<Conference abbreviation>
<Conference Series name> <Volume number and Year> <DOI Number>

A review on IoT Based Systems for Fault Detection in Power Line and Utility Poles

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Abstract

As the urgent need for dependable energy supply necessitates that utility companies establish robust fault detection systems on utility poles as the current system requires costly manual inspections of utility poles to detect faulty equipment through reactive measures. This paper presents a review of IoT-Based Autonomous Sensor Units (ASUs) that monitor voltage (V), current (I), tilt (T), and weather conditions in real time and utilise Energy Harvesting Technology (EHT) to produce up to 200 mW of electric power via long range LoRa communication technology and safer non-contact sensors. Through the findings of this work, it has been shown that IoT Systems provide a 30% increase in accuracy on the detection of faults compared to traditional electric systems, as well as decrease the time associated with the repair of such faults enabling predictive maintenance models to be implemented.

Keywords. IoT, Power Line Monitoring, Fault Detection, Smart Grid, Wireless Sensor Networks, LoRa, Predictive Maintenance.

1. INTRODUCTION

Today's electrical systems struggle with a huge amount of finding issues, keeping things reliable, and upkeep, especially in places far from cities or hard to get to. Normal ways of checking things often take a lot of time, need many workers, and only react to problems, causing long times without power and danger for those doing upkeep. Connecting devices has created new ways to watch and control important systems: allowing a big change toward fixing things before they break and using data to make decisions [1]. One big problem for linked device systems that watch electrical grids is how to power the faraway sensors. To fix this problem, getting energy from the environment was looked at as a choice, using power from high-voltage lines hanging up high and adding to it with sun power, which had already been tested for single, linked device setups in distant places [2].

Energy-saving ideas like this let the system run with almost no people needed, cutting down on setup and upkeep costs, which makes the system last longer [3].

2. LITERATURE SURVEY

The following study is classified as a systematic review. The authors searched IEEE Xplore, ScienceDirect, and SpringerLink to locate 17 articles from 2011 to 2024 related to IoT fault detection, power line monitoring, and smart grid sensing while assuring that no studies include research dealing only with SCADA systems

A. Evaluation of LoRa and LoRaWAN Broadband through Practical Applications A research group in Glasgow has evaluated the performance of both LoRa and LoRaWAN Wireless Technologies for the purpose of creating maps showing Received Signal Strength Indicator (RSSI) & distance (Tx range) using Semtech's SX1272 Transceiver Accelerators. In addition, Multitech mDot modules were used to evaluate the performance of a LoRaWAN network. It was found that there was a very high percentage of connection loss during tests of reliability due to aggressive disconnection policies for inactive phones/internet service providers (ISPs). There were improvements in the success rate of connection tests (95.5%) by introducing ICMP pings.

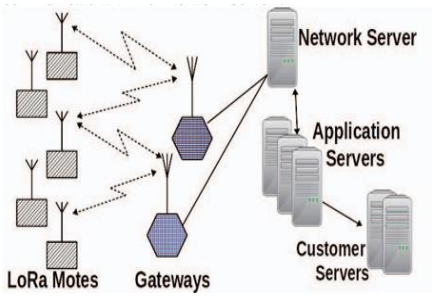

Fig. 1: Block diagram of LoRa WAN topology [3]

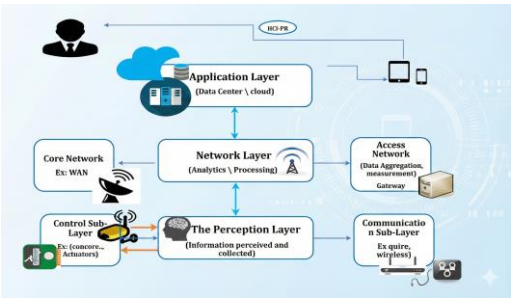

Fig. 2: Block diagram of Architecture of Iot [4]

B. IoT Architecture Alhebshi & al. [4] propose a three-tiered architecture for IoT devices consisting of: 1) the Perception Layer (for collection of data), 2) the Network Layer (for transmission) & 3) the Application Layer (for Industrial Services). They have developed an architecture based on the use of Arduino Uno (ATmega328P) devices which provide advantages such as simplicity of construction and the ability to use multiple communication module options, making them well suited for scalable fault detection and identification systems.

C. Sonoli et al. [6] proposed the use of a NodeMCU-based system that combines the ability to switch controls on and off with the ability to detect faults as a method of minimizing safety risk to linemen. The system uses a mobile app that allows linemen to turn poles on and off remotely. The downstream pole detects cut wire and signals the upstream pole to turn off electricity when the downstream pole recognizes that it no longer

has an electric current. This automatic response mechanism protects workers while also aiding in the quick identification of faults in the field.

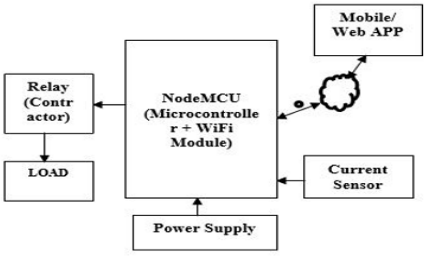

Fig. 3: Block diagram of lineman security system [6]

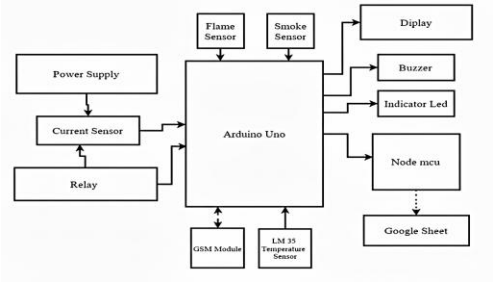

Fig. 4: Comprehensive IoT-Enabled Fault Detection and Monitoring System Using Arduino Uno. [9]

D. Alam et al. [9] developed a comprehensive monitoring system for the power grid in the country of Bangladesh using Arduino Uno. This system utilized a combination of flame and smoke sensors to monitor for fires, current sensors to monitor the loads, and temperature sensors (LM35) to assist in safety monitoring. A GSM module is used to send SMS alerts in real-time, while NodeMCU uploads the monitoring data to Google Sheets for both real-time visualization of the data and historical data analysis. This enables the user to collect data effectively from an environment with high moisture content.

E. By integrating web-connected devices with Artificial Neural Networks (ANN), Prabhu et al. [10] improved upon conventional methods used for fault detection through the use of ANNs. Their methodology incorporates pre-processing the signal data to eliminate background noise, then performing mathematical analysis on the processed signal data in order to identify the fault characteristics that were presented in the signal data. This AI-based methodology provides improved levels of accuracy and reliability when it comes to identifying faults as compared to traditional approaches.

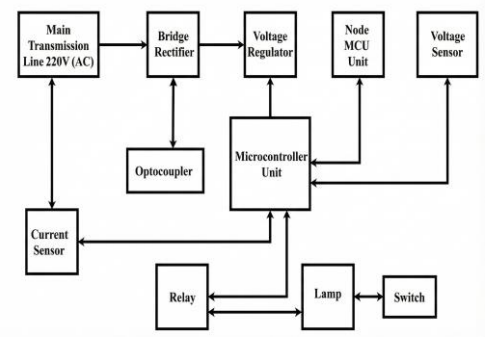

Fig. 5: Block diagram of ADFS system [10]

3. CONCLUSION

Significant progress has been made in IoT-based methods for monitoring of Power Grids as seen through the literature. Non-contact Voltage Sensing, Impedance Analysis, and Renewable Energy Harvesting have all developed from previous methods to include additional sensor types. Communication methods such as LoRa, NB-IoT, and 5G allow all the available information about a power grid to be monitored in real-time with more reliability than before. In addition to improving the safety of linemen and automating the location of faults, advancements in these technologies lead to increased resilience of the grid and less downtime.

4. FUTURE WORKS

Future studies will need to develop Hybrid Solutions combining Multi-Modal Fault Detection with Green Energy Harvesting and Predictive Analytics. The technology will also need extensive real-world Testing under Artificial Conditions to ensure the durability of these systems. Furthermore, the use of self-repairing properties and enhanced Cybersecurity Protocols will be necessary for the widespread adoption of Smart Grids.

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