

Design and Implementation of a Reliable Wireless Real-time Home Automation System Based on Arduino Uno Single-board Microcontroller

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Abstract— This paper presents design and implementation concepts for a wireless real-time home automation system based on Arduino Uno microcontroller as central controllers. The proposed system has two operational modes. The first one is denoted as a manually-automated mode in which the user can monitor and control the home appliances from anywhere over the world using the cellular phone through Wi-Fi communication technology. The second one is referred to a self-automated mode that makes the controllers to be capable of monitoring and controlling different appliances in the home automatically in response to the signals comes from the related sensors. To support the usefulness of the proposed technique, a hardware implementation with Matlab-GUI platform for the proposed system is carried out and the reliability of the system is introduced. The proposed system is shown to be a simple, cost effective and flexible that making it a suitable and a good candidate for the smart home future.

1. INTRODUCTION

Recently, man's work and life are increasingly tight with the rapid growth in communications and information technology. The informationized society has changed human being's way of life as well as challenged the traditional residence. Followed by the rapid economic expansion, living standard keeps raising up day by day that people have a higher requirement for dwelling functions. The intellectualized society brings diversified information where safe, economic, comfortable and convenient life has become the ideal for every modern family [1].

It is will know that the concept of smart home has focused the attention of researchers, lifestyle practitioners, and the consumers to be directed forward the usage of the recent technology. Considerable efforts have been made to the development of remote control systems for home automation. The earlier work of such systems are mainly based on the use of telephone line, such as a phone-based system for home automation using a hardware-based remote controller [2, 3] based on a personal computer approach [4]. These kinds of systems which make use of the telephone as the remote control input device have no way to be connected through any user interface. The proliferation of telecommunications technology has made most of recent home automation scenarios focus on using wireless communication to communicate the home appliances. Shepherd in [5] has introduced the idea of using Bluetooth wireless technology as a cable replacement that exploited the wireless interconnectivity which can be implemented using radio home automation system method. However, he gave no design and implementation details in his work. Sriskanthan et al. in [6] have developed an automated system based on Bluetooth wireless technology which allows the user to monitor and control different appliances that are connected over a Bluetooth network based on a mobile host controller. Alkar et al. in [7] have introduced an internet based wireless home automated system for multi-functional devices. Although the system has a low cost and flexible wireless solution to the home automation, there are still some limitations related to the wireless communication range and power failure. Jawarkar et al. in [8] have proposed a remote monitoring through mobile phone involving the use of spoken commands. These spoken commands are generated and sent in the form of text SMS to the control system via a microcontroller that designed on the basis of SMS where a decision of a particular task can be taken place. El-Medany et al. in [9] proposed a GSM-based remote sensing for controlling system based on using FPGA. This system has worked as a remote sensing for the electrical appliances at home to check whether it is on or off and in the same time allowed the user to control the electrical appliances at home based on SMS technique. It also works as automatic and immediate reporting to the user in case of emergency for home security. Zhang et al. in [10] showed that a home automation system based on electric power communication

(PLC) that uses household electric wire for communication and internet control with logging facilities. Although this system procedure overcome the shortcomings of communications techniques, but still need some improvement. System that uses a GSM-Bluetooth based controller and remote monitoring system is proposed in [11]. This system is scalable and permitted any number of different appliances to be added with no major changes in its core. But this system is not efficient in some situations that required strong real-time applications. Carl et al. in [12] has proposed a cost effective and flexible automation system that implemented through FPGA controller and mobile phone Bluetooth network. This method provides a parallel implementation of hardware results using fast algorithm execution. A WiFi based automation system is also implemented in [13] where a microcontroller and WiFi technology for appliances remote control have been used. They showed that from point of view of the scalability and flexibility are better than those methods using the commercially available home automation systems.

Based on all the preceding materials, a design concept for a real-time home automation system using Arduino Uno microcontroller with Matlab-GUI are proposed in this work. The proposed Arduino Uno controller introduced in this work provides a simple implementation at the system as compared to the other types of controllers in the literature. This system has two operational modes; the first one of them is based on a cellular phone while the second one is considered a

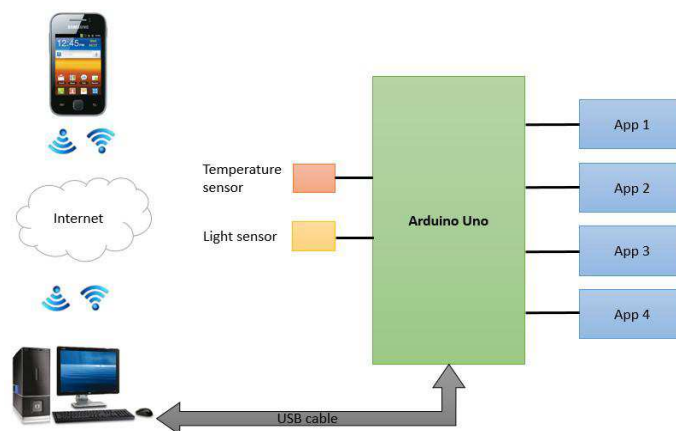


Figure 1: Proposed home automation system architecture.

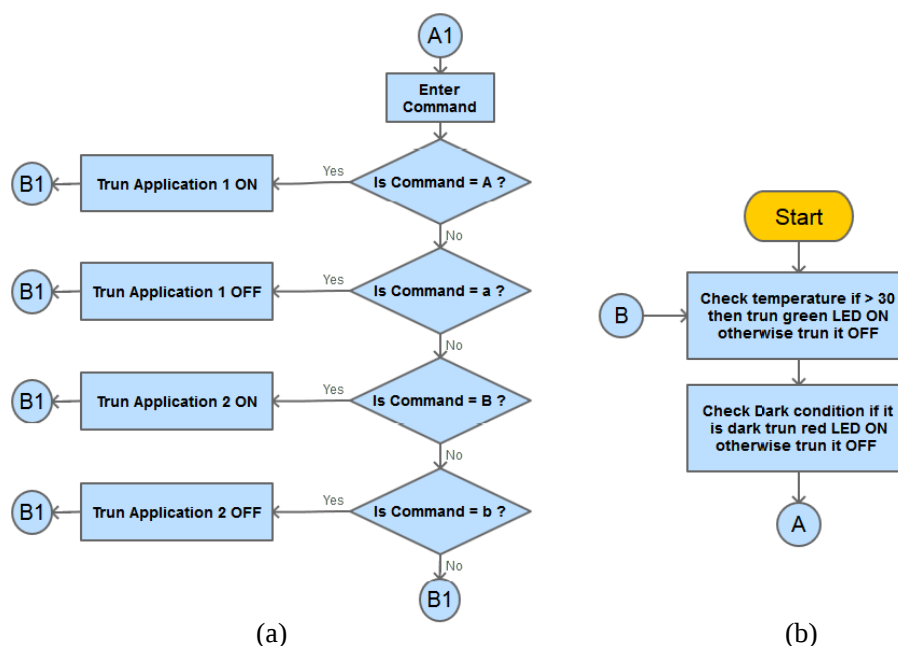


Figure 2: Proposed home automation process. (a) Manually-automated mode. (b) Self-automated mode (i.e., temperature control).

self-automated process. To support our claim, a hardware implementation for the proposed system is developed to verify its reliability and limitations.

2. SYSTEM DESIGN

The core of the home automation system consists of two main hardware components: the PC home server and the Arduino uno microcontroller board. The architecture of the system developed is shown in Figure 1. A PC home server hosts the Matlab-GUI platform management and Arduino uno control algorithm that enables the user to access the home appliances through cellular phone using Wi-Fi communication. It communicates with the Arduino Uno microcontroller board through USB data transfer cable. A number of appliances and sensors are connected to ports of the microcontroller board. The home Appliances can be monitored and accessed remotely by user cellular phone.

In this proposal, two operating modes are designed. The first one is a manually-automated mode in which the appliance is monitored and accessed manually using the cellular phone. The proposed flow chart of this process is shown in Figure 2(a). The other mode is a self-automated mode. In this case the microcontroller accesses the appliance automatically. Figure 2(b) illustrates the process of temperature self-automated control system as an example of this operating mode.

3. HARDWARE IMPLEMENTATION

To verify the correct operation and limitation of the designed system, a hardware implementation is developed to model the proposed system in its two different modes manually-automated and self-automated modes.

3.1. Manually-automated System

The appliances in home are remotely controlled using cellular telephone with Matlab-GUI platform. The designed Matlab-GUI platform can control four appliances individually or all of them at same time by pressing ON/OFF buttons as shown in Figure 3.

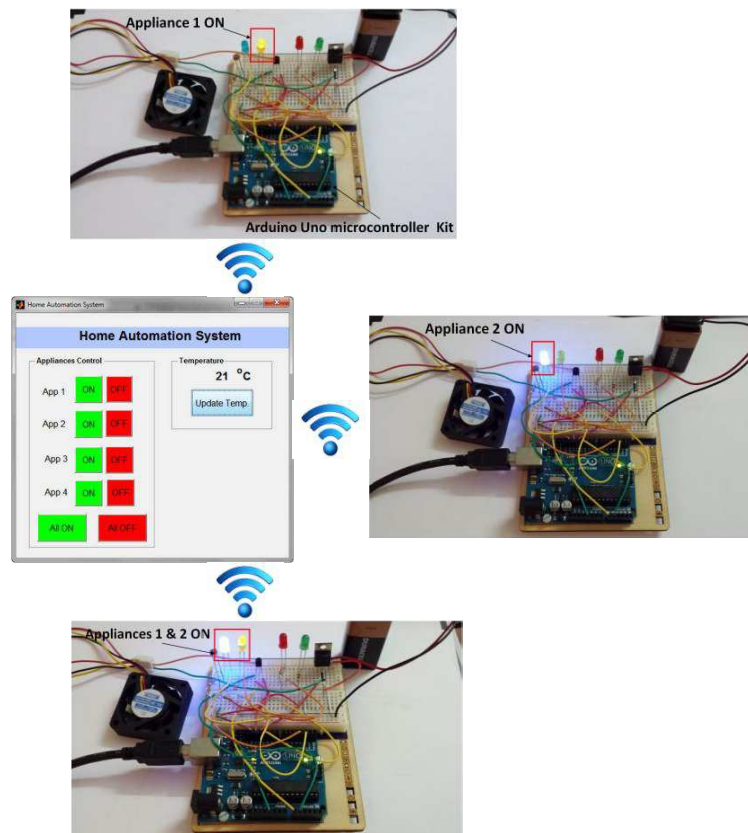


Figure 3: Proposed manually-automated mode system.

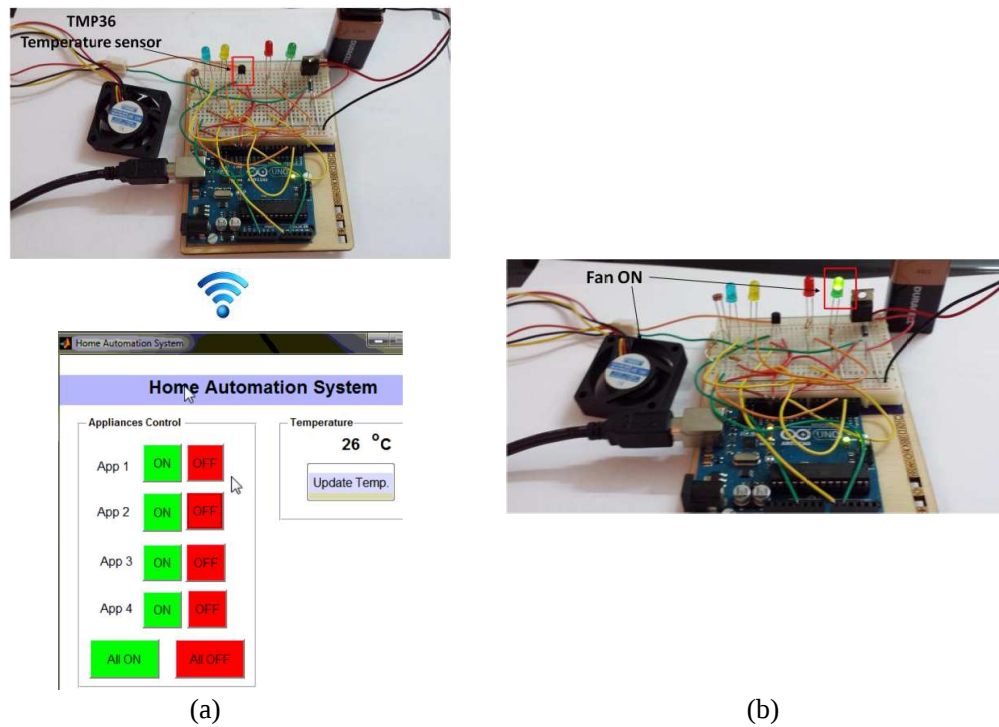


Figure 4: Temperature self-automated system. (a) Temperature is less than 30°C. (b) Temperature is greater than 30°C.

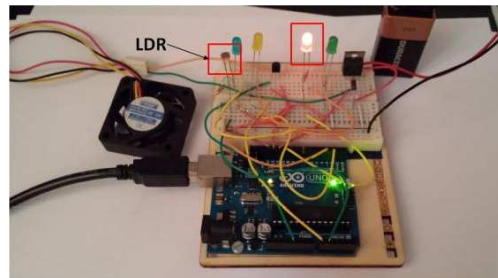


Figure 5: Light self-automated system.

3.2. Self-automated System

In case of the self-automated mode, the appliances are automatically controlled. Two systems are implemented for this case one is temperature control and monitoring system and the other is the light/dark sensing system.

In temperature control system, TMP36 temperature sensor is used to measure the ambient temperature. The temperature is adjusted to be less than 30°C. If the temperature exceeds 30°C, microcontroller will turn on the fan to reduce the temperature as shown in Figure 4.

In automatic light control system, Light Dependent Resistor (LDR) sensor is used to detect light/dark condition. In dark state the home light will turn on automatically as indicated by the LED shown in Figure 5, otherwise it will turn off. This application is important for saving the energy.

4. CONCLUSIONS

In this paper, a design concept for a wireless real-time home automation system based on Arduino Uno microcontroller as central controller has been obtained. The proposed technique provided that the automated system has two operational modes, where the first mode used a manually-automated mode technique in which users can monitor and control their home appliances from anywhere over the world using cellular phone through Wi-Fi communication technology. The second mode was a self-automated mode that made the Arduino Uno controller capable of monitoring and controlling

different appliances in the home automatically in response to any signals came from related sensors. A hardware implementation of the system was carried out to verify the reliability of the system. The implemented system was a simple, low cost and flexible that can be expanded and scaled up.

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