A Smart Home Management based on M2M/IoT Technologies

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Abstract. The advances in the applications based on Machine-to-machine (M2M) and Internet of Things (IoT) enabled the evolution of Smart home solutions wirelessly. This paper aims to present the implementation of smart homes based on M2M/IoT technologies using wireless sensor networks (WSNs). In this system, Arduino Uno microcontroller has been used with several compatible sensors, actuators, and modules to make the control and take the suitable decision. In addition, various technologies of communication such as Bluetooth, Wi-Fi, Ethernet, and GSM are used as wireless communication mediums to enable the interaction between users and the proposed system. Our Smart home implements integrated functions and services like security, indoor care, and outdoor care. A simple smartphone remotely controls these functions through our mobile application named 'Raniso'. The experimental results of using the proposed system show that a variety of events can be detected and monitored efficiently. Gas leakage, fire, and housebreaking situations can be detected and users get notified about them via Calls and messages. Also, lights, temperature monitoring, and fans can be easily controlled remotely. Besides, the proposed system can perform some proper actions including decreasing gas concentration via the opening of windows, watering the garden when the soil is dry, saving the rainwater, and so on. Our smart home system is very utile to prevent losses in resources and human life caused by undesired events as also it conserves energy and provides comfort.

Keywords: Smart home, M2M, IoT, WSNs, Mobile Application.

1 Introduction

In recent years, the evolution of wireless communication has shown rapid progress where data transmission became faster and stronger. The need for data transmission became essential not only for communication between humans but also between machines. Hence, a new technology emerged the machine-to-machine (M2M) communication. This technol-

ogy can be defined as the communication between multiple devices (machines) without or with only limited human intervention, all via wired or wireless communication networks [1]. M2M is the equivalent of another technology called the Internet of Things (IoT) that links the Internet, objects, places, and environments. M2M and IoT have been applied in various domains, e.g. the industry, security, health, home automation. A smart house is one of the most significant emerging applications that combine M2M/IoT technologies[2]. It is defined as a residence equipped with advanced technologies that aim to assist residents in various situations of domestic life. This paper represents the application of the collection of M2M communication and IoT technology in Smart Homes by using different wireless sensor networks (WSNs) like Bluetooth, Ethernet, and GSM. This paper is the extension of our earlier published chapter titled Design and Implementation of M2M-Smart Home Based on Arduino-UNO[3] and our other paper titled Application of M2M Communication based on ZigBee to Control Smart home automation[4]. Where we are keen on this work to develop smart home tasks and our mobile App named 'Raniso'. By comparing our work with previously published research like Machine-to-Machine Communications for Smart Homes[5], Internet of Things: Ubiquitous Home Control and Monitoring System using Android based Smart Phone[6], GSM based home automation system[7], Bluetooth Based Smart Automation System Using Android[8], and so forth. In these papers, we found out several limited points in addressing smart home issues, while our proposed solution represents a complete system based on M2M/IoT technologies. Our system accomplishes three functions that a smart home must provide: security, indoor care, and outdoor care. Where, we realize a smart door system, gas leak detection, fire alarm system, to ensure safety, and to preserve the life of residents. Then, to provide a comforting experience and indoors care, we control temperature and lighting remotely. As for outdoor care, we implement two main tasks garden irrigation automation system and a rain detection system. The value of this work is to create a smart home model with available equipment (sensors, actuators, shields, etc.), where Arduino card is the brain of the system. In addition to the Android platform, which is considered as the control management.

2 Design of Smart Home System Based on M2M/IoT

2.1 System design

The designed system consists of three main parts: intelligent devices, wireless connection, and mobile application as represented in Fig 1.

- **The intelligent devices:** are the equipment responsible for collecting data, for this purpose we have used Arduino UNO, sensors, and shields.

- **Wireless communication:** the wireless connection between part “1” and part “3” has been established via Bluetooth, Internet, GSM, etc.
- **The mobile application:** is a local server installed on the smartphone that allows controlling the smart home remotely through WSNs.

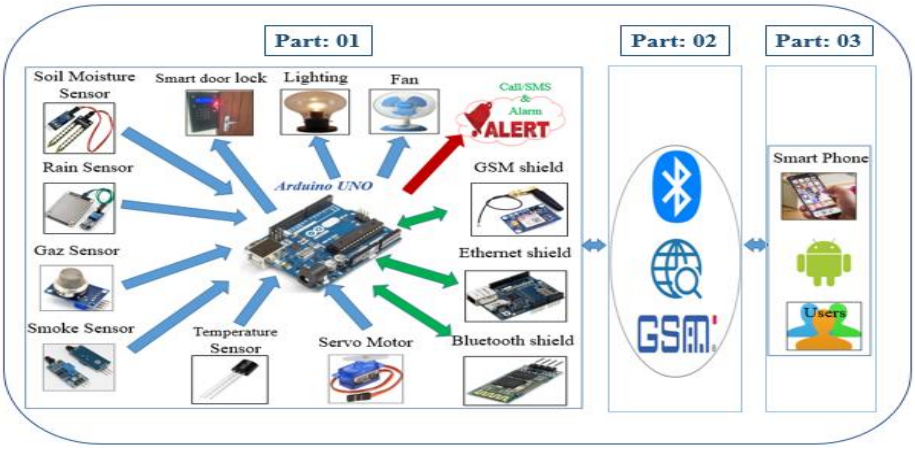

Fig. 1. System design.

2.2 Communication protocols for WSNs in Smart homes

The communication protocols infrastructure for the proposed smart home based on M2M/IoT technologies is divided into two main sections The first one concerns the communication between appliances and machines of the house. The LAN (Local Area Network) supports small area connectivity. The most important LAN technologies are IEEE802.11x and Ethernet[9]. The PAN (Personal Area Network) supports short-distance connectivity for communication among personal devices such as Bluetooth, Zigbee, RFID, and so forth[10]. The technologies of LAN and PAN are used for Home Area Network (HAN). The second one is the network for communication between devices in HAN and devices in the outside network. Wide Area Network (WAN) is employed for this purpose. Cellular network technologies like GSM and LTE are used for WAN. The suggested smart home can be controlled by different wireless sensor networks.

3 Implementation of Smart Home Services Based on M2M/IoT

3.1 Security and Safety

Smart Door System.

The proposed smart door is based on a servo motor, Keyboard, LCD, and Bluetooth HC-06, and is remotely controlled by the mobile application ‘Raniso’via Bluetooth or

by entering the correct password. For security reasons, the user must enter a password to open the door, if the correct password has been entered, the servo motor turns, the door opens and the screen displays “Door is open”, otherwise the door remains closed. To close the door press "*" on the keyboard, and the screen displays “Door is closed”. Thus, the proposed smart door ensures the protection of the home against break-ins. Fig 2 shows the suggested smart door.

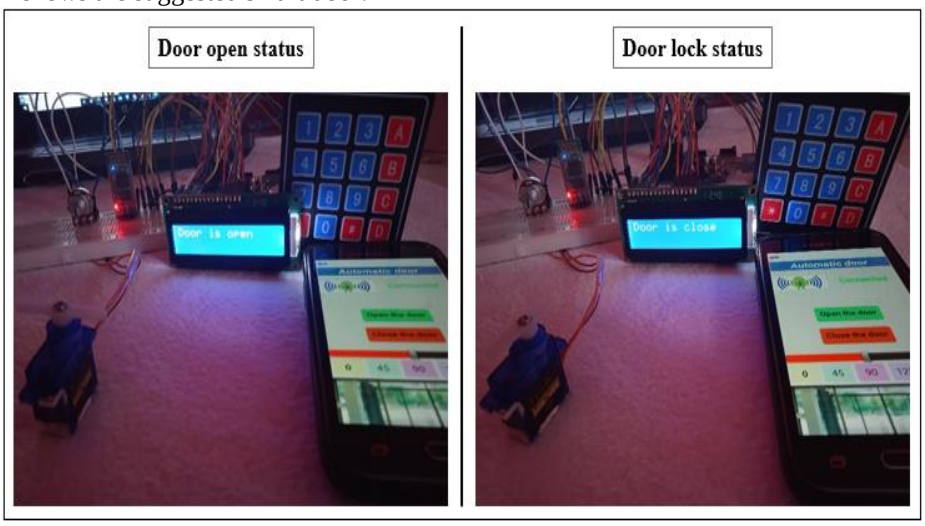

Fig. 2. Smart door system.

Gas Leak Detection.

The proposed system for gas detection is accomplished with the MQ-2 sensor, Ethernet shield, LEDs, servo motor, LCD, and buzzer. Once the user is connected to the internet, he can track the gas status of his home anywhere through our mobile application. Under normal conditions, if there is no gas leak, Raniso App interface and the LCD will show a “Safety state” message and the blue LED turns on as a safety indicator. In the case of a gas leak, Raniso App interface and the LCD screen will display the message “Gas Detected”, the red LED will light up, the buzzer will sound and the Servo motor will rotate to open the window automatically and prevent gas damages. Fig 3 represents the gas leak detection system. The proposed system for gas detection also sends a real-time alert message to the owner containing ‘Gas detected in the house’ as shown in Fig 4.

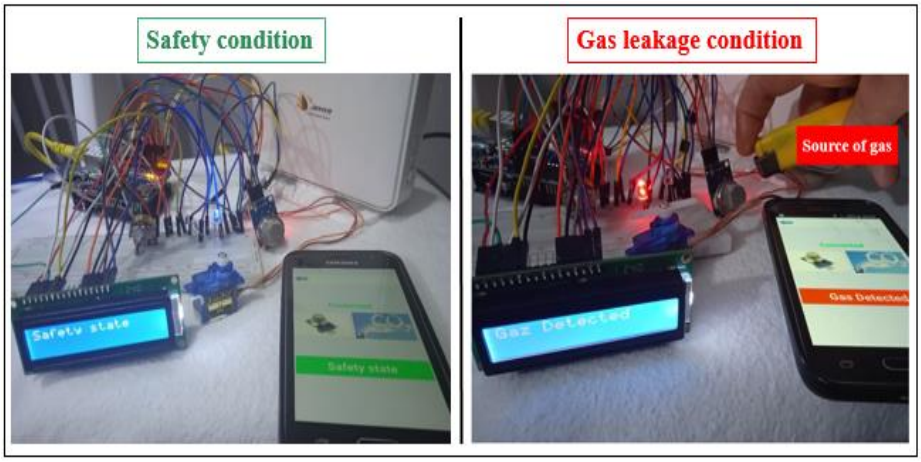

Fig. 3. Gas leak detection system.

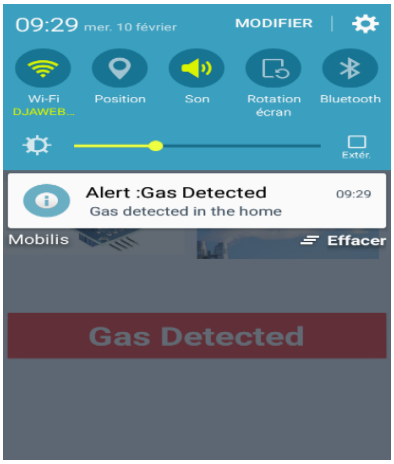

Fig. 4. An alert message of gas leak.

Fire Alarm System.

This task is based on the flame sensor, GSM shield, LEDs, and buzzer. Our solution system allows us to set up calls and send SMS (alert messages) to specified mobile numbers (see Fig 6). Also, the system activates an audible alarm and red lighting outside the house during the fire and stops it once the danger is under control to protect the house from fires. Fig 5 shows the fire alarm system proposed.

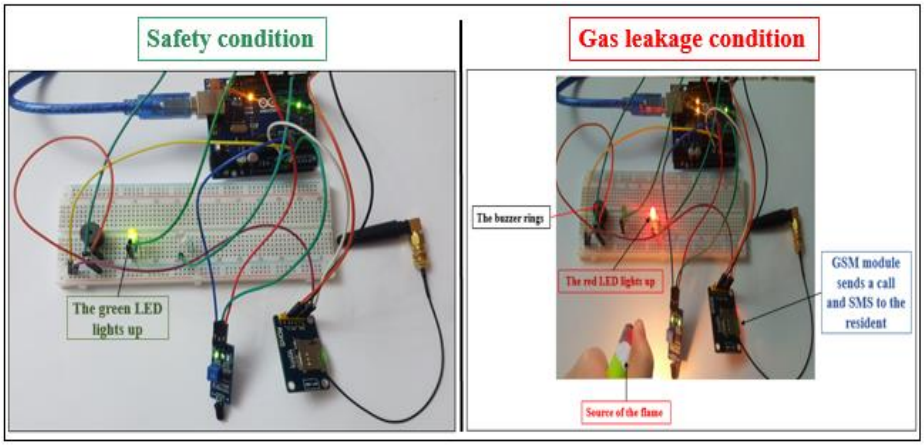

Fig. 5. Fire alarm system.

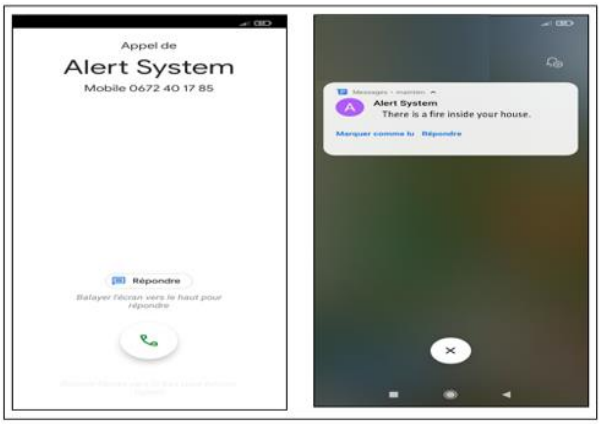

Fig.6. A call and an SMS were sent to the resident due to the occurrence of a fire.

3.2 Indoor Care

Lighting Management.

This function contains two important tasks remote lights control and automatic lights.

Remote lights.

This task is based on Bluetooth HC-06 and LEDs, to ensure comfort in the house. We can easily manage LEDs with Raniso App via Bluetooth. The lights can be turned off or on remotely as shown in Fig 7.

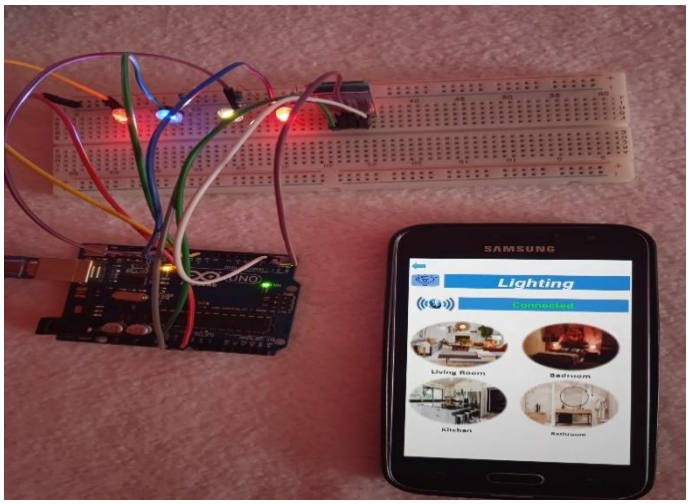

Fig.7. Lighting management via Bluetooth.

Automatic lights.

This task is based on a motion sensor, LDR, and LEDs. Lights will turn ON automatically in the dark if human movement is detected as shown in Fig 8, so the system can save as much energy as possible in the home. Such Automatic Lights can be implemented in garages, staircases, bath-rooms, and wherever there is no need for continuous lighting[11].

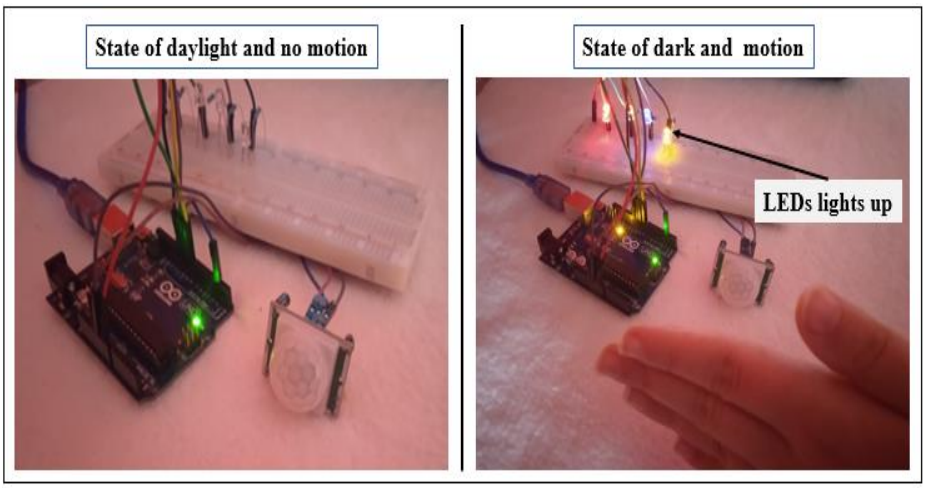

Fig.8. Automatic lights system.

Temperature Monitoring System and Fan Control.

To achieve this purpose we used an Ethernet shield, LM35 sensor, LCD, and DC fan. And the task is accomplished in three stages. First the LM35 sensor module's output

and extracts temperature value into a suitable number in the Celsius scale. The next part of the system displays the temperature on the LCD screen. The last part allows the user to monitor the temperature and control the fan remotely via the internet through Raniso App. Once the user is connected to the Internet, either (Wi-Fi, 4G, etc.), he will be able to monitor the temperature and turn the fan ON or OFF remotely as shown in Fig 9.

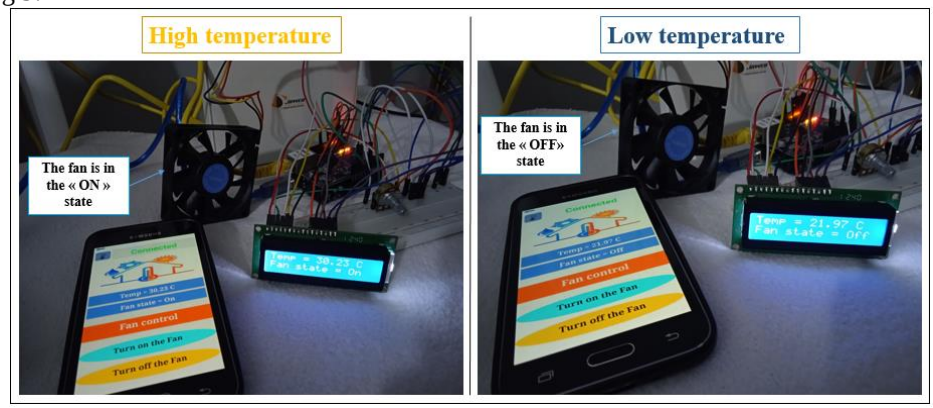

Fig. 9. Temperature monitoring and fan control system.

3.3 Outdoor care

Garden Irrigation Automation System.

This task is based on a servo motor and a soil moisture sensor that senses the level of soil moisture and determines if it is dry or wet. If the soil is dry, the red LED lights up and the buzzer emits a sound. Also, the irrigation motor operates watering the plants at the time of need for real water and switches OFF when the soil is wet in part to save water. The main advantage of using this irrigation system is to reduce human interference and ensure proper irrigation. Fig 10 shows the implemented circuit of this system.

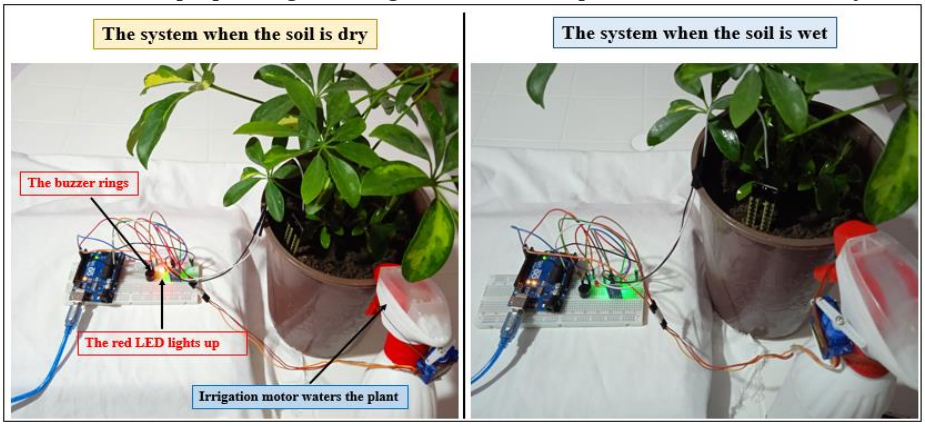

Fig. 10. Garden irrigation automation system.

Rain Detection System.

This task is based on a rain sensor, servo motor, I2C LCD, buzzer, and blue LED. This system gives the alarm when there is rain. The alarm is represented by lighting up a blue LED, ringing on the buzzer, and displaying on the LCD screen “It is raining”, so that we can make some actions for rainwater harvesting. Also, our system helps to switch ON the equipment which will automatically save rainwater as shown in Fig 11.

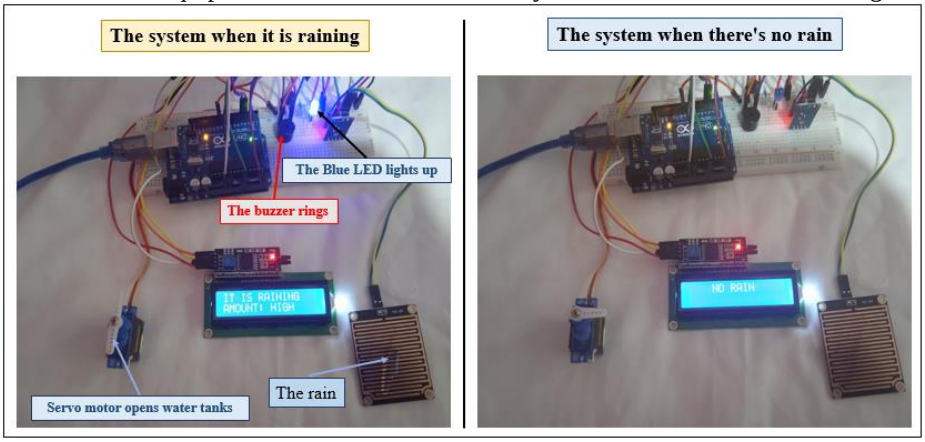

Fig. 11. Rain detection system.

4 Conclusion

This paper focuses on a smart home system based on machine-to-machine communication and Internet of Things technology. The implementation of our system started with a critical study of existing solutions to design a more functional system. Then, by building a prototype of our smart solution, we tried to make a concrete work that performs three main functions, namely security, indoor care, and outdoor care. We set up seven important services: smart door, gas leakage detection, fire alarm system, lighting management, temperature acquisition, garden irrigation automation system, and rain detection system. All these services can be remotely controlled by our mobile application named "Raniso" via the Internet/Bluetooth platform. This study focuses on the prototype design for the control, automation, monitoring, and remote control of home systems in real-time. The proposed M2M/IoT home automation system model was built and tested and it gave exactly the expected results.

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