# Tech4Safety: A Real-Time Gas Detection, Monitoring, and Alert System for Enhancing Environmental Safety and Risk Management

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**Abstract: Gas leakages, fire accidents, and explosions remain serious concerns in kitchens, particularly those that rely on LPG for cooking. Undetected leaks not only heighten the risk of fires and explosions but can also cause carbon monoxide poisoning, posing a major threat to human safety. To address these risks, this paper presents an Internet of Things (IoT)-based monitoring system designed to detect gas leakage in real time and immediately alert users to potential hazards. The system is powered by a microcontroller that manages input and output operations. An embedded MQ2 sensor is used to detect the presence of LPG, butane, propane, methane, alcohol, and hydrogen. Once the detected gas concentration exceeds a predefined threshold, the device triggers a rotary buzzer alarm and activates a P10 LED display to notify users of the leakage. This dual-alert mechanism ensures both audible and visual warnings for improved safety. The project aims to prevent or reduce the likelihood of fire, explosions, and gas-related accidents by continuously monitoring gas levels and enhancing situational awareness in kitchen environments. Moreover, it emphasizes affordability, simplicity, rapid responsiveness, and low maintenance, making it an effective prototype for practical application.**

***Keywords:*** *Gas Leakage Detection, Internet of Things (IoT), MQ2 Sensor, Kitchen Safety, LPG Monitoring, Real-Time Alert System.*

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## I. INTRODUCTION

Managing safety concerning gas levels involves reliance on more conventional methods. Manual inspections were a common practice, where safety officers or designated workers were assigned to manually and visually check the premises for signs of gas leaks, often using basic handheld gas detectors. The microcontroller device we are creating will serve a significant purpose in various locations, such as schools, workplaces, and industries. In building this device, we need to utilize the MQ-2 sensor, which can detect Butane and LPG. Additionally, we plan to incorporate essential components like the Arduino Uno. [1] The Arduino Uno is a microcontroller board that will serve as the brain of our device, facilitating the control and communication of various components. Using the microcontroller Gas sensor in different settings can provide a reliable and efficient means of detecting potential hazards.

To start the capstone project, the researchers visited one of the Bureau of Fire Protection stations to inquire about and learn about the hazardous gases used in various activities, such as cooking. This information is crucial for acquiring the necessary components for a Gas detection device. Eventually, we promptly researched the required components, such as the MQ-2 sensor and microcontroller. Each component serves a distinct function and plays a crucial role in the device, where they will work together. To successfully assemble the device, we watched relevant instructional videos and consulted with the experts to ensure the accuracy and effectiveness of our project's outcome. This project aims to develop an Arduino-based gas level monitoring system to enhance safety and alert mechanisms. Using Arduino technology, we strive to create a cost-effective system capable of real-time monitoring for the timely identification of elevated gas levels. Aligned with the broader objective of a smart and interconnected environment, this project contributes to proactive responses to potential threats, addressing rising concerns over air quality and hazards. We aspire to offer a practical and scalable solution, fostering a safer living and working environment.

## II. METHODOLOGY

This project was designed through the following phases of the Internet of Things (IoT) Lifecycle, starting from scratch to achieve the milestones the manufacturers expect, such as Data Collection, Design, Review, Prototyping, and Validation. [2] Internet of Things (IoT), as a new emerging and fast-growing technology, has attracted lots of attention worldwide recently. Successful applications of IoT have been demonstrated in many fields.

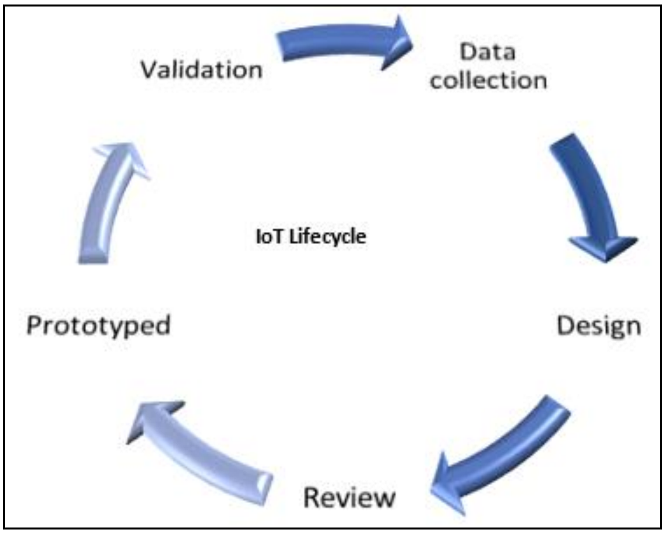

Fig 1 Internet of Things Lifecycle

Figure 1 shows the different phases of the Internet of Things (IoT) Lifecycle.

➢ *Data Collection Phase*

The first step to developing an IoT solution is understanding the needs and demands of the manufacturer. [3] The architecture and data models enable networking-aware IoT applications. Hence, the developers collect as much information as possible from the client regarding the expectations for the project. It mainly consists of details on the power and size requirements of the product. The developers analyze the information provided, arrive at an idea, and plan to depend on the functionality of the IoT device.

➢ *Design Phase*

After the customer brainstorms the requirements of the product, some engineering is involved. The engineers convert the idea into a prototype by developing a circuit design for the product. Designing a circuit requires various software skills and algorithms to arrive at an appropriate solution for the product based on the real-world market. Some critical factors in the process are range, battery life, and product cost. The best solution based on the cost and performance ratio is selected and implemented in the final project for the IoT device.

➢ *Review Phase*

Once the most appropriate circuit design is formulated, the developers must continuously make necessary changes. It is possible to review the circuit design and functionality throughout the project. The developers can change the project's layout, schematics, algorithms, or infrastructure to arrive at a reliable solution with the highest performance and cost efficiency.

➢ *Prototyping Phase*

Here comes the stage where the circuit design implementation is carried out. The developers come forward with a proof of concept for the [4] IoT solution by building the product by combining the hardware and software components. Considering the cost/performance ratio and form factor the customer requires, the developers test the various elements, such as sensors, simulators, embedded boards, modules, etc. Minimizing the error at the end of prototyping is the main aim of this step.

➢ *Validation Phase*

Testing and validating the final prototype are essential steps of the IoT lifecycle. Here, the hardware component of the prototype is tested using different parameters, such as amplitude, magnitude, voltage, power consumption, temperature, etc., using sensors. [5] To test the flow of data, capabilities of the system, and possible connection methods to the device for the various sensors. Once validated, the product is all set to be manufactured.

➢ *Components:*

- MQ2 Sensor
- Arduino Uno
- Breadboard
- P10 Led Board
- Rotary Buzzer
- Sim900A GSM Module
- Power Supply 5V 2A
- Power Relay

➢ *Data Gathering Procedures*

The researchers surveyed the respondents to gather data. The data gathered will serve as a resource for the researchers. To obtain the data required for system design, the researchers questioned how the system would be created and developed according to the requirements and considering the end users' current needs.

They acknowledged the researchers' request for permission to interview a selection of people during the system's development stage to gather data to investigate the evaluation process in the study area.

In addition, the researchers requested approval from the department/offices and potential end-users to evaluate this device. After the device had been developed, the researchers proceeded to the evaluation step, where the device was utilized and assessed by intended end-users. With the participation of the respondents/evaluators, the effectiveness and performance of the system were evaluated.

The researchers guided the respondents in answering the questionnaire to acquire feedback and evaluate the system. The two questionnaires are based on the [6] ISO 25010 Software Product Quality Standard and include the researcher-made questionnaire to ensure valid and reliable data.

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For the implementation, the researchers sought the end-user's permission to test the system and evaluate it. After the implementation stage, the researchers asked the end-users to evaluate the feasibility of the developed system's implementation by responding to a questionnaire created by the researchers.

➤ *Data Analysis*

The researchers used the response mode for data analysis, as depicted in Table 1. They gathered the data as answered by the respondents and treated the data using the weighted mean for the evaluation rating of each item in the questionnaire. Then, the average of the weighted mean was computed to.

Table 1 Response Mode

| Score | Scale | Verbal Interpretation |
|---|---|---|
| 4 | 3.25 - 4.00 | Strongly Agree |
| 3 | 2.50 - 3.24 | Agree |
| 2 | 1.75 - 2.49 | Disagree |
| 1 | 1.00 - 1.74 | Strongly disagree |

The methodology of this study was based on the functionality and quality requirements of the software being developed. The primary data collection tool was a questionnaire, the draft of which was subjected to rigorous review by professional IT developers and End-users. Their valuable feedback was integrated into the final version of the questionnaire.

The data gathered through this questionnaire were subsequently analyzed and interpreted using the weighted mean statistical method.

## III. RESULTS AND DISCUSSION

The results of the study are presented and provide an in-depth discussion of the findings in relation to the research objectives.

### A. *Internet of Things Life Cycle Model (IoTLC)*

➤ *Data Collection*

During this phase, the researchers focused on identifying the specific safety needs within their selected area, and they discovered that the kitchen in the building lacked adequate safety measures to monitor and respond to potential gas leaks. This realization led them to conceptualize a device aimed at enhancing safety through continuous gas level monitoring. To address the issue, the researchers conducted an in-depth study of the proposed project, ensuring that it would effectively safeguard the identified respondents. They researched relevant safety standards, suitable gas detection technologies, and user requirements to ensure that the device could provide real-time monitoring and an alert system in case of a gas leak. The goal was to create a solution that could be efficiently implemented once approved and provide tangible benefits.

➤ *Design*

In this phase, the processing of all necessary devices for the proposed project was involved. The researchers had prepared the devices needed, including an MQ2 Sensor, a P10 LED board, and a Rotary Buzzer. After concluding all of the necessary hardware requirements, they analyzed how they would be connected and studied the function of each device.

➤ *Review*

In this phase, the researchers conducted a comprehensive evaluation of the proposed Gas Detection, Monitoring, and Alert System. The initial design and concept were carefully reviewed to ensure that they met the safety needs. The researchers assessed whether the system could effectively monitor gas levels and provide timely notifications to safeguard end-users from potential gas leaks. They sought feedback from experts in the fields of safety systems, IoT, and electronics to validate their design choices, including the selected sensors, the Arduino setup, and the notification methods. This review process helped identify any weaknesses or areas for improvement in the system. Based on the feedback, the researchers made necessary adjustments to optimize the device's functionality, reliability, and ease of use. Through this phase, the researchers ensured that the system was not only technically sound but also tailored to address the specific safety concerns of the selected location. This review laid the groundwork for moving forward with confidence in the subsequent prototyping and testing phases.

Table 2 shows the assessment of the sets of respondents on the developed device based on its functionality.

Table 2 Functionality of Gas Detection Monitoring and Alert System as Assessed by the End-user

| Statement | Weighted Mean | Verbal Interpretation |
|---|---|---|
| 1. The device detects gas values accurately and in real-time. | 3.66 | Strongly Agree |
| 2. The design sends instant notifications when gas values exceed the safety threshold. | 3.83 | Strongly Agree |
| 3. The system provides adequate alerts (audible and visual) when gas values reach critical thresholds. | 3.5 | Strongly Agree |
| 4. The device's functionality meets the safety requirements for gas value monitoring. | 3.83 | Strongly Agree |

| | | |
|---|---|---|
| ***Average Weighted Mean*** | **3.70** | **Strongly Agree** |

The assessment of the system's functionality, as reflected in Table 2, shows a strong agreement among end-users regarding its core capabilities. With an overall weighted mean of 3.70, the system is rated as highly functional by users, indicating a strong level of trust and confidence in its ability to perform as expected. This indicates that, based on the evaluation of the respondents, the device is functional as it accomplishes its intended purpose, gas detection monitoring, and instant notification.

Table 3 shows the assessment of the respondents on the developed device based on gas detection and alert system in terms of usability.

Table 3 Usability of the Gas Detection Monitoring and Alert System as Assessed by the End-user

| Statement | Weighted Mean | Verbal Interpretation |
|---|---|---|
| 1. The device is easy to set up and configure for use. | 3.5 | Strongly Agree |
| 2. The device display clearly shows gas values information, and the layout is easy to understand and interpret. | 3.83 | Strongly Agree |
| 3. The device's alerts and notifications are easy for users to act upon. | 3.6 | Strongly Agree |
| 4. The device's physical design is ergonomic, making it comfortable and easy to handle during use, ensuring a user-friendly experience. | 3.46 | Strongly Agree |
| ***Average Weighted Mean*** | **3.59** | **Strongly Agree** |

Table 3 highlights the system's usability, which users strongly agree is easy to set up and configure. The overall usability score, 3.59, suggests that users find the system highly accessible and convenient to operate, further enhancing their ability to act promptly in case of gas level emergencies. The respondents' assessment indicated that the device achieved its full potential in terms of gas detection and monitoring systems.

The results of the assessment of the developed device in terms of reliability are shown in Table 4.

Table 4 Reliability of Gas Detection Monitoring and Alert System as Assessed by the End-user

| Statement | Weighted Mean | Verbal Interpretation |
|---|---|---|
| 1. The device provides consistent gas value readings without failures or malfunctions. | 3.63 | Strongly Agree |
| 2. The notifications from the device are reliable and always triggered when gas values change. | 3.7 | Strongly Agree |
| 3. The device consistently performs its intended functions without failure. | 3.43 | Strongly Agree |
| 4. The device provides accurate readings under various environmental conditions. | 3.76 | Strongly Agree |
| ***Average Weighted Mean*** | **3.63** | **Strongly Agree** |

These findings clearly indicate that the developed device is found to be reliable. With an overall reliability score of 3.63, the system is highly regarded for its dependable and accurate performance under different conditions.

Table 5 shows the assessment of the sets of respondents on the developed device based on reliability and availability.

Table 5 Security of Gas Detection Monitoring and Alert System as Assessed by the it Expert

| Statement | Weighted Mean | Verbal Interpretation |
|---|---|---|
| 1. The main components of the device are protected against physical damage, dust, moisture, and unauthorized access through a junction box. | 4.00 | Strongly Agree |
| 2. The gas values displayed on the dot matrix LED board are secured against tampering, ensuring that only accurate readings are shown, preventing any unauthorized modifications to the displayed values | 4.00 | Strongly Agree |
| 3. The system ensures that all security-related alerts and notifications are sent promptly and accurately without risk of interception or delay. | 4.00 | Strongly Agree |
| ***Average Weighted Mean*** | **4.00** | **Strongly Agree** |

The security evaluation shows a strong assurance of protection for the system's components. Experts confirmed that critical elements of the device are safeguarded against physical damage, unauthorized access, and environmental factors like dust and moisture through proper housing and structural design. Additionally, the data displayed on the LED board is tamper-proof, ensuring the accuracy of gas readings, while the system delivers alerts and notifications promptly without any risk of delay or interception. [7] LED provides a portable with low power input, low-intensity drifts, low cost, and ease of alignment. The average weighted mean of 4.0, with a verbal interpretation of "Strongly Agree," reflects the robustness of the device's security features.

Table 6 Efficiency of Gas Detection Monitoring and Alert System as Assessed by the it Expert

| Statement | Weighted Mean | Verbal Interpretation |
|---|---|---|
| 1. The system's ability to detect gas concentration changes and trigger alerts promptly. | 4.00 | Strongly Agree |
| 2. The MQ2 sensor is susceptible to detecting even minor fluctuations in gas value and ensuring early hazard detection. | 4.00 | Strongly Agree |
| 3. The power supply provides consistent voltage and is designed to protect the system from voltage fluctuations or interruptions, ensuring continuous operation. | 4.00 | Strongly Agree |
| ***Average Weighted Mean*** | **4.00** | **Strongly Agree** |

The system excels in efficiency, as it swiftly detects changes in gas concentration, triggering alerts immediately. The MQ2 sensor was highlighted for its sensitivity to minor fluctuations, enabling timely hazard detection. The power supply is consistent and reliable, ensuring the system remains operational even during voltage variations. This reliability was reflected in an average weighted mean of 4.0, with experts "Strongly Agree" that the system effectively fulfills its intended purpose.

Table 7 shows the assessment of the sets of respondents on the developed device based on maintainability and monitoring.

Table 7 Maintainability of Gas Detection Monitoring and Alert System as Assessed by the it Expert

| Statement | Weighted Mean | Verbal Interpretation |
|---|---|---|
| 1. The Hardware components are easily accessible for maintenance, cleaning, or replacement. | 4.00 | Strongly Agree |
| 2. The Wiring and Physical connections between the components are logically designed and accessible from potential points of failure. | 4.00 | Strongly Agree |
| 3. The device's components are designed for easy updates and troubleshooting, allowing for efficient management over time. This facilitates continuous monitoring of gas without disrupting real-time operations. | 4.00 | Strongly Agree |
| ***Average Weighted Mean*** | **4.00** | **Strongly Agree** |

In terms of maintainability, the system's design supports easy access to hardware for routine maintenance and replacements. Experts acknowledged the logical organization of wiring and connections, reducing potential points of failure and enhancing the device's durability. Furthermore, the system's components are optimized for straightforward updates and troubleshooting, allowing for uninterrupted gas monitoring. The average weighted mean of 4.0 in this category underscores the device's ease of maintenance, as rated by experts.

The overall computed mean for the evaluation by the end-user from the following criteria, namely functionality, usability, and reliability, was computed at 3.64 and similarly interpreted as strongly agree. This finding indicates that the developed device was functional, usable, and reliable.

Table 8 shows the summary of the assessments of the respondents on the developed device.

Table 8 Summary of Assessments by End-user on the Gas Detection Monitoring and Alert System

| ISO Software Quality | Weighted Mean | Verbal Interpretation |
|---|---|---|
| Functionality | 3.70 | Strongly Agree |
| Usability | 3.59 | Strongly Agree |
| Reliability | 3.63 | Strongly Agree |
| *Average Weighted Mean* | 3.64 | Strongly Agree |

The findings show that the system adheres to the quality characteristics prescribed by the ISO [6], ensuring its compliance with globally recognized standards for information security management systems (ISMS) in terms of functionality, performance, usability, reliability, efficiency, maintainability, and security.

The summary assessment by an IT expert or professional based on the following criteria, namely security, efficiency, and maintainability, was computed at 4.00 and similarly interpreted as strongly agree. This finding indicates that the developed device was secure and maintainable.

Table 9 shows the summary of the assessments of the respondents on the developed device.

Table 9 Summary of Assessments by it Expert on the Gas Detection Monitoring and Alert System

| ISO Software Quality | Weighted Mean | Verbal Interpretation |
|---|---|---|
| Security | 4.00 | Strongly Agree |
| Efficiency | 4.00 | Strongly Agree |

| | | |
|---|---|---|
| Maintainability | 4.00 | Strongly Agree |
| *Average Weighted Mean* | 4.00 | Strongly Agree |

These findings are that the developed device demonstrates a high level of reliability and effectiveness in accordance with ISO software quality standards. [8] The evaluation scheme is implemented through an approach of quality and efficiency assessment based on the ISO/IEC 25010 quality model standard. The strong ratings in security, efficiency, and maintainability suggest that the system can be trusted to safeguard data and deliver optimal performance. This indicates not only the device's current functionality and dependability but also its sustainability for long-term use. Consequently, the positive evaluation reinforces the system's value as a dependable tool that addresses essential software quality requirements.

## IV. CONCLUSION

The findings of the study affirm that the gas detection monitoring with an alert system is an effective and reliable solution for addressing potential gas-related hazards. By integrating real-time monitoring and automated alerts, the device provides a proactive safeguard that not only minimizes risks but also strengthens the overall culture of safety within the kitchen. The reduction of fear and anxiety among students and residents while using gas-powered appliances demonstrates its impact on promoting both safety and peace of mind in daily activities.

The expert evaluation further reinforces the device's practicality, as it has been proven secure, efficient, and easy to maintain, qualities that are crucial in sustaining its long-term usability in safety-critical environments. The device showcases its potential for broader application in households, commercial kitchens, and other facilities where gas is used, underscoring its relevance to community safety.

Furthermore, the study concludes that this innovative prototype is not only technically feasible but also socially significant. It demonstrates how low-cost yet efficient technological solutions can provide meaningful contributions to safety, prevention, and risk management, while also serving as a foundation for future improvements and wider adoption.

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