

PowerPath: A Mobile Application for Transformer Monitoring and Maintenance

Aman M Hafees
Department of Computer Science
Amal Jyothi College of
Engineering(Autonomous)
Kerala,India
amanmhafees2026@cs.ajce.in

Aman Yunus
Department of Computer Science
Amal Jyothi College of
Engineering(Autonomous)
Kerala, India
amanyunus2026@cs.ajce.in

Aashish Tom Raju
Department of Computer Science
Amal Jyothi College of
Engineering(Autonomous)
Kerala, India
aashishtomraju2026@cs.ajce.in

Agnus Roy
Department of Computer Science
Amal Jyothi College of
Engineering(Autonomous)
Kerala, India
agnusroy2026@cs.ajce.in

Ansamol Varghese
Assistant Professor
Department of Computer Science
Amal Jyothi College of
Engineering(Autonomous)
Kerala,India
ansamolvarghese@gmail.com

Abstract—PowerPath is an innovative mobile application designed to enhance transformer monitoring and maintenance for Kerala State Electricity Board (KSEB) officers. It provides real-time transformer status updates, fault logging, maintenance scheduling, role-based access control, and location tracking, significantly improving operational efficiency. Built with Firestore as its backend, the app ensures seamless data synchronization and easy navigation. With support for English, PowerPath enhances workforce management and streamlines transformer operations. This paper explores the app's design, implementation, and its impact on transformer management. This helps the KSEB officers to make their work easier or smoother.

Keywords—Transformer monitoring, mobile application, fault logging, maintenance scheduling, PowerPath, Firestore, KSEB.

I. INTRODUCTION

Effective transformer monitoring and maintenance are essential for ensuring reliable power distribution and operational efficiency. Traditional monitoring methods primarily depend on periodic manual inspections and reactive maintenance, which often lead to delayed fault detection, extended downtime, and inefficient resource use. Without a real-time monitoring system, maintenance teams must conduct physical site visits, which can be time-consuming and ineffective in preventing unexpected transformer failures. To address these challenges, power distribution networks such as those managed by the Kerala State Electricity Board (KSEB) need a more proactive and digitalized approach to transformer management. It will help with various functions.

The PowerPath application is set to transform transformer monitoring and maintenance by providing a

comprehensive, real-time digital platform. Designed for KSEB officers and personnel, it streamlines key tasks such as transformer tracking, fault logging, maintenance scheduling, and workforce management, ensuring a smoother and more efficient workflow. With advanced technologies like cloud storage, GPS tracking, and real-time data processing, PowerPath gives users instant access to critical transformer information, allowing them to take timely action. By shifting from manual to digital monitoring, the application enhances power distribution efficiency and helps reduce service disruptions.

PowerPath features a robust role-based access system, ensuring that engineers, system supervisors, administrators, and other personnel can efficiently carry out their responsibilities. Engineers can add new transformers, schedule maintenance, review maintenance history, and remove outdated or faulty transformers from the system. System supervisors can track active workers in a specific section, review past employees, and manage workforce transfers based on operational needs. The officials can manage their work easier. Administrators oversee workforce management by adding new employees, assigning system supervisors, creating new sections, and maintaining the overall system structure. Meanwhile, other workers have access to key functionalities such as selecting transformers, viewing their locations, logging faults, and adding notes for future reference.

One of PowerPath's key advantages is its ability to reduce service downtime through real-time fault detection and reporting. Traditional fault logging relies on manual entries and delayed communication between field engineers and control centers, often resulting in prolonged power outages. With PowerPath, faults are logged instantly, and the relevant personnel receive real-time notifications, enabling them to take immediate corrective action. This proactive approach

speeds up fault resolution, minimizes disruptions for consumers, and enhances the overall reliability of the power distribution network.

Additionally, PowerPath's maintenance scheduling feature ensures that preventive maintenance is well-planned and efficiently executed. By proactively scheduling maintenance, the application helps reduce unexpected failures and extends the lifespan of transformers. The maintenance history feature enables engineers and supervisors to track past repairs and inspections, offering valuable insights into recurring issues and areas that may need extra attention.

This paper provides a comprehensive overview of the PowerPath system, highlighting its architecture, key features, and benefits. We examine how this digital solution enhances the workflow of KSEB officers, improves service reliability, and optimizes transformer maintenance. By implementing PowerPath, power distribution management takes a significant step toward modernization, enabling maintenance teams to respond proactively and ensure an uninterrupted power supply. Overall it is very helpful for the officers to maintain their work.

II. LITERATURE REVIEW

Mobile-based solutions for monitoring and managing smart grid systems have been extensively studied. Various approaches leverage mobile devices to facilitate real-time data collection, fault detection, and remote control of grid assets. These systems often integrate communication protocols, cloud-based platforms, and data security measures to ensure efficient data management and reliable operations. The implementation of mobile applications in grid operations has demonstrated significant improvements in reducing response times and enhancing decision-making efficiency. The advantages of such solutions are evident in applications like PowerPath, which employs similar technologies for real-time transformer monitoring, fault logging, and maintenance scheduling. By streamlining field operations and providing instant access to critical data, PowerPath enhances operational efficiency and reliability in power distribution management [1].

Transformer fault diagnosis methods have been extensively reviewed, encompassing both traditional techniques and advanced digital signal processing alongside IoT-based approaches. These modern strategies emphasize real-time monitoring through digital systems and mobile applications, facilitating remote fault detection and proactive maintenance. Key aspects include the integration of sensor data, the application of machine learning for pattern recognition, and the challenges associated with implementing reliable remote diagnostics in real-world conditions. Such advancements directly relate to the PowerPath application, which incorporates real-time fault logging and analysis to ensure reliable transformer performance. By minimizing downtime and enhancing operational efficiency, PowerPath aligns with the ongoing shift towards digitized, data-driven transformer monitoring solutions [2].

The design and implementation of mobile applications for power system maintenance have been thoroughly

examined, showcasing their effectiveness in streamlining field operations. This study highlights the app's architecture, which incorporates a role-based access system, fault reporting capabilities, and maintenance scheduling features. Field evaluations demonstrated that the application significantly improved communication between field engineers and supervisors, reduced maintenance turnaround times, and enhanced overall system reliability. These findings are highly relevant to the PowerPath project, as it also utilizes mobile technology to manage transformers efficiently. The study's emphasis on real-time data access, user-friendly interfaces, and cloud integration serves as a valuable reference for developing robust and reliable utility management solutions [3].

The implementation of smart transformer monitoring systems using IoT sensors and cloud computing has revolutionized transformer management. This paper introduces a system capable of continuously assessing transformer health by analyzing data such as load variations and thermal performance. The use of remote monitoring, fault detection, and predictive maintenance significantly improves operational efficiency. PowerPath adopts a similar approach by integrating features like fault logging, maintenance scheduling, and transformer selection into a mobile application. Both systems aim to digitize transformer management, enabling proactive maintenance strategies and reducing downtime. This reference highlights the industry's ongoing transition toward digital solutions, which directly aligns with PowerPath's objective of enhancing the management and maintenance of electrical distribution networks [4].

The adoption of IoT-based systems for real-time transformer monitoring has become increasingly prevalent in power distribution management. This paper introduces a

system that tracks critical parameters such as temperature, voltage, current, and oil levels to predict potential failures. By utilizing cloud computing and machine learning, the system enables preventive maintenance and reduces downtime. PowerPath incorporates a comparable strategy by offering features for monitoring transformer health, scheduling maintenance, and accessing historical data. Both systems aim to enhance the efficiency and reliability of transformer networks by leveraging digital tools for proactive maintenance and fault management. This reference highlights the growing trend of integrating IoT and cloud technologies in power systems, reinforcing PowerPath's goal of improving operational efficiency and minimizing service disruptions [5].

The development of mobile applications for smart grid management is transforming power distribution operations. This paper explores a mobile-based system that allows users to monitor power distribution, track transformer status, and manage workforce assignments remotely. By integrating cloud storage, GPS tracking, and real-time fault logging, the application significantly improves the efficiency of power grid operations. PowerPath offers similar capabilities, including transformer status monitoring, fault logging, maintenance scheduling, and workforce management. Both

systems leverage mobile technology to enable real-time power infrastructure management, enhancing operational efficiency and reducing response times for maintenance teams. This reference underscores the effectiveness of mobile solutions in streamlining power distribution management, aligning with PowerPath's goals of digitizing and optimizing transformer monitoring processes [6].

III. METHODOLOGY

PowerPath is a Flutter-based mobile application that utilizes Firebase's cloud services to provide real-time transformer management solutions for KSEB officers. Built with a layered, modular architecture, the system ensures scalability, reliability, and seamless data flow across various user roles, enabling efficient and streamlined operations.

A. Client-Side (Mobile App):

- **User Interface (UI):** User Interface (UI): Developed using Flutter, the app provides an intuitive, responsive, and role-based interface. Different modules are designed for Engineers, System Supervisors, Admins, and Other Workers, ensuring each user sees only the functionalities relevant to their responsibilities.
- **Navigation and Interaction:** The app includes key features like Google Maps for navigating transformer locations, a dropdown search for easy transformer selection, and custom forms for logging faults and scheduling maintenance. Designed for seamless usability, the UI components are optimized for both online and offline functionality, leveraging Flutter's state management and widget architecture for a smooth and efficient experience.
- **Authentication and Role Management:** The app utilizes Firebase Authentication to provide secure, role-based user access, ensuring that sensitive transformer data and administrative functions are only available to authorized personnel. This enhances data security while maintaining efficient access control.

B. Backend (Firebase Cloud Services):

- **Data Storage:** Firestore serves as the primary realtime database, storing essential information such as transformer details, fault logs, maintenance records, employee data, and section details. Its built-in offline persistence enhances reliability, ensuring seamless operation even in low-connectivity environments.
- **Authentication:** Firebase Authentication provides a secure login system, enabling role-based access control for different user groups.
- **Real-Time Synchronization:** Cloud Firestore's realtime data capabilities ensure that updates such as transformer status changes or newly logged faults are instantly reflected across all connected devices, keeping users informed in real time.

- **Scalability and Security:** Firebase offers strong scalability and robust data security. Role-based access controls and Firestore security rules safeguard sensitive information while ensuring compliance with operational standards.

C. Integration and Data Flow:

- **Direct Data Communication:** The mobile app interacts directly with Firestore to fetch and update data in real time. Future enhancements may include Firebase Cloud Functions for automating tasks such as sending maintenance reminders or handling complex data processing

D..ROLES IN POWERPATH

1) ENGINEERS

Engineers play a vital role in the PowerPath application, ensuring efficient transformer management. They are responsible for adding new transformers to the system, accurately recording key details such as location, specifications, and installation data. To maintain optimal performance, engineers can schedule routine maintenance activities, helping to prevent failures and extend transformer lifespan.

The system also offers a detailed maintenance history for each transformer, allowing engineers to track past repairs, identify recurring issues, and make informed decisions about future servicing. Additionally, when a transformer is decommissioned or replaced, engineers can remove it from the system, keeping the database accurate and up to date. By providing a seamless digital solution for transformer management, PowerPath helps engineers minimize downtime, enhance operational efficiency, and improve the reliability of the electrical distribution network

2) SYSTEM SUPERVISOR

The System Supervisor in the PowerPath application plays a crucial role in managing and overseeing the workforce within their designated section. They have access to a real-time list of active workers, allowing them to monitor employee assignments and ensure tasks are efficiently distributed. Supervisors can also review records of past employees, providing valuable insights into workforce trends and enabling the reassignment of experienced workers when necessary. Additionally, the system allows for seamless worker transfers, enabling supervisors to reallocate employees to different sections based on workload demands, skill specialization, or operational needs. By utilizing these features, System Supervisors can effectively manage workforce distribution, optimize productivity, and maintain well-organized personnel records, ensuring smooth and efficient operations within their section.

3) ADMIN

The Admin in the PowerPath application plays a central role in managing the workforce structure and ensuring smooth operations across all sections. One of their key responsibilities is onboarding new employees, ensuring their details are properly recorded and assigning them to the appropriate sections for seamless integration into the system. Admins also have the authority to add new administrators, expanding management capabilities as needed to oversee different operational areas. Additionally,

they can create new sections, allowing for better organization of employees based on regions, tasks, or departments. Another crucial function is the ability to transfer system supervisors, reassigning them to different sections based on operational needs, workforce demand, or expertise requirements. By leveraging these features, admins maintain complete control over workforce management, ensuring an efficient, well-structured, and organized workflow across the entire system.

4) OTHER WORKERS(LINEMAN, OVERSEER)

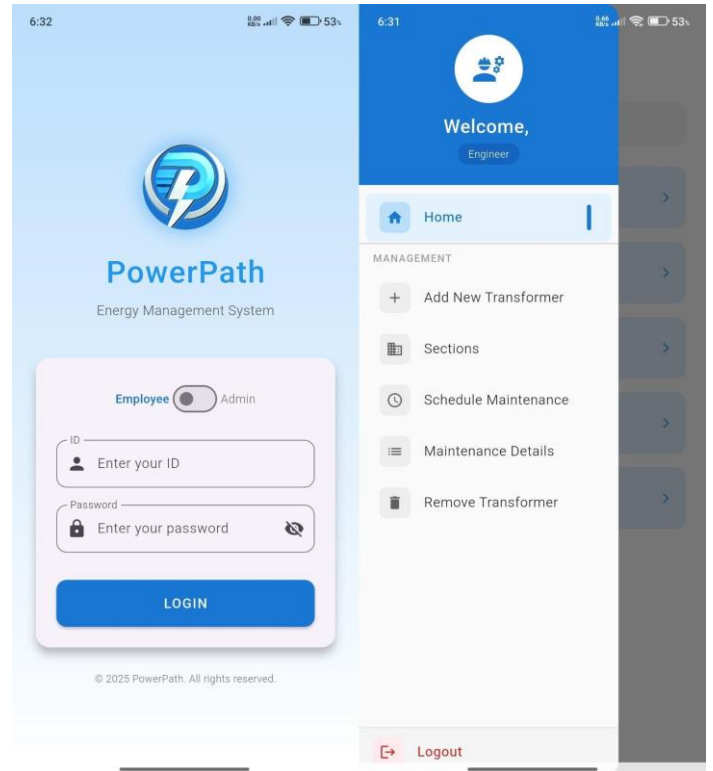
In the PowerPath application, Other Workers are equipped with essential tools to efficiently manage transformers and report issues as part of their daily tasks. One of their key functionalities is the ability to select a transformer from the available list, ensuring they can quickly identify and work with the relevant equipment assigned to them. Workers can also access the location of a transformer, making navigation easier and allowing them to reach sites efficiently. Additionally, they have the ability to log faults, enabling real-time reporting of malfunctions or issues, which helps ensure timely maintenance and repairs. Another valuable feature is the ability to add notes related to transformers. This allows workers to document important details, observations, or instructions that may assist in future inspections, troubleshooting, or maintenance activities. By providing these capabilities, PowerPath empowers workers with the tools they need to perform their roles effectively, ensuring a well-organized and efficient workflow.

This architecture enables PowerPath to deliver a seamless, real-time solution for transformer management, streamlining operations and optimizing maintenance processes for KSEB officers. By enhancing efficiency and responsiveness, the system ensures smoother workflow management and improved service reliability.

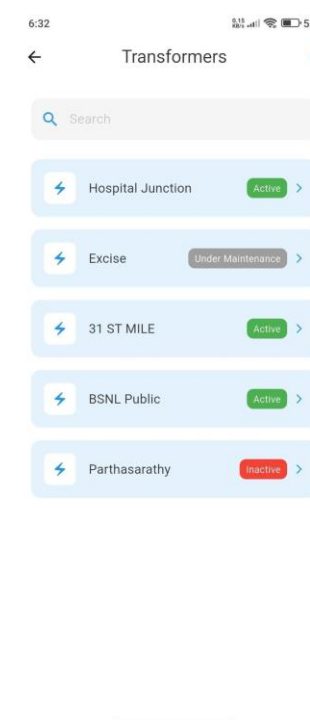
IV. RESULTS

The development of PowerPath incorporated Firebase for cloud storage and Firestore for real-time database management, ensuring seamless data handling and accessibility. The application was tested with KSEB officers, demonstrating a notable improvement in task efficiency, fault resolution time, and overall operational effectiveness. User feedback emphasized the app’s intuitive design and ease of use, highlighting its ability to simplify transformer management and enhance daily workflows.

A. USER-INTERFACE

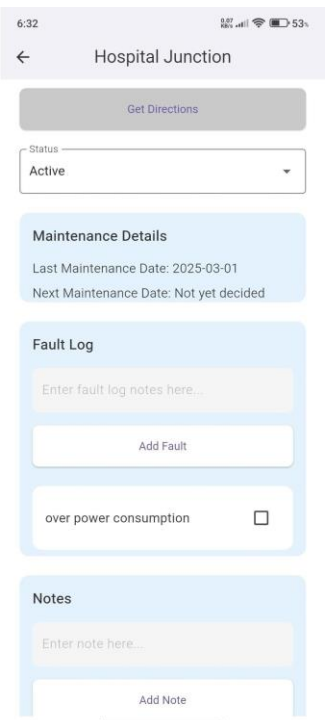


Login Page



Transformer List

Navigation Bar



Transformer Details

V. CONCLUSION

PowerPath is an innovative solution designed to simplify and enhance transformer management for KSEB officers, ensuring greater efficiency, accuracy, and ease of use. The application features role-based functionalities tailored to Engineers, System Supervisors, Admins, and other workers, enabling them to manage transformers, schedule maintenance, track employee assignments, and log faults effortlessly. Built using Flutter for seamless cross-platform compatibility and powered by Firebase for real-time data synchronization, PowerPath ensures that users receive instant updates and can continue working efficiently, even in low-connectivity environments.

PowerPath enhances operational efficiency by transforming traditionally manual processes into a streamlined digital workflow, reducing paperwork and minimizing errors. Engineers can efficiently manage transformer maintenance, System Supervisors can oversee worker assignments, and Admins can handle employee and section management with ease. Additionally, the integration of Google Maps for location tracking and offline data storage ensures seamless accessibility and reliability, making the app an invaluable tool for field workers, even in areas with limited connectivity. PowerPath harnesses modern cloud technologies and an intuitive UI/UX design to streamline transformer maintenance workflows and enhance decision-making capabilities. Its scalable architecture supports future upgrades, enabling KSEB to adapt to evolving power distribution challenges. Ultimately, PowerPath marks a significant step in digital transformation, improving the efficiency, safety, and reliability of power infrastructure management.

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