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IoT based Smart Fault Identification and Monitoring System for Electric Poles

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Abstract

Electricity is essential in modern life, but damaged power lines cause thousands of electrocutions in India every year. To fix a damaged power line, the power supply is turned off, and a fuse controller is placed on the electric feeder. If the fuse controller trips on a broken wire, the electricity is cut off until the damage is located. This process can be time-consuming and requires resources. This research aims to design a IoT based control system to reduce the time for repairing broken electrical lines and prevent accidents by adopting measures to expedite the repair process, enhance safety, and optimize maintenance efficiency. LoRa devices are installed every 1 km along the cable for a total range of 10 km. A central tower marks the halfway point. A single LoRa device at the tower may be more cost-effective than multiple devices at each pole. A control circuit embedded by transistor and diode safeguard the circuit's integrity and ensure current flows in a single direction, protecting it if a wire between two poles is damaged. After locating damage to a pole, an email is sent to the relevant authority, including location, pole number, and incident time. An automatic alarm will sound when electricity is turned off, warning the public of the danger. Additionally, this system saves time and resources, and is cost-effective.

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1. Introduction

Each year, thousands of Indians get electrocuted as a result of faulty power cables scattered throughout the streets. 9,986 electrocution deaths were reported nationwide in 2015 alone, according to the National Crime Records Bureau [1]. The number of fatal electrocutions rose from 8,945 in 2011 to 13,446 in 2020. 30 Indians lose their lives to electrocution per day, according to a 2019 Times of India investigation [2]. These are indeed startling numbers. Data from the Directorate of Electrical Safety (UP) indicates that, rather than declining, the death rate from electrocution has doubled during the past seven years [3]. Thus, the goal of this initiative is to lower the number of electrocutions-related deaths [4].In the conventional troubleshoot, when a power line is severed, the electricity supply from the substation is disconnected, and a fuse controller is installed in the feeder to enable power transmission from the substation [5]. If the feeder has four connections, each connection is equipped with a fuse controller to allow the power to pass through. At this point, the fuse controller installed in the damaged line will begin to drip off, and this process will be repeated until the damaged site is identified [6]. However, this process is time-consuming and requires a significant amount of human resources [7]. Moreover, it cannot commence until the rain subsides, which is particularly crucial during the rainy season [8].

IoT-based technology is used in this project to address the aforementioned problem [9]. In the event of a power line failure, the electricity supply is immediately disconnected, and an alarm is triggered in the affected area to alert individuals of the potential danger [10]. Simultaneously, the precise location of the damaged pole, accompanied by the date and time of the incident, is forwarded to the designated email address of the authorities. The implementation of this feature was accomplished through the use of Python programming, which enabled the transmission of a detailed email to the appropriate authorities [11]. The email includes an extensive report of the date, time, and circumstances leading up to the damage, in addition to the specific pole number where the incident took place [12].

2. Proposed System

The Figure 1 depicts the proposed system components configuration, which comprises multiple LoRa devices. The tower, which houses a built-in Wi-Fi module and Raspberry Pi, needs to be strategically placed at the center of the 1-kilometer LoRa device, which has a range of approximately 10 km [13]. A transistor is used to power off any devices that are not receiving power within the 10-kilometer radius, which triggers the LoRa device to receive the signal and use a Wi-Fi module to transmit it to the Raspberry Pi. The email received by Python programming will be sent to the designated email account of the authority [14]. The webpage created by the authority will display a graphical representation of LoRa devices within a 10 km radius of the Wi-Fi module using Python programming. This graphical representation will make it easier to identify malfunctioning LoRa devices by displaying them as a star connection [15]. This will help in replacing the broken line. Additionally, when the power in a pole is cut off, the alarm in that pole will turn on automatically.

The proposed device configuration will consist of two component boxes. Box 1 includes the Raspberry Pi and Wi-Fi module. The pole is equipped with a Raspberry Pi and a Wi-Fi module, which will have a range of ten kilometers. On the other hand, Box 2 comprises the PNPN transistor, PN junction diode, Arduino, 5V relay, buzzer, and LoRa module. The tower is placed in the center of one LoRa device, which is configured for a range of approximately one kilometer, providing coverage for an area of roughly ten kilometers.

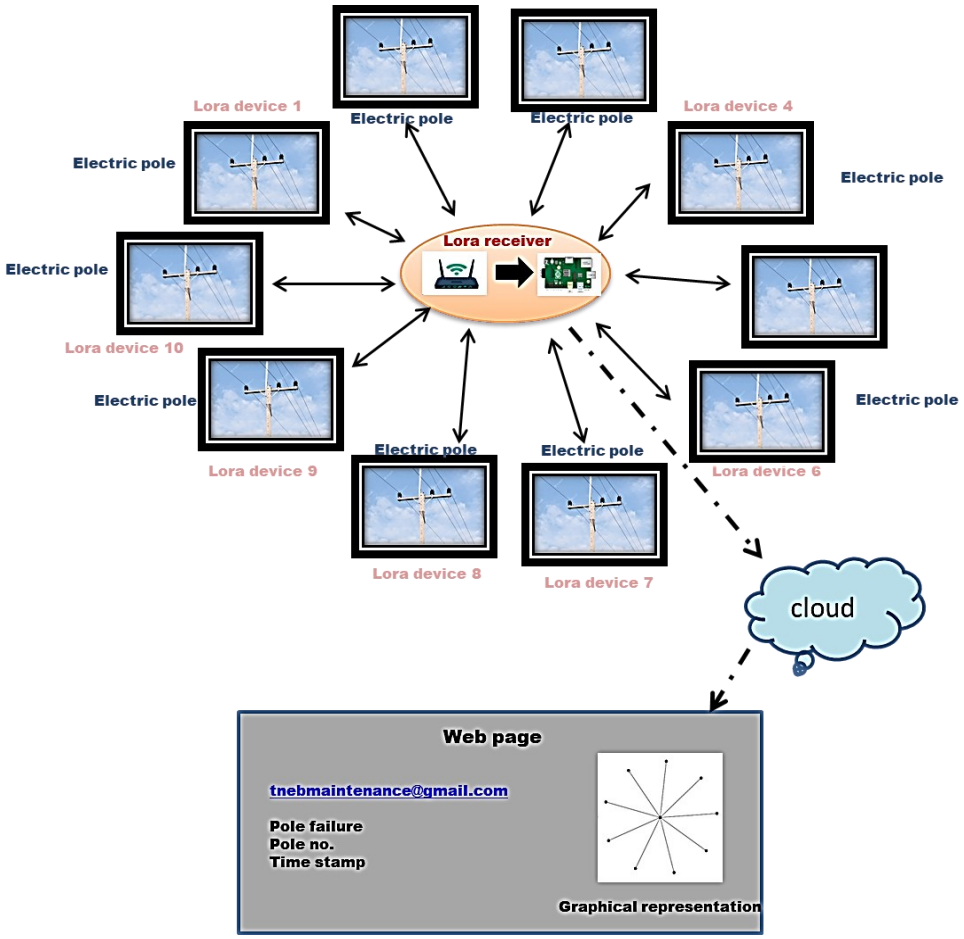

Figure 1. Overall Architecture of the Setup

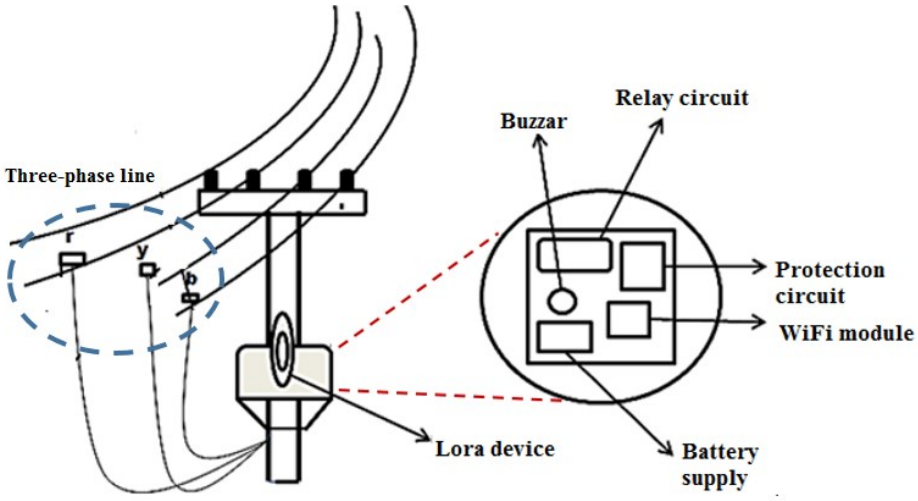

Figure 2. LoRa Device Placement in Electric Pole

The working of the proposed system is described in the following section. If a line connecting two poles within a 1km range is severed, the supply will not reach the device since the transistor and diode conduct current in only one way. As a result, the supply in that particular region will be automatically turned off. To achieve a range of approximately 10 km, a single LoRa device equipped with a Wi-Fi module and Raspberry Pi should be placed at a distance of 1.6 kilometres. If any devices do not receive the signal, the transistor turns off. The LoRa device then communicates the signal to the Raspberry Pi via the Wi-Fi module. The damaged area will be detected using Python programming and the information will be sent to the authority's predefined email address. The email will contain the specific pole number where the damage occurred, along with the date and time of the incident. Additionally, the authority's website will display a graphical representation of LoRa devices in a 10-kilometer radius surrounding the Wi-Fi module, which will show LoRa devices connected in a star pattern. This graphical representation will help identify any LoRa device problems. Fixing the damaged line will then be a straightforward process. When the power supply from the pole is cut off, an alarm is immediately triggered. The alarm will warn the public that damage has occurred in that specific area. This prevents individuals from accidentally stepping on the broken line, reducing the number of deaths caused by such situations.

3. Hardware Validation

Hardware model prototype for IoT base fault identification system for electric poles is shown in Figure 3. The pole is equipped with a Raspberry Pi and a Wi-Fi module. The protection circuit consists of NPN transistor (IN4007), PN junction diode, Arduino, 5V relay, buzzer. The communication system uses LoRa module. The protection circuit shut down the power automatically when any of the lines between any two poles gets faulted. If any of the devices do not receive the signal, then the transistor will switch OFF, and the LoRa device receives the signal and transmits the signal to Raspberry Pi with the help of the Wi-Fi module. Then by using Python programming, the mail will be sent to the predefined mail address of the authority so that the location of the damage can be identified easily. The mail comprises the exact pole number where the damage occurred and the date and time of damage. The response of the fault identification system is shown in Figure 4.Using Python programming, the authority's webpage will display a graphical representation of LoRa devices over the kilometres encircled by the Wi-Fi module. This graphical representation will display LoRa devices in a

star connection to identify LoRa device defects. Resolving the damaged line will be pretty simple. This innovation benefits to our society if a power line is destroyed, the system shuts off power in that zone and notifies authorities via email.

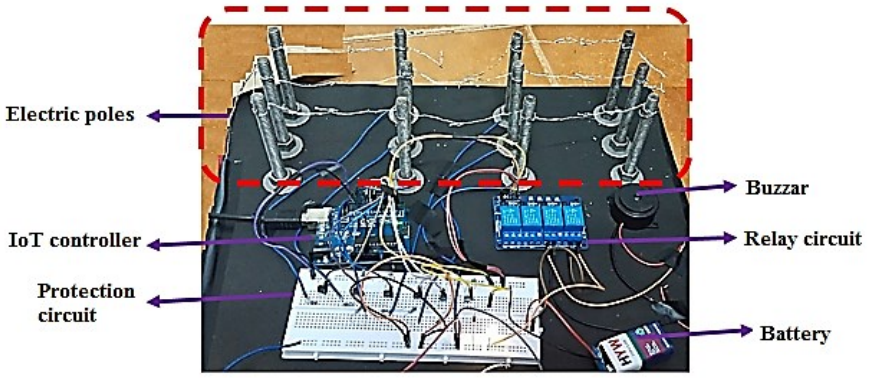

Figure 3. Hardware Image of Proposed System

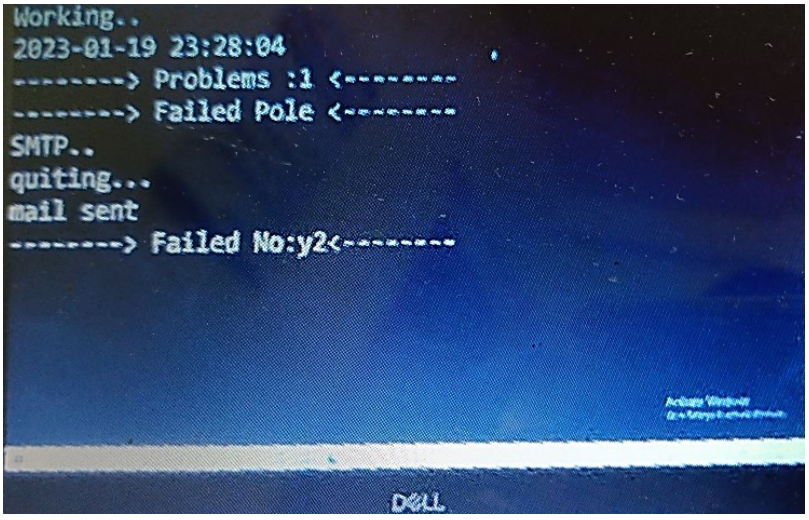

Figure 4. Fault Identification Response of Proposed System

4. Conclusion

This research presents a design of IoT based system to prevent accidents caused by broken electric lines, which would shorten the time needed to repair the lines. This IoT based control system uses a LoRa device in this configuration, as it can cover a large region. This reduces the overall cost of the research. If either of the lines connecting two poles is severed,

the power in that region will be switched off automatically. Then the mail will be transmitted to the authority's designated email address so that the site of the damage may be clearly identified. When the power goes off, the alarm will sound automatic. The alarm will alert the public that some damage has occurred in that specific region. This prevents people from stepping on that broken line, reducing the death rate due to this issue. As a result, this configuration reduces human resources, electrocution deaths, time consumption, and costs. This innovation will be highly beneficial to our society. When a line is damaged, the power supply is automatically turned off in that zone, and information is forwarded to the authorities' designated mail address.

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