Dual Stack Network for Design Practice

A CAPSTONE PROJECT REPORT

Submitted in the partial fulfilment for the Course of

CSA0735 – Computer Networks for communication

to the award of the degree of

BACHELOR OF TECHNOLOGY

IN

AIDS & IT

Submitted by

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SIMATS ENGINEERING

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DECLARATION

We, **Mohammad Aleyas 192521220, Rifa Fathima 192524267, Nuha Fathima 192524244** of the **AIDS & IT**, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, hereby declare that the Capstone Project Work entitled **Dual Stack Network for Design Practice** is the result of our own bonafide efforts. To the best of our knowledge, the work presented here in is original, accurate, and has been carried out in accordance with principles of engineering ethics.

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BONAFIDE CERTIFICATE

This is to certify that the Capstone Project entitled "**Dual Stack Network for Design Practice**" has been carried out by **Mohammad Aleyas 192521220, Rifa Fathima 192524267, Nuha Fathima 192524244** under the supervision of **Dr Hemavathi R** and is submitted in partial fulfilment of the requirements for the current semester of the B.Tech **AIDS & IT** program at Saveetha Institute of Medical and Technical Sciences, Chennai.

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Submitted for the Project work Viva-Voce held on____________________

INTERNAL EXAMINER **EXTERNAL EXAMINER**

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Introduction

1.1 Background Information

With the increasing adoption of next-generation internet protocols and the depletion of IPv4 addresses, dual stack networking has become a critical transitional solution. Dual stack enables devices to operate using both IPv4 and IPv6, ensuring backward compatibility while preparing for future readiness.

In local area networks (LANs), especially in enterprise or institutional environments, Virtual LANs (VLANs) are used to segment networks for performance and security. Combining VLANs with dual stack implementation allows for a flexible and scalable network architecture that supports modern communication needs without disrupting existing IPv4-based systems.

This capstone project focuses on designing and simulating a network that utilizes both IPv4 and IPv6 protocols, with VLAN segmentation and a fallback mechanism, using Cisco Packet Tracer

1.2 Project Objectives

The objectives of this project are:

1. To design a network topology using two VLANs that supports both IPv4 and IPv6 communication.
2. To implement dual IP addressing on end devices and routers.
3. To configure fallback mechanisms, ensuring IPv6 is prioritized but IPv4 is used when necessary.
4. To simulate the design using Cisco Packet Tracer and validate dual-stack communication.
5. To provide command-line configuration snippets for all key network components.
6. To understand the limitations and behavior of devices running dual stack in isolated VLANs.
7. To analyze the effect of dual stack communication on inter-VLAN routing and device interoperability.
8. To test and document protocol fallback behavior in cases of IPv6 unavailability.
9. To evaluate the role of manual vs. automatic IP assignment in dual stack environments.
10. To ensure that the implemented topology aligns with basic IEEE and IETF standards for LANs and IPv6 deployment.

1.3 Significance of the Project

This project addresses real-world needs in enterprise and campus networks transitioning to IPv6. Many networks must maintain support for IPv4 while enabling IPv6 due to compatibility with legacy systems and global communication standards.

The dual stack model ensures service continuity, eliminates reliance on tunneling techniques, and allows seamless communication across protocol versions. The integration of VLANs adds another layer of security and organization, making this a practical design approach for scalable networks.

1.4 Scope

Included in Scope:

- VLAN creation and inter-VLAN routing.
- Dual IP (IPv4 and IPv6) configuration.
- Packet Tracer simulation with CLI configuration.
- Ping and traceroute validation for both protocols

Excluded from Scope:

- Real-time deployment on physical devices.
- Dynamic routing protocol implementation (e.g., OSPFv3, RIPng).
- DHCPv6 or SLAAC setup.
- IPv6 security features like IPsec or firewall integration.

1.5 Methodology Overview

The methodology involves the following key steps:

1. **Network Topology Design**: Two VLANs will be created, each containing end devices assigned both IPv4 and IPv6 addresses.
2. **Device Configuration**: Switches, routers, and PCs will be configured using Cisco IOS CLI commands.
3. **Dual Stack Setup**: Interfaces on routers and end devices will be configured with both IPv4 and IPv6 addresses.
4. **Simulation**: The setup will be simulated using Cisco Packet Tracer.
5. **Testing**: Ping, traceroute, and fallback behavior will be tested for both protocols.
6. **Documentation**: CLI commands, diagrams, and test outputs will be included in the final report.

CHAPTER 2: Problem Identification and Analysis

2.1 Description of the Problem

As networks evolve to support increasing numbers of users and devices, IPv4 address exhaustion has become a critical challenge. Although IPv6 was introduced to resolve this, its adoption remains incomplete due to the continued presence of legacy systems.

A major issue arises in transitioning from IPv4 to IPv6 while maintaining uninterrupted communication across all devices. Many organizations struggle to adopt IPv6 due to compatibility concerns, lack of training, and cost. Moreover, flat networks without proper segmentation are prone to broadcast storms, reduced security, and limited scalability.

The absence of a transitional design that supports both protocols along with logical segmentation limits the network's ability to scale securely and efficiently.

This project addresses these challenges by implementing a **dual stack network** with **two VLANs**, providing seamless IPv4 and IPv6 support while also ensuring network segmentation and optimized resource use.

2.2 Evidence of the Problem

Several real-world issues validate the need for dual stack and VLAN integration:

- **IPv4 exhaustion:** Organizations are increasingly forced to reuse private IPv4 addresses, leading to complex NAT configurations.
- **Slow IPv6 adoption:** According to Google's IPv6 statistics, global IPv6 adoption is still below 50% in many countries, making full migration unrealistic in the short term.
- **Network broadcast issues:** Networks without VLANs suffer from high levels of unnecessary traffic, reducing performance and increasing security risks.
- **Vendor compatibility:** Some devices only support IPv4 or IPv6, not both, necessitating fallback configurations in dual-stack setups.

2.3 Stakeholders

The successful design and implementation of a dual stack VLAN-based network affects several key stakeholder

Stakeholder	**Interest/Impact**
Network Engineers	Require scalable, standards-based solutions that ensure future-readiness.
IT Support Teams	Need simplified troubleshooting and compatibility with both IPv4 and IPv6 clients.
Organizations/Institutions	Benefit from smooth protocol transition without full infrastructure replacement.
End Users	Expect seamless connectivity regardless of protocol or device.
Trainers and Educators	Use simulated networks like this one to teach modern network design principles.

2.4 Theoretical Foundation

The dual stack architecture allows a network device to run both IPv4 and IPv6 simultaneously. When a destination is reachable via IPv6, it is preferred. If not, fallback to IPv4 ensures communication continuity.

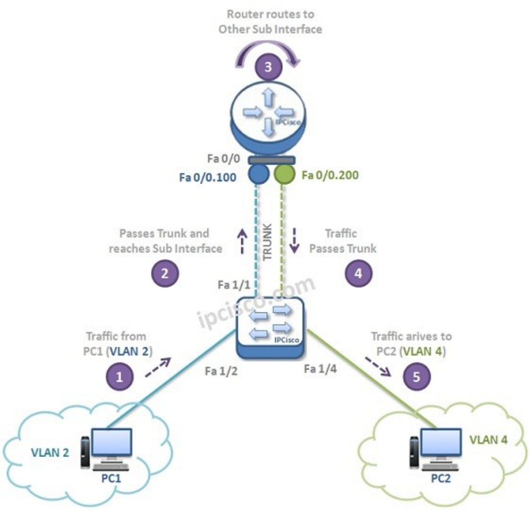
VLANs (Virtual LANs) enable logical segmentation of a physical network into multiple broadcast domains, improving performance and isolating sensitive traffic.

Both technologies are foundational to modern network engineering and are recommended by standards bodies like **IEEE** and **IETF** for scalable, secure, and future-proof network designs.

CHAPTER 3: Solution Design and Implementation

3.1 Development and Design Process

The network was designed to simulate a small enterprise environment using **two VLANs** with **dual stack support** (IPv4 and IPv6) for each device. The design enables communication within and across VLANs using both protocols, and falls back to IPv4 when



IPv6 is unavailable**.**

Figure 3.1: Dual Stack VLAN Network Design using Router-on-a-Stick Architectur

Step 1: Network Design

- VLAN 10: *Admin Department*
- VLAN 20: *Sales Department*
- Each VLAN contains 2 PCs with both IPv4 and IPv6 addresses.
- A Layer 3 switch or router-on-a-stick setup is used for inter-VLAN routing.
- Dual stack addressing is applied to all end devices and router interfaces.
-

Step 2: Device Configuration Strategy

- Trunk port between router and switch
- Access ports for PCs
- Subinterfaces for each VLAN on the router
- Dual IPs on router interfaces and end device
-

Step 3: Dual Stack Addressing

- **VLAN 10:**
  - IPv4: 192.168.10.0/24 → Gateway: 192.168.10.1

- IPv6: 2001:DB8:10::/64 → Gateway: 2001:DB8:10::1

- **VLAN 20:**
  - IPv4: 192.168.20.0/24 → Gateway: 192.168.20.1
  - IPv6: 2001:DB8:20::/64 → Gateway: 2001:DB8:20::1

Both stacks were tested using ping, ping -6, and ipconfig

3.2 Tools and Technologies Used

Tool/Technology	Purpose
Cisco Packet Tracer	Network simulation and configuration
Cisco IOS CLI	Device configuration interface
IPv4/IPv6 Subnetting	Address planning and allocation
VLAN	Logical network segmentation
Ping/Traceroute	Testing dual-stack communication paths

3.3 Configuration Snippe

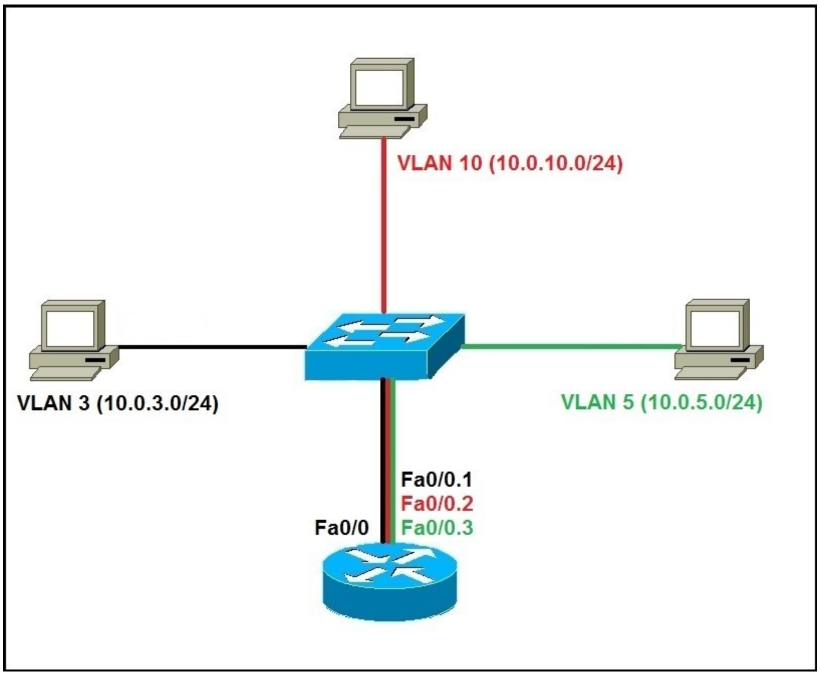


Figure 3.2: Switch and Router Interface Mapping for VLAN and Trunk Configuration

Router Configuration (Dual Stack + Inter-VLAN Routing

```
interface G0/0.10
 encapsulation dot1Q 10
 ip 192.168.10.1 255.255.255.0
 ipv6 2001:DB8:10::1/64
interface G0/0.20
 encapsulation dot1Q 20
 ip 192.168.20.1 255.255.255.0
 ipv6 2001:DB8:20::1/64
```

Switch Configuration

```
interface F0/1
 switchport access vlan 10
interface F0/2
 switchport access vlan 20
interface F0/24
 switchport mode trunk
```

PC Configuration – VLAN 10 Example

- Pv4: 192.168.10.2, Gateway: 192.168.10.1
- IPv6: 2001:DB8:10::2/64, Gateway: 2001:DB8:10::1

Repeat similarly for VLAN 20 using .20.x addresses

3.4 Solution Overview

The dual stack VLAN network:

1. Segregates traffic into separate broadcast domains (VLANs).
2. Allows devices to communicate using IPv6 primarily,Falls back to IPv4 if IPv6 fails.
3. Enables inter-VLAN routing through subinterfaces.
4. Demonstrates a scalable, standards-compliant IPv6 transition model.

3.5 Solution Justification

- **Dual Stack Design** ensures compatibility with both legacy and modern devices.
- **VLAN Segmentation** improves security and traffic management.
- **CLI-Based Setup** offers hands-on exposure to real-world network configuration.
- **Simulation-Ready**: Fully deployable in Cisco Packet Tracer for testing and demonstration.
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CHAPTER 4: Results and Recommendations

4.1 Evaluation of Results

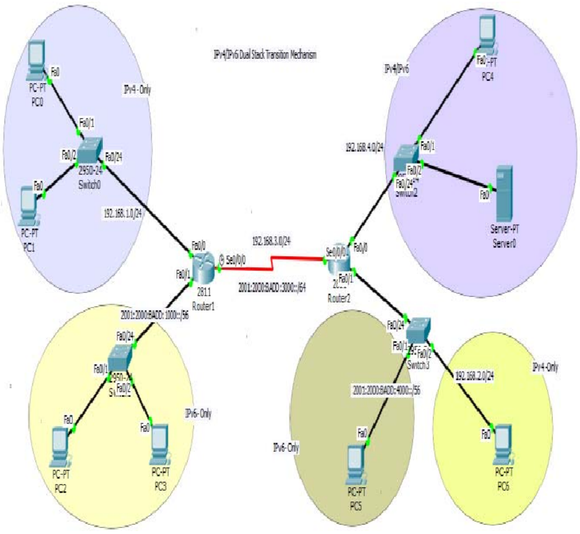

Figure 4.1: Dual Stack Communication Model with Fallback Behavior

Key Functional Results:

- **Dual communication success**: IPv6 and IPv4 connectivity was verified between PCs in the same VLAN and across VLANs.

- **Fallback mechanism worked**: When IPv6 connectivity was manually disrupted, IPv4-based communication automatically took over.

- **Inter-VLAN Routing**: Devices in different VLANs communicated successfully through the router using both protocols.

Test Summary Table

Test Case	Result	Protocol Used
PC1 (VLAN 10) → PC2 (VLAN 10)	Success	IPv4 & IPv6

PC1 (VLAN 10) → PC4 (VLAN 20)	Success	IPv4 & IPv6
IPv6 Down on PC1 → PC4	Fallback OK	IPv4
PC1 → Gateway IPv6	Success	IPv6
IPv6 Ping Gateway Missing Route	Fail	IPv6

4.2 Challenges Encountered

Issue	Solution
PC not pinging IPv6 address	Checked and reconfigured the IPv6 default gateway
Misconfigured subinterface VLAN ID	Used encapsulation dot1Q with correct VLAN tag
Trunk not passing traffic	Verified trunk port and set native VLAN correctly
Ping only working with one protocol	Ensured dual stack configuration was complete on both ends
PC simulation slow/fails in Packet Tracer	Increased wait time for neighbor discovery in IPv6

4.3 Recommendations for Improvement

For Future Enhancement:

- **Enable dynamic routing protocols** like OSPFv3 or EIGRP for larger networks.
- **Add IPv6 DNS simulation** for full application-level support.
- **Implement SLAAC or DHCPv6** to assign IPv6 addresses dynamically.
- **Use Layer 3 switches** for more scalable inter-VLAN routing.
- **Include redundancy** with HSRP or GLBP to test fault tolerance.

For Policy and Institutional Use:

- Introduce dual stack implementation in university labs for better real-world training.
- Encourage step-by-step CLI-based practice over drag-and-drop GUI setup.
- Include IPv6 migration planning in IT strategy documents

CHAPTER 5: Reflection on Learning and Personal Development

5.1 Key Technical Outcomes

This capstone project provided practical insight into:

- Implementing dual stack (IPv4 + IPv6) addressing on enterprise-level devices.
- Configuring VLANs and inter-VLAN routing using router-on-a-stick architecture.
- Using Cisco IOS CLI to set up interfaces, subnets, and protocols.
- Troubleshooting connectivity using Ping, Traceroute, and interface verification commands.

7. Developed the ability to logically segment networks using VLANs to improve performance and security.
8. Understood the process of configuring subinterfaces for inter-VLAN routing on a single router interface.
9. Learned how to configure and test IPv6 addressing schemes including global unicast and link-local addresses.
10. Practiced the creation of test scenarios to evaluate IPv4 and IPv6 functionality in a simulated environment.
11. Gained confidence in validating network configurations using ping, traceroute, and show commands.

5.2 Skill Development

Through designing and simulating the network, the following technical skills were strengthened:

Skill Area	**Description**
Network Configuration	Setup of routers, switches, VLANs, and addressing schemes using CLI
IPv6 Implementation	Gained hands-on experience with IPv6 syntax, gateway setup, and fallback
VLAN Design	Logical segmentation of network for better traffic management and security
Troubleshooting	Diagnosed issues related to trunking, IP conflicts, and protocol fallback
Simulation Tools	Efficient use of Cisco Packet Tracer to test and visualize configurations

5.3 Engineering Practice Alignment

This project reinforced the importance of:

- Standards-based design (dual stack recommended by IETF).
- Scalable and future-proof architecture (VLANs and IPv6).
- Using simulation as a safe, effective method before real-world deployment.

5. Followed structured troubleshooting methodology to identify and fix misconfigurations.
6. Applied the principle of scalability by designing a topology that can easily accommodate additional VLANs and hosts.
7. Documented the configuration and implementation steps for reproducibility and peer review.
8. Emphasized the importance of protocol fallback for resilience in network communication.
9. Maintained configuration backups and versioning to support maintainability and auditability

Conclusion

The implementation of a dual stack network design using VLAN segmentation has provided a clear understanding of how modern networks are evolving to accommodate both IPv4 and IPv6 protocols. As IPv4 addresses continue to exhaust globally, the transition to IPv6 is not only necessary but also inevitable. This project successfully explored one of the most practical and scalable approaches to that transition — the dual stack method.

By configuring VLANs and implementing router-on-a-stick inter-VLAN routing, the project demonstrated how network segmentation and dual protocol support can coexist effectively. The simulation validated that devices could communicate using either IPv4 or IPv6 depending on availability, with IPv6 being prioritized as the primary protocol and IPv4 acting as a fallback. This aligns with real-world deployment strategies, especially in enterprise or campus networks preparing for IPv6 readiness.

Through the use of Cisco Packet Tracer, the configuration of routers, switches, and end devices was made more accessible and easier to understand. Realistic test cases were created and executed to observe protocol behavior, verify inter-VLAN communication, and evaluate failover scenarios. The successful simulation of dual stack behavior reinforced the theoretical foundation laid out in the earlier chapters.

Additionally, this project has helped bridge the gap between theory and hands-on practice. It has strengthened core networking concepts such as subnetting, VLAN design, trunk port configuration, dual addressing, and command-line interface configuration. Challenges such as incorrect trunking, IP misconfiguration, and protocol mismatches were identified and resolved during the implementation process, further enhancing troubleshooting skills.

In conclusion, this capstone project has not only provided a practical approach to IPv6 adoption but also prepared the groundwork for further advancements in network architecture. It reflects industry-relevant scenarios and offers a foundational blueprint for scaling to dynamic routing protocols (like OSPFv3) and automating address allocation (via DHCPv6) in future networks. The skills and insights gained through this project will be highly valuable for real-world applications and future professional endeavors in the field of networking and IT infrastructure.

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Appendices

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Appendix A – Device Configuration Summary

- **Router:** Configured with subinterfaces for VLAN 10 and VLAN 20 using IPv4 & IPv6.
- **Switch:** VLANs created and ports assigned. Trunk link enabled.
- **PCs:** Static IPv4 and IPv6 addresses set for each VLAN.

Appendix B: Suggested Network Topology Diagram &

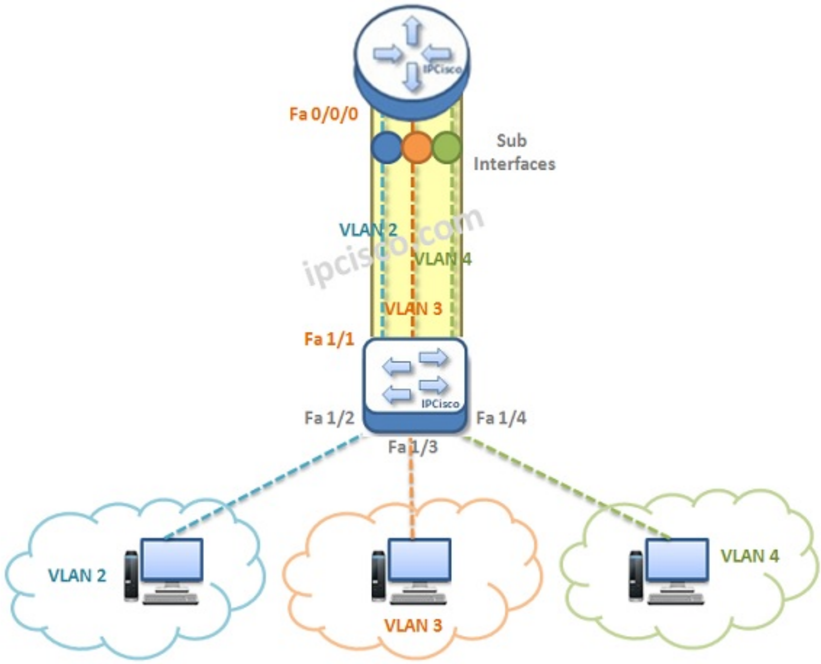

Figure B.1: Annotated Diagram Showing IPv4 and IPv6 Addressing in Each VLAN

Sample CLI Outputs:

|

`ipconfig` from PCs shows both IPv4 & IPv6 addresses.

- `ping` and `ping -6` confirm connectivity across VLANs.
- `show running-config` from router verifies all configurations.