

Nextcloud Based Personal Cloud Storage Implementation on Raspberry-Pi 4 for Lightweight Cloud Infrastructure

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Abstract

Cloud computing has emerged as a prevalent technique for data storage and management via internet-based platforms, eliminating the need for local storage devices. Nonetheless, public cloud services like Google Drive and Dropbox have issues related to data privacy, security, and user control over the foundational infrastructure. This study advocates for the deployment of a private cloud storage system utilizing Nextcloud on a Raspberry Pi 4 as a streamlined and economical infrastructure option. The Raspberry Pi is chosen for its compact dimensions, little power usage, and cost-effectiveness relative to traditional servers. The system is constructed on Ubuntu Server, utilizing Apache as the web server, MySQL as the database management system, and PHP to facilitate the Nextcloud application. The research process encompasses system requirements analysis, system design, implementation, and thorough testing. The findings indicate that the system effectively delivers critical cloud storage capabilities, encompassing file upload, download, sharing, data synchronization, and user access management. The performance assessment reveals that the system functions stably, responsively, and reliably for small to medium-scale storage requirements, while ensuring a sufficient degree of security.

Keywords: Cloud computing; Cloud storage; Raspberry-pi; Nextcloud; Lightweight cloud infrastructure;

Abstrak

Cloud computing menjadi teknologi yang banyak diadopsi untuk penyimpanan dan pengelolaan data melalui internet tanpa bergantung pada perangkat lokal. Namun, layanan cloud publik seperti Google Drive dan Dropbox menimbulkan kekhawatiran terkait privasi, keamanan, serta kendali pengguna terhadap data dan infrastruktur. Penelitian ini mengusulkan implementasi sistem cloud pribadi berbasis Nextcloud pada Raspberry Pi 4 sebagai solusi infrastruktur ringan dan berbiaya rendah. Raspberry Pi dipilih karena ukurannya ringkas, hemat daya, serta ekonomis dibandingkan server konvensional. Sistem dibangun menggunakan Ubuntu Server dengan Apache sebagai web server, MySQL sebagai database, serta PHP untuk mendukung aplikasi. Metodologi penelitian meliputi analisis kebutuhan, perancangan sistem, implementasi, dan pengujian sistem secara menyeluruh dan terstruktur. Hasil menunjukkan sistem mampu menyediakan fitur unggah, unduh, berbagi file, sinkronisasi data, serta manajemen akses pengguna secara efektif dan efisien. Pengujian kinerja menunjukkan sistem berjalan stabil, responsif, dan andal untuk kebutuhan penyimpanan skala kecil hingga menengah secara optimal dan berkelanjutan dengan tingkat keamanan yang memadai.

Kata kunci: Komputasi awan; Penyimpanan awan; Raspberry-pi; Nextcloud; Infrastruktur awan ringan

1. Introduction

The swift advancement of digital technology has markedly augmented the quantity of data produced and retained by individuals and companies. Thus, efficient and accessible data storage solutions have become imperative to support contemporary computing environments.

Conventional storage options, including local hard drives and external storage devices, frequently exhibit constraints regarding accessibility and centralized data management, especially when users require data access from various devices or remote locations. The swift advancement of information technology has revolutionized the storage and retrieval of digital data in contemporary computer settings. The rising utilization of digital devices, including computers, smartphones, and tablets, has resulted in a substantial volume of data that necessitates secure storage and easy access. Consequently, cloud computing has arisen as a proficient method for overseeing digital data storage via internet-based infrastructure [1]. Cloud computing offers computing resources, including storage, servers, applications, and networking services, accessible on demand via the internet. Cloud storage, a prevalent service in cloud computing, allows users to remotely store and retrieve data using internet-connected devices. Cloud storage systems offer numerous benefits, such as flexibility, high availability, and enhanced collaboration among users.

Many prevalent cloud storage services depend on public cloud infrastructure administered by third-party providers, potentially raising problems over data privacy and user control over stored information. The utilization of public cloud storage services like Google Drive, Dropbox, and Microsoft OneDrive presents several issues around privacy, data ownership, and reliance on external service providers. To mitigate these problems, private cloud computing has been suggested as a viable solution enabling enterprises or individuals to establish their own cloud infrastructure within a regulated network environment. Private cloud systems allow users to retain complete control over their storage infrastructure and security protocols while still leveraging cloud computing functionalities. Numerous studies have shown that private cloud storage systems enhance centralized data management and diminish reliance on local storage devices [5]. Nonetheless, traditional private cloud deployments typically necessitate costly server hardware and increased operational resources, rendering them less appropriate for small-scale or individual use. This constraint underscores the necessity for a more economical, adaptable, and readily implementable private cloud solution.

Prior research has utilized cloud storage platforms through open-source software solutions. Irawan and Sari established a Nextcloud-based cloud storage system within an educational context, demonstrating its capability to facilitate file sharing and collaborative data management among users [6]. Moreover, virtualization-based private cloud infrastructures have been extensively examined utilizing platforms like OpenStack to deliver Infrastructure as a Service (IaaS) for corporate networks [7]. Research by Afrianto and Hendrawan indicated that private cloud data center architectures enhance server resource management and decrease operational expenses [8]. A crucial element of cloud storage systems is data security. Hariyadi et al. examined security vulnerabilities in private cloud storage settings and suggested client-side protection measures to improve data confidentiality and integrity [9]. Hidayat et al. developed a private cloud storage system utilizing OwnCloud with monitoring tools to guarantee system reliability and performance [10]. Recent advancements in cloud computing technology have introduced new hardware platforms, such as Raspberry Pi, enabling the implementation of cloud infrastructures. The Raspberry Pi can operate Linux-based systems and handle many server applications, including web servers and cloud storage solutions. Numerous studies have investigated its implementation in cloud systems. The establishment of private cloud storage utilizing Raspberry Pi and Nextcloud facilitates a flexible and cost-effective architecture, while performance constraints may arise with concurrent access by numerous users [12]. Mustaqim established that Raspberry Pi-based cloud storage may accommodate multi-user scenarios within local networks [13]. Nextcloud is a prevalent open-source platform for establishing private cloud storage, providing functionalities such as file syncing, sharing, and user administration. Research conducted by Reon et al. validated its efficacy in facilitating collaborative contexts [15]. Additional research has examined virtualization-based infrastructures [16], enterprise cloud systems [17], governmental implementations [18], and secure enterprise storage solutions [19]. The amalgamation of Raspberry Pi with cloud platforms has been examined as a cost-efficient approach [20], whereas comparative analyses between OwnCloud and Nextcloud underscore disparities in performance and usability [21]. Moreover, recent studies underscore the necessity of maintaining data integrity in dispersed cloud systems [22]. Nonetheless, while these studies have examined cloud storage systems, private cloud infrastructures, and Raspberry Pi-based implementations, the majority concentrate on discrete components rather than offering a cohesive, cost-effective, and functional personal cloud solution.

Recent improvements in tiny computing systems like Raspberry Pi offer new prospects for creating lightweight and cost-effective cloud infrastructures. Integrating Raspberry Pi with open-source cloud platforms like Nextcloud enables the creation of a cost-effective, adaptable, and easily deployable personal cloud storage solution. This project intends to establish a personal cloud storage system utilizing the Nextcloud platform, run on a Raspberry Pi 4 as a lightweight cloud infrastructure. The suggested system aims to deliver a cost-efficient solution for small-scale or personal cloud storage settings, ensuring data accessibility and user control. This research adopts an integrated strategy that integrates low-cost hardware, open-source software, and practical deployment factors, in contrast to earlier studies that largely focus on infrastructure, platform, or performance elements in isolation. This integration offers a more pragmatic and relevant alternative for the establishment of personal-scale cloud storage.

2. Method

This study adopts a system implementation approach to design and develop a personal cloud storage system using Raspberry Pi and Nextcloud. The research methodology consists of several stages including problem identification, literature review, system requirement analysis, system design, system implementation, and system testing. These stages are carried out systematically to ensure that the developed system can function properly and meet the intended objectives. The research process begins with identifying the problems related to data storage limitations and the lack of centralized storage infrastructure. This is followed by conducting a literature review on cloud computing, private cloud architecture, Raspberry Pi technology, and the Nextcloud platform. Based on the findings from previous studies, system requirements are analyzed and used as the basis for designing the proposed cloud storage system. The overall research workflow used in this study is illustrated in **Figure 1**. The diagram illustrates the sequential stages performed during the research process, starting from identifying the problem to evaluating the system performance after implementation.

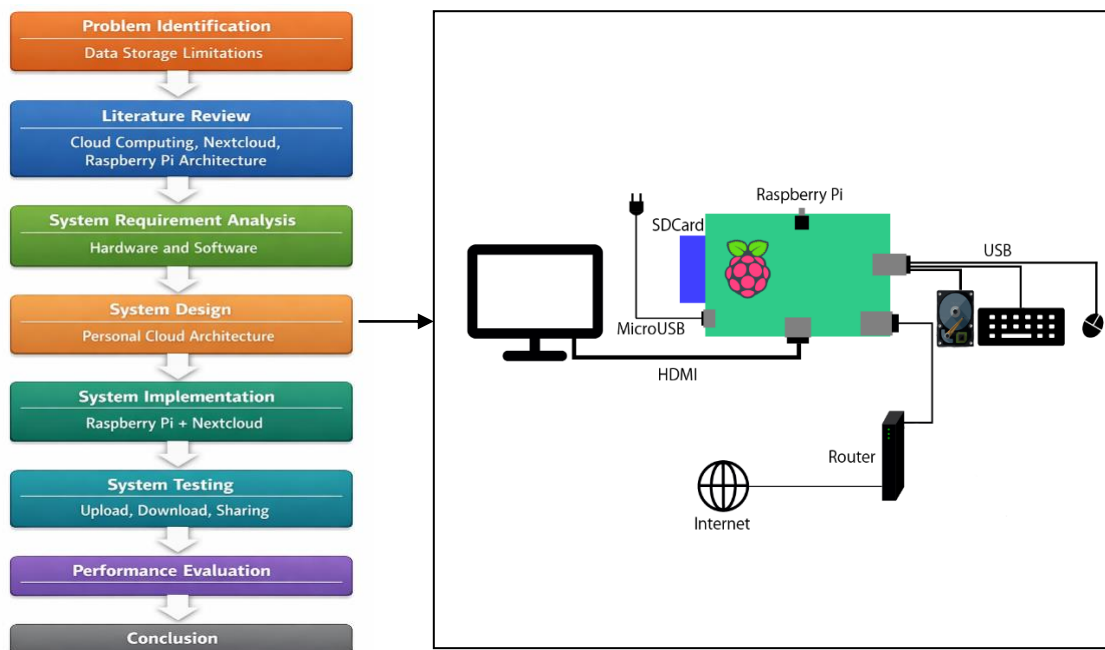


Figure 1. Research Methodology

Figure 1. Proposed Lightweight Cloud Architecture

The system requirement analysis stage aims to identify the hardware and software components needed to develop the proposed personal cloud storage system. The hardware used in this study includes a Raspberry Pi 4 as the main server, a 32 GB SD card for operating system installation, a 1 TB external hard disk for storage, a router for network connectivity, and input/output devices such as a monitor, keyboard, and mouse. The detailed hardware specifications used in this research are shown in **Table 1**. Raspberry Pi 4 is selected as the

core server device because it provides sufficient computing capability while maintaining low power consumption and relatively low hardware cost. In addition, it supports Linux-based operating systems and can run server applications such as web servers, databases, and cloud storage platforms, making it suitable for implementing a small-scale or lightweight cloud infrastructure.

Table 1. Hardware Requirements

Hardware	Specification
Raspberry Pi 4	Quad-core ARM processor
SD Card	32 GB
External Hard Disk	1 TB
Router	Network connectivity
Monitor, Keyboard, Mouse	Input/output devices

The proposed system architecture is designed using a client–server model. In this architecture, the Raspberry Pi device functions as the main cloud storage server that runs the Nextcloud application and manages data storage operations. Users access the cloud storage system through client devices such as laptops, smartphones, or tablets connected to the same network or through internet access. The system architecture designed in this research is illustrated in Figure 2. In this architecture, Raspberry Pi functions as the central node responsible for managing file storage, user authentication, and data synchronization processes. Client devices communicate with the server through HTTP or HTTPS protocols via the network infrastructure.

The system implementation stage involves installing and configuring the required software components on the Raspberry Pi server to support the personal cloud storage system. The process begins with installing the Ubuntu Server operating system on the Raspberry Pi device, followed by configuring network settings and storage devices. After the basic system configuration is completed, the Apache web server, MySQL database server, and PHP along with the required libraries are installed to support the web-based cloud platform. Subsequently, the Nextcloud application is deployed as the primary cloud storage service. The final step involves configuring user accounts and storage directories to enable file management and access control within the system. Once the installation and configuration processes are completed, the cloud storage system can be accessed through a web browser by entering the IP address of the Raspberry Pi server.

The system testing stage aims to evaluate the functionality and performance of the implemented cloud storage system. The testing process focuses on verifying the main features provided by the Nextcloud platform to ensure that the system operates as expected. Several functional tests are conducted, including file upload and download operations, file sharing between users, user account management, as well as folder creation and file organization within the storage system. These tests are performed to confirm that the implemented system can support basic cloud storage services effectively. The results obtained from this testing stage are further analyzed to assess system performance and reliability.

3. Results And Discussion

3.1 Implementasi dan Pengujian Model

The implementation results demonstrate that the proposed personal cloud storage system can operate effectively as a cloud-based data storage service. The system was successfully implemented using Raspberry Pi 4 as the main server platform. The server operates using the Ubuntu Server operating system and integrates several supporting components, including the Apache web server, MySQL database management system, and PHP as the server-side scripting environment required to run the Nextcloud platform. This configuration enables the Raspberry Pi device to function as a lightweight cloud server capable of providing web-based storage services while maintaining low hardware cost and energy consumption. The configuration and installation of these components were verified through several system tests to ensure that the server environment operates correctly. The storage device used for cloud data storage was successfully detected and mounted by the operating system, as shown in **Figure 3**. The PHP environment required to support the Nextcloud platform was also tested to ensure that all required modules were functioning correctly, as illustrated in **Figure 4**.

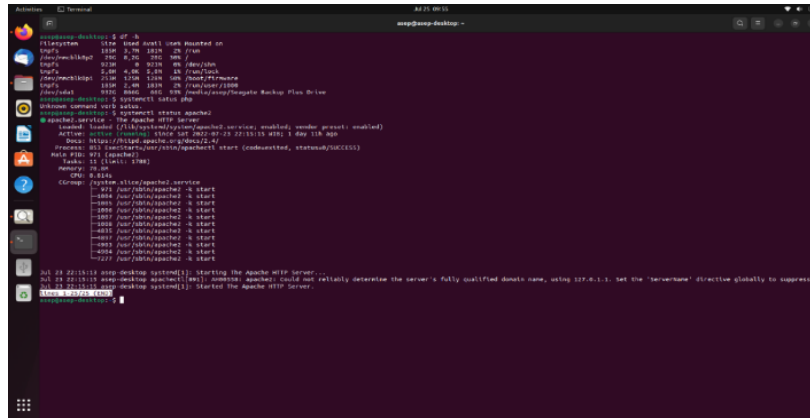


Figure 4. Apache Testing

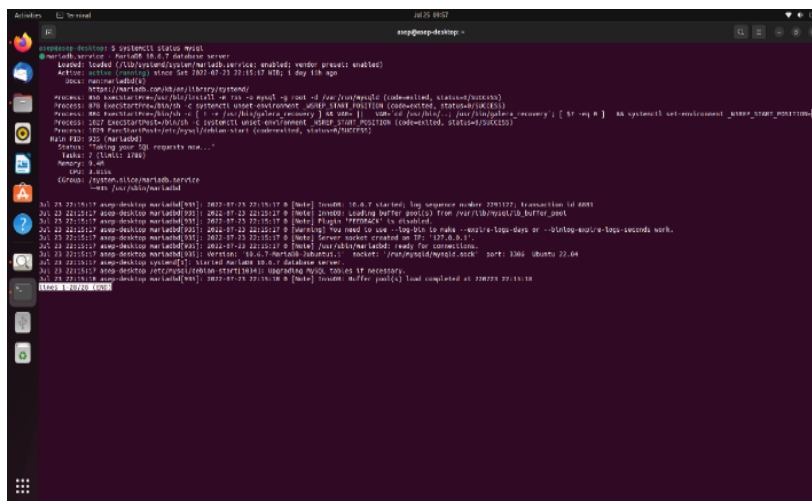


Figure 5. MySQL Server Testing

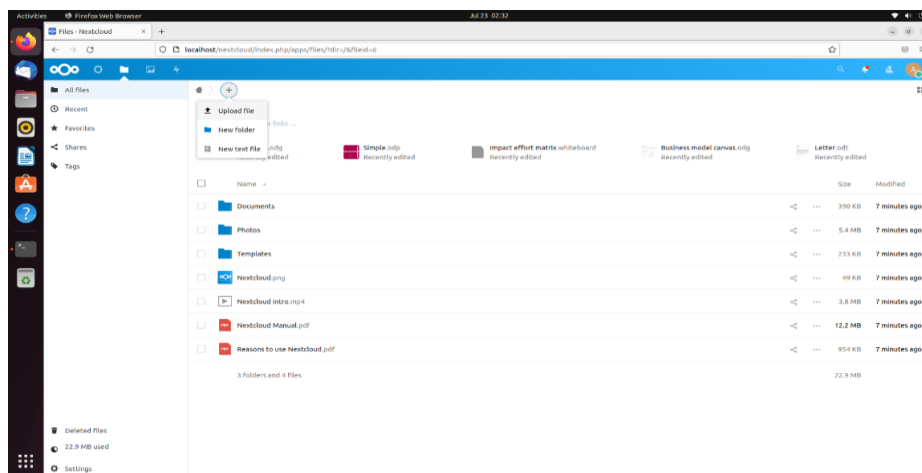


Figure 6. Nextcloud Implementation Results on Raspberry Pi 4 as Lightweight Cloud Infrastructure

Functional testing was conducted to evaluate whether the implemented system is capable of supporting the primary services of the cloud storage platform. The testing process focuses on validating the core functionalities provided by the Nextcloud system to ensure that the implemented infrastructure operates as expected. Several functional aspects were examined, including file upload and download operations, file sharing between users, user

account management, as well as folder creation and file organization within the storage environment. The testing results indicate that all functionalities operate properly. Users are able to upload files to the cloud server, download stored files, organize data by creating directories, and share files with other registered users through the Nextcloud interface. These results demonstrate that the implemented system successfully fulfills the fundamental requirements of a personal cloud storage service and provides reliable file management capabilities within the private cloud environment.

Table 2. File Transfer Performance Test

File Type	File Size	Upload Time	Download Time
Document	5 MB	1.8 s	1.5 s
Image	15 MB	4.2 s	3.9 s
Video	50 MB	12.6 s	11.3 s
Large File	100 MB	25.7 s	23.1 s

Performance testing was conducted to evaluate the system's capability in handling file transfer operations within the implemented personal cloud storage environment. The testing process involved uploading and downloading files with different sizes to measure the response time and observe the system performance under varying data loads. The detailed results of the performance testing are presented in **Table 2**, which shows the recorded upload and download times for several file types with different file sizes. Based on the results presented in **Table 2**, the Raspberry Pi server is capable of handling file upload and download processes effectively for small to medium-scale storage environments. As the file size increases, the transfer time also increases proportionally, which is consistent with typical network-based file transfer behavior. Larger files require longer transmission times due to the increased amount of data that must be transferred through the network. The testing results also demonstrate that the proposed system is capable of maintaining stable file transfer performance under varying file sizes, indicating that the Raspberry Pi-based cloud server can adequately support personal cloud storage operations. Nevertheless, the performance of the system is influenced by several factors, including network bandwidth, storage device performance, and the processing capability of the Raspberry Pi hardware. Although Raspberry Pi does not provide the same level of computing power as conventional server hardware, the results demonstrate that it is still capable of supporting personal cloud storage services for small-scale environments. Furthermore, the use of Raspberry Pi as a cloud server offers several advantages such as low hardware cost, reduced power consumption, compact system size, and ease of deployment, making it a practical solution for implementing a personal cloud storage infrastructure.

4.2 Discussion

The findings of this study demonstrate that the suggested personal cloud storage system utilizing Raspberry Pi 4 and Nextcloud effectively resolves the primary issue outlined in the introduction, specifically the demand for an economical, manageable, and accessible data storage solution. The system effectively executes essential cloud storage functions, including file upload, file download, file sharing, and user access management. These capabilities facilitate centralized data management and enhance accessibility without dependence on third-party public cloud services.

The proposed system partially fulfills the research objectives regarding problem-solving efficacy. The functional testing outcomes demonstrate that all essential functions perform correctly, signifying that the system can deliver fundamental cloud storage services in a private and regulated setting. This directly resolves concerns around restricted data ownership and privacy issues typically associated with public cloud services. Moreover, the capability of users to handle files, arrange directories, and share data illustrates that the system augments user autonomy in data management. The correlation between the assessed variables and the research problem is evident from the chosen test features: file upload, file download, file sharing, and file transfer time. These variables denote the fundamental activities of a cloud storage system and are intrinsically linked to storage capacity, accessibility, and system efficiency. The results indicate that the system can execute all these functions efficiently while sustaining steady performance across various file sizes. The proportional rise in transfer duration relative to file size signifies uniform system performance in accordance with standard

network attributes. Consequently, the assessed factors are pertinent and indicative in tackling the research issue. In comparison to prior studies, the outcomes of this investigation both corroborate and enhance existing findings. The research conducted by Irawan et al. [6] indicated that Nextcloud is proficient in file sharing and data administration, but studies employing virtualization techniques like OpenStack [7] highlight efficiency in managing large-scale infrastructures. Conversely, research into the utilization of Raspberry Pi as a cloud server [12], [13] has demonstrated its potential as an economical solution for some applications.

This research, unlike other studies, combines the Nextcloud platform with Raspberry Pi to create a cohesive architecture aimed at establishing a lightweight cloud infrastructure. The results affirm that each component is effective on its own and illustrate that their integration yields a system that is functional, stable, and suitable for personal and small-scale organizational applications. This investigation reinforces the assertion that a lightweight methodology utilizing low-cost hardware is both conceptually viable and practically executable. This study enhances the comprehension of private cloud storage deployment utilizing basic hardware platforms. This research adopts a holistic approach by integrating hardware, software, and system functionality, in contrast to earlier studies that often examine specific areas such as platform, infrastructure, or performance in isolation. This suggests that cloud infrastructure development does not inherently necessitate extensive resources, but may be tailored into more adaptable and cost-effective solutions.

This study's results have significant ramifications from an implementation standpoint. The suggested system offers a cost-effective alternative for users seeking centralized data storage while maintaining complete control over their data. The system possesses potential uses in educational settings, small offices, and home use. This study also acknowledges numerous limitations, notably performance constraints due to the hardware capabilities of Raspberry Pi and the lack of modern security methods. Consequently, forthcoming study need to concentrate on augmenting scalability, fortifying system security, and refining efficiency to accommodate more intricate use cases.

4. Conclusion

This study successfully implemented a lightweight cloud infrastructure using the Nextcloud platform deployed on Raspberry Pi 4 as the main server device. The system integrates several supporting components, including the Ubuntu Server operating system, Apache web server, MySQL database management system, and PHP scripting environment to provide a web-based cloud storage service. The implementation demonstrates that Raspberry Pi can function as a lightweight cloud server capable of supporting personal data storage services. The functional testing results confirm that the system is able to perform essential cloud storage operations such as file uploading, downloading, file sharing, folder management, and user account management through the Nextcloud interface. In addition, performance testing indicates that the system is capable of handling file transfer operations with varying file sizes while maintaining stable performance within a small to medium-scale storage environment. The main contribution of this research lies in demonstrating the feasibility of implementing a lightweight cloud infrastructure based on Raspberry Pi and open-source cloud platforms. The proposed system provides an alternative solution for individuals or small organizations that require centralized data storage while maintaining full control over their storage infrastructure. From a practical perspective, the implementation offers several advantages including low hardware cost, low power consumption, compact system size, and ease of deployment. These characteristics make Raspberry Pi a practical platform for developing lightweight cloud infrastructures, particularly for educational environments, small offices, or home-based data storage solutions. Future research may focus on improving system performance and scalability by integrating more advanced storage technologies, implementing stronger security mechanisms such as data encryption and authentication systems, and optimizing network configurations to enhance system reliability and data transfer efficiency.

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