Design and Implementation of a Secure On-PremisenCloud Storage Solution Using Raspberry Pi and Docker

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Abstract—**The development of reliable and secure on-premises cloud storage solutions is critical in the era of growing data privacy concerns. The paper introduces an innovative on premises cloud storage system using the Raspberry Pi 4, hosting Nextcloud On Docker through Pi-host Portainer. The system is designed for the execution steps including the deployment of the Nextcloud image, hosted on the Portainer as a Docker Image and database support provided by MariaDB, ensuring robust data management. By leveraging the lightweight and modular capabilities of containerization, the solution ensures simplified deployment, seamless updates, and scalability to meet diverse user requirements. Unlike legacy solutions like Own-Cloud and Open Media-Vault, which are no longer actively maintained, this system incorporates advanced functionalities such as file synchronization, collaborative tools, and secure data sharing, powered by Next-cloud. The integration with MariaDB further enhances the storage system's reliability and scalability. The use of Raspberry Pi 4 ensures an energy-efficient and cost-effective platform, making it accessible for individuals and small businesses.**

Keywords — On-premises Cloud Storage, Nextcloud , Modular cloud architecture ,Containerized Application, Raspberry-Pi.

I. INTRODUCTION

The Nextcloud setup on Raspberry Pi offers significant advantages over public cloud services like Google Drive , Dropbox , one Drive,etc are widely used for data storage and sharing. However, concerns about data privacy, security, and control have led many users to adopt self-hosted solutions. Nextcloud has become a popular choice, offering secure file synchronization, collaborative tools, and data-sharing capabilities.Despite its advantages, deploying Nextcloud can be technically complex, often requiring significant resources and expertise. To address these challenges, this paper introduces a cost-effective self-hosted cloud storage system using the Raspberry Pi 4. The Raspberry Pi 4, known for its affordability and energy efficiency, provides a reliable platform for hosting Nextcloud. The solution employs Portainer, a lightweight container management platform, to simplify the deployment and management of Docker images for Nextcloud and its backend services. This paper details the architecture, deployment steps, and performance, offering a secure, scalable, and user-friendly alternative to commercial cloud storage solutions.

II. RELATED WORKS

1] describe public cloud systems as platforms that allow users to access cloud resources via web browser interfaces, with a billing model based on usage duration, akin to utility services such as electricity billing. This approach significantly reduces IT operational costs. However, public clouds face security challenges due to their openness, making data and applications more susceptible to cyberattacks. Implementing robust security measures, including validation protocols on both the client and vendor sides, can enhance the overall security of public cloud environments. The private cloud systems operate within an organization's internal infrastructure, offering benefits such as improved security management, simplified maintenance, and greater control over resource allocation and deployment. These systems resemble intranets, where resources and applications are managed internally by the organization, in contrast to public clouds where external service providers handle these aspects.This System highlights the hybrid cloud model, which integrates private and public cloud environments. This model allows organizations to use private clouds for secure, critical operations while leveraging public clouds for additional resources when needed. By combining the security and control of private clouds with the scalability and accessibility of public clouds, hybrid cloud systems address diverse organizational requirements effectively.

[2] provide an overview of the current features and functionalities offered by cloud storage solutions. Their review highlights that numerous companies offer cloud services, but the available features vary significantly across providers. The paper discusses how a Raspberry Pi can be utilized to create a customized personal cloud storage system. By following appropriate configuration steps, the Raspberry Pi can be transformed into a cloud storage solution tailored to individual needs.They also elaborates on the process of setting up a personal cloud storage system using Raspberry Pi. This involves installing software like Putty, Raspbian, and Nextcloud. The Raspberry Pi is configured using Raspbian's command-line interface, enabling it to function as a cloud server. According to Nextcloud, It is an open-source platform, provides an excellent alternative to proprietary cloud service providers. It enables users to configure Raspberry Pi as a cloud server where they can store and retrieve data from any location with an internet connection.

[3] describe the Raspberry Pi as a versatile board equipped with essential components such as a processor, graphics chip, RAM, and connectors for peripheral devices. The board features a 1.2 GHz 64-bit quad-core ARM Cortex-A53 processor, integrated 802.11n Wi-Fi, Bluetooth capabilities, and support for USB boot. The processor utilizes SD flash memory as its primary storage medium. The Raspberry Pi is powered through a micro-USB connector, and network connectivity can be established using either an Ethernet or LAN cable.

III. PROPOSED APPROACH

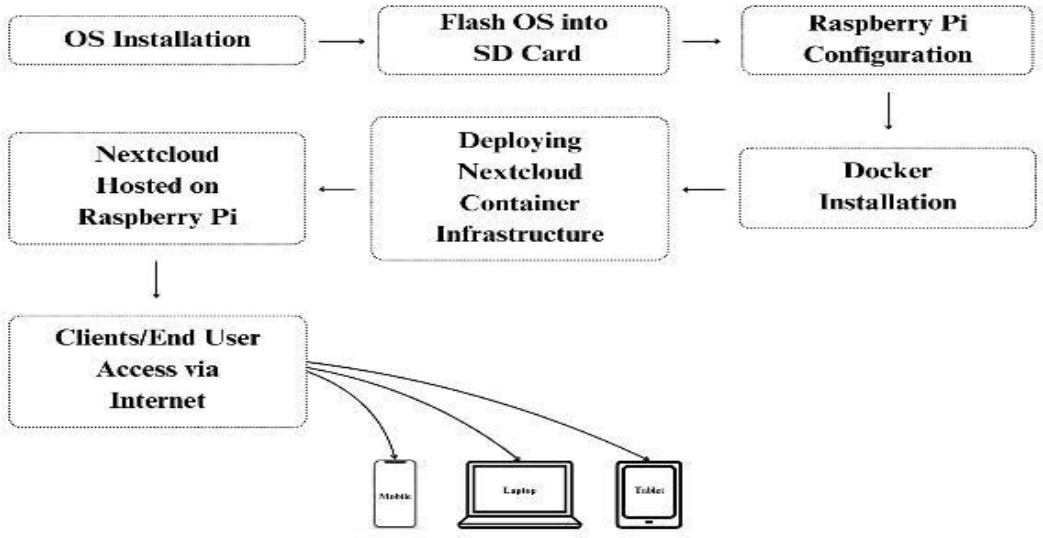

Figure 1:Architecture for proposed Approach

***Hardware Set-up**:*
Fig.1 illustrates the Architecture for the proposed cloud storage solution leverages the Raspberry Pi 4 Model B as the core hardware platform, supported by robust software components to create a reliable, scalable, and cost-effective system. The architecture utilizes open-source and lightweight technologies, ensuring accessibility and affordability without compromsing performance

A. Raspberry Pi 4
The Model B-board computer equipped with a quad-core ARM Cortex- The Raspberry Pi 4 Model B is a compact and powerful single A72 processor, multiple RAM options (up to 8GB), and a variety of connectivity interfaces. Its low power consumption and affordability make it ideal for deploying lightweight cloud services. The device supports Ethernet and Wi-Fi connectivity, enabling flexible networking options**.** The Raspberry Pi 4 Model B is a compact and powerful single-board computer that delivers exceptional performance and versatility for a wide range of applications. Equipped with a quad-core ARM Cortex-A72 processor running at 1.5GHz, it provides the computational power needed for demanding tasks while maintaining low energy consumption. This makes it an ideal choice for lightweight cloud services, edge computing, and IoT deployments.

B. MicroSD Card
The microSD card plays a critical role as the primary storage medium for the Raspberry Pi, hosting its operating system, configuration files, and other essential software components. This small yet powerful storage device provides the foundation for the Raspberry Pi's functionality, enabling the device to boot, execute tasks, and manage applications seamlessly. The microSD card acts as the Raspberry Pi's "hard drive," storing the operating system (such as Raspberry Pi OS, DietPi, or other compatible Linux distributions) and creating an environment for deploying a wide range of software tools and applications. Its lightweight and compact design make it an ideal storage solution for the Raspberry Pi, which is often used in projects that prioritize portability, energy efficiency, and minimal hardware.The storage capacity of the microSD card significantly influences its performance and suitability for different applications. For basic tasks, an 8GB or 16GB card may suffice, while more advanced projects involving large datasets, multimedia files, or complex applications may require higher-capacity cards, such as 64GB or 128GB. Additionally, the card's read/write speed (denoted by speed class ratings) impacts the Raspberry Pi's performance, particularly during tasks like booting, data processing, and running intensive applications

C. Docker
Docker is a powerful containerization platform that revolutionizes the way applications are developed, deployed, and managed. It enables lightweight and isolated application deployment by packaging software and its dependencies into containers. These containers operate consistently across diverse environments, from local development machines to production servers, ensuring portability and reducing compatibility issues .As the foundation for managing services such as databases, web applications, and cloud platforms. Docker plays a vital role in modern software architecture, It ensures scalability by allowing multiple containers to run simultaneously on a single host while efficiently utilizing system resources. This makes it possible to deploy and scale applications quickly without over provisioning hardware or encountering resource bottlenecks.

D. Portainer
Portainer is a user-friendly and intuitive management interface designed to streamline the use of Docker containers. It provides a comprehensive platform for administrators to deploy, monitor, and manage containerized applications with minimal effort, making it an excellent choice for users at all skill levels. By offering a clean and accessible graphical user interface (GUI), Portainer eliminates the steep learning curve often associated with command-line Docker management, empowering users to efficiently manage their container environments. One of the key features that sets Portainer apart is its template-based configuration system. This functionality simplifies the deployment of popular services, such as MariaDB, Nextcloud, WordPress, and more. With pre configured templates, administrators can deploy these services in just a few clicks, bypassing the need for extensive manual configurations. This is particularly valuable for beginners, as it reduces complexity and accelerates the process of building a functional environment.

E. Nextcloud

Nextcloud is an open-source file hosting and collaboration platform that provides core cloud storage functionality. It enables users to store, access, and share files securely from any location. Its customizable nature and extensive plugin ecosystem make it suitable for diverse use cases.It also helps in designing and configuring the tool for the personal use cases and maintain a good cloud Infrastructures. One of Nextcloud's key strengths is its ability to offer users full control over their data. Unlike traditional cloud services, which store data on third-party servers, Nextcloud can be deployed on private servers, including on-premises hardware or virtualized environments. This ensures that sensitive information remains secure and complies with data sovereignty regulations. The platform's end-to-end encryption and advanced authentication methods further bolster its security, making it a trusted choice for industries that handle confidential data, such as healthcare, education, and finance. Nextcloud's user-friendly interface allows for intuitive file management, enabling users to upload, organize, and access files with ease. It supports file versioning, which ensures that changes can be tracked and previous versions restored if necessary. The platform also integrates robust sharing options, allowing users to share files and folders with specific permissions, such as view-only or editing rights, either internally or with external collaborators.

F. Client and End-user

Clients and end-users can access the Nextcloud server hosted on a Raspberry Pi through a variety of methods, ensuring flexibility and convenience across platforms. Using a web browser, users can log in via the server's IP address or a configured domain name for full access to the dashboard and its features. Mobile apps for Android and iOS provide on-the go access, enabling file synchronization, sharing, and automatic media uploads, while desktop clients for Windows, macOS, and Linux ensure seamless synchronization of files across devices with options for selective syncing. Integration with third-party tools, such as Google Drive, Dropbox, and office suites like Collabora Online or Only Office, expands functionality, allowing centralized data management and real-time collaboration. Additionally, offline access through mobile and desktop clients ensures productivity without an active internet connection, with automatic synchronization when reconnected. Advanced security measures, including two-factor authentication and encryption, protect user data, while APIs empower developers to build custom integrations, making Nextcloud a comprehensive, secure, and versatile cloud platform for diverse needs.

IV. WORKFLOW

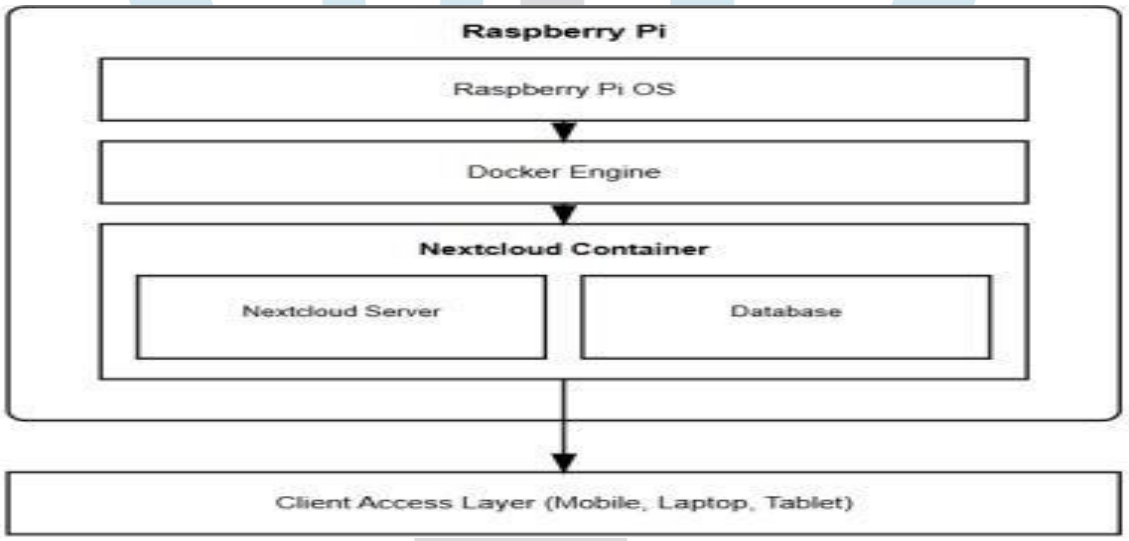

Figure 2: Architecture diagram for Workflow

A. OS Installation

Fig 2. Begins by downloading the Raspberry Pi Imager software from the official Raspberry Pi website. Use the raspberry-pi imager and Choose the raspberry-pi os-lite for 64 bit and write the chosen operating system (OS) onto a microSD card.Once The Image Is fetched It Is ready for further configuration.

B. Wifi-configuration

For Network connectivity, we have to configure the device while fetching the os it involves the Device SSID and Password for the configuration to the pi Setup ,Once Its turned on the system automatically finds the device and get paired.we can Also use ethernet connection to enable remote management and data accessibility, which are critical for hosting cloud-based applications. The Device connected to the network ensures a stable and secure access to your resource.

C. Identifying the Raspberry Pi's IP Address

The Raspberry pi ip address is required to connect to the device for the other configuration.The Angry-ip Scanner Tool Is Used Identify And Manage The Devices connected to the particular Ip ranges . Once you Identify The Ip you can Connect to the with the help of ssh Tool called "windows putty".

D. Docker Installation

Deploying a Docker on a Raspberry Pi involves setting up a lightweight containerization platform to run applications in isolated environments. The process starts with ensuring the Raspberry Pi's operating system is updated to its latest version for compatibility and security. Docker can then be installed by adding its official repository and installing the necessary software packages. Once installed, Docker enables you to create, manage, and run containers, which are portable, self-contained units of software that include everything needed to run an application.

E. Nextcloud Container Infrastructure

The infrastructure is orchestrated through a container management tool like Portainer, enabling seamless monitoring and configuration. Storage is integrated via mounted volumes or network-attached storage to persist data beyond container lifecycles. This modular, container-based setup ensures a robust, flexible, and resource-efficient environment, making it ideal for Raspberry Pi or other resource-constrained devices.

F. Nextcloud Container Hosted on Raspberry Pi

Running Nextcloud in a container on a Raspberry Pi is a streamlined way to set up a private cloud with minimal overhead. This containerized approach ensures that Nextcloud and its dependencies are isolated and easily manageable, offering portability and simplicity. The Raspberry Pi, with its compact size and energy efficiency, serves as a reliable host for the Nextcloud container, making it an affordable and sustainable solution for personal or small scale use. The scalability of this setup makes it ideal for personal use, small businesses, or educational purposes. Users can easily expand their system by adding storage through external drives or networked storage solutions. The modularity of Nextcloud, coupled with its extensive plugin ecosystem, allows for customization to suit individual needs, whether for basic file hosting, collaborative document editing, or advanced workflows.

V. OUTPUT

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Figure 3. User login Figure

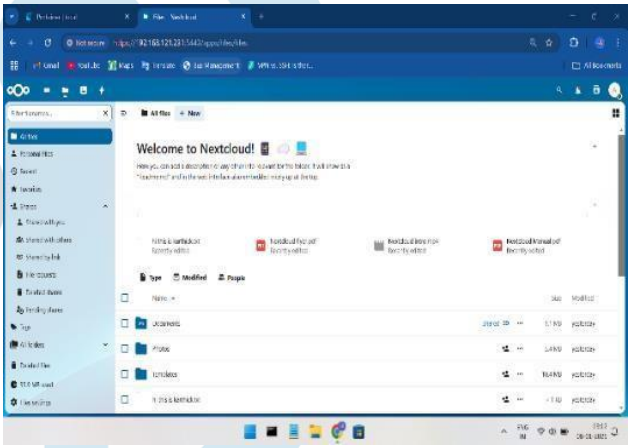

Figure 4 . Nextcloud-Dashboard

Nextcloud simplifies daily tasks by providing a unified platform for file storage, collaboration, and management. Users can securely log in to their accounts Fig 3 from any device using a web browser or dedicated mobile and desktop applications. The login interface ensures privacy and security with support for multi-factor authentication and encrypted connections. Once logged in, users can access their personal dashboard, where they can upload, organize, and share files, create and edit documents, and manage calendars, contacts, and tasks. This flexibility makes it an ideal solution for both personal productivity and teamcollaboration.

The Nextcloud dashboard, Fig 4 serves as a central hub for operations, offering intuitive navigation and seamless integration with third party apps like video conferencing tools, email clients, and office suites. From the dashboard, users can monitor storage usage, configure sharing permissions, and set up automated file synchronization across devices. Additionally, administrators can manage user accounts, monitor system performance, and apply security policies directly from the interface. This comprehensive yet user-friendly approach streamlines daily operations, ensuring an efficient and secure workflow for individuals and teams.From the dashboard, users can monitor key metrics such as storage usage, providing insights into available capacity and helping users manage their files effectively. This feature is particularly useful in environments with multiple users or shared storage resources, where efficient data management is crucial. Users can also configure granular sharing permissions directly from the dashboard, ensuring that files and folders are securely shared with specific individuals or groups with customizable access levels, such as read-only or full editing rights.

For administrators, the Nextcloud dashboard provides robust tools for managing the platform at scale. Admins can create and manage user accounts, assign roles and access permissions, and enforce organization-wide policies directly from the interface. The ability to monitor system performance, including server health, storage utilization, and network activity, enables proactive maintenance and optimization of the system. Administrators can also apply security policies, such as enabling two-factor authentication, setting password strength requirements, or configuring encryption options, to enhance the overall security of the platform.

In summary, the Nextcloud dashboard is a powerful and user friendly centerpiece for managing cloud-based workflows. Its ability to centralize key functions, integrate with third-party tools, and provide advanced administrative controls ensures an efficient and secure environment for individuals, teams, and organizations

VI. CONCLUSION

Deploying Nextcloud on a Raspberry Pi 4 using Docker and Portainer with Raspberry Pi OS Lite 64-bit is a powerful yet cost-effective way to build a private cloud solution. This setup leverages the lightweight and efficient nature of Docker containers to isolate and manage Nextcloud and its dependencies seamlessly. Portainer further simplifies container orchestration with its intuitive graphical interface, enabling effortless monitoring, deployment, and updates. Raspberry Pi OS Lite 64-bit provides a stable and optimized environment, ensuring the system can handle modern workloads while minimizing resource usage.

The security features of Nextcloud, such as encryption, two factor authentication, and fine-grained access controls, ensure that data is protected, while the containerized approach simplifies maintenance and updates. Moreover, the low power consumption of the Raspberry Pi makes this solution environmentally friendly, offering a sustainable alternative to traditional cloud hosting services. This combination not only empowers users with full control over their data but also offers scalability, flexibility and robust security features. Whether for personal use or small teams, this setup transforms the Raspberry Pi 4 into a reliable private cloud server, making file storage, synchronization, and collaboration accessible to anyone. With proper configuration, including external storage and secure access, this solution provides a practical and sustainable alternative to commercial cloud services.

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