Implementation of Remote Teleprotection Monitoring Using Zabbix Network Monitoring System at Paiton–Probolinggo Substation Link

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Abstract

Teleprotection systems play a critical role in ensuring the reliability and security of power transmission networks by enabling fast and selective fault isolation between substations. However, in existing operational conditions, teleprotection devices are often monitored manually and locally, causing limitations in real-time visibility, early fault detection, and operational efficiency. This study presents the design and implementation of a remote teleprotection monitoring system using the Zabbix Network Monitoring System at the Paiton–Probolinggo substation link under PT PLN (Persero) UP2B East Java. The proposed system integrates teleprotection devices, communication networks, and a centralized Zabbix server to monitor device status, communication link availability, alarm conditions, and connectivity performance in real time. System development was carried out through field observation, system analysis, network design, device integration, and functional testing. The implementation results show that the monitoring system is able to provide centralized visualization, automated alarm notifications, and faster detection of teleprotection disturbances. The developed system improves operational visibility, reduces manual inspection activities, and supports faster decision-making in fault handling. This study demonstrates that Zabbix can be effectively utilized as a reliable and scalable monitoring platform for teleprotection systems in power transmission substations.

Keywords: *Teleprotection, remote monitoring, Zabbix, power transmission substation.*

I. INTRODUCTION

Power transmission systems require highly reliable protection mechanisms to ensure system stability and minimize the impact of faults. One of the key components supporting protection coordination between substations is the teleprotection system, which enables fast and selective signal exchange through communication media such as fiber optic networks. Teleprotection plays a vital role in reducing fault clearing time and preventing wider system disturbances in high-voltage transmission networks [1, 2].

In practice, the operation and monitoring of teleprotection devices in many substations are still performed locally and manually. Engineers often need to be physically present or access internal networks to check device status, communication links, and alarm events. This condition limits real-time visibility, delays fault detection, and increases operational workload, especially for substations distributed across wide geographical areas. The absence of an integrated and centralized monitoring system also makes it difficult to perform early diagnosis of communication failures and teleprotection disturbances [3-6].

Along with the development of digital substations and network-based protection systems, the implementation of remote monitoring has become an important requirement to support operational efficiency and system reliability. Network monitoring platforms such as Zabbix provide capabilities for real-time data acquisition, centralized visualization, automated alarms, and historical data analysis. These features offer potential benefits when applied to monitoring teleprotection systems, particularly in improving fault detection speed and reducing manual inspection activities [3, 6-8].

This study focuses on the design and implementation of a Zabbix-based remote monitoring system for teleprotection devices at the Paiton–Probolinggo substation link under PT PLN (Persero) UP2B East Java. The objective of this work is to develop a centralized monitoring solution that enables real-time visibility of teleprotection status, communication link conditions, and alarm events. The proposed system is expected to enhance operational monitoring, support faster fault response, and contribute to the digitalization of power transmission substation operations.

II. THEORY

A. Teleprotection System in Power Transmission

Teleprotection systems are communication-based protection schemes used in power transmission networks to ensure fast and coordinated fault clearing between substations. These systems transmit protection signals, such as trip or blocking commands, through reliable communication media including fiber optic networks, power line carriers, or microwave links. By enabling high-speed signal exchange, teleprotection reduces fault isolation time and minimizes the risk of cascading outages in transmission systems [1, 2, 9].

Modern teleprotection devices are designed to operate with high reliability, low latency, and immunity to communication disturbances. They are commonly integrated with digital protection relays and substations automation systems. However, the effectiveness of teleprotection strongly depends on the availability and quality of the communication channel. Any failure or degradation in the telecommunication link may affect protection performance and system stability [2, 4, 5, 8, 10].

B. Remote Monitoring Systems

Remote monitoring systems are implemented to observe the operational condition of devices and networks from a centralized location. In power transmission substations, remote monitoring supports real-time supervision of equipment status, communication performance, and alarm conditions without requiring physical presence at the site. This approach improves operational efficiency, reduces maintenance time, and enables early detection of abnormal conditions [3, 5, 10, 11].

A centralized monitoring system typically collects data from field devices using network protocols, processes the data on a monitoring server, and presents the information through dashboards, graphs, and alarm notifications. The availability of automated alerts allows operators to respond more quickly to failures and reduces dependency on manual inspections [4, 8, 12, 13].

C. Zabbix Network Monitoring System

Zabbix is an open-source network monitoring platform widely used to monitor servers, network devices, applications, and services in real time. Zabbix supports various data collection methods, including agent-based monitoring, Simple Network Management Protocol (SNMP), Internet Control Message Protocol (ICMP), and custom scripts. These features make Zabbix flexible and suitable for monitoring heterogeneous systems [12].

The Zabbix architecture consists of several main components, including the Zabbix server, agents, web interface, database, and optional proxy. The server functions as the core system that processes incoming data and triggers alarms based on predefined thresholds. The web interface provides visualization in the form of dashboards, graphs, and status indicators, enabling operators to monitor system conditions efficiently [7].

Due to its scalability, real-time alerting capabilities, and ease of integration, Zabbix can be effectively applied as a monitoring platform for teleprotection systems. By utilizing Zabbix, teleprotection devices and communication links can be monitored centrally, allowing faster detection of faults and improved operational awareness in power transmission substations [3, 7].

III. METHOD

This study was conducted using an applied system development approach focusing on the implementation of a remote teleprotection monitoring system. The research object was the teleprotection system at the Paiton–Probolinggo substation link operated by PT PLN (Persero) UP2B East Java. The method consists of several sequential stages, including system analysis, system design, implementation, and testing.

A. System Analysis

The system analysis stage was carried out through direct field observation and discussions with telecommunication and protection engineers. This stage aimed to identify existing operational conditions, monitoring limitations, and user requirements related to teleprotection devices and communication links. The analysis showed that teleprotection monitoring was still performed locally, making it difficult to detect communication failures and device status in real time. Based on these findings, key monitoring parameters were defined, such as device connectivity, link availability, alarm status, and communication performance.

B. System Design

The system design stage focused on developing the architecture and workflow of the remote monitoring system. The proposed design integrates teleprotection devices, communication networks, and a centralized Zabbix server. Teleprotection devices installed at substations transmit operational data through fiber optic communication networks. The Zabbix server

functions as the central monitoring unit that collects, processes, and visualizes data from monitored devices.

Monitoring parameters were configured using ICMP, SNMP, and Zabbix templates to represent device availability, network latency, packet loss, and alarm conditions. Dashboards and triggers were designed to provide clear visualization and automated notifications when abnormal conditions occur.

C. System Implementation

System implementation involved configuring the Zabbix server, registering teleprotection-related hosts, and defining monitoring items, triggers, and alert mechanisms. Devices and communication links were mapped into the monitoring system to ensure accurate data acquisition. Visualization was implemented through dashboards displaying real-time status, graphs, and alarm indicators to support operational monitoring by system operators.

D. System Testing

System testing was conducted to verify the functionality and reliability of the implemented monitoring system. Testing included connectivity verification, alarm triggering, dashboard visualization, and fault detection scenarios. The system was evaluated based on its ability to detect teleprotection link failures, display real-time status information, and generate timely notifications. Successful testing indicates that the monitoring system operates according to the defined requirements and supports effective teleprotection supervision.

IV. RESULTS AND DISCUSSION

A. Implementation of the Teleprotection Monitoring System

The proposed remote teleprotection monitoring system was successfully implemented at the Paiton–Probolinggo transmission substation link using the Zabbix Network Monitoring System.

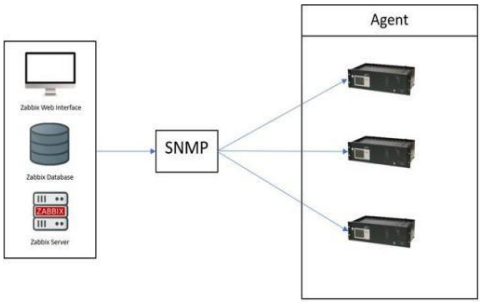


Figure 1. Architecture of Zabbix-Based Remote Teleprotection Monitoring System

The implementation integrates teleprotection devices, fiber optic communication networks, and a centralized monitoring server to enable real-time supervision of system conditions.
Teleprotection devices installed at the substations transmit operational data, such as device availability and communication link status, through the fiber optic network. The data is collected and processed by the Zabbix server and then presented to operators through a web-based monitoring interface. This centralized implementation replaces the previous local and manual monitoring approach. Figure 2 illustrates the workflow of the teleprotection monitoring system implementation, starting from teleprotection device selection and configuration to real-time monitoring, alarm generation, and system analysis.

B. Monitoring Dashboard and Visualization Results

The monitoring dashboard developed in Zabbix provides a comprehensive visualization of teleprotection system conditions. The dashboard displays device status, communication link availability, and alarm indicators using graphical and color-coded representations. This visualization enables operators to quickly identify abnormal conditions without accessing the devices directly.

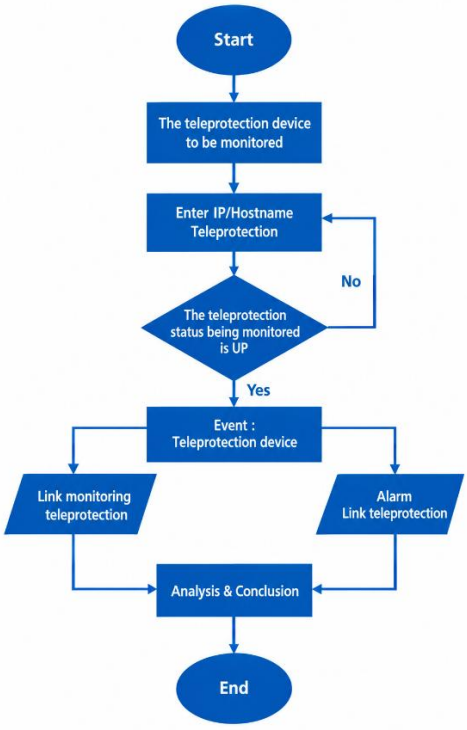


Figure 2. Workflow of Teleprotection Monitoring System Implementation



Figure 3. Zabbix Dashboard for Teleprotection Monitoring

The dashboard also presents historical data and performance trends, allowing operators to analyze system behavior over time. Compared to the previous monitoring method, the dashboard significantly improves situational awareness and reduces the time required to identify potential issues.

C. Alarm and Fault Detection Performance

Alarm and notification mechanisms were configured using predefined triggers in the Zabbix system. These triggers are based on parameters such as device reachability, communication link availability, and response time thresholds. When abnormal conditions occur, the system automatically generates alarms and sends notifications to system operators.

System testing results indicate that the monitoring system is capable of detecting teleprotection link failures and device downtime in real time. Automated alarms enable faster response and reduce dependency on routine manual inspections.

D. Discussion

The results demonstrate that the implemented Zabbix-based monitoring system effectively enhances teleprotection supervision in power transmission substations. Centralized monitoring improves visibility of device and communication link conditions, while automated alarms support faster fault detection and corrective action.

In addition, the system supports scalability, allowing new substations or teleprotection devices to be integrated with minimal configuration effort. This capability makes the proposed solution suitable for broader deployment across transmission networks and supports digital transformation initiatives in power system operation and maintenance.

Table I.
Teleprotection Monitoring Parameters and Alarm Configuration

Parameter Monitored	Monitoring Method	Alarm Condition	Purpose
Device availability	ICMP Ping	Host unreachable	Detect device failure
Communication link	ICMP / SNMP	Link down	Detect link interruption
Network latency	ICMP response time	Threshold exceeded	Identify performance degradation
Alarm status	Zabbix trigger	Trigger activated	Early fault notification

V. CONCLUSION

This study presents the design and implementation of a Zabbix-based remote monitoring system for teleprotection at the Paiton–Probolinggo power transmission substation link. The developed system integrates teleprotection devices, communication networks, and a centralized monitoring server to provide real-time visibility of device status, communication link conditions, and alarm events.

The implementation results demonstrate that the proposed monitoring system is capable of improving operational visibility, accelerating fault detection, and reducing reliance on manual inspections. The use of dashboards and automated alarm notifications enables operators to respond more quickly and accurately to teleprotection disturbances. As a result, the system contributes to improved reliability and efficiency of teleprotection operations in transmission substations.

Furthermore, the scalability and flexibility of Zabbix allow the monitoring system to be extended to additional substations and teleprotection devices. This makes the proposed solution suitable for supporting digital transformation initiatives and enhancing centralized monitoring practices in power transmission networks.

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