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Design of Cellular Device for Home Automation based on IoT Technology

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Abstract- This paper presents a new device for controlling electrical devices using a SIM card, harnessing the power of cellular Internet of Things (IoT) technology. With the growing reliance on the internet and the increasing popularity of smart devices, automated systems have become a preferred choice for managing everyday tasks. The proposed system integrates both hardware and software interfaces, providing users with comprehensive control and real-time monitoring of electrical outlets and lighting systems. This not only saves time and effort but also contributes to energy efficiency. A significant feature of the system is the incorporation of voice control via a dedicated mobile application, which is particularly beneficial for individuals with special needs and the elderly, offering them enhanced accessibility and ease of use. A key innovation lies in the use of a SIM card, simplifying the setup process and eliminating the need for complicated installations. Additionally, the system employs NodeMCU ESP8266 technology, which facilitates the control of appliances and sensors. The mobile application is designed to be user-friendly, supporting multi-user functionality, thereby offering an efficient and convenient solution for smart home management and energy optimization. This approach makes smart home automation more accessible and practical for a wide range of users.

Keywords- *IoT, Smart home, SIM card, NodeMCU, SYMO.*

I. INTRODUCTION

Home automation systems have gained significant popularity worldwide, offering numerous benefits to users, especially those with disabilities or the elderly. These systems can be classified into two main categories: wired and wireless. While wired systems connect appliances directly to a central controller, wireless systems utilize wireless communication to link devices. The introduction of wireless technology has eliminated the need for complex wiring and enhanced the flexibility of home automation solutions [1].

Home automation systems can be operated using various switches and can be powered by electricity or a chip. They serve as a central hub for controlling and managing different aspects of a home, including lighting, appliances, security, and more. By automating household tasks, smart homes can improve safety, enhance usability, and make life easier for people of all abilities [2].

The proposed model introduced in this paper controls the devices in a smart way through multiple communication, which provides us with solutions that eliminate many of problems as follows:

- Life problem: by facilitating people's daily routine regarding controlling electrical appliances, thus saving time and effort, preserving electricity, preserving the life of the devices, and the possibility of making a complete follow-up of the electrical outlets to avoid the occurrence of fires resulting from electrical short circuits, and thus not losing or forgetting any of the devices when they are in operation.
- The social problem: By providing solutions for people with special needs and the elderly in remote control through voice control and without the need for human assistance.
- The technical problem: by solving the problem of the complex installations, the problem of converting devices into smart ones and the problem of the difficulty of dealing with people as shown in Fig. 1.

Figure 1: The technical problem with the installations

II. Cellular IoT

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In today's connected world, cellular or mobile networks not only connect us to our family and friends, but also numerous other devices like our Gmail server and Facebook account. This is the age of the "Internet of Things" or IoT, in which, more and more devices are being connected online. Consequently, the demand for technology that can connect physical devices like your car, audio speaker, or television along with other devices like highway signals and electricity lines, to the cellular network is on the rise. This is the driving force behind Cellular IoT technology [3].

So, what is cellular IoT and how is it useful? Cellular IoT is the technology that connects physical objects to the internet utilizing the same cellular network currently used by smartphones. In other words, this technology can connect IoT devices using existing mobile networks. Thus, it eliminates the need to invest and develop a separate dedicated network infrastructure just for IoT devices. The idea behind Cellular IoT enablement is to use cellular networks, including 3G, 4G/LTE or 5G, for connecting devices like streetlights, agricultural, and healthcare equipment [4].

When evaluating the most suitable low power wide-area network (LPWAN) technology for your IoT application, it's crucial to consider various factors beyond just technical specifications, which can widely diverge from real-world performance. These are some of the key reasons why cellular IoT can be a more suitable choice for your IoT application as opposed to LoRaWAN, Sigfox, or other LPWANs.

Regarding licensed vs unlicensed frequency bands: cellular IoT operates in licensed frequency bands that leverage existing global infrastructure. While they entail subscription fees, they guarantee wide coverage, scalability, built-in quality of service, reliability, and uncompromising security. This allows you to focus on your specific IoT product development without the need to deploy and maintain infrastructure associated with other LPWAN technologies operating in unlicensed frequency bands.

Regarding data rate and robustness, the LPWAN technologies are typically used for devices that transmit/receive data infrequently. However, certain operations benefit from higher data rates, such as remote firmware updates. This is where cellular IoT stands-out as it can serve the infrequent data transmissions as well as the more intensive data bursts when they are needed [5].

Regarding power consumption: Narrow Band – Internet of Things (NB-IOT) and Long-Term Evolution – Machine (LTE-M) technologies were developed to enable low power, massive machine type communication applications. While other LPWAN technologies may look better on paper, that can often change drastically based on the use case and many other factors, and it comes at the cost of limited data rates. With cellular IoT you don't need to compromise between power consumption and data rates, you get the best of both worlds [6, 7].

III. The Proposed Model

The proposed model in this paper is considered as an ideal solution for solving the problems mentioned before. Accordingly, the solution is presented in a device that is called "SYMO". SYMO provides us with a device through which we can fully monitor the electrical outlets and control all the lighting outlets, thus saving time and effort and greatly preserving our electricity consumption. Thus, we will preserve the life of the devices and avoid the occurrence of any fires.

Also, through the device, we can help people with special needs and the elderly by controlling the devices through voice commands, and all of this is done through a mobile application through which you can easily control anything.

By using the device, you will be able to solve the problem of complex installations and connections by replacing the router and the landline with a SIM card. This will give us ease of delivery and speed of spread using cellular IoT.

The cellular IoT is like a cellular phone, but we removed the phone from the topic, and we put in its place the IoT devices, which are smart devices and home automation.

In the past, the topic was running by default on the network, and because of the problems mentioned before, we made the automation devices work with the SIM card instead of using the network. We added the special thing that we introduced by working with the SIM card to provide us with a better speed of spread. The installation is so easy, the chip is placed in the device, and it connects continuously. This makes it easy to use, it can be installed anywhere without any configuration operations, and this allows you to be active on the network continuously.

This device also will be useful in places where there is no easy connection, such as carnivals, travel routes, and yachts. For example, the connection in yacht is very complicated , so we will solve and limit these connections by using the proposed model.

IV. SYMO DEVICE

The SYMO device is implemented via NodeMCU based on LTE module with SIM card. The main components of the device is as follows: NodeMCU ESP8266, LTE Module, led (5mm), 6 led (3mm), 8 resistance, capacitor, 6 optocoupler, 6 transistors, 6 diodes, 6 relays, power supply Hi-Link, fuse (holder), varistor., push button, 6 connector 3pin, iack 2pin., jack 4pin, 6 terminal 3pin, 2 terminal 2pin, 1 terminal5pin, 1 terminal 2 pin (High Power) and copper spacer F/F.

The device allows you to control all electrical outlets and lighting system, even if they are not smart. It consists of 4 to 6 channels that are controlled via a mobile application. You can control it in more than one place and with more than one device, and one of its most important features is that it can move from anywhere easily. The device can move around in places such as carnivals, show rooms, yacht, or service vehicles, and dealing will be easy and without any complications.

In this paper, the device is used for controlling the lighting system in home using an ESP8266 development board and firebase cloud database service. The system allows users to turn appliances ON and OFF and is connected to the relay through simple switches. There is often a need for remote control of home appliances, especially for people who have difficulty with allergies or want to control appliances from different places in the home. The proposed device provides an effective and effective solution to achieve this.

V. SIMULATION OF SYMO DEVICE

Before the hardware implementation of the proposed device "SYMO", simulation is obtained using a 14x15 control system constructed using the EasyEDA platform [8, 9] as shown in Fig. 2. This simulation incorporates a variety of essential components. These components included a relay module containing two types of relays (5V, 16A and 5V, 30A) for controlling high-load devices. Also, a switch module with switches for various functions such as controlling output power, receiving responses from devices, and controlling WiFi configuration exists. Additionally, a power module was included to supply power to the circuit, a socket for the 4G module to provide power and

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switching, and a NodeMCU ESP8266 as the primary microcontroller for the system. A reset switch and a WiFi status indicator were also included to allow the system to restart and to indicate the status of WiFi connection.

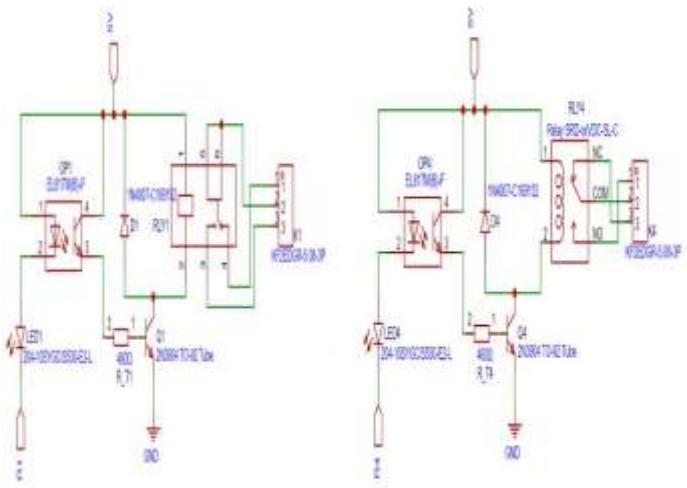

Figure 2: Schematic Design of the SYMO Device

VI. PCB IMPLEMENTATION

The implenatation is obtained using double sided PCBs or 2-layer PCB as shown in Fig. 3. The double-sided PCB, has two conductive layers, one on the top and one on the bottom, separated by an insulating substrate of the board can be connected on the other side of the board with the help of holes drilled on the board.

Although these may be more difficult to produce as compared to single sided PCBs, its advantages far outweigh the complexity of production. This beacuse of the big advantages of double-sided boards that allows an added layer where components can be added which increases the density of the circuit. Typically, as appliances become smaller, the extra layer goes a long way in terms of increasing the flexibility of design. Since you can effectively use both sides, the size of the board can be reduced. Hence, they are highly effective for miniaturized appliances [10-12].

Figure 3: PCB Design of the SYMO device

The double-sided PCB was designed using EasyEDA and printed by NORI solution. The final design and the shape of the SYMO device are shown in figures 4 and 5 respectively.

To validate the functionality of the proposed model, the model was implemented in a smart home to control the lighting system (as shown in Fig. 6), and the results show that it functions effectively

Figure 4: Final Design of the SYMO device

Figure 5: SYMO Device

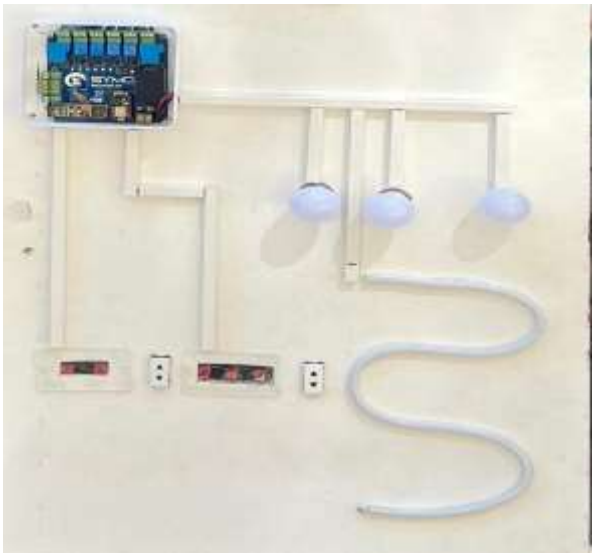

Figure 6: SYMO in Smart Home

VII. CONCLUSION

In this paper, an effective and safe approach for smart homes was proposed and implemented. The 4G module is used with a SIM card and a NodeMCU (Microcontroller) to control the devices via voice commands, all done through a mobile application through which you can control anything easily.

A Cellular IoT smart home controller designed to address the growing need for user-friendly and accessible smart home automation. The proposed device “SYMO” offers a compelling

value proposition by simplifying installation through cellular IoT connectivity, eliminating reliance on complex Wi-Fi configurations. This user-centric design caters to a broad audience, even those with limited technical expertise.

SYMO device, a novel smart home control system powered by cellular IoT technology. SYMO offers a user-friendly and accessible solution for managing electrical outlets and lighting, prioritizing safety, energy efficiency, and convenience. Its voice control functionality empowers individuals with special needs and the elderly, while its customizable features cater to diverse user preferences.

In the step further, SYMO has the potential to revolutionize smart home automation through integration with popular ecosystems, AI, and enhanced security. Its versatility and adaptability make it a promising solution for shaping the future of connected living.

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