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Simulation of Web-Based Fiber Optic Network Monitoring Development for Optimizing Infrastructure Maintenance

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Abstract

The rapid expansion of fiber optic networks has increased the complexity of infrastructure management, particularly in joint closure documentation, core configuration, and connection quality monitoring. Manual management and fragmented documentation often lead to inconsistent data, limited traceability, and inefficient maintenance processes. This study aims to develop a web-based fiber optic network management system that integrates asset documentation, core structure visualization, attenuation history recording, location documentation, and reporting into a unified platform. The system was developed using the Software Development Life Cycle (SDLC) with the Waterfall model, including requirement analysis, system design, implementation, and testing. The developed system successfully manages joint closure data, visualizes a 192-core structure, records attenuation measurement history, tracks user activities, and generates digital reports. Functional testing confirmed that all major features performed according to the specified requirements. The integrated system enhances documentation accuracy, accelerates network condition identification, improves maintenance efficiency, and provides an effective solution for comprehensive fiber optic infrastructure management.
Keywords: *Fiber Optics; Network Management; Joint Closure; Web-Based System; Core Visualization.*

Abstrak

Perkembangan jaringan fiber optik yang semakin pesat meningkatkan kompleksitas pengelolaan infrastruktur, khususnya dalam dokumentasi joint closure, konfigurasi core, dan pemantauan kualitas sambungan. Pengelolaan yang masih dilakukan secara manual atau menggunakan dokumen terpisah menyebabkan informasi sulit ditelusuri, berpotensi menimbulkan inkonsistensi data, serta menghambat proses pemeliharaan jaringan. Penelitian ini bertujuan mengembangkan sistem manajemen jaringan fiber optik berbasis web yang mampu mengintegrasikan dokumentasi aset, visualisasi struktur core, pencatatan riwayat redaman (attenuation), dokumentasi lokasi, dan pelaporan dalam satu platform. Sistem dikembangkan menggunakan metode Software Development Life Cycle (SDLC) yang meliputi analisis kebutuhan, perancangan, implementasi, dan pengujian. Hasil penelitian menunjukkan bahwa sistem mampu mengelola data joint closure, menampilkan visualisasi struktur 192 core, menyimpan riwayat pengukuran redaman, merekam aktivitas pengguna, serta menghasilkan laporan digital. Pengujian fungsional menunjukkan seluruh fitur utama berjalan sesuai kebutuhan. Integrasi seluruh fungsi tersebut meningkatkan akurasi dokumentasi, mempercepat identifikasi kondisi jaringan, serta mendukung proses pemeliharaan infrastruktur fiber optik secara lebih efektif dan efisien.
Kata Kunci: *fiber optik; manajemen jaringan; joint closure; sistem berbasis web; visualisasi core*

1. Introduction

Fiber optic networks have become the backbone of modern telecommunications infrastructure because they can provide high transmission capacity, low latency, and greater resistance to electromagnetic interference compared to copper-based transmission media [1]. The growth of digital services, such as cloud computing, the Internet of Things (IoT), Artificial Intelligence, data centers, high-resolution video services, and the implementation of 5G networks, has significantly driven the growth of data traffic. This condition has been accompanied by the expansion of backbone networks and Fiber to the Home (FTTH), so that the amount of fiber optic infrastructure that must be managed keeps increasing [2], [3]. As network scale increases, the need for an accurate, well-documented, and easily accessible infrastructure management system is becoming increasingly important to maintain the reliability of telecommunications services.

One important component of this infrastructure is the fiber optic closure or joint closure, a passive device that functions as a point of connection, distribution, and protection for fiber optic splices [4]. Each joint closure can hold hundreds of cores, grouped into several tubes, so that any change in splice configuration must be consistently documented. Outdated documentation can cause core identification errors, increase Mean Time to Repair (MTTR), and slow down the maintenance and troubleshooting process. In addition, poorly documented attenuation measurement history makes it difficult for technicians to detect early declines in network quality [4], [5].

Various studies have developed Network Management Systems (NMS) to improve the efficiency of telecommunications network management. These approaches generally utilize protocols such as Simple Network Management Protocol (SNMP), NETCONF, and YANG for device configuration, performance monitoring, and fault detection on active devices such as routers, switches, and Optical Line Terminals (OLT) [6]. This concept has been implemented on various commercial network management platforms, such as Cisco Prime Infrastructure, which provides centralized monitoring of network devices [7]. In fiber optic access networks, monitoring OLT conditions is also an important factor in maintaining service quality and network continuity [7].

This challenge becomes even greater in large-scale fiber optic networks, because the continuously growing number of assets requires consistent, easily traceable, and constantly updated documentation so that operation and maintenance processes can be carried out efficiently **[8], [9].**

However, most existing studies still focus on specific aspects and have not been able to fully support fiber optic infrastructure management. NMS systems tend to focus more on monitoring active devices **[10]**, while asset documentation applications generally function only as data repositories. Integration between joint closure documentation, core structure visualization, attenuation measurement history, location documentation, field photo documentation, and user activity history (audit trail) is still rarely available in a single, unified platform. As a result, technicians still have to access several different applications or documents during the operation and maintenance process, which increases the potential for data inconsistency and slows down the decision-making process **[11]**.

Based on this condition, there is still a need for a fiber optic network management system capable of integrating asset documentation, core structure visualization, attenuation measurement history, location information, and digital reporting into a single web-based application. This integration is expected to improve documentation consistency, speed up the identification of network conditions, support the tracing of configuration change history, and help technicians carry out infrastructure operation and maintenance more effectively.

This study develops a web-based fiber optic network management system that integrates joint closure management, visualization of the 192-core structure, location documentation based on geographic coordinates, attenuation history recording, field photo documentation, an audit trail, and digital reporting in a single platform. Unlike previous studies, which generally focus only on asset documentation or active device monitoring, the proposed system combines physical documentation with operational information, thereby providing more comprehensive information to support fiber optic infrastructure management.

Based on the above description, this study aims to develop and evaluate a web-based fiber optic network management system capable of integrating joint closure documentation, core structure visualization, attenuation measurement history, location documentation, and digital reporting. The evaluation is carried out through functional testing to assess the system's ability to support fiber optic infrastructure documentation and maintenance processes more effectively and in an integrated manner.

2. Method

This study uses the Software Development Life Cycle (SDLC) method with the Waterfall model to develop a web-based fiber optic network management system. The Waterfall model was chosen because the system requirements had been identified from the outset, allowing each stage to be carried out sequentially, with the output of each stage serving as input for the next. The research flow consists of four stages: Requirement Analysis, System Design, System Implementation, and System Testing, as shown in **Figure 1.**

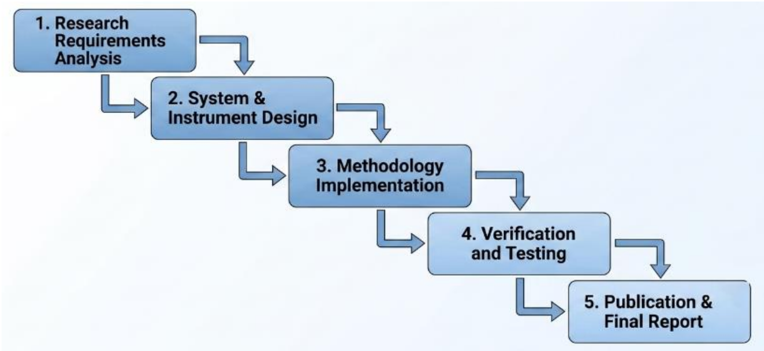

Figure 1. Research stages using the Waterfall model

2.1 Requirement Analysis

The requirement analysis stage aims to identify user needs and system specifications based on a literature study, observation of the fiber optic network documentation process, and identification of the needs of technicians involved in network operation and maintenance.

The analysis results show that joint closure documentation, core configuration, attenuation measurement history, and location information are still managed using separate documents, which often causes data inconsistency and slows down the information retrieval process. Based on these findings, the system was designed to meet the following functional requirements:

1. user authentication and authorization
2. joint closure data management
3. geographic coordinate-based location management
4. visualization of the 192-core structure
5. management of the configuration and status of each core
6. report generation in Microsoft Excel and PDF format

In addition to functional requirements, the system was designed to meet non-functional requirements, including access security using JSON Web Token (JWT) [12], data communication via REST API, an easy-to-use web-based interface, and compatibility with modern browsers.

2.2 System Design

The design stage aims to translate the system requirements into an application architecture design, a user interaction model, and a database structure so that the system is easy to develop and maintain.

2.2.1 System Architecture

The system uses a three-tier architecture consisting of a presentation layer, application layer, and data layer. This approach separates the user interface, business logic, and data management, thereby making the application easier to develop and maintain **[13]**. The user interface was developed using React , while the application service was built using Flask **[14], [15]**. Communication between the frontend and backend follows RESTful Web Services principles, exchanging data in JSON format. All data is stored in a relational SQLite database, while user authentication uses JSON Web Token (JWT). The system architecture is shown in **Figure 2**.

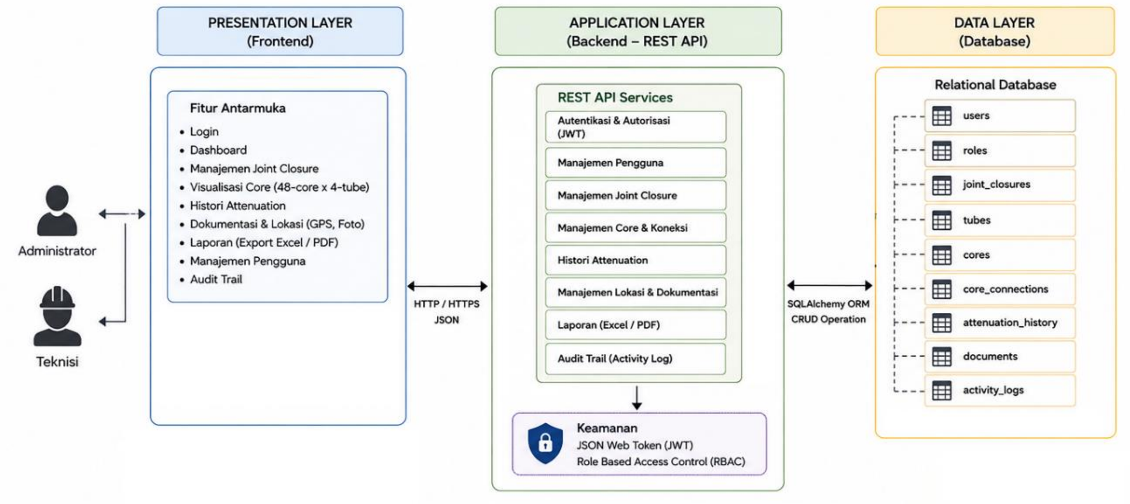

Figure 2. Fiber Optic Network Management System Architecture

2.2.2 Use Case Diagram

The Use Case Diagram is used to illustrate the interaction between users and the system. The system has two actors: Administrator and Technician. The Administrator has access rights to all system functions, including user management, joint closures, attenuation history, reporting, and the activity log. The Technician is responsible for managing joint closure data, updating core configurations, recording attenuation measurement results, uploading field documentation, and viewing reports according to the assigned access rights. The use case diagram is shown in **Figure 3.**

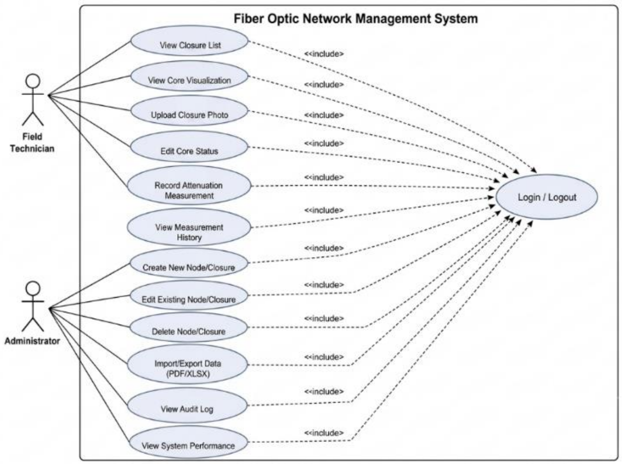

Figure 3. System Use Case Diagram

2.2.3 Database Design

The database was designed using a relational model to maintain data integrity and consistency. The main entities consist of User, Joint Closure, Core Connection, Attenuation History, and Activity Log. The relationships between entities are illustrated using an Entity Relationship Diagram (ERD) in **Figure 4.**

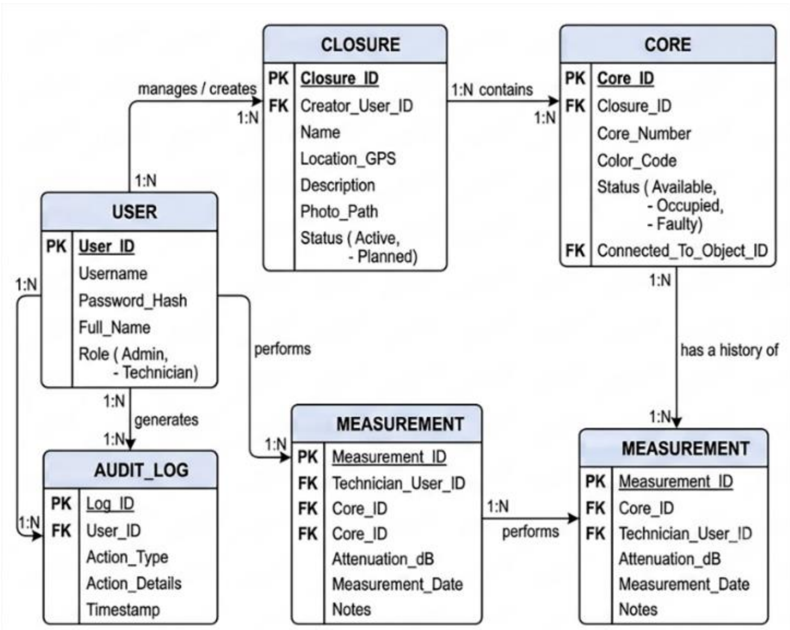

Figure 4. System Entity Relationship Diagram

2.3 System Implementation

System implementation follows modern web application development principles that support the separation of the user interface and application services, making the system easier to develop and maintain on an ongoing basis **[13]**.

The implementation stage was carried out by building the web-based application according to the system design. The backend was developed using Python Flask, while the user interface was built using React. All application functions are accessed through REST API services. The implemented modules include user authentication, joint closure management, visualization of the 192-core structure, attenuation history recording, GPS-based location documentation, field photo documentation, user management, activity logging, and report export in Microsoft Excel and PDF formats.

2.4 System Testing

Testing was carried out using the Black-box Testing method **[16]** to evaluate the conformity of the system's functions with the established requirements. The test scenarios include user authentication, joint closure management, core management, structure visualization of the core, attenuation history, user management, activity log, and report export. In addition to functional testing, integration testing was carried out to ensure that communication between the frontend, backend, and database runs properly. The testing includes JWT authentication validation, REST API services, database data integrity, and consistency of data exchange in JSON format.

3. Results and Discussion

This section presents the implementation results of the web-based fiber optic network management system along with the discussion. The presentation of results follows the research stages described in the method section, namely system implementation and functional testing. The results are then analyzed to evaluate the system's contribution to fiber optic infrastructure management.

3.1 Results

3.1.1 System Implementation

The research result is a web-based application that integrates joint closure documentation, core structure visualization, attenuation measurement history, location documentation, and reporting into a single platform. The system was developed using a client-server architecture, so that the user interface, application services, and database can work in an integrated manner through the REST API. As the central hub for information management, the system provides a dashboard page that displays a summary of network conditions, the number of joint closures, the number of users, and the latest activities. This information provides an overview of the infrastructure condition so that administrators can carry out monitoring more efficiently. The dashboard display is shown in **Figure 5**.

3.1.1 System Dashboard

The system provides a joint closure management module to document asset identity, installation location, geographic coordinates, description, and field photo documentation. Through this module, all infrastructure data is stored centrally, making it easier to search for and update information. The joint closure management interface is shown in **Figure 5.**

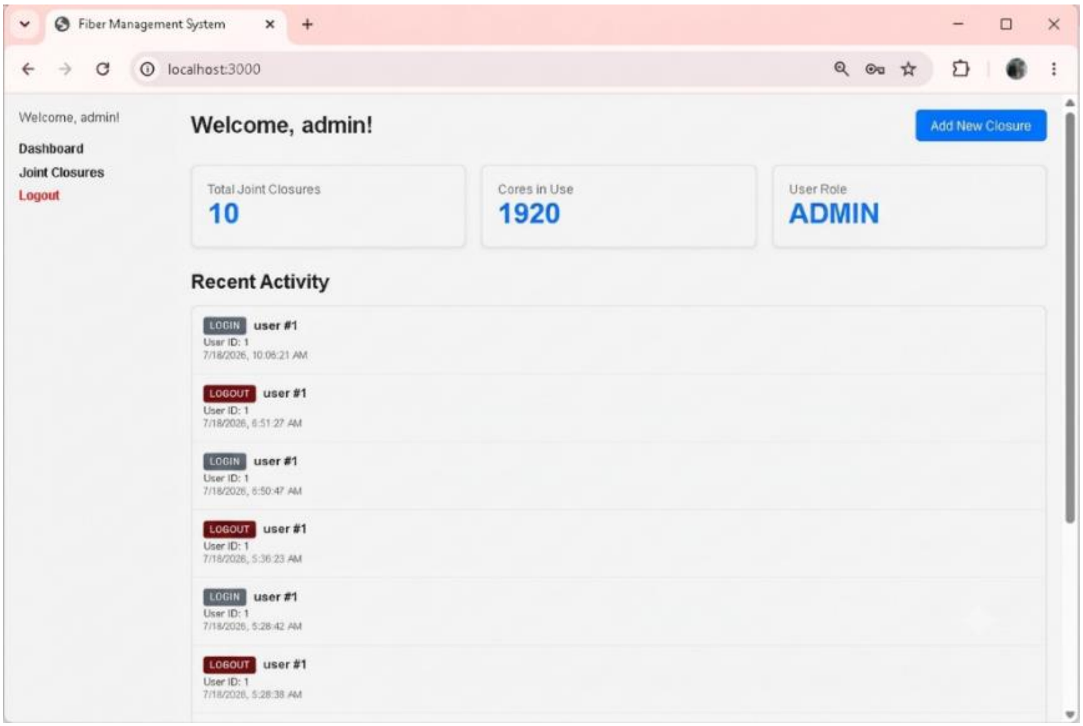

Figure 5. System Dashboard

3.1.2 Adding Joint Closure Data

The process of adding joint closure data is carried out through a form designed to make it easier for technicians to fully document fiber optic infrastructure information. This form provides several key attributes: closure name, installation address or location, geographic coordinates, additional description, and field photo documentation. The data entry interface is shown in **Figure 6.**

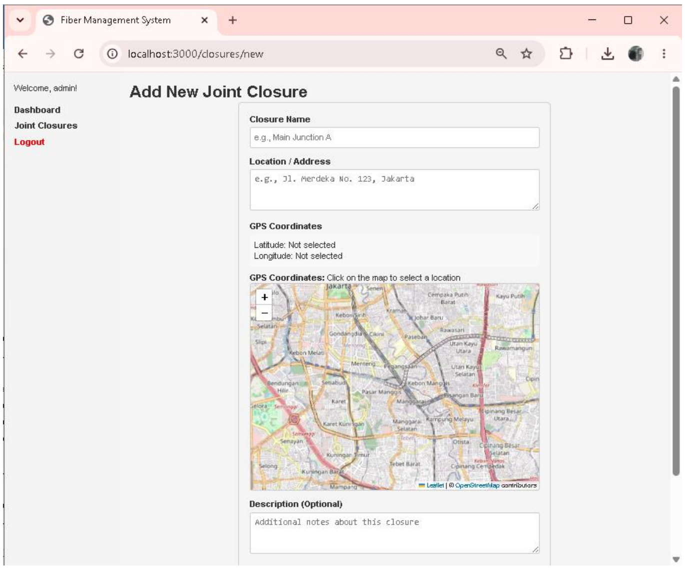

Figure 6. Joint Closure Data Entry Page

3.1.3 Joint Closure Management

The Joint Closure module is used to add, edit, delete, and search closure data. Each record contains closure identity information, geographic coordinates, location address, description, and photo documentation, as shown in **Figure 7.**

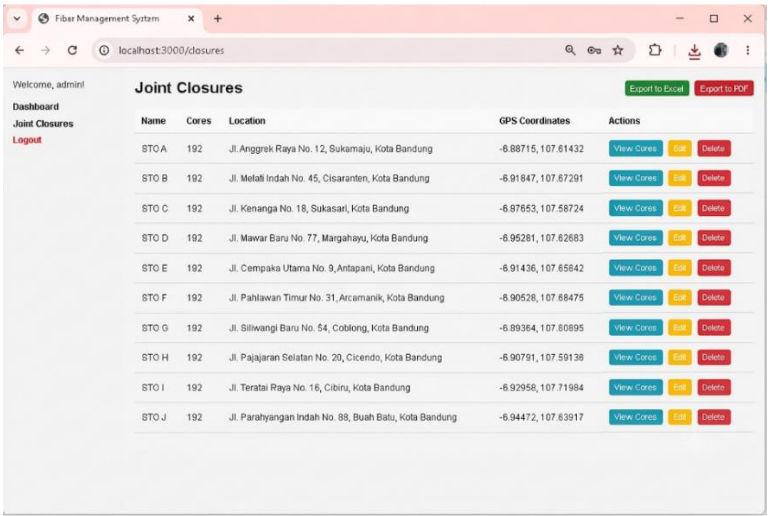

Figure 7. Joint Closure Management Page

3.1.4 Core Structure Visualization

One of the main results of this research is the development of a core structure visualization based on the physical layout of the joint closure. The system represents four tubes, each consisting of 48 cores, so it can display up to 192 fiber cores per closure.

The core structure visualization in this study applies information visualization principles that make it easier for users to understand the relationships between objects through graphical representation, thereby speeding up the network configuration identification process **[17].**

Interactive visualization implementations can also be developed using a data-driven, model-based visualization approach [17]. This visual representation is shown in Figure 8.

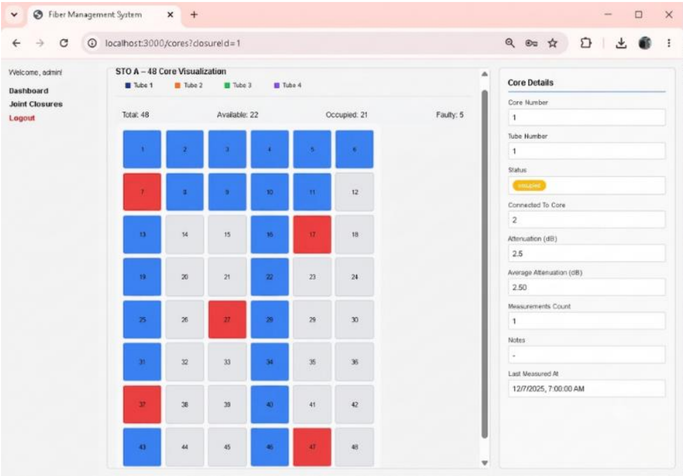

Figure 8. 48-Core × 4-Tube Visualization

3.1.5 Reporting

The system provides a facility for exporting data to Microsoft Excel and PDF formats. This feature makes it easier for administrators to generate documentation reports and data recapitulations that can be used for archiving or evaluation purposes, as shown in Figure 9.

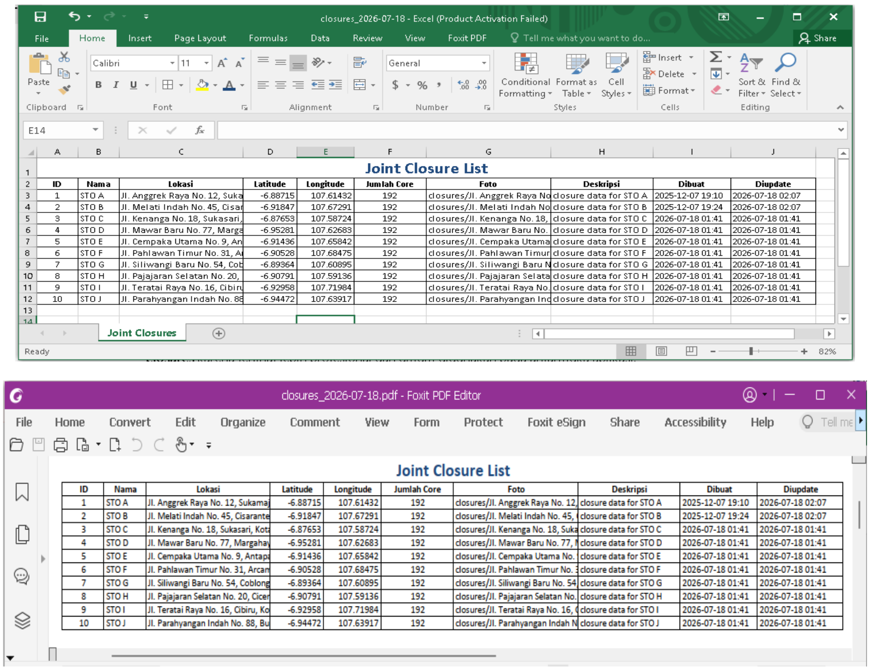

Figure 9. Excel and PDF Export

With the availability of automatic reporting facilities, the report preparation process becomes faster compared to manually preparing reports using a spreadsheet.

3.1.6 System Testing Results

Testing was carried out using the Black-box Testing method on all the system's main functions. The test scenarios include user authentication, joint closure management, core management, core visualization, attenuation history, activity log, and report export. The test results for each module are summarized in **Table 1.**

Table 1. Black-box Testing Results

Module	Test Scenario	Expected Result	Test Result	Status
Login	User logs in with a valid username and password	The system successfully authenticates and displays the dashboard page	The dashboard is successfully displayed after successful authentication	Success
User Management	Adding, editing, deleting, and displaying user data	All user CRUD operations can be performed according to access rights	All CRUD operations run properly	Success
Joint Closure	Adding, editing, deleting, and displaying *joint closure*	Data *joint closure* is correctly stored, updated, deleted, and displayed	All CRUD operations run according to specification	Success
Core Management	Managing the data of each *core* in *joint closure*	Data *core* can be added, edited, deleted, and displayed	All *core* management functions run properly	Success
Core Visualization	Displaying the 48-*core* × 4-*tube* (192 *core*)	The system displays visualization of all *core* according to the *joint closure*	Visualization of the 192 *core* is displayed correctly	Success
Attenuation History	Adding and updating attenuation measurement data	Historical data is stored and displayed according to measurement time sequence	Attenuation history is successfully stored and displayed	Success
Activity Log	Recording user activity for every data change	All user activity is automatically recorded	User activity is successfully recorded in the *activity log*	Success
Export Excel	Exporting data to Microsoft Excel format	The system generates an Excel file according to the selected data	The Excel file is successfully generated and can be downloaded	Success
Export PDF	Exporting the report to PDF format	The system generates a PDF report according to the selected data	The PDF file is successfully generated and can be downloaded	Success
REST API	Sending and receiving data in JSON format	All REST API endpoints respond according to specification	All endpoints function properly and return correct responses	Success

Based on **Table 1**, all main functions were successfully executed according to the system requirements. All Create, Read, Update, and Delete (CRUD) operations could be performed without any functional failures found during the testing process. In addition, integration testing showed that communication between the frontend, backend, and database was consistent, so that all REST API services could be used properly.

3.2 Discussion

The implementation results show that the system is able to integrate asset documentation, core structure visualization, attenuation measurement history, location documentation, and reporting into a single platform. This integration reduces the use of separate documents, thereby improving data consistency and making it easier to trace information during network operation and maintenance.

The visualization of the 192-core structure is one of the main contributions of this study because it presents the splice configuration according to the physical representation of the joint closure. Compared to presentation in table form, the visual approach makes it easier to identify core positions and reduces the potential for errors during the maintenance process. This finding is in line with studies showing that information visualization can increase the speed of data interpretation and support decision-making in information systems [18].

The integration of attenuation measurement history provides the ability to continuously trace changes in network quality. This historical documentation supports a more proactive maintenance process, since changes in network characteristics can be identified before they develop into disruptions that affect service. This approach is also in line with the development of data-based maintenance systems in telecommunications infrastructure [10].

The implementation of the audit trail increases the accountability of data management because every configuration change is automatically documented. In addition to supporting the evaluation process, this mechanism makes it easier to trace the history of changes when the system is used by many technicians simultaneously.

Compared to previous studies, which generally focus on monitoring active devices or asset documentation separately, this study offers an integration of physical documentation, core visualization, attenuation history, location documentation, and reporting within a single application. This integration extends the system's function from mere data storage to a tool that supports decision-making in network operation and maintenance activities.

The digitalization of asset documentation, as implemented in this study, supports the transformation of telecommunications infrastructure management toward a more documented, collaborative, and efficient process, thereby facilitating decision-making in operation and maintenance activities **[19].** Future development can be directed toward the use of a more scalable database, integration with GIS, direct integration with OTDR devices, and the application of artificial-intelligence-based analytics to support predictive maintenance, as has been widely applied in modern network management **[8], [20]**.

4. Conclusion

This study has successfully developed a web-based fiber optic network management system that integrates joint closure documentation, core structure visualization, attenuation measurement history, location documentation, an audit trail, and digital reporting into a single platform. The functional testing results show that all main modules, including user authentication, joint closure management, core visualization, attenuation history, activity log, and report export, function according to the system requirements. The integration of these various functions improves documentation consistency, makes it easier to identify core configurations, speeds up the retrieval of infrastructure information, and supports network operation and maintenance processes more effectively than documentation managed separately. Thus, the developed system functions not only as a data storage medium but also as a tool that supports decision-making in fiber optic infrastructure management.

This study still has limitations because the implementation uses an SQLite database and does not yet support direct integration with measurement devices or real-time network monitoring systems. Therefore, future research can be directed toward the use of a more scalable database, integration with a Geographic Information System (GIS) and Optical Time Domain Reflectometer (OTDR) devices, and the application of artificial-intelligence-based analytics to support predictive maintenance in fiber optic networks.

References

[1] A. R. Dwiputra, D. A. Maulana, Z. Nurzamilah, A. P. Pambudi, L. Nurpulaela, and S. Andromeda, "Peran fiber optik dalam revolusi teknologi jaringan telekomunikasi," *JATI (Jurnal Mhs. Tek. Inform.*, vol. 9, no. 1, pp. 1657–1663, 2025.

[2] T. Mulyadi and A. J. Wahidin, "Analisis Dan Desain Jaringan Fiber to the Home Di Kelurahan Bungur," *J. Komput. Dan Sist. Inf.*, vol. 2, no. 1, pp. 1–10, 2025.

[3] C. H. NUGROHO, "PEMBANGUNAN INFRASTRUKTUR JARINGAN FIBER TO THE HOME BIZNET NETWORKS DI PERUMAHAN GRIYA SAVANNAH CIBINONG," 2025.

[4] A. SANDY, "ANALISA KINERJA DAN MAINTAINABILITY KABEL SERAT OPTIK JALUR GARDU INDUK KERAMASAN PADA PT. INDONESIA COMNETS PLUS (ICON+) SBU PALEMBANG," *Anal. KINERJA DAN Maintainab. Kabel SERAT Opt. JALUR GARDU INDUK KERAMASAN PADA PT. Indones. COMNETS PLUS SBU PALEMBANG*,

2021.

[5] P. Adinda Larasati, M. Meilany, L. Nurpulaela, and S. Andromeda, "Monitoring dan Analisis Respons Pengguna Terhadap Gangguan Jaringan Internet di PT. Telkom Witel Karawang," *JATI (Jurnal Mhs. Tek. Inform.*, vol. 8, no. 5, pp. 10630–10636, 2024, doi: 10.36040/jati.v8i5.10023.

[6] A. Wiyono and R. R. Santika, "MANAJEMEN JARINGAN BEBASIS WEB MENGGUNAKAN SNMP UNTUK FAKULTAS EKONOMI DAN BISNIS UNIVERSITAS TRISAKTI".

[7] I. A. Kamolan, I. L. Sampebatu, I. F. Tangdililing, and I. N. Lorinanto, *Teknologi Telekomunikasi Modern: dari 4G ke 6G*. PENERBIT NAGA PUSTAKA, 2026.

[8] R. A. Lubis and Y. D. Lestari, "PENGEMBANGAN SISTEM LABELING JARINGAN FIBER OPTIK ISP BERBASIS WEB MENGGUNAKAN INTEGRASI GPS," *Explore*, vol. 16, no. 1, pp. 102–109, 2026.

[9] M. A. Rahman *et al.*, "Sistem Informasi Instalasi Kabel Serat Optik Di Kabupaten Bangkalan Menggunakan Model Waterfall," *Elkom J. Elektron. dan Komput.*, vol. 18, no. 2, pp. 151–163, 2025.

[10] Z. Wen *et al.*, "The Design of Power Optical Fiber Online Monitoring and Fault Early Warning System," in *2025 5th International Conference on Electrical Engineering and Mechatronics Technology (ICEEMT)*, 2025, pp. 283–286.

[11] A. K. Putra, A. Alim, and C. K. Sastradipraja, "SISTEM INFORMASI PENDATAAN KLIEN JARINGAN PADA LOKASI TERDISTRIBUSI MENGGUNAKAN PHP DAN MYSQL," *J. Teknol. Komput. dan Inform.*, vol. 4, no. 1, pp. 25–38, 2025.

[12] A. Ramadhan and S. Mulyati, "Implementation Of Json Web Token In The Development Of Village Monograph Database Based On Restapi," *J. Tek. Inform.*, vol. 5, no. 6, pp. 1849–1860, 2024.

[13] A. Nursodiq and E. S. Eriana, *Pengembangan Sistem Informasi Berbasis Web dan Mobile*. CV Eureka Media Aksara, 2026.

[14] M. A. Agil, I. Sodikin, and A. Hamdani, "PERANCANGAN SERVER APLIKASI SEDERHANA GUNA MENINGKATKAN EFEKTIVITAS PENGELOLAAN DATA," *J. Inform. dan Tek. Elektro Terap.*, vol. 14, no. 1, 2026.

[15] J. V. Dachi and J. Suhada, "Implementasi basis data sederhana menggunakan MySQL/PostgreSQL," *Router J. Tek. Inform. dan Terap.*, vol. 3, no. 2, pp. 197–207, 2025.

[16] B. Beizer and J. Wiley, "Black box testing: Techniques for functional testing of software and systems," *iEEE Softw.*, vol. 13, no. 5, p. 98, 1996.

[17] S. Dharwiyanti and R. S. Wahono, "Pengantar unified modeling language (uml)," *IlmuKomputer. com*, vol. 11, no. 1, pp. 1–13, 2003.

[18] N. Aminudin, N. Hidayat, D. Feriyanto, H. Mukaromah, D. Septasari, and I. Awaliyani, "A User-Driven E-Audit System for Improving Transparency and Efficiency in Regional Government Supervision," *J. Tek. Inform.*, vol. 6, no. 4, pp. 2348–2366, 2025.

[19] T. TRIWANDI, "infrastrukur dan jaringan komputer, Komisi Pemilihan Umum provinsi sumatera selatan.," *SKRIPSI Mhs. TI S1*, 2013.

[20] M. T. Shehadeh and M. J. Al-Qaralleh, "Development of a GIS Tool to Find Fiber Cable Fault Using Python Scripting for ArcGIS in Amman City.," *Jordan J. Soc. Sci.*, vol. 17, no. 2, 2024.