynamic Routing:** Supports protocols like OSPF and BGP to dynamically adjust routes.

• **Static Routing:** Allows manual configuration of routes for predictable performance.

• **Network Address Translation (NAT):** Enables multiple devices to share a single public IP address.

• **Quality of Service (QoS):** Prioritizes traffic to ensure critical applications perform well.

• **Applications of a Router:**

• Connecting a LAN to the Internet.

• Creating multiple networks and managing traffic between them.

• Implementing security policies to protect the network.

• Providing VPN access for remote users.

• Prioritizing traffic for VoIP and video conferencing.

• **Types of Routers:**

• **Wired Routers:** Connect devices via Ethernet cables.

• **Wireless Routers:** Connect devices wirelessly via Wi-Fi.

• **Core Routers:** High-capacity routers used in the core of a network.

• **Edge Routers:** Connect edge networks to the core.

• **Virtual Routers:** Software-based routers running on virtual machines.

*[Diagram: Diagram of a Router connecting a home network to the Internet. Arrows indicate data being routed between the network and the Internet.]*

### Switch

• **What is a Switch?**

• A switch is a networking device that connects multiple devices in a network and forwards data packets only to the intended recipient. It operates at the data link layer (Layer 2) of the OSI model.

• Switches use MAC addresses to learn and forward traffic efficiently.

• **Features of a Switch:**

• **Unicast Transmission:** Sends data only to the intended recipient, reducing traffic congestion.

• **MAC Address Learning:** Learns MAC addresses of connected devices and builds a switching table.

• **Full-Duplex Communication:** Devices can send and receive data simultaneously.

• **VLAN Support:** Supports virtual LANs to segment the network logically.

• **Spanning Tree Protocol (STP):** Prevents loops in the network topology.

• **Quality of Service (QoS):** Prioritizes traffic based on application or user.

• **Applications of a Switch:**

• Connecting devices in a LAN.

• Creating VLANs to segment the network for security or performance.

• Connecting multiple switches to create a larger network.

• Providing PoE (Power over Ethernet) to power devices like IP phones and cameras.

• **Types of Switches:**

• **Unmanaged Switches:** Simple switches with no configuration options.

• **Managed Switches:** Offer advanced features like VLANs and QoS.

• **PoE Switches:** Provide power over Ethernet to connected devices.

• **Layer 3 Switches:** Can perform routing functions in addition to switching.

*[Diagram: Diagram of a Switch connecting multiple computers. Arrows indicate data being sent only to the intended recipient.]*

### Bridge

• **What is a Bridge?**

• A bridge is a networking device that connects two or more network segments, forwarding traffic between them based on MAC addresses.

• It operates at the data link layer (Layer 2) of the OSI model and helps in segmenting networks to reduce traffic congestion.

• **Features of a Bridge:**

• **MAC Address Filtering:** Learns MAC addresses of devices on each segment and forwards traffic accordingly.

• **Loop Prevention:** Some bridges implement spanning tree protocol to prevent loops.

• **Segmentation:** Divides a large network into smaller segments to improve performance.

• **Applications of a Bridge:**

• Connecting two Ethernet networks.

• Extending the reach of a network by connecting distant segments.

• Reducing traffic congestion in a large network.

• **Types of Bridges:**

• **Transparent Bridges:** Automatically learn MAC addresses and forward traffic.

• **Source-Routing Bridges:** Rely on source devices to specify the path for the data.

*[Diagram: Diagram of a Bridge connecting two network segments. Arrows indicate data being forwarded between the segments.]*

### Gateway

• **What is a Gateway?**

• A gateway is a networking device that connects two networks using different protocols, allowing them to communicate with each other.

• It acts as a translator between different network architectures.

• **Features of a Gateway:**

• **Protocol Conversion:** Translates data between different protocols.

• **Address Translation:** Converts addresses between different network addressing schemes.

• **Security:** Can provide security features like firewalls and intrusion detection.

• **Applications of a Gateway:**

• Connecting a local network to the Internet.

• Connecting networks using different protocols, such as TCP/IP and SNA.

• Providing access to different services on a network.

*[Diagram: Diagram of a Gateway connecting two different networks with different protocols. Arrows indicate data being translated between the networks.]*

### Modem

• **What is a Modem?**

• A modem (Modulator-Demodulator) is a device that converts digital signals from a computer into analog signals for transmission over telephone lines or other analog media, and vice versa.

• **Features of a Modem:**

• **Modulation:** Converts digital signals to analog signals for transmission.

• **Demodulation:** Converts analog signals back to digital signals.

• **Data Compression:** Some modems support data compression to increase transmission speed.

• **Error Correction:** Some modems provide error correction to ensure reliable data transmission.

• **Applications of a Modem:**

• Connecting to the Internet via dial-up.

• Sending faxes over telephone lines.

• Connecting to remote networks over analog lines.

• **Types of Modems:**

• **Dial-Up Modems:** Use telephone lines for data transmission.

• **Cable Modems:** Use cable TV lines for data transmission.

• **DSL Modems:** Use digital subscriber lines for data transmission.

*[Diagram: Diagram of a Modem connecting a computer to the Internet via telephone line. Arrows indicate modulation and demodulation of signals.]*

### Repeater

• **What is a Repeater?**

• A repeater is a device that amplifies and regenerates signals to extend the distance over which they can be transmitted. It operates at the physical layer (Layer 1) of the OSI model.

• **Features of a Repeater:**

• **Signal Amplification:** Boosts the signal strength to overcome attenuation.

• **Signal Regeneration:** Cleans the signal by removing noise and distortion.

• **Simple Device:** Easy to install and configure.

• **Applications of a Repeater:**

• Extending the reach of a network cable.

• Overcoming signal degradation in long cable runs.

*[Diagram: Diagram of a Repeater amplifying a signal over a long cable run. Arrows indicate the signal being boosted.]*

### NIC (Network Interface Card)

• **What is a NIC?**

• A NIC (Network Interface Card) is a hardware component that allows a computer to connect to a network. It provides a physical interface for connecting to network cables or wireless networks.

• **Features of a NIC:**

• **Physical Interface:** Provides a connector for network cables or antennas for wireless networks.

• **Data Transmission:** Sends and receives data packets over the network.

• **MAC Address:** Has a unique MAC address that identifies the device on the network.

• **Protocol Support:** Supports various network protocols such as Ethernet and Wi-Fi.

• **Applications of a NIC:**

• Connecting a computer to a LAN.

• Connecting a computer to the Internet.

• Enabling wireless connectivity on a computer.

• **Types of NICs:**

• **Ethernet NICs:** Use Ethernet cables for network connectivity.

• **Wireless NICs:** Use Wi-Fi for network connectivity.

*[Diagram: Diagram of a Network Interface Card (NIC) installed in a computer. Connectors for Ethernet cable and antenna for wireless are shown.]*

|  |  |  |  |
| --- | --- | --- | --- |
| Device | Layer | Function | Key Features |
| Hub | Physical (Layer 1) | Connects devices, broadcasts data | Simple, broadcast transmission |
| Switch | Data Link (Layer 2) | Connects devices, forwards data based on MAC address | Unicast transmission, MAC address learning |
| Router | Network (Layer 3) | Connects networks, forwards data based on IP address | Routing, security features, NAT |
| Bridge | Data Link (Layer 2) | Connects network segments, filters traffic | MAC address filtering, segmentation |
| Gateway | Application (Layer 7) | Connects networks with different protocols | Protocol conversion, address translation |
| Modem | Physical (Layer 1) | Converts digital to analog and vice versa | Modulation, demodulation |
| Repeater | Physical (Layer 1) | Amplifies and regenerates signals | Signal amplification, signal regeneration |
| NIC | Physical/Data Link (Layer 1/2) | Provides physical interface for network connection | Physical interface, data transmission, MAC address |

```

1. Find out the cases where above devices are used?

**Answer:**

```docx

\*\*Answer:\*\*

The cost of network devices can vary significantly based on specifications, features, and manufacturer. Below are approximate costs and some manufacturers for the listed devices. Please note that prices are subject to change.

**Hub**

• **Approximate Cost:** Obsolete Technology, but older models might be found for $20 - $50.

• **Manufacturers:**

• 3Com (legacy)

• D-Link (legacy)

**Switch**

• **Approximate Cost:** $30 - $200+ (depending on features like PoE, managed/unmanaged, port count, and speed)

• **Manufacturers:**

• Cisco

• TP-Link

**Router**

• **Approximate Cost:** $50 - $300+ (depending on features like Wi-Fi standards, speed, security features, and range)

• **Manufacturers:**

• Netgear

• ASUS

**Bridge**

• **Approximate Cost:** $40-$150 (Bridges are often integrated into switches now, so stand-alone devices are less common)

• **Manufacturers:**

• D-Link

• TP-Link

**Gateway**

• **Approximate Cost:** Gateways are often integrated into routers or firewalls, so the cost depends on the device they are part of. A basic gateway function is included in most home routers ($50-$300). More advanced gateways for enterprise solutions can cost $500 - $5000+

• **Manufacturers:**

• Cisco (enterprise)

• Juniper Networks (enterprise)

**Modem**

• **Approximate Cost:** $50 - $200 (depending on DOCSIS version, features, and whether it's cable or DSL)

• **Manufacturers:**

• Arris

• Netgear

**Repeater**

• **Approximate Cost:** $20 - $100 (primarily for Wi-Fi range extenders)

• **Manufacturers:**

• TP-Link

• Netgear

**NIC (Network Interface Card)**

• **Approximate Cost:** $10 - $50 (depending on speed, interface (PCIe, USB), and features)

• **Manufacturers:**

• Intel

• TP-Link

```

2. Differentiate each device?

3. Give approximate cost of each device with name of 2 manufactures.

# References used by the students:

# <https://www.geeksforgeeks.org/network-devices-hub-repeater-bridge-switch-router-gateways/>

# Rubric wise marks obtained:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Rubrics | Practical Understanding | | Problem Solving | | Task Execution | | Documentation and Reporting | | Ethical and Professional Conduct | | Total |
| Good (2) | Avg.(1) | Good (2) | Avg. (1) | Good (2) | Avg. (1) | Good (2) | Avg.(1) | Good (2) | Avg. (1) |
| Marks |  |  |  |  |  |  |  |  |  |  |  |

**Experiment No: 2**

**AIM: Study of different types of network cables and practically implements the cross-wired cable and straight through cable using clamping tool**

**Date:**

**Competency and Practical Skills:** Identify different types of network cables and Prepare own LAN Cable

**Relevant CO: CO1:** Familiarize with the basic taxonomy - terminologies used in networking and the layered architecture of computer networks

**Objectives:** (a) To see and check various network Cables.

(b) Find out usage of each in different case with advantage and disadvantage

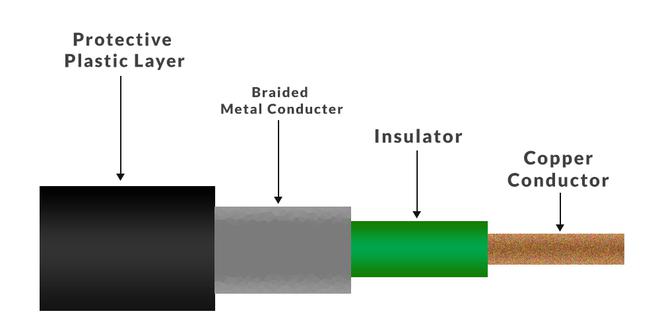
(c) Prepare own cross-wired cable and straight through cable using clamping tool.

**Equipment/Instruments:** RJ-45 connector, Clamping Tool, Twisted pair Cable

**Theory:**

**Study four different types of cables:**

* + 1. **Coaxial Cable**
* A coaxial cable is an electrical cable with a copper conductor and an insulator shielding around it and a braided metal mesh that prevents signal interference and cross talk.
* Coaxial cable is also known as coax.
* The term [coaxial](https://en.wikipedia.org/wiki/Coaxial) refers to the inner conductor and the outer shield sharing a geometric axis.

****

**Fig. 1. Coaxial Cable**

**Structure of coaxial cable:**

**Copper conductor:**A central conductor, which consists of copper. The conductor is the point at which data transmits.

**Insulator:** Dielectric plastic insulation around the copper conductor. It is used to maintain the spacing between the center conductor and shield.

**Braided mesh:** A braided mesh of copper helps to shield from electromagnetic interference, the braid provides a barrier against EMI moving into and out of the coaxial cable

**Protective plastic layer:** An external polymer layer, which has a plastic coating. It is used to protect internal layers from damages.

**Types of coaxial cables:**

* Hard line coaxial cable.
* Flexible coaxial cable.
* Semi-rigid coaxial cable.
* Formable coaxial cable.
* Rigid coaxial cable.
* Twin axial cable.
* Triaxial cable.

**Advantages:**

1. Coaxial cables have better cut-through resistance so they are more reliable and durable.
2. Less affected by noise or cross-talk or electromagnetic inference.
3. Coaxial cables support multiple channels

**Disadvantages:**

1. Coaxial cables are expensive.
2. The coaxial cable must be grounded in order to prevent any crosstalk.
3. As a Coaxial cable has multiple layers it is very bulky.

**2. Twisted Pair Cable**

Twisted pair cables consist of pairs of wires twisted together to reduce electromagnetic interference (EMI) from external sources and crosstalk between neighboring pairs. This cable type is commonly used in telecommunications and networking applications, particularly for Ethernet networks**.**

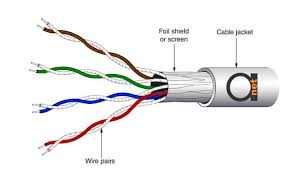
* **Shielded Twisted Pair (STP) Cable**

**Construction**: STP cables have an additional shielding (usually a foil or braided shield) around each pair of wires or around the overall cable, which helps to further reduce EMI and crosstalk.

**Common Variants**:

* + **Individual Shielding**: Each pair of wires is individually shielded.
  + **Overall Shielding**: A single shield is placed around all pairs within the cable.
  + **Combination**: Some cables may have both individual and overall shielding for maximum protection.

**Figure**:



#### **Advantages**:

* **Improved EMI Protection**: The shielding provides superior protection against external interference and crosstalk, making it ideal for environments with high EMI.
* **Better Performance**: Capable of maintaining signal integrity over longer distances and at higher speeds compared to UTP.

#### **Disadvantages**:

* **Higher Cost**: Generally more expensive than UTP cables due to the additional materials and construction complexity.
* **Less Flexible**: The shielding adds bulk and rigidity, making the cable less flexible and harder to install.
* **Grounding Issues**: Improper grounding of the shield can lead to performance issues, including signal reflection and interference.

#### **Applications**:

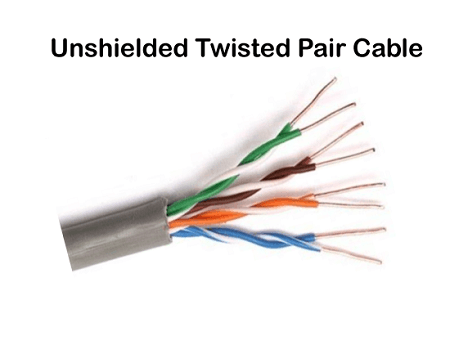
* **Industrial Environments**: Used in environments with high levels of EMI, such as factories or data centers, where signal integrity is critical.
* **High-Speed Networks**: Suitable for applications requiring high data rates and long-distance transmission without signal degradation.
* **Sensitive Data Transmission**: Preferred in situations where data security and integrity are paramount, due to the reduced risk of interference.
* **Unshielded Twisted Pair (UTP) Cable**

**Construction**: UTP cables consist of pairs of copper wires twisted together without any additional shielding. Each pair is twisted to different degrees to help minimize interference.

**Common Categories**:

* + **Cat5e**: Supports up to 1 Gbps Ethernet over distances up to 100 meters.
  + **Cat6**: Supports up to 10 Gbps Ethernet over short distances and 1 Gbps over 100 meters.
  + **Cat6a**: Enhanced version of Cat6, supports up to 10 Gbps over 100 meters.

**Figure:**



#### **Advantages**:

* **Cost-Effective**: Generally less expensive than STP and other types of cables.
* **Flexibility**: Easier to install and more flexible due to the absence of shielding.
* **Widely Available**: Standardized and widely used in many networking applications, making it readily available.

#### **Disadvantages**:

* **Less Protection**: More susceptible to electromagnetic interference (EMI) and crosstalk compared to shielded cables.
* **Shorter Distance at High Speeds**: Performance may degrade over longer distances, particularly at higher data rates.

#### **Applications**:

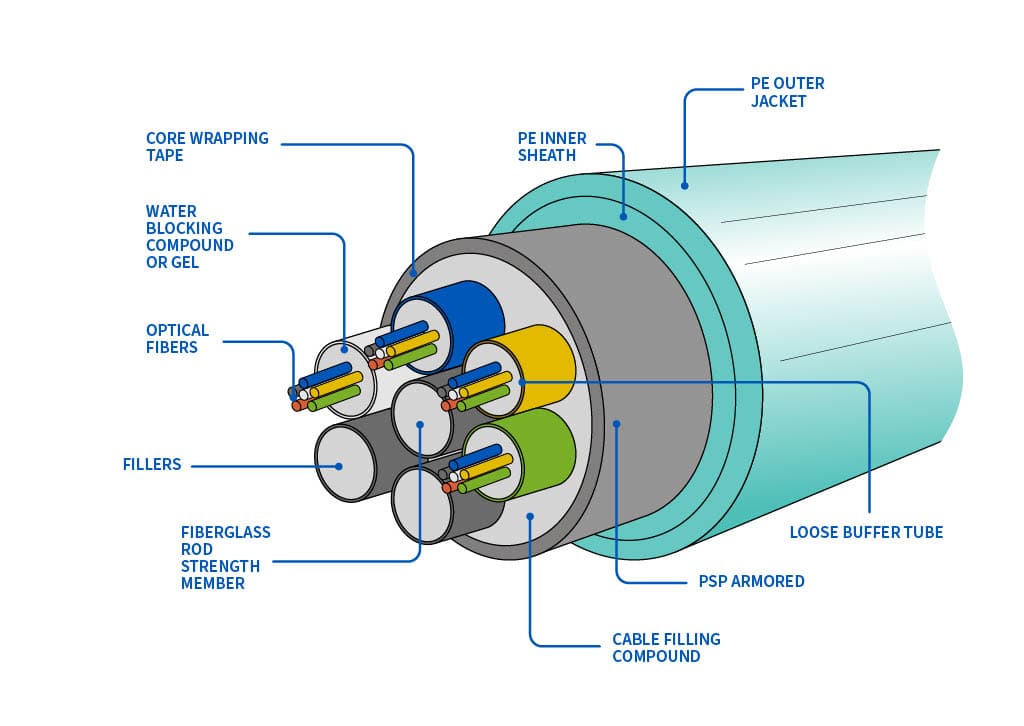
* **Local Area Networks (LANs)**: Widely used in Ethernet networks for connecting computers, switches, routers, and other network devices.
* **Telephone Networks**: Commonly used in both traditional and VoIP telephone systems.
* **Residential Cabling**: Used for home networking and Internet connections.

**3. Fiber Optical Cable**

**Fiber optical cables** are advanced communication cables that use light to transmit data over long distances at high speeds. These cables consist of one or more optical fibers, which are thin strands of glass or plastic that carry light signals.

* **Structure**: Fiber optical cables are made up of several layers:
  + **Core**: The innermost part of the fiber, made of glass or plastic, where the light travels.
  + **Cladding**: Surrounds the core and reflects light back into the core to prevent signal loss.
  + **Buffer Coating**: Protects the fiber from moisture and physical damage.
  + **Strengthening Elements**: Provide additional protection and tensile strength, usually made of Kevlar or other strong materials.
  + **Outer Jacket**: The external layer that protects the cable from environmental damage.
* **Types**:
  + **Single-Mode Fiber (SMF)**: Has a small core (about 9 microns) and is designed for long-distance communication with higher bandwidth.
  + **Multi-Mode Fiber (MMF)**: Has a larger core (50-62.5 microns) and is used for shorter distances, typically within buildings or campuses.

**Figure:**



**Advantages of Fiber Optic Cables:**

* High bandwidth for fast data transmission.
* Long-distance transmission with minimal signal loss.
* Immune to electromagnetic interference (EMI).
* Enhanced security, as tapping is difficult.
* Lightweight and thinner than copper cables**.**

**Disadvantages:**

* More expensive than copper cables, including installation costs.
* Fragile and prone to breaking if mishandled.
* Complex installation requiring specialized equipment and expertise.
* Less widespread infrastructure, especially in rural areas.

**Applications:**

* Internet backbone and telecommunications infrastructure.
* Data centres for fast data transfer.
* Enterprise networks for secure communication.
* Medical imaging and sensing.

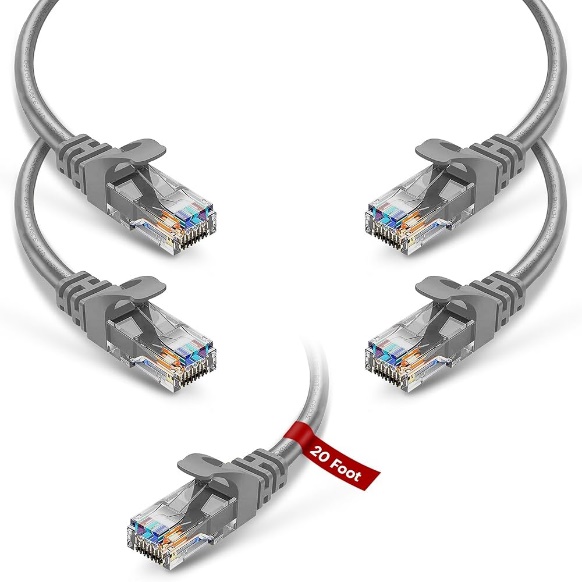
1. **Patch Cable**

**Patch cables** are short-length cables used to connect devices to a network or to interconnect networking devices like switches, routers, and patch panels. They can be made from various types of cables, including twisted pair (UTP/STP) and fiber optic cables, depending on the specific application.

**Structure**:

* + **Twisted Pair Patch Cable**: Usually made from Cat5e, Cat6, or Cat6a UTP or STP cables, with RJ45 connectors on both ends.
  + **Fiber Optic Patch Cable**: Made from fiber optic cables with connectors such as LC, SC, or ST on both ends.
  + **Length**: Typically ranges from 1 to 10 feet, but can be longer or shorter based on specific needs.
  + **Connectors**: Terminated with connectors that match the devices they connect, like RJ45 for Ethernet, LC/SC for fiber optics, or others depending on the application.

**Figure**:



### Advantages:

* **Easy to Use**: Simple to connect and disconnect, making them ideal for temporary connections and quick changes in network configurations.
* **Versatile**: Available in various lengths, colors, and types, making it easy to organize and manage connections in networking setups.
* **Reliable Connections**: Provides a stable and reliable connection between network devices, ensuring consistent data transfer.
* **Cost-Effective**: Generally inexpensive and readily available, making them a practical choice for most networking needs.

### Disadvantages:

* **Limited Length**: Typically designed for short distances, so they are not suitable for long-range connections between network devices.
* **Potential for Tangles**: If not managed properly, patch cables can create a tangled mess, especially in environments with many connections, leading to difficult troubleshooting and maintenance.
* **Cable Management Issues**: Overuse or poor organization of patch cables can lead to cluttered spaces, which can impact airflow in data centers and increase the risk of damage.

### Applications:

* **Networking Equipment Connections**: Commonly used to connect networking devices such as switches, routers, and patch panels in network racks.
* **End-User Device Connections**: Used to connect computers, printers, and other network devices to wall outlets or network jacks.
* **Data Centers**: Essential for connecting servers, storage devices, and networking equipment within data center racks.
* **Telecommunications**: Used in telecommunications rooms and setups to connect equipment, ensuring proper signal routing and management.

**Ref:** http://swayam.gov.in/

Computer Networking- A Top-Down approach (6th edition), Kurose and Ross, Pearson

**Procedure to prepare cross-wired cable and straight through cable using clamping tool**

1. Start by stripping off about 2 inches of the plastic jacket off the end of the cable. Be very careful at this point, as to not nick or cut into the wires, which are inside. Doing so could alter the characteristics of your cable, or even worse render is useless. Check the wires, **one more time** for nicks or cuts. If there are any, just whack the whole end off, and start over.
2. Spread the wires apart, but be sure to hold onto the base of the jacket with your other hand. You do not want the wires to become untwisted down inside the jacket. Category 5 cable must only have 1/2 of an inch of 'untwisted' wire at the end; otherwise it will be 'out of spec'. At this point, you obviously have ALOT more than 1/2 of an inch of un-twisted wire.
3. You have 2 end jacks, which must be installed on your cable. If you are using a pre-made cable, with one of the ends whacked off, you only have one end to install - the crossed over end. Below are two diagrams, which show how you need to arrange the cables for each type of cable end. Decide at this point which end you are making and examine the associated picture below.

## Following diagram shows you how to prepare Cross wired connection

## 

**Fig. 2. Cross Wired Connections.**

Following diagram shows you how to prepare straight through wired connection

## 

**Fig. 3. Straight Through Wired Connections.**

**Answer:**

```docx

**Answer: Cases Where Above Cables Are Used**

To understand the usage of network cables, it's important to first classify the types of cables commonly used in computer networks. While the provided text doesn't specify \*which\* cables, it \*does\* describe network devices and their applications, implying the context is Ethernet cables (primarily twisted pair) and potentially fiber optic cables. So, the following answer will be based on these cables.

• **Types of Network Cables**

• **Twisted Pair Cable:** This is the most common type of cable used in Ethernet networks. It consists of pairs of wires twisted together to reduce electromagnetic interference. There are two main types:

• **Unshielded Twisted Pair (UTP):** This is the most common type due to its low cost and ease of use.

• **Shielded Twisted Pair (STP):** This type has a foil or braid shield around the wires to provide better protection against interference.

• **Fiber Optic Cable:** This cable transmits data as light pulses through thin strands of glass or plastic. It offers much higher bandwidth and longer distances than twisted pair cables.

• **Coaxial Cable:** While less common in modern LANs, it's still used for cable TV and some older network installations.

• **Cases Where Cables are Used**

• **UTP Cable Applications:**

• **Local Area Networks (LANs):** UTP cables are the workhorse of most office and home networks, connecting computers, printers, and other devices to a central switch or router. Common categories include Cat5e, Cat6, and Cat6a.

• ***Example:*** Connecting a desktop computer to a network switch in an office environment.

• ***Example:*** Linking a wireless access point to a router.

• **Short-Distance Connections:** UTP is suitable for relatively short distances (up to 100 meters) within a building.

• **Telephony:** Older telephone systems often used UTP cable. While digital phone systems using VoIP now often share the same Ethernet infrastructure as data networks.

• **Cost-Effective Solutions:** When budget is a primary concern, UTP is a good choice for many network installations.

• **STP Cable Applications:**

• **Environments with High Interference:** STP is used in areas with significant electromagnetic interference (EMI), such as factories with heavy machinery or near radio transmitters.

• ***Example:*** Connecting devices in an industrial plant where electrical noise is prevalent.

• **Security-Sensitive Environments:** In some environments where eavesdropping is a concern, the shielding can provide some added protection against signal interception.

• **High-Performance Networks:** In situations where minimizing signal degradation is critical, STP can provide a more reliable connection.

• **Fiber Optic Cable Applications:**

• **Long-Distance Connections:** Fiber optic cables can transmit data over very long distances (kilometers) without significant signal loss.

• ***Example:*** Connecting buildings in a campus network.

• ***Example:*** Connecting cities or countries through undersea cables.

• **High-Bandwidth Applications:** Fiber is used for applications requiring very high bandwidth, such as video streaming, data centers, and backbone networks.

• ***Example:*** Connecting servers in a data center.

• ***Example:*** Supporting high-speed internet connections to homes and businesses (FTTH - Fiber to the Home).

• **Electrically Isolated Environments:** Because fiber optic cables transmit light instead of electricity, they are immune to electrical interference and are used in environments where electrical isolation is important.

• ***Example:*** Medical equipment or industrial control systems.

• **Secure Communications:** Fiber optic cables are more difficult to tap into than copper cables, making them suitable for secure communications.

• **Coaxial Cable Applications:**

• **Cable Television (CATV):** This is the most common application for coaxial cable.

• **Older Ethernet Networks:** Older 10BASE2 (Thinnet) and 10BASE5 (Thicknet) Ethernet networks used coaxial cable. These are largely obsolete.

• **Connecting Antennas:** Coaxial cable is used to connect antennas to receivers and transmitters, such as for radio communications or satellite dishes.

• **Security Systems:** For connecting CCTV cameras to recording devices.

• **Summary Table:**

<table>Cable Type|Typical Applications|Advantages|Disadvantages

UTP|LANs, short-distance connections|Low cost, easy to install|Limited distance, susceptible to interference

STP|High-interference environments, security-sensitive areas|Improved interference protection|More expensive, harder to install

Fiber Optic|Long-distance connections, high-bandwidth applications|High bandwidth, long distance, immune to interference|Expensive, requires specialized equipment

Coaxial|Cable TV, older Ethernet networks|Good bandwidth, relatively inexpensive|Bulky, limited distance compared to fiber</table>

*[Diagram: A diagram showing the cross-sections of UTP, STP, Fiber Optic, and Coaxial cables side-by-side for visual comparison. Each cable should be labeled with its name and a brief description of its components.]*

• **Choosing the Right Cable**

The choice of cable depends on several factors:

• **Bandwidth Requirements:** How much data needs to be transmitted?

• **Distance:** How far does the signal need to travel?

• **Budget:** How much can be spent on cabling?

• **Environmental Conditions:** Is there significant electrical interference?

• **Security Concerns:** Are there concerns about eavesdropping?

By considering these factors, you can select the most appropriate cable for your specific networking needs.

```

**Quiz:** (Sufficient space to be provided for the answers)

**Answer:**

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# Differentiating Network Devices

Here's a detailed comparison of various network devices, focusing on their functionality, features, and applications:

• **Hub**:

• **What is a Hub?** A hub is a basic networking device used to connect multiple Ethernet devices in a local area network (LAN). It operates at the physical layer (Layer 1) of the OSI model.

• **Features of a Hub**:

• **Broadcast Transmission**: Transmits data packets to all connected devices, leading to unnecessary network traffic and potential collisions.

• **Simple Device**: Straightforward and easy to use, with no configuration needed.

• **Operates at Layer 1**: Does not process data; simply repeats packets to other ports.

• **No Traffic Filtering**: Every device connected receives all data packets sent over the network.

• **Half-Duplex Communication**: Devices can either send or receive data at one time, but not both simultaneously.

• **Limited Security**: Offers no security features for data filtering or protection due to the broadcast nature of data transmission.

• **Applications of a Hub**:

• **Small Home Networks**: Suitable for small home or office networks where simplicity is prioritized.

• **Legacy Systems**: May be employed in environments where older networking hardware is still in use.

• **Network Monitoring**: Can be used in setups where data needs to be captured for analysis since they broadcast all packets to all connected devices.

• **Types of Hubs**:

• **Passive Hub**: Connects devices and passes electrical signals without amplification. Does not require a power source. Suitable for small networks with short distances between devices.

• **Active Hub**: Amplifies and regenerates the signal before broadcasting it. Requires a power source and provides better performance than passive hubs. Used in larger networks.

• **Intelligent Hub**: Includes additional features such as remote management capabilities, diagnostics, and monitoring. Used in more complex networks where monitoring and management are essential.

*[Diagram: A diagram showing a hub with multiple devices connected to it. The hub is in the center, and arrows indicate that data is sent to all connected devices.]*

• **Router**:

• **What is a Router?** A router is a networking device that forwards data packets between computer networks, directing traffic on the Internet. It operates at the network layer (Layer 3) of the OSI model.

• **Features of a Router**:

• **Traffic Direction**: Analyzes incoming data packets and determines the best path to reach their destination.

• **Network Layer Operations**: Operates at the network layer, handling IP addresses and routing protocols.

• **Security**: Provides features such as firewalls, VPNs, and filtering to secure the network.

• **Dynamic Routing**: Supports routing protocols like OSPF, BGP, and RIP to dynamically adjust routes based on current network conditions.

• **Static Routing**: Allows manual configuration of routes for predictable and stable network performance.

• **Network Address Translation (NAT)**: Enables multiple devices on a local network to share a single public IP address.

• **Quality of Service (QoS)**: Prioritizes certain types of traffic to ensure critical applications receive adequate bandwidth.

• **Applications of a Router**:

• **Connecting Networks**: Connects multiple networks together, such as connecting a home network to the Internet.

• **Internet Access**: Directs data between devices and the Internet, enabling web browsing, email, and other online activities.

• **Network Segmentation**: Divides a network into multiple subnetworks for improved security and performance.

• **VPN Services**: Provides secure remote access to a network using VPN technology.

• **Types of Routers**:

• **Wired Routers**: Connect devices using Ethernet cables.

• **Wireless Routers**: Connect devices wirelessly using Wi-Fi.

• **Core Routers**: High-capacity routers used in the core of a network to forward large amounts of traffic.

• **Edge Routers**: Connect edge networks to the core network.

*[Diagram: A diagram showing a router connecting two different networks (e.g., a home network and the internet). Arrows indicate data flow between the networks.]*

• **Switch**:

• **What is a Switch?** A switch is a networking device that connects multiple devices in a network and forwards data packets to the correct destination based on their MAC addresses. It operates at the data link layer (Layer 2) of the OSI model.

• **Features of a Switch**:

• **Unicast Transmission**: Forwards data packets only to the intended recipient, reducing network congestion.

• **MAC Address Learning**: Learns the MAC addresses of connected devices and creates a MAC address table.

• **Operates at Layer 2**: Operates at the data link layer, handling MAC addresses.

• **Full-Duplex Communication**: Allows devices to send and receive data simultaneously.

• **VLAN Support**: Supports virtual LANs (VLANs) to segment the network for improved security and performance.

• **Quality of Service (QoS)**: Prioritizes certain types of traffic to ensure critical applications receive adequate bandwidth.

• **Applications of a Switch**:

• **Connecting Devices in a LAN**: Connects computers, printers, and other devices in a local area network.

• **Network Segmentation**: Segments a network into VLANs for improved security and performance.

• **Improving Network Performance**: Reduces network congestion by forwarding data only to the intended recipient.

• **Types of Switches**:

• **Unmanaged Switches**: Simple switches with no configuration options.

• **Managed Switches**: Switches with advanced configuration options, such as VLAN support, QoS, and port mirroring.

• **PoE Switches**: Switches that provide power over Ethernet (PoE) to connected devices.

*[Diagram: A diagram showing a switch with multiple devices connected to it. Arrows indicate data being sent directly between devices, rather than being broadcast.]*

• **Bridge**:

• **What is a Bridge?** A bridge is a networking device that connects two or more network segments together. It operates at the data link layer (Layer 2) of the OSI model.

• **Features of a Bridge**:

• **MAC Address Filtering**: Filters traffic based on MAC addresses to reduce network congestion.

• **Operates at Layer 2**: Operates at the data link layer, handling MAC addresses.

• **Forwarding Decisions**: Makes forwarding decisions based on MAC address tables.

• **Spanning Tree Protocol (STP)**: Prevents loops in the network by blocking redundant paths.

• **Applications of a Bridge**:

• **Connecting Network Segments**: Connects two or more network segments to create a larger network.

• **Reducing Network Congestion**: Reduces network congestion by filtering traffic based on MAC addresses.

*[Diagram: A diagram showing a bridge connecting two network segments. The bridge filters traffic between the segments based on MAC addresses.]*

• **Gateway**:

• **What is a Gateway?** A gateway is a networking device that connects two networks that use different protocols. It can operate at multiple layers of the OSI model, depending on the protocols being translated.

• **Features of a Gateway**:

• **Protocol Conversion**: Converts data between different protocols.

• **Interoperability**: Enables communication between networks that use different technologies.

• **Security**: Provides security features such as firewalls and access control lists.

• **Applications of a Gateway**:

• **Connecting Different Networks**: Connects networks that use different protocols, such as connecting a LAN to a WAN.

• **Enabling Interoperability**: Enables devices on different networks to communicate with each other.

*[Diagram: A diagram showing a gateway connecting two networks that use different protocols. The gateway translates data between the protocols.]*

• **Modem**:

• **What is a Modem?** A modem (modulator-demodulator) is a device that converts digital signals from a computer into analog signals for transmission over telephone lines and vice versa.

• **Features of a Modem**:

• **Signal Conversion**: Converts digital signals to analog and analog signals to digital.

• **Data Transmission**: Enables data transmission over telephone lines.

• **Applications of a Modem**:

• **Connecting to the Internet**: Connects computers to the Internet using telephone lines.

• **Types of Modems**:

• **Dial-up Modems**: Use telephone lines to connect to the Internet.

• **Cable Modems**: Use cable TV lines to connect to the Internet.

• **DSL Modems**: Use digital subscriber lines (DSL) to connect to the Internet.

*[Diagram: A diagram showing a modem connecting a computer to the internet via a telephone line.]*

• **Repeater**:

• **What is a Repeater?** A repeater is a networking device that amplifies and regenerates a signal to extend the distance it can travel. It operates at the physical layer (Layer 1) of the OSI model.

• **Features of a Repeater**:

• **Signal Amplification**: Amplifies the signal to overcome signal loss due to distance.

• **Signal Regeneration**: Regenerates the signal to reduce noise and distortion.

• **Applications of a Repeater**:

• **Extending Network Distance**: Extends the distance a signal can travel in a network.

*[Diagram: A diagram showing a repeater amplifying a signal. The signal is weak before the repeater and strong after the repeater.]*

• **NIC (Network Interface Card)**:

• **What is a NIC?** A network interface card (NIC) is a hardware component that enables a device to connect to a network. It provides a physical interface between the device and the network.

• **Features of a NIC**:

• **Physical Interface**: Provides a physical connection to the network.

• **MAC Address**: Contains a unique MAC address that identifies the device on the network.

• **Applications of a NIC**:

• **Connecting Devices to a Network**: Enables devices to connect to a network.

• **Types of NICs**:

• **Ethernet NICs**: Connect devices to an Ethernet network.

• **Wireless NICs**: Connect devices to a wireless network.

*[Diagram: A diagram showing a NIC inserted into a computer, with a network cable connected to the NIC.]*

<table>Device|Layer|Function|Key Features|Applications

Hub|Physical (Layer 1)|Connects devices, broadcasts data|Simple, inexpensive, broadcasts to all ports|Small, simple networks

Switch|Data Link (Layer 2)|Connects devices, forwards data based on MAC address|Intelligent, reduces collisions, VLAN support|Modern LANs, enterprise networks

Router|Network (Layer 3)|Connects networks, forwards data based on IP address|Connects networks, routing, NAT, firewall|Internet connectivity, network segmentation

Bridge|Data Link (Layer 2)|Connects network segments, filters traffic|Reduces congestion, MAC address filtering|Connecting older networks

Gateway|Various|Connects dissimilar networks, translates protocols|Protocol conversion, interoperability|Connecting networks with different protocols

Modem|Physical|Converts digital to analog and vice versa|Enables data transmission over phone lines|Dial-up internet access (legacy)

Repeater|Physical (Layer 1)|Amplifies and regenerates signals|Extends network distance|Extending network cable runs

NIC|Physical/Data Link|Provides network connectivity to a device|Physical interface, MAC address|Connecting devices to a network</table>

```

**Answer:**

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**Answer: Approximate Cost of Cables and Manufacturers**

While the provided lab manual excerpt offers valuable information on network devices like hubs and routers, it does ***not*** include details about network cable costs or manufacturers. Therefore, I will provide a general overview based on common knowledge of network cables. Note that prices are approximate and can vary significantly based on vendor, cable length, quantity purchased, and current market conditions.

• **Cable Types and Approximate Costs**:

• **Cat5e Cable**: This is an older standard, but still functional for many home networks. Expect to pay around $0.20 - $0.40 per foot. A 1000ft spool can cost $70 - $150.

• **Cat6 Cable**: Offers better performance than Cat5e, supporting Gigabit Ethernet. Cost is roughly $0.30 - $0.60 per foot. A 1000ft spool can cost $100 - $200.

• **Cat6a Cable**: An enhanced version of Cat6, offering even better performance and shielding, especially for 10 Gigabit Ethernet. Expect to pay $0.50 - $1.00 per foot. A 1000ft spool can cost $170 - $350.

• **Fiber Optic Cable**: Used for high-speed, long-distance connections. Costs vary widely based on type (single-mode or multi-mode), connectors, and length. Expect to pay $1.00 - $5.00+ per foot depending on the specification.

• **Note**: These costs are for the cable itself. Connectors (RJ45 for Cat5e/6/6a) and the labor to terminate the cables will add to the overall cost. Pre-made patch cables (e.g., 6ft Cat6 cable) typically range from $3-$10 depending on length and quality.

• **Manufacturers**:

• **CommScope**: A well-known manufacturer of a wide range of network infrastructure products, including high-quality cables.

• **Belden**: Another reputable manufacturer offering various types of network cables, known for their durability and performance.

• **Siemon**: Specializes in network cabling and infrastructure solutions, offering a range of Cat5e, Cat6, Cat6A, and fiber optic cables.

• **Leviton**: Offers a comprehensive selection of networking cables, including Cat5e, Cat6, and Cat6A, as well as connectivity products.

• **PANDUIT**: A global leader providing network cabling and connectivity solutions, known for their innovative and reliable products.

```

1. Find out the cases where above cables are used?

2. Differentiate each device.

3. Give approximate cost of each cable with name of 2 manufactures.

# References used by the students

# <https://www.bostonindia.in/blog/2019/05/01/network-cables-reference-guide.aspx>

# <https://www.geeksforgeeks.org/types-of-ethernet-cable/>

# Rubric wise marks obtained:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Rubrics | Practical Understanding | | Problem Solving | | Task Execution | | Documentation and Reporting | | Ethical and Professional Conduct | | Total |
| Good (2) | Avg.(1) | Good (2) | Avg. (1) | Good (2) | Avg. (1) | Good (2) | Avg.(1) | Good (2) | Avg. (1) |
| Marks |  |  |  |  |  |  |  |  |  |  |  |

**Experiment No: 3**

**AIM: Study of basic network command and Network configuration commands**

**Date:**

**Competency and Practical Skills:** Exploration of network commands to troubleshoot networking errors.

**Relevant CO: CO1:** Familiarize with the basic taxonomy - terminologies used in networking and the layered architecture of computer networks

**Objectives:** (a) To understand the usage of various network commands

(b) Perform commands with various options on given OS.

(c) Prepare the report with screenshots/Output and analyze the usage of each command.

**Equipment/Instruments:** Desktop/laptop

**Theory:**

The operating system consists of various built-in, command-line networking utilities that are used for network troubleshooting. There are many various commands such as:

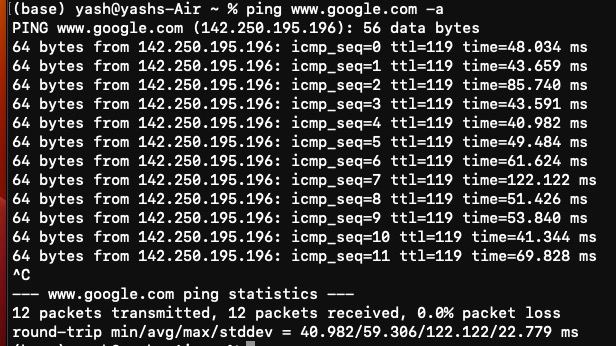
* Ping
* Ipconfig
* Tracert
* Hostname
* Pathping
* Route
* Nslookup
* Netstat
* ARP
* Getmac

1. **Ping:**

* The ping command is also known as **Packet Internet** **Groper**.
* The ping command is used to ensure that a computer can communicate to a specified device over the network.
* The pings command sends Internet Control Message Protocol (ICMP) Echo Request messages in the form of packets to the destination computer and waits in order to get the response back. Once the packets are received by the destined computer, it starts sending the packets back.
* This command keeps executing until it *si* interrupted.
* ping command provides details such as
* number of packets transmitted
* number of packets received
* time taken by the packet to return
* ping command in generally used for the following purposes:
* measuring the time taken by the packets to return to determine the speed of the connection
* to make sure that the network connection between the host and the destined computer can be established
* The ping command uses various options such as :
* target - This is the destination IP address or a hostname user want to ping.
* -a - This option resolves the hostname of an IP address target.
* -t - This ping command option will ping the target until you stop it by pressing Ctrl-C.
* -n count - This option is used to set the number of ICMP Echo Requests to send, from 1 to 4294967295. If -n is not specified, the ping command will return 4 by default.



**Fig. 1. Use of PING command to check connection**



**Fig. 2. Use of PING command with “–a” option**

# Getting Help

In any command mode, you can get a list of available commands by entering a question mark (?).

Router>**?**

To obtain a list of commands that begin with a particular character sequence, type in those characters followed immediately by the question mark (?).

Router#**co?**

Configure connect copy

To list keywords or arguments, enter a question mark in place of a keyword or argument. Include a space before the question mark.

Router#**configure?**

memory Configure from NV memory

network Configure from a TFTP network

host terminal Configure from the terminal

You can also abbreviate commands and keywords by entering just enough characters to make the command unique from other commands. For example, you can abbreviate the **show** command to **sh**.

# Configuration Files

Any time you make changes to the router configuration, you must save the changes to memory because if you do not they will be lost if there is a system reload or power outage. There are two types of configuration files: the running (current operating) configuration and the startup configuration.

Use the following privileged mode commands to work with configuration files.

* + **configure terminal** – modify the running configuration manually from the terminal.
  + **show running-config** – display the running configuration.
  + **show startup-config** – display the startup configuration.
  + **copy running-config startup-config** – copy the running configuration to the startup configuration.
  + **copy startup-config running-config** – copy the startup configuration to the running configuration.
  + **erase startup-config** – erase the startup-configuration in NVRAM.
  + **copy tftp running-config** – load a configuration file stored on a Trivial File Transfer Protocol (TFTP) server into the running configuration.
  + **copy running-config tftp** – store the running configuration on a TFTP server.

# IP Address Configuration

Take the following steps to configure the IP address of an interface.

Step 1: Enter privileged EXEC mode:

Router>**enable** password

Step 2: Enter the **configure terminal** command to enter global configuration mode. Router#**config terminal**

Step 3: Enter the **interface** type slot/port (for Cisco 7000 series) or **interface** type port (for Cisco 2500 series) to enter the interface configuration mode.

Example:

Router (config)#**interface ethernet 0/1**

Step 4: Enter the IP address and subnet mask of the interface using the **ip address** ipaddress subnetmask command.

Example,

Router (config-if) #**ip address 192.168.10.1 255.255.255.0**

Step 5: Exit the configuration mode by pressing Ctrl-Z

Router(config-if) #**[Ctrl-Z]**

**(Give details of each command as above)**

**Observations:**

**Answer:**

```docx

### Troubleshooting Network Connectivity: A Systematic Approach

When faced with network connectivity issues, a systematic approach to troubleshooting is essential. This involves using a series of commands and tools to diagnose the problem and identify the root cause. The following sequence outlines the typical troubleshooting steps, along with justifications for each command.

• \*\*Step 1: Verify Physical Connections\*\*

• \*\*Command:\*\* Visual inspection of cables, connectors, and device power.

• \*\*Justification:\*\* Physical layer problems are the most common and easiest to identify. Ensure all cables are securely connected to the correct ports on devices such as computers, routers, switches, and modems. Check power lights on devices to confirm they are powered on.

• \*\*Step 2: Check IP Configuration\*\*

• \*\*Command:\*\* `ipconfig /all` (Windows), `ifconfig` (Linux/macOS)

• \*\*Justification:\*\* This command displays the current IP address, subnet mask, default gateway, and DNS server settings of the device. Incorrect IP configuration can prevent communication with the network.

• **Common Issues to Look For**:

• Is an IP address assigned to the network interface? If not, there may be a problem with DHCP or the interface may be disabled.

• Is the IP address in the correct subnet? An incorrect subnet mask can prevent communication with other devices on the same network.

• Is the default gateway correct? The default gateway is the router that the device uses to send traffic to other networks. If the default gateway is incorrect, the device will not be able to access the internet or other networks.

• \*\*Step 3: Test Local Connectivity with `ping`\*\*

• \*\*Command:\*\* `ping <IP address of another device on the same subnet>`

• \*\*Justification:\*\* The `ping` command sends ICMP (Internet Control Message Protocol) echo requests to a specified IP address. If the target device responds, it confirms basic network connectivity within the local subnet.

• If the ping fails, it suggests a problem with:

• The network interface of the source or destination device.

• The cabling between the devices.

• A firewall on the destination device blocking ICMP traffic.

• \*\*Step 4: Test Default Gateway Connectivity with `ping`\*\*

• \*\*Command:\*\* `ping <IP address of the default gateway>`

• \*\*Justification:\*\* If local connectivity is working, the next step is to verify connectivity to the default gateway (usually the router). A successful ping confirms that the device can communicate with the router, which is necessary for accessing external networks.

• If the ping fails, it indicates a problem with:

• The router's network interface.

• The cable connecting the device to the router.

• A misconfigured default gateway on the device.

• \*\*Step 5: Test DNS Resolution with `ping`\*\*

• \*\*Command:\*\* `ping <hostname> (e.g., ping google.com)`

• \*\*Justification:\*\* This tests whether the DNS (Domain Name System) server is correctly resolving hostnames to IP addresses. If the ping to a hostname fails but pinging a known IP address (e.g., 8.8.8.8 for Google's public DNS) works, it suggests a DNS issue.

• If DNS resolution fails, possible causes include:

• An incorrect DNS server address configured on the device.

• A problem with the DNS server itself.

• A network issue preventing access to the DNS server.

• \*\*Step 6: Trace the Route with `tracert` (Windows) or `traceroute` (Linux/macOS)\*\*

• \*\*Command:\*\* `tracert <destination hostname or IP address>` (Windows), `traceroute <destination hostname or IP address>` (Linux/macOS)

• \*\*Justification:\*\* This command displays the path that packets take to reach a specified destination. It shows each hop (router) along the way and the time it takes to reach each hop. This can help identify where the connection is failing or experiencing high latency.

• By examining the output of `tracert` or `traceroute`, you can identify:

• The point at which the connection fails.

• Routers with high latency.

• Potential routing loops.

• \*\*Step 7: Use `nslookup` to Troubleshoot DNS Issues\*\*

• \*\*Command:\*\* `nslookup <hostname>`

• \*\*Justification:\*\* `nslookup` (Name Server Lookup) is a command-line tool used to query DNS servers. It helps verify if the DNS server is correctly resolving domain names to IP addresses and provides information about the DNS records for a domain.

• If `nslookup` fails to resolve a domain name, it could indicate:

• A problem with the DNS server.

• An incorrect DNS server address configured on the device.

• A network issue preventing access to the DNS server.

• \*\*Step 8: Check Firewall Settings\*\*

• \*\*Command:\*\* Review firewall configurations on the device and network devices.

• \*\*Justification:\*\* Firewalls can block network traffic based on predefined rules. Ensure that the firewall is not blocking necessary traffic, such as ICMP (for ping), DNS queries, or HTTP/HTTPS traffic.

• Common firewall issues include:

• Incorrectly configured rules.

• Blocking traffic from specific IP addresses or ports.

• Blocking outgoing connections.

• \*\*Step 9: Check Router Configuration\*\*

• \*\*Command:\*\* Access the router's web interface or command-line interface (CLI).

• \*\*Justification:\*\* Routers can have various configuration issues that can affect network connectivity.

• Common router issues include:

• Incorrect routing tables.

• DHCP server not assigning IP addresses correctly.

• Firmware issues.

• Misconfigured NAT (Network Address Translation) settings.

• Blocked ports or services.

• \*\*Step 10: Analyze Network Traffic with Wireshark\*\*

• \*\*Command:\*\* Run Wireshark to capture and analyze network packets.

• \*\*Justification:\*\* Wireshark is a powerful network protocol analyzer that allows you to capture and examine network traffic. This can help identify specific issues, such as:

• Malformed packets.

• Excessive retransmissions.

• Protocol errors.

• Security vulnerabilities.

By systematically following these steps and using the appropriate commands, you can effectively diagnose and resolve a wide range of network connectivity issues. Remember to document your findings and the steps you take to troubleshoot the problem, as this can be helpful for future reference.

```

**Quiz:** (Sufficient space to be provided for the answers)

1.Give the sequence of troubleshoots commands you will perform with proper justification if your network is not working.

Suggested Reference: <https://www.cisco.com/c/en/us/td/docs/routers/nfvis/switch_command/b-nfvis-switch-command-reference.html>

References used by the students: <https://www.cisco.com/c/en/us/td/docs/routers/nfvis/switch_command/b-nfvis-switch-command-reference.html>

# Rubric wise marks obtained:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Rubrics | Practical Understanding | | Problem Solving | | Task Execution | | Documentation and Reporting | | Ethical and Professional Conduct | | Total |
| Good (2) | Avg.(1) | Good (2) | Avg. (1) | Good (2) | Avg. (1) | Good (2) | Avg.(1) | Good (2) | Avg. (1) |
| Marks |  |  |  |  |  |  |  |  |  |  |  |

**Experiment No: 4**

**AIM: Implement different LAN topologies using Network Simulator**

**Date:**

**Competency and Practical Skills:** Exploration of network layout to connect devices with each other to establish network

**Relevant CO: CO-5** Implement different types of network using different tools and simulators

**Objectives:** (a) Download network simulator – preferably cisco packet tracer

(b) Implement topologies by configuring interconnecting devices and computing devices.

(c) Analyze the performance of connecting devices in different ways

**Equipment/Instruments:** Desktop/laptop, Network simulator

**Theory:**

**What is Network Topology?**

The arrangement of a network that comprises nodes and connecting lines via sender and receiver is referred to as network topology.

There are various types of topologies and they are:

* Bus Topology
* Star Topology
* Ring Topology
* Mesh Topology
* Hybrid Topology

1. **Bus Topology:**

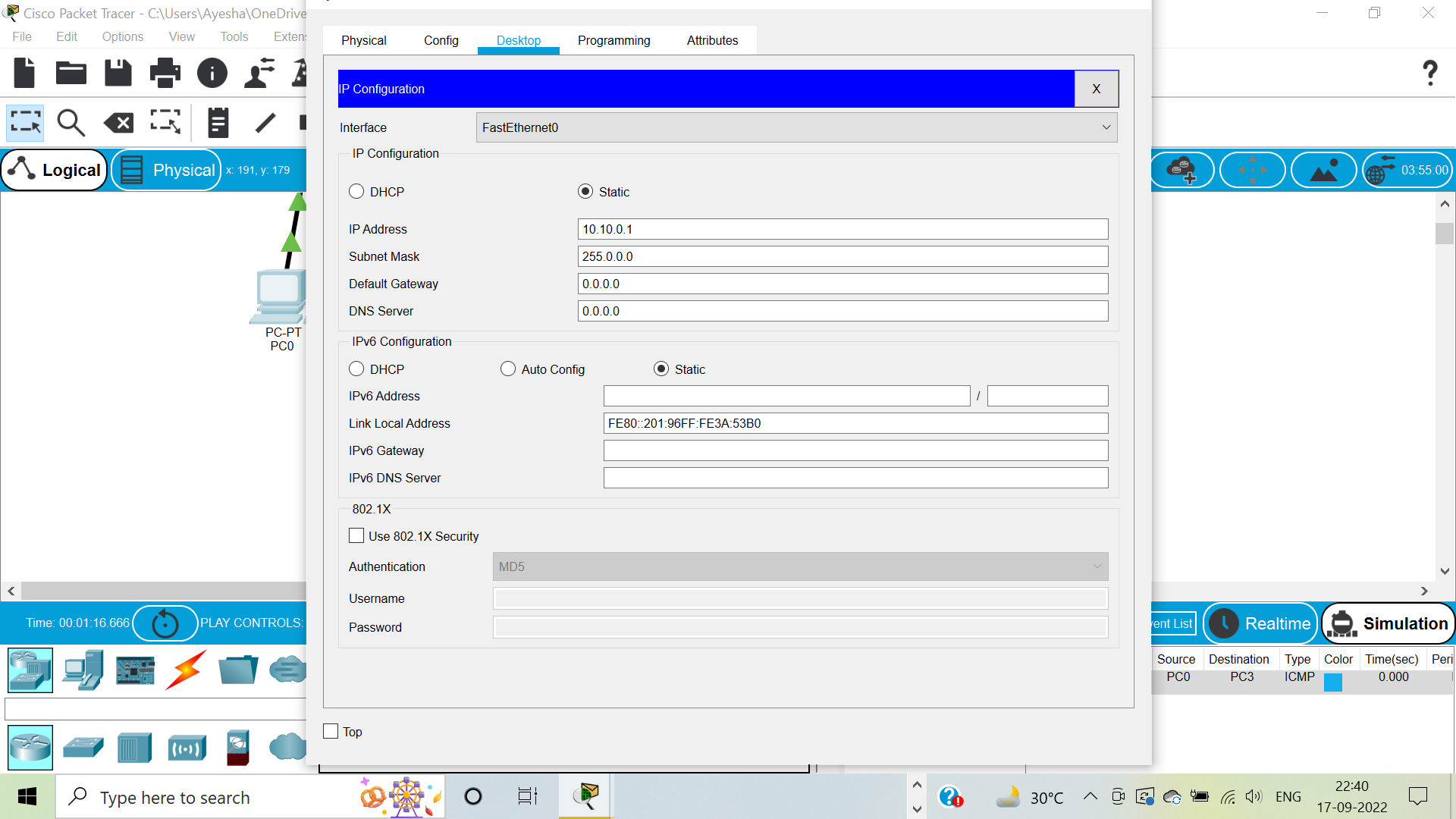
(Give details of each topology with advantages, disadvantages and applications.)

**Bus topology using Packet Tracer:**

* Take 4 switches, connect them through single cable.
* Each of the switches will be connected with an end device whose IP addresses are given.
* To configure the IP addresses of the devices “Click on the device for which you want to configure the IP address-> Click Desktop -> IP configuration -> Provide IP of your choice -> Press Tab for automatically having Subnet Mask which is: 255.0.0.0 for all the devices available in the topology.
* Provide IP addresses to all the End devices only and then you can send the data among these devices.

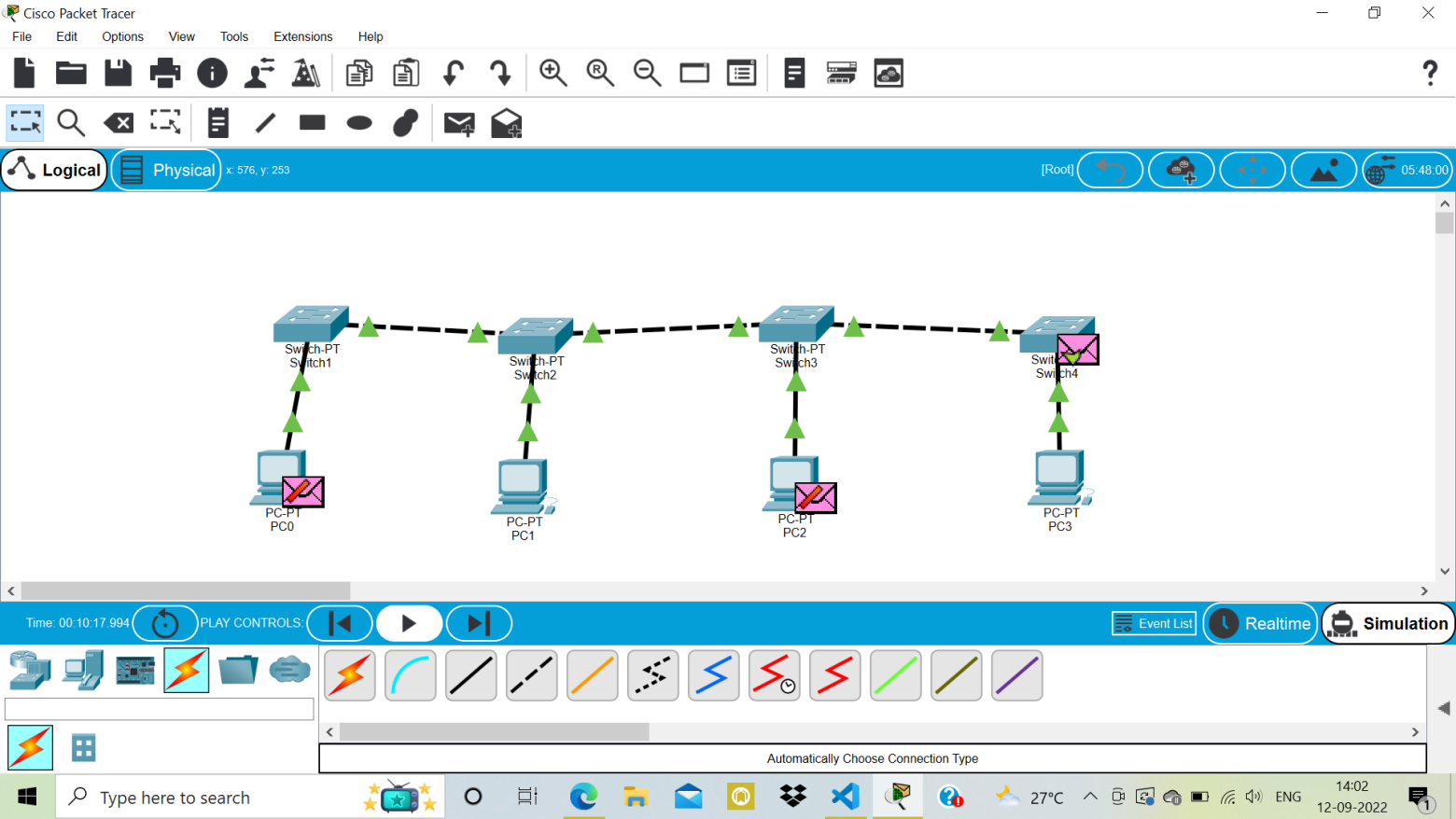


**Fig. 1. Bus Topology.**

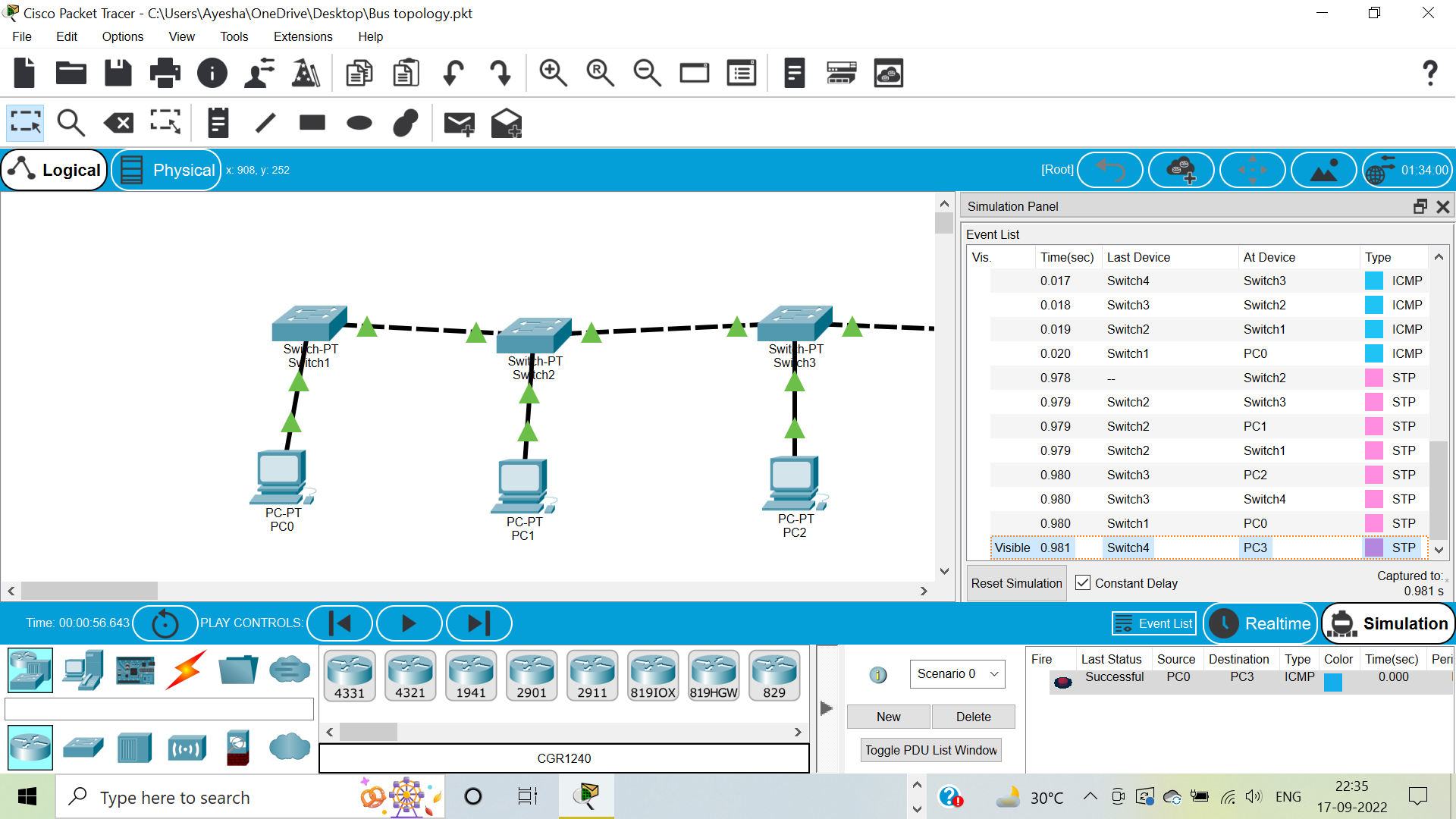


**Fig. 2. Static IP Configuration**

* Check the network by sending messages/packets from one device to another and check the status of the message as “Successful”. If the messages are not sent due to some reasons it will show “Failed” as the status of the message.



**Fig. 3. Bus topology configuration in simulator**



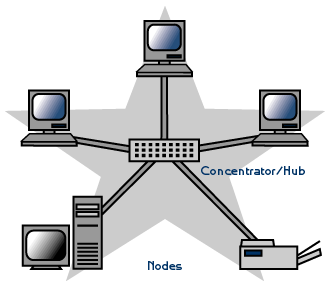
**Fig. 4. Bus topology simulation**

1. **Star Topology:**

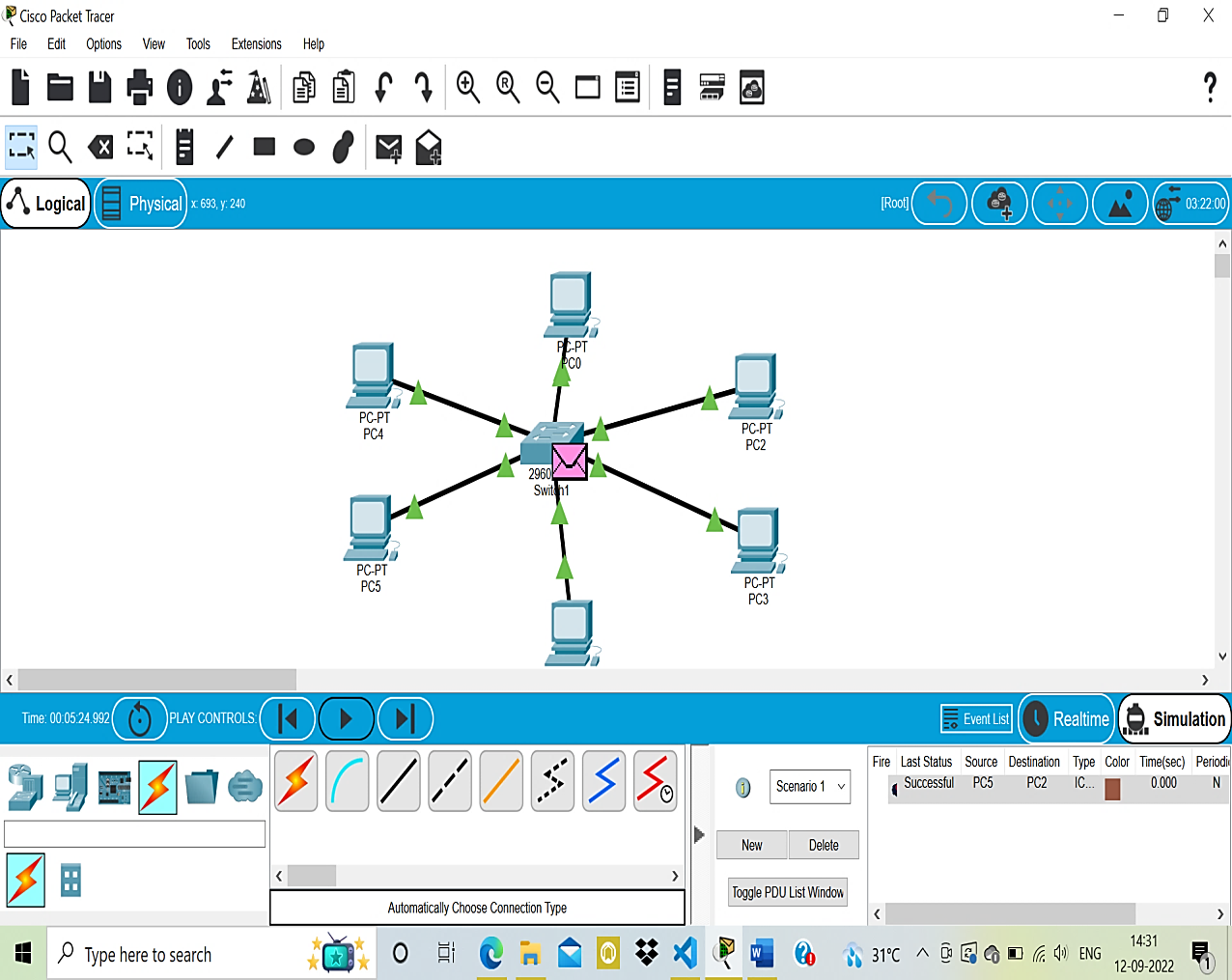
* A star topology is a topology for a Local Area Network (LAN) in which all nodes are individually connected to a central connection point, sort of a hub or a switch.

**Star Topology Using Packet Tracer:**

* Have a single switch which will be the central node.
* All the end devices are connected with the central switch so if any of the cable fail occurs it does not affect the whole system.
* Configure the IP address of all the connected devices.
* Send messages to other devices connected to the same Switch.
* As we can see in the below image we can send the messages from one device to another and we can also see the status of the message as “Successful” here. If the messages are not sent due to some reasons it will show “Failed” as the status of the message.



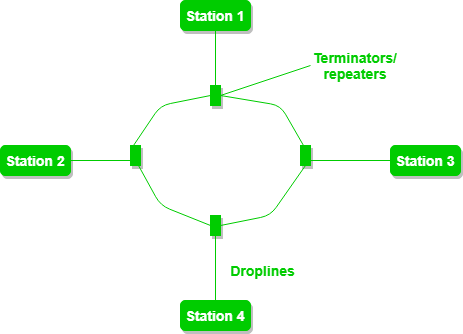
**Fig. 5. Star Topology.**



**Fig. 6. Star Topology in simulator.**

1. **Ring Topology:**

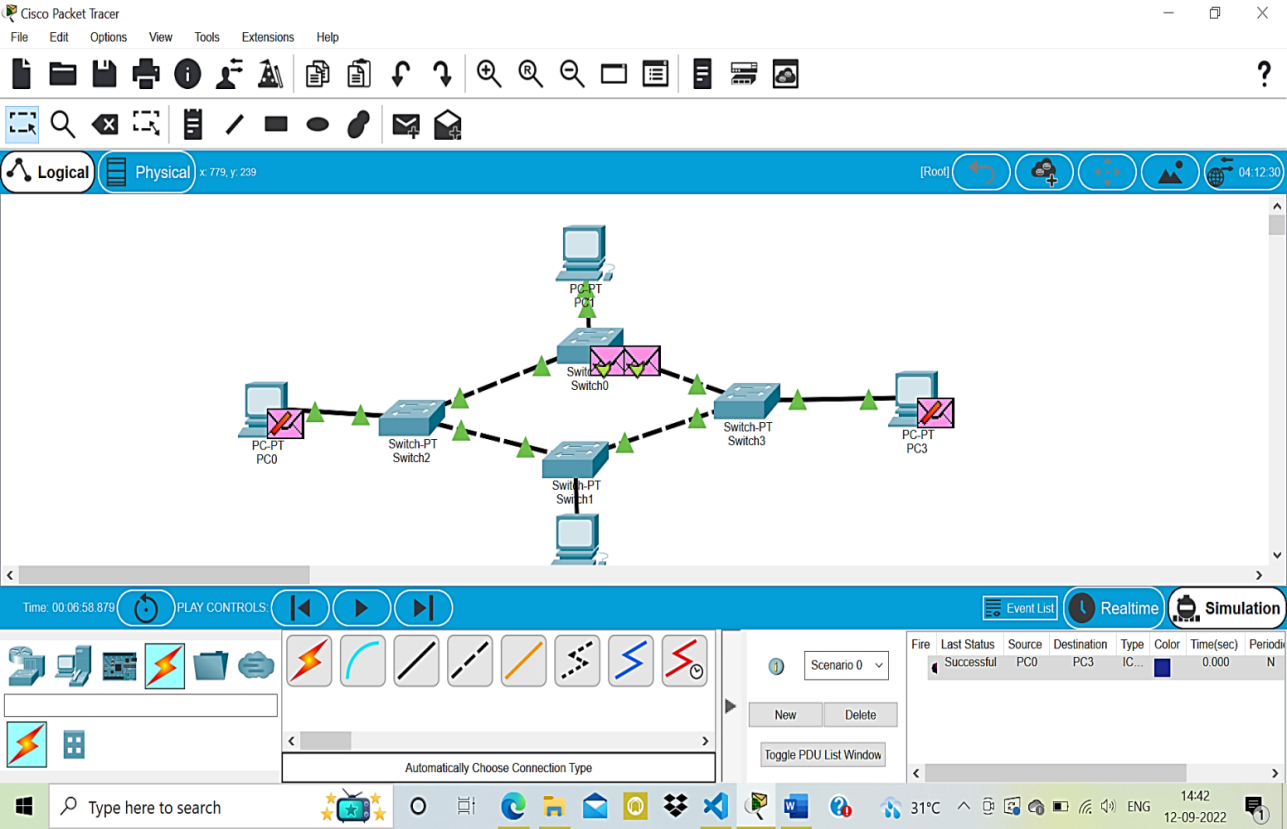
* In this topology, it forms a ring connecting devices with exactly two neighboring devices.
* It is a network configuration where device connections create a circular data path. In this each device is connected to with its exactly two neighboring devices, like points on a circle which forms like a ring structure.
* The most common access method of ring topology is token passing.



**Fig. 7. Ring Topology.**

**Ring Topology using Packet Tracer:**

* Take 4 switches and connect them with each other.
* Each of the hubs is connected with an end device whose IP addresses can be configured
* After configuring the IP addresses send messages to other devices connected in the Network.
* As we can see in the below image we can send the messages from one device to another and also see the status of the message as “Successful” here. If the messages are not sent due to some reasons it will show “Failed” as the status of the message.

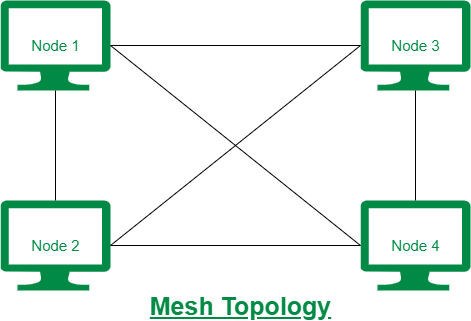


**Fig. 8. Ring Topology in simulator.**

**4. Mesh Topology:**

* In a mesh topology, every device is connected to another device via a particular channel.
* There are two types of Mesh topologies:

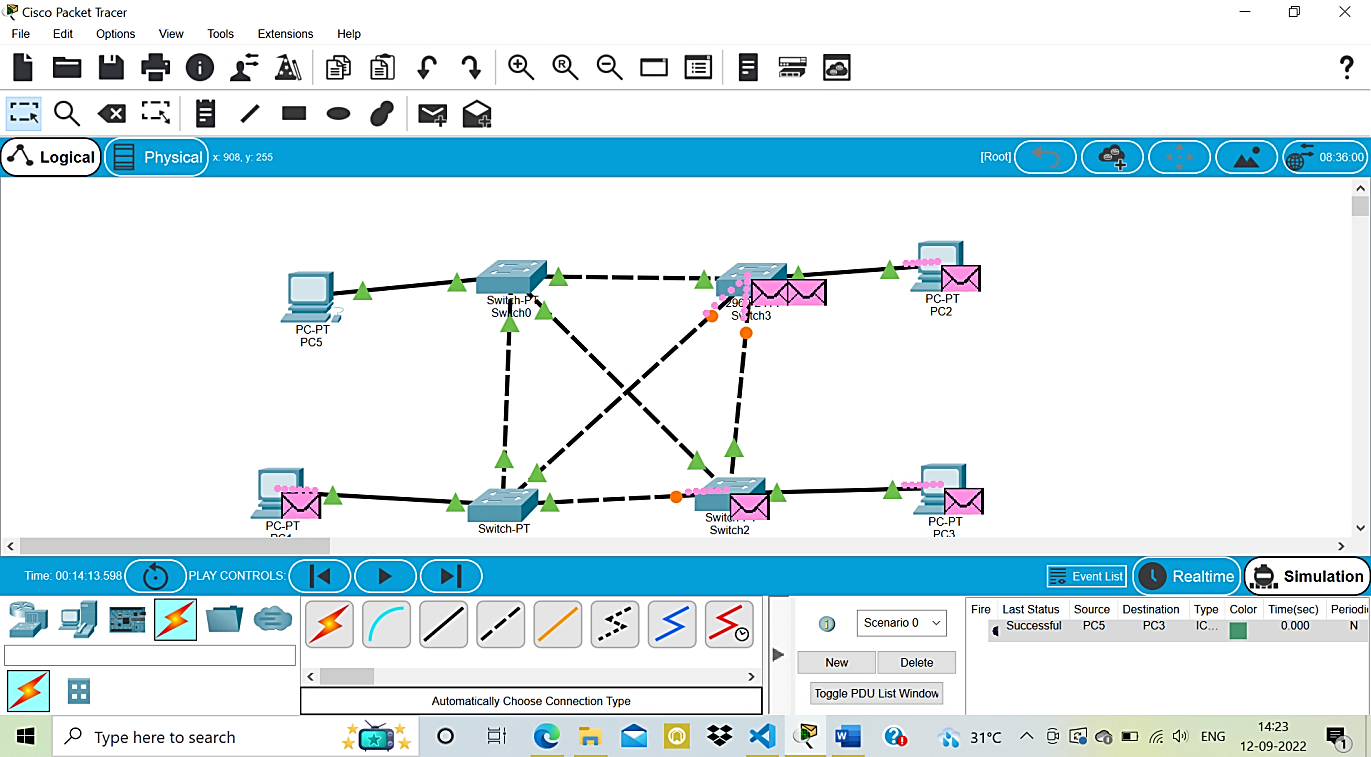
1. Fully-connected Mesh Topology
2. Partially-connected Mesh Topology



**Fig. 9. Mesh Topology**

**Mesh Topology using Packet Tracer:**

* 4 network switches which are connected to each other through network cables.
* Each of the switch is connected all the other switches as well as an end device.
* Configure the end devices and then can send the message to any other device connected to particular network.
* As we can see in the below image we can send the messages from one device to another and we can also see the status of the message as “Successful” here. If the messages are not sent due to some reasons it will show “Failed” as the status of the message.



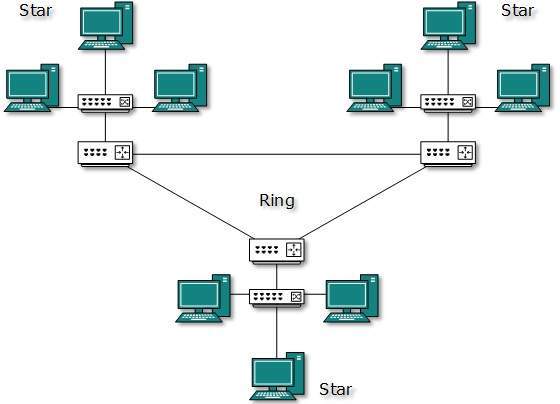
**Fig. 10. Mesh Topology in simulator.**

**5. Hybrid Topology:**

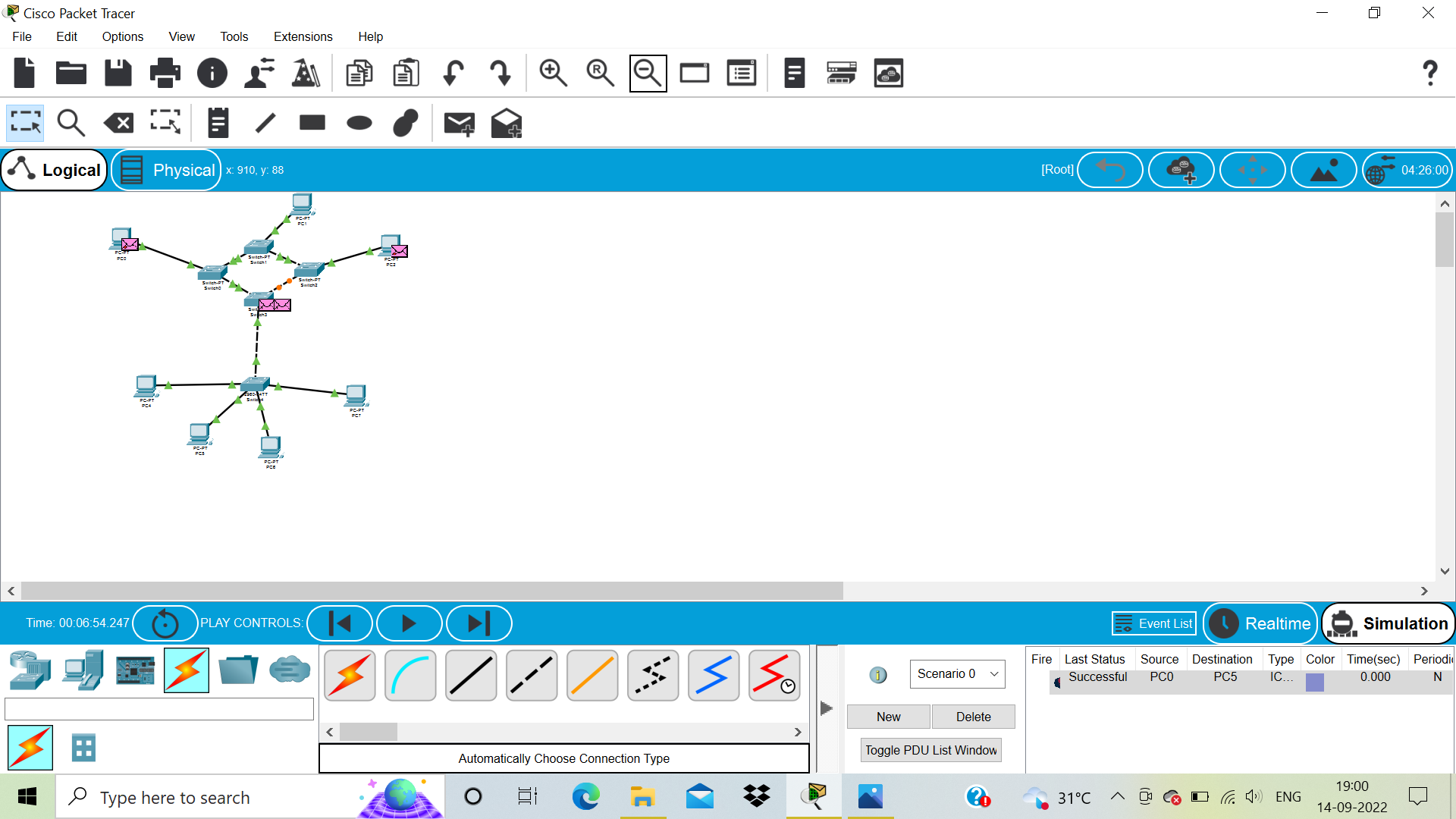
* A network structure whose design contains more than one topology is said to be hybrid topology. Hybrid topology inherits merits and demerits of all the incorporating topologies.

**Hybrid Topology Using Packet Tracer:**

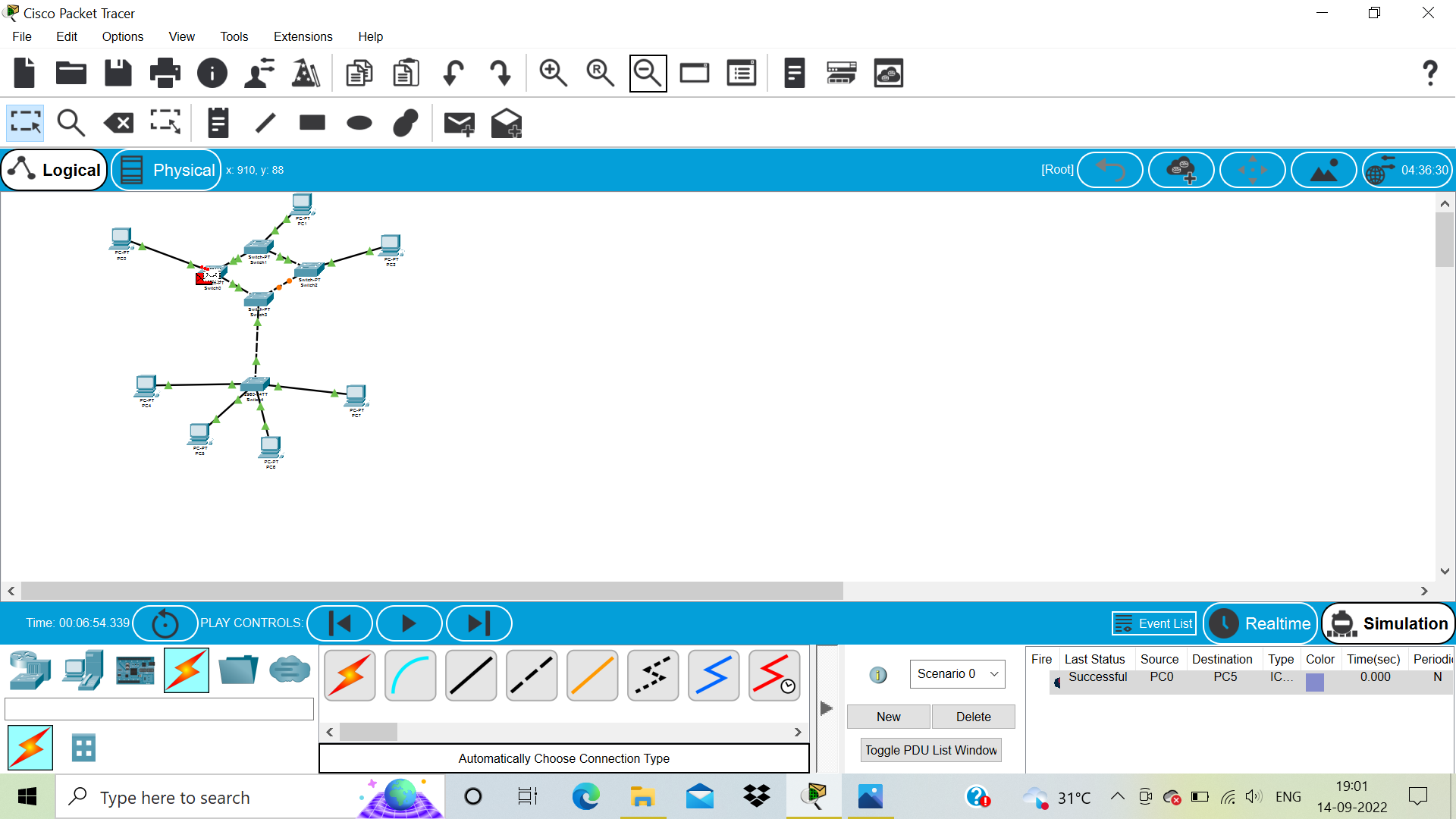
* Have 4 network switches which are connected to each other through network cables forming ring.
* Then have central switch which is connected to one of the switches used in forming ring and also to other devices forming star, thus forming hybrid topology.
* Each of the switch is connected all the other switches as well as an end device.
* We can configure the end devices as seen before and then can send the message to any other device connected to particular network.



**Fig. 11. Hybrid Topology.**

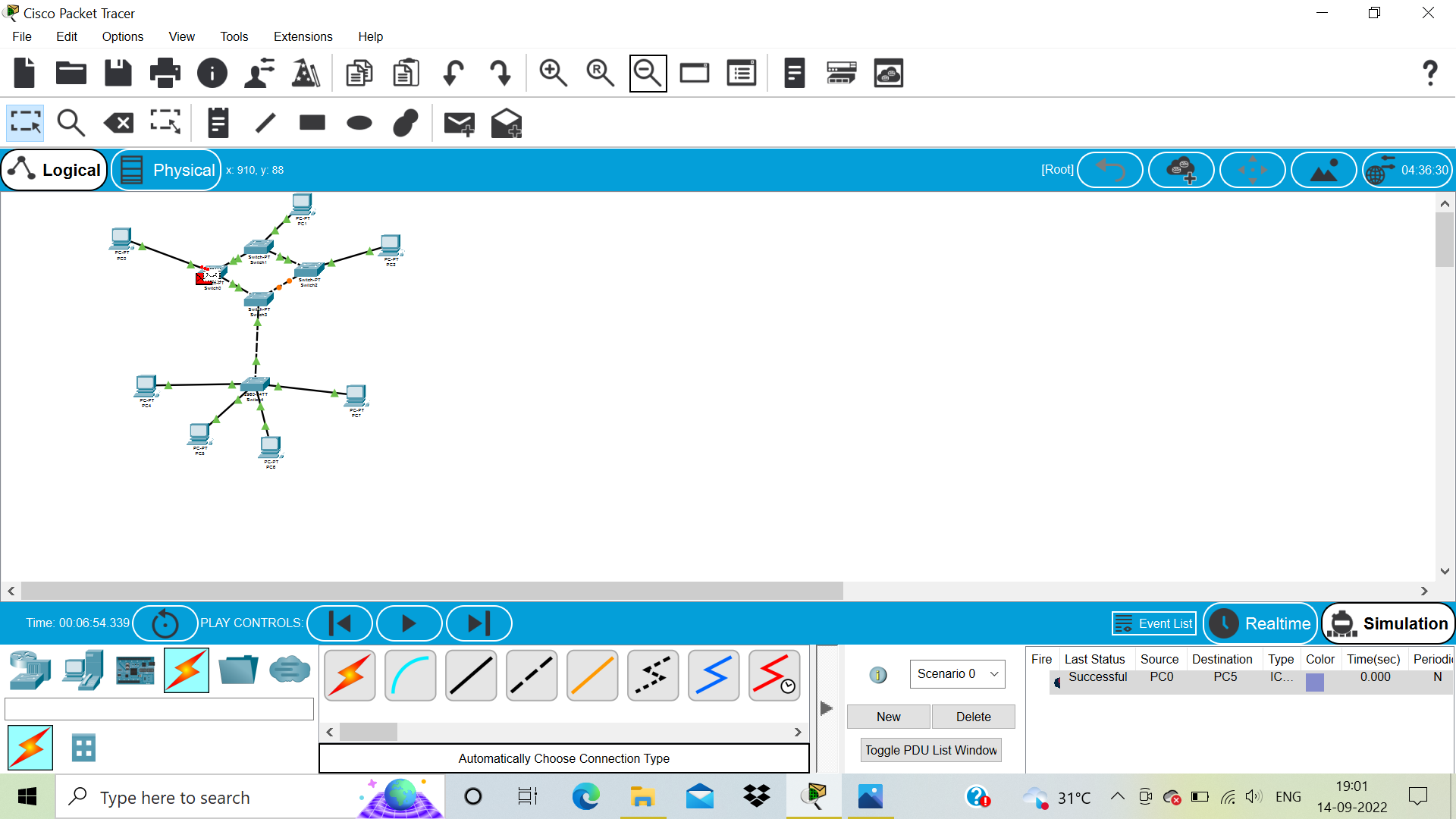


**Fig. 12. Hybrid Topology in simulator (Packet Sent).**



**Fig. 13. Hybrid Topology in simulator (Packet lost).**

* As we can see in the below image we can send the messages from one device to another and we can also see the status of the message as “Successful” here. If the messages are not sent due to some reasons it will show “Failed” as the status of the message.



**Fig. 14. Status of the sent message in simulator.**

**Observations:**

(1) Which topology or topologies are implemented at your institute?

**Answer:**

```docx

## Advantages and Disadvantages of Network Topologies

Here's a detailed look at the advantages and disadvantages of various network topologies:

### Bus Topology

• **Description:** In a bus topology, all devices are connected to a single cable called the bus or backbone.

*[Diagram: Devices connected to a single line, with terminators at each end.]*

• **Advantages:**

• *Simple and Easy to Implement:* Relatively inexpensive and easy to set up.

• *Low Cost:* Requires less cable compared to other topologies.

• *Suitable for Small Networks:* Works well for a small number of devices.

• **Disadvantages:**

• *Difficult Troubleshooting:* Identifying the source of a problem can be challenging.

• *Single Point of Failure:* If the main cable fails, the entire network goes down.

• *Limited Scalability:* Performance degrades as more devices are added due to increased traffic and collisions.

• *Not Suitable for Large Networks:* Performance bottlenecks and collisions become more frequent.

• *Security Risks:* all nodes on the network can see all data transmissions, posing a security risk.

### Star Topology

• **Description:** In a star topology, all devices are connected to a central hub or switch.

*[Diagram: Multiple devices connected to a central hub/switch in a star-like fashion.]*

• **Advantages:**

• *Easy to Troubleshoot:* Problems are easier to isolate since each device has a direct connection to the central hub.

• *Easy to Expand:* Adding new devices is simple and doesn't disrupt the network.

• *Reliable:* If one device fails, it doesn't affect the rest of the network.

• *Centralized Management:* Easier to monitor and manage the network from a central point.

• *Fault Isolation:* Failure of one node or cable does not affect the rest of the network.

• *High Scalability:* Additional nodes can be easily added to the network through the central device.

• *Reduced Congestion:* Using a switch instead of a hub significantly reduces network congestion.

• **Disadvantages:**

• *Central Point of Failure:* If the central hub/switch fails, the entire network goes down.

• *More Expensive:* Requires more cable than a bus topology.

• *Dependent on Central Device:* The performance of the network depends on the capacity of the central hub/switch.

### Ring Topology

• **Description:** In a ring topology, each device is connected to exactly two other devices, forming a circular path for data.

*[Diagram: Devices connected in a circular fashion, each connected to two neighbors.]*

• **Advantages:**

• *Relatively Simple:* Easier to manage than some other topologies.

• *Reduced Data Collision:* Data flows in one direction, reducing the chances of collisions.

• *Equal Access:* Each device gets a chance to transmit data.

• *Good Performance:* Performs better than bus topology under heavy network load.

• *Good for short distances:* Ring topologies are often more effective with shorter distances and higher speeds between nodes.

• *Reliability:* Data can be transmitted even if one node fails (with dual ring implementation).

• **Disadvantages:**

• *Difficult Troubleshooting:* Locating faults can be challenging.

• *Single Point of Failure:* Failure of one device can disrupt the entire network.

• *Difficult to Expand:* Adding or removing devices is more complex.

• *Latency:* Data must pass through multiple devices to reach its destination, which can increase latency.

• *Complexity:* implementing and managing a ring topology can be more complex than other basic topologies.

### Mesh Topology

• **Description:** In a mesh topology, each device is connected to every other device in the network (full mesh) or to several other devices (partial mesh).

*[Diagram: Multiple devices interconnected, with many or all devices directly connected to each other.]*

• **Advantages:**

• *Highly Reliable:* Multiple paths between devices provide redundancy.

• *Fault Tolerant:* If one path fails, data can be routed through another path.

• *Secure:* Difficult for unauthorized access due to the distributed nature.

• *No Traffic Problems:* each connection can simultaneously carry its own data.

• *Increased Capacity:* handles high traffic volume due to multiple routes.

• *Simplified Fault Detection:* Easy to identify fault points.

• **Disadvantages:**

• *Expensive:* Requires a lot of cabling.

• *Complex:* Difficult to install and manage, especially in a full mesh configuration.

• *Difficult to Manage:* managing and maintaining a mesh network can be complex and time-consuming.

• *High Space Requirements:* large networks need a lot of space.

### Tree Topology

• **Description:** A tree topology combines characteristics of bus and star topologies. It consists of a hierarchy of devices, with a root node connected to multiple branches, which in turn connect to other devices.

*[Diagram: A hierarchical structure with a root node branching out to multiple levels of star networks.]*

• **Advantages:**

• *Scalable:* Easier to expand than bus or star topologies.

• *Hierarchical Structure:* Easy to manage and maintain.

• *Point-to-Point Wiring:* For individual segments.

• *Easy to Manage:* Each branch can be managed independently.

• *Extension of Bus and Star Topologies:* supports characteristics of both topologies.

• **Disadvantages:**

• *Complex:* More complex than bus or star topologies.

• *Central Point of Failure:* If the root node fails, the entire network is affected.

• *Costly:* Can be more expensive than simpler topologies.

• *Maintenance Overhead:* High maintenance and management costs.

• *Difficult Configuration:* Requires specialized configuration due to its complexity.

### Hybrid Topology

• **Description:** A hybrid topology combines two or more different topologies to create a more robust and flexible network.

*[Diagram: A network combining different topologies like star and bus, or star and ring.]*

• **Advantages:**

• *Flexible:* Can be designed to meet specific network requirements.

• *Reliable:* Can inherit the fault tolerance of the combined topologies.

• *Scalable:* Can be expanded easily by adding new topologies.

• *Versatility:* Can be designed to meet specific organizational needs.

• *Adaptability:* well suited to accommodate future network expansion.

• *Effective Resource Utilization:* Enables optimal usage of available resources.

• **Disadvantages:**

• *Complex:* More complex to design and manage.

• *Expensive:* Can be more expensive than using a single topology.

• *Difficult to Manage:* Complex setup and management.

• *Design Complexity:* Requires careful planning and designing.

• *High Installation Cost:* complex implementation translates to high costs.

```

(2) If there is a small setup of your office having 10 Computers connected, which topology you will prefer? Why?

**Answer:**

```docx

**Experiment 1: Application Cases of Network Topologies**

This section explores application cases for different network topologies, highlighting their advantages and disadvantages in various scenarios.

**Hub**

• **What is a Hub?** A hub is a basic networking device used to connect multiple Ethernet devices in a local area network (LAN). It operates at the physical layer (Layer 1) of the OSI model.

• **Features of a Hub:**

• **Broadcast Transmission:** Transmits data packets to all connected devices.

• **Simple Device:** Easy to use with no configuration needed.

• **Layer 1 Operation:** Operates at the physical layer, repeating signals to all ports.

• **No Traffic Filtering:** Does not filter traffic, leading to potential collisions.

• **Half-Duplex Communication:** Supports half-duplex communication.

• **Limited Security:** Offers no security features for data filtering.

• **Applications of a Hub:**

• **Small Home Networks:** Suitable for small networks where simplicity is prioritized.

• **Legacy Systems:** Used in environments with older networking hardware.

• **Network Monitoring:** Can be used to capture data for analysis.

• **Device Connectivity:** Connects multiple devices in a LAN without advanced management.

• **Types of Hubs:**

• **Passive Hub:** Connects devices and passes signals without amplification.

• Features: No power source needed, does not strengthen signals.

• Use Case: Small networks with short distances between devices.

• **Active Hub:** Amplifies and regenerates the signal.

• Features: Requires power, provides better performance.

• Use Case: Larger networks where the signal needs to be strengthened.

• **Intelligent Hub:** Includes remote management and monitoring capabilities.

• Features: Network management, diagnostics, troubleshooting.

• Use Case: Complex networks where monitoring is essential.

*[Diagram: Diagram of a hub with multiple connected devices, illustrating broadcast transmission.]*

**Router**

• A router is a networking device that forwards data packets between computer networks, directing traffic on the Internet. It operates at the network layer (Layer 3) of the OSI model.

• **Features of a Router:**

• **Traffic Direction:** Analyzes incoming data packets and determines the best path.

• **Network Layer Operations:** Operates at the network layer, handling IP addresses and routing protocols.

• **Security:** Provides features such as firewalls, VPNs, and filtering.

• **Dynamic Routing:** Supports routing protocols like OSPF, BGP, and RIP.

• **Static Routing:** Allows manual configuration of routes for predictable performance.

• **Network Address Translation (NAT):** Enables multiple devices to share a single public IP address.

• **Quality of Service (QoS):** Prioritizes traffic to ensure critical applications receive adequate bandwidth.

• **Applications of a Router:**

• **Connecting Networks:** Connects multiple networks, such as a LAN to the Internet.

• **Internet Access:** Provides internet access to devices on a local network.

• **Network Segmentation:** Segments networks to improve security and performance.

• **VPN Connections:** Establishes secure connections between networks.

• **Wireless Networking:** Provides wireless connectivity in homes and offices.

• **Types of Routers:**

• **Wired Routers:** Connect devices via Ethernet cables.

• Use Case: Homes, offices, and data centers where wired connections are preferred for stability and speed.

• **Wireless Routers:** Provide wireless connectivity via Wi-Fi.

• Use Case: Homes, small offices, and public places where mobility and convenience are important.

• **Core Routers:** High-capacity routers that handle large volumes of traffic within an ISP's network.

• Use Case: Backbone of the Internet and large enterprise networks.

• **Edge Routers:** Connect internal networks to external networks like the Internet.

• Use Case: Enterprise networks and ISPs for connecting to the wider Internet.

• **Virtual Routers:** Software-based routers that run on virtual machines.

• Use Case: Cloud environments and software-defined networking (SDN).

*[Diagram: Diagram of a router connecting multiple networks, showing traffic flow and different types of connections (wired, wireless).]*

```

(3) Interpret and analyze the output of each topology

**Answer:**

```docx

Choosing a Campus Network Topology

The selection of a network topology for a campus environment is a critical decision that impacts performance, scalability, cost, and manageability. Several factors must be considered, including the size of the campus, the number of users, the types of applications used, and the budget. Given these considerations, a ***hierarchical star topology***, often incorporating elements of other topologies, is generally the most suitable choice for a campus network.

Rationale for Choosing a Hierarchical Star Topology

• **Scalability**: A hierarchical star topology allows for easy expansion. New buildings or departments can be added to the network without disrupting the existing infrastructure. This is achieved by connecting new star networks to the higher-level distribution or core layers.

• **Fault Tolerance**: The hierarchical design enhances fault tolerance. If a switch or link fails in one part of the network, it typically does not affect other parts of the network. Redundant links can be implemented at the core and distribution layers to provide even greater resilience.

• **Manageability**: Centralized management is a key advantage. Network administrators can monitor and manage the entire network from a central location. This includes configuring security policies, monitoring network performance, and troubleshooting issues.

• **Performance**: By segmenting the network into smaller star networks, traffic is localized, reducing congestion and improving performance. High-bandwidth links can be used at the core and distribution layers to ensure fast data transfer between different parts of the campus.

• **Cost-Effectiveness**: While the initial cost may be higher due to the need for more hardware (switches, routers, and cabling), the long-term operational benefits, such as reduced downtime and easier management, make it cost-effective.

• **Security**: A hierarchical star topology allows for the implementation of security policies at different layers of the network. Firewalls, intrusion detection systems, and access control lists can be strategically placed to protect sensitive data and prevent unauthorized access.

Topology Components and Structure

A hierarchical star topology for a campus network typically consists of three layers:

1. **Access Layer**:

• This is the lowest layer of the hierarchy.

• It connects end-user devices (computers, printers, IP phones) to the network.

• Typically uses switches to create star networks within individual buildings or departments.

• Focuses on providing high-bandwidth access to users.

2. **Distribution Layer**:

• This layer aggregates traffic from multiple access layer switches.

• Provides connectivity between different buildings or departments.

• Uses higher-performance switches or routers to handle the increased traffic volume.

• Implements security policies and quality of service (QoS) to manage traffic flow.

3. **Core Layer**:

• This is the highest layer of the hierarchy.

• Connects the distribution layer to the campus backbone network or the Internet.

• Uses high-end routers or switches to provide very high-speed connectivity.

• Focuses on providing fast and reliable data transfer between different parts of the campus network.

*[Diagram: Diagram of a hierarchical star topology showing access layer switches connecting to distribution layer switches, which in turn connect to core layer routers. The access layer represents individual buildings or departments, the distribution layer provides inter-building connectivity, and the core layer connects the campus to the internet.]*

Alternative Topologies and Their Limitations

While a hierarchical star topology is generally the best choice for a campus network, it's important to understand the limitations of other topologies:

• **Bus Topology**:

• All devices are connected to a single cable (the bus).

• **Limitations**: Difficult to troubleshoot, not scalable, single point of failure (if the bus breaks, the entire network goes down), and performance degrades as more devices are added.

• **Ring Topology**:

• Devices are connected in a closed loop.

• **Limitations**: Difficult to troubleshoot, not scalable, failure of one device can disrupt the entire network.

• **Mesh Topology**:

• Every device is connected to every other device.

• **Limitations**: Very expensive to implement and maintain, complex to manage, and not practical for large networks.

Conclusion

In conclusion, a ***hierarchical star topology*** offers the best balance of scalability, fault tolerance, manageability, performance, and cost-effectiveness for a campus network. By segmenting the network into smaller star networks and using a layered approach, it is possible to create a robust and efficient network that can meet the needs of a large and diverse user base. While other topologies may be suitable for smaller or more specialized applications, they are generally not appropriate for the scale and complexity of a campus environment.

```

**Quiz:** (Sufficient space to be provided for the answers)

1. Give Advantages, disadvantages of each topology

2. Find out application case of each topology

3. Which topology you will implement in your campus and why?

**Suggested Reference:**

1.<https://www.netacad.com/courses/packet-tracer>

2.Computer Networks- A Top-Down approach, Behrouz Forouzan, McGraw Hill

# References used by the students: (Sufficient space to be provided)

# Rubric wise marks obtained:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Rubrics | Topology Selection and Understanding | | Topology Implementation | | Simulation and Testing | | Documentation and Reporting | | Ethical and Professional Conduct | | Total |
| Good (2) | Avg. (1) | Good (2) | Avg.(1) | Good (2) | Avg. (1) | Good (2) | Avg.(1) | Good (2) | Avg. (1) |
| Marks |  |  |  |  |  |  |  |  |  |  |  |

**Experiment No: 5**

**AIM: Implement the concept of VLAN using Network Simulator.**

**Date:**

**Competency and Practical Skills:** Exploration of network layout and configuration to connect devices with each other to establish VLAN

**Relevant CO: CO-5:** Implement different types of network using different tools and simulators

**Objectives:** (a) Download network simulator – preferably cisco packet tracer

(b) Implement VLAN by configuring interconnecting and computing devices.

(c) Analyze the performance of Network

**Equipment/Instruments:** Desktop/laptop, Network simulator

**Theory:**

**What is VLAN?**

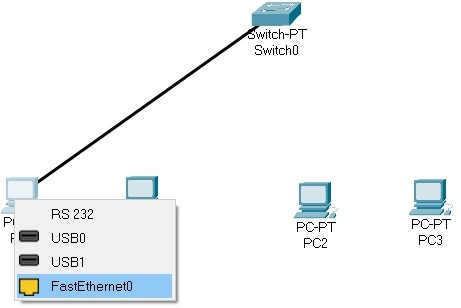
Virtual Local Area Networks or Virtual LANs (VLANs) are a logical group of computers that appear to be on the same LAN irrespective of the configuration of the underlying physical network.

**Features of VLANs:**

**VLAN ranges:**

**Steps to Implement a Virtual Local Area Network (VLAN):**

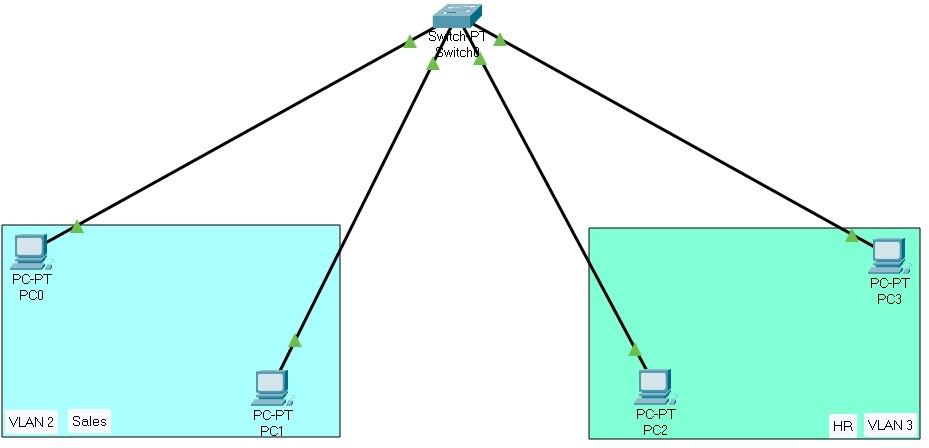
1. Take a switch and 4 end devices (PCs), and connect the switch with end devices using Copper Straight-Through cable. While connecting the cables it is needed to select the port through which you want to connect the switch to the end devices.



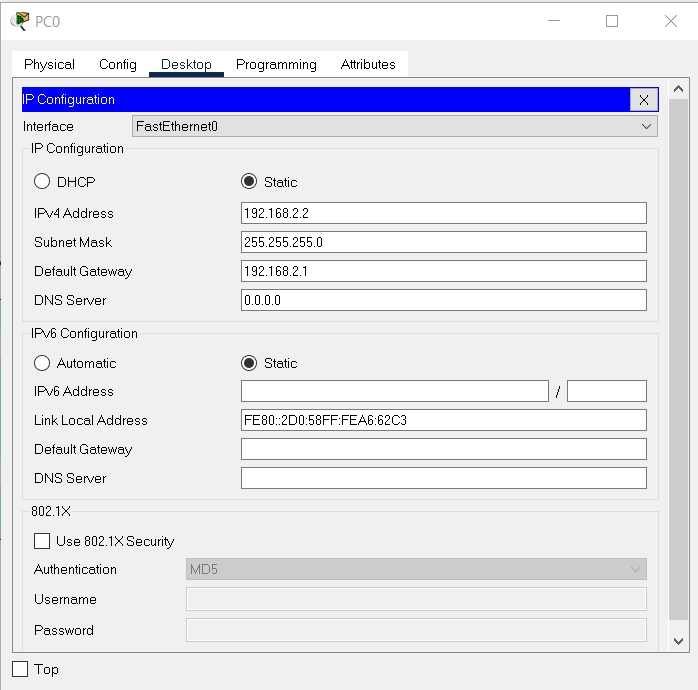
**Fig. 1. Configuring VLAN in simulator.**

* + As in the above images to connect switch to PC0 choose ‘FastEthernet0/1’ port in the switch and then in PC0 is selected ‘FastEthernet0’ port. Similarly, connect the entire PC with the switch.

1. Now, to configure two VLANs in which take 2 PC for each VLAN. Separate 2 PCs for each VLAN which are numbered as VLAN 2 and VLAN 3. We cannot use VLAN 1 because it default VLAN used by the switch. Let us assume that the VLAN 2 is being used by the Sales Department of the organization and VLAN 3 being used by the HR Department of the organization

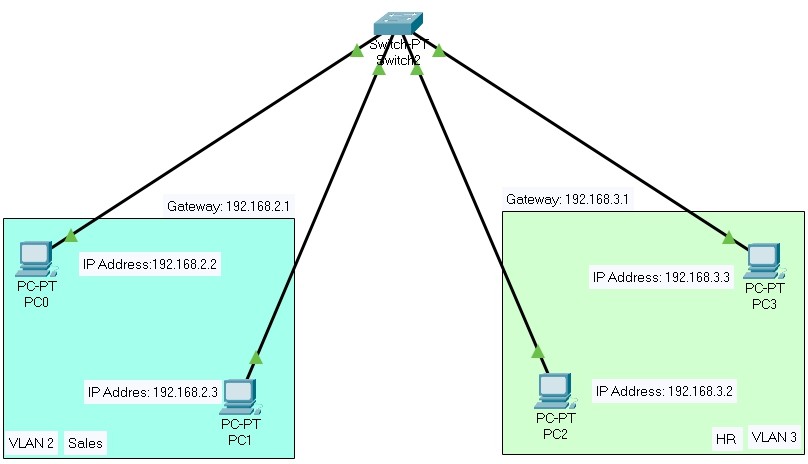


**Fig. 2. Configuring two VLANs in simulator.**

1. Provide the IP addresses and gateways to the end devices as shown in the below image.

**Fig. 3. Providing IP address and gateways to end devices.**

**Note:** To provide IP address and gateways click on the PC you want provide IP address to and then click Desktop -> IP Configuration

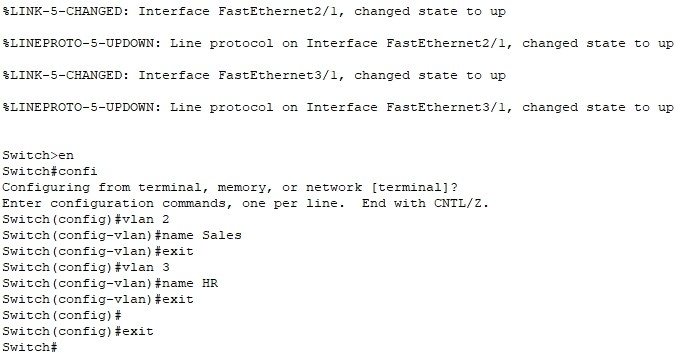


**Fig. 4. Providing IP addresses to VLANs**

1. Configure the VLAN

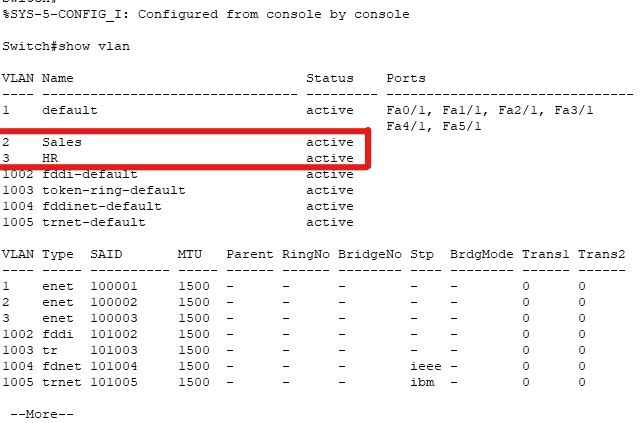
click on the switch -> go to CLI and press “Enter” then write the following commands to configure the VLANs and provide the names to VLANs.

* Commands:
* en/enable: Logs you into enable mode, which is also known as user exec mode or privileged mode.
* confi/configure terminal: Logs you into configuration mode.
* vlan number(except 1): Creates a VLAN and enters VLAN configuration mode for further definitions of specified number of the VLAN.
* name vlan\_name: Provides the specified name to the VLAN chosen by the vlan number command. To provide name to VLAN 2 we have to write name Sales after vlan 2 command. To provide name to VLAN 3 we have to write name HR after vlan 3 command.
* exit: Exits from VLAN configuration mode.



**Fig. 5. Providing specific name to VLANs**

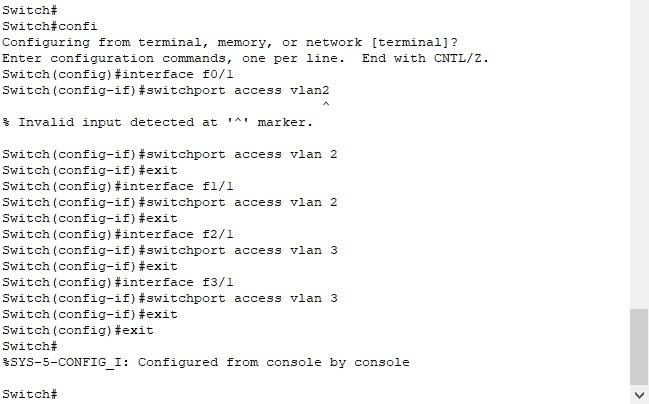
1. Now, both the VLANs have been configured. To verify whether the VLANs have been activated or not we have to write “**show vlan**” command. And after pressing Enter we can see both the created VLANs as shown in the below image.



**Fig. 6. VLANs activation status.**

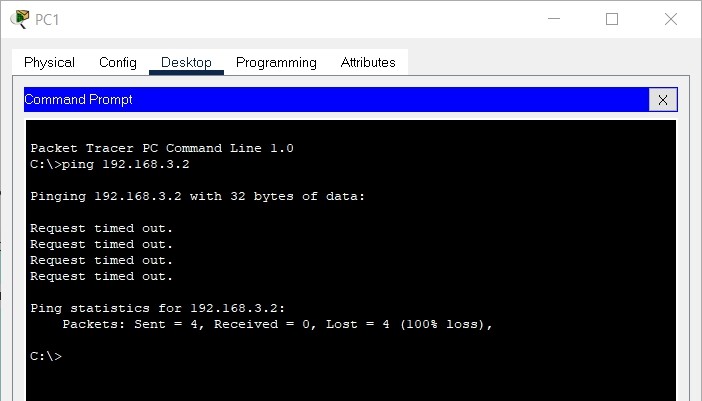
Here we can see in the above image that both the VLANs (VLAN 2 & VLAN3) which are “Sales” & “HR” are successfully configured and are active.

1. Now, to make the VLANs work properly we have to assign the devices among the manually configured host which are “VLAN 2(Sales)” & “VLAN 3(HR)”.
   * To assign devices among the VLANs we have to write series of commands which are:
2. confi/configure terminal: Logs you into configuration mode.
3. interface: Enters interface configuration mode for the specified fast ethernet interface
4. switchport access vlan: Sets the VLAN that the interface belongs to. It means it assigns the previously specified interface using interface command to work in the specific VLAN only if the device from the other VLAN tries to communicate with the specific interface it will not be successful.



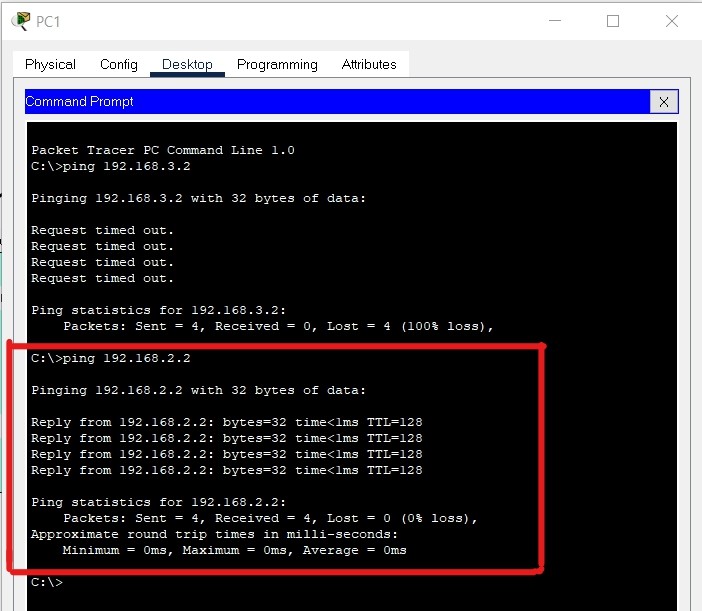
**Fig. 7. Configuring interface to VLANs**

Now we can see in the below image that if we send the message to the device in the same VLAN then the message is sent successfully, but if we send the message to the device in the different VLAN it cannot be sent to successfully.

****

**Fig. 8. Sending message to different VLAN**

Now to check whether the message can be sent to the device in another VLAN we will click the PC from which we have to send the message and then click “Desktop” and then go to “Command Prompt” and then give command “ping IP address” here the IP address in the command specifies the destination device’s IP address



**Fig. 9. Sending message to same VLAN**

As we can see in the above image if we ping to the device from another VLAN it will not give reply as it is in the other VLAN. But if we ping to the device which is in the same VLAN as the sender is then the message will be successfully sent.

Now to check whether the message can be sent to the device in another VLAN we will

click the PC from which we have to send the message and then click “Desktop” and then

go to “Command Prompt” and then give command “ping IP address” here the IP address

in the command specifies the destination device’s IP address

**Observations:**

**Answer:**

```docx

**Give Advantages, disadvantages of VLAN**

**Answer:**

Virtual LANs (VLANs) are logically independent broadcast domains created within a physical network infrastructure. They allow network administrators to segment a network based on factors such as function, project team, or application, without the need for physical rewiring. VLANs offer several advantages and disadvantages that should be considered when designing and implementing a network.

**Advantages of VLANs:**

• **Enhanced Security:**

• VLANs segment the network, isolating traffic within each VLAN. This reduces the scope of security breaches, as an attacker gaining access to one VLAN cannot easily access other VLANs without routing.

• Access control lists (ACLs) can be implemented at the VLAN level to control traffic flow between VLANs, further enhancing security.

• **Improved Performance:**

• By dividing a large network into smaller broadcast domains, VLANs reduce broadcast traffic congestion. This improves overall network performance and reduces latency.

• Localizing traffic within a VLAN ensures that only relevant devices receive broadcasts, minimizing unnecessary processing and bandwidth usage.

• **Simplified Network Management:**

• VLANs allow administrators to logically group users and devices, making it easier to manage network resources and apply policies.

• Changes to the network, such as adding or moving users, can be made through software configuration rather than physical rewiring, simplifying network administration.

• **Cost Reduction:**

• VLANs reduce the need for physical network segmentation, which can save on hardware costs such as routers and switches.

• Streamlined network management and reduced downtime can also lead to cost savings.

• **Flexibility and Scalability:**

• VLANs provide flexibility in network design, allowing administrators to quickly adapt to changing business needs.

• New VLANs can be easily created and configured to support new applications, departments, or projects, making the network more scalable.

• **Broadcast Control:**

• VLANs limit broadcast domains, preventing broadcast storms that can cripple network performance.

• By containing broadcasts within a VLAN, network stability is improved, and resources are used more efficiently.

**Disadvantages of VLANs:**

• **Inter-VLAN Routing Required:**

• Communication between different VLANs requires routing, which can introduce complexity and overhead.

• Routers or Layer 3 switches are needed to forward traffic between VLANs, adding to the network's cost and management burden.

• **Configuration Complexity:**

• Setting up and managing VLANs can be complex, especially in large networks with many VLANs.

• Careful planning and configuration are essential to ensure that VLANs are properly implemented and maintained.

• **VLAN Hopping:**

• VLAN hopping is a security vulnerability that allows attackers to bypass VLAN segmentation and gain access to other VLANs.

• Proper security measures, such as disabling trunk ports and using private VLANs, are needed to mitigate this risk.

• **Spanning Tree Issues:**

• In complex VLAN environments, spanning tree protocols (STP) can become more complex, potentially leading to convergence issues.

• Careful STP configuration and optimization are necessary to ensure network stability and prevent loops.

• **Increased Management Overhead:**

• While VLANs can simplify some aspects of network management, they also add additional configuration and monitoring tasks.

• Administrators must track VLAN assignments, monitor inter-VLAN traffic, and troubleshoot VLAN-related issues.

• **Potential for Misconfiguration:**

• Incorrect VLAN configuration can lead to network connectivity problems and security vulnerabilities.

• Proper documentation, change management procedures, and regular audits are essential to prevent misconfiguration.

```

(1) Differentiate LAN and VLAN.

**Answer:**

```docx

## Application Cases of VLANs

This section explores the application cases of Virtual Local Area Networks (VLANs), highlighting their benefits and usage scenarios.

• **What is a VLAN?**

• A VLAN is a logically isolated broadcast domain created within a physical network infrastructure. This means that even though devices are connected to the same physical switch, they can be segmented into different VLANs, behaving as if they are on separate physical networks.

• **Key Benefits of VLANs**

• **Enhanced Security:**

• VLANs isolate network traffic, preventing unauthorized access between different departments or groups of users. For example, sensitive data in the finance department can be kept separate from the guest network.

• **Improved Performance:**

• By reducing the size of broadcast domains, VLANs minimize unnecessary traffic on the network, leading to better performance and reduced congestion.

• **Simplified Network Management:**

• VLANs make it easier to manage and administer the network by grouping users and devices based on function or department. This simplifies tasks such as applying access control lists (ACLs) and quality of service (QoS) policies.

• **Cost Reduction:**

• VLANs reduce the need for physical network segmentation, lowering hardware costs and simplifying cabling.

• **Application Cases of VLANs**

• **Departmental Segmentation:**

• **Scenario:** A company wants to separate network traffic for different departments (e.g., Sales, Marketing, Engineering, HR) to improve security and performance.

• **Implementation:** Each department is assigned to a separate VLAN. For example, VLAN 10 for Sales, VLAN 20 for Marketing, etc.

• **Benefits:** Isolates sensitive data within each department, prevents broadcast storms from affecting the entire network, and simplifies applying specific security policies to each department.

• **Guest Network Isolation:**

• **Scenario:** A business wants to provide internet access to guests without compromising the security of the internal network.

• **Implementation:** Create a separate VLAN for guest users with limited access to internal resources. This VLAN is typically configured with internet access only and may include a captive portal for authentication.

• **Benefits:** Prevents unauthorized access to sensitive company data and protects the internal network from potential security threats originating from guest devices.

• **Voice and Data Separation:**

• **Scenario:** An organization uses Voice over IP (VoIP) phones and wants to prioritize voice traffic for better call quality.

• **Implementation:** Assign VoIP phones to a separate VLAN and configure QoS policies to prioritize voice traffic over data traffic.

• **Benefits:** Ensures high-quality voice communication by minimizing latency and jitter, providing a better user experience.

• **Server Isolation:**

• **Scenario:** A company hosts various servers (e.g., web servers, database servers, application servers) and wants to isolate them for security and performance reasons.

• **Implementation:** Place servers in separate VLANs based on their function or security requirements. For example, a DMZ (Demilitarized Zone) VLAN for publicly accessible web servers and a separate VLAN for database servers.

• **Benefits:** Reduces the risk of unauthorized access to critical servers and limits the impact of security breaches.

• **Wireless Network Segmentation:**

• **Scenario:** An organization wants to segment its wireless network for different user groups (e.g., employees, guests, IoT devices).

• **Implementation:** Configure different SSIDs (Service Set Identifiers) for each user group, each mapped to a separate VLAN.

• **Benefits:** Provides granular control over network access and security for wireless devices, preventing unauthorized access to internal resources.

• **Lab Environment Isolation:**

• **Scenario:** In educational or research institutions, it's essential to isolate lab environments from the production network to prevent accidental disruptions or security breaches.

• **Implementation:** Create a dedicated VLAN for the lab environment, isolating it from the main network and allowing for experimentation without affecting production systems.

• **Benefits:** Provides a safe and isolated environment for testing and development, preventing potential disruptions to the production network.

• **Example Diagram**

*[Diagram: A diagram showing a switch with multiple VLANs configured. VLAN 10 (Sales) has three computers connected to it. VLAN 20 (Marketing) has two computers and a printer connected to it. VLAN 30 (Engineering) has three computers and a server connected to it. Each VLAN is color-coded for clarity. The diagram should clearly indicate the logical separation of the VLANs within the physical switch.]*

• **VLAN Configuration Considerations**

• **VLAN ID:** Each VLAN is assigned a unique ID (typically between 1 and 4094).

• **Port Assignment:** Each switch port is assigned to a specific VLAN.

• **Trunking:** Trunk links are used to carry traffic for multiple VLANs between switches.

• **Routing:** A router or Layer 3 switch is needed to enable communication between different VLANs.

• **Conclusion**

VLANs are a powerful tool for segmenting and managing networks, providing enhanced security, improved performance, and simplified administration. Understanding their application cases is crucial for network administrators to design and maintain efficient and secure network infrastructures.

```

(2) Interpret and analyze the output

**Quiz:** (Sufficient space to be provided for the answers)

1. Give Advantages, disadvantages of VLAN

2. Find out application case of VLAN

**Suggested Reference:**

1.<https://www.netacad.com/courses/packet-tracer>

2.Computer Networks- A Top-Down approach, Behrouz Forouzan, McGraw Hill

# References used by the students: (Sufficient space to be provided)

# Rubric wise marks obtained:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Rubrics | Topology Selection and Understanding | | Topology Implementation | | Simulation and Testing | | Documentation and Reporting | | Ethical and Professional Conduct | | Total |
| Good (2) | Avg. (1) | Good (2) | Avg.(1) | Good (2) | Avg. (1) | Good (2) | Avg.(1) | Good (2) | Avg. (1) |
| Marks |  |  |  |  |  |  |  |  |  |  |  |

**Experiment No: 6**

**AIM: Implement the concept of static routing.**

**Date:**

**Competency and Practical Skills:** Exploration of network routing and configuration to connect devices to establish static routing

**Relevant CO: CO-4:** Design network architecture, assign IP addressing and applyvarious networking algorithms

**Objectives:** (a) Download network simulator – preferably cisco packet tracer

(b) Implement static routing algorithm by configuring interconnecting devices and computing devices.

(c) Analyze the performance of Network

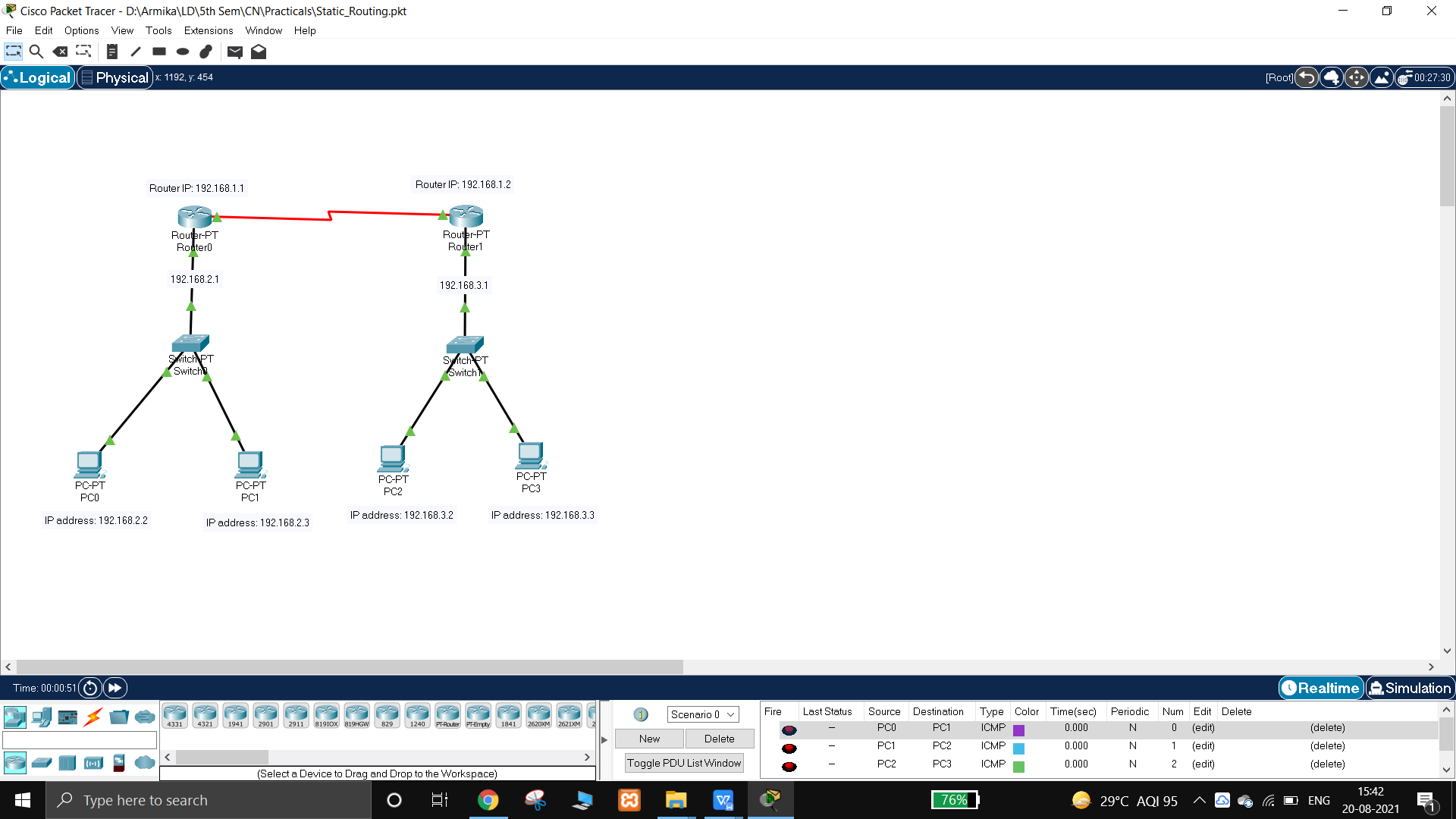
**Equipment/Instruments:** Desktop/laptop, Network simulator

**Theory:**

* Static routing is a form of [routing](https://en.wikipedia.org/wiki/Routing) that occurs when a router uses a manually-configured routing entry, rather than information from dynamic routing traffic.
* In many cases, static routes are manually configured by a [network administrator](https://en.wikipedia.org/wiki/Network_administrator) by adding in entries into a [routing table](https://en.wikipedia.org/wiki/Routing_table), though this may not always be the case. Unlike [dynamic routing](https://en.wikipedia.org/wiki/Dynamic_routing), static routes are fixed and do not change if the network is changed or reconfigured.
* Static routing and [dynamic routing](https://en.wikipedia.org/wiki/Dynamic_routing) are not mutually exclusive. Both dynamic routing and static routing are usually used on a router to maximize routing efficiency and to provide backups in the event that dynamic routing information fails to be exchanged. Static routing can also be used in [stub networks](https://en.wikipedia.org/wiki/Stub_network), or to provide a [gateway of last resort](https://en.wikipedia.org/wiki/Default_route).

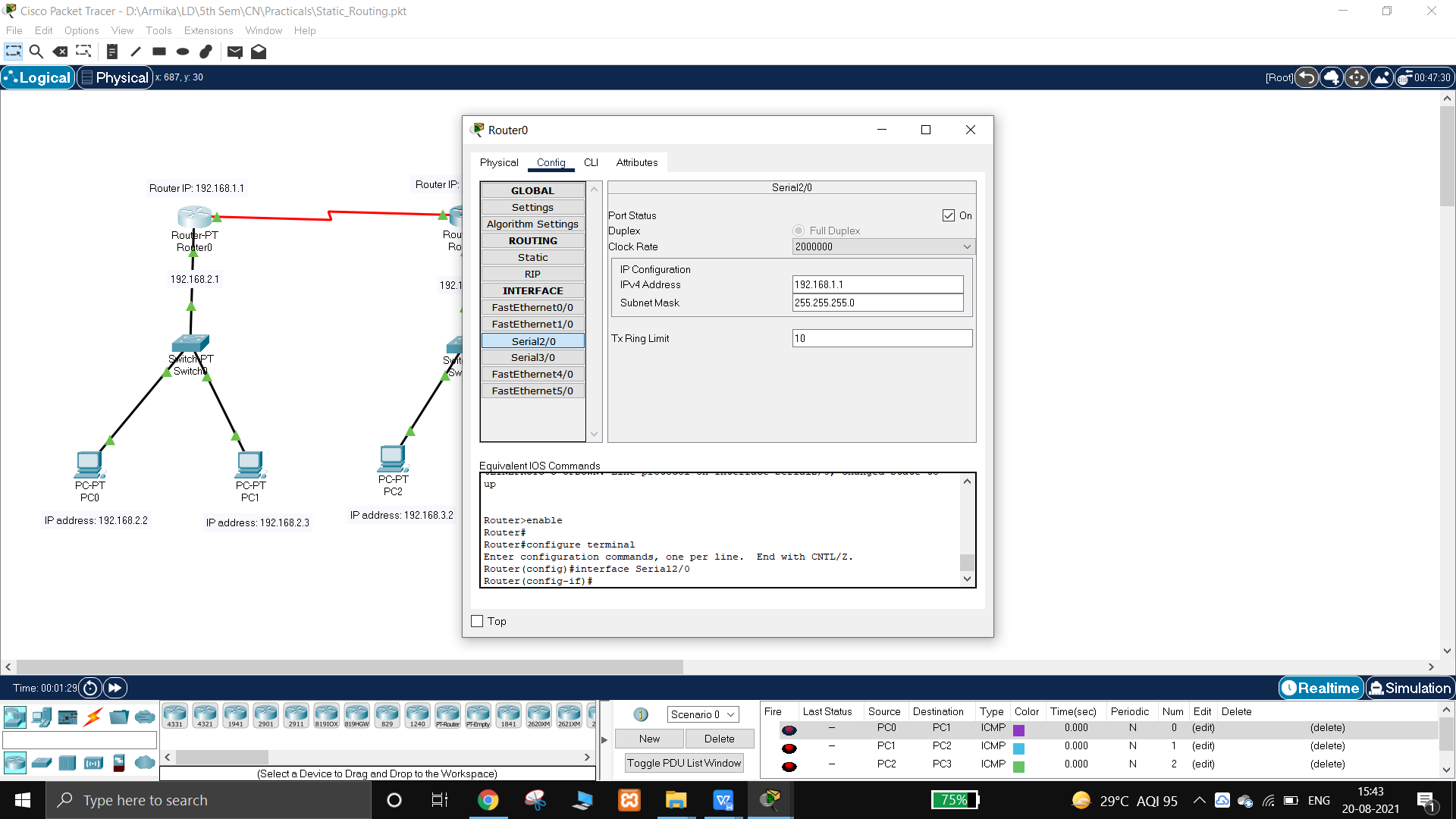
**Implementation of Static Routing:**

1. Take 2 routers, 2 switches and 4 end devices and connect them as shown in below image. Connect both the routers with each other using Serial DTE cable, and to connect router-switch and switch-end devices use copper straight-through cables.



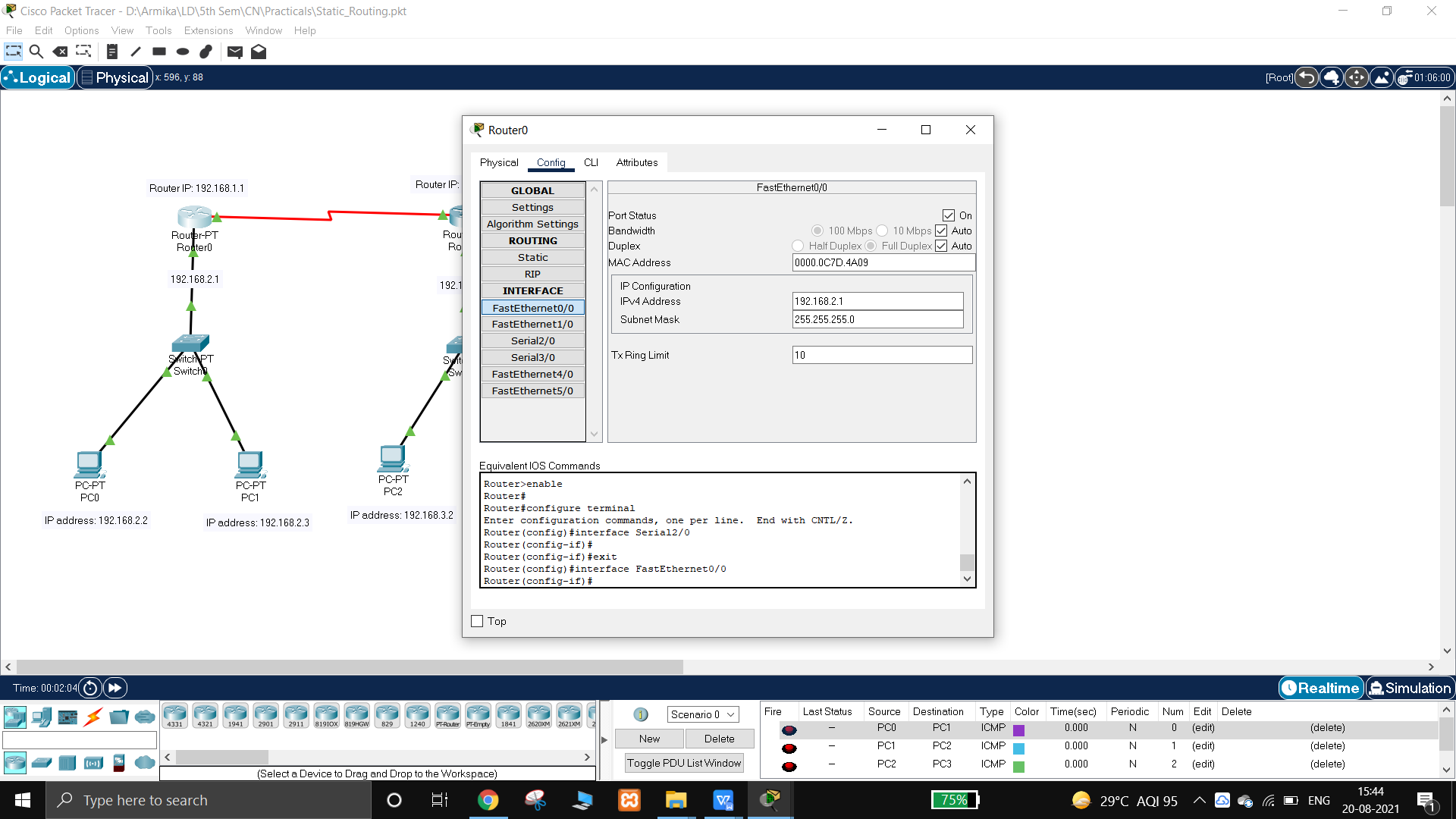
**Fig. 1. Static routing**

1. Configure both the routers and provide them IP addresses as shown in the below images. We need to take care that both the routers be in the same network so that they will be accessible to each other. To achieve the same we need to give IP address to the routers as following: click on router -> go to config -> go to serial 2/0 (in our case) and provide IP as 192.168.1.1 and 192.168.1.2 to router0 and router1 respectively.

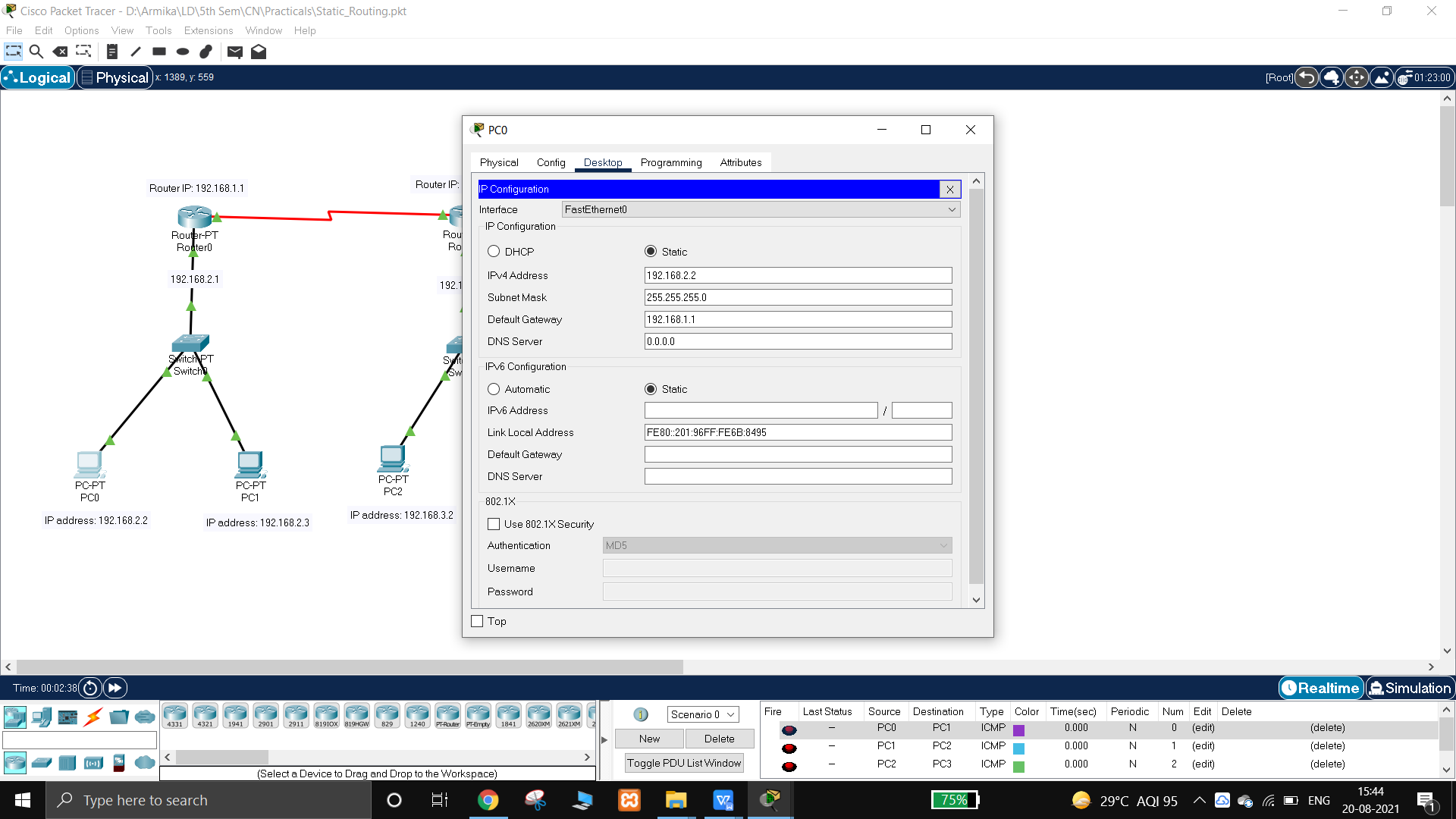


**Fig. 2. Router configuration**

1. Now, we need to connect the router to the switch, for that we need to provide the IP address in the FastEthernet0/0(in our case). In both the routers we will provide 192.168.2.1 and 192.168.3.1 respectively. Here after providing the IP addresses and connecting the router with the switch there are 2 networks are separated which are 192.168.2.0 and 192.168.3.0 hence, now both the routers are connected to switches and also to the end devices via switch.



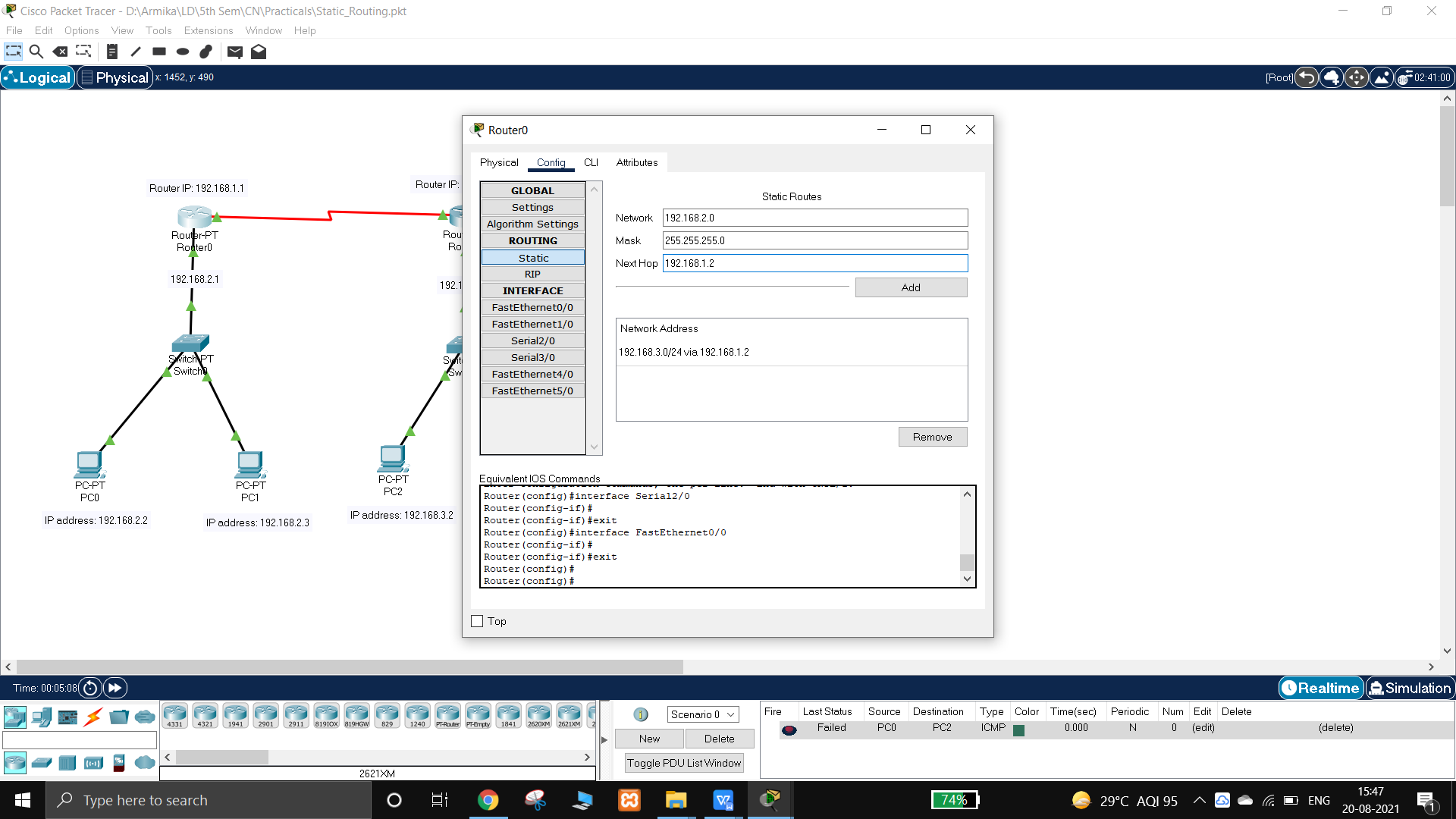
**Fig. 3. Connecting Routers with switch**



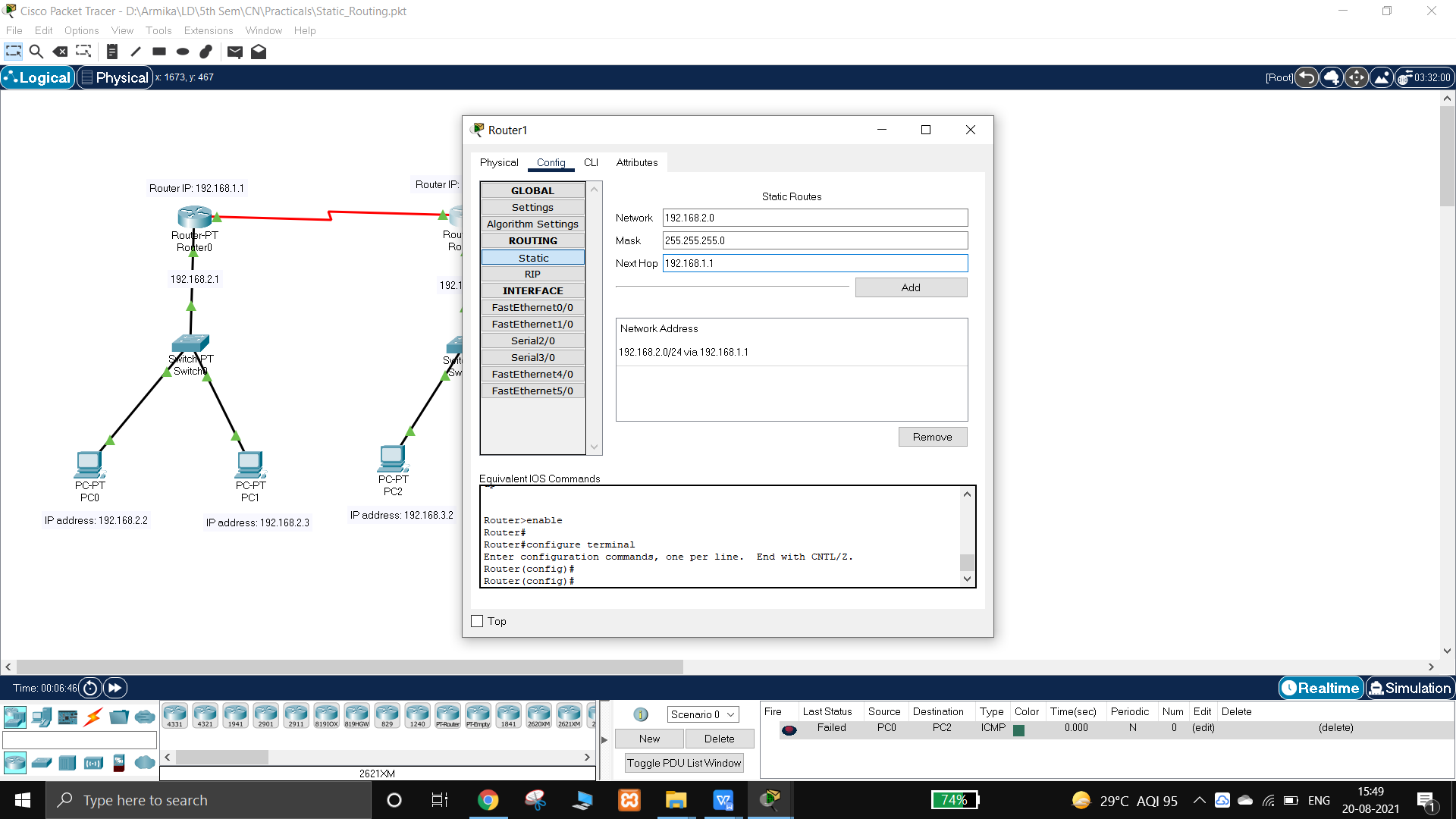
**Fig. 4. Providing IP address to end devices**

1. Provide the IP addresses and default gateways to the end devices, and be careful about the network they reside in. In our case we give the IP addresses to the end devices as shown above. And the default gateways will be the IP address of the routers they are connected with which are 192.168.1.1 and 192.168.1.2(in our case). To provide IP address and default gateway click on end device -> go to desktop -> go to IP configuration and provide IP address and default gateway to all the end devices.
2. Select the static routing path from router0 to router 1 and router1 to router0 for that again click on router -> go to config -> go to static available under **ROUTING,** and provide the details as follows. In network field provide the IP address of the network you want to communicate with which for router0 is 192.168.3.0, it means that the end devices with the IP address containing the 3rd digit as 3 (i.e 192.168.3.2 or 192.168.3.3 in our case) can be communicated through router0. And in next hop field provide the IP address of the router of the network you want to communicate (i.e 192.168.1.2 IP address of router1).

**Router0:**



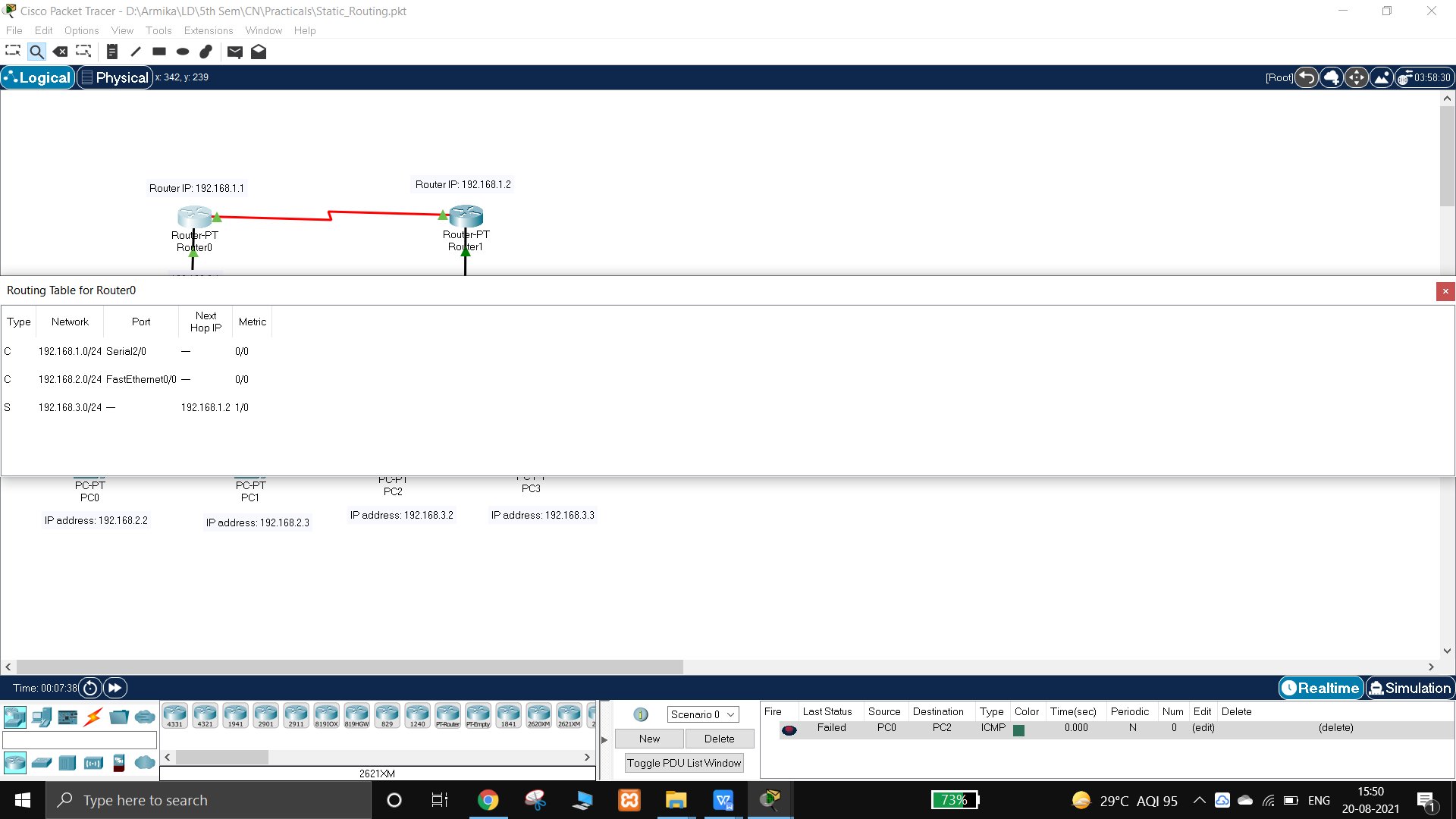
**Fig. 5. Providing static routing path from router0**

**Router1:**

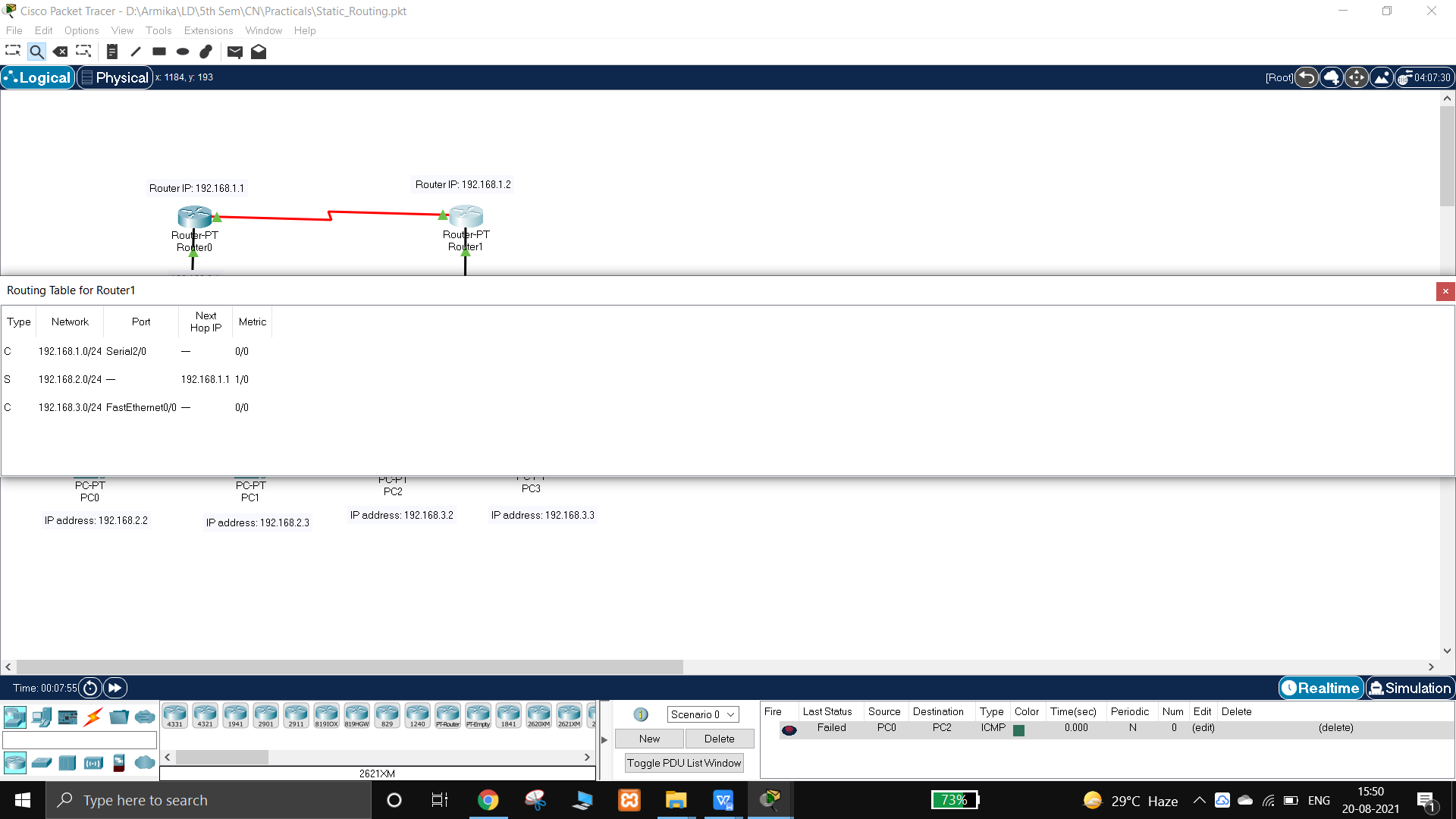
**Fig. 6. Providing static routing path from router1**

1. To check whether the static routing is done or not, check the routing tables of the routers for that select the magnify icon and click on the router you wish to check the routing table and select the routing table from the dropdown.

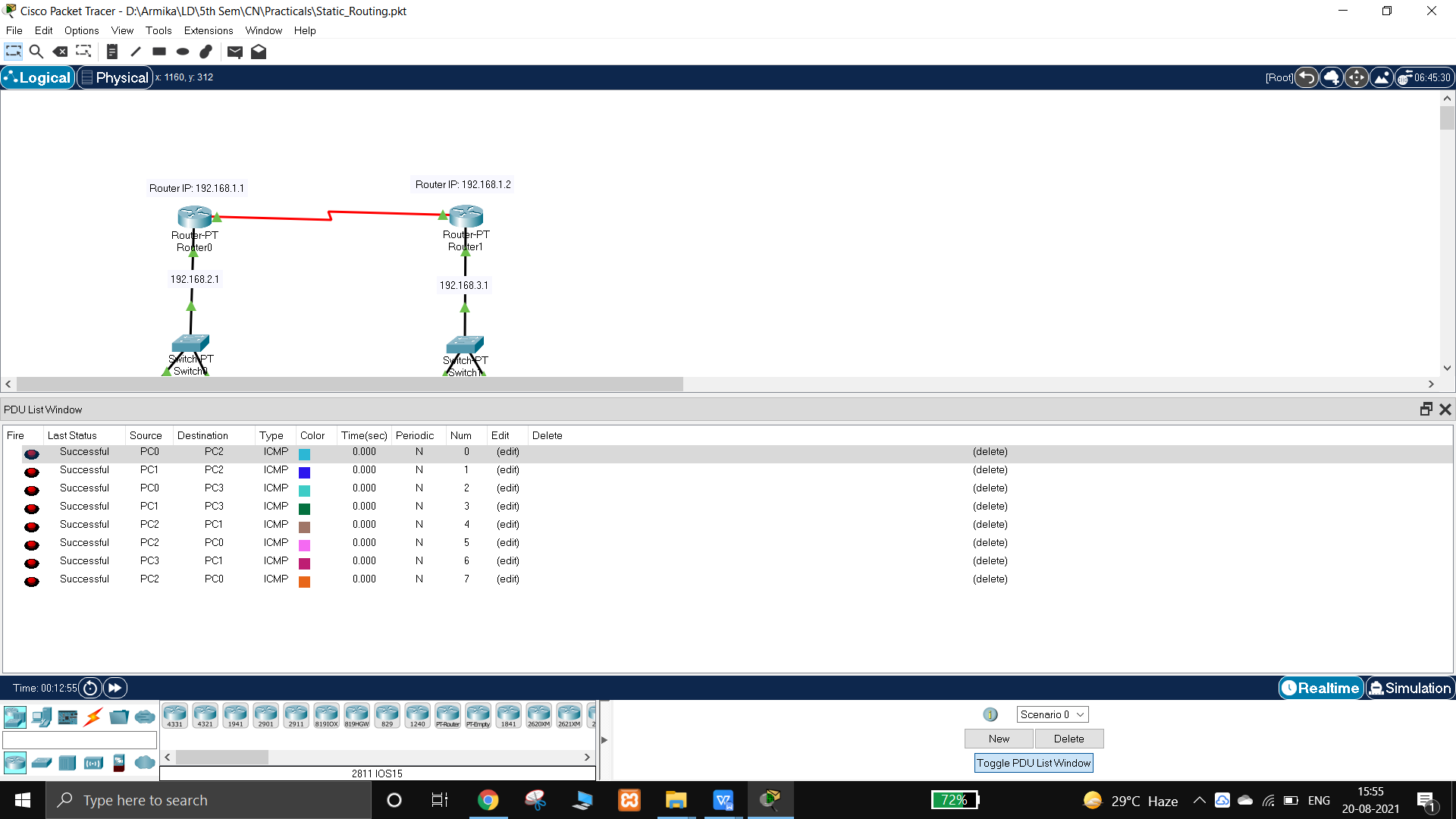
**Routing table for Router0:**



**Routing table Router1:**



1. After the completion of all the above steps we can say that the static routing concept is implemented successfully by sending the messages from 1 network to the other via the routers.



**Observations:**

**Answer:**

```docx

## Advantages and Disadvantages of Static Routing

Static routing is a method of configuring network routes manually, where the network administrator explicitly defines the path that data packets should take to reach a destination. Unlike dynamic routing, static routes do not change automatically based on network conditions.

• **Definition**: Static routing is a manual method of configuring network routes where the network administrator explicitly defines the path that data packets should take to reach a destination.

• **Explanation**: In static routing, the routes remain fixed unless the network administrator manually changes them. This is in contrast to dynamic routing, where routes are automatically adjusted based on network conditions.

### Advantages of Static Routing

• **Simplicity**:

• Configuration is straightforward, especially for small networks.

• No complex routing protocols to learn or configure.

• **Security**:

• Network administrators have complete control over routing paths.

• Reduces the risk of routing information being compromised by malicious actors, as there is no exchange of routing updates.

• **Resource Efficiency**:

• Lower overhead on routers since there is no need to run routing algorithms or exchange routing updates.

• This is particularly beneficial for networks with limited processing power or bandwidth.

• **Predictability**:

• Static routes provide predictable paths for data, which can be advantageous for applications that require consistent latency.

• Useful in scenarios where specific paths need to be enforced.

• **Administrative Control**:

• Network administrators have explicit control over the path that data takes.

• Can be used to enforce specific routing policies or traffic engineering strategies.

### Disadvantages of Static Routing

• **Scalability Issues**:

• Difficult to manage in large or complex networks due to the manual configuration required for each route.

• As the network grows, the administrative overhead increases significantly.

• **Lack of Adaptability**:

• Static routes do not automatically adjust to changes in network topology or failures.

• If a link goes down, traffic will not be rerouted unless the administrator manually reconfigures the routes.

• **Maintenance Overhead**:

• Requires manual intervention to update routes when network changes occur.

• This can be time-consuming and prone to errors if not managed carefully.

• **Single Point of Failure**:

• If a static route points through a specific device or link, the failure of that component can disrupt network connectivity.

• There is no automatic failover or alternative path.

• **Not Suitable for Dynamic Environments**:

• In networks where topology changes frequently, static routing is not practical.

• Dynamic routing protocols are better suited for environments where adaptability is essential.

### Summary Table

|  |  |
| --- | --- |
| Advantages | Disadvantages |
| Simplicity | Scalability Issues |
| Security | Lack of Adaptability |
| Resource Efficiency | Maintenance Overhead |
| Predictability | Single Point of Failure |
| Administrative Control | Not Suitable for Dynamic Environments |

### Conclusion

Static routing is best suited for small, stable networks where simplicity and security are prioritized over adaptability. In contrast, dynamic routing is more appropriate for larger, more complex networks that require automatic adjustment to changing network conditions. Understanding the advantages and disadvantages of each approach is crucial for designing and managing efficient and reliable networks.

```

**Answer:**

```docx

**Answer: Application Case of Static Routing**

Static routing is a manual method of configuring network routes in a router. Unlike dynamic routing protocols that automatically learn and adapt to network changes, static routes are fixed and must be manually updated by a network administrator. While it might seem less flexible than dynamic routing, static routing has specific use cases where it is advantageous.

• **When to Use Static Routing**

• **Small Networks**: In small networks with only a few routers and paths, the overhead of running dynamic routing protocols can be unnecessary. Static routing is simple to configure and maintain in such environments.

• **Stub Networks**: A stub network is a network that has only one route to reach any external network. Since there is only one exit point, static routing is a natural fit.

• **Backup Routes**: Static routes can be configured as backup routes. If a dynamic routing protocol fails or a primary link goes down, the static route can provide a fallback path to ensure connectivity.

• **Security**: Static routes can provide a higher level of security because the network administrator has explicit control over the routing paths. This can prevent unauthorized or unexpected traffic routes.

• **Specific Path Control**: In situations where certain traffic must follow a specific path for compliance, security, or quality of service reasons, static routes can enforce this requirement.

• **Resource Constraints**: On routers with limited processing power or memory, static routing can reduce the load compared to running complex dynamic routing protocols.

• **Application Cases with Examples**

• **Small Office/Home Office (SOHO) Network**:

• Scenario: A small office has a single router connecting its internal network to the Internet.

• Static Routing Configuration: The default gateway on the office router is set to the ISP's router. All traffic destined for the Internet is directed to this gateway.

• Advantage: Simple setup, minimal overhead.

• Disadvantage: Not suitable for larger, more complex networks.

• **Stub Network in a Branch Office**:

• Scenario: A branch office has a single connection back to the main office.

• Static Routing Configuration: Configure a static route on the branch office router to forward all traffic to the main office router.

• Advantage: Easy to configure and maintain since there's only one path.

• Disadvantage: If the connection to the main office fails, the branch office loses connectivity.

• **Backup Route for a Primary Dynamic Route**:

• Scenario: A network uses OSPF (Open Shortest Path First) as its primary routing protocol, but a backup route is needed in case the primary link fails.

• Static Routing Configuration: Configure a static route with a higher administrative distance than OSPF. If OSPF fails to find a route, the static route will be used.

• Advantage: Provides redundancy and ensures connectivity in case of primary link failure.

• Disadvantage: Requires manual configuration and may not adapt to network changes as quickly as dynamic routing.

• **Traffic Shaping and QoS (Quality of Service)**:

• Scenario: A network administrator wants to ensure that VoIP (Voice over IP) traffic takes a specific path to minimize latency.

• Static Routing Configuration: Configure a static route for VoIP traffic to use a low-latency link.

• Advantage: Ensures that critical traffic follows the desired path, improving performance.

• Disadvantage: Requires careful planning and configuration to avoid creating routing loops or bottlenecks.

• **Security and Compliance**:

• Scenario: A financial institution requires that all traffic to its payment gateway goes through a specific, highly secure link.

• Static Routing Configuration: Configure a static route to force all traffic destined for the payment gateway to use the secure link.

• Advantage: Enhances security by ensuring that sensitive traffic follows a predetermined path.

• Disadvantage: Less flexible and requires manual updates if network topology changes.

• **Advantages of Static Routing**

• **Simplicity**: Easy to configure and understand, especially for small networks.

• **Security**: Provides more control over routing paths, enhancing security.

• **Low Overhead**: Requires less processing power and memory compared to dynamic routing protocols.

• **Predictability**: Routes are fixed, making network behavior predictable.

• **Disadvantages of Static Routing**

• **Lack of Adaptability**: Does not automatically adjust to network changes, requiring manual updates.

• **Scalability Issues**: Not suitable for large, complex networks due to the administrative overhead of manual configuration.

• **Potential for Human Error**: Manual configuration can lead to errors, such as incorrect routes or routing loops.

• **Maintenance Overhead**: Requires ongoing maintenance to ensure routes are up-to-date and accurate.

• **Configuration Example (Cisco IOS)**

To configure a static route on a Cisco router, you would use the following command:

<code>ip route <destination\_network> <subnet\_mask> <next\_hop\_ip\_address></code>

Example: To route all traffic destined for the 192.168.2.0/24 network through the next hop IP address 192.168.1.2:

<code>Router(config)# ip route 192.168.2.0 255.255.255.0 192.168.1.2</code>

In summary, static routing is best suited for simple networks, stub networks, or specific scenarios where control and predictability are more important than adaptability. While it has limitations in larger, dynamic environments, it remains a valuable tool for network administrators in the right context.

```

(1) What is the range of IP addresses given to Devices?

**Answer:**

```docx

# **Experiment Answer: What is Ethernet?**

Ethernet is a fundamental technology for computer networking, particularly for local area networks (LANs). Here’s a detailed explanation:

• **Definition:** Ethernet is a family of networking technologies defined in the IEEE 802.3 standard that specifies how data is formatted and transmitted over a network. It defines the physical and data link layers of the OSI model.

• **Key Characteristics:**

• **Wired Communication:** Traditionally, Ethernet uses cables (e.g., twisted pair, fiber optic) to connect devices. However, wireless Ethernet (Wi-Fi) is also prevalent.

• **Frame-Based:** Data is transmitted in units called Ethernet frames, which include source and destination addresses, error-checking information, and the payload.

• **CSMA/CD (Carrier Sense Multiple Access with Collision Detection):** Original Ethernet used this protocol to manage network access. Devices listen for traffic before transmitting, and if a collision occurs (two devices transmit simultaneously), both stop, wait a random time, and retransmit. (Note: This is largely obsolete in modern switched Ethernet networks).

• **Switched Networks:** Modern Ethernet networks primarily use switches, which forward frames only to the intended destination, improving efficiency and reducing collisions.

• **MAC Addresses:** Ethernet relies on Media Access Control (MAC) addresses, unique identifiers assigned to network interfaces, to identify devices on the network.

• **Layers in the OSI Model:** Ethernet primarily operates at two layers of the OSI model:

• **Physical Layer:** Defines the physical characteristics of the network, such as cabling, voltages, and data rates.

• **Data Link Layer:** Defines how data is formatted for transmission, how MAC addresses are used, and how error detection is performed. The Data Link Layer is further divided into the LLC (Logical Link Control) and MAC sublayers.

• **Ethernet Frame Structure:** An Ethernet frame consists of several fields:

• **Preamble:** A sequence of alternating 1s and 0s used for synchronization.

• **Start-of-Frame Delimiter (SFD):** Indicates the beginning of the frame.

• **Destination MAC Address:** The MAC address of the intended recipient.

• **Source MAC Address:** The MAC address of the sending device.

• **EtherType/Length:** Specifies the protocol of the data being carried (e.g., IPv4, IPv6) or the length of the data field.

• **Data (Payload):** The actual data being transmitted, which can be up to a maximum size (MTU - Maximum Transmission Unit, typically around 1500 bytes).

• **Frame Check Sequence (FCS):** A checksum used for error detection.

• **Evolution of Ethernet:**

• **Original Ethernet (10BASE-T):** 10 Mbps over twisted pair cable.

• **Fast Ethernet (100BASE-T):** 100 Mbps, improving speed significantly.

• **Gigabit Ethernet (1000BASE-T):** 1 Gbps, widely used in modern networks.

• **10 Gigabit Ethernet (10GBASE-T):** 10 Gbps, for high-bandwidth applications.

• **40 Gigabit Ethernet, 100 Gigabit Ethernet, etc.:** Even faster speeds for data centers and high-performance networks.

• **Advantages of Ethernet:**

• **Widespread Adoption:** Ethernet is the most widely used LAN technology, ensuring compatibility and availability.

• **Scalability:** Ethernet can be scaled from small home networks to large enterprise networks.

• **Cost-Effective:** Ethernet hardware is relatively inexpensive.

• **High Speed:** Modern Ethernet standards offer very high data rates.

• **Reliability:** Ethernet includes error detection mechanisms to ensure reliable data transmission.

• **Components in Ethernet Networks:**

• **Network Interface Card (NIC):** The hardware that allows a device to connect to an Ethernet network.

• **Ethernet Cables:** Twisted pair cables (e.g., Cat5e, Cat6) or fiber optic cables used to connect devices.

• **Switches:** Devices that forward Ethernet frames to the appropriate destination based on MAC addresses.

• **Routers:** Devices that connect different networks together, forwarding data based on IP addresses.

<diagram>

A simple Ethernet network diagram showing multiple computers connected to a switch. The switch is connected to a router, which in turn connects to the Internet. Label the computers, switch, router, and internet connection. Indicate Ethernet cables connecting the devices.

</diagram>

• **Applications of Ethernet:**

• **Local Area Networks (LANs):** Connecting computers and devices within a limited area, such as a home, office, or school.

• **Data Centers:** Providing high-speed connectivity for servers and storage devices.

• **Enterprise Networks:** Supporting communication and resource sharing across an organization.

• **Industrial Networks:** Connecting devices in manufacturing and automation environments.

In summary, Ethernet is a versatile and widely used networking technology that provides reliable and high-speed communication for a variety of applications. Its evolution has kept pace with increasing bandwidth demands, making it a cornerstone of modern networking.

```

(2) Interpret and analyze the output

**Quiz:** (Sufficient space to be provided for the answers)

1. Give Advantages, disadvantages of Static routing

2. Find out application case of Static routing

3. What is Ethernet?

**Suggested Reference:**

1. <https://www.netacad.com/courses/packet-tracer>

2. Computer Networks- A Top-Down approach, Behrouz Forouzan, McGraw Hill

# References used by the students: (Sufficient space to be provided)

# Rubric wise marks obtained:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Rubrics | Topology Selection and Understanding | | Topology Implementation | | Simulation and Testing | | Documentation and Reporting | | Ethical and Professional Conduct | | Total |
| Good (2) | Avg. (1) | Good (2) | Avg.(1) | Good (2) | Avg. (1) | Good (2) | Avg.(1) | Good (2) | Avg. (1) |
| Marks |  |  |  |  |  |  |  |  |  |  |  |

**Experiment No: 7**

**AIM: Implement the concept of dynamic routing (RIP, OSPF, and BGP).**

**Date:**

**Competency and Practical Skills:** Exploration of Routing Algorithms to configure network.

**Relevant CO: CO-4:** Design network architecture, assign IP addressing and applyvarious networking algorithms

**Objectives:** (a) Download network simulator – preferably cisco packet tracer Configure all workstations

(b) Implement dynamic routing algorithm (RIP, OSPF, and BGP) by configuring interconnecting devices and computing devices.

(c) Analyze the performance of Network

**Equipment/Instruments:** Desktop/laptop, Packet Tracer Software

**Theory:**

**What Is Dynamic Routing?**

* **Dynamic routing** is a networking technique that provides *optimal* data routing. Unlike static routing, dynamic routing enables routers to select paths according to real-time logical network layout changes.
* Dynamic routing uses multiple algorithms and protocols. The most popular are Routing Information Protocol (RIP) and Open Shortest Path First (OSPF).
* Dynamic routing protocols allow routers to share information about the network with other routers to allow them to select the best path to reach a destination.

**About Dynamic routing :**

**Advantages of dynamic routing:**

**Disadvantages of Dynamic Routing:**

**1) RIP Routing Protocol**

**About RIP** :

**Steps To Implement RIP Routing Protocol:**

1. Prepare topology as shown in below figure.

* The network PC is connected to the switch with Copper-Straight through Cable.
* Each Switch is connected to the router using Copper-Straight through Cable.
* And to connect two routers with each other add Serial ports to the router for that turn off the router Select WIC-2T and add it to the router and turn on the router.
* Two routers are connected using serial DTE cable.

Graphical user interface, application

Description automatically generated

**Fig. 1. Network using two switch and two routers**

1. Set the IP Address of the each PC with respect to network address for example here PC0 is in the 192.168.1.0 network so the IP address of PC0 is 192.168.1.1.

Graphical user interface, application, email

Description automatically generated

**Fig. 2. Setting up IP address for PC0**

1. Once the IP address of each PC is set, set the IP address of the fast Ethernet port of router to which switch is connected. And then turn on the port. Follow the same process for second (Router 1) router.

Graphical user interface, text, application, email

Description automatically generated

**Fig. 3. Setting up connection with fast Ethernet port for Router0**

Graphical user interface, text, application, email

Description automatically generated

**Fig. 4. Setting up connection with fast Ethernet port for Router1**

1. Set the IP address serial port of all routers.

Graphical user interface, text, application

Description automatically generated

**Fig. 5. Setting up IP address serial port for Router0**

Graphical user interface, text, application

Description automatically generated

**Fig. 6. Setting up IP address serial port for Router1**

1. Add number of network in RIP routing.

* To add number of network - open the settings of router head to the RIP category. And in there add the network address of another network to which we want to connect our router.
* For example in above image if we want to access network 192.168.1.0 add that network address in network.
* Follow the same process for Router 1. And with this our routing is completed.

Graphical user interface, application

Description automatically generated

**Fig. 7. Network using two switch and two routers**

Graphical user interface, application

Description automatically generated

**Fig. 8. Adding network to RIP**

1. Test the network. - Transfer the data packet from one network pc to other network pc.

Graphical user interface, application

Description automatically generated

**Fig. 9. Transferring the data packet from one network pc to other network pc**

1. **OSPF Routing Protocol:**

* Open Shortest Path First is the dynamic routing protocol used in large to very large IP networks.
* **About OSPF**
* **Advantages of OSPF**
* **Disadvantages of OSPF**
* **Applications of OSPF**
* **Steps To Implement OSPF Routing Protocol:**

1. Add Network Devices in Network As Following:

* Here in the network PC is connected to the switch with Copper-Straight through Cable. Each Switch is connected to the router using Copper-Straight through Cable.
* To connect two routers with each other we have to add Serial ports to the router for that turn off the router Select WIC-2T and add it to the router and turn on the router.
* Three routers are connected using serial DTE cable.

Graphical user interface

Description automatically generated

**Fig. 10. Network using two switch and two routers through OSPF**

2) Set the IP Address of the each PC with respect to network address for example here PC0 is in the 192.168.1.0 network so the IP address of PC0 is 192.168.1.1.

Graphical user interface, application, email

Description automatically generated

**Fig. 11. Setting up the IP Address**

3) Once the IP address of each PC is set, set the IP address of the fast Ethernet port of router to which switch is connected. And then turn on the port. Follow the same process for second (Router 1) router.

Graphical user interface, text, application, email

Description automatically generated

**Fig. 12. Setting up connection with fast Ethernet port for Router0**

Graphical user interface, text, application, email

Description automatically generated

**Fig. 13. Setting up connection with fast Ethernet port for Router1**

1. Now we will have to set the IP address serial port of all routers.

Graphical user interface, text, application

Description automatically generated

**Fig. 14. Setting up connection with fast Ethernet port for Router0**

Graphical user interface, text, application, email

Description automatically generated

**Fig. 15. Setting up connection with fast Ethernet port for Router1**

Graphical user interface, text, application

Description automatically generated

**Fig. 16. Setting up connection with fast Ethernet port for Router2**

1. Our network is ready only one thing is left to do which is to add number of network through OSPF Command.

![Graphical user interface, text, application

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generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDcRXhpZgAATU0AKgAAAAgABAE7AAIAAAAGAAAISodpAAQAAAABAAAIUJydAAEAAAAMAAAQyOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAGFkbWluAAAFkAMAAgAAABQAABCekAQAAgAAABQAABCykpEAAgAAAAM0OAAAkpIAAgAAAAM0OAAA6hwABwAACAwAAAiSAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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**Fig. 17. Setting up connection with Router0 through OSPF**

![Graphical user interface, text, application

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDcRXhpZgAATU0AKgAAAAgABAE7AAIAAAAGAAAISodpAAQAAAABAAAIUJydAAEAAAAMAAAQyOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAGFkbWluAAAFkAMAAgAAABQAABCekAQAAgAAABQAABCykpEAAgAAAAMyNwAAkpIAAgAAAAMyNwAA6hwABwAACAwAAAiSAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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**Fig. 18. Setting up connection with Router1 through OSPF**

![Graphical user interface, text, application

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDcRXhpZgAATU0AKgAAAAgABAE7AAIAAAAGAAAISodpAAQAAAABAAAIUJydAAEAAAAMAAAQyOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAGFkbWluAAAFkAMAAgAAABQAABCekAQAAgAAABQAABCykpEAAgAAAAM0MgAAkpIAAgAAAAM0MgAA6hwABwAACAwAAAiSAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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**Fig. 19. Setting up connection with Router2 through OSPF**

1. Test the network. Transfer the data packet from one network pc to other network pc.

Graphical user interface

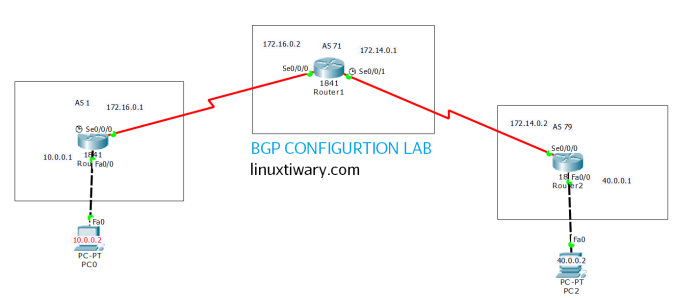
Description automatically generated

**Fig. 20. Testing the network**

**3) BGP Routing Protocol:**

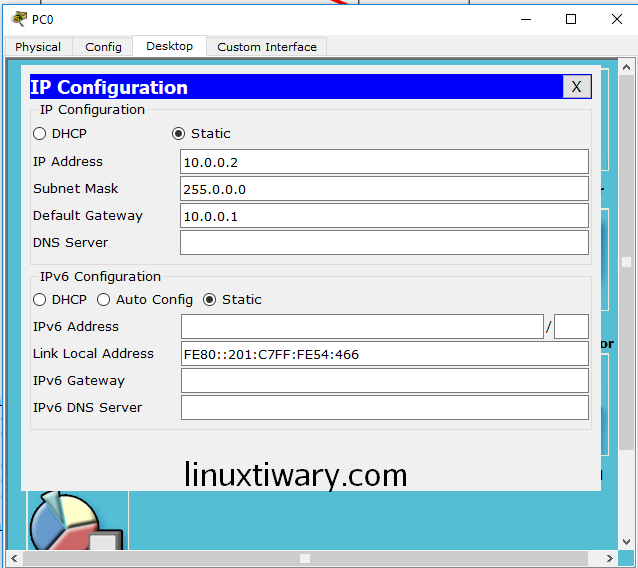
* Border Gateway Protocol (BGP) is the postal service of the Internet. When someone drops a letter into a mailbox, the postal service processes that piece of mail and chooses a fast, efficient route to deliver that letter to its recipient. Similarly, when someone submits data across the Internet, BGP is responsible for looking at all of the available paths that data could travel and picking the best route, which usually means hopping between autonomous systems.
* BGP is the protocol that makes the Internet work. It does this by enabling data routing on the Internet. When a user in Singapore loads a website with origin servers in Argentina, BGP is the protocol that enables that communication to happen quickly and efficiently.
* **Steps To Implement BGP Routing Protocol:**

1. Draw BGP Topology Diagram:



**Fig. 21. BGP Topology Diagram**

1. Assign ip address on each device as mentioned in Diagram:



**Fig. 22. Assigning IP address to PC0**

Graphical user interface, text, application, email

Description automatically generated

**Fig. 23. Assigning IP address to PC2**

1. BGP configuration on Router 1:

R1(config)#router bgp 1

R1(config-router)#neighbor 172.16.0.2 remote-as 71

R1(config-router)#network 10.0.0.0 mask 255.0.0.0

R1(config-router)#exit

R1(config)#do write

Building configuration...[OK]

R1(config)#

1. BGP configuration on Router 2:

R2(config)#router bgp 71

R2(config-router)#neighbor 172.16.0.1 remote-as 1

R2(config-router)#neighbor 172.14.0.2 remote-as 79

R2(config-router)#network 40.0.0.0 mask 255.0.0.0

R2(config-router)#exit

R2(config)#do write

Building configuration...[OK]

R2(config)#

1. BGP Configuration on Router 3:

R3(config)#router bgp 79

R3(config-router)#neighbor 172.14.0.1 remote-as 71

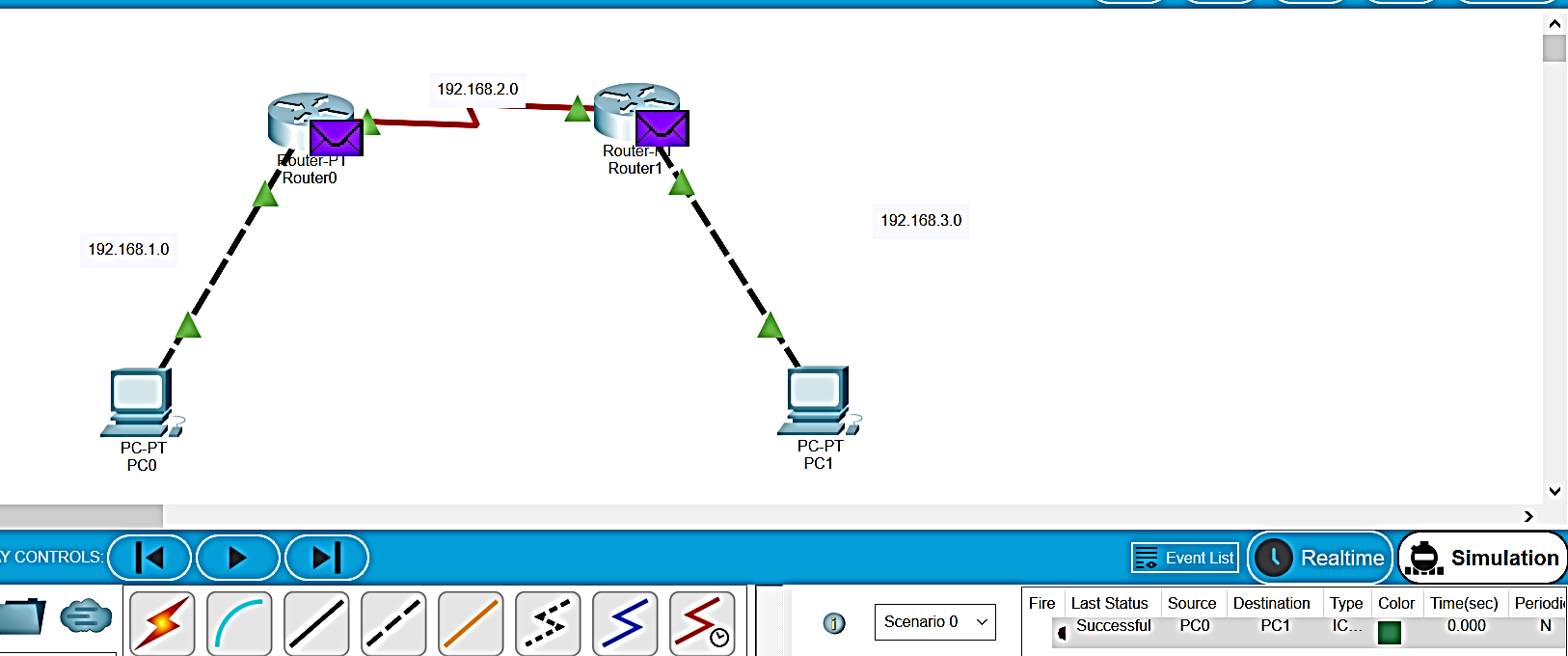
R3(config-router)#network 40.0.0.0 mask 255.0.0.0

R3(config-router)#exit

R3(config)#do write

Building configuration...[OK

R3(config)#



**Fig. 23. Testing the Network**

**Answer:**

```docx

## Differentiating Static and Dynamic Algorithms

When designing and implementing algorithms, it's crucial to understand whether they are ***static*** or ***dynamic***. These terms describe how the algorithm adapts to changes in the input or the environment during its execution.

• **Definition:** An algorithm is a well-defined sequence of instructions to solve a specific problem. These instructions are executed in a specific order to produce the desired output.

• **Key Differences:** The primary distinction lies in the algorithm's adaptability and the timing of decision-making.

• **Static Algorithm:**

• **Definition:** A static algorithm makes all its decisions before the execution begins. Once started, its behavior remains fixed, irrespective of changes in the input data or the environment.

• **Characteristics:**

• **Predefined Behavior:** The algorithm's steps and decisions are predetermined and do not change during runtime.

• **Fixed Resources:** Resource allocation (memory, computational units) is typically fixed before execution.

• **No Adaptation:** It does not adapt to changes in the input or the environment.

• **Simplicity:** Generally simpler to design and implement.

• **Example:**

• **Sorting a fixed array:** An algorithm that sorts an array with a known size and elements before the sorting process begins. The algorithm does not account for any new elements being added during the sorting process.

• **Shortest path in a static graph:** Dijkstra's algorithm to find the shortest path in a graph where the graph's structure and edge weights are fixed.

• **Advantages:**

• Simpler to implement and debug.

• Predictable behavior.

• Suitable for environments where the input and conditions are stable.

• **Disadvantages:**

• Inflexible and cannot adapt to changing conditions.

• May be inefficient or ineffective if the initial assumptions change.

• Not suitable for dynamic environments.

• **Dynamic Algorithm:**

• **Definition:** A dynamic algorithm makes decisions and adapts its behavior during execution, based on changes in the input data or the environment.

• **Characteristics:**

• **Adaptive Behavior:** The algorithm can change its steps and decisions during runtime in response to new information.

• **Dynamic Resources:** Resource allocation can change during execution based on the algorithm's needs.

• **Feedback Loop:** Often involves a feedback loop, where the algorithm monitors the environment and adjusts its actions accordingly.

• **Complexity:** Generally more complex to design and implement.

• **Example:**

• **Adaptive Routing Protocols:** Routing protocols in computer networks that dynamically adjust routes based on network congestion or link failures.

• **Online Machine Learning:** Algorithms that learn from data as it arrives and update their model continuously.

• **Advantages:**

• Highly adaptable to changing conditions.

• More efficient and effective in dynamic environments.

• Can handle unexpected or variable inputs.

• **Disadvantages:**

• More complex to design, implement, and debug.

• Less predictable behavior.

• May require more computational resources due to the need for continuous monitoring and adaptation.

• **Summary Table:**

|  |  |
| --- | --- |
| Static Algorithm | Dynamic Algorithm |
| Decisions made before execution | Decisions made during execution |
| Behavior is fixed during runtime | Behavior adapts to changes |
| Resource allocation is fixed | Resource allocation can change |
| Simpler to implement | More complex to implement |
| Predictable behavior | Less predictable behavior |
| Suitable for stable environments | Suitable for dynamic environments |
| Inflexible | Highly adaptable |

• **Example Scenario:**

• Consider a routing algorithm in a computer network.

• **Static Routing:** A static routing algorithm predefines fixed paths between network nodes. If a link fails, the algorithm will not automatically adjust the path, potentially leading to communication failures.

• **Dynamic Routing:** A dynamic routing algorithm adjusts the paths based on real-time network conditions. If a link fails, the algorithm recalculates the routes to find an alternative path, ensuring continuous communication.

• **Use Cases:**

• **Static Algorithms:**

• Sorting a fixed set of data.

• Calculating routes on a map where the roads and distances are constant.

• Batch processing jobs where the input data is known in advance.

• **Dynamic Algorithms:**

• Traffic management systems that adapt to real-time traffic conditions.

• Adaptive cruise control in vehicles that adjust speed based on surrounding traffic.

• Financial trading algorithms that respond to market changes.

• **Conclusion:**

• The choice between static and dynamic algorithms depends on the specific requirements of the problem and the nature of the environment. Static algorithms are suitable for stable, predictable environments where simplicity is a priority. Dynamic algorithms are essential for dynamic, unpredictable environments where adaptability and efficiency are crucial. Understanding these differences enables developers to select the most appropriate approach for their application.

```

**Observations:**

**Answer:**

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## Approximate Cost of Establishing a Network of 10 Devices

This section outlines the approximate cost of establishing a network of 10 devices. The devices selected will be a mix of desktop computers, laptops, a network switch, a router, and necessary cabling. Prices are approximate and can vary based on vendor, specifications, and location.

• \*\*Assumptions:\*\*

• The network is a small to medium-sized local area network (LAN) intended for general office or home use.

• The cost estimates include the basic hardware and software required for the devices to connect to the network and operate efficiently.

• Prices are based on current market rates and may fluctuate.

• \*\*Devices and Estimated Costs:\*\*

• **Desktop Computers (5 units)**

• Specification: Standard business-class desktops with Intel Core i5 processor, 8GB RAM, 256GB SSD, and Windows 10/11.

• Estimated Cost per unit: $500

• Total Cost: 5 \* $500 = $2500

• **Laptops (5 units)**

• Specification: Standard business-class laptops with Intel Core i5 processor, 8GB RAM, 256GB SSD, and Windows 10/11.

• Estimated Cost per unit: $700

• Total Cost: 5 \* $700 = $3500

• **Network Switch (1 unit)**

• Specification: 24-port Gigabit Ethernet switch.

• Estimated Cost: $150

• **Router (1 unit)**

• Specification: Wireless router with Gigabit Ethernet ports and standard security features.

• Estimated Cost: $100

• **Ethernet Cables**

• Specification: CAT6 Ethernet cables (10 cables, varying lengths).

• Estimated Cost: $50

• **Network Interface Cards (NICs) / Wireless Adapters (if needed)**

• Assuming all devices have built-in NICs/Wireless Adapters, no additional cost.

• If required, estimated cost per NIC: $20. Total: $20 \* number of devices needing NIC.

• **Software (Operating Systems, Security)**

• Operating Systems: Assuming Windows licenses are included with desktops/laptops. If not, ~$100 per license.

• Basic Antivirus Software: Free or open-source options available. Paid options ~$50 per year for all devices.

• **Setup and Configuration**

• Labor cost for setting up the network: $200 (This can vary significantly based on the complexity and location)

• \*\*Cost Summary:\*\*

• **Desktop Computers:** $2500

• **Laptops:** $3500

• **Network Switch:** $150

• **Router:** $100

• **Ethernet Cables:** $50

• **Setup and Configuration:** $200

• **Optional: Antivirus software:** $50

• **Total Estimated Cost: $6500**

• \*\*Additional Considerations:\*\*

• **Network Security:** Implementing advanced security measures, such as a firewall or intrusion detection system, can add to the cost.

• **Backup System:** Consider the cost of a backup solution, either cloud-based or on-site.

• **Print Server:** If a shared printer is needed, factor in the cost of a print server.

• **Uninterruptible Power Supply (UPS):** To protect against power outages, a UPS may be necessary for critical devices like the router and servers.

• **Future Scalability:** Plan for future expansion by selecting devices that can accommodate additional connections and bandwidth.

• \*\*Conclusion:\*\*

The approximate cost of establishing a network of 10 devices, including desktops, laptops, a switch, a router, and necessary cabling, is around $6500. This is a rough estimate, and actual costs can vary based on specific requirements and vendor pricing. It’s important to assess the specific needs of the network and obtain quotes from multiple vendors to get an accurate estimate.

```

(1) Find out the algorithms/ protocol used in your network

(2) Give name of protocol of which the packets sent for testing

**Quiz:** (Sufficient space to be provided for the answers)

1. Differentiate static and dynamic algorithm

2. What is the approximate cost of establishing the network of 10 devices? (Take devices as per your requirements and choice) give details

**Suggested Reference:**

1. <https://www.netacad.com/courses/packet-tracer>

2. Computer Networks- A Top-Down approach, Behrouz Forouzan, McGraw Hill

# References used by the students: (Sufficient space to be provided)

# Rubric wise marks obtained:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Rubrics | Topology Selection and Understanding | | Topology Implementation | | Simulation and Testing | | Documentation and Reporting | | Ethical and Professional Conduct | | Total |
| Good (2) | Avg. (1) | Good (2) | Avg.(1) | Good (2) | Avg. (1) | Good (2) | Avg.(1) | Good (2) | Avg. (1) |
| Marks |  |  |  |  |  |  |  |  |  |  |  |

**Experiment No: 8**

**AIM: To Simulate Web Server configuration using Cisco Packet tracer simulator.**

**Date:**

**Competency and Practical Skills:** Exploration of network routing and configuration to connect devices to establish static routing

**Relevant CO: CO-2:** Explain work of layers of OSI and TCP/IP model according to how they can be used to assist in network design and implementation.

**Objectives:** (a) Download network simulator – preferably cisco packet tracer

(b) Configure a simulated web server and establish connections between devices.

(c) Gain hands-on experience in setting up a Virtual Local Area Network.

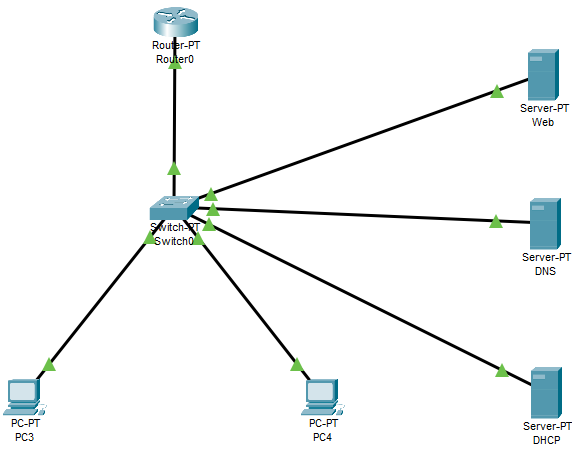
**Equipment/Instruments:** Desktop/laptop, Network simulator

**Theory:**

* A web server is a specialized computer system that stores and delivers web content to clients, usually web browsers, upon request. In this experiment, we will virtually configure a web server using Cisco Packet Tracer, which is a network simulation tool that allows us to create and interact with network topologies..

**Implementation of Web Server configuration:**

1. Select End devices as mentioned below.
   1. Router (Router-PT)
   2. Switch (Switch-PT)
   3. PC0 and PC1
   4. 3 Servers (Server-PT)
2. Connect PC0 and PC1 with switch, Switch to Router, and Servers to Switch (Refer the figure given below)



1. Select Switch-PT. Switch it off. Select the second module from the left pan of physical configuration. Place it on the area of RJ-45 connectors. Switch it on.
2. Configure Router:
   1. Click on Router -> Click on Config -> Select fast Ethernet0/0 from the tabs
   2. Set IP – 192.168.1.1 and Then Tick mark the check box of ‘Port Status’.
   3. Call CLI -> Press Enter.
   4. Type IP dhcp pool netA and Press Enter
   5. Type network 192.168.1.0 255.255.255.0 and Press Enter
   6. Type default-router 192.168.1.1
   7. Exit
3. Configure Servers:
   1. Click Server 0 -> Rename to Web
   2. Click Server 1 -> Rename to DNS
   3. Click Server 0 -> Rename to DHCP
4. Configure PCs:
   1. Click on PC0-> Select Desktop -> Set radio button of ‘DHCP’ to ON
   2. Click on PC0-> Select Desktop -> Set radio button of ‘DHCP’ to ON
5. Select DHCP server -> Select Desktop -> Set IP to 192.168.1.4, default gateway to 192.168.1.1, DNS to 192.168.1.5
6. Select DNS server -> Select Desktop -> Set IP to 192.168.1.5, default gateway to 192.168.1.1, DNS to 192.168.1.5
7. Set the mappings of IP and name of the website (e.g cn.edu)
8. Select Web server -> Select Desktop -> Set IP to 192.168.1.6, default gateway to 192.168.1.1, DNS to 192.168.1.5
9. Select service HTTP in Web server.
10. Edit the index page as per your need. (e.g Welcome to Computer Network Lab)
11. To test the web server through through DNS and DHCP
    1. Select PC0 -> Select Desktop -> Select Browser -> Type the <http://192.168.1.6> or http://www.cnlab.edu
    2. Select PC0 -> Select Desktop -> Select Email -> Select ‘Receive’. It will display the email conversation done so far.

**Answer:**

```docx

**Explain the significance of a web server in the context of internet communication.**

A web server plays a crucial role in internet communication. It acts as the foundation for delivering web content to users across the globe. Here's a detailed explanation of its significance:

• **Definition and Core Function**: A web server is a software and hardware system that uses HTTP (Hypertext Transfer Protocol) to serve files that form web pages to users, in response to their requests, which are forwarded by their computers' HTTP clients. Essentially, it receives requests from clients (usually web browsers), processes these requests, and sends back the requested web resources.

• **Key Components**:

• **Hardware**: The physical computer that stores the web server software and related files. It must be powerful enough to handle multiple requests simultaneously.

• **Software**: The actual web server application (e.g., Apache, Nginx, Microsoft IIS). This software listens for incoming requests, retrieves the requested files, and sends them back to the client.

• **The Client-Server Model**: The web server embodies the server-side of the client-server model.

• **Client (Web Browser)**: Initiates a request for a web resource (e.g., a web page, an image, or a document) using its URL.

• **Server (Web Server)**: Receives the request, locates the resource, and sends it back to the client.

• **Role in Delivering Web Content**:

• **Hosting Websites**: Web servers host all the files (HTML, CSS, JavaScript, images, videos, etc.) that make up a website. When a user enters a website's URL into their browser, the browser sends a request to the web server hosting that website.

• **Serving Dynamic Content**: Modern web servers can do more than just serve static files. They can also execute server-side scripts (e.g., PHP, Python, Node.js) to generate dynamic content in response to user input or database queries. This enables interactive web applications.

• **Content Management Systems (CMS)**: Platforms like WordPress, Drupal, and Joomla rely heavily on web servers to deliver dynamic content. The CMS software runs on the server, generating web pages from data stored in a database.

• **Protocols and Communication**:

• **HTTP/HTTPS**: Web servers communicate with clients using HTTP (or the secure version, HTTPS). HTTP defines the format of the requests and responses exchanged between the client and server.

• **TCP/IP**: HTTP operates on top of the TCP/IP protocol suite, which handles the reliable transmission of data packets over the internet.

• **Handling Concurrent Requests**:

• **Multithreading/Multiprocessing**: Web servers use multithreading or multiprocessing to handle multiple requests concurrently. This allows them to serve many users at the same time without significant performance degradation.

• **Load Balancing**: In high-traffic scenarios, multiple web servers may be used in conjunction with a load balancer. The load balancer distributes incoming requests among the servers to ensure that no single server becomes overloaded.

• **Security Considerations**:

• **HTTPS**: Using HTTPS ensures that communication between the client and server is encrypted, protecting sensitive data (e.g., passwords, credit card numbers) from eavesdropping.

• **Firewalls**: Web servers are often protected by firewalls, which filter incoming traffic and block malicious requests.

• **Access Control**: Web servers can be configured to restrict access to certain resources based on IP address, user authentication, or other criteria.

• **Examples of Web Servers**:

• **Apache HTTP Server**: One of the most popular web servers, known for its flexibility and extensive module support.

• **Nginx**: Another widely used web server, known for its high performance and ability to handle large numbers of concurrent connections.

• **Microsoft IIS (Internet Information Services)**: A web server developed by Microsoft, commonly used in Windows environments.

• **Node.js**: A JavaScript runtime environment that can be used to build web servers and other network applications.

• **Significance Summary**:

• **Enables Access to Web Resources**: Without web servers, users would not be able to access websites or online applications.

• **Supports E-commerce**: Web servers are essential for hosting online stores and processing transactions.

• **Facilitates Communication**: Web servers enable email, chat, and other forms of online communication.

• **Drives Information Sharing**: Web servers allow individuals and organizations to share information with a global audience.

In conclusion, a web server is a fundamental component of the internet. It is responsible for delivering web content to users, supporting online applications, and facilitating communication and information sharing on a global scale. Without web servers, the modern internet as we know it would not exist.

```

**Observations:**

**Answer:**

```docx

# Simulating Web Server Configuration Using Cisco Packet Tracer: A Step-by-Step Guide

This document outlines the general steps involved in simulating web server configuration using Cisco Packet Tracer.

• **Step 1: Design the Network Topology**

• Determine the network requirements. Consider factors such as the number of clients, server location, and network addressing scheme.

• Drag and drop the necessary devices from the device palette onto the Packet Tracer workspace. This will typically include:

• A server (to act as the web server)

• PCs or laptops (to act as client devices)

• A switch (to connect the clients and the server in a local network)

• (Optional) A router (to connect the local network to the Internet or another network)

• Connect the devices using appropriate cables. Packet Tracer offers automatic connection, but it is recommended to select the correct cable type (e.g., copper straight-through for connecting PCs to a switch, and usually copper straight-through for connecting a switch to a router.)

*[Diagram: A simple network topology diagram showing a server, a switch, and multiple PCs connected. The server is labeled "Web Server", the switch is labeled "Switch", and the PCs are labeled "Client PC1", "Client PC2", etc. Cables connect each PC to the switch, and the server to the switch.]*

• **Step 2: Configure IP Addresses**

• Assign IP addresses to each device on the network. A common practice is to use a private IP address range (e.g., 192.168.1.0/24).

• Configure the server with a static IP address (e.g., 192.168.1.10). This ensures that the server's address remains consistent.

• Configure the client PCs with static IP addresses or enable DHCP (Dynamic Host Configuration Protocol) on the router if one is included in the topology.

• Set the subnet mask for all devices (e.g., 255.255.255.0).

• If a router is present, configure the default gateway on the PCs and server to point to the router's interface IP address.

• To configure IP addresses on a device:

• Click on the device.

• Go to the "Config" tab.

• Navigate to the "Interface" section (e.g., "FastEthernet0/0").

• Enter the IP address and subnet mask.

• If setting up a gateway, enter the Gateway IP address in the settings.

• **Step 3: Configure the Web Server**

• Click on the server device.

• Go to the "Config" tab.

• Select "Services" and then "HTTP".

• The HTTP service should be "On" by default. If not, enable it.

• You can edit the default HTML page ("index.html") by clicking on the "Edit" button. Modify the HTML code to customize the web page content.

• Save any changes made to the HTML file.

• **Step 4: Test the Web Server**

• On one of the client PCs, click on the device.

• Go to the "Desktop" tab.

• Open the "Web Browser" application.

• Enter the IP address of the web server in the address bar (e.g., 192.168.1.10).

• Press "Go".

• If the web server is configured correctly, the customized web page should be displayed in the browser.

• Troubleshoot if necessary:

• Ping the web server from the client PC to check network connectivity. Open the "Command Prompt" on the client PC and type "ping [server IP address]". If the ping fails, check the IP addresses, subnet masks, and default gateway settings.

• Verify that the HTTP service is enabled on the web server.

• Check the HTML code for errors if the web page is not displaying correctly.

• **Step 5: (Optional) Configure DNS (Domain Name System)**

• To access the web server using a domain name instead of an IP address, configure a DNS server.

• Add another server to the topology and configure it as a DNS server.

• Assign a static IP address to the DNS server.

• Go to the "Config" tab of the DNS server.

• Select "Services" and then "DNS".

• Enable the DNS service.

• Add a new record:

• Name: Enter the desired domain name (e.g., "www.example.com").

• Type: Select "A" (Address) record.

• Address: Enter the IP address of the web server.

• Click "Add".

• On the client PCs, configure the DNS server IP address under the IP configuration settings.

• Now, in the web browser, you can enter the domain name (e.g., "www.example.com") instead of the IP address to access the web server.

• **Step 6: (Optional) Implement a Router for Internet Access**

• Include a router in the topology to simulate connecting to the internet.

• Configure one interface of the router to connect to the local network (using an IP address in the same subnet as the web server and clients). This will be the default gateway for the local network.

• Configure another interface of the router to simulate the internet connection. You can use a different IP address range for this interface.

• Configure routing on the router. For a simple simulation, you can use static routes. For a more advanced simulation, you can use dynamic routing protocols like RIP or OSPF.

• If you want the local network to access the internet, you may need to configure NAT (Network Address Translation) on the router.

By following these steps, you can successfully simulate a web server configuration in Cisco Packet Tracer and test its functionality. This provides a valuable learning experience in networking concepts and web server administration.

```

1. How was the overall network performance during interactions between clients and the web server?
2. Was the web server successfully configured and set up?
3. Did you observe any patterns in network traffic during interactions between clients and the web server?

**Quiz:** (Sufficient space to be provided for the answers)

1. Explain the significance of a web server in the context of internet communication.

2. Outline the general steps involved in simulating web server configuration using Cisco Packet Tracer.

**Suggested Reference:**

1. <https://www.netacad.com/courses/packet-tracer>

2. Computer Networks- A Top-Down approach, Behrouz Forouzan, McGraw Hill

# References used by the students: (Sufficient space to be provided)

# Rubric wise marks obtained:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Rubrics | Understanding of Web Server Configuration | | Configuration and Connectivity | | Troubleshooting and Problem-Solving | | Performance Analysis and Evaluation | | Documentation and Reporting | | Total |
| Good (2) | Avg. (1) | Good (2) | Avg.(1) | Good (2) | Avg. (1) | Good (2) | Avg.(1) | Good (2) | Avg. (1) |
| Marks |  |  |  |  |  |  |  |  |  |  |  |

**Experiment No: 9**

**AIM: To Simulate E-mail Server configuration using Cisco Packet tracer simulator.**

**Date:**

**Competency and Practical Skills:** Exploration of network routing and configuration to connect devices to establish static routing

**Relevant CO: CO-2:** Explain work of layers of OSI and TCP/IP model according to how they can be used to assist in network design and implementation.

**Objectives:** (a) Gain an understanding of the fundamental concepts of an e-mail server,

(b) Simulate the setup of an e-mail server by configuring relevant software,

(c) Gain hands-on experience in setting up a Virtual Local Area Network.

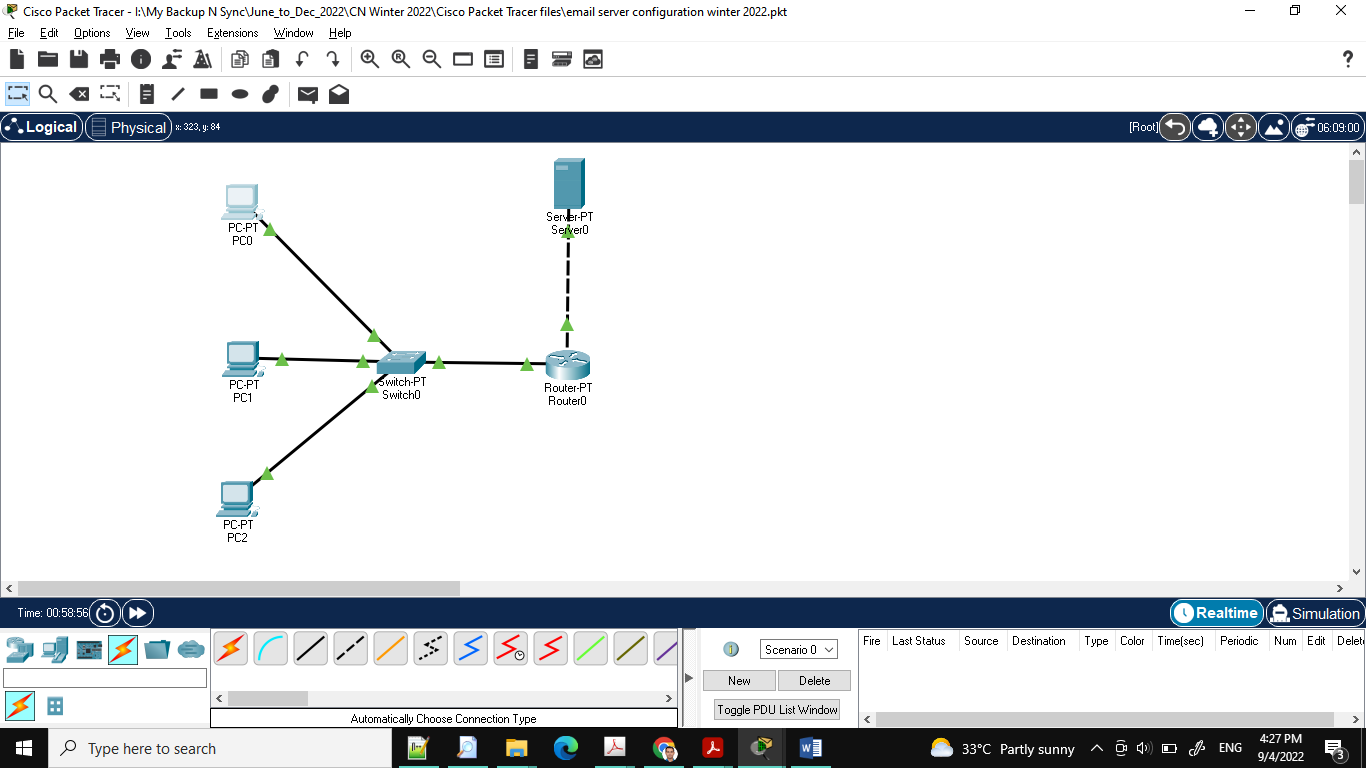
**Equipment/Instruments:** Desktop/laptop, Network simulator

**Theory:**

* An email server handles the sending, receiving, and storing of email messages. It operates based on standard protocols such as SMTP (Simple Mail Transfer Protocol) for sending emails and IMAP (Internet Message Access Protocol) or POP3 (Post Office Protocol) for receiving and storing emails. In this experiment, we will virtually configure an email server using Cisco Packet Tracer, allowing participants to explore the intricacies of email communication within a simulated network.

**Implementation of Web Server configuration:**

1. Select End devices as mentioned below.
   1. Server (Server-PT)
   2. Router (Router-PT)
   3. Switch (Switch-PT)
   4. PC0 PC1 and PC2



1. Connect all three PCs to Switch, Switch to Router and then Router to Server. (Refer the figure given above)
2. Configure Router:

Click on Router -> Click on Config -> Select fast Ethernet0/0 from the tabs

* 1. Set IP – 192.168.1.1 and Then Tick mark the check box of ‘Port Status’.

Click on Router -> Click on Config -> Select fast Ethernet1/1 from the tabs

* 1. Set IP – 192.168.2.1 and Then Tick mark the check box of ‘Port Status’.

1. Configure PCs:

Click PC0 -> Select Desktop -> Select IP Configuration -> Set IP 192.168.1.2 and Default Gateway as 192.168.1.1

Click PC1 -> Select Desktop -> Select IP Configuration -> Set IP 192.168.1.2 and Default Gateway as 192.168.1.2

Click PC2 -> Select Desktop -> Select IP Configuration -> Set IP 192.168.1.2 and Default Gateway as 192.168.1.3

1. Configure Server:

Click on Server-> Select Services -> Make sure SMTP and POP services radio buttons are marked ‘ON’.

* 1. Set domain name e.g <http://www.cnlab.edu>
  2. Set username and password for each individual PCs connected on machine,
  3. Username password
  4. pc0 pc0
  5. pc1 pc1
  6. pc2 pc2

click on Desktop -> set IP 192.168.2.2 and Default Gateway 192.168.2.1

1. Select PC0 -> Select Desktop -> Select Email -> Select Configuration Email (by default the screen appears first time)

Set the value for each key as follows:

* 1. Your Name: PC0, Email Address:pc0@cn.edu, Incoming Mail Server:192.168.2.2, Outgoing Mail Server:192.168.2.2
  2. Username:pc0, password:pc0

Repeat the steps for the PC1 and PC2

1. To test the email conversation through email server
   1. Select PC0 -> Select Desktop -> Select Email -> Select ‘Compose’ -> Put the address, subject and email text
   2. Repeat the steps for PC1 and PC2 and then
   3. Select PC0 -> Select Desktop -> Select Email -> Select ‘Receive’. It will display the email conversation done so far.

**Observations:**

1. Observing the installation and configuration process of the e-mail server software on the designated server device.
2. Observing the interaction between the configured e-mail server and the client devices.

**Quiz:** (Sufficient space to be provided for the answers)

1. Explain two benefits of using Cisco Packet Tracer to simulate e-mail server configuration.
2. Briefly describe the purpose of SMTP and IMAP/POP3 in the context of email communication

**Suggested Reference:**

1. <https://www.netacad.com/courses/packet-tracer>
2. Computer Networks- A Top-Down approach, Behrouz Forouzan, McGraw Hill

# References used by the students: (Sufficient space to be provided)

# Rubric wise marks obtained:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Rubrics | Understanding of E-mail Server Configuration | | Configuration and Connectivity | | Troubleshooting and Problem-Solving | | Performance Analysis and Evaluation | | Documentation and Reporting | | Total |
| Good (2) | Avg. (1) | Good (2) | Avg.(1) | Good (2) | Avg. (1) | Good (2) | Avg.(1) | Good (2) | Avg. (1) |
| Marks |  |  |  |  |  |  |  |  |  |  |  |

**Experiment No: 10**

**AIM: Packet capture and header analysis by wire-shark (TCP, UDP, IP).**

**Date:**

**Competency and Practical Skills:** Exploration of Network protocols and header using wireshark tool

**Relevant CO: CO3:** Examine work of protocols of TCP/IP protocol suite.

**Objectives:** (a) Download Wireshark.

(b) Capture the Packet

(c) Perform header analysis

(d) Answer the given questions with screenshots

**Equipment/Instruments:** Desktop/laptop

**Theory:**

**What is wireshark?**

* Wireshark is an open-source packet analyzer, which is used for education, analysis, software development, communication protocol development, and network troubleshooting.

**How to capture Packet in Wireshark?**

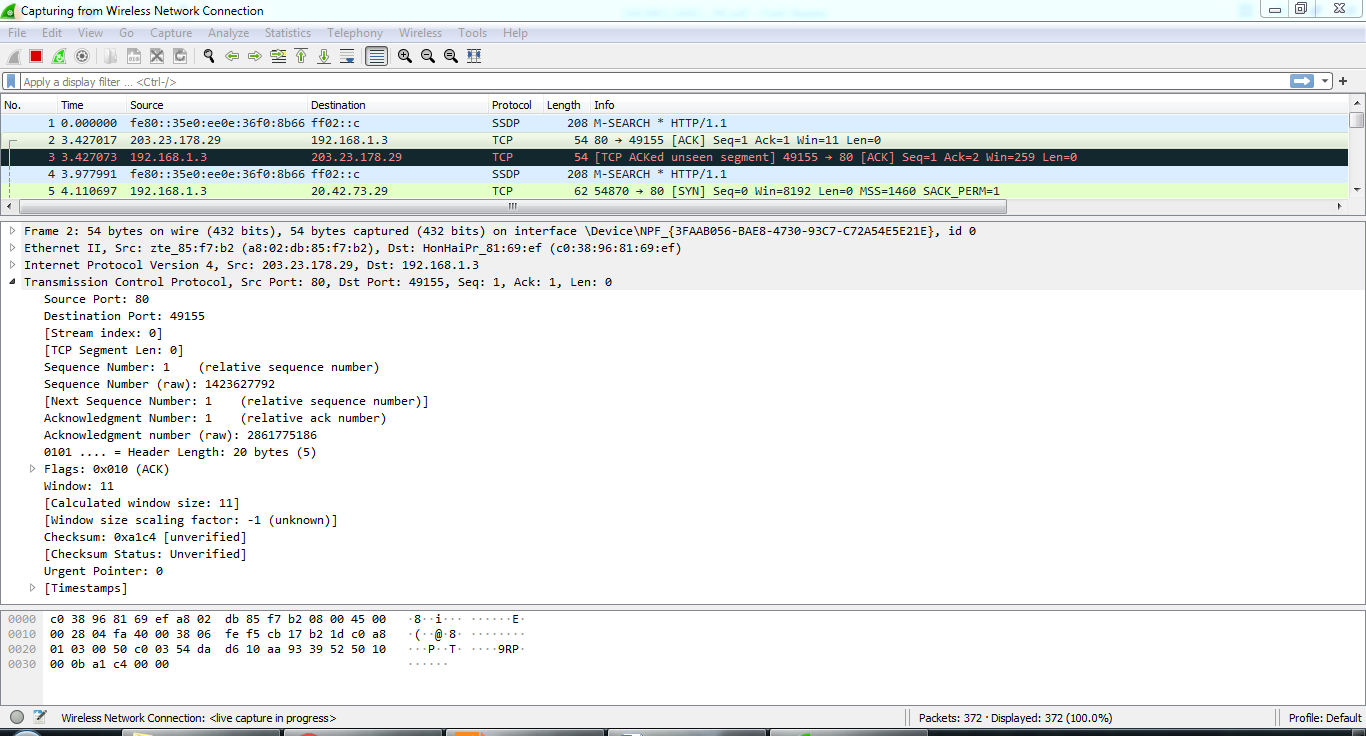
* Connect to Router from which you want to capture packet.
* Next step is to launch wireshark in your pc.
* Click on capture to start capturing the packets with optional filter option.



**Fig. 1. Wireshark Network Analyzer**

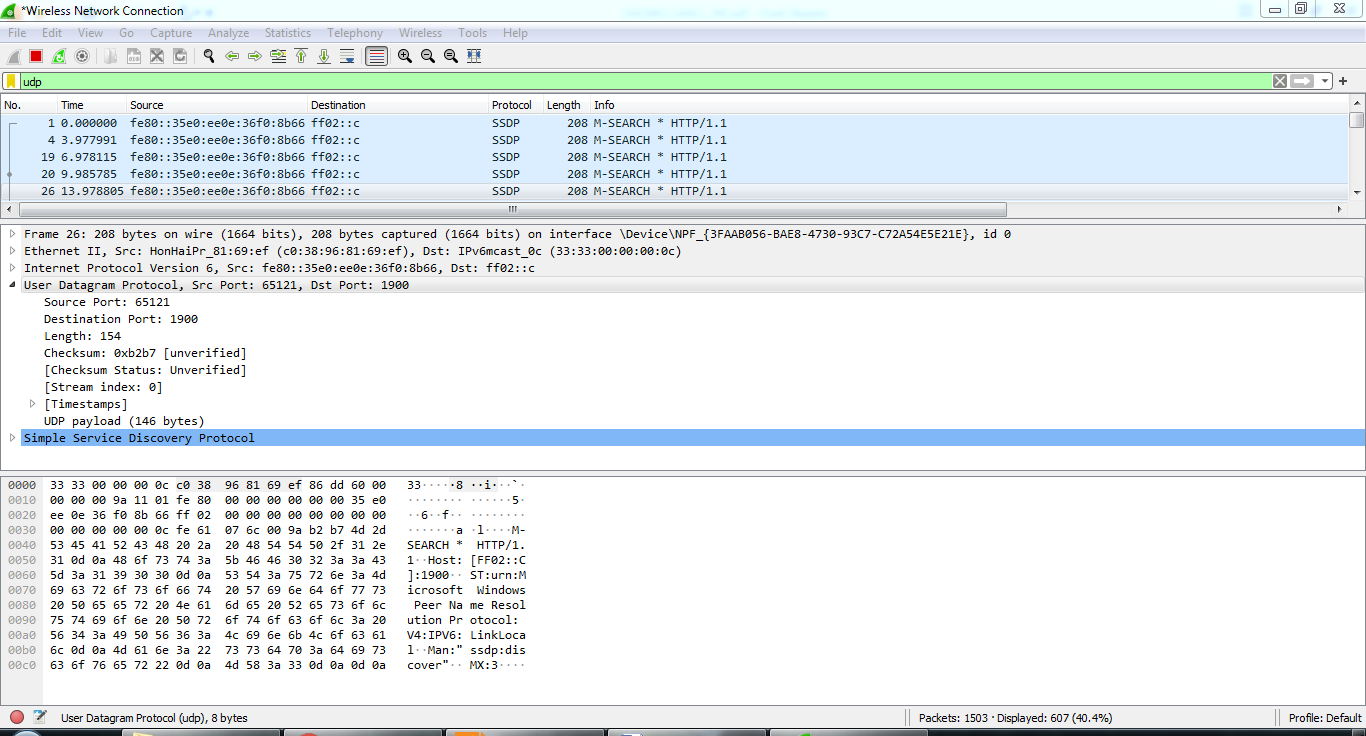
**Capture Different Types of packets and analyze them:**

1. **TCP Packets:**



**Fig. 2. Capturing TCP packet from Wireless Network**

1. **UDP Packets:**

****

**Fig. 3. Capturing UDP packet from Wireless Network**

**Observations:**

Use Wireshark tool and explore the packet format and content at each TCP/IP layer

**Answer:**

Here's a detailed explanation of the various planes or windows in the Wireshark user interface, formatted for direct insertion into a Microsoft Word document:

# Wireshark User Interface Planes/Windows

Wireshark's user interface is divided into several key panes (or windows) that provide different perspectives on captured network traffic. Understanding these panes is crucial for effective network analysis. The main window typically consists of three primary panes: the Packet List Pane, the Packet Details Pane, and the Packet Bytes Pane. Additionally, Wireshark offers various other windows and dialogs for specific tasks such as filtering, statistics, and endpoint analysis.

• **Packet List Pane**: This is the *top* pane in the main Wireshark window. It provides a summary of each captured packet.

• Each row represents a single packet.

• Common columns include:

• **No.**: The packet number (sequential).

• **Time**: The time the packet was captured, relative to the start of the capture or the absolute time.

• **Source**: The IP address or name of the device that sent the packet.

• **Destination**: The IP address or name of the device that received the packet.

• **Protocol**: The protocol used in the packet (e.g., TCP, UDP, HTTP, DNS).

• **Length**: The size of the packet in bytes.

• **Info**: A brief, protocol-specific description of the packet's contents. For example, for HTTP packets, this might show the HTTP method (GET, POST) and the requested URL.

• Clicking on a packet in this pane selects it, and its details are then displayed in the other panes.

• The appearance of packets can be customized using color filters, making it easier to identify traffic of interest.

• **Packet Details Pane**: This is the *middle* pane in the main Wireshark window. It displays the decoded protocol data for the packet selected in the Packet List Pane.

• This pane presents a hierarchical view of the packet's protocol layers.

• Each layer of the protocol stack (e.g., Ethernet, IP, TCP, HTTP) is shown as a collapsible/expandable section.

• Expanding a layer reveals the fields and values within that layer's header.

• This pane allows you to examine the contents of the packet in a structured and human-readable format.

• Right-clicking on a field in the Packet Details Pane allows you to apply it as a filter, follow a TCP stream, or copy the field's value.

• **Packet Bytes Pane**: This is the *bottom* pane in the main Wireshark window. It displays the raw data of the selected packet as hexadecimal and ASCII (if printable).

• The hexadecimal representation of the packet data is shown on the left.

• The corresponding ASCII representation is shown on the right. Non-printable characters are typically displayed as dots ('.').

• When you select a field in the Packet Details Pane, the corresponding bytes are highlighted in the Packet Bytes Pane, making it easy to correlate decoded information with the raw packet data.

• This pane is useful for examining the exact bytes transmitted, especially when dealing with unusual protocols or needing to verify the decoded interpretation.

• **Filter Toolbar**: Located at the top of the Wireshark window, this toolbar allows you to enter display filters to selectively show packets that match certain criteria.

• Filters can be based on protocols, IP addresses, ports, or any other field available in the Packet Details Pane.

• Examples:

• `http`: Shows only HTTP packets.

• `ip.addr == 192.168.1.100`: Shows packets with the IP address 192.168.1.100 as either the source or destination.

• `tcp.port == 80`: Shows packets with TCP port 80 (commonly used for HTTP).

• Wireshark provides filter autocompletion and syntax checking to help you construct valid filters.

• **Statistics Window**: Wireshark provides various statistics windows accessible through the "Statistics" menu. These windows offer summaries and visualizations of the captured traffic.

• **Capture File Properties**: Provides general information about the capture file, such as the file size, capture duration, and the number of packets.

• **Protocol Hierarchy**: Shows a breakdown of the protocols present in the capture and the percentage of traffic each protocol represents.

• **Conversations**: Lists the conversations between different endpoints, grouped by Ethernet, IP, TCP, or UDP.

• **Endpoints**: Lists all the unique endpoints (MAC addresses, IP addresses, ports) seen in the capture and the amount of traffic associated with each.

• **IO Graphs**: Allows you to create custom graphs of network traffic over time, based on various metrics like packet rate, byte rate, and custom filter expressions.

• **Follow TCP Stream/UDP Stream**: This feature allows you to reconstruct and view the entire conversation between two endpoints in a TCP or UDP stream.

• Right-clicking on a packet in the Packet List Pane and selecting "Follow" -> "TCP Stream" (or "UDP Stream") will open a new window showing the complete stream.

• This is particularly useful for analyzing application-level protocols like HTTP, SMTP, or FTP, where a single transaction may span multiple packets.

• The stream content can be filtered and exported for further analysis.

• **Go Menu**: This menu provides options for navigating through the captured packets.

• "Go to Packet…" allows you to jump to a specific packet number.

• "Next Packet" and "Previous Packet" let you move through the packets sequentially.

• "Find Packet…" allows you to search for a packet based on a string or hexadecimal value.

• **Capture Options**: The "Capture" -> "Options" menu (or clicking the "Capture Options" icon) opens a dialog that allows you to configure the capture settings.

• You can select the network interface to capture traffic from.

• You can specify a capture filter to only capture packets that match certain criteria, reducing the size of the capture file and focusing on relevant traffic. ***Capture filters are different from display filters; they are applied during the capture process itself.***

• You can configure options such as promiscuous mode (capturing all traffic on the network, not just traffic destined for your machine), and automatic saving of capture files.

<diagram>

A screenshot of the Wireshark user interface should be included. The screenshot should clearly label the following:

1. Packet List Pane (Top Pane)

2. Packet Details Pane (Middle Pane)

3. Packet Bytes Pane (Bottom Pane)

4. Filter Toolbar

</diagram>

Understanding and effectively using these various panes and windows is essential for conducting thorough and insightful network traffic analysis with Wireshark.

Answer following questions for one packet

**Answer:**

```docx

## Detailed Answer: Use of Wireshark Tool

Wireshark is a powerful and versatile network protocol analyzer, also known as a packet sniffer. It is widely used for network troubleshooting, analysis, software and communications protocol development, and education. Wireshark captures network traffic in real-time and allows you to inspect the data at a granular level.

• **Core Functionality**:

• **Packet Capture**: Wireshark's primary function is to capture network packets from various network interfaces (e.g., Ethernet, Wi-Fi). It captures this traffic non-intrusively, meaning it doesn't alter the packets in any way.

• **Packet Analysis**: Once captured, Wireshark allows you to dissect each packet, displaying the contents of different protocol layers. This includes Ethernet headers, IP headers, TCP/UDP headers, and application-layer data (e.g., HTTP, DNS, SMTP).

• **Filtering**: Wireshark provides robust filtering capabilities to isolate specific traffic of interest. You can filter based on protocol, IP address, port number, or even content within the packet.

• **Color Coding**: Packets are often color-coded based on their protocol type, making it easier to visually identify different types of traffic in the capture.

• **Statistics**: Wireshark can generate statistics about the captured traffic, such as the number of packets per protocol, the average packet size, and the traffic volume over time.

• **Key Applications**:

• **Network Troubleshooting**:

• Identifying network bottlenecks: By analyzing packet delays and retransmissions, you can pinpoint areas where network performance is suffering.

• Diagnosing connectivity issues: Wireshark can help determine if a device is sending and receiving traffic correctly. If not, it can reveal where the connection is failing.

• Detecting network anomalies: Unusual traffic patterns can indicate security breaches or misconfigured devices.

• **Security Analysis**:

• Identifying malicious traffic: Wireshark can be used to detect suspicious activity, such as malware communication or unauthorized access attempts.

• Analyzing security protocols: You can examine the handshake process of protocols like TLS/SSL to ensure they are configured correctly.

• Investigating network intrusions: By capturing and analyzing network traffic during a security incident, you can gain valuable insights into how the attack occurred and what data was compromised.

• **Protocol Development and Debugging**:

• Verifying protocol implementations: Developers can use Wireshark to ensure that their protocol implementations conform to the specifications.

• Debugging protocol errors: When a protocol is not behaving as expected, Wireshark can help identify the root cause of the problem.

• Analyzing protocol interactions: Wireshark allows you to observe the sequence of messages exchanged between different devices, which can be helpful for understanding complex protocols.

• **Education and Training**:

• Learning about network protocols: Wireshark provides a hands-on way to learn how network protocols work by allowing you to examine the actual data exchanged between devices.

• Understanding network communication: Students can use Wireshark to visualize the flow of data across a network and to gain a deeper understanding of network concepts.

• Developing network skills: By using Wireshark, students can develop practical skills in network troubleshooting, analysis, and security.

• **Benefits of Using Wireshark**:

• **Open Source and Free**: Wireshark is an open-source tool, meaning it is free to download and use. This makes it accessible to anyone who needs to analyze network traffic.

• **Cross-Platform**: Wireshark is available for a variety of operating systems, including Windows, macOS, and Linux.

• **Extensive Protocol Support**: Wireshark supports a vast number of network protocols, including common protocols like HTTP, DNS, TCP, UDP, and more specialized protocols. Protocol support is constantly being updated and expanded.

• **Powerful Filtering and Search**: Wireshark's filtering capabilities allow you to quickly find the packets you are interested in, even in very large capture files.

• **Graphical User Interface (GUI)**: Wireshark has a user-friendly GUI that makes it easy to navigate and analyze captured data.

• **Command-Line Interface (CLI)**: TShark, the command-line version of Wireshark, is useful for automating packet capture and analysis tasks.

• **Capture File Support**: Wireshark supports various capture file formats (e.g., PCAP, PCAPNG), allowing you to analyze captures created by other tools.

• **Example Scenario**:

Suppose a user is experiencing slow website loading times. You can use Wireshark to capture the traffic between the user's computer and the web server. By analyzing the capture, you might discover:

• Excessive TCP retransmissions, indicating network congestion or packet loss.

• High latency, suggesting a problem with the network path.

• Slow DNS resolution, indicating a problem with the DNS server.

• Large image files that are not optimized for the web, contributing to slow loading times.

*[Diagram: Diagram showing Wireshark's main window with captured packets. Highlight columns like "Time", "Source", "Destination", "Protocol", and "Info". Show a selected packet's details in the panel below, expanding TCP and HTTP layers to reveal header information.]*

In summary, Wireshark is an indispensable tool for anyone working with computer networks. Its ability to capture and analyze network traffic provides invaluable insights for troubleshooting, security analysis, protocol development, and education. Its open-source nature and cross-platform compatibility make it a widely accessible and versatile tool for network professionals and enthusiasts alike.

```

(1) What is the source and destination IP address?

**Answer:**

```docx

## Wireshark Options Exploration

This section explores various important options available in the Wireshark tool, a powerful network protocol analyzer. Understanding these options is crucial for effective network traffic analysis and troubleshooting.

• \*\*Capture Options:\*\* These options control how Wireshark captures network traffic.

• **Interface Selection:**</b> Allows you to choose the network interface card (NIC) from which to capture traffic. You can select from a list of available interfaces, including Ethernet, Wi-Fi, and virtual interfaces.

• **Capture Filter:**</b> Specifies a filter to capture only specific types of traffic. This can significantly reduce the size of the capture file and make analysis easier. Capture filters use a syntax similar to the `tcpdump` command. For example, `tcp port 80` will capture only HTTP traffic.

• **Promiscuous Mode:**</b> When enabled, the NIC captures all traffic on the network segment, regardless of the destination MAC address. This is necessary for analyzing traffic that is not directly addressed to your machine. However, promiscuous mode may not work on all network environments, such as switched networks.

• **Capture File:**</b> Specifies the file to which the captured traffic will be saved. Wireshark supports various capture file formats, including `.pcap` and `.pcapng`.

• **Ring Buffer:**</b> Allows you to create a capture file that automatically overwrites older data when it reaches a certain size. This is useful for continuous monitoring of network traffic without consuming excessive disk space.

• **Stop Capture Options:**</b> Defines criteria to automatically stop the capture process. Options include stopping after a specified number of packets, after a specified file size is reached, or after a specified duration.

• \*\*Display Filters:\*\* These options allow you to filter the captured traffic based on various criteria, making it easier to find specific packets of interest. Display filters do ***not*** affect the captured data, only what is currently displayed.

• **Protocol Filtering:**</b> Filter traffic based on protocol, such as TCP, UDP, HTTP, DNS, etc. For example, `http` will display only HTTP traffic.

• **Address Filtering:**</b> Filter traffic based on source or destination IP address or MAC address. For example, `ip.src == 192.168.1.100` will display traffic originating from the IP address 192.168.1.100. `eth.dst == 00:11:22:33:44:55` will display traffic destined for MAC address 00:11:22:33:44:55.

• **Port Filtering:**</b> Filter traffic based on source or destination port number. For example, `tcp.dstport == 80` will display TCP traffic destined for port 80.

• **Content Filtering:**</b> Filter traffic based on the contents of the packet. This can be useful for finding packets containing specific strings or patterns.

• **Logical Operators:**</b> Combine multiple filters using logical operators such as `and`, `or`, and `not`. For example, `tcp.dstport == 80 and ip.src == 192.168.1.100` will display TCP traffic destined for port 80 and originating from the IP address 192.168.1.100.

• \*\*Follow TCP Stream:\*\* This option allows you to reconstruct the entire TCP conversation between two endpoints, making it easier to analyze the data exchanged.

• Right-click on a TCP packet in the packet list pane.

• Select "Follow" -> "TCP Stream".

• A new window will appear, showing the entire TCP stream.

• You can filter the stream to show only data from one endpoint or the other.

• This is especially useful for analyzing HTTP requests and responses, or other protocol data that is transmitted over TCP.

• \*\*Statistics:\*\* Wireshark provides various statistics about the captured traffic, which can be helpful for identifying network problems.

• **Capture File Properties:**</b> Displays information about the capture file, such as the number of packets, the capture duration, and the file size.

• **Protocol Hierarchy:**</b> Shows the distribution of traffic by protocol, allowing you to quickly identify the most common protocols in the capture.

• **Endpoints:**</b> Lists all of the endpoints (IP addresses and MAC addresses) that were involved in the captured traffic.

• **Conversations:**</b> Lists all of the conversations (pairs of endpoints) that were involved in the captured traffic.

• **IO Graphs:**</b> Creates graphical representations of network traffic over time, allowing you to visualize traffic patterns and identify bottlenecks.

• \*\*Coloring Rules:\*\* Wireshark allows you to define coloring rules to highlight packets based on various criteria. This can make it easier to identify specific types of traffic or to spot potential problems.

• You can create coloring rules based on protocol, IP address, port number, or other criteria.

• Coloring rules are applied to the packet list pane, highlighting packets that match the specified criteria.

• Coloring rules can be used to quickly identify important packets, such as error messages or packets from a specific host.

• \*\*Expert Information:\*\* Wireshark's "Expert Information" feature analyzes the captured traffic and provides suggestions for troubleshooting network problems.

• The "Expert Information" window displays a list of potential problems, along with descriptions and recommendations.

• Expert Information can help you identify issues such as TCP retransmissions, DNS errors, or HTTP errors.

• The severity of the issues is indicated by different colors (e.g., red for errors, yellow for warnings, blue for notes).

<diagram>

A screenshot of the Wireshark interface, highlighting the following key areas:

1. The capture interface selection dropdown.

2. The capture filter input field.

3. The display filter input field.

4. The packet list pane, showing captured packets with coloring rules applied.

5. The packet details pane, showing the contents of a selected packet.

6. The packet bytes pane, showing the raw bytes of a selected packet.

7. The Statistics menu.

8. The Expert Information button.

</diagram>

<table>

Packet Filtering Options|Description

Capture Filters|Used ***during*** the capture process to limit the packets saved to the capture file. Can't be changed after the capture starts.

Display Filters|Used ***after*** the capture is complete to filter the packets displayed in the Wireshark interface. Can be changed at any time.

</table>

By mastering these options, you can effectively use Wireshark to analyze network traffic, troubleshoot network problems, and gain a deeper understanding of network protocols.

```

(2) What is the MAC address of source and destination?

(3) What is the port address of source and destination?

(4) What is the TTL fields value in IP layer of the packet

Add screenshots of all above answers in your document.

**Quiz:** (Sufficient space to be provided for the answers)

1. Explain various planes or windows shown in user interface of Wireshark tool

2. What is the use of Wireshark tool?

3. Explore various important options available in Wireshark tool

**Suggested Reference**: <https://www.wireshark.org/>

**References used by the students**: (Sufficient space to be provided)

# Rubric wise marks obtained:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Rubrics | Understanding of Protocols | | Effective Packet Capture | | Header Analysis | | Problem Solving and Troubleshooting | | Documentation and Reporting | | Total |
| Good (2) | Avg. (1) | Good (2) | Avg.(1) | Good (2) | Avg. (1) | Good (2) | Avg.(1) | Good (2) | Avg. (1) |
| Marks |  |  |  |  |  |  |  |  |  |  |  |