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Smart Home Energy Management System

Mrs. Nisha Wilvicta J *, Rakshitha V**, Sreelatha C***, Venkatesh M ****, Vinod Erappa Bidari *****

*(Department of Computer Science and Engineering, T. John Institute of Technology, Bengaluru-560083, Karnataka, India Email: nishawilvicta@gmail.com)

**(Department of Computer Science and Engineering, T. John Institute of Technology, Bengaluru-560083, Karnataka, India Email: rakshithav60@gmail.com)

***(Department of Computer Science and Engineering, T. John Institute of Technology, Bengaluru-560083, Karnataka, India Email: latavamsi07@gmail.com)

****(Department of Computer Science and Engineering, T. John Institute of Technology, Bengaluru-560083, Karnataka, India Email: venkateshmanmohan@gmail.com)

*****(Department of Computer Science and Engineering, T. John Institute of Technology, Bengaluru-560083, Karnataka, India Email: vinodeb123@gmail.com)

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Abstract:

This paper depicts a Clever Home Energy the Executives Framework (SHEMS) utilising the ESP32 microcontroller that is able to integrate high level elements such as energy maximization, security and smart home implementation. This framework of SHEMS utilizes fire, gas, temperature, light dependent resistors, and IR sensors to ensure inhabitance detection and to enable energized saving calculations such as light and fan regulation based on real-time habitant occupation and environmental conditions. Basic sensors give prompt cautions to fire and gas spills by means of Message warnings and a bell, improving wellbeing. The framework additionally integrates a free power supply for continuous activity during blackouts, helping fundamental machines like fridges. Also, constant observing and control are conceivable through Bluetooth, permitting far off administration. This IoT-based arrangement consolidates energy effectiveness, wellbeing, and accommodation, adding to more brilliant, greener, and more supportable living conditions.

Keywords — **Smart Home, Energy Management, IoT, ESP32, Automation, Security, Energy Efficiency, Sustainability.**

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I. INTRODUCTION

This paper presents the plan and execution of an IoT-based savvy home energy the board framework utilizing the ESP32 microcontroller, a minimal expense, flexible stage.

The framework coordinates various sensors, including fire, gas, temperature, light-subordinate resistors (LDR), and infrared (IR) sensors, to screen ecological boundaries and inhabitance progressively.

It includes light robotization that changes brightening in view of normal light and inhabitance, diminishing energy utilization ([1], [2]), and an astute fan control system that powerfully changes fan speed as per temperature and inhabitance ([3],[4]).

The framework likewise incorporates an independent power supply for basic apparatuses, guaranteeing ceaseless activity during blackouts ([8]).

Security is improved through fire and gas spill location, with moment warnings sent by means of Wire and a discernible alert for prompt reaction ([7], [9]). This adaptable, savvy arrangement consolidates energy effectiveness, robotization, and security, adding to more intelligent, more reasonable homes

and supporting worldwide energy preservation endeavors ([6], [11]).

II. METHODOLOGY

A. System Design

A Product Prerequisites Determination (SRS) presents the useful and non-utilitarian necessities of a product framework, itemizing what the framework ought to do and giving a premise to approval ([10]). Created through coordinated effort between the client and the advancement group, the SRS incorporates use cases and plan limitations, guaranteeing clear correspondence to accumulate all important necessities for effective turn of events.

B. Key Modules

1) ***Efficiency optimization :*** The framework computerizes lighting and fan control in view of inhabitance and natural circumstances, lessening energy squander and further developing effectiveness ([1], [5]).

2) ***Real-Time Monitoring :*** Ongoing sensors screen temperature, light, movement, fire, and gas, empowering quick changes in accordance with machines and lighting ([3]).

3) ***User Satisfaction :*** Robotized energy the executives and wellbeing highlights, including Wire alarms and a bell, improve accommodation, solace, and security ([2], [9]).

4) ***Security :*** Fire and gas spill location with moment alarms through Message and bell guarantee fast crisis reactions and inhabitant wellbeing ([7], [9]).

5) ***Scalability and integration :*** The particular plan permits simple redesigns and coordination with arising advances like artificial intelligence, IoT, and sustainable power sources ([6], [11]).

C. Development Workflow

1) ***Equipment Combination :*** Sensors (temperature, movement, fire, gas, LDR) were incorporated with the ESP32 to screen natural circumstances and inhabitance ([3], [8]).

2) ***Frontend Advancement :*** Job based UIs with responsive dashboards were made for energy checking and occurrence revealing ([4]).

3) ***Backend Combination :*** Firebase Verification oversaw secure login, while Firebase Cloud Informing and Fire store took care of constant warnings and information stockpiling ([10]).

4) ***Mechanization and Control :*** Computerization rationale was carried out for energy streamlining, changing lighting and fan control in view of sensor information ([2]).

5) ***Testing and Approval :*** The framework went through unit, combination, and client acknowledgment testing to guarantee usefulness and ease of use ([11]).

6) ***Sending and Observing :*** The framework was conveyed with continuous checking and controller abilities for progressing execution following ([7]).

III. RESULTS

The SRS was deployed and evaluated in a simulated environment to assess its performance and usability. The results were promising:

A. Performance Evaluation

1) ***Efficiency :*** The IoT-based framework upgrades energy use via mechanizing lighting and fan control in view of regular light, inhabitance, and temperature, lessening waste ([1], [2]).

2) ***Real-Time Communication :*** Constant sensor checking (fire, gas, temperature, LDR, IR) empowers prompt acclimations to lighting, fan speed, and apparatuses for responsive control ([3]).

3) ***User Satisfaction :*** Robotized energy the board and wellbeing highlights, including Message cautions and a bell for fire/gas location, upgrade solace and security ([9]).

4) ***Security :*** Coordinated fire and gas spill recognition promptly cautions clients through Wire and initiates a bell, guaranteeing wellbeing and speedy reaction ([7], [9]).

B. Feature Demonstrations

1) ***Low Light detection:*** Light gets automatically turned ON based on natural occurrences .

Fig. 1 Low Light Detection

2) ***Gas Detection :*** When gas leakage is detected, it sends a notification via Telegram, including a beep sound via buzzer.

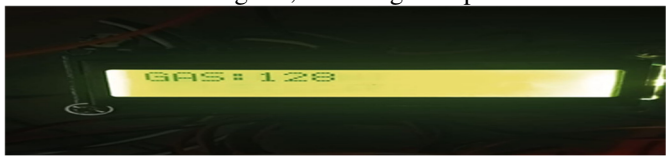

Fig. 2 Gas Detection

3) ***Fire Detection*** *:* When fire is detected, it sends a notification via Telegram, including a beep sound via buzzer.

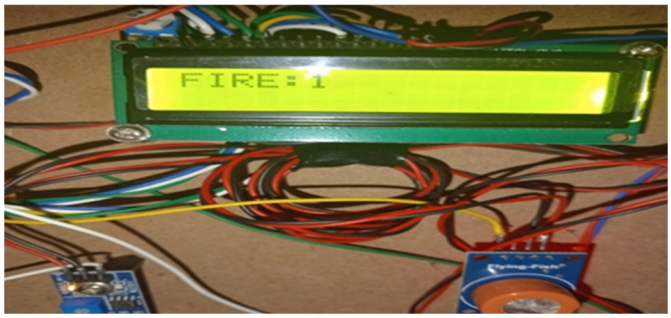

Fig. 3 Fire Detection

4) ***Humidity and Temperature Check :*** Based on the room's temperature, the fan gets automatically turned ON, i.e., when temp > 35°C

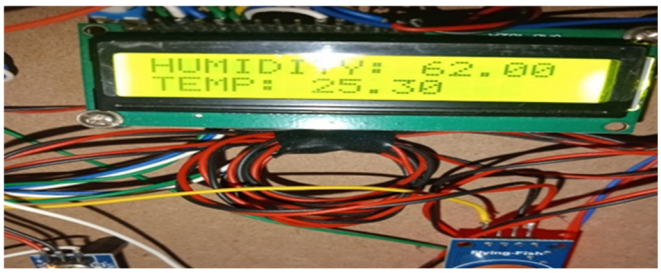

Fig. 4 Humidity and Temperature Check

5) ***Notification System*** *:* When any function is performed in the prototype, instant notifications are sent via Telegram.

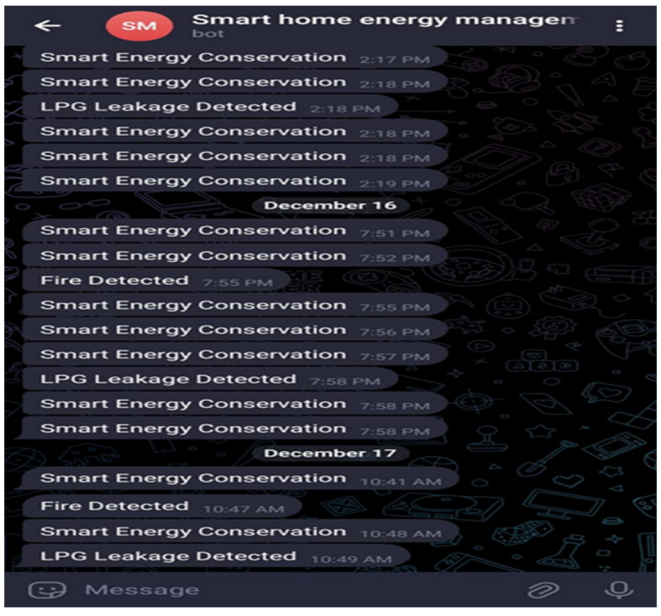

Fig. 5 Notification System

IV. CONCLUSION

The Smart Home Energy Management System (SHEMS) leverages IoT and automation to provide an efficient, secure, and sustainable solution for modern homes.

The system integrates the ESP32 microcontroller with sensors for fire, gas, temperature, LDR, and IR that allow for real-time monitoring and control, which leads to energy optimization and safety.

The automation of lighting and fan control based on the environmental conditions and occupancy level minimizes energy waste considerably. The integration of fire and gas detection systems with real-time notifications ensures timely action in case of emergencies that improve household safety. Additionally, the robustness and convenience in use are further emphasized by the capability of the system to function in the event of a power outage and seamless remote control through Bluetooth. Overall, SHEMS contributes to smarter, greener, and more sustainable living environments while addressing key challenges in energy management and home security.

V. FUTURE SCOPE

SHEMS has a great potential for further development, especially with the adoption of IoT and the necessity of smarter, energy-efficient homes. Future developments can include the integration of advanced technologies such as renewable energy systems, artificial intelligence, and edge computing to enhance better performance and scalability.

Future iterations of the system can integrate with renewable energy sources like solar panels to further enhance energy efficiency and sustainability.

A. AI-Driven Insights

Incorporating machine learning algorithms can enable predictive analytics for better energy usage patterns and proactive maintenance.

B. Enhanced Scalability

Expanding the modular design to include advanced sensors and devices like smart appliances, air quality monitors, and voice-controlled systems can broaden the system's functionality.

C. Edge Computing Capabilities

The embedding of edge computing capabilities can further reduce latency and dependence on cloud infrastructure, thereby providing faster decision-making and privacy.

D. Global Connectivity

It will integrate more with global IoT platforms, , to promote wider compatibility and user acceptance.

E. Real-Time Analytics Dashboards

Advanced analytics and visualizations can further provide more insights into energy consumption and system performance to the user.

F. Improved Security Protocols

Enhancing data encryption and authentication methods can safeguard the system against potential cyber threats.

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