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IoT-Enabled Landslide Monitoring System using LoRa Technology

S.Esakki Rajavel[1], B.Pradheep T Rajan[2], P.Haseena[3], Janani Esther Nilani A[4], Gomathi H[5]

Assistant Professor, Department of ECE, Faculty of Engineering, Karpagam Academy of Higher Education, Coimbatore, Tamil Nadu, India[1]

Assistant Professor, Department of ECE, Francis Xavier Engineering College, Tirunelveli, Tamil Nadu, India[2]

UG Scholar, Department of ECE, Francis Xavier Engineering College, Tirunelveli, Tamil Nadu, India[3,4,5]

Abstract: Slope collapses are a serious hazard to human beings and civilization because they are frequently caused by events like intense rain, seismic activity, or human interference. On the other hand, because of their shortcomings with regard to cost-effectiveness, real-time data collecting, and coverage, conventional monitoring techniques frequently fail. In terms of an early warning system for landslides, monitoring sloping areas involves long-term interactions, little human intervention, and a climate devoid of resources. Depending on the characteristics of the climate, information changes in the checking region may not be noticeable for several days, months, or years. As a result, it is not anticipated that a massive amount of data from the monitored region will be sent to a cloud server in one go. Additionally, long-term correspondence provided low power consumption and lower information rates with a full range correspondence convention. We designed an adjusted device network and passage network to monitor the progressions sporadically while using less energy thanks to LoRa innovation. We evaluated the measurable metrics of the sensor and door hubs, including transmitting element, alertness, time-live, power consumption, connect expenditure schedule, and the lifespan of batteries. Finally, this study concludes with issues that were gradually examined in which the sensor data was obtained via a modified device network and doorway on the web server. Finally, this study concludes with issues that were continually investigated and in which sensor data was obtained via an altered gauges network and gateway on the internet-based server.

Keywords: Landslide monitoring, customized node, Internet of Things, long range radio, LoRa link budget, LoRa sensitivity

I. Introduction

The increased precipitation brought on by climate change constantly increases the risk of landslides. Furthermore, optional factors, like out-of-control fires, greatly contribute to the formation of avalanches. The residents who are least fortunate will typically be the most vulnerable to avalanches because they frequently reside in dangerous areas. This is especially true in the Andes, where over 10 million people have regularly faced threats and there is a great deal of inequality. In order to forecast devices, factors like as conductivity measurement, quantity of water, and capacity for water are used. Fiber-optic delivered wirelessly has additionally been used for avalanche monitoring and also features a measuring resolution level of one meter. Large-scale erosion cases are monitored for disaster mitigation utilizing satellite SAR interferometry and corner reflector technology. A microprocessor in the sensor node of the early detection system for erosion reads data from the vibration sensor and transfers it to the master node via the WIFI module. Utilizing radar and optical remote sensing for mapping and monitoring landslides. A temperature sensor and extensimeter sensor are used in the landslide monitoring system to provide a range of measurement of 1023 mm and 1 mm of accuracy. The changing shape of soil and the amount of ground water are the primary indicators that are utilized as a signal of landslides, according to a number of researches. The web of things, or IoT, is an interconnected series of objects in which commonplace items have been equipped with controllers, which devices, and computer software. This allows the items to gather and exchange data with users and a variety of objects, making them vital components of the internet. There is an enormous need for Web application development nowadays. Therefore, IoT is an essential invention that allows us to create a variety of practical online apps. IoT stands for Internet of Things, which is essentially a network in which all physical items exchange data and are linked to the internet via network

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devices or routers. IoT makes it possible to manipulate objects over current network configurations. IoT is an excellent and clever approach that makes physical things easily accessible and minimizes individual effort. Additionally, this technology offers autonomous control, which enables any gadget to operate without the need for human intervention. The goal of the Internet of Things paradigm is to increase its persistence. In addition, the Internet of Things (IoT) facilitates simple access and communication with a broad range of devices, including home appliances, security cameras, monitoring sensors, and so forth. This allows developers to create apps that leverage the copious amounts of data generated by these objects and offer services. On the other hand, analysts have also seen the advancement in IoT innovation and low power wide area networks remote detecting (LPWAN) networks. The industry appears to be more focused on promoting technologies based on LoRa to support human culture. IoT environments powered by LoRa provide multidimensional operation in a variety of disciplines. End devices, an interface that connects end devices to servers, are a sensor hub found in LoRa networking. LoRaWAN has the capability to provide enhanced communication between the sender and the recipient. IP association is used to connect servers and doors in a star topology. A game plan that is several to many, multiple to one, or one too many might be laid out using leap connect. Within the corporation, all hubs exchange and receive data. For remote applications where end hubs are transported over a considerable distance, LoRa is the best option. In order to lower the risks connected to and lessen the damage caused of these climatic events, this system work aims at creating early notification and immediate data gathering capabilities. Warning can be set up in the system to be sent to the appropriate parties, such as rescue organizations and the municipal government. Users can receive these warnings via email. The solution can drastically cut down on emergency services' and authorities' reaction times by giving them access to real-time data. IoT sensors have the ability to continuously gather and provide data regarding temperature, precipitation, stream levels, humidity in the soil, and other pertinent environmental factors. In addition to crisis management, renewable energy initiatives can make use of the gathered data. For instance, keeping an eye on sediment movement and collapse of soil can aid in the development of ecosystem protection plans. [4] discussed that A robot is a machine that can automatically do a task or a series of tasks based on its programming and environment. They are artificially built machines or devices that can perform activities with utmost accuracy and precision minimizing time constraints. Service robots are technologically advanced machines deployed to service and maintain certain activities. Research findings convey the essential fact that serving robots are now being deployed worldwide. Social robotics is one such field that heavily involves an interaction between humans and an artificially built machine.

II. Methodology

LoRa wireless networking provides remarkable far-ranging transmission capabilities with minimal electric utilization, hence addressing these difficulties. Because of this, it's a great option to build a solid Internet of Things infrastructure for monitoring landslides. Using an IoT strategy based on LoRa has many advantages. First of all, it permits timely identification, which enables societies and administrations to respond proactively to conditions that change. With so many low-power sensor types supported by the sensor node that is being shown, there is a wide range of potential applications. In order to identify the soil movement and humidity that typically result in avalanches, a landslide monitoring system was constructed for this project. Detects the flood monitoring alarm by keeping an eye on the water level as well. Wide area network (LoRa) technology, which is long-range and low-power, is used in the proposed system. Numerous devices, including motion, wetness, float, and moisture sensors are part of this system. The Arduino NANO has been combined with these sensed devices. These sensors provide the data, which is then wirelessly transferred to a central monitoring station via the LoRa network. Here, utilize modern data analysis to identify early indicators of impending landslides, such as abnormal shifting of the earth, changes in humidity, and elevations of water. The technology may automatically send emails and warnings to the appropriate authorities and local communities in the event that an eventual avalanche event is recognized. By facilitating prompt evacuation and disaster management, this quick reaction system eventually lessens the toll that landslides take on human life and property. Avalanche-inclined region observation hubs powered by the Web of Things (IoT) are used to monitor the exact slant strength advancements and respond to cloud presidents optimally to carry out extra necessary advancements. The goal of the sensor hub, facilitator hub, and door hub is to improve society by using little power and covering a wide communication range.

System Architecture:

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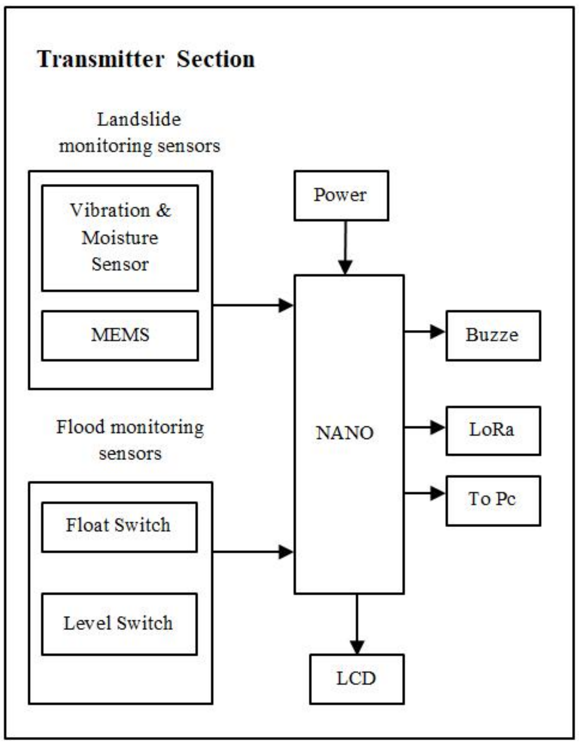

Fig (a) Transmission Module

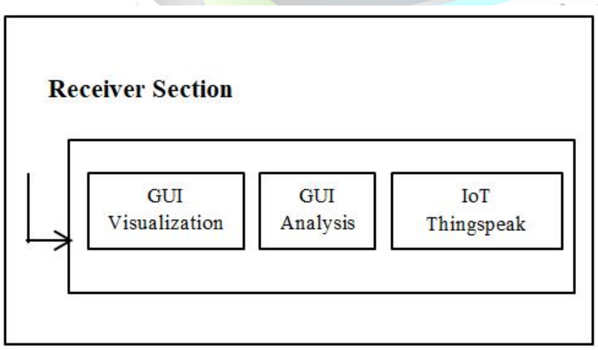

Fig (b) Receiver Module

There are two portions in this work: the receiver-monitoring section and the transmitter section. The transmitter block diagram shown above displays the proposed transmitter portion. The Arduino NANO, a number of sensors, including a humidity, rainfall, MEMS, vibration, and float sensor, as well as a power supply component, make up the transmitter section. These devices track temperature, which avalanche detection, moisture content in the soil, and rainfall. Float sensors measure the level of water in the rain, which investigates flood warnings. Monitoring and observation over the working atmosphere could be aided by continuous tracking mechanisms. Instantaneous monitoring systems can benefit greatly from LoRa technology, as it offers numerous advantages. With that in mind, the main goal of this effort is to create an effective real-time monitoring system that will enable the detection of landslide hazards and the subsequent development of preventative initiatives. The warning signal will go off right away if there is any spontaneous movement for ground shifting because it will be clearly marked as the greatest hazard. Through the use of a web page on a computer connected via a USB port, the tracking of this landslide may be checked and observed directly.

A. Data Collection:

Using a variety of electronic parts and devices, an IoT-based LoRa-based avalanche and flood detection system must be designed in order to gather pertinent data. A moisture analyser measures the moisture content of the soil to track variations in surface hydration. Soil moisture levels are regularly monitored by a moisture sensor. Unexpected rises in moisture content could be a sign of landslide-prone areas. Float Sensor keeps an eye on water levels to spot possible floods. This sensor keeps an eye on the water levels in reservoirs, streams, and rivers. Flood warnings are issued when water levels increase quickly. A vibration sensor picks up vibrations in the ground brought on by a variety of things, such as landslides or construction work. Unusual trends prompt additional research. For thorough data analysis, MEMS sensor measurements are employed to identify environmental factors including temperature, humidity, and pressure. Unexpected changes, particularly after a lot of rain, may indicate a landslide risk.

B. Landslide Detection:

Periodically, information from sensors is gathered and compiled for examination. Utilizing LoRa technology, integrated information can be seamlessly sent across vast distances while consuming minimal power. The data is transported, received, processed, and stored in a database for analysis by a central server or cloud-based platform. Real-time analysis is performed on received sensor data. Data is processed by algorithms to find trends and abnormalities. Every sensor has a threshold value set. A possible landslide alert is set off if measurements from sensors exceed these levels. The device sounds a bell and notifies the appropriate authorities as well as local neighbours when it detects a possible landslide. Real-time representation of data is available on the LCD panel, which displays status

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notifications and present sensor measurements. In case of landslide or flood detection, the LCD display shows alert messages and advises necessary precautions. [6] discussed that using wireless technologies like Wi-Fi or WiMAX, a VANET enables communication between and among moving vehicles as well as Road Side Units. As VANETs develop, their potential uses will increase. As well as safety apps, it is expected that automobiles will be able to run entertainment apps like those that allow passengers to share media or connect to the internet while on the go. Most of the time, this is what causes your mobile data plan to go over.

III. Implementation Results

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Several IoT sensors are combined using the hardware configuration. Real-time data monitoring is done with Arduino NANO-controlled sensors. Based on the monitoring data, it can be said that the system's design effectively captures changes in the displacement of landslide fractures. Because there will be outside influences during actual monitoring—such as severe rains, fog, and tree cover—the impact of these conditions on the monitoring system should also be taken into account. This mostly refers to the interference of LoRa's transmission signal. The findings demonstrate that the LoRa ad hoc network reflects the benefits of wireless sensors for detecting certain kinds of collapses; nevertheless, for larger-scale and larger-volume landslides, additional switches may be needed to realize the efficient transmission of data.

A. Arduino NANO

Although it comes in a different package, Arduino Nano shares many of the same features as Arduino Duemilanove. Similar to the Arduino UNO, the Nano is built with an ATmega328P microprocessor. The primary distinction between the two is that the Nano is offered in a TQFP (plastic quad flat pack) configuration with 32 pins, while the UNO board is supplied in a PDIP (Plastic Dual-In-line Package) shape with 30 pins. While the Arduino Nano has eight ADC ports compared to the UNO's six, the extra two pins on the Nano are used for ADC functions. Unlike other Arduino boards, the Nano board contains a mini-USB connector in place of a DC power jack. Both serial monitoring and programming are done on this port. The intriguing thing about Nano is that it will select the strongest power source with its potential difference, and the power source selecting jumper is invalid.

B. LoRa module

LoRa modules offer fervent wide-ranging bandwidth for energy-efficient intercommunication and dependable interference security. The automated system became stronger as a result. A printed circuit board (PCB) had an antenna and a microcontroller embedded into it.

LoRa is a spread spectrum-based low-power long-range wireless modulation and demodulation system. The Semtech Corporation of America pioneered and implemented the first ultra-long-distance wireless transmission technique as a linear modulation of frequencies spread spectrum modulation technology. Compared to other modulation systems, it has a substantially higher receiving sensitivity and an extended transmission range.

C. MEMS Sensor

A wide variety of manufacturing uses rely on MEMS, which are inexpensive, very accurate inertial measurement devices. Micro-electro-mechanical system technology, which is chip-based, is used by this sensor. Through the aid of certain industrial processes, those devices are utilized to both detect and quantify external stimuli such as pressure. They then react to the detected pressure.

Fig (a) MEMS Sensor

D. Vibration Sensor

A small, core less direct current motor is what a vibration motor is made of. This motor's principal function is to notify the user when a call comes in by vibrating or making noise. These motors can be used in many various applications, such as smartphones, pagers, and handheld devices. The primary characteristics of this motor are its tiny size, lightweight design, and magnetic qualities. The motor performance is quite constant based on these characteristics. There are two types of configurations available for these motors: a coin model and a cylinder model.

Fig (b) Vibration Sensor

E. Float Sensor

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This kind of interface water level sensor turns on a switch within a tank by use of a float. Another name for this switch is a level sensor. These relays are essential for regulating motors and other machinery, such as sirens that sound when the amount of fluid reaches or falls below a certain threshold.

Fig (c) Float Sensor

F. LCD Display

An electronic display unit known as an LCD (Liquid Crystal Display) screen has several uses. One of the most fundamental modules seen in many different devices and circuits is the 16x2 LCD display.

With a 16x2 LCD, there are two lines and 16 characters per line of text. Each character is shown in a 5x7 pixel matrix on this LCD. Command and Data are the two registers on this LCD. Data to be displayed on the LCD is stored in the data register, while command instructions are stored in the command register.

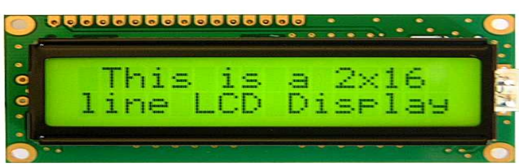

Fig (d) LCD Display

G. Moisture Sensor:

The soil moisture sensor is one kind of sensor used to gauge the volumetric content of water within the soil. As the straight gravimetric dimension of soil moisture needs eliminating, drying, as well as sample weighting. These sensors measure the volumetric water content not directly with the help of some other rules of soil like dielectric constant, electrical resistance, otherwise interaction with neutrons, and replacement of the moisture content.

Fig (e) Moisture Sensor

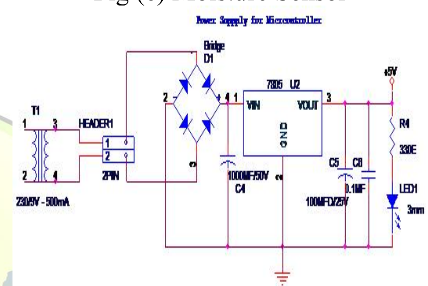

Fig (f) Power Supply

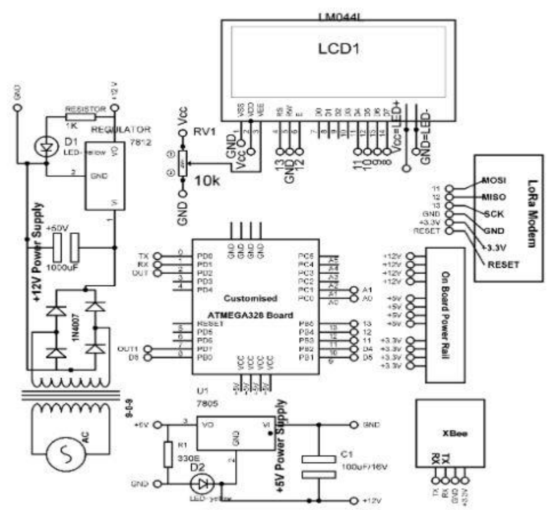

Fig (g) Circuit diagram

This section displays the data obtained from the sensor hub and entrance cloud servers in a running example. To obtain information, use detector ports connected to a door LoRa module at 433MHz. For data collection and monitoring, we installed accelerometers, moisture sensors, float sensors, and vibration sensors. Information was successfully posted to the entrance by the facilitator hub. Additionally, the door gathers data and stores it on a cloud server with the help of the LoRa module. Block-based coding design is used at this stage. The intended application shall display the float sensor, soil moisture, scope, and longitude data at the level of the prior warning notification. Furthermore, based on the rating received on the cloud, an immediate hazard signal will also be displayed on the application. The implemented use provided an outbreak tab to utilize in a current instance and an assistance tab to obtain the software's operating behaviour.

IV. Conclusion

The wireless communications protocol plays a major role in reliable communication between sensor hubs and a server in the Internet of Things. Among the well-known and emerging remote associations that adhere to the wide-ranging communication and minimum consumption of energy standards of the Internet of Things is LoRa. In this evaluation, we have designed an adjusted board and experimented with several LoRa evaluations for the structure of architecture in the Avalanche observation application. Upgrading early warning systems and mitigating catastrophic disasters are two important benefits of using LoRa-based avalanche and water overflow monitoring systems with IoT innovation. These observation frameworks provide continuous data collection, analysis, and transmission by combining the constant network of IoT devices with the wide-ranging, minimal power consumption capabilities of LoRa technology. Better accuracy, efficacy, and practicality in identifying and responding to probable avalanche and flood events result from this. This project included the programming and hardware of a remote checking framework and introduced an avalanche and flood observing framework with enhanced natural checking capabilities. In light of LoRa innovation, this project suggests the design and implementation of an IoT ecological monitoring, alerting, and regulating framework. IoT-enabled LoRa-based avalanche and flood observation systems save fatalities and damage to property while preparing for increasingly sophisticated, data-driven executive tactics. The ability to remotely monitor natural boundaries and gradually involve experts to take preventative action, removes residents from dangerous areas, and minimizes potential mishaps. Moreover, the data acquired over time can contribute to a deeper understanding of natural events, assisting long-term planning and strategy development for disaster-prone areas. All of the custom hubs participated in the real-time experiment, and data on cloud server periodicity was obtained. The application additionally displays a transmitting globe along with constant device network data. The upcoming redesigned organizer hub may be equipped with mist figuring in the future so that it may respond to changing conditions or, conversely, issue warnings.

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