Development of Custom-Built Network Attached Storage (NAS) System

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Abstract - With the rapid expansion of digital data, the need for efficient, secure, and cost-effective storage solutions has increased significantly. Network-Attached Storage (NAS) systems have emerged as a viable alternative to cloud-based storage, offering users full control over their data while ensuring high-speed local access. However, traditional NAS systems face several challenges, including security vulnerabilities, high costs, and complex configurations. This research presents a customized NAS solution that integrates remote access, automated backup, lightweight web hosting, and real-time system monitoring to overcome these limitations. Performance evaluations demonstrate the system's efficiency in terms of data transfer speed, security, and accessibility. The proposed solution provides an affordable and scalable alternative for individuals and small businesses seeking secure, self-hosted storage with cloud-like features.

Key Words: NAS, Cloud Storage, Data Privacy, Remote Access, Auto-Backup, Web Hosting, Network Security

I . INTRODUCTION

The rapid expansion of digital data has necessitated the development of efficient, secure, and scalable storage solutions for both individuals and organizations. Cloud storage services such as Google Drive, Dropbox, and OneDrive have gained widespread adoption due to their flexibility, remote accessibility, and ease of use. However, these services come with drawbacks, including recurring subscription fees, potential data privacy risks, and reliance on stable internet connectivity. Additionally, cloud providers maintain control over stored data, raising concerns about unauthorized access, data breaches, and compliance with data protection regulations. These challenges have led to a growing interest in alternative storage solutions that offer greater control, enhanced security, and cost-effectiveness.

Network-Attached Storage (NAS) presents a viable alternative to cloud-based storage, allowing users to create a centralized, locally controlled storage system with remote access capabilities. NAS offers benefits such as high-speed local access, data encryption, customizable security settings, and independence from third-party service providers. However, traditional NAS solutions are often criticized for their complex setup, high initial costs, and lack of advanced features such as automated backups, web hosting, and system monitoring. This research paper explores the limitations of existing NAS systems and proposes an optimized NAS model that integrates enhanced functionalities. By addressing common NAS challenges and evaluating its performance, this study aims to present an effective, user-friendly, and secure data storage solution suitable for both personal and small business applications.

II. LITERATURE SURVEY

1. Title: "A Comparative Study of NAS and Cloud Storage"
   Author**:** Smith, J & Brown, L Smith
   Published**:** 2023
   This study presents a detailed comparison between NAS and cloud storage based on cost, security, and performance. It highlights that while cloud storage provides accessibility and scalability, it suffers from privacy risks and high long-term costs. NAS, on the other hand, offers better control over data and high-speed local access. The study concludes that NAS is a more cost-effective solution for users requiring high security and local data management.

2. Title: "Configuring Secure NAS Solutions"
   Author**:** TrueNAS Documentation
   Published**:** 2024
   This documentation provides guidelines on configuring NAS for security and performance optimization. It discusses encryption techniques, role-based access control, and VPN integration for secure remote access. The findings suggest that properly configured NAS systems can provide enterprise-level security while maintaining local control over data.

3. Title: "Enhancing NAS with Cloud Property" Author: NextCloud Official Site
Published: 2024
This research explores the integration of NAS with cloud-like features using NextCloud. The study demonstrates how adding remote access and real-time synchronization improves user experience while maintaining the advantages of local storage. The results indicate that hybrid NAS-cloud models can effectively combine the security of NAS with the flexibility of cloud services.

4. Title: "Security Challenges in NAS Systems"
Author**:** Gupta, R, & Patel
Published: 2024
This paper analyzes security vulnerabilities in NAS, including unauthorized access, ransomware threats, and weak encryption mechanisms. The study recommends multi-layer security protocols such as two-factor authentication (2FA), advanced encryption standards (AES-256), and real-time access logging to mitigate these risks. The findings emphasize the need for continuous security enhancements in NAS solutions.

5. Title: "Securing Remote Access for NAS"
Author(s):OpenVPN
Documentation Published**:** 2024
This study focuses on implementing secure remote access for NAS systems using VPN technology. It highlights the importance of encrypted data transmission and authentication mechanisms to prevent unauthorized access. The results demonstrate that VPN-based remote access significantly enhances the security and usability of NAS for remote users.

III. METHODOLOGY

This research follows a structured approach to designing, developing, and evaluating an improved Network-Attached Storage (NAS) system. The methodology includes defining the system architecture, implementing key functional modules, and analyzing performance metrics to assess efficiency, security, and usability.

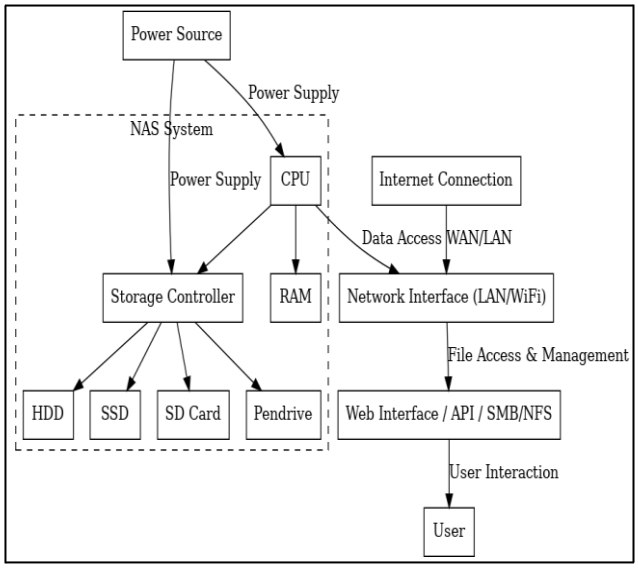

Figure 1: NAS System Architecture

The NAS system is designed with essential hardware components, including a central processing unit (CPU), memory (RAM), and a storage controller responsible for managing connected storage devices such as HDDs, SSDs, and external USB drives. A dedicated power source ensures continuous and stable system operation. The CPU and RAM work in tandem to execute data processing tasks efficiently, while the storage controller optimizes data organization and retrieval. This structure facilitates seamless storage management and ensures fast and reliable access to stored data.

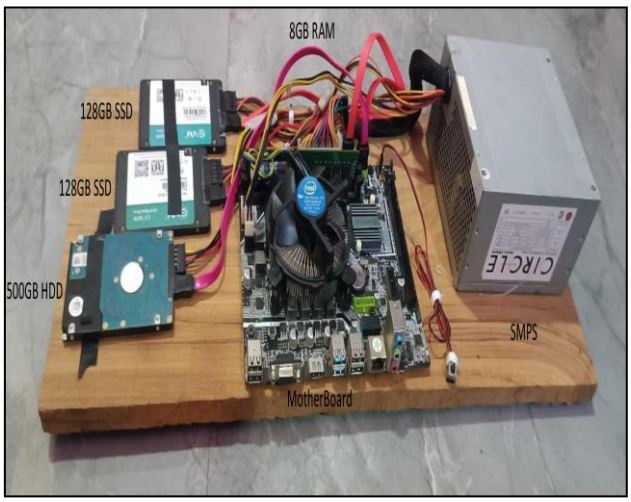

Figure 2: Custom Build NAS system

1) Requirement Analysis for NAS System

To ensure smooth operation, efficiency, and security, it is essential to conduct a comprehensive requirement analysis.

A. Functional Requirements

The functional requirements define the essential tasks the NAS system must perform to ensure reliability and usability.

i. User Management & Access Control

- The system should allow multi-user access with authentication mechanisms.
- Role-based access control (RBAC) should be implemented to differentiate user privileges, such as Admin, Standard Users, and Guest Users.

ii. Data Storage & Retrieval

- The NAS must provide high-speed data read/write operations for efficient file transfers.
- Users should be able to store various file formats, including documents, multimedia, and backups.

iii. Remote Access & File Sharing

- The NAS should support secure remote access via web-based applications or VPN.
- File sharing functionality should be integrated, enabling public and private sharing options.

iv. Data Security & Encryption

- The NAS must incorporate AES-256 encryption for secure data storage.
- Two-factor authentication (2FA) should be implemented to enhance login security.

v. Network Configuration & Performance

- The NAS should be accessible over both wired (Ethernet) and wireless (Wi-Fi) networks.
- It should include static IP and dynamic IP assignment capabilities.
- The system must optimize data transfer speeds based on network bandwidth.

vi.Backup & Data Recovery

- The NAS should enable scheduled and incremental backups to avoid data redundancy.
- A disaster recovery mechanism should be in place for restoring lost or corrupted data.

vii. Web Hosting & Application Support

- The NAS should support lightweight web hosting for personal and small business websites.
- It must allow integration with third-party applications such as NextCloud.

B. Non-Functional Requirements

Non-functional requirements define the overall performance, security, and maintainability of the NAS system.

i. Performance Requirements

- The NAS should provide low-latency access to stored files.
- It must support multiple users simultaneously without performance degradation.

ii. Security & Privacy

- User authentication should be enforced with strong password policies.
- The system must support firewall and intrusion detection mechanisms to prevent cyber threats.

iii. Scalability & Expandability

- The NAS should support additional storage devices to expand capacity.
- It should be compatible with cloud integration for hybrid storage solutions.

iv. Usability & Accessibility

- The NAS should have an intuitive web-based interface for easy configuration and management.
- It must support multi-device compatibility, including PCs, smartphones, and tablets.

v. Reliability & Maintenance

- The system should provide self-diagnostic tools to detect failures.
- Regular software updates should be supported to enhance security and performance.

- The NAS should feature an automated cooling mechanism to prevent overheating.

C. Hardware Requirements

- Processor: Multi-core CPU for handling simultaneous requests.
- RAM: Minimum 8GB DDR4 for smooth operation.
- Storage: SSD for OS and cache, HDDs for primary data storage.
- Network: Gigabit Ethernet and Wi-Fi for reliable connectivity.
- Power Supply: Uninterrupted Power Supply (UPS) to prevent data loss.
- Cooling System: Efficient heat dissipation to maintain system stability.

D. Software Requirements

- Operating System: TrueNAS,
- File System Support: ZFS, Btrfs, or EXT4 for data integrity.
- Backup Software: Integrated backup solutions like Rsync or Bacula.
- Security Features: SSL/TLS encryption, VPN support, and firewall protection.

IV. WORKING MODULES

The custom-built NAS system was effectively implemented using TrueNAS, offering a centralized storage solution with secure access and optimized file management. To ensure its efficiency, multiple tests were performed, including file-sharing capabilities, data transfer rates, and system responsiveness. The following sections highlight the essential observations and performance outcomes derived from the NAS setup.

A. User Interface of NAS System

The TrueNAS web-based dashboard enables administrators to create user accounts, set role-based permissions, and enforce data encryption for security.

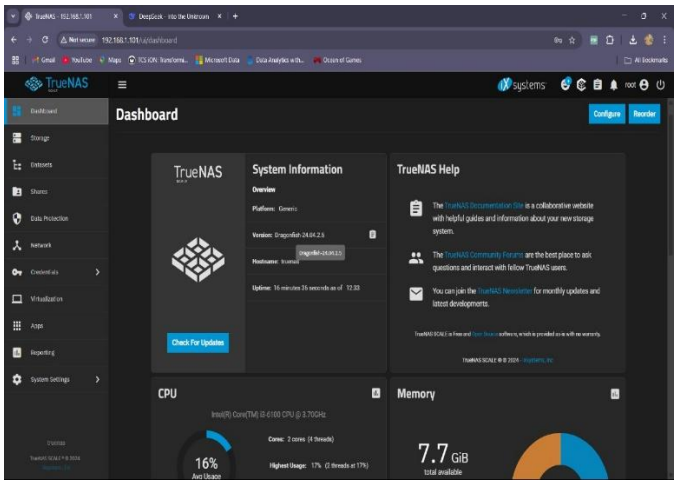

Figure 3: TrueNAS Web Interface

B. Automated Backup

Custom NAS offers a built-in snapshot feature for automated backups, ensuring data protection against accidental deletions or corruption. Scheduled backups can be configured for external storage devices or cloud platforms.

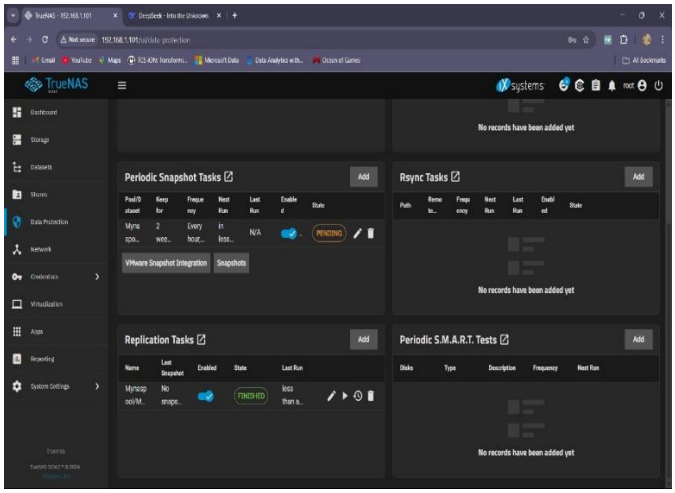

Figure 4: TrueNAS Web Interface

C. Logs Creation

TrueNAS offers a logging feature that records system activities such as file access, errors, and user actions. Logs can be accessed through the TrueNAS web interface and configured for detailed tracking. They help with security monitoring and system performance, and can be exported or integrated with external servers for centralized management.

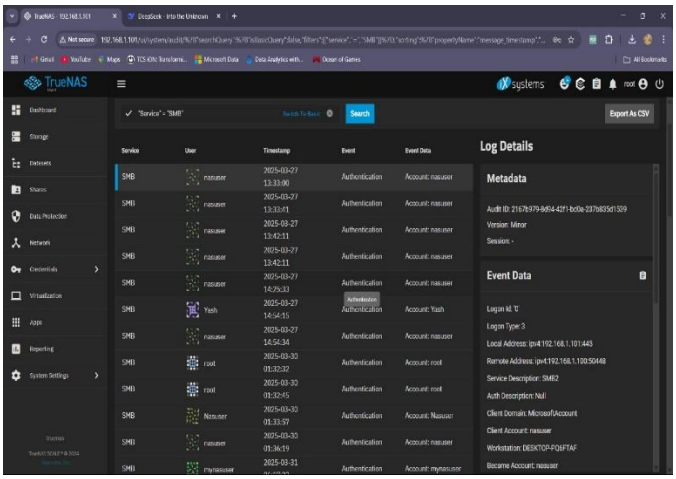

Figure 5: Immutable Logs Created By NAS

D. File Sharing and Receiving Speed

The file sharing and receiving speed of a custom NAS system depends on factors like storage type, network interface, and the protocol used

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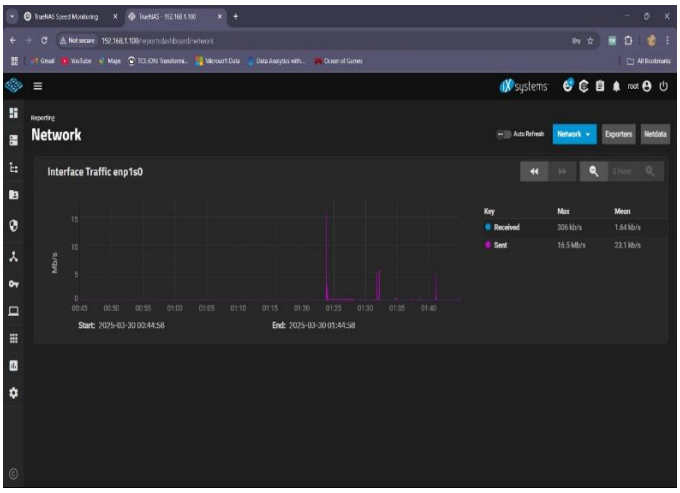

Figure 6: File sharing speed of NAS

E. NAS Datasets

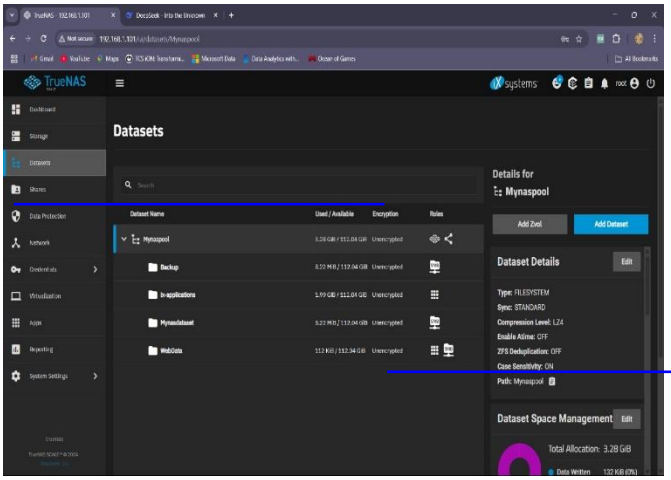

Figure 7: Dataset Created for NAS

V. CONCLUSIONS

A custom-built Network-Attached Storage (NAS) system provides a reliable, secure, and cost-efficient solution for managing and storing data. Unlike traditional cloud-based storage, which often involves recurring subscription costs and privacy concerns, a custom NAS setup offers full control over data, high-speed local access, and secure remote connectivity. The integration of automated backups, multi-device support, and web hosting capabilities enhances its overall functionality, making it an ideal choice for both individuals and small businesses.

The proposed NAS system has demonstrated efficient performance, enhanced security, and seamless accessibility. By eliminating the reliance on third-party cloud services, users can safeguard sensitive information while reducing long-term operational expenses. Future enhancements could focus on AI-driven storage optimization, advanced encryption mechanisms, and better mobile integration to further improve usability and security. This research highlights the potential of custom NAS solutions in addressing modern data storage challenges, providing a scalable and adaptable alternative to traditional storage methods.

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