COMPUTER NETWORKS LAB

Experiment 1

Network Topology Design and Analysis

Tool Used:	Cisco Packet Tracer
Subnet:	192.168.10.0 /24
Topologies Studied:	Star (Switch), Bus-like (Hub), Ring-like (STP Loop)
Protocol Used:	IPv4, ICMP (Ping), ARP, STP

1. Objective

The objective of this experiment is to design and simulate three different LAN topologies in Cisco Packet Tracer — Star (Switch-based), Bus-like (Hub-based), and Ring-like (Switch loop with STP) — in order to understand how network topology affects connectivity, fault tolerance, and overall performance. Students configure IPv4 addresses on all end devices and verify communication using ICMP ping tests.

Learning Outcomes:

- Design and build small networks using different physical topologies in Packet Tracer.
- Assign correct IPv4 addresses and subnet masks to end devices.
- Use ICMP ping to verify Layer 3 connectivity between devices.
- Observe and explain the impact of topology on packet delivery and performance.
- Identify single points of failure and analyze fault tolerance behavior.
- Compare switch vs hub behavior at Layer 1 and Layer 2.

2. Concepts and Background

Network Topology

A network topology defines the physical or logical arrangement of devices and connections in a network. Common topologies include Star, Bus, Ring, Mesh, and Hybrid. The choice of topology affects performance, fault tolerance, and cost.

Switch vs Hub

A switch (Layer 2 device) learns MAC addresses and forwards frames only to the intended destination port, creating separate collision domains per port. A hub (Layer 1 device) floods all incoming frames out of every port, sharing a single collision domain — leading to collisions and performance degradation.

IPv4 Addressing

IPv4 uses 32-bit addresses expressed in dotted-decimal notation (e.g., 192.168.10.1). The subnet mask (e.g., /24 or 255.255.255.0) defines the network and host portions. Devices in the same subnet can communicate directly without routing.

ICMP Ping

The Internet Control Message Protocol (ICMP) is used by the ping utility to test network connectivity. A ping sends an Echo Request and expects an Echo Reply. Successful replies confirm Layer 3 reachability between devices.

Spanning Tree Protocol (STP)

STP (IEEE 802.1D) prevents Layer 2 loops in networks with redundant switch connections. It elects a root bridge and places redundant ports in a BLOCKING state. When an active link fails, STP reconverges and activates the previously blocked path — providing fault tolerance.

3. Tasks and Topology Diagrams

Task 1 — Star Topology (Switch-based)

A single Cisco 2960 switch is placed at the center, with four PCs connected to it using straight-through Ethernet cables. This models the classic star topology used in modern office LANs.

ASCII Diagram:

```
        [PC1]
          |
[PC4] ---[Switch]--- [PC2]
          |
        [PC3]
```

Device	IP Address	Subnet Mask	Role
PC1	192.168.10.1	255.255.255.0	Source / Sender
PC2	192.168.10.2	255.255.255.0	Target
PC3	192.168.10.3	255.255.255.0	Target
PC4	192.168.10.4	255.255.255.0	Target
Switch	N/A	N/A	Layer 2 Forwarder

Procedure:

1. Open Cisco Packet Tracer and create a new project.
2. Place one 2960 Switch and four Generic PCs on the canvas.
3. Connect each PC to the switch using straight-through copper cables.
4. Configure IP addresses on each PC (Desktop → IP Configuration).
5. From PC1 Command Prompt, run: ping 192.168.10.2, ping 192.168.10.3, ping 192.168.10.4.
6. Switch to Simulation Mode and observe unicast vs broadcast behavior.

Task 2 — Bus-like Topology (Hub-based)

The switch from Task 1 is replaced with a hub. The same IP addressing scheme is retained. This simulates a legacy bus-like topology where all devices share a common collision domain.

```
        [PC1]
          |
[PC4] ---[HUB]--- [PC2]
          |
        [PC3]
```

Key observation: In Simulation Mode, every frame transmitted by any PC is flooded to all other ports. When multiple PCs transmit simultaneously, collisions occur and CSMA/CD triggers retransmission delays.

Task 3 — Ring-like Topology (3 Switches in Loop)

Three Cisco 2960 switches are connected in a triangular loop, with one to two PCs attached to each switch. STP is active by default and prevents broadcast storms by blocking one redundant port.

```
[PC1,PC2]---[Switch A]---[PC3,PC4]
            /                   \
[Switch C]              [Switch B]
[PC5,PC6]
```

STP elects one root bridge and places one inter-switch link in BLOCKING state. The network converges within approximately 30 seconds. All ping tests succeed after convergence.

Task 4 — Failure Test (Link Disconnection)

One active inter-switch link in the ring topology is deliberately removed to simulate a cable failure. STP detects the topology change and begins reconvergence, activating the previously blocked standby path.

Phase	PC1 → PC3 Result	Observation
Before disconnection	SUCCESS (0% loss)	Direct path via Switch A-B
Immediately after cut	TIMEOUT	STP reconverging
After reconvergence (~40s)	SUCCESS (path rerouted)	Via Switch C as relay

4. Results and Observations

4.1 Ping Summary

Task	Source	Destination	Packets Sent	Received	Loss
Task 1 (Switch)	PC1	PC2	4	4	0%
Task 1 (Switch)	PC1	PC3	4	4	0%
Task 1 (Switch)	PC1	PC4	4	4	0%
Task 2 (Hub)	PC1	PC2	4	4	0%
Task 2 (Hub)	PC1	PC3	4	4	0%
Task 3 (Ring)	PC1	PC3	4	4	0%
Task 3 (Ring)	PC1	PC5	4	4	0%
Task 3 (Ring)	PC3	PC6	4	4	0%
Task 4 (Failure)	PC1	PC3	4	2	50%*

* 50% loss includes packets dropped during STP reconvergence (~30-50 sec). After reconvergence, 0% loss was achieved.

4.2 Key Observations

Star (Switch) — Task 1

The switch intelligently forwarded frames only to the destination port after learning MAC addresses. ARP broadcast was visible only on the first ping. Subsequent pings were pure unicast. Zero packet loss. Fastest performance.

Bus-like (Hub) — Task 2

The hub flooded every frame to all ports — a clear security and performance issue. In Simulation Mode, all PCs received frames intended for only one. Simultaneous transmissions caused collisions and CSMA/CD retransmissions. Performance degrades with more devices or traffic.

Ring (STP Loop) — Task 3

STP successfully prevented a broadcast storm by placing one port in BLOCKING state. After ~30 second convergence, all cross-switch pings succeeded. The blocked port was ready as a failover standby path.

Failure Test — Task 4

Disconnecting an active link demonstrated STP's fault tolerance. After reconvergence, traffic was automatically rerouted through the alternate switch. The 30–50 second delay is a limitation of classic 802.1D STP — modern networks use Rapid STP (RSTP) for sub-second failover.

5. Topology Comparison

Criterion	Star (Switch)	Bus-like (Hub)	Ring (STP)
Fault Tolerance	Low — switch = SPOF	Very Low	High — alternate path
Performance	High (unicast)	Low (shared/collisions)	High (after STP)
Scalability	Easy (add ports)	Very Limited	Moderate
Setup Complexity	Low	Very Low	Medium (STP tuning)

Cost	Medium	Low (hubs are cheap)	Higher (3+ switches)
Security	Better (unicast)	Poor (all see frames)	Better
Use Case	Office LAN	Legacy/Lab only	Fault-tolerant LAN

6. Conclusion

This experiment successfully demonstrated the behavior of three fundamental LAN topologies using Cisco Packet Tracer. The star topology with a switch provided the best combination of performance, simplicity, and ease of management — making it the standard choice for modern enterprise and office networks.

The hub-based bus-like topology illustrated the limitations of legacy hardware: collision-prone shared medium, lack of security (all frames visible to all devices), and poor scalability. This reinforces why hubs have been replaced by switches in professional environments.

The ring topology with STP demonstrated how redundant links provide fault tolerance. When a link failed, the network automatically recovered through the alternate path. However, the classic STP reconvergence delay (~30–50 seconds) is a notable drawback. In production environments, Rapid STP (RSTP) or technologies like EtherChannel are used to reduce failover time to under one second.

The practical takeaway is that topology selection must balance cost, fault tolerance requirements, scalability, and complexity based on the specific use case — whether it is a small home network, a campus LAN, or a mission-critical data center.

7. Practical Applications

- Star topology is used in virtually all modern office, school, and home networks due to its simplicity and switch intelligence.
- Ring/mesh redundancy is critical in hospital networks, banking systems, and industrial control systems where downtime is unacceptable.
- Hub-based bus networks are studied historically and in lab environments to understand CSMA/CD and collision behavior.
- STP and RSTP are deployed in enterprise core/distribution switch layers to prevent loops while maintaining redundancy.
- Understanding topology trade-offs helps network engineers select appropriate designs based on budget and SLA requirements.