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Lora Based Intelligent Automation for Home & Commercial Application

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Abstract: LoRa (Long-Range) has become the Deoxyribo Nucleic Acid (DNA) of the Internet of things (IoT) for equipping smart solutions. Home automation is responsible for providing a safe and stylish home. This paper proposes a capable architecture of home automation for long-range utilizing multiple communication technologies, namely LoRaWAN, server-based LoRa gateway. This Integrated system effectively controls distinct types of home appliances and keeps smart management among all the electronics components. A regular user can easily manage these unified systems by using an Android application. This paper also presents experimental data analysis. The results and discussion section provide a set of experiments like estimated transmission delay calculation for LoRa[1].

Keywords: LoRa = Long Range Radio, DNA= Deoxyribo Nucleic Acid ,CSS = Chirp Spread Spectrum ,LoRaWAN = Long Range Radio Wide Area Network (LoRaWAN) ,Wi-Fi = Wireless fidelity.

I. INTRODUCTION

Home automation refers to building automation, also called Smart home applications. Home automation technologies are used to control electronic components, entertainment system as well as home appliances. The home automation system also includes a security system for safety and security. When the whole system is connected to the internet, the corresponding operation has become a part of IoT. Thus, the global market for home automation is increasing day by day. LoRa has become one of the most effective solutions in the field of the Internet of things (IoT) as serving some most significant features, such as low cost and low power wireless platforms. LoRa technology uses LoRa Wide Area Network (LoRaWAN) protocol to solve several types of real-life problems like controlling pollution, preventing disaster, managing energy, reducing natural resources, and automation[2].

II. COMPONENTS AND SOFTWARE USED

Arduino UNO, ESP32 NodeMCU Sensor ,Relays, DC motor, Light,, power supply, Arduino IDE,

Gas leakage sensor ,Temperature sensor , Seismic sensor , Micro controller , Relay, LCD.

3. Block Diagram

DEVICE SECTION :-

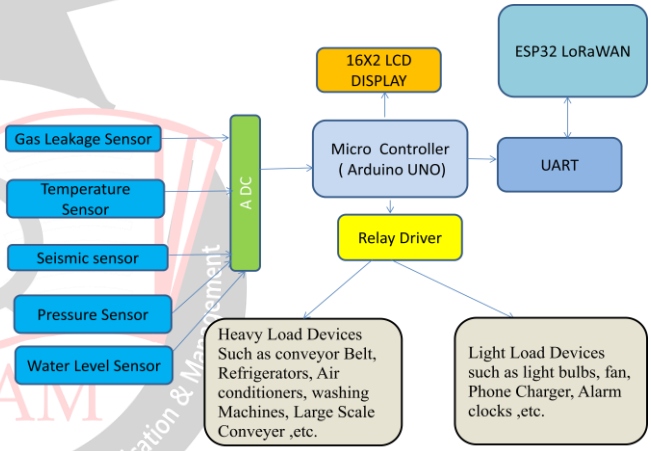
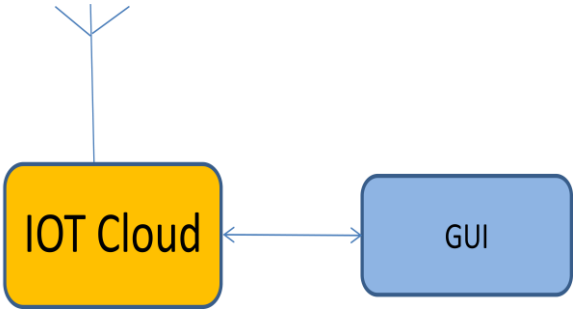


Figure 1: Block Diagram of experiment

IOT SECTION (USER SIDE):-



4. Specification of Components

4.1 Arduino UNO Board

The **Arduino Uno** is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator.

4.3 ESP32 NodeMCU

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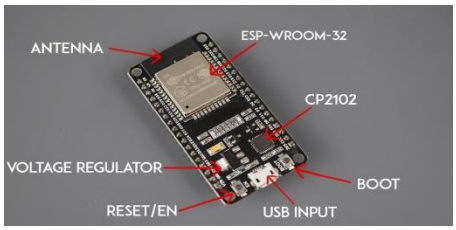

Figure 3: ESP32 NodeMCU

Specifications:-

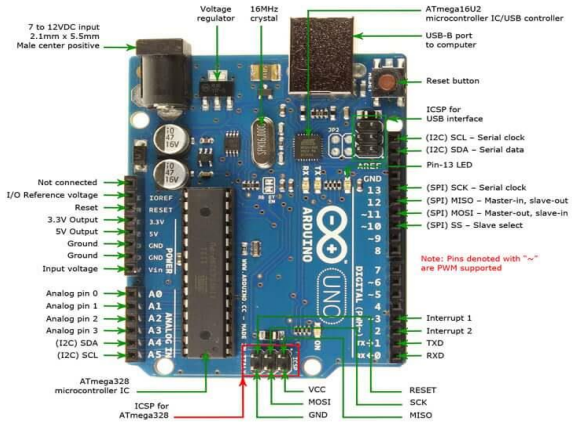

Figure 2: Arduino UNO Board

A USB connection, a power jack, an ICSP header, and a reset button. Arduino is an **open**-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and **turn** it into an output - **activating** a motor, **turning** on an LED[3].

4.2 5V Relays

One of the most useful things you can do with an Arduino is control higher voltage (120-240V) devices like fans, lights, heaters, and other household appliances. Since the Arduino operates at 5V it can't control these higher voltage devices directly, but you can use a 5V relay to switch the 120-240V current and use the Arduino to control the relay. A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal.

Figure 3: 5v Relay

The Arduino can be programmed to turn on the relay when a certain event occurs, for example when the temperature ofa thermistor gets higher than 30° C. Or when the resistance of a photoresistor drops below 400 Ohms. Almost any sensor can be used to trigger the relay to turn on or off[4].

- Microcontroller: ESP32-D0WDQ6
- CPU: Dual-core Tensilica LX6
- Operating Voltage: 3.3V
- Digital I/O Pins: 38
- Analog Input Pins: 18
- Flash Memory: 4MB
- SRAM: 520KB
- Clock Speed: Adjustable, up to 240 MHz

USES:-

- **Device Control:** The ESP32 NodeMCU serves as a node within the home automation network, enabling control over various smart devices such as lights, switches, and actuators.
- **Data Processing:** ESP32 NodeMCU processes data collected from sensors deployed throughout the home environment, analyzing environmental conditions and user preferences to make intelligent automation decisions.
- **LoRa Communication:** The ESP32 NodeMCU utilizes LoRa technology to communicate with other nodes and the Arduino Uno gateway, facilitating long-range, low-power communication for seamless connectivity.
- **User Interface:** ESP32 NodeMCU can host a user interface, allowing users to monitor and control the home automation system remotely through a web interface or mobile application.
- **Energy Efficiency:** With its low-power capabilities, the ESP32 NodeMCU helps optimize energy usage within the home automation system, contributing to overall energy efficiency and sustainability[5].

Overall, the ESP32 NodeMCU plays a crucial role in the LoRa-based intelligent home automation system by enabling device control, data processing, communication, and user interaction, ultimately enhancing convenience, efficiency, and user experience.

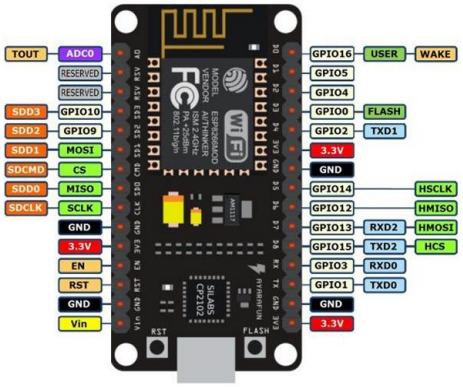

Figure 3: ESP32 NodeMCU

4.4 GAS LEAKAGE SENSOR

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A gas sensor is an electronic device that is used to detect the presence and concentration of specific gases in the air. The most common types of gases that are detected by these sensors include carbon monoxide (CO), hydrogen (H_2), methane (CH_4), and propane (C_3H_8).

MQ2 Gas Sensor specifications

Operating Voltage: 5V

Operating Current: 150mA

Concentration: 300-10000 ppm

Figure 4: GAS

LEAKAGE SENSOR

MODEL	MQ2 GAS SENSOR
OPERATING VOLTAGE	5V (DC)
ANALOG OUTPUT VOLTAGE	0V TO 5V
DIGITAL OUTPUT VOLTAGE	0V TO 5V (TTL Logic)
DIMENSIONS	3.6 x 2 x 1 cms
WEIGHT	5 grams

Table 1: GAS LEAKAGE SENSOR

4.5 Temperature sensor:

There're many types of devices that can be employed as temperature sensors. They include integrated circuits (ICs), pyrometers, resistance temperature detectors (RTDs), thermistors, thermocouples, electromechanical & volume (EMV). LM35 is a precision IC temperature sensor with its output proportional to the temperature

(in ^oC). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, temperature can be measured more accurately than with a thermistor[6].

Figure 5: Temperature sensor

Specifications:-

- Programmable Digital Temperature Sensor
- Communicates using 1-Wire method
- Operating voltage: 3V to 5V
- Temperature Range: -55°C to +125°C
- Accuracy: ±0.5°C
- Output Resolution: 9-bit to 12-bit (programmable)
- Unique 64-bit address enables multiplexing
- Conversion time: 750ms at 12-bit
- Programmable alarm options
- Available as To-92, SOP and even as a waterproof sensor[7].

4.6 Seismic sensor:-

- Seismic sensors serve the dual role of velocity sensors and accelerometers, monitoring the earth's vibrations.
- These sensors gather data about occurrences within a specified region when used for securing premises. They are adept at identifying ground vibrations, analyzing the data in real-time, and sending alerts to operators in case of a security breach.
- The system's intricacy can dictate the sensors' ability to distinguish whether the vibrations originate from human activity or vehicles and can also help pinpoint their exact location.
- These qualities make seismic sensors invaluable in infrastructure security, fencing, and perimeter protection.

Figure 6: Seismic sensor

Seismic Sensor Specifications

- Type of Sensor: Accelerometer
- Frequency Range: 0.1 Hz to 1000 Hz
- Sensitivity: 100 mV/g
- Dynamic Range: ±50 g
- Resolution: 0.01 g
- Temperature Range: -40°C to 85°C
- Output Signal: Analog (Voltage or Current)
- Power Supply: 12-24 VDC
- Environmental Ratings: IP65
- Physical Dimensions: 50mm x 50mm x 20mm

4.7 Relay:-

- A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used.

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- Relays are used where it is necessary to control a circuit by a low-power signal or where several circuits must be controlled by one signal.
- The first relays were used in long distance telegraph circuits, repeating the signal coming in from one circuit and re-transmitting it to another. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

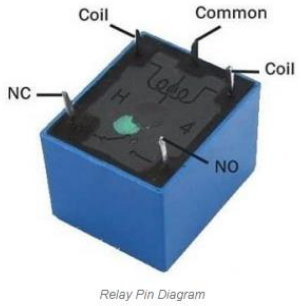

Figure 7: Relay

For commercial and industrial applications, several sensors are commonly used to monitor various parameters. Here are a few examples:

4.8 Pressure Sensor:

- Pressure sensors are essential for monitoring and controlling pressure levels in industrial processes. They measure the force exerted by gases or liquids on a surface and convert it into an electrical signal.
- They are used in applications such as HVAC systems, hydraulic systems, pneumatic systems, and industrial machinery.
- Pressure sensors help ensure the safety, efficiency, and reliability of industrial processes by providing accurate pressure measurements and enabling timely adjustments.

Figure 8: Pressure Sensor

Pressure Sensor Specifications:-

- **Type of Sensor**: Piezoresistive
- **Pressure Range**: 0-1000 psi
- **Accuracy**: ±0.5% full scale
- **Resolution**: 0.01 psi
- **Response Time**: 10 milliseconds
- **Temperature Range**: -40°C to 125°C
- **Output Signal**: 0-5 VDC
- **Power Supply**: 5-24 VDC
- **Environmental Ratings**: IP67
- **Physical Dimensions**: 20mm diameter, 10mm height

4.9 Temperature Sensor:

- Temperature sensors are crucial for monitoring and controlling temperature levels in commercial and industrial environments. They measure the thermal energy of a substance and convert it into a readable signal.
- Various types of temperature sensors are available, including thermocouples, resistance temperature detectors (RTDs), and thermistors, each suited for different temperature ranges and applications.
- Temperature sensors are used in HVAC systems, refrigeration units, manufacturing processes, food processing, and environmental monitoring, among other applications.
- They help maintain optimal temperature conditions, ensure product quality and safety, prevent equipment overheating or freezing, and comply with regulatory requirements.

Figure 9:Temperature Sensor

5. Water Level Sensor:

- Water level sensors are used to monitor and control the levels of liquids in tanks, reservoirs, and pipelines in industrial and commercial settings.
- They detect the presence or absence of liquid, measure the depth or height of the liquid level, and provide feedback to control systems.
- Water level sensors are employed in industries such as wastewater treatment, chemical processing, agriculture, water management, and oil and gas production.
- They help prevent overflow or underflow incidents, optimize water usage, ensure adequate supply for processes, and maintain operational efficiency.

Figure 10: Water Level Sensor

Specification:-

- Operating Voltage: +5V

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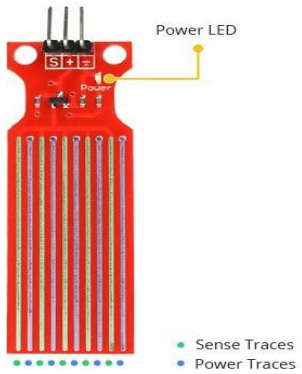
- Working Current : < 20mA
- Sensor Type : Analog or Digital
- Water Detection Area :. 1.58in X .63in (40mm X 16mm)
- Mounting Hole Size : 0.12in (3mm)
- Operating Humidity: 10% to 90% (non-condensing)
- Working Temperature: (-30 to 50degrees ºC)



Experimental Setup of Home And Commercial Automation Setup

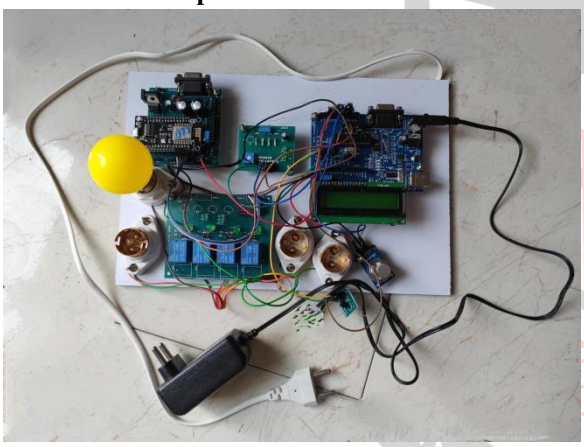


Figure 11 : Experimental Setup

OPERATION:-

i. Device Section:-

- Gas leakage sensor, temperature sensor, and seismic sensor are connected to an Analog to Digital Converter (ADC), which in turn is connected to an Arduino Uno.
- The Arduino Uno can accommodate up to 6 sensors, facilitating data collection from multiple sources.

1. **Internet of Things (IoT) Connectivity**:

- The data collected by the Arduino Uno is transmitted to the internet using LoRaWAN.
- LoRaWAN(ESP32 NodeMCU) acts as a connecting gateway between an Arduino Uno and a Wi-Fi modem.
- The ESP32 NodeMCU is programmed to handle LoRa communication and data transmission[8].

2. **Data Transmission:**

- Data from the sensors is transferred from the Arduino Uno to the ESP32 NodeMCU through LoRaWAN.
- The ESP32 NodeMCU then transmits the data to the internet via Wi-Fi.
- UART protocol is utilized for data transfer, which includes one start bit, 8 data bits, one data bit, a parity bit (optional), and a stop bit.

3. **Control Mechanisms**:

- The system supports both automatic and manual control of devices such as switches and relays.
- Threshold values are set for the sensors, and when these values are exceeded, automated actions are triggered.

4. **Data Display**:

- Sensor data is displayed on both an LCD display and a web page.
- The web page is designed and configured using PHP, providing a graphical user interface (GUI) for users to monitor sensor readings remotely[9].

5. **Transmission Frequency and Delay**:

- Sensor data is updated and transmitted every 30 seconds to minimize transmission delay.
- MQTT protocol is used on the data server side, facilitating efficient communication with minimal network footprint.
- LoRaWAN offers minimal transmission delay compared to Bluetooth or Wi-Fi, but Wi-Fi connectivity may still incur delays based on internet speed.

6. **Distance Considerations**:

- LoRaWAN has a maximum separation distance of 200 km, providing extended coverage for internet connectivity.
- Once LoRaWAN is paired with the Wi-Fi modem, remote control and monitoring can be accessed from anywhere in the world.

In conclusion, the system integrates various sensors, microcontrollers, communication protocols, and control mechanisms to enable remote monitoring and control of devices through the internet. By leveraging LoRaWAN and Wi-Fi connectivity, along with efficient data transmission protocols, the system ensures real-time monitoring with minimal transmission delay[10].

III. FUTURE SCOPE

In this paper, we have shown the result found on transmitting numeric data between modules.The effect while transmitting large data can be analyzed and presented. LoRa transmission between multiple devices can be tried to implement and the analysis for the same

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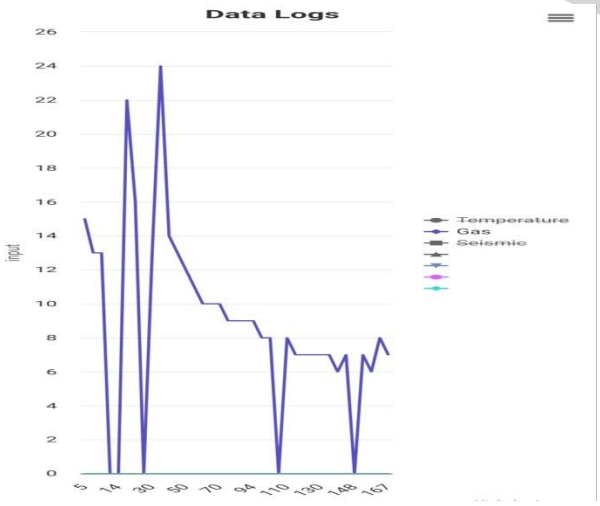
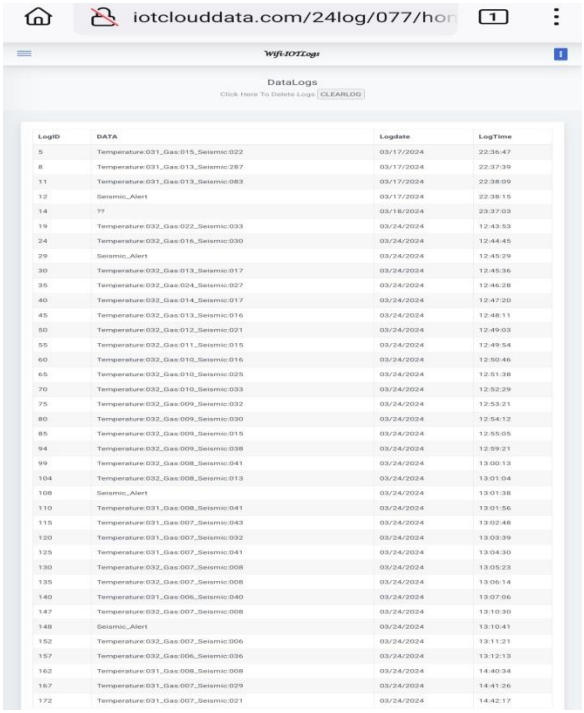
can be performed. The increment of the data rate without affecting power consumption could be a possible improvement in the technology.

IV. CONCLUSION

- LoRa-based automation systems offer a compelling solution for both home and commercial applications. Their cost-effectiveness, suitability for diverse settings, and affordability within the range of Rs 5000 to 10,000 make them accessible to a wide range of users. Compared to existing systems, LoRa-based automation significantly reduces power consumption, making it a sustainable choice. Moreover, its advantages in communication range, real-time responsiveness, power efficiency, enhanced security and privacy, as well as scalability and flexibility, make it the preferred option for modern automation needs.
- As a result, it's noted that transmission delays are contingent upon internet speed. To counter this, data is updated every 30 seconds. Unlike Bluetooth, LoRa experiences no transmission delay. However, transmission delays persist with Wi-Fi due to internet speed.
- To mitigate this, data is updated every 30 seconds, improving efficiency. Overall, LoRa technology presents a promising avenue for advancing society's automation capabilities in a cost-effective and efficient manner.
- LoRa technology has its own purpose of designing. So it incoperates different advantages and disadvantages.It has vast field of applications which can be explored. It has major application in IoT data transmission. It is cost effective and also covers wide area. So it has application in home automation , security systems , sensor connectivity etc.

V. RESULT ANALYSIS





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