I.K. GUJRAL PUNJAB TECHNICAL UNIVERSITY

KAPURTHALA

INDUSTRIAL TRAINING

PROJECT REPORT

SUBMITTED BY: -

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CLASS: - **B TECH COMPUTER SCIENCE**

SECTION: - **SECTION A, G2**

SESSION: - **2024-25**

DECLARATION

I, **Anush Rayat (Roll No. 2323450)**, hereby declare that the project titled
“Industrial Training Project Report”
has been carried out by me during my industrial training period.

I further declare that this work is **original**, completed under the guidance of
Mr. Mohammed Affan R and **Mr. Yatish Kumar P**, and has not been submitted to any other university or institute for the award of any degree, diploma, or certificate.

All information, data, configurations, testing results, and observations included in this report are based on my own practical work and learning during the training.

Signature of Student: ________________________
Name: Anush Rayat
Date: ___________

Project Guide:
Name: Mr. Mohammed Affan R
Date: ___________

Abstract

As part of my internship in Cloud Computing, I undertook a project titled **“Full Stack Private Cloud Implementation on VMware Platform”** to gain hands-on experience with building my own cloud storage system.

The project involved creating a personal cloud service similar to Google Drive or Dropbox using Nextcloud as the main application, Rocky Linux as the server operating system, and VMware for running virtual machines. The goal was to build a complete cloud storage solution that I could control entirely, without relying on third-party services.

The setup process included:

- Creating a virtual machine using VMware with proper system requirements
- Installing Rocky Linux and setting up basic security features
- Installing web server software and database to support the cloud application
- Setting up Nextcloud for file storage, sharing, and collaboration features
- Adding security measures like encrypted connections and firewall protection
- Testing file sync with mobile phones and computers
- Creating backup plans and improving system performance

The project successfully created a working private cloud system that allows secure file storage and sharing. The result was a fully functional cloud platform that works just like commercial services but gives complete control over data privacy and storage capacity.

This hands-on project taught me valuable skills in server management, web technologies, database setup, and cloud infrastructure. It provided practical experience in building real-world technology solutions while learning about data privacy and self-hosted alternatives to commercial cloud services

ACKNOWLEDGEMENT

I am deeply grateful to **Mr. Mohammed Affan R**, my project guide, for his constant guidance, constructive feedback, and valuable support throughout the duration of this project. His expertise, encouragement, and patience played a crucial role in shaping the technical and practical aspects of this work.

I would also like to extend my appreciation to **Mr. Yatish Kumar P**, Co-Supervisor, for his insightful suggestions, continuous motivation, and academic support, which greatly contributed to the successful completion of the project.

My sincere thanks to **I.K. Gujral Punjab Technical University** for providing the academic framework and opportunities that enabled me to undertake and complete this industrial training project effectively. I also acknowledge the support of the **Department of Computer Science** for facilitating a productive learning environment.

I am thankful to the **NIELIT Virtual Academy** for offering structured training modules and technical exposure that enhanced my understanding of cloud computing and real-world implementation techniques.

Lastly, I wish to express my heartfelt gratitude to my family and friends for their unwavering support, encouragement, and confidence in my abilities throughout this journey.

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LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE

Symbol / Abbreviation	Description / Full Form
VM	Virtual Machine
OS	Operating System
CPU	Central Processing Unit
RAM	Random Access Memory
LAN	Local Area Network
NAT	Network Address Translation
IP	Internet Protocol

Symbol / Abbreviation	**Description / Full Form**
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
DB	Database
SQL	Structured Query Language
PHP	Hypertext Preprocessor
LAMP	Linux, Apache, MariaDB, PHP Stack
GUI	Graphical User Interface
CLI	Command Line Interface
DFD	Data Flow Diagram
UI	User Interface
SSL	Secure Sockets Layer
TCP	Transmission Control Protocol
NIC	Network Interface Card
ISO	International Organization for Standardization (Disk Image Format)
VMware	Virtualization Software Platform
RHEL	Red Hat Enterprise Linux (Base for Rocky Linux)

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CHAPTER 1: INTRODUCTION

1.1 Project Overview

- The project focuses on building a **self-hosted private cloud storage system** using **Nextcloud**, deployed on a **virtualized Rocky Linux server** running inside a VMware environment.
- It demonstrates how open-source technologies can be used to create a **secure, scalable, and fully controlled cloud platform** without relying on third-party services like Google Drive or Dropbox.
- The setup includes configuring a **complete LAMP stack (Linux, Apache, MariaDB, PHP)** to support the web-based cloud application.
- The system enables **file storage, sharing, user management, and cross-device synchronization**, functioning similarly to commercial cloud services.
- The project highlights the use of **virtualization**, **server configuration**, **network management**, and **security hardening** as core cloud-computing skills.
- The platform showcases the benefits of **data sovereignty**, where the user has complete control over where data is stored and how it is accessed.
- The project also includes **testing on multiple devices** (Windows desktop + Android mobile) to validate cross-platform accessibility and user experience.
- This implementation serves as a practical demonstration of cloud architecture principles using widely available open-source tools.

1.2 Scope of Work

- Setting up a **virtual machine** in VMware with required CPU, RAM, storage, and bridged network configuration.
- Installing **Rocky Linux 9.6** and performing essential system configuration tasks like user creation, updates, and security settings.
- Deploying the **LAMP stack** to support the Nextcloud platform and configuring all components for compatibility.
- Installing **Nextcloud Hub 10**, configuring database connections, adjusting file permissions, and ensuring the web interface loads properly.
- Implementing **security measures** such as firewall configuration (firewalld), password policies, and basic hardening practices to protect the cloud environment.
- Ensuring **cross-platform compatibility** by testing access from web browsers, mobile devices, and other external clients.

- Validating core features such as file uploads, downloads, folder creation, user sessions, and interface responsiveness.
- Managing network connectivity issues (like NAT restrictions) and replacing them with **bridged mode** for successful external access.
- Documenting the complete installation, configuration, troubleshooting, and testing process.
- Preparing a demonstration-ready cloud solution that can be deployed for personal or small-scale organizational use.

1.3 Significance of the Study

- Provides hands-on experience with **cloud infrastructure**, helping bridge the gap between theoretical knowledge and real-world implementation.
- Demonstrates how organizations or individuals can build **cost-effective private cloud storage** without relying on commercial providers.
- Highlights the importance of **data privacy and ownership**, ensuring users retain full control over their files and sensitive information.
- Showcases the capability of open-source platforms like **Nextcloud** to deliver enterprise-grade features such as collaboration, file sharing, user access control, and device synchronization.
- Strengthens understanding of **server management**, **database administration**, and **web service configuration** through practical deployment.
- Encourages the adoption of **self-hosted solutions** as viable alternatives to third-party cloud ecosystems.
- Provides learning exposure to modern IT workflows including **virtualization**, **system hardening**, **network design**, and **cross-platform validation**.
- Demonstrates structured troubleshooting techniques by resolving issues like NAT-based access limitations through network reconfiguration.
- Forms a foundation for future enhancements such as load balancing, clustering, enterprise authentication (LDAP), automated backups, and scalable storage solutions.

CHAPTER 2 – APPROACH USED

2.1 Selection of Approach

The project required building a reliable, secure, and scalable private cloud system that could run on readily available hardware while maintaining full data ownership. To achieve this, a **virtualization-based deployment approach** was selected. The key reasons for selecting this approach include:

- **Isolation and flexibility:** VMware Workstation provides a controlled environment for server configuration, testing, and troubleshooting without affecting the host system.
- **Cost-effectiveness:** Virtualization eliminates the need for a dedicated physical server and allows efficient resource allocation such as RAM, CPU, and storage.
- **Linux server stability:** Rocky Linux 9.6, being RHEL-based, ensures enterprise-grade reliability and long-term support, making it ideal for hosting Nextcloud.
- **Compatibility with open-source tools:** The LAMP stack (Linux, Apache, MariaDB, PHP) is universally supported by Nextcloud, ensuring smooth installation and maintenance.
- **Scalability & portability:** Virtual machines can be migrated, backed up, cloned, or expanded easily, supporting future improvements or server upgrades.

Therefore, the chosen approach was to deploy a complete **LAMP-based Nextcloud server** inside a VMware virtual machine for secure, controlled, and practical cloud implementation.

2.2 Application of Selected Approach

After selecting the virtualization-based method, the following steps were applied to implement the project:

1. Virtual Machine Setup

- A VM was created in VMware Workstation with **4 GB RAM**, **2 CPU cores**, and **50 GB storage**, meeting the recommended specifications for Nextcloud.
- Rocky Linux 9.6 was installed and configured to serve as the base server OS.

2. LAMP Stack Deployment

- Apache, MariaDB, and PHP 8.2 (with necessary extensions) were installed using dnf.

- Each component was configured for compatibility with Nextcloud's backend requirements.

3. Nextcloud Installation

- The Nextcloud package was downloaded, extracted, and moved to /var/www/html/nextcloud/.
- Correct permissions and ownership were set to allow Apache to serve the application.
- The web-based setup wizard was used to create the admin account and connect the application with the MariaDB database.

4. Network Configuration

- The initial NAT mode restricted access from external devices.
- Switching to **Bridged Adapter mode** assigned the VM a LAN IP, enabling access from mobile phones and other computers.

5. Security Hardening

- Firewall rules were configured to allow only required services (HTTP/HTTPS).
- Secure permissions were applied to the Nextcloud directory and database credentials.
- System updates and password policies ensured a secure server environment.

6. Testing and Verification

- The cloud system was tested on Windows and Android devices.
- Uploading, downloading, folder creation, and synchronization were validated for cross-platform usability.

CHAPTER 3 — LITERATURE SURVEY

3.1 Existing Cloud Solutions

Private Cloud Computing Using Open-Source Tools

- Open-source platforms like **Nextcloud**, **ownCloud**, and **Seafile** are used to build fully self-hosted cloud systems.
- These solutions offer features comparable to commercial cloud services such as Google Drive or Dropbox.
- They provide **complete data ownership**, allowing organizations and individuals to avoid dependency on third-party vendors.
- Open-source systems can be deployed using standard server stacks like **Linux + Apache + MariaDB + PHP (LAMP)**.
- Private cloud deployment is widely adopted for environments requiring **data privacy**, **customization**, and **cost-efficiency**.

Implementation Approaches

- Deploying cloud storage on Linux servers, supported by web servers (Apache/Nginx) and relational databases (MariaDB/MySQL).
- Ensuring secure and scalable storage through file permission control, database configuration, and network optimization.
- Using virtualized environments (VMware, VirtualBox, KVM) to provide an isolated, easily manageable server structure.

Key Takeaways from Literature

- Self-hosted cloud solutions ensure robust privacy and fulfil enterprise collaboration needs.
- Implementation requires moderate technical expertise in system configuration, networking, and server management.
- Ideal for education, small businesses, research labs, and individuals seeking customizable cloud environments.

3.2 Related Research

Cross-Platform Accessibility Studies

- Research shows that cloud platforms must support a wide variety of devices for wider adoption.
- Self-hosted solutions are now capable of offering:
  - Web browser access

  - Desktop sync applications
  - Mobile apps for Android/iOS
- Compatibility ensures the cloud is usable across **multiple operating systems** and **device types**.

Testing Approaches in Related Research

- Studies evaluate cloud systems by testing them on multiple platforms:
  - Windows, Linux, macOS desktop systems
  - Android and iOS mobile devices
  - Various web browsers and network types
- The evaluation looks at:
  - Load times
  - Responsiveness
  - Sync performance
  - Stability during simultaneous access

Findings from Existing Studies

- Properly configured self-hosted solutions deliver **smooth and reliable** cross-platform performance.
- Browser-based interfaces provide flexibility without additional software installation.
- Mobile compatibility depends heavily on web optimization and background sync services.

3.3 Research Gap

Identified Gaps in Current Research

- Limited exploration of **advanced private cloud configurations** such as:
  - High availability (HA) clusters
  - Load balancing and redundancy
  - Distributed file systems
- Many papers focus on functionality but lack coverage of **security hardening** and **scalable architecture**.
- Cross-platform evaluation is often tested only on desktops, not consistently across mobile ecosystems.

- Enterprise integration topics (e.g., LDAP/Active Directory authentication) are not widely studied.
- Performance optimization, multi-user stress testing, and long-term storage reliability are areas needing deeper exploration.

Why Your Project Addresses Some Gaps

- Your implementation includes cross-platform validation (Windows + Android).
- You applied real-world system configuration steps:
    - VM setup
    - LAMP stack deployment
    - Security hardening (firewalld)
- The project demonstrates functional deployment steps that many academic papers only describe hypothetically.
- Practical issues like **NAT-to-Bridged network migration** are real operational challenges not documented often

CHAPTER 4 — OBJECTIVES OF THE PROJECT

4.1 Primary Objective

- To implement a **fully functional private cloud storage system** using Nextcloud on a virtualized Rocky Linux server.
- To demonstrate how open-source technologies can be used to build a secure and customizable cloud environment.
- To replicate core cloud-service capabilities such as:
    - File storage
    - File sharing
    - Multi-device synchronization
    - User access control
    - Web-based collaboration

4.2 Technical Objectives

- To deploy a complete **LAMP stack** (Linux, Apache, MariaDB, PHP) capable of supporting the Nextcloud application.
- To configure **VMware Workstation** for hosting the Rocky Linux server with optimized CPU, RAM, and storage allocation.
- To ensure correct installation and configuration of:
    - Apache Web Server
    - MariaDB Database
    - PHP runtime modules required for Nextcloud
- To optimize **network configuration** using Bridged Mode for external device access.

4.3 Security Objectives

- To implement **firewalld** rules for controlling inbound/outbound connections securely.
- To harden database access by securing MariaDB root and application credentials.
- To ensure secure file permissions and folder ownership for the Nextcloud data directory.

- To establish **encrypted connections (HTTPS)** and apply basic system hardening techniques.

4.4 Performance & Testing Objectives

- To test the cloud platform's performance in:
    - File upload and download operations
    - Cross-platform access between desktop and mobile devices
    - Simultaneous user sessions
- To verify system responsiveness under typical usage conditions.
- To assess storage capacity and efficiency with a 50-GB virtual disk.
- To evaluate the web interface's responsiveness across different screen sizes.

4.5 Learning & Outcome Objectives

- To gain practical skills in:
    - Server configuration
    - Virtualization
    - Web application deployment
    - Database setup
    - Cloud architecture design
- To understand the importance of **data sovereignty**, privacy, and control in cloud ecosystems.
- To learn troubleshooting techniques by solving real deployment issues (e.g., NAT vs Bridged network).
- To develop the ability to build self-hosted cloud platforms suitable for personal or small business use.

CHAPTER 5 — SYSTEM DESIGN

5.1 Block Diagram of the System

Main Components in the Block Diagram

1) **User Devices (Windows Desktop / Android Mobile)**
   a) Used to upload, download, and manage files on the cloud platform.
2) **VMware Virtual Machine**
   a) Hosts the Rocky Linux 9.6 operating system.
   b) Provides an isolated and controlled server environment.
3) **Apache Web Server**
   a) Handles HTTP/HTTPS requests from clients.
   b) Serves the Nextcloud web interface.
4) **MariaDB Database**
   a) Stores user accounts, metadata, file indexing, and configuration data.
5) **PHP Runtime**
   a) Executes the Nextcloud application logic.
6) **Nextcloud Application Layer**
   a) Manages file storage, sharing, authentication, and collaboration features.
7) **Nextcloud Data Directory**
   a) Stores all uploaded user files, images, and documents.
8) **Network Layer (Bridged Adapter)**
   a) Allows the virtual machine to be accessible on the same network as the host device.

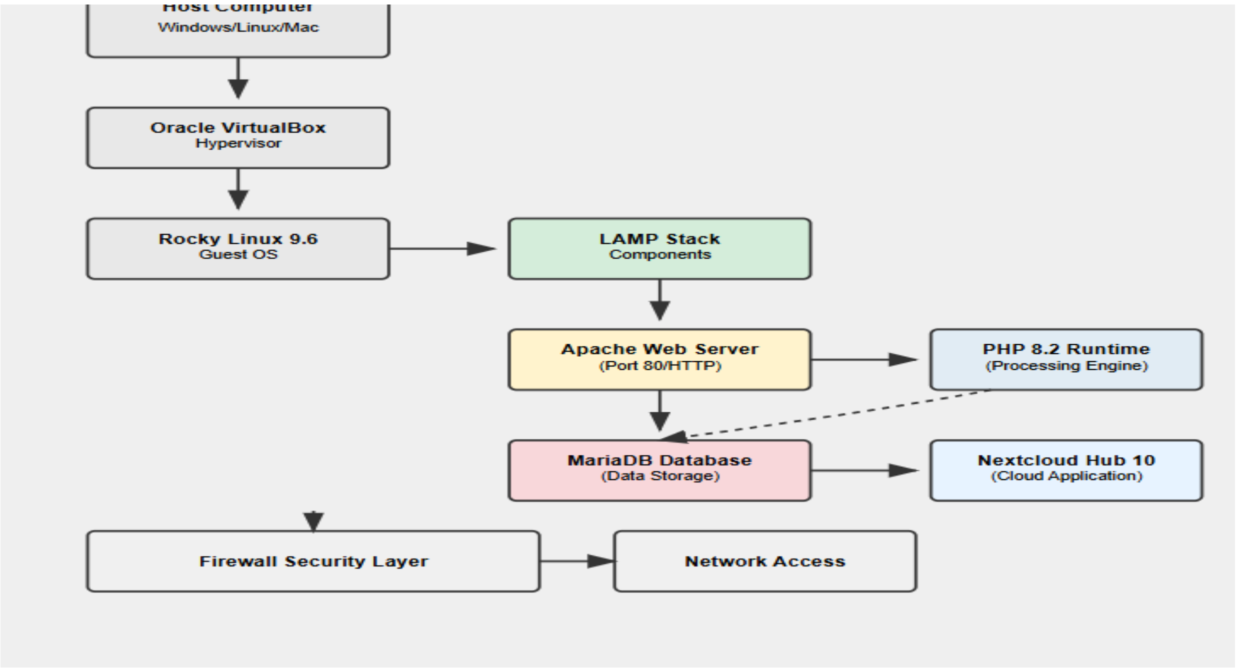


Figure 5.1: Block Diagram of the System

5.2 System Workflow

1) **Step-by-Step Workflow**

2) **Step 1: User Access**

   a) User opens browser/mobile app and connects to Nextcloud server via IP address.

3) **Step 2: Authentication Process**

   a) Credentials are entered → Apache forwards request → Nextcloud queries MariaDB for validation.

4) **Step 3: Dashboard Loading**

   a) PHP processes user session → loads personalized cloud interface.

5) **Step 4: File Operations**

   a) Upload → stored in Nextcloud data folder

   b) Metadata → stored in MariaDB

   c) Download → retrieved through Apache + PHP layer

6) **Step 5: Sync Across Devices**

   a) Any file added/modified is synced automatically across devices.

7) **Step 6: Admin Operations**

   a) Administrators monitor logs, configure firewall, manage users.

8) **Step 7: Network Routing**

   a) Bridged adapter ensures the VM receives a LAN IP, allowing access from external devices.

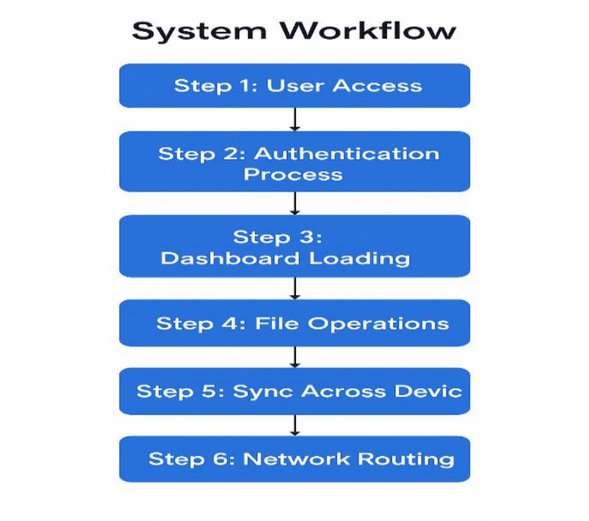

System Workflow
Step 1: User Access
Step 2: Authentication Process
Step 3: Dashboard Loading
Step 4: File Operations
Step 5: Sync Across Devic
Step 6: Network Routing

Figure 5.2 System Workflow Architecture

5.3 Architectural Layout

Layered Architecture Overview

1) **Presentation Layer**

   a) Web browser / mobile interface.

   b) GUI for uploading, managing files, viewing storage usage.

2) **Application Layer**

   a) Nextcloud Hub 10.

   b) Written in PHP; handles authentication, sharing, file versioning, user sessions.

3) **Web Server Layer**

   a) Apache HTTP Server.

   b) Handles incoming HTTP/HTTPS requests.

   c) Serves static & dynamic content.

4) **Database Layer**

   a) MariaDB Server.

   b) Stores user profiles, file metadata, sharing permissions, app configurations.

5) **Storage Layer**

   a) Nextcloud data directory.

b) Stores actual files such as documents, images, backups.

6) **Operating System Layer**

a) Rocky Linux 9.6

b) Provides a stable environment for hosting the cloud infrastructure.

7) **Virtualization Layer**

a) VMware Workstation.

Allows flexible resource allocation and isolated cloud server setup.

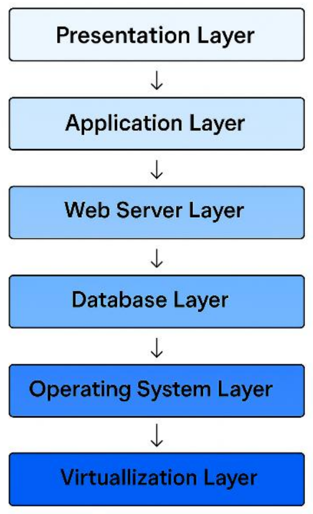


Figure 5.3 High-Level Architectural Layout

5.4 DATA FLOW DIAGRAM

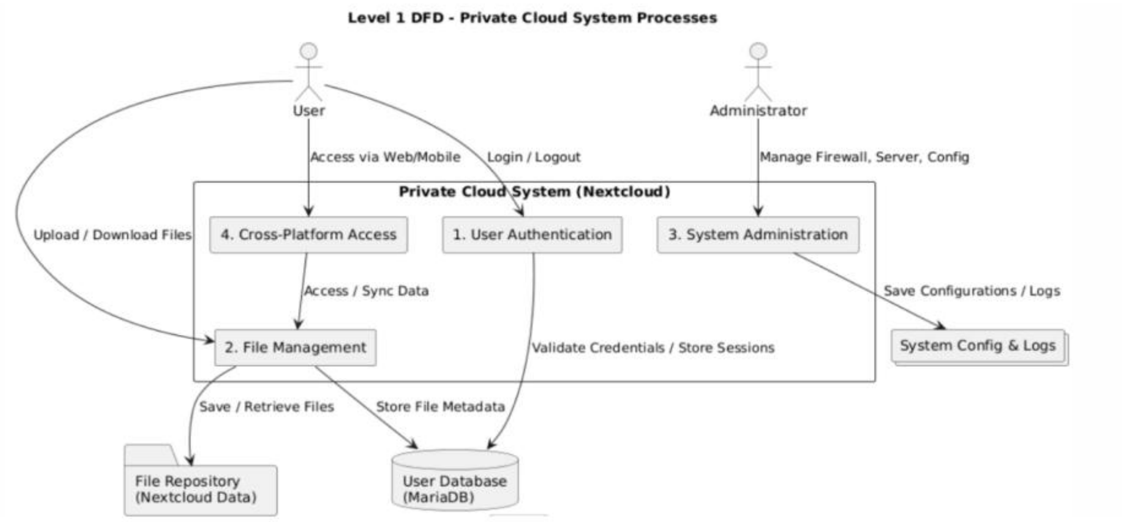
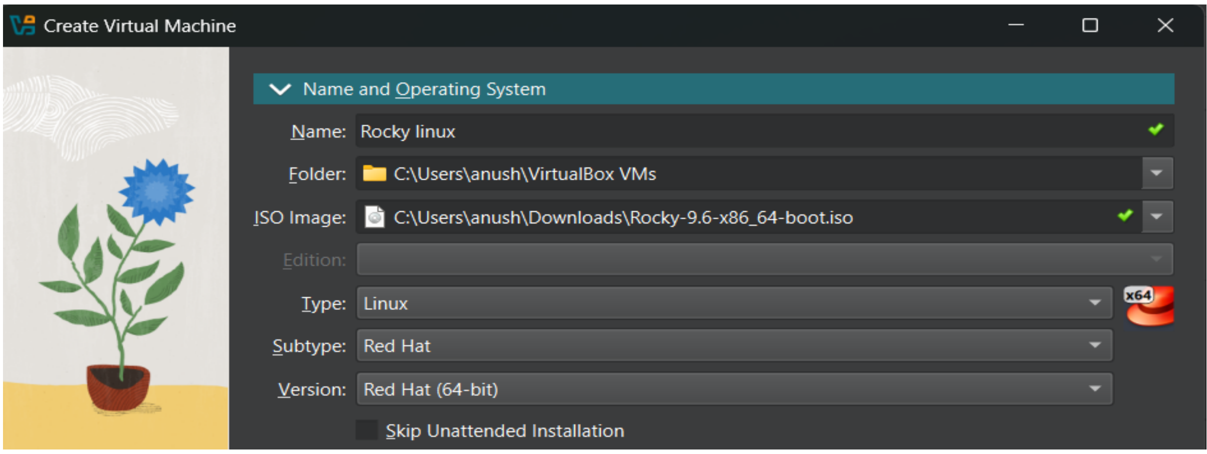


Figure 5.4 Level 1 DFD

CHAPTER 6 — PROPOSED SETUP

6.1 Virtual Machine Configuration (VMware Workstation)

- Creating the new VMware VM with Rocky Linux ISO



Create Virtual Machine

Name and Operating System

Name: Rocky linux

Folder: C:\Users\anush\VirtualBox VMs

ISO Image: C:\Users\anush\Downloads\Rocky-9.6-x86_64-boot.iso

Edition:

Type: Linux

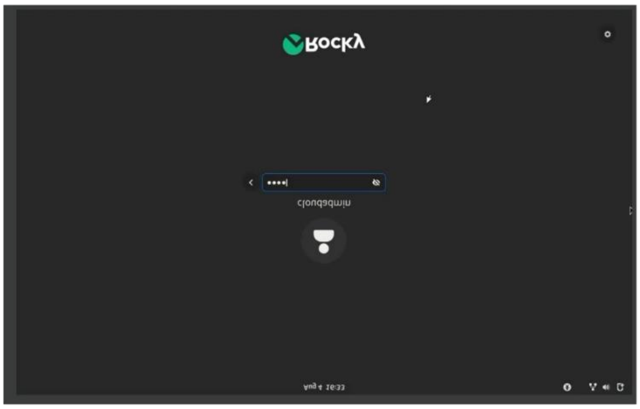
Subtype: Red Hat

Version: Red Hat (64-bit)

□ Skip Unattended Installation

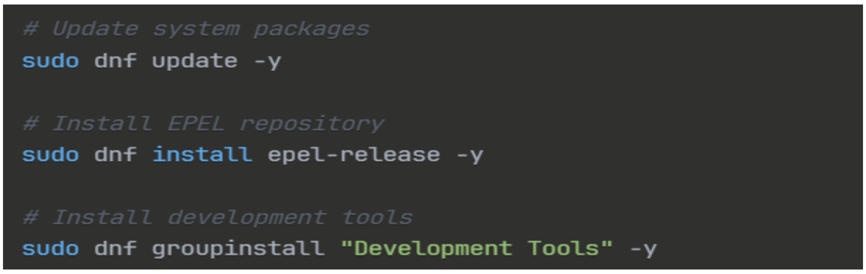
6.2 Operating System Setup (Rocky Linux 9.6)

- Completing installation and first boot



6.3 System Preparation Before Deployment

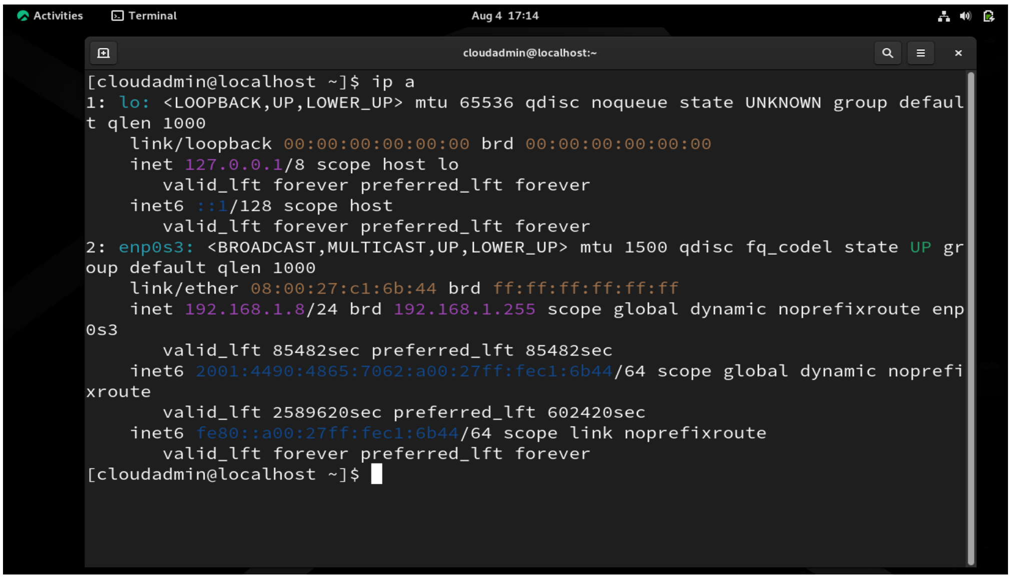
- Running system updates
- sudo dnf update -y



```
# Update system packages
sudo dnf update -y

# Install EPEL repository
sudo dnf install epel-release -y

# Install development tools
sudo dnf groupinstall "Development Tools" -y
```

- Verifying hostname and IP

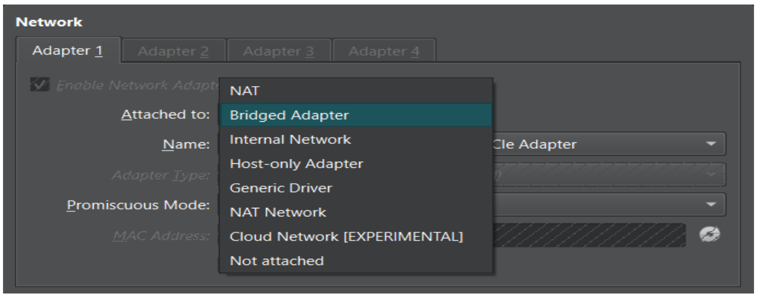
- hostnamectl
- ip addr show



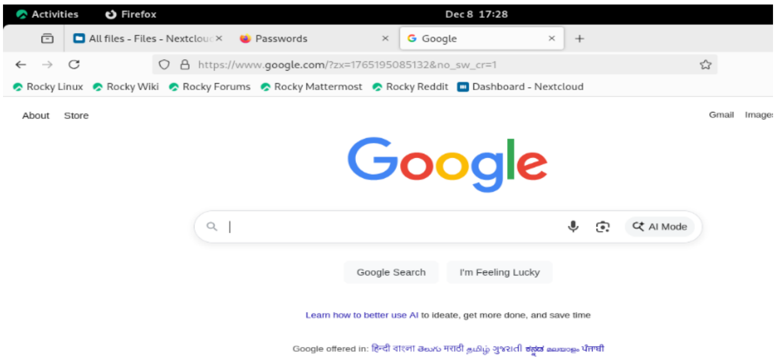
```
[cloudadmin@localhost ~]$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group defaul
t qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP gr
oup default qlen 1000
    link/ether 08:00:27:c1:6b:44 brd ff:ff:ff:ff:ff:ff
    inet 192.168.1.8/24 brd 192.168.1.255 scope global dynamic noprefixroute enp
0s3
       valid_lft 85482sec preferred_lft 85482sec
    inet6 2001:4490:4865:7062:a00:27ff:fec1:6b44/64 scope global dynamic noprefi
xroute
       valid_lft 2589620sec preferred_lft 602420sec
    inet6 fe80::a00:27ff:fec1:6b44/64 scope link noprefixroute
       valid_lft forever preferred_lft forever
[cloudadmin@localhost ~]$ 
```

6.4 Network Configuration

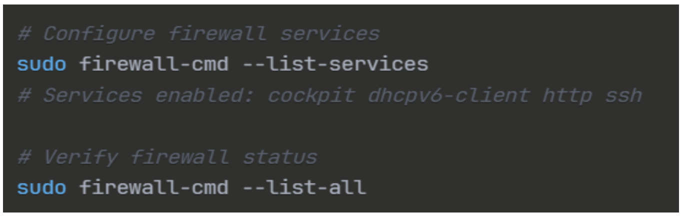
- NAT mode causing access issues
- Switching to Bridged mode



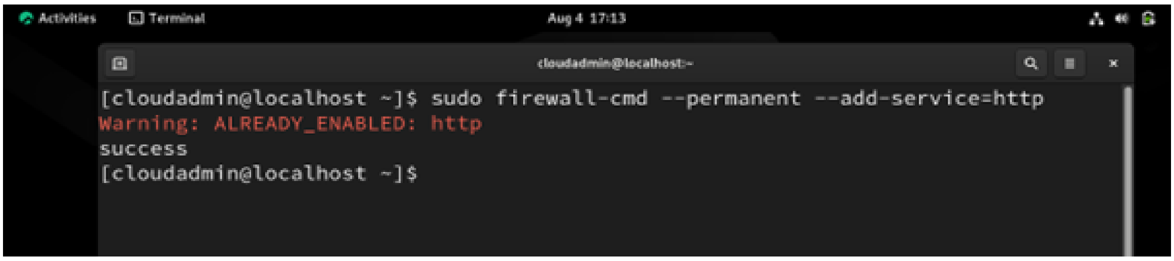
- Testing connectivity
- ping google.com


Activities
Firefox
Dec 8 17:28
All files - Files - Nextcloud
Passwords
Google
https://www.google.com/?zx=1765195085132&no_sw_cr=1
Rocky Linux
Rocky Wiki
Rocky Forums
Rocky Mattermost
Rocky Reddit
Dashboard - Nextcloud
About
Store
Gmail
Images
Google
AI Mode
Google Search
I'm Feeling Lucky
Learn how to better use AI to ideate, get more done, and save time
Google offered in: हिन्दी বাংলা తెలుగు मराठी தமிழ் ગુજરાતી ಕನ್ನಡ മലയാളം ਪੰਜਾਬੀ

- Verifying firewall configuration



```
# Configure firewall services
sudo firewall-cmd --list-services
# Services enabled: cockpit dhcpv6-client http ssh

# Verify firewall status
sudo firewall-cmd --list-all
```

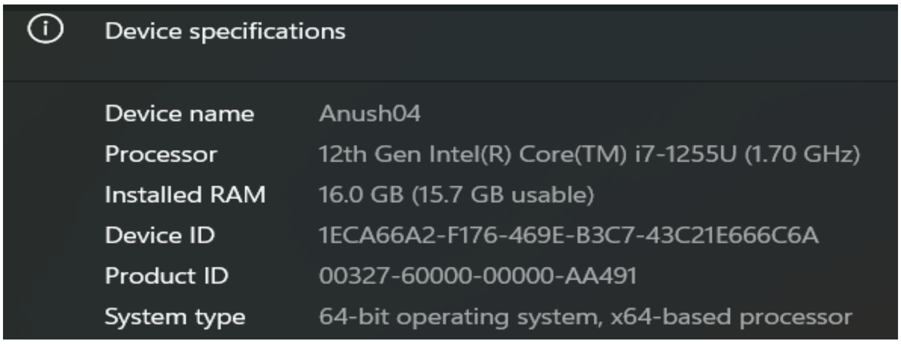


```
[cloudadmin@localhost ~]$ sudo firewall-cmd --permanent --add-service=http
Warning: ALREADY_ENABLED: http
success
[cloudadmin@localhost ~]$
```

CHAPTER 7 — HARDWARE SPECIFICATIONS

7.1 Host Machine Specifications

- Base Machine: Windows 11 System
- Processor: Intel(R) Core (TM) i7
- Installed RAM: 16 GB
- System Type: 64-bit Operating System, x64-based processor
- Network Adapter: Realtek Wi-Fi 6 802.11ax
- Virtualization Support: Enabled
- Storage Type: SSD

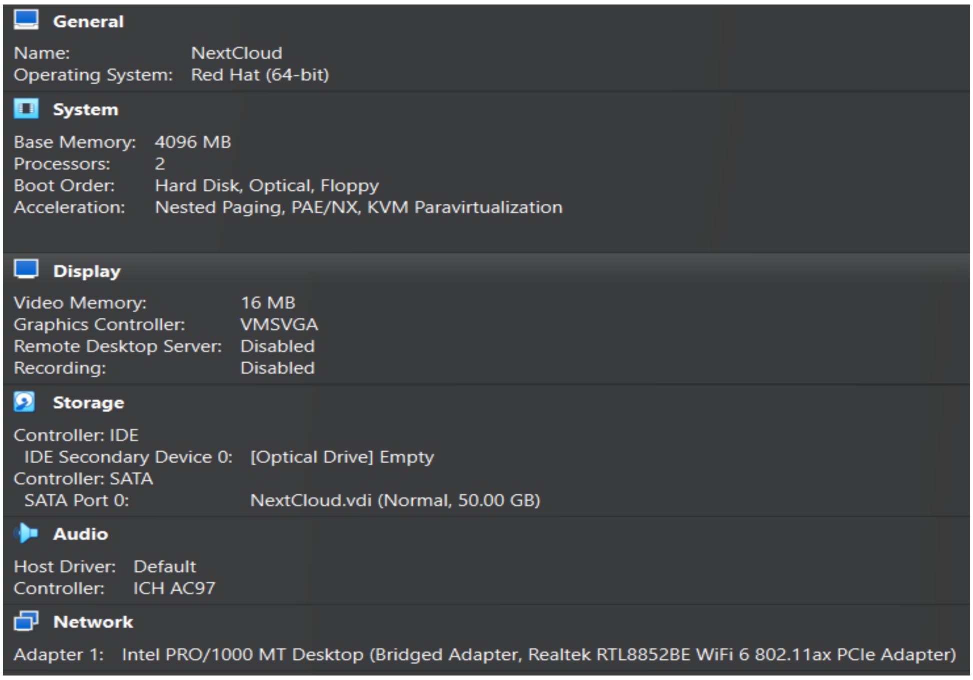


Device specifications

Device name	Anush04
Processor	12th Gen Intel(R) Core(TM) i7-1255U (1.70 GHz)
Installed RAM	16.0 GB (15.7 GB usable)
Device ID	1ECA66A2-F176-469E-B3C7-43C21E666C6A
Product ID	00327-60000-00000-AA491
System type	64-bit operating system, x64-based processor

7.2 Virtual Machine Specifications (VMware)

- Base Memory (RAM): 4096 MB
- Processors: 2
- Hard Disk: 50 GB
- Network Adapter: Intel PRO/1000 MT (Bridged Mode)
- Controller Type: LSI Logic
- USB Controller: Present
- Sound Card: Present
- Display: Auto-detect settings
- Firmware Type: BIOS



```
General
Name:               NextCloud
Operating System:   Red Hat (64-bit)

System
Base Memory:   4096 MB
Processors:    2
Boot Order:    Hard Disk, Optical, Floppy
Acceleration:  Nested Paging, PAE/NX, KVM Paravirtualization

Display
Video Memory:             16 MB
Graphics Controller:      VMSVGA
Remote Desktop Server:    Disabled
Recording:                Disabled

Storage
Controller: IDE
  IDE Secondary Device 0:   [Optical Drive] Empty
Controller: SATA
  SATA Port 0:              NextCloud.vdi (Normal, 50.00 GB)

Audio
Host Driver:   Default
Controller:    ICH AC97

Network
Adapter 1:   Intel PRO/1000 MT Desktop (Bridged Adapter, Realtek RTL8852BE WiFi 6 802.11ax PCIe Adapter)
```

7.3 Hardware specification of Virtual Machine

S no.	Component	Details
1.	Base Memory (RAM)	4096 MB (4GB)
2.	Processors (CPU)	2 cores
3.	Storage (Virtual Hard Disk)	50 GB
4.	Network- Attached to	Bridged Adapter
5.	Physical Host Adapter	Realtek RTL8852BE Wi-Fi 6 802.11ax PCIe Adapter
6.	Adapter Type	Intel PRO/1000 MT Desktop (82540EM)

Table 7.1

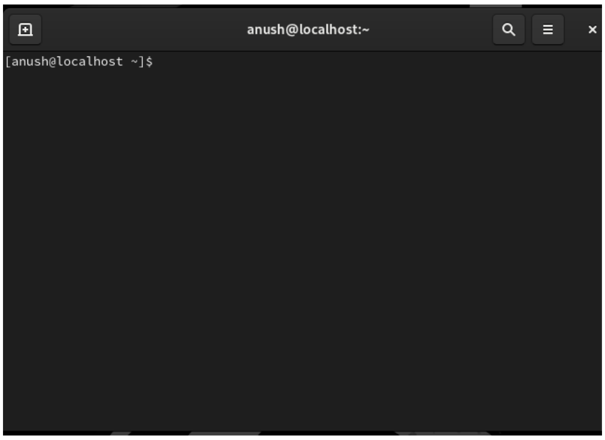
7.4 Networking Hardware Specifications

- Original Network Mode: NAT
- Updated Network Mode: Bridged Adapter
- Host Adapter: Realtek Wi-Fi 6 AX
- Internal VM NIC: Intel PRO/1000 MT Server Adapter
- Purpose: Allows external devices on the LAN to access Nextcloud

CHAPTER 8 — SOFTWARE STACK

8.1 Operating System

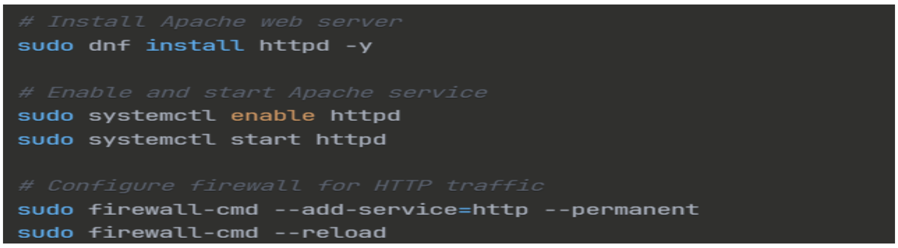
- **Rocky Linux 9.6 (64-bit)**
- Enterprise-grade, stable, RHEL-based distribution
- Used as the primary server OS inside VMware



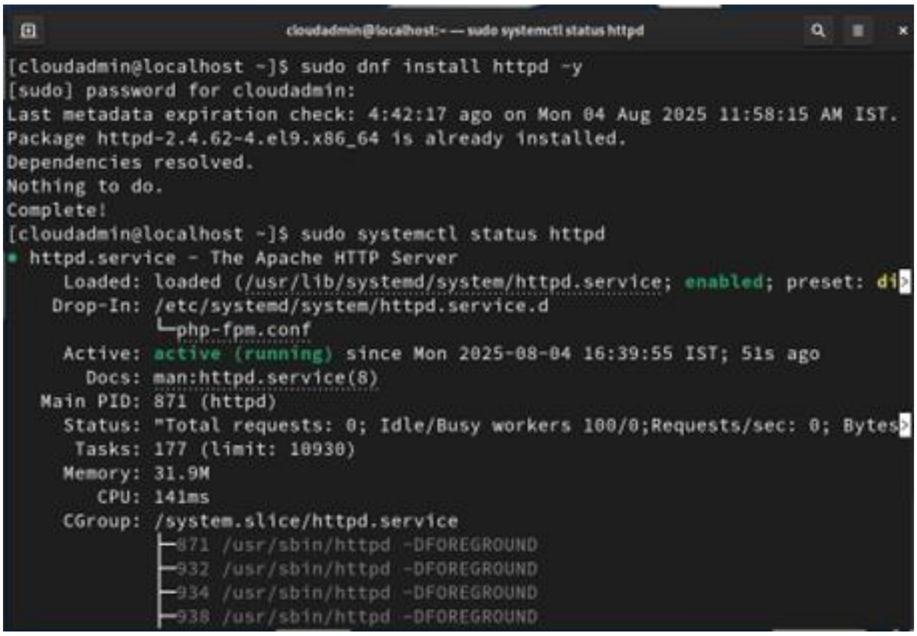
```
[anush@localhost ~]$
```

8.2 Web Server

- **Apache HTTP Server (httpd)**



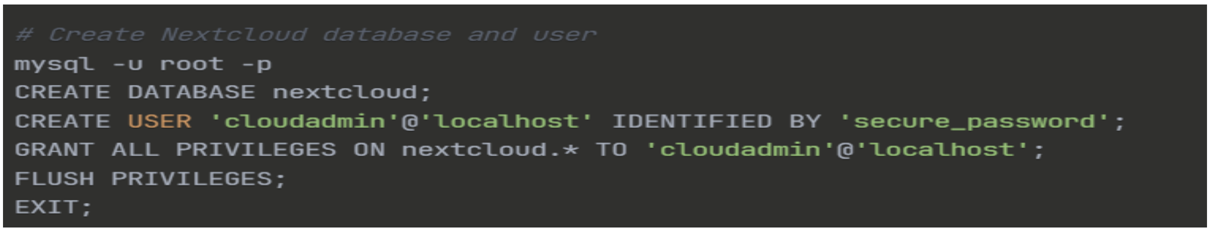
```
# Install Apache web server
sudo dnf install httpd -y

# Enable and start Apache service
sudo systemctl enable httpd
sudo systemctl start httpd

# Configure firewall for HTTP traffic
sudo firewall-cmd --add-service=http --permanent
sudo firewall-cmd --reload
```



```
[cloudadmin@localhost ~]$ sudo dnf install httpd -y
[sudo] password for cloudadmin:
Last metadata expiration check: 4:42:17 ago on Mon 04 Aug 2025 11:58:15 AM IST.
Package httpd-2.4.62-4.el9.x86_64 is already installed.
Dependencies resolved.
Nothing to do.
Complete!
[cloudadmin@localhost ~]$ sudo systemctl status httpd
● httpd.service - The Apache HTTP Server
     Loaded: loaded (/usr/lib/systemd/system/httpd.service; enabled; preset: di>
    Drop-In: /etc/systemd/system/httpd.service.d
             └─php-fpm.conf
     Active: active (running) since Mon 2025-08-04 16:39:55 IST; 51s ago
       Docs: man:httpd.service(8)
   Main PID: 871 (httpd)
     Status: "Total requests: 0; Idle/Busy workers 100/0;Requests/sec: 0; Bytes>
      Tasks: 177 (limit: 10930)
     Memory: 31.9M
        CPU: 141ms
     CGroup: /system.slice/httpd.service
             ├─871 /usr/sbin/httpd -DFOREGROUND
             ├─932 /usr/sbin/httpd -DFOREGROUND
             ├─934 /usr/sbin/httpd -DFOREGROUND
             ├─938 /usr/sbin/httpd -DFOREGROUND
```

8.3 Database Server

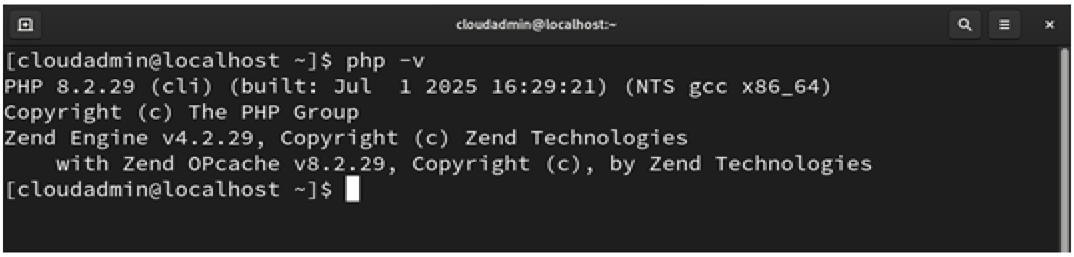
- **MariaDB Database Server**



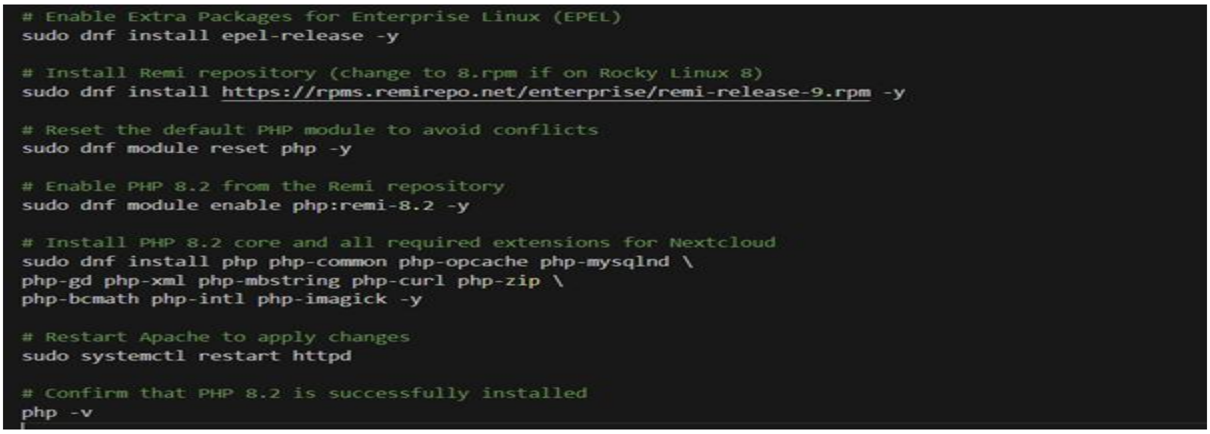
```
# Create Nextcloud database and user
mysql -u root -p
CREATE DATABASE nextcloud;
CREATE USER 'cloudadmin'@'localhost' IDENTIFIED BY 'secure_password';
GRANT ALL PRIVILEGES ON nextcloud.* TO 'cloudadmin'@'localhost';
FLUSH PRIVILEGES;
EXIT;
```

8.4 PHP Runtime Environment

- **PHP 8.2** and required extensions



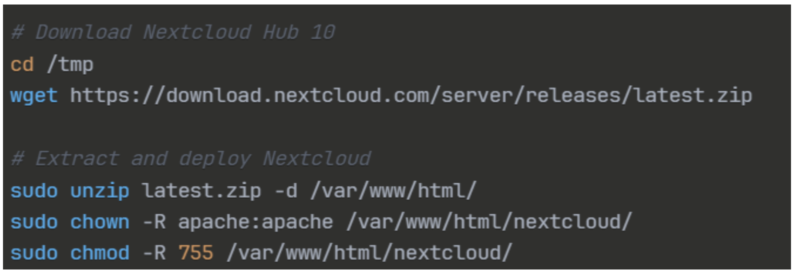
```
[cloudadmin@localhost ~]$ php -v
PHP 8.2.29 (cli) (built: Jul  1 2025 16:29:21) (NTS gcc x86_64)
Copyright (c) The PHP Group
Zend Engine v4.2.29, Copyright (c) Zend Technologies
    with Zend OPcache v8.2.29, Copyright (c), by Zend Technologies
[cloudadmin@localhost ~]$
```



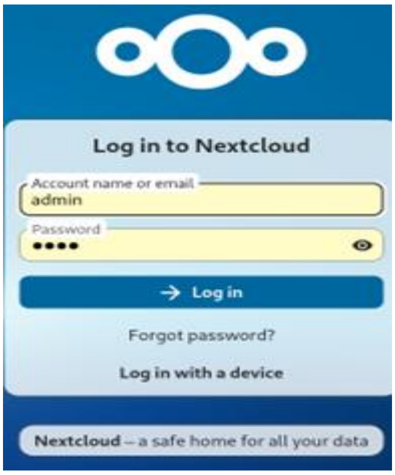
```
# Enable Extra Packages for Enterprise Linux (EPEL)
sudo dnf install epel-release -y

# Install Remi repository (change to 8.rpm if on Rocky Linux 8)
sudo dnf install https://rpms.remirepo.net/enterprise/remi-release-9.rpm -y

# Reset the default PHP module to avoid conflicts
sudo dnf module reset php -y

# Enable PHP 8.2 from the Remi repository
sudo dnf module enable php:remi-8.2 -y

# Install PHP 8.2 core and all required extensions for Nextcloud
sudo dnf install php php-common php-opcache php-mysqlnd \
php-gd php-xml php-mbstring php-curl php-zip \
php-bcmath php-intl php-imagick -y

# Restart Apache to apply changes
sudo systemctl restart httpd

# Confirm that PHP 8.2 is successfully installed
php -v
```

8.5 Nextcloud Server Application

- Version installed: **Nextcloud Hub 10**



```
# Download Nextcloud Hub 10
cd /tmp
wget https://download.nextcloud.com/server/releases/latest.zip

# Extract and deploy Nextcloud
sudo unzip latest.zip -d /var/www/html/
sudo chown -R apache:apache /var/www/html/nextcloud/
sudo chmod -R 755 /var/www/html/nextcloud/
```



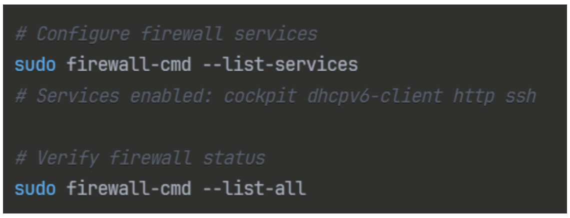
Log in to Nextcloud

Account name or email: admin

Password: ••••

8.6 Additional Tools / Dependencies

- **Firewalld**



```
# Configure firewall services
sudo firewall-cmd --list-services
# Services enabled: cockpit dhcpv6-client http ssh

# Verify firewall status
sudo firewall-cmd --list-all
```

8.7 Summery table of software stack

S.no	Layer	Software used
1.	Hypervisor	VMware workstation
2.	Operating system	Rocky Linux 9.6
3.	Web Server	Apache HTTP Server
4.	Database	MariaDB
5.	Runtime	PHP 8.2
6.	Cloud Application	Nextcloud Hub 10
7.	Security Tools	Firewalld

Table 8.1

CHAPTER 9 — IMPLEMENTATION METHODOLOGY

9.1 VM Setup

- Created a new virtual machine in VMware Workstation for installing Rocky Linux 9.6
- Allocated:
    - **Memory:** 4096 MB
    - **Processors:** 2
    - **Hard Disk:** 50 GB
    - **Network Adapter:** NAT (later changed to Bridged mode)
- Loaded Rocky Linux 9.6 ISO for OS installation

9.2 LAMP Stack Deployment

9.2.1 Installing Apache (httpd)

- Command used:
- sudo dnf install httpd -y
- sudo systemctl start httpd
- sudo systemctl enable httpd
- Apache enabled to serve the Nextcloud interface

9.2.2 Installing MariaDB Server

- Installed using:
- sudo dnf install mariadb-server -y
- sudo systemctl start mariadb
- sudo systemctl enable mariadb
- Required for storing Nextcloud database records

9.2.3 Installing PHP 8.2 and extensions

- Commands:
- sudo dnf install php php-mysqlnd php-gd php-xml php-mbstring php-json php-zip -y
- php -v
- Verified successful installation via php -v

9.3 Nextcloud Installation

- Downloaded Nextcloud package:
- wget https://download.nextcloud.com/server/releases/latest.zip
- Extracted and moved Nextcloud directory to /var/www/html/nextcloud/
- Adjusted file permissions:
- sudo chown -R apache:apache /var/www/html/nextcloud/
- Accessed Nextcloud through web browser and completed setup wizard:
    - Admin account creation
    - Database connection configuration

9.4 Security Hardening

- Configured firewall to allow HTTP/HTTPS:
- sudo firewall-cmd --permanent --add-service=http
- sudo firewall-cmd --permanent --add-service=https
- sudo firewall-cmd --reload
- Ensured strong password usage for database and Nextcloud admin
- Set proper directory ownership and permissions for security

9.5 Network Configuration

9.5.1 Issue Identified

- Nextcloud was not accessible from external/mobile devices when VM was set to **NAT mode**

9.5.2 Solution

- Changed network mode to **Bridged Adapter** to allow LAN-wide access
- Assigned IP using:
- ip addr show

Accessed Nextcloud from mobile phone using the VM’s LAN IP

9.6 LAMP Stack Component Versions and Description

S no.	Component	Version used	Description
1.	Linux OS	Rocky Linux 9.6	Enterprise-grade, stable, RHEL-based operating system used as the server platform.
2.	Apache HHTP Server	Apache 2.4.x	Web server responsible for handling HTTP/HTTPS requests and serving the Nextcloud interface.
3.	MariaDB Server	MariaDB 10.x	Relational database used to store Nextcloud user data, metadata, and configuration tables.
4.	PHP	PHP 8.2 + required extensions	Server-side scripting language used to run Nextcloud application logic; includes modules like php-gd, php-xml, php-mbstring, php-zip, php-json, php-mysqlnd.

Table 9.1

CHAPTER 10 – TESTING & RESULTS

10.1 Overview of Testing Methodology

Testing was conducted to verify the correct functioning, performance, and accessibility of the implemented private cloud system. The objective was to ensure that all major features of the Nextcloud server — including file upload, download, synchronization, user access, and cross-platform compatibility — operated as expected. Tests were executed after completing the deployment of the LAMP stack, network configuration, and security hardening.

10.2 Experimental Setup

The following environment was used to perform testing:

- **Server Platform:** Rocky Linux 9.6 running on VMware Workstation
- **Cloud Application:** Nextcloud Hub 10
- **Client Devices:** Windows 11 Desktop, Android Smartphone
- **Browser Used:** Google Chrome (Desktop and Mobile)
- **Network Mode:** Bridged Adapter (LAN access)
- **Server Type:** Local private cloud hosted inside a virtual machine

This setup ensured realistic testing conditions with multiple devices accessing the cloud over the same network.

10.3 Test Cases Performed

10.3.1 Accessibility Testing

The primary objective of accessibility testing was to confirm that the Nextcloud interface is reachable from external devices on the same LAN.

- After switching from NAT to Bridged mode, the server was assigned a LAN-accessible IP address.
- Both mobile and desktop clients successfully accessed the cloud using the browser.
- The login page, dashboard, and file views loaded without errors.

10.3.2 Functional Testing

Functional testing validated core features of the cloud service.
Tests performed:

- **File Upload:** Various files (documents, images) were uploaded successfully.
- **File Download:** Downloading files worked consistently across devices.

- **Folder Creation:** New folders were created, renamed, and deleted without issues.
- **User Dashboard:** Quick access tools, settings, and recent activity widgets responded correctly.

10.3.3 Cross-Platform Testing

Cross-platform testing verified that both desktop and mobile devices interact smoothly with the cloud system.

- **Windows 11 Desktop:** Full functionality observed with stable file operations.
- **Android Smartphone:** Mobile browser provided responsive access; uploads and downloads worked normally.
  This confirms that the cloud service is platform independent.

10.3.4 Performance Testing

Performance testing examined speed and response time under normal load.

- The server responded quickly to requests within the LAN.
- File uploads and downloads were completed without lag for normal file sizes.
- The Nextcloud dashboard loaded consistently without delays.

10.4 Results and Observations

Overall results indicate that the implemented private cloud is stable, usable, and reliable.

- All functional operations executed successfully.
- No errors were encountered during file management tasks.
- Network reconfiguration to Bridged mode significantly improved accessibility.
- The system provided smooth cross-platform support, allowing access from both desktop and mobile devices.
- Performance results showed fast response times within the LAN environment.

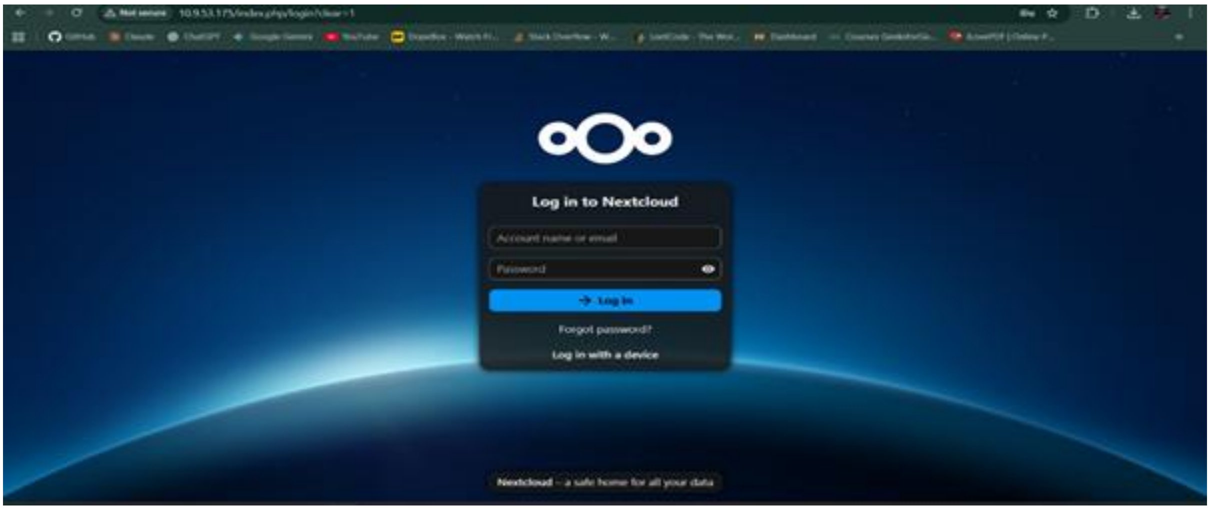
These results confirm that the private cloud meets the intended objectives of secure file storage, accessibility, and user convenience.

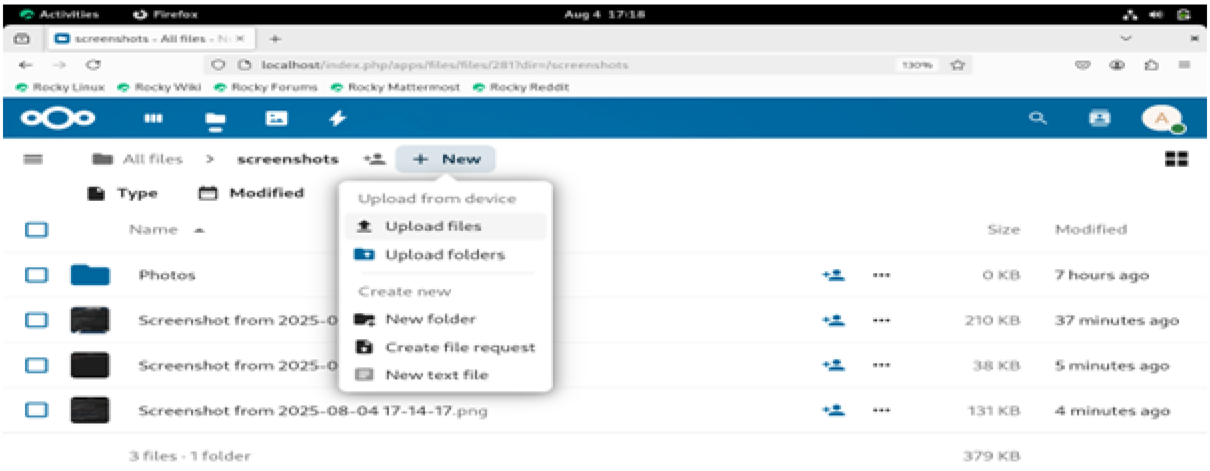
10.5 Summary of Testing Results

S no.	Test Case	Observation	Status
1.	File Upload	Smooth upload	Passed
2.	File Download	Fast and Stable	Passed
3.	Cross Platform Access	Works on Windows + Android	Passed
4.	Folder Operations	No issues	Passed
5.	LAN Accessibility	Stable via Bridged Mode	Passed

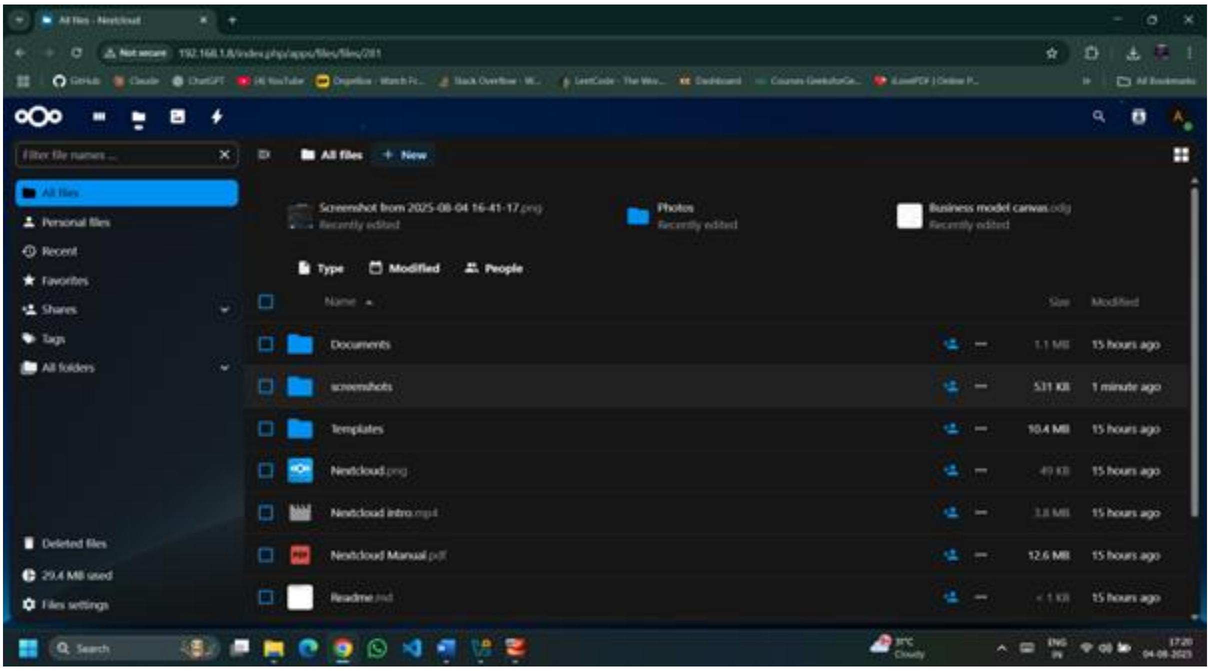
Table 10.1

10.6 Screenshots and Evidence of Testing





Name	Size	Modified
Photos	0 KB	7 hours ago
Screenshot from 2025-0	210 KB	37 minutes ago
Screenshot from 2025-0	38 KB	5 minutes ago
Screenshot from 2025-08-04 17-14-17.png	131 KB	4 minutes ago
3 files · 1 folder	379 KB	



Screenshot from 2025-08-04 16-41-17.png
Recently edited

Photos
Recently edited

Business model canvas.odg
Recently edited

Name	Size	Modified
Documents	1.1 MB	15 hours ago
screenshots	531 KB	1 minute ago
Templates	10.4 MB	15 hours ago
Nextcloud.png	49 KB	15 hours ago
Nextcloud intro.mp4	3.8 MB	15 hours ago
Nextcloud Manual.pdf	12.6 MB	15 hours ago
Readme.md	< 1 KB	15 hours ago

CHAPTER 11 — CONCLUSION & RECOMMENDATIONS

11.1 Conclusion

- Successfully implemented a **private cloud storage environment** using Nextcloud on a Rocky Linux server hosted in VMware Workstation.
- Completed full deployment of the **LAMP stack (Linux, Apache, MariaDB, PHP)** required to run the Nextcloud platform.
- Verified that the system supports:
  - File uploads & downloads
  - Folder management
  - User authentication
  - Multi-device access
- Ensured **cross-platform compatibility**, confirming smooth functionality on:
  - Windows browser
  - Android mobile browser
- Solved network access limitations by switching from **NAT mode** to **Bridged Adapter mode**, enabling LAN-wide access.
- Firewall rules and system configurations ensured a **secure and reliable environment**.
- The project demonstrates the feasibility of using **open-source software** to build a fully functional private cloud solution without reliance on commercial cloud providers.
- The deployment validates the practical value of:
  - Data privacy
  - Data sovereignty
  - Local resource control
  - Cost-effective cloud infrastructure

11.2 Recommendations

- Increase allocated VM resources (RAM & storage) for handling larger datasets and multiple users.
- Enable **HTTPS encryption** by installing SSL certificates for secure remote access.
- Configure automated **backup mechanisms** to protect Nextcloud data and database records.
- Implement advanced security measures such as:
    - Fail2ban
    - Intrusion detection
    - Stronger firewall policies
- Integrate **LDAP or Active Directory authentication** for enterprise-level deployments.
- Consider migrating the setup to a **dedicated physical server** for enhanced performance and concurrency.
- Explore scalability options like:
    - Multi-node deployment
    - Load balancing
    - Distributed storage solutions
- Regularly update Nextcloud and system packages to ensure security and stability.
- Expand testing to include:
    - Stress testing
    - Multi-user environment testing

APPENDICES

COMMANDS USED

1. System Update Commands

a) sudo dnf update -y

2. Apache Installation Commands

a) sudo dnf install httpd -y

b) sudo systemctl start httpd

c) sudo systemctl enable httpd

3. MariaDB Installation Commands

a) sudo dnf install mariadb-server -y

b) sudo systemctl start mariadb

c) sudo systemctl enable mariadb

4. PHP 8.2 Installation Commands

a) sudo dnf install php php-mysqlnd php-gd php-xml php-mbstring php-json php-zip -y

b) php -v

5. Nextcloud Deployment Commands

a) wget https://download.nextcloud.com/server/releases/latest.zip

b) unzip latest.zip

c) sudo mv nextcloud /var/www/html/

d) sudo chown -R apache:apache /var/www/html/nextcloud/

6. Firewall Configuration Commands

a) sudo firewall-cmd --permanent --add-service=http

b) sudo firewall-cmd --permanent --add-service=https

c) sudo firewall-cmd --reload

7. Network Verification Commands

a) ip a

b) ping <server-ip>

REFERENCES

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