Implementation of Polinema Streaming Web Server by Integrating ONT and STB

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***Abstract*—The growing demand for dynamic content delivery in academic institutions necessitates robust streaming solutions. This study implements and evaluates a high-performance Streaming Web Server at Malang State Polytechnic by integrating an Optical Network Terminal (ONT) and a Set-Top Box (STB). The design synergizes the ONT's high-speed broadband capabilities with the STB's multimedia delivery function to create a dedicated campus streaming ecosystem. System performance was evaluated based on network latency, packet loss, server response, and load handling. Test results demonstrate excellent network quality with low latency (0.596ms at NAS, 1.585ms at AI Building, 2.647ms at AH Building) and minimal packet loss (ranging from 0.429% to 3.11%). The server efficiently processes requests with an average execution time of 1904ms, a throughput of 46.1 requests per second, and zero errors. Crucially, the implemented load balancing mechanism successfully maintains service stability for 1000 concurrent users. The integration of ONT and STB effectively optimizes bandwidth utilization, reduces packet loss, and ensures responsive streaming. This study concludes that the proposed integrated system delivers optimal, scalable, and reliable performance, suitable for supporting essential streaming services and information distribution within a campus network.**

***Keywords*— Load balancing, Optical Network Terminal (ONT), Quality of Service (QoS), Set-Top Box (STB), Streaming Web Server, Campus Network.**

I. INTRODUCTION

In the digital era, advancements in information technology have significantly transformed how institutions disseminate and access information. Streaming services have emerged as crucial tools for educational environments, enabling students, lecturers, and campus employees to engage with dynamic multimedia content seamlessly. The integration of these services into campus life not only enhances the educational experience but also ensures that information is distributed efficiently and interactively [1].

At Malang State Polytechnic, a progressive approach toward adopting the latest technologies is evident in their commitment to implementing a Streaming Web Server that integrates Optical Network Terminals (ONT) and Set-Top Boxes (STB). This integration aims to address the limitations of existing information dissemination methods, which currently rely on localized information TV systems that offer limited functionality and reach. By leveraging optical networks, Malang State Polytechnic can provide high-speed, reliable access to streaming services across multiple buildings and areas within the campus [2].

Optical Network Terminals (ONT) play a pivotal role in this transformation by serving as the primary interface between fiber-optic networks and user devices. ONTs convert optical signals into digital data, facilitating high-speed data access essential for streaming services. Their integration into the campus infrastructure supports the scalability and robustness required for large-scale data transmission [3].

Set-Top Boxes (STB), on the other hand, enhance the streaming experience by decoding digital signals and presenting multimedia content in an accessible format. STBs are integral to bridging the gap between conventional television systems and modern streaming platforms, thus enabling interactive services and internet connectivity within the campus environment [4].

The synergy between ONT and STB in the Streaming Web Server setup at Malang State Polytechnic is designed to create an ecosystem that maximizes the strengths of both technologies. This approach ensures not only efficient data management but also the seamless delivery of high-quality multimedia content. Furthermore, the use of STBs as NAS servers enhances the reliability and performance of the streaming services, providing consistent availability for campus-wide users [5].

This study aims to explore the effectiveness of ONT and STB integration in improving the distribution of information at Malang State Polytechnic, with a focus on interactive media usage such as interviews and video presentations. The findings are expected to contribute to the broader discourse on the role of modern technology in educational settings, highlighting the potential of optical networks and multimedia platforms in transforming information access and dissemination.

Following the background, the study formulates the problem by focusing on two main aspects: the integration of Optical Network Terminal (ONT) and Set-Top Box (STB) in managing the Quality of Service (QoS) for streaming across campus areas and the effectiveness of the load balancing system in handling

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concurrent user requests without significant performance degradation. The research is confined to the AI and AH buildings at Malang State Polytechnic and evaluates the streaming service quality based on latency, bandwidth usage, packet loss, and jitter under controlled network conditions. The study also explores the capacity of STBs to manage up to 1000 concurrent users, utilizing specific hardware such as the Indihome HG680P STB and Toshiba Canvio Basics 1TB hard drive, along with a 250-meter drop core fiber optic cable. The objectives include assessing the QoS of ONT and STB integration, measuring the load balancing system's effectiveness, and ensuring the web server's performance in providing reliable streaming services. The research outputs aim to deliver an integrated streaming service solution that enhances access to high-quality academic content and to publish the findings in a scientific journal, contributing to the broader understanding of streaming service optimization in educational institutions [6].

Previous research provides essential insights that guide this study, particularly in the domain of integrating Set Top Boxes (STB) and Optical Network Terminals (ONT) for streaming services. A significant study on the application of STB as entertainment devices in Indonesia focused on the transition from analog to digital television. It highlighted challenges such as implementation difficulties and the need for public awareness regarding digital TV. The findings emphasized the role of STBs in receiving digital broadcasts and improving image quality, along with practical solutions for easing the transition to digitalization [7].

Further research explored the innovative use of repurposed STBs as mini cloud servers. This study demonstrated that by installing a Linux-based operating system, STBs could be transformed into mini servers capable of handling network storage tasks. While this study showed the potential of STBs as servers, it recommended additional research to thoroughly investigate their capabilities as cloud servers, indicating a promising area for further exploration [8].

In parallel, performance comparisons between Apache and Nginx web servers revealed that Nginx could handle client requests more efficiently than Apache. This study, utilizing Apache Bench for benchmarking, provided insights into the relative strengths of these web servers in managing large volumes of client requests. The findings serve as a crucial reference for choosing web servers in environments requiring high performance, laying the groundwork for evaluating server efficiency in the context of web streaming services [9].

Optical Network Terminals (ONT) play a crucial role in fiber optic network infrastructure, serving as a bridge between the service provider and the customer's electronic devices. Installed in homes or locations requiring fiber optic services, ONTs convert optical signals into electrical signals, facilitating access to the internet, television, and telephone services. Acting as the termination point for signal distribution to household devices, ONT provide reliable connections, support VoIP services, enhance security, and ensure efficient signal distribution through routers. In the context of this research, the integration of ONT is pivotal for connecting the core network with user devices across the campus. This integration simplifies access to various services such as data, video, and voice, enabling users to benefit from multi play services through a single fiber optic line. By supporting these services, ONTs ensure a seamless and efficient network experience for all users within the campus environment [10].

Electronic devices known as *set-top box* (STB) is responsible for converting digital television signals into formats that can be understood by television. Not only is it beneficial for digital signal decryption, but also for the conversion process that produces optimal sound and images. STBs also serve as an interactive interface for users, so they select channels, access services *On-Demand*, and adjust their preferences [11].

One of the key features of STBs is their ability to serve multimedia content over an internet connection, which expands the entertainment experience with access to a wide range of streaming services and apps. With increasingly sophisticated features, in addition, STB has the ability as a local server, which can store and distribute web content on the local network. The use of STB as a local server in the context of education can increase the accessibility and speed of access to learning materials on campus [12].

Flashing involves charging the SD card with firmware and then inserting it into the STB card slot. So that users perform the update themselves without the help of a technician and include recharging with the latest firmware for fast and effective operating system updates. Users can ensure that STB devices stay up to date with the latest technology, improving their functionality and performance, by understanding the role of SD Cards in flashing. Adhering to the user manual provided by the STB manufacturer is essential for the smooth and successful flashing process [13].

Hard disks play a very important role in NAS architecture. Hard disks are also used to store images of virtual machines (VMs) in a virtualized environment, which allows multiple virtual servers to operate on top of a single physical hardware. Hard disks are also used to store user data, applications, and configuration files that are required to run cloud services. Data backups can also be stored on hard disks, which is essential for business continuity and disaster recovery. The read and write speeds of hard drives affect the time it takes to access data and applications in the cloud, which has a direct impact on the user experience [14].

CasaOS is a platform designed to simplify home server management and make it easier for users to set up and manage NAS. Easy-to-understand and user-friendly user interface makes configuring and operating the server easy even for users with no technical expertise. In addition, CasaOS allows the installation and operation of various applications on the server, including various applications involving the home. CasaOS emphasizes the security aspect by offering features such as access control, data encryption, and support for Virtual Private Networks (VPN), one of the main features being efficient storage management. Users can easily set up and manage data storage, including RAID settings for better data redundancy, ensuring that critical data remains secure and available even in the event of a hardware failure.

CasaOS as a NAS is implemented in several key steps. First, it is installed and configured on the selected hardware or virtual machine, including basic settings such as networking and storage. After that, users can manage applications such as media servers, web servers, or file-sharing services. Another key focus is security, with configurations that include the use of encryption and VPN to protect data and guarantee secure access. In addition, monitoring and maintenance routines are carried out to ensure that server performance remains optimal and that servers continue to operate properly [15].

Apache JMeter can be used in Web Server Streaming testing at the State Polytechnic of Malang to measure server latency and response time when serving streaming requests, measure throughput and bandwidth usage when a large number of users are accessing content simultaneously, perform stress testing to find out the maximum capacity of the server before a failure occurs, and test server performance with various load scenarios to ensure that the server is functioning properly. The Malang State Polytechnic can ensure that the Web Server Streaming they implement is able to provide high-quality services to students, lecturers, and campus staff even under high load conditions by using Apache JMeter [16].

Wireshark can inspect various layers of data packets, from Ethernet headers to application payloads. It provides an in-depth understanding of how data moves through the network and enables security analysis, performance optimization, and network problem recognition. The easy-to-understand graphical interface allows users to start and stop the data capture process, use filters to identify specific packets, and analyze complex data streams. For network administrators, security engineers, and network researchers, Wireshark is a very useful tool because it has features such as a hierarchical protocol view, protocol statistics, and the ability to follow TCP flows [17].

Wireshark supports many network and Internet protocols, such as Ethernet, Wi-Fi, Bluetooth, and Internet protocols such as TCP, UDP, HTTP, and FTP, among others. Additionally, Wireshark can work with other tools such as tshark, tcpdump, and editcap to provide more flexible and in-depth analysis.

Wireshark can be used to measure and analyze Quality of Service (QoS) parameters such as latency, packet loss, and jitter. By capturing and analyzing data packets sent and received by streaming servers, Wireshark can help find network bottlenecks, ensure that video data is transmitted properly, and find potential problems. Additionally, the tool is particularly beneficial for ensuring that security and encryption protocols are properly implemented to protect sensitive information during transmission. Therefore, Wireshark plays an important role in ensuring that the streaming service at the Malang State Polytechnic operates safely and with a high level of performance [18].

Linux armbian be platform Basic Operating System for Single Board Computer (SBC) which is made on one small PCB board. It is one of the distributions Linux Based Debian or Ubuntu light weight specifically for the development of SBCs with ARM processors. Distribution Linux lightweight debian-based for ARM development board users, operating system changes from the operating system Pulpstone become an operating system Linux armbian, carried out in stages starting from inserting the Linux armbian installation into the Memory MicroSD 32Gb which serves as a storage medium Linux armbian on the device Set Top Box HG680-P Next Installation Linux armbian into the device Set Top Box HG680-P that has been entered into Memory Micro SD 32Gb contains Files booting Linux armbian [19].

BalenaEtcher (Commonly referred to as 'Etcher') is a free and open-source utility used to write image files such as .iso and .img files, 20 as well as zip folders to storage media to create direct SD cards and USB flash drives. It was developed by Balena, and is licensed under the Apache License 2.0. Etcher was developed using the Electron framework and supports Windows, macOS and Linux. BalenaEtcher was originally named Etcher, but its name was changed on October 29, 2018 when Resin.io changed its name to Balena [20].

In computer networks, Quality of Service (QoS) is an idea and mechanism that aims to manage and ensure optimal performance for applications and services that require special priorities, such as video streaming, VoIP, and other real-time applications. QoS includes a variety of techniques for measuring, regulating, and improving various network parameters to provide an optimal user experience [21].

The main parameters set in QoS include latency, jitter, bandwidth, and packet loss. Latency is the time it takes for a data packet to move from source to destination, with low latency being critical for real-time applications. Jitter refers to variations in the arrival time of data packets, which can affect the quality of streaming services and voice communications. Bandwidth is the maximum capacity of a network to transfer data in a given period of time, where the right allocation of bandwidth ensures critical applications get enough priority. Packet loss occurs when one or more data packets fail to reach their destination, and QoS aims to minimize packet loss in order to maintain the integrity and quality of the transmitted data.

QoS implementation techniques include traffic management to control data flow, priority to give higher priority to certain types of traffic, resource reservations for network resource reservations, and traffic management to reduce network congestion. In various network environments, such as wireless networks, business networks, and internet services, QoS is essential. Quality of Service (QoS) in the Malang State Polytechnic streaming service ensures that video and audio content is presented in high quality without interruption, even when the network is busy. It supports the organization's goals in effective and efficient information dissemination.

II. METHOD

The research method "Implementation of the Malang State Polytechnic Streaming Web Server by Integrating ONT and STB" involves multiple stages: analysis, design, implementation, and evaluation. The process begins with a literature review to understand the concepts of Web Server

Streaming, ONT, and STB technologies, followed by a needs analysis to tailor streaming services to the academic requirements at the Malang State Polytechnic. A technological analysis evaluates the integration of ONT and STB with the streaming web server, focusing on compatibility and technical considerations. The research employs a quantitative approach, emphasizing network topology performance testing. System design encompasses network architecture, device integration, and user interface, followed by system implementation through the configuration of ONT, STB, and the streaming server. Trials and evaluations ensure system functionality, with data analysis assessing performance, integration effectiveness, and user responsiveness. The findings are compiled in a systematic report, providing conclusions, recommendations, and suggestions for future studies, aiming to enhance streaming services at the Malang State Polytechnic for improved academic information access.

A. Research Stages

The research stages in the Implementation of the Malang State Polytechnic Streaming Web Server by Integrating ONT and STB can be explained as follows:

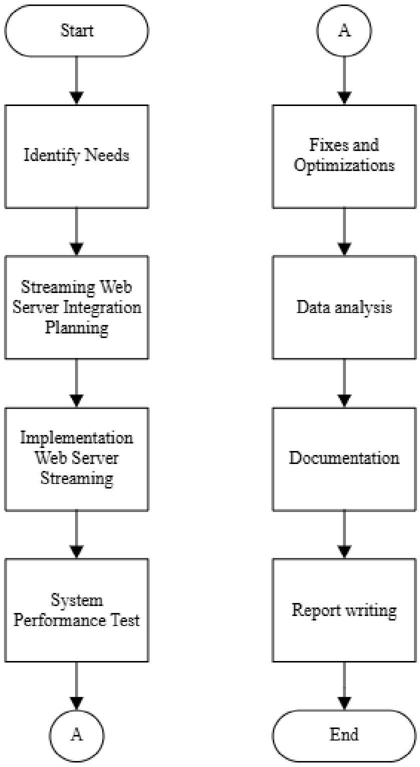

Figure 1. Research flowchart

In Fig. 1, The methodology for this research follows a structured approach to implement the Streaming Web Server with ONT and STB integration at the Malang State Polytechnic. The first step involves identifying the specific needs and requirements for the integration, which includes understanding the users' demands, network infrastructure, and project objectives. Following this, the planning stage is carried out, focusing on the creation of an implementation plan that encompasses technical configurations, software settings for the streaming server, and the setup of STBs. After the plan is approved, the next step is the implementation phase, where streaming server software is installed, STBs are configured, and necessary network infrastructure is set up to support multimedia streaming services. Once the system is implemented, a system performance test is conducted to measure access speed, system response, and the reliability of streaming services to ensure functionality. Based on the results and user feedback, improvements and optimizations are made to enhance system performance. Data analysis is then performed to evaluate the test results and answer research questions. Finally, comprehensive documentation of each stage, including the implementation, testing, user assessments, and optimizations, is compiled into a research report that presents the findings, conclusions, and recommendations for further development.

B. System Planning

The design of this system is divided into 2 sub-chapters, namely tool design, web server design.

1) Tool Design:

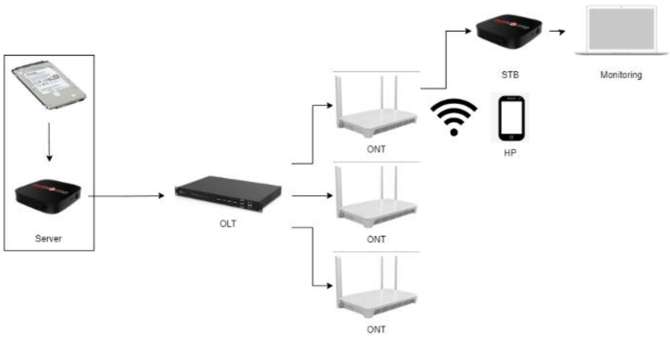

Figure 2. System diagram

In Fig. 2, the system is meticulously designed to integrate web server streaming services with Optical Network Terminals (ONT) and Set-Top Boxes (STBs) within the POLINEMA environment, creating a seamless multimedia delivery network. This network topology is structured with a server at its core, which is directly connected to an Optical Line Terminal (OLT). The OLT functions as a central hub, efficiently distributing the data stream to various ONTs, which are strategically placed on the user side to serve as gateways. These ONTs play a crucial role in converting high-speed optical signals into electrical signals that can be further processed by the connected STB.

Each ONT is linked to an STB, which acts as an intermediary device, bridging the gap between the network's optical backbone and the user's display equipment. The STBs are responsible for decoding the streaming content received from the ONTs and rendering it accessible on TVs or monitors. This setup ensures that users at Malang State Polytechnic can effortlessly access streaming content, with the STBs providing the necessary interface for multimedia playback.

This network topology emphasizes a robust and well-ordered connection among all components, from the server to the user's display. By focusing on excellent connectivity, efficient data routing, and a user-friendly interface, the design aims to optimize the streaming experience, ensuring that users receive high-quality, uninterrupted multimedia services. Each element, from the server to the end-user display, is carefully integrated to support a smooth and reliable web streaming environment, enhancing the overall user experience at POLINEMA.

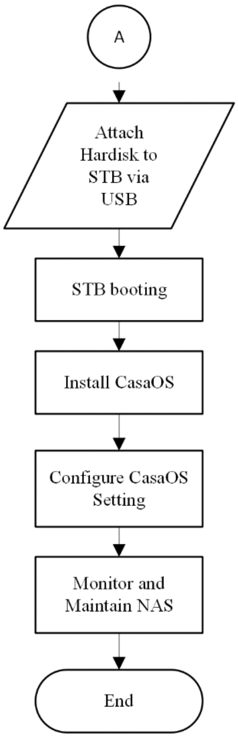

Figure 3. NAS design flowchart

In designing the system show in the Fig. 3, a detailed flowchart is created to illustrate the sequence of processes and algorithms involved in setting up a Network Attached Storage (NAS) using a Set-Top Box (STB) and a Hard Disk for storage, all managed through CasaOS. The workflow begins with the initialization process, where the entire system is prepared and configured to ensure all components are ready for operation. Following this, Linux firmware is carefully installed on an SD card, which is then used to boot the STB. The STB, which has been rooted to allow enhanced functionality, is configured to boot using the SD card containing the Linux firmware.

Once the STB is successfully booted, it transitions into functioning as a mini server, forming the core of the NAS setup. The Hard Disk serves a critical role as the main storage unit, designed to store various types of content that will be accessible through the streaming web server. After the STB is operational, CasaOS, a user-friendly platform for managing home servers, is installed on it. This installation allows users to access the NAS system conveniently through a web browser using the STB's assigned IP address. The comprehensive workflow ensures seamless integration of the STB and Hard Disk, facilitating efficient storage management and easy access to multimedia content via CasaOS.

2) Application Design:

The design of this Web server includes the installation of Apache, MariaDB, php in docker compose, CasaOS, and wireframes. Web servers are designed to facilitate the development of web applications and services with a focus on speed and efficiency.

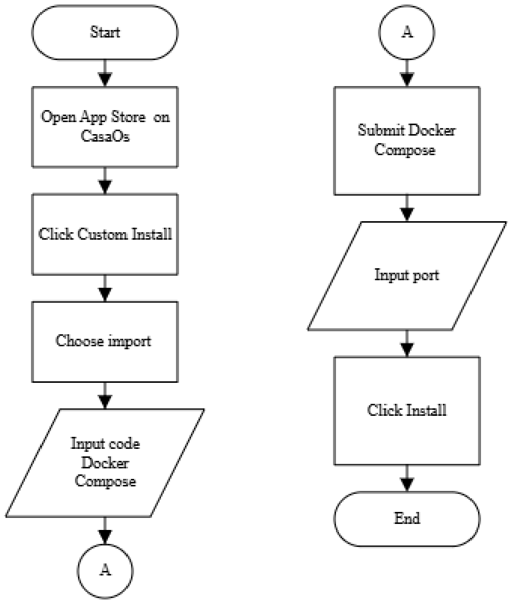

Figure 4. Flowchart web server installations

In Fig. 4 installation of Apache, MariaDB, php and the use of Docker Compose in CasaOS are some of the important steps in the design of this web server. The use of Docker Compose in CasaOS facilitates more efficient management of the various services required by this web server. With Docker Compose, setting up and managing containers for Apache, MariaDB, php can be easy, which increases speed and efficiency in web application and web application development.

Installing Apache as a web server makes it easy to set up and host web applications with high performance and stability. Meanwhile, MariaDB is used as a reliable relational database management system, which offers effective support for data storage and retrieval. PHP, as a server-side scripting language, allows for the creation of interactive and dynamic web applications. It works to process the data sent from the client, interact with the database, and generate dynamic HTML content to display in the browser.

Based on Fig. 5, the Data Flow Diagram (DFD) Level 0 for the information web illustrates the flow of data between external entities and the system. The primary entities are Users and Admins (if necessary). Users interact with the system to access information on Study Programs, Research, Academics, and News. They send requests, and the system processes these to deliver relevant results. Admins, when included, manage the system's content.

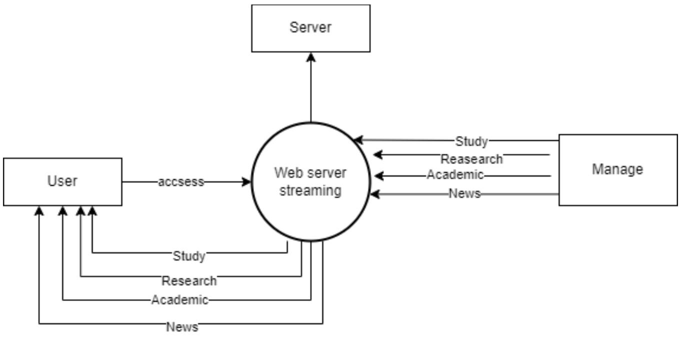

Figure 5. DFD planning level 0

The system comprises four main subprocesses: Manage Study Programs, Manage Research, Manage Academics, and Manage News. Each subprocess handles specific content areas, such as details about study programs, research projects, academic schedules, and institutional news. The Level 0 DFD outlines how the system processes user requests by accessing and delivering appropriate data, providing a clear and structured view of the system's data flow, aiding developers and stakeholders in understanding its workflow.

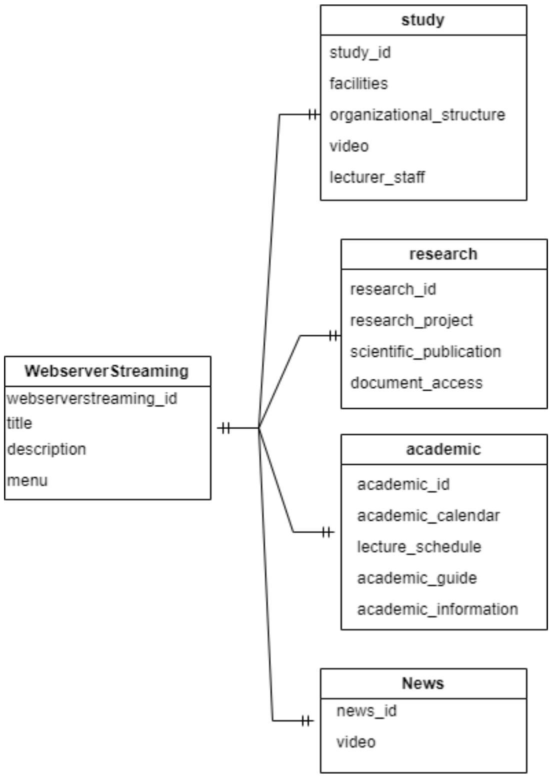

Figure 6. Entity-Relationship Diagram (ERD)

In the Fig. 6, the Entity-Relationship Diagram (ERD) focuses on the Content entity, which centralizes the management of various types of campus information, such as Study Programs, Research, Academic details, and News. This central entity stores essential data like titles, descriptions, content types, and timestamps for creation and updates, streamlining data management and searchability.

Content is linked to four main entities: Prodi, Research, Academic, and News, each handling specific details within its category. Prodi manages facilities, organizational structures, videos, and staff lists. Research covers projects, publications, and documents. Academic includes the academic calendar, schedules, and guides. News organizes campus-related updates and videos.

The one-to-many relationship between Content and these entities ensures centralized and flexible content management, making the system structured, organized, and easier to maintain. This setup enhances the efficiency of adding, updating, and deleting content while keeping all information interconnected.

C. *System Implementation*

The implementation of NAS Tools and Configuration includes booting on the STB using an SD Card that has been flipped in the linux armbian firmware, installing CasaOS and configuring the hard disk to increase the storage capacity on the NAS.

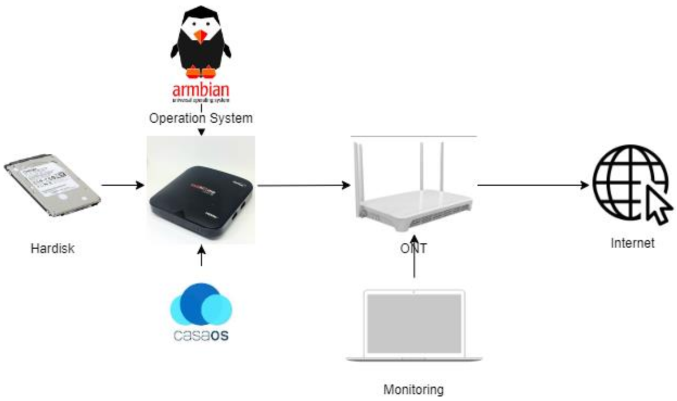

Figure 7. NAS diagram block

III. RESULTS AND DISCUSSION

This chapter discusses the results of hardware and software build and testing implementations, which include activities, application functionality testing, and database management on the CasaOS platform.

A. *System Design Result*

The figure showcases the successful integration of a NAS (Network-Attached Storage) system utilizing an STB (Set-Top Box) and a Hard Disk, all components working harmoniously to deliver efficient data storage and access. The system is powered by a 12V DC adapter port, which serves as the main voltage source, ensuring a steady supply of electricity to all parts of the setup. The Ethernet port on the STB is a vital component, providing internet connectivity that allows the STB to communicate with the network, facilitating smooth data transfer and streaming services.

Additionally, the USB port plays a crucial role by linking the Hard Disk to the STB, creating a reliable storage solution where various content can be saved and accessed easily. This connection transforms the STB into a functional mini-server, capable of handling data requests efficiently. The SD card slot is another essential feature, accommodating an SD card that contains the new firmware necessary for booting the STB. This firmware upgrade enhances the STB's capabilities, optimizing it for use as part of the NAS system. Each component's integration ensures the system operates seamlessly, offering a robust and flexible storage solution tailored to meet diverse user needs.

Figure 8. NAS

In Fig. 8 integrated Network-Attached Storage (NAS) interface interface with CasaOS and Set-Top Box (STB) shows a combination of software and hardware for storage management. The system dashboard displays a summary of the status such as storage usage, hardware health, and network statistics. The list of connected devices also shows the STBs and additional hard drives that have been configured.

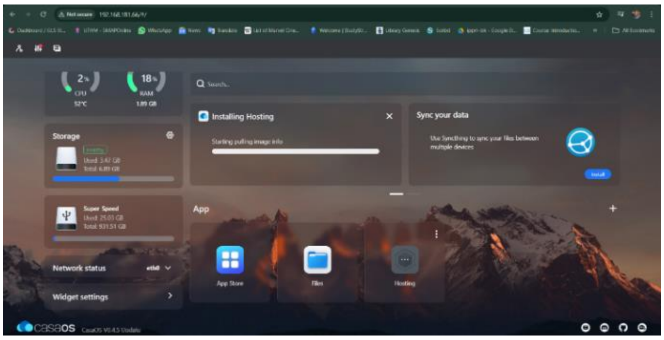

Figure 9. CasaOS display with pre-configured storage

Here is a look at the website as show on Fig.9 that has been successfully hosted on CasaOS. To access the website, use the IP address and port that has been configured for the webserver.

Figure 10. Website Display

B. *Service Quality Management (QoS) Analysis*

In this section, will discuss the results of Quality of Service (QoS) testing conducted with a focus on the integration of Optical Network Terminal (ONT) and Set-Top Box (STB) in service quality management. This test aims to evaluate the overall network performance, especially in ensuring optimal performance in supporting streaming services and information dissemination in the Malang State Polytechnic campus environment. The QoS parameters analyzed include delay, jitter, throughput, and packet loss, which are observed under various service usage conditions.

TABLE I
DELAY TESTING

	Experiment 1	**Experiment 2**	**Experiment 3**	**Average**
NAS	0.596ms	1,273ms	0.873ms	0,914ms
AH Building	2,647ms	3,098ms	1,305ms	2,35ms
AI Building	1,585ms	0.943ms	2,174ms	1,567ms

The network performance test at three locations—NAS, AH Building, and AI Building—revealed variations in delay values. NAS demonstrated the best performance with an average delay of 0.914ms, indicating a highly stable and low-latency connection, ideal for campus information and streaming services. The AH Building showed a higher delay of 2.35ms on average, with peaks reaching 3.098ms, suggesting potential network congestion or load issues that may require optimization. The AI Building performed better than the AH Building, also with an average delay of 2.35ms, though slightly higher than NAS This shows that while the network in the AI Building is working quite well, there is a potential improvement to reduce latency further. Overall, NAS has the best performance, followed by AI Building, and AH Building with the highest latency, which may require upgrades to its network infrastructure.

TABLE II
PACKET LOSS TESTING

	Experiment 1	**Experiment 2**	**Experiment 3**	**Average**
NAS Values	3,11%	2,15%	1,98%	2,15%
AH Building	0,43%	1,03%	0,74%	0,73%
AI Building	0,55%	0,98%	1,25%	0,55%

Packet loss testing at NAS, AH Building, and AI Building revealed different levels of network efficiency in transmitting data without loss. NAS recorded the highest packet loss at 2.15%, suggesting potential network congestion or high traffic load despite its low latency. In contrast, the AH Building had a much lower packet loss of 0.73%, indicating better data integrity despite higher latency. The AI Building showed a packet loss of 0.55%, slightly higher than the AH Building but still significantly lower than NAS. This high performance shows that the network infrastructure in the AI Building is more optimal, making it the location with the highest throughput capacity among the three locations tested.

TABLE III
THROUGHPUT TESTING

	Experiment 1	Experiment 2	Experiment 3	Average
NAS Values	285,510.08 Kbps	145,510.07 Kbps	354,890.167 Kbps	261970 Kbps
AH Building	465,122.131 Kbps	276,185.63 Kbps	478,532.762 Kbps	406613,508 Kbps
AI Building	911,661.514 Kbps	1,004,982.024 Kbps	732,521.09 Kbps	883054,876 Kbps

Throughput testing at NAS, AH Building, and AI Building revealed significant variations in data transmission speed. NAS recorded the lowest average throughput at 261970 Kbps, likely due to hardware or network capacity limitations, despite its low latency. The AH Building showed a higher throughput of 406613.508 Kbps, indicating better data handling despite higher latency. The AI Building achieved the highest throughput at 883054.876 Kbps, demonstrating superior network capacity and efficiency. Overall, the AI Building had the best data transmission performance, while NAS exhibited the lowest throughput, requiring potential network improvements.

C. Load Balancing Analysis

In this test, load balancing will be tested using Apache JMeter to simulate several simultaneous users accessing various menus on the web server simultaneously. This simulation involves variations in the number of users, ranging from 10, 20, 50, to 100 users simultaneously. This user load simulation configuration, which includes setting the number of threads (virtual users), test duration, and workload distribution to several STB. These settings are made to ensure that the test scenario reflects the actual conditions of web server usage. In addition, other parameters, such as access time intervals and variations in user access patterns, are also adjusted to evaluate the effectiveness of load balancing in situations with dynamic workloads.

1) 10 Users:

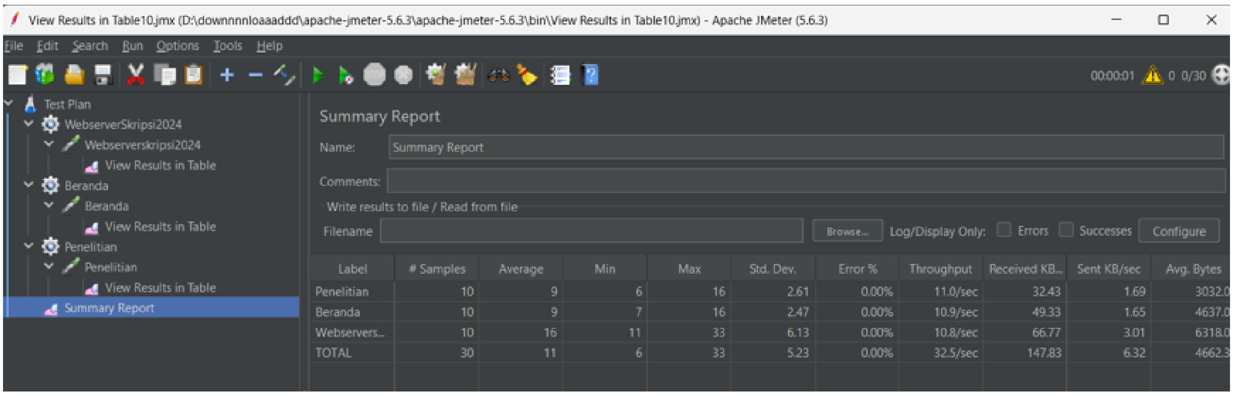

Figure 11. Summary report 10 users

Load balancing tests on the web server showed efficient load distribution without errors. Performance testing with ten users revealed that the Research and Home pages completed requests in an average of 9 seconds, with throughputs of 11.0 and 10.9 requests per second, respectively, indicating stable performance. The WebserverSkripsi2024 page had a longer response time of 16 seconds but maintained a high throughput of 10.8 requests per second. Overall, the server demonstrated reliability, stability, and effective load handling under high-demand conditions as shown in Fig. 11.

2) 20 Users:

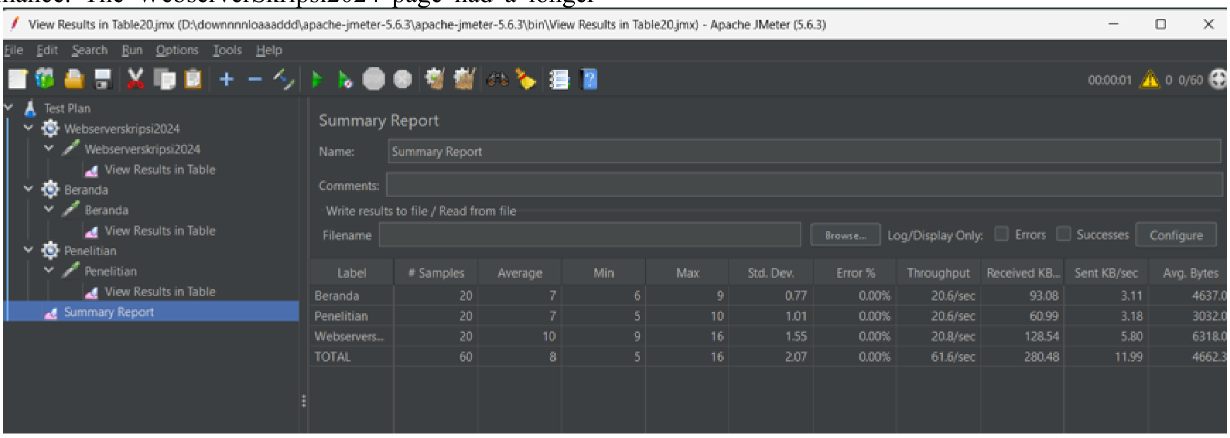

Figure 12 Sumary Report 20 Users

In Fig. 12 Load balancing tests with 20 users confirmed the web server's efficiency in handling increased traffic without errors. The Research and Home pages processed requests in 7 seconds with a throughput of 20.6 requests per second, demonstrating stability under higher loads. The WebserverSkripsi2024 page had a slightly longer response time of 10 seconds, likely due to its complexity, but maintained a high throughput of 20.8 requests per second. Overall, the server successfully handled increased user demand while maintaining stability, reliability, and efficient load distribution.

3) 50 Users:

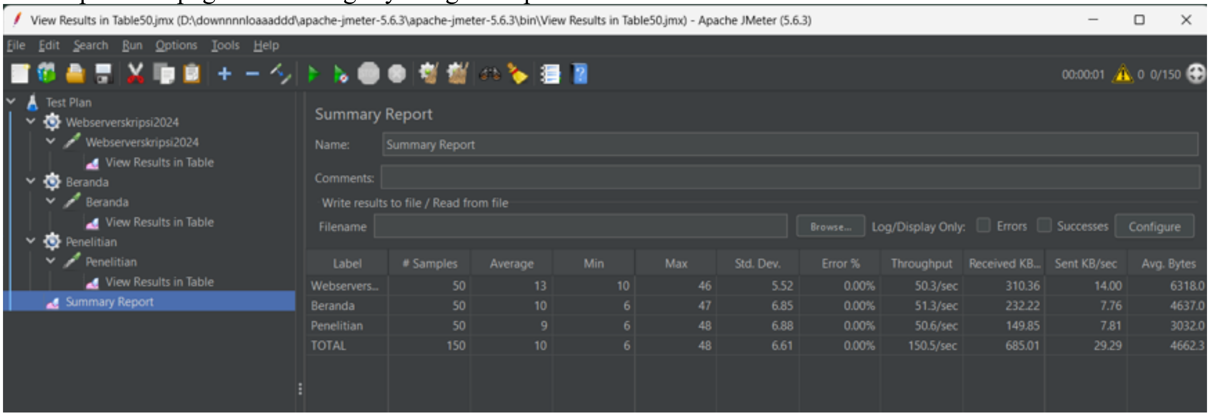

Figure 13. Summary report 50 users

Load balancing tests with 50 users confirmed the web server's ability to handle a significantly higher load while maintaining stability and performance. The Research page processed requests in 9 seconds with a throughput of 50.6 requests per second, showing high efficiency. The Home page had a slightly longer response time of 10 seconds but achieved an even higher throughput of 51.3 requests per second. The WebserverSkripsi2024 page, being more complex, had a response time of 13 seconds but maintained a strong throughput of 50.3 requests per second. No errors were recorded, proving the system's reliability. Overall, the server demonstrated the capacity to handle heavy user loads without sacrificing service quality, with variations in response time due to differences in page complexity as shown in Fig. 13.

4) 100 Users:

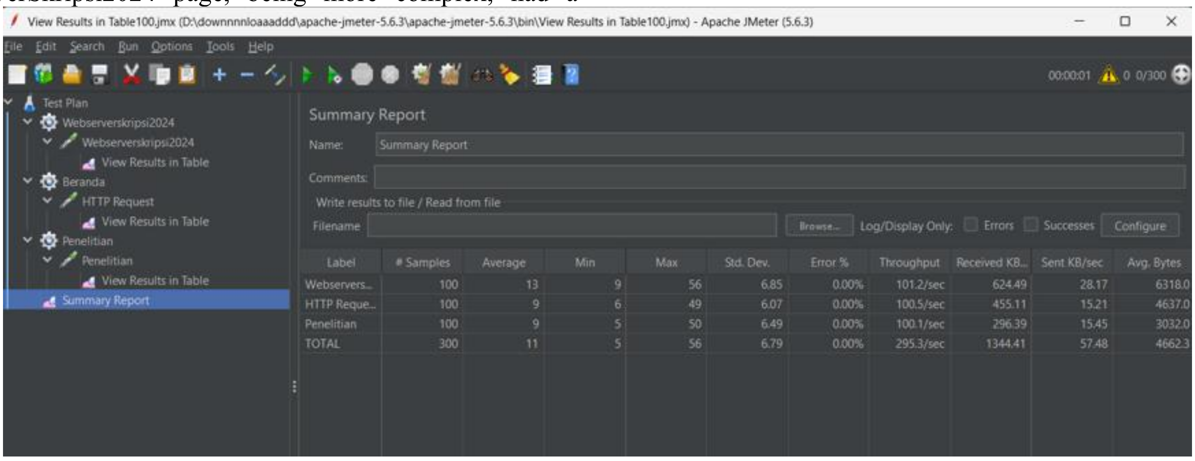

Figure 14. Summary report 100 users

Load balancing tests with 100 users confirmed that the web server maintains stable and efficient performance under high loads. The Research page processed requests in 9 seconds with a throughput of 100.1 requests per second, demonstrating excellent efficiency. The Home page had a similar response time of 9 seconds but achieved a slightly higher throughput of 100.5 requests per second. The WebserverSkripsi2024 page, due to its complexity, had a longer response time of 13 seconds but still maintained a strong throughput of 101.2 requests per second. No errors were recorded during the tests, indicating high system reliability. Overall, the results confirm that the server can handle heavy loads effectively, with variations in response time attributed to page complexity rather than system limitations.

IV. CONCLUSION

Based on the research that has been carried out in "Implementation of Polinema Streaming Web Server by Integrating ONT and STB", the following conclusions are obtained:The results of testing the streaming server web system at the Malang State Polytechnic show excellent performance. QoS testing shows that NAS, AH Building, and AI Building have their own strengths and weaknesses in terms of delay, packet loss, and throughput. NAS offers very low latency but faces problems with high packet loss. The AH Building has more stable latency and packet loss, but its throughput is still inferior to the AI Building. The AI building shows the best performance in throughput and still maintains a relatively low packet loss rate, but with higher latency than NAS. To improve the overall quality of service, the focus should be on reducing packet loss in the NAS and optimizing latency and throughput in the AH Building. The integration of Optical Network Terminal (ONT) and Set-Top Box (STB) is proven to improve the quality of streaming services by optimizing response times, bandwidth usage, and reducing packet loss rates. The load balancing system implemented is also effective in distributing the workload evenly among multiple STB, ensuring that simultaneous users can be served without significant performance degradation. Testing with 10, 20, 50, and 100 users showed that the tested web server has excellent stability and reliability, with 0% errors in all scenarios. Response time remained consistent in the 7 to 13 seconds range, even as the number of users increased, while throughput increased proportionally, reaching more than 100 requests per second at 100 users. This server has proven to be efficient in handling high loads and has good scalability, making it a reliable choice for more extensive operational needs in the future.

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