Fault and disturbance records sharing platform – what it is and why we need it

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1. Introduction

Modern electric power systems rely heavily on sophisticated protection and control schemes to maintain reliability and resilience. At the heart of these schemes are Intelligent Electronic Devices (IEDs) and disturbance recording systems that capture detailed information during system faults. These records provide a wealth of data about the behavior of power systems under abnormal conditions, offering insights into fault characteristics, protection system performance, and overall grid dynamics.

Fig. 1 Fault recording

Despite the value of this information, fault and disturbance records often remain confined within the organizations that collect them. Once used for immediate troubleshooting or post-fault analysis, these records are frequently archived with limited further utilization. This siloed approach represents a missed opportunity for the broader power system protection community to learn from real-world events and improve protection practices across the industry.

This paper proposes establishing a collaborative platform for sharing fault and disturbance records among industry stakeholders. By creating a secure, standardized environment for exchanging this data, the power system protection community can unlock new possibilities for research, development, and innovation.

2. What is a Fault and Disturbance Records Sharing Platform?

2.1 Definition and Scope

A fault and disturbance records sharing platform is a centralized digital infrastructure designed to facilitate the collection, storage, retrieval, and analysis of power system fault data from multiple contributing organizations. The platform would serve as a repository for various types of records, including oscillography data from protection relays and IEDs, sequence of events records, power quality monitoring data, phasor measurement unit (PMU) data, digital fault recorder (DFR) files, and system operator notes with contextual information.

2.2 Key Components

The platform would consist of several interconnected components, beginning with a secure, scalable database system capable of storing large volumes of diverse fault records. Standardization tools would convert proprietary file formats into standardized formats such as COMTRADE (IEEE C37.111) to ensure interoperability across systems. A comprehensive metadata framework would tag records with relevant information such as fault type, voltage level, equipment involved, geographical location, and weather conditions.

Users would interact with the system through a search and retrieval interface allowing participants to locate specific types of fault records based on various criteria. Integrated analysis tools would offer preliminary examination of fault records, visualization capabilities, and comparative features. Privacy controls would anonymize sensitive information while preserving the technical value of the data, and collaboration features such as forums and annotation capabilities would facilitate knowledge exchange around specific fault events.

2.3 Governance Structure

The platform would be governed by a representative body of stakeholders, potentially including utility representatives, equipment manufacturers, academic institutions, industry associations (e.g., IEEE PES, CIGRE), standards development organizations (e.g., IEEE PES, IEC), and regulatory authorities in an advisory capacity. This governance structure would establish policies for data sharing, privacy, access rights, and platform development, ensuring all participants' interests are represented and protected.

3. Why Do We Need a Fault and Disturbance Records Sharing Platform?

3.1 Current Limitations

Several factors limit the industry's ability to fully leverage fault and disturbance records. Fault data remains isolated within individual organizations, preventing cross-organizational learning and broader industry insights. Individual utilities may experience relatively few major faults of a particular type, making it difficult to draw statistically significant conclusions from limited sample sizes. Additionally, many utilities lack the specialized expertise or resources to conduct advanced analysis of fault records.

The use of different proprietary formats by various manufacturers complicates data exchange and comprehensive analysis, creating technical barriers to collaboration. Privacy concerns also present a significant obstacle, as utilities may be reluctant to share operational data due to security, competitive, or regulatory considerations.

3.2 Benefits of a Shared Platform

For protection equipment manufacturers, access to diverse real-world fault data enables testing and refinement of protection algorithms against a broader range of scenarios than would be possible with in-house testing alone. New protection functions can be validated against historical fault records before deployment, reducing the risk of field issues. Comprehensive data on protection system performance in various real-world conditions supports continuous product improvement and innovation.

Utilities and network operators would gain benchmarking opportunities to compare their protection system performance against industry peers. Knowledge transfer would allow less experienced utilities to learn from more established organizations, accelerating the development of expertise. Shared analysis reduces the need for each utility to independently develop advanced analytical capabilities, allowing more efficient use of limited resources. Ultimately, better understanding of fault characteristics informs future system design and protection coordination decisions.

Academic and research institutions would benefit from access to real-world data that would otherwise be difficult or impossible to obtain. Theoretical power system models could be validated against actual fault recordings, improving the accuracy of simulation tools and research outcomes. As an educational resource, students could study actual fault cases, bridging the gap between theoretical classroom learning and practical field experience.

For the industry as a whole, collaborative analysis would accelerate the identification of emerging issues and development of solutions to common problems. Comprehensive fault data would inform the development of more effective standards and guidelines. Systematic analysis of fault patterns across multiple systems would enable proactive measures to enhance overall grid reliability and resilience.

3.3 Enabling Advanced Applications

The platform would provide the large, diverse dataset necessary for developing effective AI and machine learning applications in power system protection. Neural networks could be trained to rapidly identify fault types and characteristics with greater accuracy than conventional methods. Predictive maintenance algorithms might detect emerging equipment issues before they cause failures, reducing outages and extending asset life. Adaptive protection schemes could self-optimize protection settings to adapt to changing system conditions, improving both security and dependability.

Deep learning techniques show particular promise for fault analysis but require substantial quantities of labeled data. Convolutional Neural Networks could be applied to waveform analysis for pattern recognition in fault signatures. Recurrent Neural Networks would be useful for analyzing time-series data and predicting system behavior during abnormal conditions. Newer approaches such as transformers and attention mechanisms could help identify complex relationships between different system parameters during fault conditions. Transfer learning techniques would enable knowledge gained from one power system to be applied to others with different characteristics, maximizing the value of shared data.

4. How Can We Establish a Fault and Disturbance Records Sharing Platform?

4.1 Technical Implementation

A successful technical implementation would likely involve cloud-based infrastructure providing scalability, accessibility, and robust security features. The architecture would balance centralized storage for ease of access with distributed components for resilience against failures. An API-driven design would enable integration with existing utility systems and analysis tools, minimizing the barriers to participation.

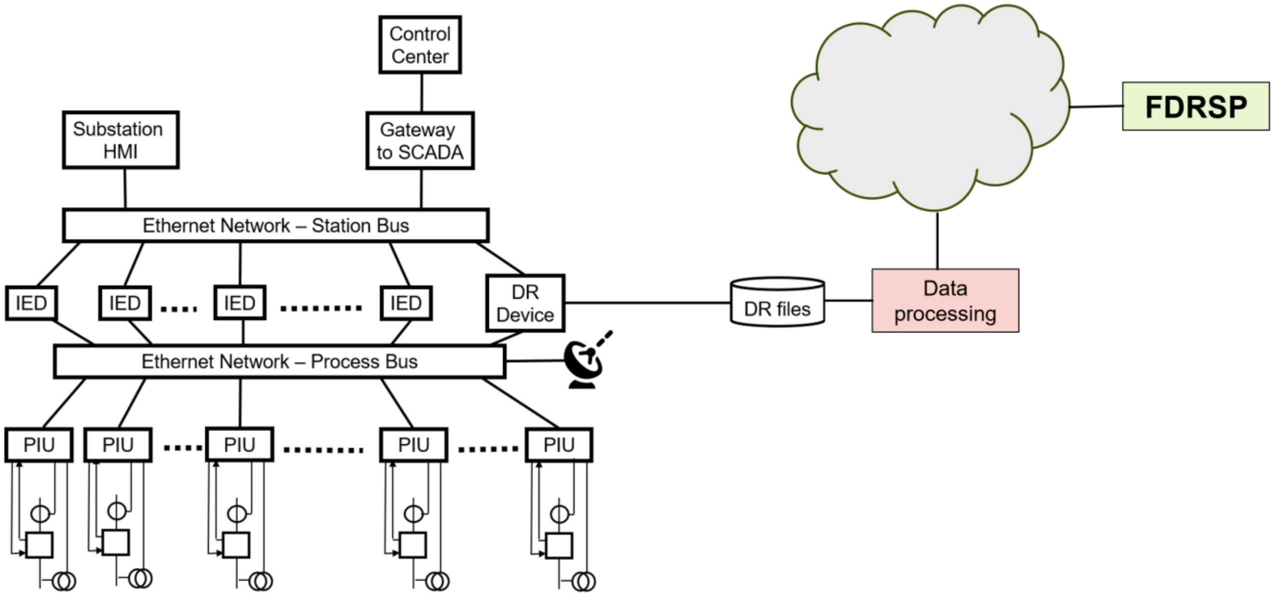

Fig. 2 Abstract system architecture

Data standardization would be crucial for interoperability across the diverse landscape of protection and control equipment. Automated tools would convert proprietary formats to standards like COMTRADE, ensuring consistent interpretation. A comprehensive taxonomy for fault record classification would facilitate effective searching and analysis. Data quality guidelines would establish minimum requirements for completeness and accuracy, ensuring the value of shared information.

Security and privacy measures would be essential for building trust in the platform. Data anonymization techniques would remove identifying information while preserving technical value for analysis. Granular access controls would determine who can view, download, or analyze specific records based on contributor preferences and sensitivity levels. End-to-end encryption would protect data during transfer and storage, and comprehensive audit trails would log all platform activities for accountability.

4.2 Organizational Implementation

The governance model would ensure all participant categories have appropriate representation in decision-making processes. Transparent procedures for platform development and policy decisions would maintain trust among diverse stakeholders. Mechanisms to address disputes or competing interests would resolve conflicts constructively when they arise.

Sustainable operation requires appropriate funding mechanisms, which might include joint funding by major industry stakeholders through a consortium approach. A tiered membership model could base fees on organization size and access level, ensuring equitable participation. Public-private partnerships might leverage government interest in grid resilience, while research grants could support specific platform capabilities aligned with power system research initiatives.

To encourage participation, the platform could implement reciprocity requirements making access to others' data contingent on contributing one's own. Recognition programs would acknowledge significant contributors, creating positive incentives for sharing. Participants would receive valuable analytical insights derived from the collective dataset, offering immediate benefits from participation. Working with regulators to recognize platform participation as evidence of industry best practices could create additional incentives for utilities.

4.3 Implementation Roadmap

A phased implementation approach would be most practical. The foundation phase would establish the governance structure and initial stakeholder group, develop platform requirements and technical specifications, create data sharing agreements and policies, and implement basic platform infrastructure. This would be followed by an initial deployment phase with a limited pilot group, development of standardization tools and initial analysis capabilities, collection of feedback, and gradual expansion of the participant base.

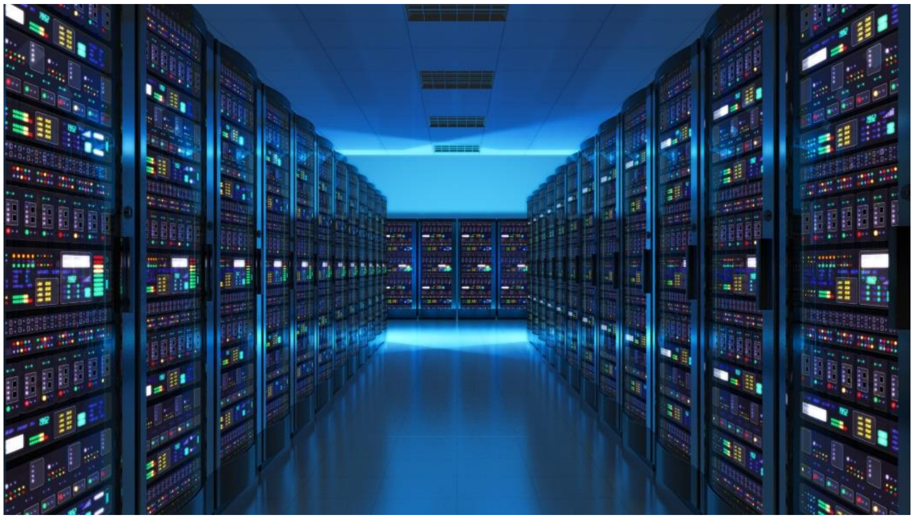

Fig. 3 Data center

The full operation phase would scale to production capacity, implement advanced analytics and AI capabilities, develop integration with existing utility systems, and establish a long-term sustainability model. The platform would then enter an evolution phase of continuous improvement based on user feedback, expansion to additional data types, development of specialized analytical tools, and integration with other industry initiatives.

4.4 Addressing Potential Challenges

Legal and regulatory concerns must be addressed through clear policies establishing that contributors retain ownership of their data. Agreements would limit liability for consequences of data use, protecting all participants. The platform design would ensure compliance with relevant regulations in different jurisdictions where participants operate.

Industry resistance may stem from competitive concerns about sharing operational data. Education about the shared benefits that outweigh potential competitive disadvantages would be necessary. Cultural barriers must be overcome, addressing the tradition of information siloing in the utility industry. Perceived security risks would require education about security measures and controlled access limitations.

Technical challenges include managing potentially enormous datasets as the platform grows. The wide variety of proprietary formats presents conversion and interpretation challenges requiring sophisticated standardization tools. Methods for assessing and ensuring the quality of contributed records would be necessary to maintain the value of the shared repository.

5. Case Studies and Potential Applications

A regional consortium of utilities might use the platform to analyze fault records from multiple interconnected systems, identifying coordination issues that only become apparent when examining the interaction between neighboring protection systems. This analysis could lead to revised coordination practices that eliminate potential cascade failure mechanisms, improving regional grid stability.

Equipment manufacturers studying hundreds of fault records involving their relays could identify specific system configurations where performance improvements are possible. This information might lead to firmware updates that enhance performance for all customers using that relay type, supporting continuous product improvement without requiring field issues to occur first.

Academic researchers analyzing thousands of fault records might discover previously unrecognized patterns in high-impedance fault signatures. This research could lead to new detection methods that significantly improve safety across the industry, demonstrating the scientific value of large-scale fault data collection and analysis.

6. Conclusions

The establishment of a fault and disturbance records sharing platform represents a significant opportunity for the power system protection community to advance collective knowledge, improve system reliability, and accelerate innovation. By pooling resources and sharing experiences, the industry can address challenges that no single organization could tackle alone.

The technical, organizational, and governance frameworks outlined in this paper provide a starting point for making this vision a reality. While challenges exist, they are outweighed by the potential benefits: enhanced protection system design, improved operational practices, accelerated research and development, and ultimately, a more reliable and resilient power grid.

This paper calls upon industry leaders, professional organizations, academic institutions, and regulatory bodies to collaborate in establishing this platform. By working together, the power system protection community can create a resource that serves the entire industry and advances our collective mission of ensuring safe, reliable electrical power for all.