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A Critical Review on Implementation of FLISR Technology in Distribution Management System (DMS) using Computational Intelligence Technique

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***Abstract*— There is continuous research in various disciplines to address the issues posed by changes in distribution networks, such as islanding detection and microgrid development. Power converters, defect detection, enhancing power system quality, decreasing system inertia, and network reconfiguration are all examples of active energy markets. This critical study is made for the Fault Location, Isolation, and Service Restoration in distribution management systems using various computational intelligence techniques, and conclusions are drawn based on the published research works.**

Keywords—FLISR, DMS, Computational Intelligence Techniques. Smart Grids.

I. INTRODUCTION

The advance technology using computers are playing vital roles in this era, especially the computational techniques like Artificial intelligence, Data Mining, Robot automated technologies are becoming part of every new research of every disciplines. With the rise of Internet of Things (IoT) technologies and Artificial Intelligence, the energy business has shifted from a hardware to a software-oriented focus in recent years. This has resulted in a vast body of research aimed at increasing grid resiliency, accommodating the integration of renewable energy resources (RES), and utilizing data gathered from the electrical network to give Analysis approaches that can detect system issues and aid in restoring power in a way that affects fewer users [1]. The conventional electric power distribution network has been in service for decades, unable to meet consumer energy demand, particularly when electric power demand is ever-increasing with limited supply [2]. The basic goal of the electrical distribution network is to consistently supply the required electrical energy to the end user, which is dependent on the electrical distribution network quality and efficacy. Because of the rapid increase in power demand, power generation capacity must be increased to avoid blackouts, which cause serious financial problems in developing countries [3]. There is ongoing research in various domains to address challenges introduced by distribution system changes, such as islanding detection, microgrid formation, transactive energy markets, power converters, fault detection, improving power system quality, decreasing system inertia, and network reconfiguration [4,5].Analysis approaches that can detect system issues and aid in restoring power in a way that affects fewer user Resilience is a critical requirement for a grid modernization technology module such as the fault location, isolation, and service restoration (FLISR) scheme to ensure reliable operation in the face of natural disasters or cyberattacks. FLISR has been shown to reduce the number of customers affected by system outages by up to 45% while also lowering consumer outages. Time can be cut by up to 51% [6] However, such advancements necessitate a more robust communication infrastructure for remote grid systems, as well as the ability to operate successfully when the distribution network fails. A centralized distribution management system (DMS) that functions in a hub-and-spoke logical framework is frequently used in modern distribution systems [7] A software architecture that manages sensor and network data is at the heart of smart grid operation.

When the distribution system is built and operated to minimize the effects of any failure, the highest levels of service dependability are obtained. that may happen. In this regard, the Fault Location Isolation and Service Restoration (FLISR) application is one of the most critical applications currently being adopted by the majority of distribution utility companies and also made available by the majority of advanced distribution management system (ADMS) vendors to autonomously manage system outages. [8,9]

The software foundation enables new services and functionalities; nevertheless, its integration with technologies from many manufacturers necessitates interoperability enablers such as communication protocols and a common information model (CIM) applicable to data obtained from diverse sensors. [10,11]

This study reviews the state of work carried by various researchers in the field of FLISR in distribution management systems by using various computational methods. We give a much-needed evaluation of the trends and needs in protection research in this review paper, focusing on the remarkable approaches over the recent years. Finally, this review intends to serve as a summary of the key highlights of interest for system protection, modern computational approaches, and underlying assumptions.

2.APPLICATION OF FLISR IN MODERN TRENDS:

Fault location, isolation, and restoration (FLISR) is a critical function in distribution management systems (DMSs). It is used to quickly and accurately locate and isolate faults in power networks, which can help to improve the reliability and efficiency of power delivery.

The FLISR application function detects, locates, and isolates the defective segment of the network in order to restore service to clients downstream of the fault via switching actions.

Early FLISR applications were built on the assumption that a problem was caused by a single source. The conventional FLISR is influenced by several generating sources paired with low fault-current characteristics.
In recent years, there has been a growing interest in using computational intelligence techniques for FLISR in DMSs. These techniques offer a number of advantages over traditional methods, such as the ability to handle noisy data and the ability to learn from past data.

The need for a more dependable grid has prompted utilities to investigate and adopt FLISR to achieve this goal. A study of five FLISR implementations undertaken by the Department of Energy in 2014 concluded that CMLs and CIs might be reduced by up to 51% and 45%, respectively, for a fault occurrence resulting in an outage [12]. One of the primary characteristics that improve smart grid networks is the use of fault location, isolation, and service restoration technologies, which reduce or decrease network downtime when a failure occurs. The United States Department of Energy states that "FLISR technologies include automated feeder switches and reclosers, line monitors, communication networks, distribution management system (DSM), outage management system (OMS), supervisory control and data acquisition (SCADA) systems, grid analytics, models, and data processing tools [13]

Algorithms can be used to automate FLISR operations. based on logic incorporated in controllers for appropriate signals, a multi-agent strategy, or more complex methods such as the genetic algorithm or Prim's algorithm [14,15]

The concept of transforming existing grids into Smart Grids enables us to use FLISR automation, which is a dependable technology. A way to improve grid efficiency, dependability, and security. However, the best results are produced when considering the distributed architecture of FLISR automation, due to increased monitoring opportunities, scalability, and compatibility with contemporary grids. The proposed distributed FLISR automation, which is ideal for grids earthed by resistors or for reclosers situated deep in the compensated network, was realized for a bilaterally powered loop topology with field controllers installed in MPS stations, NOPs and other locations. Appropriate style is still applied to each section, reapplying styles if necessary.[16]

Many elements influence the dynamic of FLISR automation development, including

- financial resources.
- Defined Goals
- Technologies that are widely available.
- Local research center policies.
- Offers from companies that provide smart grid solutions in each location. [17]

The FLISR strategy necessitates modern GOOSE technology as well as connectivity. The final option is to employ a SCADA system in conjunction with distribution network management software. Based on information from feeder devices such as FTUs, fault indicators, reclosers, and so on, the computer application creates fault isolation and restoration plans. The SCADA/DMS may gather and transmit data as well as perform switching actions. In the event of a network failure, feeder terminal units can interact with one another and complete FLISR steps automatically.[18]

To assist the distribution network fault management process, multi-agent systems (MAS) have been proposed, which might be an emergency control agent, restoration agent, corrective control agent, or preventative control agent. More specifically, when a fault occurs, the emergency control agent sends out signals to isolate the defect. The most recent data from the database is then used for restoration plans carried out by the restoration agent. [19,20]

Smart grid applications including enhanced outage management and fault location, isolation, and service restoration (FLISR) are being developed and incorporated into Outage Management Systems (OMSs) and Distribution Management Systems (DMSs). These technologies aid distribution operators in developing optimal system operation strategies and responding quickly to disturbances with control actions.[21] The self-healing and robustness of the power system largely depends on the Fault Location, Isolation, and Service Restoration Systems (FLISR) techniques used [22].

The demand for and utilization of FLISR is increasing. Recent advancements in the adoption of the FLISR methodology include computational methods.

3.COMPUTATIONAL INTELLIGENCE TECHNIQUES FOR FLISR

A few computational intelligence techniques have been used for FLISR in DMSs, including:

- Artificial neural networks (ANNs)
- Fuzzy logic
- Genetic algorithms
- Support vector machines
- Bayesian networks

- Expert System
- Support Vector Machines.

These techniques have been shown to be effective in locating and isolating faults in power networks. However, there are still some challenges that need to be addressed, such as the need for more accurate data and the need for more efficient algorithms.

In general, developing a fast and effective FLISR algorithm within the allotted restoration time is critical. Several methodologies, including as heuristics, meta-heuristics, expert systems, and mathematical programming, have been presented to develop service restoration plans in the distribution network.[23,24]

Neural networks (NN), genetic algorithms (GA), fuzzy theory, tabu searching (TS), particle swarm optimisation (PSO), simulated annealing (SA), non-dominated sorting generic algorithm-II (NSGA-II), and ant colonies (ANT) are used to develop service restoration solutions. However, when used in actual distribution networks, these meta-heuristic approaches need a significant amount of processing time [25,26] A distribution automation solution based on a multi-agent system is proposed to solve the service restoration part of the FLISR problem.

Furthermore, the literature review revealed that the MAS application in the domain of power systems is still restricted to theory and lab simulations [27]. There is still a sizable disconnect between laboratory setting and industrial field systems. Real-time and offline methodologies are employed for the simulation and verification of MAS application in the power system [28]. Some authors used MATLAB to integrate the MAS and power system model, similar to [29]. Data from the offline power system is used as an input by the offline approaches for the MAS. Using an electric network, a telecommunication network, and an application network, MAS-based steps to integrate the simulation environment are provided in Therefore, one of the gaps that can be filled by future study is applying the MAS approach to industrial products.

The researchers describe an anti-islanding solution based on an artificial neural network. of the distributed generators, whereas [30] proposes a convolutional Neural Method for detecting islanding in networks. [31] proposes a fault zone identification system based on a logistic regression binary classifier employing one-cycle post-fault current signals for fault detection. The researchers in [32] apply heuristics to locate faults in power distribution networks with DERs using voltage and current phasor data. Using metaheuristics, a differential evolution method, and linear programming formulations, [33] provides directed overcurrent coordination. The authors of [34] employ a support vector machine-based regression model for disturbance detection in low-voltage islanded microgrids

4. CHALLENGES AND FUTURE RESEARCH SCOPE OF FLISR

There are a number of challenges that need to be addressed in order to improve the implementation of FLISR technology in DMSs using computational intelligence techniques. These challenges include:

- The need for more accurate data: The data used for FLISR is often noisy, which can affect the performance of computational intelligence techniques. More accurate data is needed to improve the performance of these techniques.
- The need for more efficient algorithms: The algorithms used for FLISR can be computationally expensive. More efficient algorithms are needed to reduce the computational burden of FLISR.
- The need for more robust techniques: FLISR techniques need to be more robust to changes in the power network. This is especially important for techniques that learn from past data.

In general, a FLISR approach can only be successful if it relies on the operation of both hardware and software, such as [35]

- smart metres, actuators, switches, communication channels,
- fault detection and location algorithms, circuit breaker and tie switch switching sequences during fault isolation and system restoration.
- Installation of intelligent equipment, such as remote terminal units, intelligent electronic devices (IEDs), fault indicators, or advanced metering infrastructures (AMI), is suggested to aid in the execution of the FLISR plan
- Upgrading existing equipment to gain smart capabilities; Using a decentralized control system for real-time self-healing; Using two-way data communication networks;
- Improving fault detection, localization, and isolation algorithms;
- Service restoration options with the least number of disrupted customers and the least amount of downtime
- Reducing the entire processing time of fault detection, localization, and isolation, as well as the post-fault service restoration process,
- by increasing the number of switching operations without breaching operation restrictions.

5.CONCLUSION

The implementation of FLISR technology in DMSs using computational intelligence techniques is a promising area of research. These techniques offer a number of advantages over traditional methods, such as the ability to handle noisy data and the ability to learn from past data. However, there are still some challenges that need to be addressed in order to improve the performance of these techniques.

- Future research in this area should focus on addressing the challenges of data accuracy, computational efficiency, and robustness with further research, FLISR techniques have the potential to significantly improve the reliability and efficiency of power delivery.

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