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IoT in Smart Homes: Gas Leakage Detection and Prevention

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Abstract:

Gas leakage and poor management of kitchen safety and leakage of gases continue to be major causes of domestic accidents, damages to property, and severe health risks. Due to the fast performance of Internet of Things (IoT) technologies, nowadays, it is possible to implement measures against such risks in the form of intelligent monitoring and automated safety measures. The current paper outlines the design and implementation of a gas safety alert and smart kitchen monitoring system based on IoT technology that has a mobile application as a remote monitoring and control tool. The suggested system will constantly check the important environmental parameters including gas level, temperature, and the weight of the LPG cylinders with the assistance of sensor data which will be delivered via the Blynk cloud platform. An Android mobile app created on Android Studio is a secure user interface that has authentication capabilities and allows users to see real-time sensor readings and remotely control kitchen appliances.

In case of any degrading situations like gas leakage, extreme temperature, etc. The system will automatically start various safety systems like the instantaneous mobile notification, audible alert systems, automatic shut-off of the stove and activating the exhaust fan to avoid the possibility of gas build-up. Moreover, the system gives in to predictive cylinder monitoring as it constantly monitors the cylinder weight of LPG so that the user gets informed whether the gas is low and if he or she needs to replace it. Virtual data streams and dashboards on clouds will keep the data synchronized in real-time between sensors, simulation modules, and the mobile application. The modeling system of sensor behavior and emergency situations with the help of a Python based simulation environment proves that the system can identify unsafe situations and take timely security measures. The given solution should provide customers with a fast, economical, and easyto-use structure of smart home gas security that could increase the level of protection of households by eliminating accidents before they happen.

Keywords: **Gas leakage detection, IoT-based safety system, Blynk Cloud, virtual sensor simulation, predictive gas monitoring, context-aware alerting, smart appliance integration, Android application, REST API communication, real-time automation, warning and alarm alert system and cloud-based control.**

I. INTRODUCTION

Gas leakage placed in houses or business premises is a significant safety concern since it may readily result in fires, explosions, breathing complications, and severe property loss. Liquefied Petroleum Gas (LPG) is commonly present in homes under kitchens because of its efficiency, cheapness, and convenience. Nevertheless, the issue of gas leakage is still one of the key safety threats in residential areas, which mostly causes fire accidents, explosions, and other serious health threats. The majority of the accidents happen because of the undetected gas leakage, the incorrect ventilation, or the time-consuming reaction of people. The older or common gas detectors are all responsive to the gas when it has already reached a dangerous level; therefore, they react late. Conventional gas safety tools usually involve the use of manual ways of detecting gas e.g., by smell or rudimentary detectors with no mechanism of automatic action. They provide certain protection but do not forecast anything; they do not assist much in remote monitoring and cannot act independently, controlling the appliances. As the IoT becomes ubiquitous, there is now a strong necessity of smarter safety systems capable of monitoring the gas levels at all times, detecting the potential risks in time, and automatically acting and notifying people in realtime through various means of communication.

In this paper, a gas safety monitoring and alert system is implemented on IoT to be based on a Python sensor simulator, an IoT cloud, and an Android application. This is unlike the traditional solutions, which solely relied on physical sensors to provide the data, unlike the current solution, which begins with a Python program that produces realistic gas concentration, temperature, and LPG cylinder weight data. The system constantly examines environmental conditions like gas concentration, temperature, and weight of LPG cylinders and notifies us about the unsafe conditions. The basic threshold technique is used to determine whether the environment is safe or not. The resulting processed data is then uploaded to the Blynk Cloud where it is displayed in dashboards where the values are displayed in real time and can be remotely monitored via a web interface and a special Android mobile app. The mobile application is also secure in its user interface and has authentication features to enable the user to access system status and remotely control connected devices.

The cloud system is also capable of automatically adjusting responses such as turning off the stove, turning on the exhaust fan, activating alarms for audible warnings, and adjusting LED displays whenever leakage is detected. To ensure this cloud automation, an Android application service has a background service that continuously fetches the status of leaks through the Blynk Cloud.

In case the app identifies an unsafe environment, it alerts the user with a warning and alert sound if gas leakage is detected. The notification is sent through warning messages that are received by the users even in the absence of the internet, which is highly crucial in times of crisis.

In addition to gas leak detection, the system also monitors the LPG cylinder weight. In the app, the cylinder weight is displayed so that the user can monitor the cylinder weight and can replace the cylinder. This enhances convenience and eliminates a situation whereby individuals run out of gas in the course of cooking.

With simulation, cloud control, mobile alerting, appliance automation, and cylinder monitoring, the system becomes a complete end-to-end safety solution that does not entirely depend on hardware and can be easily expanded in the future. Different conditions, including gas leakage or a temperature variation, can also be tested with the use of a Pythonbased simulation environment, which guarantees the reliability of the system.

There are 3 main objectives:

A predictive gas safety system is a device that evaluates the pressure drop across a pipeline and sends continuous information to the appropriate operators.

1) ***Predictive Gas Safety System***

A predictive gas safety system is a device that measures the pressure drop across a pipeline and transmits constant data to the relevant operators. The first is to develop a gas safety system, which can detect potential leaks in advance and eliminate them before they become hazardous. To this effect, the system considers past usage behavior, simulated readings, and conditions around it. This prediction is made at an early stage; thus, this is the biggest improvement compared to the normal detectors that only respond when danger has been observed.

2) ***Literature on Context-Aware Alerting***

The second objective is to issue warnings depending on circumstances and the individual requiring the information. The app identifies any leakage detected; it sends an alert to the user with a warning and alarm sound if gas leakage is detected. The notification is sent through warning messages that are received by the users even in the absence of the internet, which is highly crucial in times of crisis.

3) Smart Mixed Accessibility of Appliances

The third objective is to link the system of detection to domestic appliances. It can also turn off stoves immediately, turn on exhaust fans, improve ventilation, create an alarm alert, and update LED indicators whenever a leak is detected. It saves time; any mistake by the human being is done away with and chances of fire or suffocation are minimized by this automatic response.

In general, the system provides a powerful and smart IoT-based solution that integrates prediction, automation, real-time monitoring, and an alarm alert system. It makes homes safer, ensures more convenience with cylinder monitoring and a base on which smart-home applications of the future may need to make fast decisions, less dependency on hardware, and integration between the cloud and mobile platform.

II. LITERATURE REVIEW

Various scholars have already designed IoT-based LPG leak detection systems, and every research appears to address the issue differently. As an example, in Sharma et al. (2023) a system was developed based on an Arduino platform, an MQ-7 gas sensor, a load cell to check the weight of the cylinder, a servo motor to automatically turn off the stove, and a GSM module to send SMS notifications[1]. On the one hand, their work is primarily aimed at stable monitoring, reminders to users when the cylinder is depleted, minimizing errors related to people forgetting things, and a servo with direct shut-off control. This renders it to be realistic with standard residential homes that are not connected to numerous smart devices.

Altale and Sanjary (2025) were a bit further as they utilized ESP32 with the MQ-2 and DHT22 sensors to monitor the level of LPG, temperature, and humidity. Their system can be connected by Wi-Fi and even to Google Home in order to receive voice alerts[2]. Instead, they also pushed their data in Google sheets which assists in analyzing long term trends, and how safe or unsafe an environment has been in the past.

Hazmi, Patchmuthu and Thien Wan (2021) employed another study employing a WeMos D1 ESP8266, an MQ-5 sensor, an HX711 load cell, and a valve powered by a servo to close the gas. They were storing all that in Firebase real time[3]. Their model was based on not only preventing them, but also monitoring the remaining amount of gas in the cylinder and allowing users to project their refills through weight. However, they also indicated that the system required a more robust load cell, and a superior power configuration and that perhaps the system should have been replaced with a solenoid valve instead of the servo motor in order to work more well in the real world.

On the same note, Kumaran and Hounandan (2021) developed a LPG explosion prevention system with ESP-32 by using MQ-6 sensor, load cell, and the DC motor with relays to regulate the regulator. They included a combination of interfaces in their system LCD display, LEDs, the Blynk mobile app, and even their own React web dashboard. It had the potential to close the regulator when the concentration of the gas went beyond the danger level[4]. Nevertheless, the study did not explicitly state any limitation or the future scalability of the system.

Another system developed by Gopalram et al. (2023) paid more attention to remote control over the valve. They have used ESP8266 NodeMCU with HTTP communication, one relay module and a mobile/web dashboard. They had a concept of allowing the user to control the LPG valve anywhere to prevent wastage and errors due to the negligence of the human being[5]. However, this configuration did not entail leak warnings, forecasting, and a complete cloud automation chain.

Paul et al. (2021) came up with an intelligent natural gas leakage. IoT-based detection and control system. The system used communication and gas sensors functions to measure gas leakages and realtime alerts. It was also in favor of automated monitoring, which minimized the requirement to have gas pipelines manually checked regularly. By the system is faster in detecting and responding added to the enhancement of safety and efficiency in gas monitoring [6]. The accuracy of the sensors however are occasionally influenced by the environment like humidity and temperature.

A wireless system of gas leakages was launched by Fraiwan et al. (2011) in order to enhance security at home environments. Gas sensors were combined in the system equipped with a wireless communication unit to monitor LPG leakage and notify users. It was made up of a sensing unit and a surveillance unit which gave warning signals when the gas concentration was more than the safe level. This design enhanced swift reaction and minimized the risks by the users of those accidents, as in fire outbreaks due to gas leakage. Though the system enhanced safety by means of it had certain limitations, it was early detected[7]. In particular, the sensor employed could not differentiate correctly of the gases of various kinds, which may influence the overall detection accuracy.

The idea of an industrial gas was suggested by Kodali et al. (2018) to improve the monitoring system through the use of IoT technology safety in industrial plants. The system made use of gas communication modules, microcontrollers and sensors. to continuously check the gas levels in industrial. environments. Alarm when a leakage of gases occurred so messages were communicated to the users or monitoring authorities that action could be taken immediately [8]. The proposed Remote monitoring and enhanced the system was made possible general handling of safety in industries. Despite these merits, the system had certain issues, especially delays in communication and reliability problems in the process of message transmission.

A digital gas monitoring system using IoT was done under consideration in 2023 to enhance gas leakage detection and safety. Gas sensors were incorporated into the system continuously monitor the level of gases with the IoT technology and issue real-time notifications to users. By using internet. The system enabled remote monitoring, of which the system was known as connectivity that the users would be able to respond promptly in case of gas leakage. This strategy increased the safety as it was possible to make smart surface inspection and notification in time [9]. However, the some of the technical aspects were not explicitly covered in the study scalability and other limitations, in particular system performance on larger deployments.

Jinfeng et al. (2021) suggested an indoor gas safety NB-IoT-based management system. The system combined gas sensors and NB- IoT gas meters to measure the gas leakage in the indoor settings [10]. On identifying a leak, users were alerted or through communication networks, relevant authorities. This system improved security through real-time inspecting and quicker reactions to the possible leakage of gas incidents. However, the work of the sensors but might be affected by environmental interference, and this can interfere with the accuracy of gas detection.

When all these researches are put into consideration, it is apparent that IoT-based LPG systems have been evolved over time becoming better. They had started with primitive sensors and straight forward notifications and then increasingly rose to the cloud dashboards, wireless communications, automatic cut-offs and mobile interfaces. Despite that advancement, there are still certain gaps. Most systems do not have as predictive leakage detection, and predictive leakage detection features alone few of them contain alerts that are different on the individual to whom the information is needed. SMS the exception is notifications offline and there is not a large amount of work in combining cloud analytics and mobile services in one system. As well, complete appliance. The system can be programmed to do some tasks automatically in charge of a variety of devices at once-largely absent.

These weaknesses indicate that a more thorough, intelligent, and scalable gas-safety solution would become. must exist, and this would allow users to monitor in real-time, foresee risks before they take place, have automatic operations and alerts through. various channels so that the users are as safe as they can be.

III. METHODOLOGY

The Gas Safety Monitoring and Alert System is essentially a combination of three distinct technologies that include Blynk Cloud, a Python program, which is fake sensors, and an Android application, which checks all things in the background silently. When all these components are properly communicated with each other, the system is able to monitor the gas amounts continuously, determine whether anything is amiss and act in a very fast manner. It is more comprehensible to explain step by step the way the whole method.

The methodology of the proposed system follows serval functional stages including data acquisition, cloud communication, mobile monitoring, automated safety response and simulation-based testing. The combination of these stages will guarantee constant supervision of the conditions in the kitchen in terms of safety and quick response to the incident of possible gas leakage.

A. Blynk IoT Cloud Characteristics

The initial step in the project is to configure the Blynk Cloud as it serves as the central hub where all the information of the sensors will flow and at this point the mobile application will receive information.Within the Blynk Developer Console, a new device template is created which in our case is the Gas Safety Sim, which will essentially tell Blynk what type of data it must receive and how the device will communicate, in our case it is by Wi-Fi.

Once the template has been prepared, some virtual pins (V0-V9) are integrated. Each virtual pin is rather similar to its own data line. V0 and V1 for example are used to read the temperature respectively and V2 to indicate whether there is a leak or not. The remaining pins are dedicated to the switch on off of the stove or the fan, lighting the LEDs, and displaying the weight of the cylinder. When the correct units such as: ppm, degC and kg are used everything appears clear once it is displayed on the dashboard.

These parameters are the most important environmental parameters that have to be taken into consideration in the monitoring of kitchen safety. The level of gas concentration can tell whether there is the presence of leaked LPG in the atmosphere, temperature monitoring can be used to detect the possible occurrence of abnormal heat conditions that can cause fire hazards, and the weight that is left on the cylinder can be known through cylinder weight monitoring.

Name	Pin	Color	Data Type	Is Y	Units	Is Raw	Min
Gas_MQ2	V3		Double		°C	false	0
Temperature	V1		Ineteler			false	0
Leak_Status	V2		Integer			false	0
Stove_Control	V5		Integer			false	0
Exhaust_Fan	V7		Integer			false	0
Cylinder_Weight	V8		Double			false	0
Leak_LED	V8		Integer			false	0
Safe_LED	V9		Integer			false	0

Fig. 1 Datastreams

A Web Dashboard is then drawn up. This dashboard is simply the interface upon which the user may see the readings in real time. The gauges on the dashboard continue to move because of the change in the gas and temperature, the LEDs are lit up when it is unsafe and the switches allow you to control the fan, or the stove when necessary. The design does not need to be anything extraordinary, just as long as the key information is made visible, that is all. This cloud based architecture allows remote monitoring, centralized data management and device-mobile application communication.

Lastly, Blynk produces an AUTH TOKEN. This token is very crucial since the python code as well as the android app make use of it to send and receive data without this token the cloud simply disregards whatever you are sending to it. Once this part of the setup is complete, the cloud basically becomes the focal point, which connects the entire system.

Fig. 2 Blynk Web Dashboard

B. Python Documentation: Simulation and Leak Detector

After sorting out the cloud side, one then writes their Python script that simulates the functionality of the gas sensors that we do not physically possess. The point behind this is that, even without the actual sensors at hand, this script will enable the user to test everything. The Python simulator serves as the data acquisition unit, in which the real life environmental measurements are created and sent to the cloud system. The requests library is pushing these numbers to the cloud effectively going through the process that actual IoT device would undergo to transmit its data.

The script does this by random generation of numbers within reasonable ranges. As an example, gas values are increasing and decreasing between 150-500ppm as it is about the range where normal gas readings may fall. The temperature is produced in the range of 25-90 C, which is more or less comparable to the temperature generated in a kitchen. The cylinder weight will change anywhere between 2-15 kg, which is closely comparable to the real LPG cylinder gradually becoming lighter with time. These values are realistic operating provisions of a kitchen environment where LPG is utilized.

To detect leaks, the script simply takes a simple principle whereby when gas concentration exceeds 350 ppm or when the temperature exceeds 75degC, then the script considers the scenario as unsafe.

These values are grounded on frequently referred to safety limits. The Python file relays whatever it has altered with the Blynk Cloud every few seconds with a regular REST request, ensuring that the dashboard and the mobile application always receive updated information. But it doesn't stop there. In case it detects something that seems to have leaked, it immediately acts in response - the stove shuts down, the exhaust fan goes on, and the leak indicator is immediately lit and the alarm is sounded in order to attract attention of those nearby.

Once the readings are back to the safe range, the system restores all things back to its usual state. Since the script does not only a monitoring but also control logic, it acts as a real-world IoT safety device. The simulation method enables the system to be tested in various environmental conditions without the use of physical sensors and therefore helps to confirm the reliability of the system and its response time.

C. Android App for Leak Alerts

The second thing is to develop a simple Android app that will be able to continuously scan the Blynk Cloud in the background and provide the user a notification even when they do not even have the dashboard open. The app is created with the help of Android Studio and offers a simple interface to monitor the environment of the kitchen remotely.

There are two major permissions needed within the app in order to perform its duties correctly, the first one is the access to internet connectivity to obtain sensor values on Blynk Cloud and the second one is the ability to send SMS notifications in case of an emergency or a major event. To have a secure access, the application has also been equipped with the features of authentication like user login where only the authorized users are allowed to access the monitoring dashboard.

The application is largely separated into two parts:

1) *The Home Screen*

After the login page home page is displayed. The main role of the Home Screen which is to start the background service that constantly checks everything in the background. It allows the users to see the real-time sensor-reading of gases concentration, temperature and weight of the cylinder directly on the interface.

It is also equipped with some manual control features which enable one to remotely operate the appliances like the exhaust fan or the stove in case they need to be operated manually.

2) Background Verification

This is where the app will be primarily used. The background service helps to constantly monitor the current leak status stored in the cloud. The benefit of this service is that it is capable of starting on its own, i.e., even when the user closes the app or the phone shuts down the application, the monitoring process goes on. In case of unsafe conditions, the system will generate a warning by sending an SMS message and high priority notification to the user instantly.

D Integrating Everything Together

When all the components have been linked, the whole system starts to work like one entity. The Python script keeps on giving new readings and the dashboard is updated in real-time. The user is able to see the real-time information of gas level, temperature, leak status, and cylinder weight. The current leakage is stored in the cloud and is monitored by the android application in the background.

An automatic chain reaction in case of a leak is automatic:

- The stove is switched off
- The fan is turned on
- The leak LED lights up
- The audible alarm is activated

- The emergency state is presented on the dashboard visually
- A user is notified by an SMS.

Each and every one of these responses is automatic and user friendly without ambidexter of the user taking any action, this is extremely fast in responding to an emergency.

Fig .3 App login page page

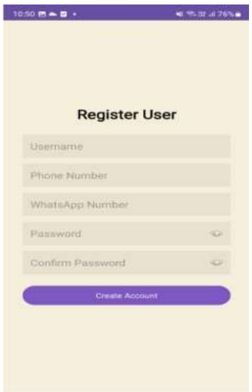

Fig. 4 App Registration

Fig. 5 App Dashboard

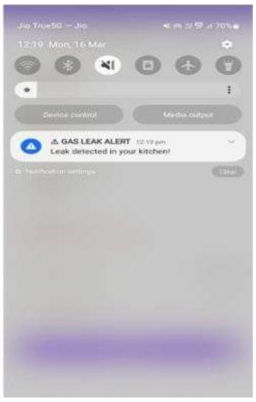

Fig. 6 Warning notification

E. Full Workflow

The overall functionality of the system goes by the following workflow:

- The Python script is used to create realistic values of gas, temperature and weight of the cylinder.
- These readings are compared with preset safety limit levels.
- Android application continuously check the leak status in the cloud
- If unsafe conditions occurs, warning and alarm alert are sent immediately
- In the meantime, the stove is installed off and the fan is activated automatically.
- The user can see the cylinder weight in the dashboard and replace the cylinder if the weight is low
- This process will continue in the system until all things resume normalcy.

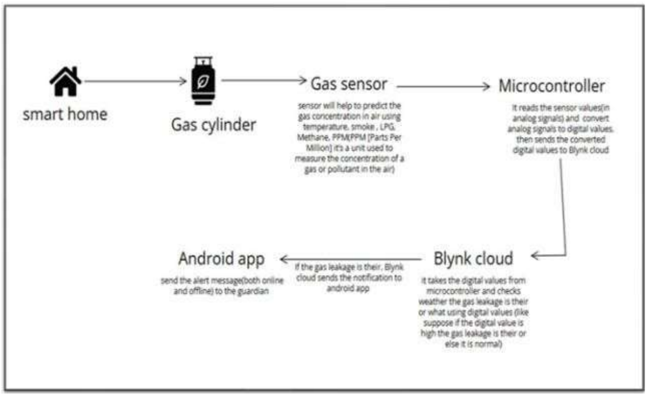

Fig.7 over all working

All processes run continuously even without physical sensors, which makes the system convenient for testing, demonstration, and further development.

IV. CONCLUSION

This project demonstrates that a plain IoT-based system can be implemented to check the gasses and tell people in time when everything becomes dangerous. The system uses Python to formulate the gas, temperature, and cylinder-weight readings instead of physical sensors and forwards all these to the Blynk Cloud. It is also easy to monitor all the values such as gas concentration, temperature variations, leak position, and the even controls of the stove, fan and LEDs all through the dashboard. All the updating is automatic, hence the user will not require any manual work.

Android app continues to check the status of the leaks in the cloud every few seconds on the other side. In case it detects that a leak has been detected then it sends an SMS notification to the user. In addition to that, the system also switches the stove off and switches on the exhaust fan that prevents dangerous cases. Given the fact that the alerts may pass via SMS, the configuration will operate even when there is no internet connection at any particular time and therefore, it is more effective in daily applications.

In general, the project demonstrates that the IoT, cloud services, and mobile apps can be united to create a smarter and less expensive gas safety system. The findings confirm that the entire design is effective in real time monitoring, rapid leakages, and fast response to emergencies. The same system may be enhanced further in the future with the addition of real sensors, machine learning to generate more accurate predictions or support more methods of communication in order to be utilized in more locations.

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