**1. Abstract**

* This paper outlines a cost-effective, reliable IoT-based home monitoring and control system using the ESP32 microcontroller.
* The system connects to local Wi-Fi, allowing remote access and control via an Android smartphone application.
* Key functionalities include:
  + Monitoring various conditions like room temperature, gas leakage, water levels in a tank, and detecting presence within the home.
  + Control over devices such as lights, fans, motors, and gas knobs based on sensor feedback.
* Aim: Reduces human effort, conserves energy, and saves time through remote access and automated controls.

**2. Introduction**

* **IoT Advancements**: IoT facilitates monitoring and controlling devices over the internet, benefiting home and industrial settings.
* **Home Automation Focus**: This system allows users to control home appliances remotely, enhancing convenience, security, and energy efficiency.
* **System Overview**: Utilizes ESP32 as the main controller, enabling users to monitor and control home devices from a smartphone via Wi-Fi. The system includes a web-based dashboard for ease of use.

**3. Related Work**

* **Prior Systems**:
  + Systems using **Wi-Fi and Arduino**: Control devices remotely via a webpage server.
  + **SMS/GPRS-based systems**: Send messages to users, allowing remote control and monitoring of appliances.
  + **Cloud Computing**: Storing data and running applications remotely, accessible from connected devices.
  + **GSM and Bluetooth Integration**: Short- and long-range control for monitoring and controlling lights, temperature, and detecting intrusions.
  + **ADK-based Systems**: Focus on light, smoke, and temperature control using an Android interface.
  + **GSM-based Security**: Provides warnings for gas leaks and fires, enhancing safety in homes.
  + **ESP8266 Cloud-Based Systems**: Use PIR sensors for intrusion detection, sending alerts to users' smartphones.
* **Identified Limitations**: Complex circuitry and the need for advanced technical knowledge hinder user-friendliness in some of these systems.

**4. Proposed System**

* **System Overview**:
  + Aims to provide an efficient, easy-to-use, real-time monitoring and control system using ESP32, with simplified setup and control.
  + Uses cloud storage (*ThingSpeak*) for data storage and retrieval and an MIT App Inventor-created Android app as a dashboard.

**4.1 Hardware Components**

* **ESP32 Microcontroller**:
  + Central component of the system, handling sensor data, processing, and communication.
  + Dual-mode Bluetooth and Wi-Fi capabilities.
  + Operates at a voltage range of 2.2–3.6V, with typical power supplied at 3.3V.
* **Gas Sensor (MQ-3)**:
  + Detects gases such as LPG, methane, i-butane, alcohol, hydrogen, and smoke.
  + Electrochemical sensor with a heating element, sensitive to gas concentrations from 0.05 mg/L to 10 mg/L.
  + Commonly used for gas leakage detection in both residential and industrial environments.
* **PIR (Passive Infrared) Sensor**:
  + Detects motion by sensing infrared radiation from warm objects like humans or animals.
  + In this system, it is employed to detect human presence in a room, sending signals to ESP32 to trigger actions based on occupancy.
* **Relay Module**:
  + Four-channel 5V relay, essential for controlling high-voltage home appliances.
  + Relay outputs are connected to appliances like lights, fans, and motors, enabling ESP32 to control them via digital output signals.
* **Water Level Sensor**:
  + Measures the level of liquid in a tank, converting it into a voltage signal (0-5V).
  + 0V indicates minimum water level, and 5V represents maximum level, allowing the system to track water levels and control devices accordingly.
* **Servo Motor**:
  + Operates on servo mechanism principles, with position feedback.
  + Limited to a rotational range of 0° to 180°, often used in automated systems for controlled positioning tasks.
* **Buzzer**:
  + Audio alarm device for alerting users, often triggered by reaching critical threshold levels (e.g., gas leakage or water overflow).
  + Provides an immediate audio response, enhancing safety and awareness.
* **Temperature Sensor (LM35)**:
  + Monitors ambient temperature, providing a linear output voltage proportional to temperature (10 mV per °C).
  + Designed to operate within a range suitable for home environments, connected to ESP32 to trigger fan control when necessary.

**4.2 Software Implementation**

* **System Logic and Flowchart**:
  + The software monitors sensor data (temperature, gas levels, water level, and movement) and performs actions based on pre-set thresholds.
    - **Temperature**: If temperature exceeds a set threshold, the fan is activated, and data is stored in the cloud.
    - **Water Level**: When water reaches the threshold, the motor is deactivated, or the buzzer sounds, with data updates sent to the cloud.
    - **Gas Leakage**: If gas is detected, the servo motor is triggered, and values are sent to the cloud.
    - **Motion Detection**: When the PIR sensor detects movement, the buzzer sounds, and the data is recorded.
  + **Data Storage and App Display**:
    - Sensor data is uploaded to the *ThingSpeak* cloud storage.
    - The MIT App Inventor-created Android app dashboard shows live sensor values and actuator statuses.

**5. Results**

* **Hardware Setup**:
  + All components are embedded in a compact, durable box for protection and ease of deployment.
  + The system continuously records sensor values (temperature, gas, PIR, water level) and updates them on *ThingSpeak*.
* **Real-Time Monitoring and Alerts**:
  + The ESP32 continuously updates sensor data to the cloud, which is then accessible via the app.
  + If sensor values exceed predefined thresholds, the operator dashboard receives immediate alerts, and appropriate actions are taken (e.g., sounding the buzzer or switching devices on/off).
* **Dashboard Interface**:
  + The MIT App Inventor dashboard displays current values for each sensor:
    - **Temperature**: e.g., 13°C.
    - **Motion (PIR)**: Indicates occupancy (1 if detected).
    - **Water Level**: Displays tank status (e.g., “4” for a mid-level indicator).
    - **Gas Leakage**: Shows gas concentration (e.g., “459” for detected leakage).
  + Actuator status is displayed, providing users with control and real-time feedback.

**6. Conclusion**

* **System Summary**:
  + The ESP32-based system enables multi-device monitoring and control, enhancing home automation with IoT technology.
  + Three operational phases:
    1. **Monitoring**: Continuously tracks sensor data (temperature, gas, water level, and motion), updating data to the cloud and mobile app.
    2. **Automated Controls**: Executes specific actions automatically, like controlling the motor pump or gas knob when critical levels are reached.
    3. **User-Controlled Actions**: Users can manually control devices such as fans and lights through the mobile app.
* **Advantages**:
  + Cost-effective, straightforward operation, suitable for integration with various home appliances.
  + Improves energy efficiency, user convenience, and safety through automatic and remote controls.