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B.Tech CSE - CSCD Project Report

Project Title: Hospital Management Networks

Group Number: 1

Department: FET

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Certificate of the Guide

This is to certify that the project titled “Hospital Management Networks” submitted by the following students:

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of the Faculty of Engineering and Technology has been carried out under my guidance in partial fulfilment of the requirements for the award of the degree. To the best of my knowledge, this work has not been submitted to any other university or institution for the award of any degree or diploma.

Guided By:

Dr. Lal Mohan Patnaik - Assistant Professor

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Institution: Sri Sri University

(Signature)

Student Declaration

We hereby declare that the project work entitled "Hospital Management Networks" submitted to Faculty of Engineering and Technology, Sri Sri University Cuttack Odisha, is a record of original work carried out by us under the guidance of Prof. Lal Mohan Patnaik & Mr. Aayush Joshi.

This work has not been submitted anywhere else for any other degree or diploma.

- Snigdha Rani Behera (FET-BCD-2023-27-001)
- Om Asutosh Das (FET-BCD-2023-27-005)
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Date:

Place: Cuttack

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Finally, we thank each other as a team for the hard work and collaboration that made this project a success.

Students Signatures:

- 1.
- 2.
- 3.
- 4.

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Abstract

The CareNet Infrastructure project is dedicated to the design and implementation of a robust, secure, and scalable hospital network aimed at enhancing connectivity, operational efficiency, and data security within a modern healthcare environment. With the increasing reliance on digital technologies such as Electronic Medical Records (EMRs), telemedicine, and IoT-enabled medical devices, the need for a well-structured and secure network has become critical. This project seeks to integrate various hospital departments through a high-availability, hierarchical network design while ensuring data privacy and regulatory compliance. The network architecture incorporates advanced features such as VLAN segmentation, encryption, access control mechanisms, and redundancy to support uninterrupted medical services. This document presents the motivation, objectives, problem statement, literature review, work plan, testing methodologies, and expected outcomes, providing a comprehensive overview of the project's approach and its significance in supporting the digital transformation of healthcare systems.

Introduction

This project is centred on the design and implementation of a robust and well-structured hospital network infrastructure tailored to meet the demands of modern medical operations. The primary objective is to seamlessly integrate various hospital departments—such as Electronic Medical Records (EMRs), telemedicine platforms, and IoT-enabled medical devices—through secure, reliable, and efficient communication channels.

In today's digitally evolving healthcare landscape, real-time communication, data integrity, and secure access to patient information are critical to operational success. This project addresses these needs by developing a scalable and secure network that enhances inter-departmental collaboration, streamlines medical workflows, and ensures compliance with healthcare data protection standards.

The proposed network employs a hierarchical architecture, comprising Core, Distribution, and Access layers, to provide high performance, fault tolerance, and ease of management. Key security features—including data encryption, VLAN segmentation, and role-based access controls—are integrated to protect sensitive patient information and ensure the integrity of connected medical devices. By aligning with the latest networking standards and healthcare IT requirements, this project contributes to building a future-ready infrastructure for advanced healthcare delivery.

Objective & Scope

The primary objective of this project is to design and implement a secure, cost-effective, and scalable hospital network infrastructure that enhances operational efficiency and supports modern healthcare technologies. The solution aims to:

- Optimize resource utilization through virtualization and open standards.
- Ensure continuous and reliable operations with redundancy and failover mechanisms.
- Support future expansion using SDN and NFV for automation and flexibility.
- Maintain data security and regulatory compliance (e.g., HIPAA) through robust access controls and encryption.
- Deliver high-speed, low-latency connectivity with advanced networking technologies like Wi-Fi 6 and QoS-enabled Ethernet.

The scope of this project includes:

Designing a hierarchical network architecture (Core, Distribution, Access layers) tailored for hospital environments.

Integrating essential healthcare services including EMRs, telemedicine, IoT medical devices, and cloud platforms.

Implementing network virtualization, SDN, and NFV to support dynamic configurations and service deployment.

Deploying advanced security mechanisms, such as VLANs, ACLs, firewalls, and encrypted communication protocols.

Providing high availability and scalability to accommodate future healthcare innovations and patient care demands.

Conducting comprehensive testing and evaluation to validate performance, reliability, and compliance.

Problem Statement

Modern hospitals rely heavily on digital technologies such as Electronic Medical Records (EMRs), telemedicine, IoT-enabled medical devices, and real-time patient monitoring systems. However, many existing hospital networks lack the scalability, security, and reliability required to support these critical services. Challenges such as downtime due to lack of redundancy, security vulnerabilities, bandwidth limitations, and poor device interoperability hinder effective healthcare delivery. There is a pressing need for a robust, secure, and future-ready network infrastructure that can ensure high availability, protect sensitive patient data, optimize bandwidth, and seamlessly integrate diverse medical systems. This project addresses these issues by designing and implementing a well-structured hospital network that meets modern healthcare requirements while being scalable for future technological advancements. There are some core area problems:

Lack of Redundancy: Existing networks are prone to failures, leading to downtime in critical care operations.

Insufficient Security Measures: Inadequate encryption and access controls put patient data at risk of breaches and non-compliance with healthcare regulations.

Bandwidth Bottlenecks: Current infrastructure struggles to support high-resolution imaging, telemedicine, and real-time monitoring simultaneously.

Limited Scalability: Inability to accommodate growing demands from IoT devices and cloud-based healthcare systems.

Poor Device Interoperability: Fragmented systems make it difficult to integrate EMRs, IoT devices, and departmental applications efficiently.

Motivation

The motivation behind this project arises from the growing need for hospitals to adopt efficient, secure, and scalable network infrastructures that can support modern healthcare technologies. Current hospital networks often face significant challenges such as:

Inadequate data protection, exposing sensitive patient information to cybersecurity risks.

Network congestion, resulting in delays in accessing critical medical systems and patient records.

Limited scalability, restricting the adoption of emerging technologies like IoT and cloud-based healthcare solutions.

By addressing these issues, a well-designed hospital network can enhance data integrity, improve operational efficiency, and elevate the overall quality of patient care. This project aims to empower healthcare facilities with a future-ready digital infrastructure that meets current demands and anticipates future growth.

Literature Review

S.No.	Author(s)	Year	Title	Objective	Methodology	Key Findings	Gaps Identified
1	Ewoh P Vartiainen T	2024	Vulnerability to Cyberattacks and Sociotechnical Solutions for Health Care Systems: Systematic Review	To explore why digital healthcare systems are vulnerable to cyberattacks and provide sociotechnical solutions.	Conducted a systematic literature review focusing on sociotechnical factors affecting healthcare cybersecurity.	Identified human error, lack of investment, and outdated systems as key vulnerabilities ; proposed sociotechnical interventions.	Highlighted the need for integrated approaches combining technical and human factors in cybersecurity strategies.
2	Hasegawa K et al	2024	Cybersecurity Interventions in Health Care Organizations in Low- and Middle-Income Countries: Scoping Review	To describe cybersecurity interventions implemented in healthcare organizations in low- and middle-income countries and evaluate their impact.	Performed a scoping review of literature focusing on cybersecurity interventions in LMIC healthcare settings.	Found limited research on cybersecurity interventions in LMICs; emphasized the need for context specific strategies.	Identified a lack of evaluation of intervention outcomes and impact in existing studies.
3	Alanazi AT et al	2023	Clinicians' Perspectives on Healthcare Cybersecurity and Cyber Threats: A Qualitative Study	To explore clinicians' perspectives on cybersecurity in healthcare, including its impact on patient safety and organizational functioning.	Utilized the Delphi technique to gather opinions from clinical informaticians across various health science backgrounds	Found that clinicians recognize the critical importance of cybersecurity for protecting data and ensuring patient safety	Identified challenges such as time/resource constraints and disruption to workflows in implementing cybersecurity measures.
4	Dameff C et al	2023	Ransomware Attack Associated With Disruptions at Adjacent Emergency	To examine the impact of a ransomware attack on emergency department operations.	Analyzed the effects of a ransomware attack on emergency departments, including disruptions to	Found that the attack led to significant operational disruptions, highlighting the vulnerability of healthcare	Suggested the need for improved cybersecurity preparedness and response strategies in

			Departments in the US		clinical operations.	infrastructure to cyber threats.	healthcare settings.
5	Alkinoon M et al	2023	Understanding the Security and Performance of the Web Presence of Hospitals: A Measurement Study	To analyse the security and performance of hospital websites.	Conducted a measurement- based analysis of hospital websites, assessing security attributes and performance metrics.	Found significant security gaps in hospital web presences, including lack of HTTPS and outdated software.	Recommend ed regular security assessments and updates for hospital websites.
6	Ahmed M A Sindi H F & Nour M	2022	Cybersecurity in Hospitals: An Evaluation Model	To develop a model for evaluating cybersecurity in hospitals.	Proposed an evaluation model focusing on various cybersecurity dimensions within hospital settings.	Provided a framework to assess and improve hospital cybersecurity posture	The model's applicability across different hospital environment s requires further validation.
7	Newaz A I et al	2020	A Survey on Security and Privacy Issues in Modern Healthcare Systems: Attacks and Defences	To survey security and privacy challenges in modern healthcare systems and discuss potential defences.	Reviewed existing literature on healthcare system vulnerabilities and proposed defence mechanisms.	Identified common attack vectors and suggested comprehensive defence strategies.	The need for real-world validation of proposed defence mechanisms was noted.
8	Argaw S T et al	2020	Cybersecurity of Hospitals: Discussing the Challenges and Working Towards Mitigating the Risks	To discuss challenges in hospital cybersecurity and propose mitigation strategies.	To discuss challenges in hospital cybersecurity and propose mitigation strategies.	Highlighted the need for proactive cybersecurity measures and interdisciplinary collaboration.	Emphasized challenges in implementing standardized security protocols across diverse healthcare settings.

Proposed Solution

To address the challenges faced by modern healthcare facilities, this project proposes the implementation of a secure, scalable, and high-performance hospital network infrastructure. The solution is built on the following core components:

Hierarchical Network Design: Utilize a three-tier architecture—Core, Distribution, and Access layers—to ensure efficient traffic management, performance optimization, and network scalability.

High Availability: Integrate redundant links and devices to maintain continuous network operation and eliminate single points of failure, ensuring uninterrupted healthcare services.

Advanced Security Implementation: Deploy robust security mechanisms including data encryption, VLAN segmentation, firewalls, and access control policies to safeguard sensitive patient information and ensure regulatory compliance (e.g., HIPAA).

Scalability and Future-Readiness: Design the network to support the integration of IoT medical devices and cloud-based healthcare applications, allowing for seamless future expansion.

System Integration: Enable unified and efficient operations by integrating Electronic Medical Records (EMRs), telemedicine platforms, and connected medical devices within the network.

Centralized Monitoring and Management: Implement centralized tools for real-time network monitoring, performance analytics, and automated alerts, enabling proactive issue resolution and consistent service delivery.

This solution ensures the hospital network is resilient, secure, and adaptable to the evolving demands of digital healthcare environments.

Workplan & Timeline

Process	December	January-February	March	April
Research	2 weeks	1 week	-	-
Network Design	-	3 weeks	-	-
Configuration	-	-	5 weeks	-
Files & Documentation	-	-	1 week	1 week
Final Submission	-	-	-	10 th April

System Design

The proposed hospital network system is designed using a hierarchical architecture model, structured into three layers-Core, Distribution, and Access—to optimize performance, scalability, and manageability across all departments. This design supports seamless communication among critical systems like EMRs, telemedicine, IoT devices, and cloud services while maintaining strict security and availability standards.

1. Core Layer

The backbone of the network, responsible for high-speed data transfer and interconnectivity between distribution layers. It ensures fast and resilient data transmission, with redundancy protocols such as HSRP and dynamic routing for high availability.

2. Distribution Layer

Acts as a mediator between the Core and Access layers. It handles routing, filtering, and policy enforcement, managing traffic between departments like radiology, emergency, labs, and administration. VLAN segmentation and access control lists (ACLs) are implemented here to ensure data security and departmental isolation.

3. Access Layer

Connects end-user devices such as medical equipment, workstations, IP cameras, and IoT-enabled monitoring tools. It supports Wi-Fi 6 and PoE (Power over Ethernet) for seamless device integration and ensures quality of service (QoS) for latency-sensitive applications like telemedicine.

Security & Management Integration

Firewalls, encryption protocols, and role-based access controls (RBAC) are embedded across layers to protect sensitive patient data and ensure HIPAA compliance.

Centralized network monitoring tools (e.g., Cisco DNA Centre, Wireshark, SNMP) provide real-time visibility, performance analytics, and automated alerting for fault tolerance and proactive issue resolution.

Scalability & Future-Readiness

Designed to support Software-Defined Networking (SDN) and Network Functions Virtualization (NFV) for automated, policy-driven control and easy expansion.

Capable of integrating upcoming technologies like cloud-based health platforms, AI diagnostic systems, and additional IoT devices without impacting current operations.

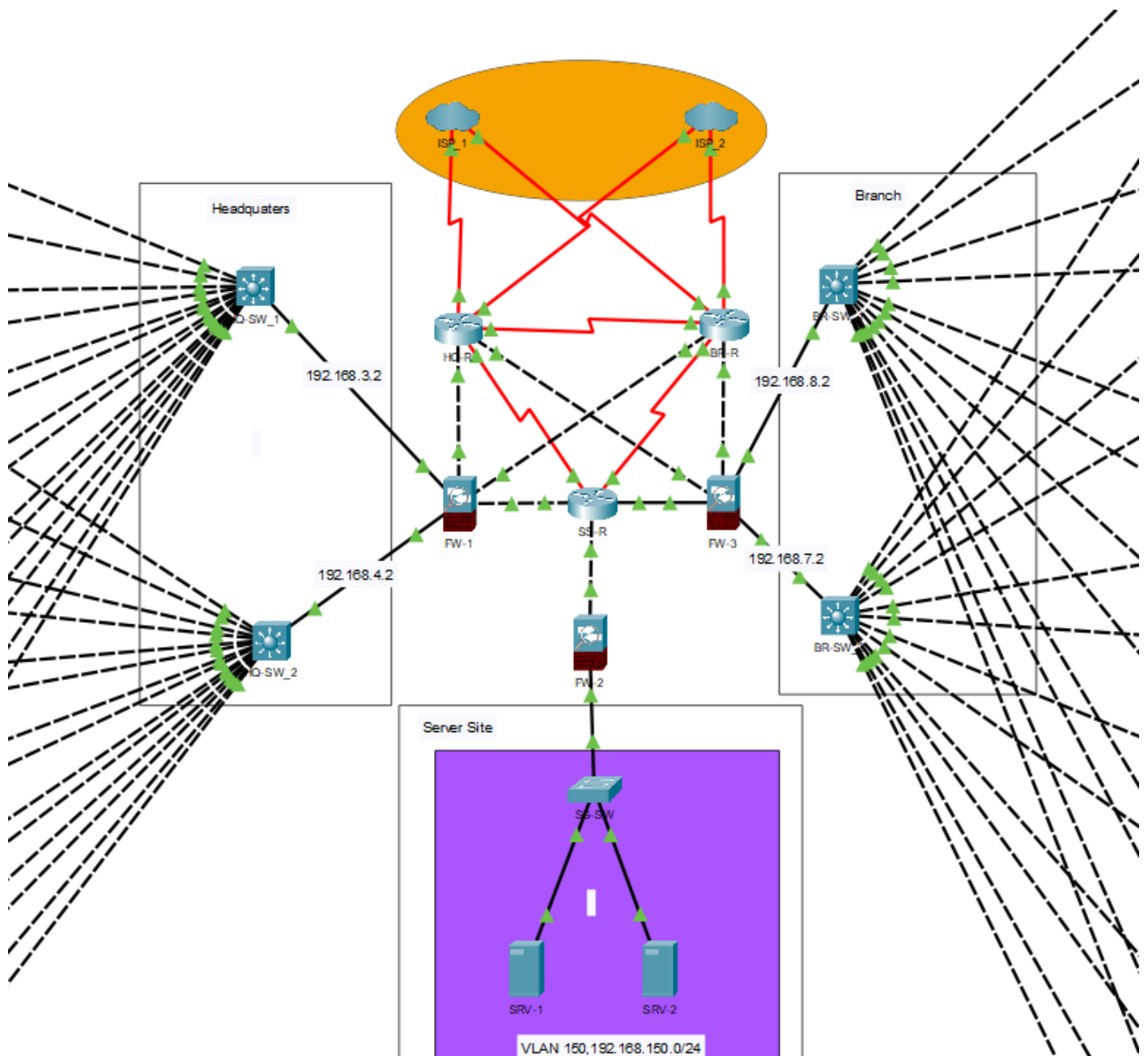


Figure 1: Core Part

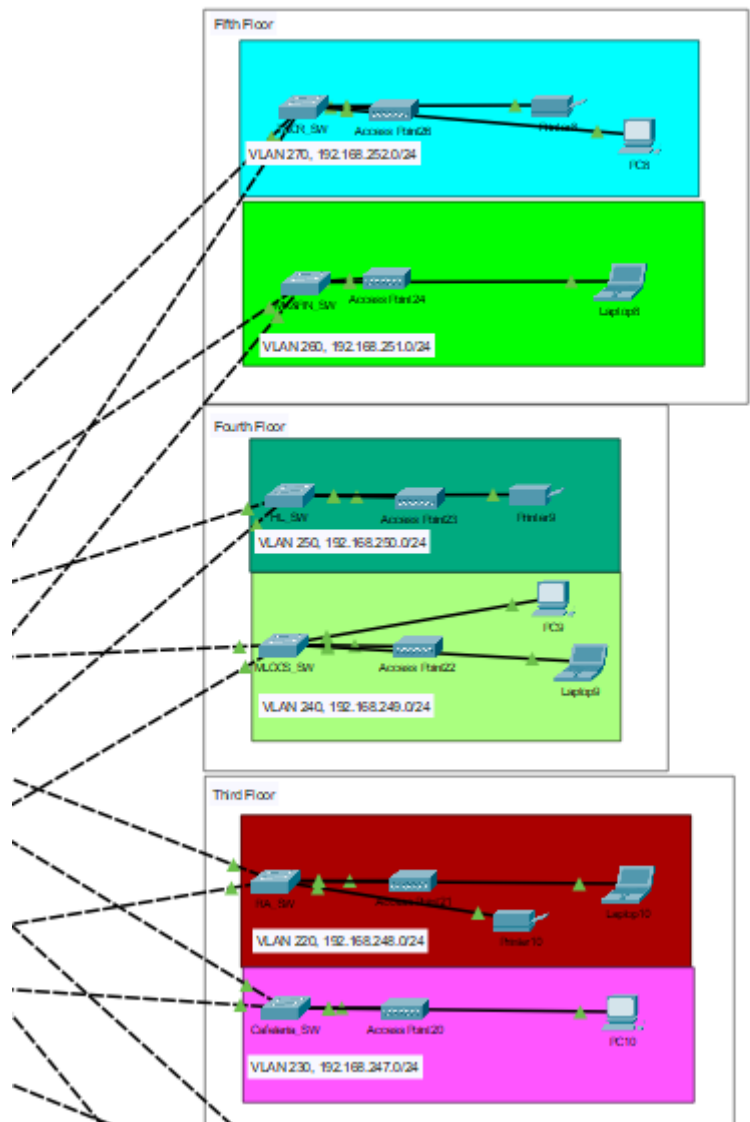


Figure 2.1: Branch Side

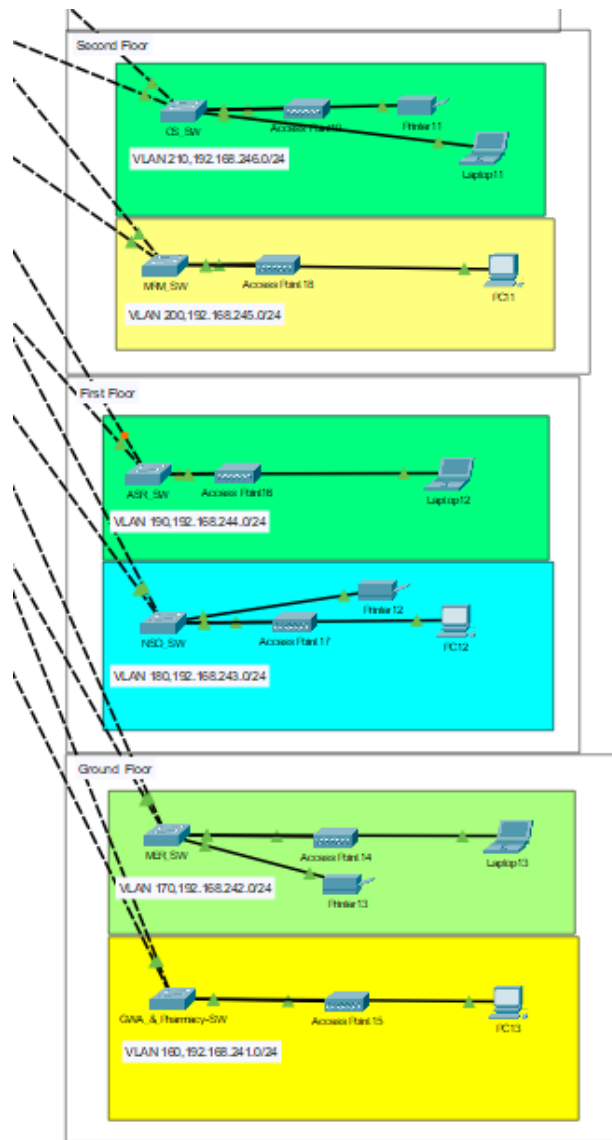


Figure 2.2: Branch Side

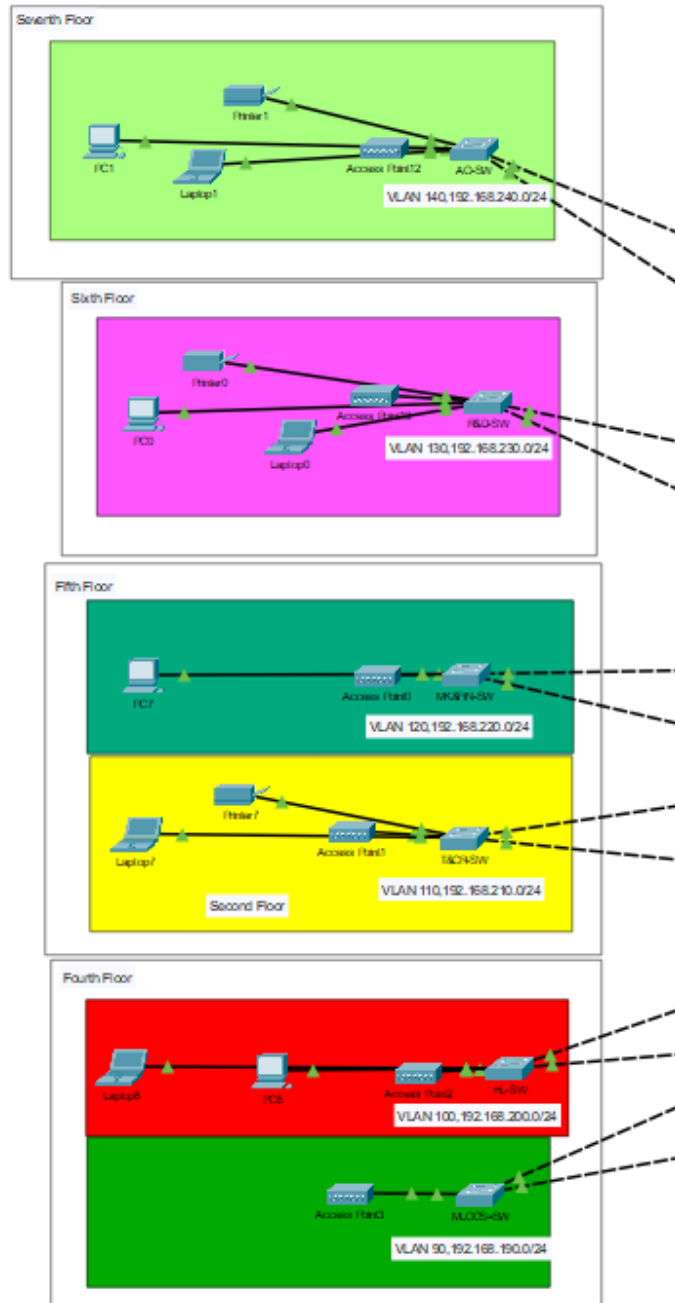


Figure 3.1: Headquarter Side

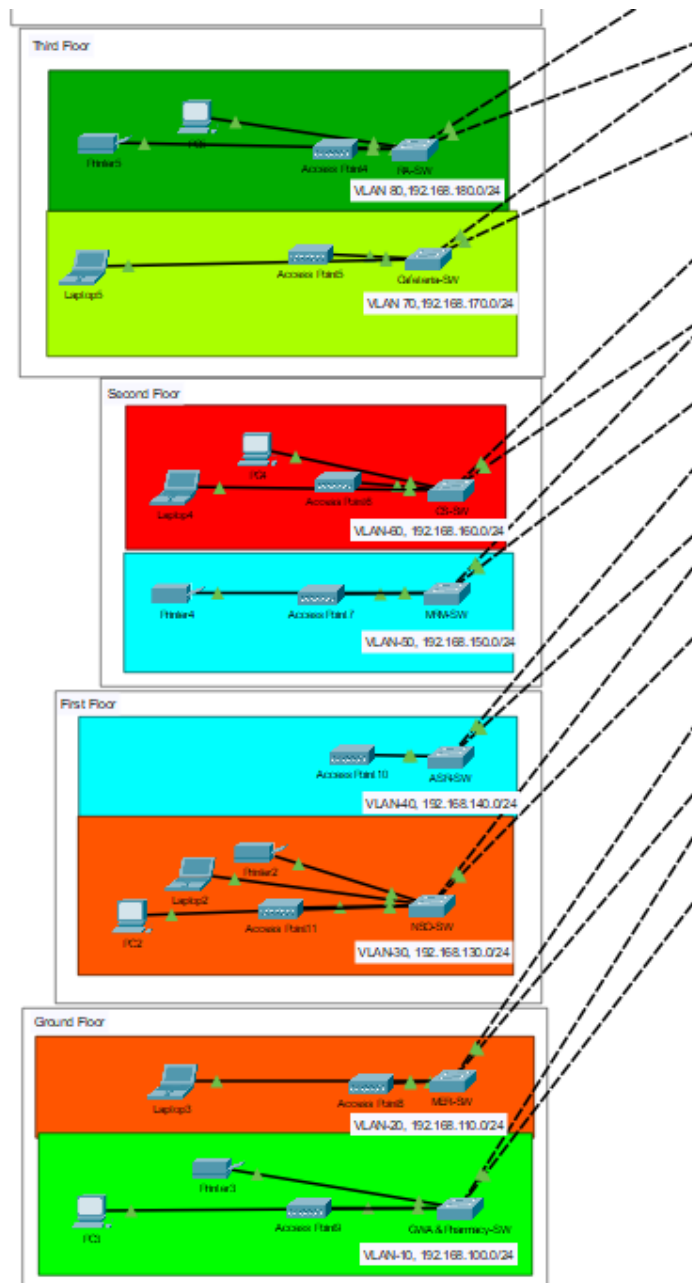


Figure 3.2: Headquarter Side

Technical Details

Hardware Components

Routers: 3 × Cisco ISR4331 Routers – used for core routing, OSPF, and NAT configuration.

Switches: 4 × Cisco 3650-24PS Multilayer & Access Switches – provide Layer 2 and Layer 3 switching and VLAN support.

Firewalls: 3 × Cisco ASA 5506-X – enforce security policies and inspect traffic across the network.

Servers: 2 × Central Servers – configured for DHCP, monitoring, and future cloud-based healthcare services.

End Devices: PCs, medical printers, and IoT-enabled devices for various hospital departments.

Power Backup: Uninterruptible Power Supply (UPS) ensures 24/7 network reliability.

WAN: Ensures connectivity between headquarters (HQ) and branch offices (BRs) via dedicated lines.

Software & Tools

Cisco Packet Tracer: Used for designing, simulating, and testing the network configuration.

DHCP Server: Automatically allocates dynamic IP addresses to client devices.

Routing Protocols:

OSPF (Open Shortest Path First): Used for dynamic routing between internal routers.

NAT Overload (PAT): Enables internal devices to access the internet with a single public IP.

IP Addressing Scheme

Base Network: 192.168.0.0/16 – used as the private address space.

Allocated IP Range: 192.168.0.0 – 192.168.255.255 – assigned across departments and sites.

VLAN Configuration:

VLANs ranging from VLAN 10 to VLAN 260 are created for HQ and Branch segmentation.

Each department (e.g., EMR, Labs, Admin, Radiology) is assigned a separate VLAN for better traffic management and security.

Implementation

To achieve a secure, scalable, and efficient hospital network, the following implementation strategies were adopted:

1. VLAN Segmentation

VLANs were created for each department (e.g., EMR, Radiology, IoT, Admin) to ensure logical separation of traffic.

Specific VLANs were assigned to IoT devices, enabling secure communication and reducing the risk of cross-traffic attacks.

```
int range fa0/1-2
switchport mode trunk
exit
vlan 30
name Finance
vlan 99
name BlackHole
exit
int range fa0/3-24
switchport mode access
switchport access vlan 30
exit
int range gig0/1-2
switchport mode access
switchport access vlan 99
shutdown
exit
do wr
```

2. Port Security

Port security was enabled on access switches using the sticky MAC address method.

This approach restricts unauthorized devices from connecting to the network, enhancing endpoint-level security.

```
interface range fastEthernet0/3-24 # Specifies a range of switch ports
switchport port-security maximum 1 # Sets the maximum number of allowed MAC
addresses to 1
switchport port-security mac-address sticky # Enables sticky MAC addresses to
dynamically learn and secure MAC addresses
switchport port-security violation shutdown # Configures the violation action
to shut down the port in case of a violation
```

3. Firewall Configuration

A dedicated firewall (Cisco ASA 5506-X) was deployed in the DMZ (Demilitarized Zone) to monitor and control incoming and outgoing traffic to/from the server room.

Firewall rules were defined to inspect and filter traffic based on security policies.

```
Rack_2(config)#
Rack_2(config)#
Rack_2(config)#
Rack_2(config)#no ip domain-lookup
Rack_2(config)#
Rack_2(config)#end
Rack_2#gns3
*Mar 15 16:51:26.119: %SYS-5-CONFIG_I: Configured from console by console
Rack_2#gns3network
Translating "gns3network"

Translating "gns3network"

% Unknown command or computer name, or unable to find computer address
Rack_2#
```

4. Secure Device Management

SSH (Secure Shell) was configured on all routers and multilayer switches for encrypted remote access.

Access Control Lists (ACLs) were applied to restrict administrative access only to authorized personnel and devices, safeguarding sensitive resources.

```

=====
L3
=====

ip routing
router ospf 10
router-id 2.2.2.2
network 192.168.10.0 0.0.0.255 area 0
network 192.168.20.0 0.0.0.255 area 0
network 192.168.30.0 0.0.0.255 area 0
network 192.168.40.0 0.0.0.255 area 0
network 192.168.50.0 0.0.0.255 area 0
network 192.168.60.0 0.0.0.255 area 0
network 10.10.10.0 0.0.0.3 area 0
network 10.10.10.8 0.0.0.3 area 0

do wr

=====
core router
=====

router ospf 10
router-id 3.3.3.3
network 10.10.10.0 0.0.0.3 area 0
network 10.10.10.4 0.0.0.3 area 0
network 103.133.254.0 0.0.0.3 area 0
network 103.133.254.8 0.0.0.3 area 0

do wr
exit

```

5. Routing & NAT

OSPF (Open Shortest Path First) was implemented as the internal dynamic routing protocol to ensure efficient route convergence and scalability.


```

hostname Finance-SW
line console 0
password cisco
login
exit

enable password cisco
no ip domain-lookup
banner motd #No Unauthorised Acces!!!#
service password-encryption

do wr

ip domain name cisco.net
username admin password cisco
crypto key generate rsa
1024
line vty 0 15
login local
transport input ssh
exit

ip ssh version 2
do wr

```

NAT Overload (PAT) was configured on core routers, allowing multiple internal devices to access external networks securely using a single public IP address.

```

-----
# Example ACL to permit traffic from VLAN 10 to VLAN 20 and deny all other
traffic
access-list 100 permit ip 192.168.10.0 0.0.0.255 192.168.20.0 0.0.0.255
access-list 100 deny ip any any

# Applying the ACL to an interface (in this case, the interface connecting to
VLAN 10)
interface vlan 10
ip access-group 100 in
exit

```

These implementations collectively enhance the confidentiality, integrity, and availability of the hospital's network, ensuring it remains resilient and secure in supporting critical healthcare operations.

Testing & Results

The hospital network was rigorously tested using Cisco Packet Tracer, a powerful network simulation tool that replicates real-world networking environments. The simulation and validation process included the following steps:

1. Network Topology Simulation

The complete network topology—comprising routers, multilayer switches, firewalls, PCs, servers, and IoT devices—was virtually constructed within Packet Tracer based on predefined hardware specifications.

2. Configuration & Deployment

Device configurations such as VLAN segmentation, OSPF routing, port security, SSH, ACLs, and NAT Overload were implemented using Packet Tracer's CLI interface, closely simulating actual Cisco device behavior.

3. Traffic Simulation & Fault Tolerance

Network traffic and device communication were simulated to test data flow and service delivery under normal and stress conditions.

Redundancy and high availability were verified by simulating device and link failures. The network successfully rerouted traffic through backup paths, ensuring zero downtime and continuous operation.

4. Security Validation







Security implementations were tested using modern tools like Nmap and Metasploit. These penetration tests confirmed the effectiveness of firewalls, VLAN segmentation, port security, and ACLs, ensuring robust defence against unauthorized access and cyber threats.







5. Performance Testing

Data throughput and latency were assessed using real-time traffic simulations. The network demonstrated stable performance under high-load conditions, such as during simultaneous EMR access and telemedicine sessions.

6. Scalability Testing

The network's scalability was validated by integrating additional IoT devices and cloud-based healthcare services within the simulation. No performance degradation was observed, confirming the design's adaptability for future expansion.

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num
	Successful	BR-R	HQ-R	ICMP		0.000	N	0
	Successful	SS-R	BR-R	ICMP		0.000	N	1
	Successful	SS-R	HQ-R	ICMP		0.000	N	2

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num
	Successful	PC3	Laptop3	ICMP		0.000	N	0
	Successful	PC13	PC9	ICMP		0.000	N	1
	Successful	Lapto...	PC12	ICMP		0.000	N	2

```
C:\Users\ASUS>ping 8.8.8.8

Pinging 8.8.8.8 with 32 bytes of data:
Reply from 8.8.8.8: bytes=32 time=2ms TTL=59
Reply from 8.8.8.8: bytes=32 time=2ms TTL=59
Reply from 8.8.8.8: bytes=32 time=2ms TTL=59
Reply from 8.8.8.8: bytes=32 time=2ms TTL=59

Ping statistics for 8.8.8.8:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 2ms, Maximum = 2ms, Average = 2ms
```

Cost Analysis

Component	Total Cost (INR)	Recurring Cost (INR/Year)	Maintenance Cost (INR/Year)
Core Router (HQ & Branch)	₹180,000	₹10,000	₹12,000
Multi-Layer Switch (HQ & Branch)	₹160,000	₹8,000	₹10,000
Access Switch (HQ & Branch)	₹390,000	₹4,000	₹6,000
Wireless Access Point (HQ & Branch)	₹260,000	₹2,000	₹3,000
Servers (Web, DNS, DHCP, Firewall)	₹150,000	₹20,000	₹30,000
Firewall (HQ & Branch)	₹180,000	₹6,000	₹8,000
UPS (Uninterruptible Power Supply)	₹120,000	₹5,000	₹5,000
Cabling & Miscellaneous	₹50,000	-	₹10,000
ISP Cost (Internet)	₹55,000	₹360,000/year	-
Compliance Cost	-	₹50,000/year	-
Inventory Management Cost	₹25,000/year	-	-
Server Rack	₹100,000	₹5,000	₹5,000
End Point Devices (PCs, Laptops, etc.)	₹400,000	₹40,000/year	₹20,000/year
Total (Including Recurring Costs)	₹2,070,000	₹550,000/year	₹109,000/year

Social & Industry Impact

The implementation of a secure, scalable, and well-configured hospital network has far-reaching impacts on both society and the healthcare industry.

Social Impact:

Enhanced Patient Care: By enabling seamless integration of Electronic Medical Records (EMRs), telemedicine services, and IoT-based medical monitoring, the project improves the speed and quality of patient care.

Data Privacy and Trust: Strong encryption, VLAN segmentation, and access controls ensure the protection of sensitive patient data, enhancing trust between patients and healthcare providers.

Improved Access to Remote Healthcare: The network supports telehealth services with minimal latency and high reliability, bridging the gap for patients in rural and underserved areas.

Continuity of Critical Services: High availability and redundancy ensure uninterrupted medical operations, even in the event of hardware or link failure, thus protecting lives during emergencies.

Industry Impact:

Digital Transformation in Healthcare: The project supports the ongoing digitalization of healthcare infrastructure, aligning with global trends in smart healthcare systems.

Compliance and Security Standards: By implementing secure protocols and ensuring HIPAA-compliant configurations, the project serves as a model for modern hospital networks that need to meet legal and regulatory requirements.

Cost-Effective Network Design: Using SDN, NFV, and Cisco-based simulation tools, hospitals can adopt future-ready, virtualized solutions that reduce operational costs and simplify management.

Scalable Blueprint for Other Institutions: The modular, hierarchical network architecture can be replicated in various healthcare facilities, paving the way for industry-wide standardization in secure medical networking.

Conclusion & Future Scope

This project successfully demonstrates the design and deployment of a robust, secure, and scalable hospital network that addresses the critical needs of modern healthcare environments. By ensuring seamless communication among departments and enabling real-time access to patient data, the network improves the overall efficiency and responsiveness of hospital operations. Through the implementation of VLAN segmentation, encrypted communication, and access controls, the network provides strong data privacy and compliance with healthcare regulations such as HIPAA. The use of redundancy and failover mechanisms ensures high availability and business continuity even during hardware or connectivity failures. The architecture supports advanced healthcare applications like telemedicine, IoT-enabled monitoring devices, and cloud integration, all while maintaining consistent performance and low latency. With the use of OSPF, NAT Overload, and centralized monitoring tools, network management is streamlined for both scalability and proactive issue resolution. Additionally, the project offers a cost-effective and replicable model for other healthcare institutions aiming to modernize their IT infrastructure. The combination of virtual simulation (Packet Tracer) and practical configurations ensures both theoretical soundness and real-world feasibility. In conclusion, this hospital network design is not only aligned with current industry standards but is also future-ready, setting a benchmark for digital healthcare transformation.

To stay ahead of the evolving demands in digital healthcare, the proposed hospital network can be further enhanced through the following future developments:

Upgraded Bandwidth Capabilities: Transitioning to 10/40/100 Gigabit Ethernet (GbE) will enable faster data transfers and support the growing volume of medical imaging, real-time analytics, and telehealth services.

Advanced Wireless Infrastructure: Implementing Wi-Fi 6 and Wi-Fi 6E will provide improved wireless performance, reduced latency, and better support for high-density environments like emergency rooms and patient monitoring zones.

Enhanced Security Frameworks: Adopting a Zero Trust Architecture, Next-Generation Firewalls (NGFWs), and real-time threat detection tools will offer more comprehensive protection against advanced and evolving cyber threats.

Cloud and Edge Integration: Leveraging cloud computing for scalable data storage and edge computing for low-latency processing near medical devices will increase efficiency and responsiveness in critical care applications.

IoT and AI Expansion: Integrating IoT-based medical devices and AI-driven analytics will improve patient monitoring, predictive diagnostics, and resource optimization across departments.

Automation and Smart Management: Incorporating Software-Defined Networking (SDN) and Network Functions Virtualization (NFV) will simplify management, reduce operational costs, and enable agile network provisioning.

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Appendix

Abbreviations:

ACL - Access Control List

DHCP - Dynamic Host Configuration Protocol

DMZ - Demilitarized Zone

IoT – Internet of Things

IP - Internet Protocol

ISPs - Internet Service Providers

MAC Address - Media Access Control Address

NAT - Network Address Translation

OSPF - Open Shortest Path First

PAT - Port Address Translation

HIPAA - Health Insurance Portability & Accountability Act

SDN - Software Defined Networking

SSH - Secure Shell

STP - Spanning Tree Protocol

UPS - Uninterrupted Power Supply

WAP - Wireless Access Points

VLAN - Virtual Local Area Network