GBI-Based Wireless Home Automation System Using IoT

Anas Javaid, Anis Fariza Md. Pazil, Chong Hock Siong, and Nurulazlina Ramli

Abstract This paper proposed the design and implementation of Green Building Index (GBI)-based of home automation for monitoring and controlling with safety features integrated by the adoption of Internet of Things. The GBI criteria encompasses the energy efficiency, indoor environmental quality, water efficiency and innovation were implemented for this project focusing on lighting, heating, and ventilation of indoor and outdoor applications. The integration of smart plant irrigation system with rainwater harvesting system is also proposed for plants watering automation. To complement the GBI-based innovation criteria, the add-on features of smart security system such as facial recognition, movement and flame detection using various sensors were also incorporated into the design. In the end, all of the subsystems are connected into the cloud server for electrical power consumption monitoring performed by the smart energy meter. Finally, a working prototype is developed to address the proposed solutions and has successfully accomplished all tested conditions.

Keywords Green building index · Home automation · Internet of things · Smart security

1 Introduction

The Green Building Index (GBI) is Malaysia's recognized green rating system to promote sustainability in the built environment and raise awareness about environmental issues and responsibility to the future generations [1]. The six GBI assessment for building provides an opportunity for project developers and can be used by homeowners to improve green design and construction to their own properties. When GBI

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Z. Zakaria and S. S. Emamian (eds.), *Recent Advances in Electrical and Electronic Engineering and Computer Science*, Lecture Notes in Electrical Engineering 865, https://doi.org/10.1007/978-981-16-9781-4_12

features is integrated with Internet of Things (IoT) for the smart home automation system, the end result will be more remarkable as it incorporates sustainability weightage with the giant network connecting human and appliances/devices.

An IoT platform is a technology that allow sharing, control, and automate directly any connected IoT devices. The main concept is to attach various devices to a specific cloud with high-level of security, pliant options of connection, with a wide and fast data processing ability. Today, the increasing demand of automated systems especially for home leads to abundance research and studies being conducted in this area of interest.

The studies in [2] presented the research work of smart home automation and security using the Arduino modules but without surveillance system unlike the work presented in [3] which includes in the surveillance monitoring in their system using the Raspberry Pi board. Nevertheless, the design in [3] might get a bit complicated as it is developed using Linux, Python and Apache Server which needs basic programming skills in the above language. In addition, both systems do not have any considerations at all on GBI-based implementation. Therefore, this project mainly aims to enhance the current wireless home automation system by integrating IoT features with GBI-based criteria to promote green building with technology. This is to encourage the efficient use of natural resources particularly in energy and water while at the same time being supported by robust security features.

2 Methodology

Figure 1 shows the basic block diagram of the proposed methodology made up of 5 main subsystems categories implemented into this project while having a flexibility for the system to add more modular subsystem if needed. The indoor and outdoor lighting and smart system of fire, camera and movement detector are powered by the solar for the system security sustainability in case of power outage. The employability of the dependable wireless technology which connects multiple modules to the home automation system's server; provides greater flexibility the design solution. The goal of this proposed methodology is to develop and implement a cost-effective design of smart home automation system while sustaining the environmentally friendly ambience driven by GBI guidelines.

2.1 System Design

2.1.1 Arduino D1 Wemos

The Wemos D1 development board is based on the popular chip that revolutionized Wi-Fi in embedded systems of serial ESP8266. This simple module allows for system prototyping for the IoT in a less complicated manner as does not require

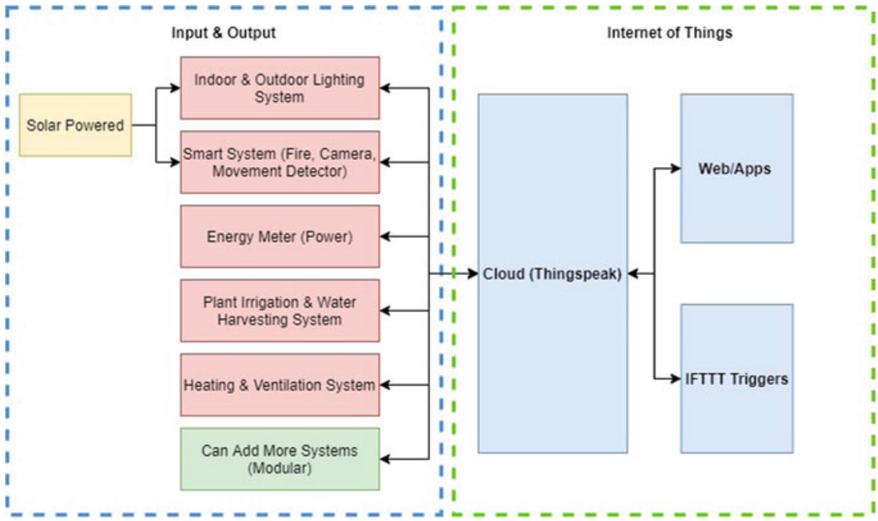

Fig. 1 Basic block diagram of the proposed methodology

other accessories to have an internet connection such as the official Arduino ethernet shield or Wi-Fi shield accessory. In addition, Wemos D1 can be programmed using the Arduino IDE in C and C++ languages which provides an advantage for programming flexibility.

2.1.2 Sensors and Camera Interfacing

Various of sensors are used in this project such as DH11 to measure the humidity and the temperature, flame sensor of LM393 to detect fire and Passive Infrared (PIR) sensor to detect motion of 10 m range. In addition, a soil moisture sensor which is an analog sensor is also used that shows values in voltage by which can be converted into percentage for indicator reference. The Light Dependent Resistor (LDR) sensor used in this project is to calculate the intensity of the light while the water level sensor detects the level of the water touching the surface of the sensor and gives feedback accordingly. To measure the power for the energy system, a voltage sensor (ZMPT101B) and current sensor (ACS712 5A) is integrated to the system. Finally, the camera used in this project is ESP32-CAM, which is based on the ESP32 board that allows direct camera module integration and at the same time used for motion detection and facial recognition.

Table 1 The input and output of GBI-based IoT System Design

GBI criteria	Subsystems	Input	Output
Energy efficiency	Power energy meter	Voltage & current	Voltage & current graph visuals on IoT Cloud
	Lighting system	Smart devices & LDR	Graph visuals, ON/OFF control using mobile, automatic garden lights
	Solar power system	Sunlight	Regulated DC Supply
Water efficiency	Plant irrigation system	Soil moisture sensor	Water pump, moisture graph visuals & data on IoT Cloud
	Water level harvesting	SL067 sensor	Water level visuals on IoT Cloud
Indoor environment quality	Heating & ventilation system	DHT sensor	Auto fan & Exhaust, T & H graphs on IoT Cloud
Innovation	Security & fire alarm system	LM393, Camera, PIR	Buzzer, IoT data Cloud, live-feed & door control

2.1.3 Architecture of the Proposed GBI-Based IoT System Design

Table 1 shows the input and the output of the proposed GBI-based with the related sensors, devices, and equipment for the implementation of this project.

The block diagram in Fig. 2 below shows several blocks supported by the subsystem indicating the connectivity of all sensors, devices and equipment implemented for this project. From the figure shown, all data from the sensors are being collected by the Thingspeak cloud which served as an IoT cloud platform. The data will be further analysed, monitored, and can be used for applications such as '*If This Then That*' (IFTTT), MATLAB Analysis or Webhooks. In this project, IFTT is used as the platform application as it provides simplicity in design implementation.

3 Implementation

3.1 Hardware Implementation

As shown in Fig. 3, the major components of hardware parts used in the subsystems are Arduino microcontrollers, camera, and sensors with relays. Many sensors are interfaced with Arduino through C programming language and the output can be viewed on the cloud server, webpage, and mobile platform.

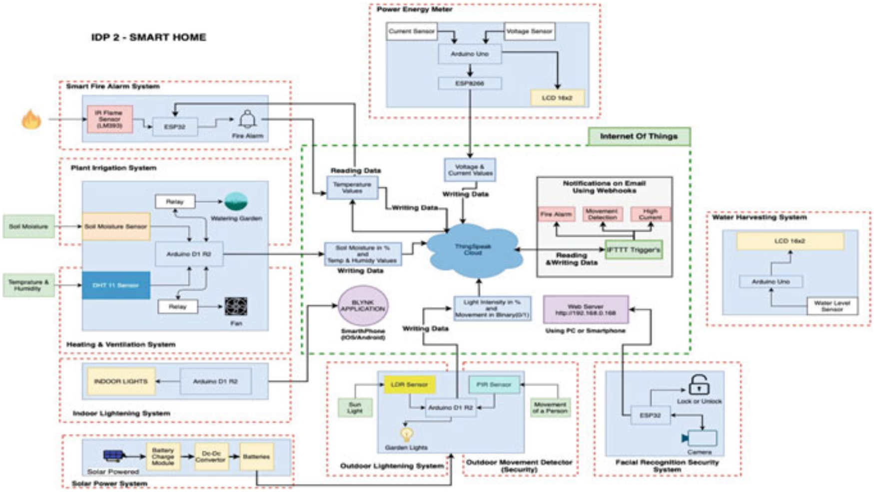

Fig. 2 Block diagram of the integrated architecture for proposed design

3.2 Software Implementation

In this project, Thingspeak online platform is used as it is one of the easiest platforms to set up as compared to other online platforms especially for data configuration. In addition, it also provides a high quality of support. This online platform can visualize data in real time where results can be obtained instantaneously. This means that the data processing can be performed on real time-based with visualization feature for the interaction ability with apps and plugins. It is also low cost as there are options for a free user account. Another software integrated into the design is IFTTT which allows the user to use all data being collected by ThingSpeak and also Blynk app for subsystem control application [4, 6].

4 Result

As shown in Fig. 4, a simplified house prototype has been developed to demonstrate the functionality and the output of each subsystem. The results displayed for all of the subsystems shows that the system has been integrated and developed successfully that met the criteria and objectives of the proposed design.

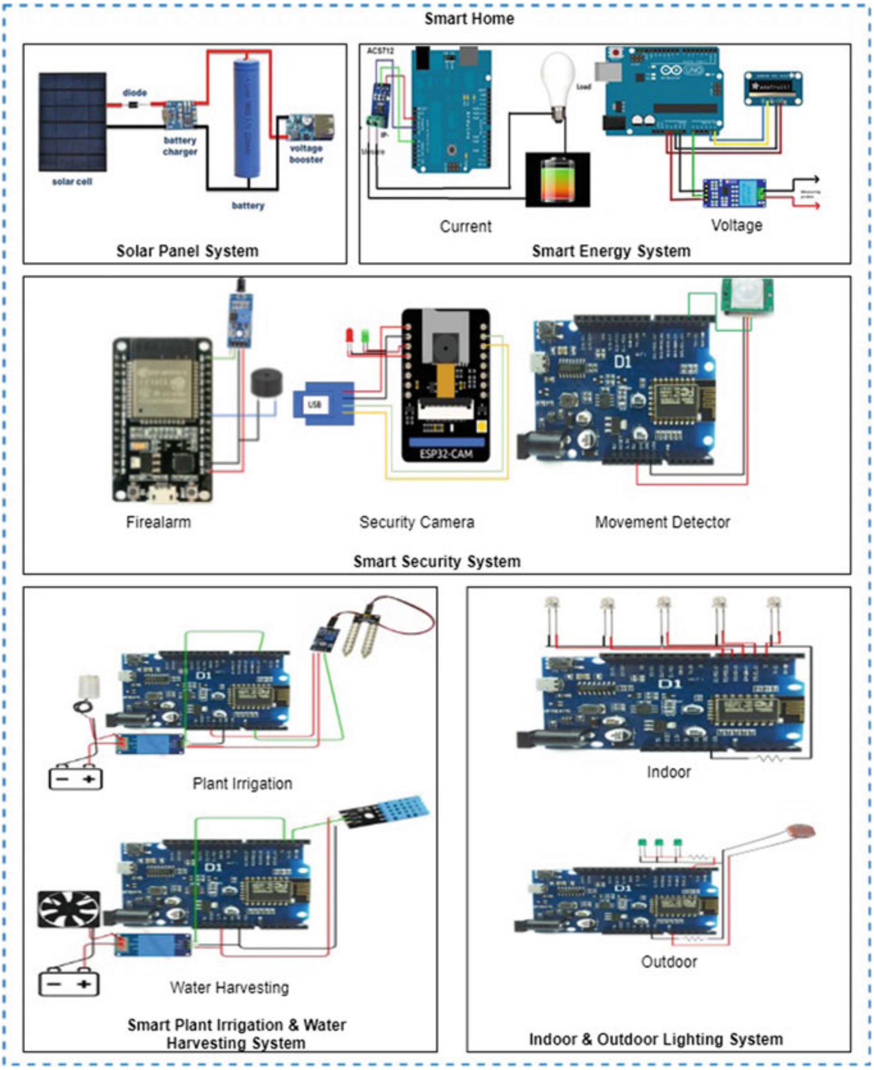

Fig. 3 Hardware implementation

Meanwhile, Fig. 5 shows the display results extracted from the Thingspeak cloud. These panels or dashboard shown will help the user to have a full control of their smart home by monitoring each subsystems functionality from any choice of smart device.

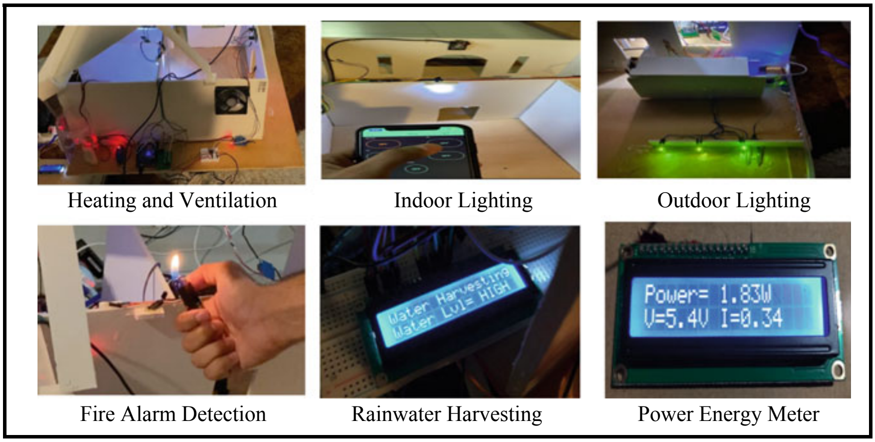

Fig. 4 Subsystem hardware prototype display results

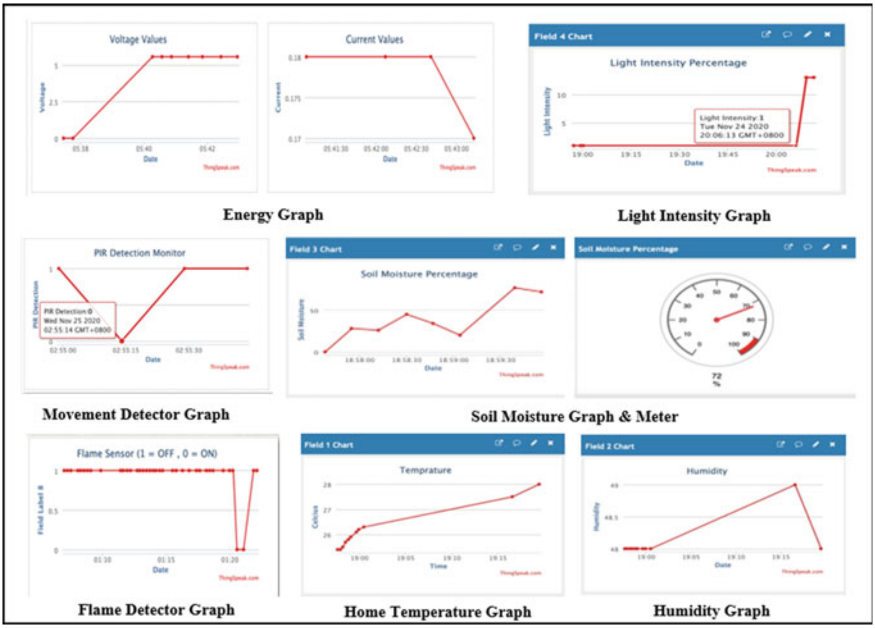

Fig. 5 Subsystems visual display for result monitoring from the online platform

4.1 Security System

In Fig. 6, the results from security camera are shown whereby the top left picture shows intruder alert when the person is not registered to the system while the top right

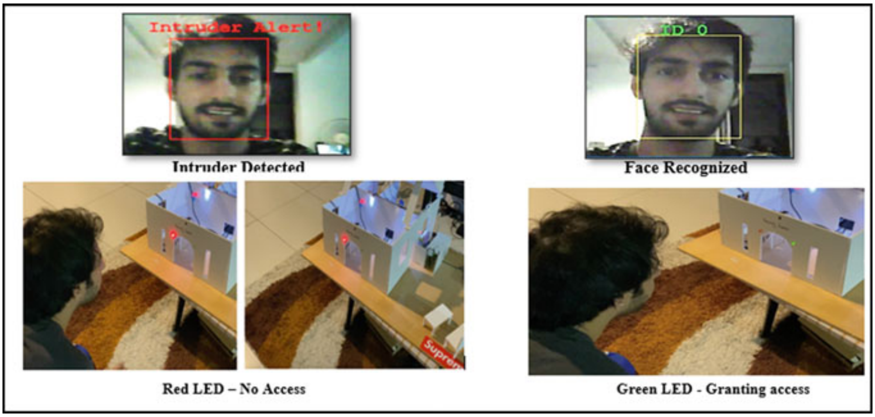

Fig. 6 Results shown from the security camera

picture shows the person is recognized after being registered. Meanwhile, the house model of picture below showing the red light indicating the intruder is prohibited from entering the house and a green light granting access to the person.

5 Comparison with Existing System

Table 2 shows the comparison of the proposed system with the existing system based on the wireless home automation system application. To the authors' knowledge, no prior studies have been performed so far to integrate the IoT element with the GBI-based features for the wireless home automation system.

Table 2 Comparison between proposed and existing systems

References	Parameters	Existing systems	Proposed system
Gupta and Chhabra [5]	Green technology	Less or none	GBI-based
Santoso and Vun [7]	Circuit integration	Complex	Simplified
Jabbar et al. [8]	User Friendly	Less or none	Highly interactive
Pătru et al. [9]	Modular	None	Upgradable by subsystem(s) addition

6 Conclusion

The GBI criteria meeting the requirements of energy efficiency, indoor environmental quality, water efficiency and innovation has been fully developed in this home automation system with IoT adoption. The application of monitoring and controlling with safety features incorporated into the design by Arduino D1 Wemos and the online platform of ThingSpeak and Blynk app shows an excellent agreement with the aim of the project. This design provides moderate and less expensive way of sensing, monitoring, and controlling system in the most efficient way while considering the sustainability of natural resources of the world. In future, it is expected that more GBI-based criteria such as wastewater recycling management can be incorporated into the design for greater benefits to the ecosystem. While for future design, it can be proposed that the controlling of the systems to be done via voice recognition to enhance the security features of the design.

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