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Server Hardware Design and LUA based Implementation using Wi-Fi based RISC Processor

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***Abstract*—**Embedded system configuration and communication with the software environment is presently of utmost importance for efficient interface development that leads to immediate and fast services to end users providing integration between hardware and software parameters. A programmable language, LUA i.e. a specialized and optimized language is used to develop the interface to connect the appliances along with a processor ESP8266 consisting of RISC microprocessor and peripheral components like light dependent resistor sensor. LUA provides a platform that consists of simple server statements where remote connection is efficient to apply. In this research work, server hardware system has been designed and implemented. LUA based interface has been developed to analyze and test the design with the controlled parameters and constraints. The system developed is beneficial for large controlling devices, installations, in institutions, campuses and in developing automated systems that helps in reducing energy consumption.

***Keywords*—**Embedded systems; ESP8266; LDR; LUA interface; Wireless network.

I. Introduction

Emerging trends and advancement in technology and networks aims at revamping the conventional electric system by integrating the developments in information and communication technology. Internet is playing a beneficial role currently, as all the appliances are getting automated reducing manual efforts. The internet serves as a mediator that monitors, controls and communicates with machine and device [1], [2]. The circuits along with its software application are developed to provide automation in an efficient way that provides efficient use of energy and security. The circuit developed is reliable that controls the lighting system of university, offices, buildings with the application of automatically adjusting a lighting device's output based on various parameters and generating various patterns to handle lighting system [3]. The various patterns where automatic system can work upon are based on chronological time i.e. day, week, month, natural pattern (sunrise/sunset), program logic consisting of conditional statements [4].

The automatic system provides a means of switching on or off the lamps at the correct time whenever there is a need to do and even over faraway places, the user can control the appliances directly. During darkness, the resistance of the light dependent resistor that is used to sense the intensity of light decreases and the light goes on but when there is brightness, the resistance of the light dependent resistor increases and the light goes off [5]. The system is the intelligent network based lighting control solution that incorporates communication between various system inputs and outputs related to lighting control with the use of one or more central computing devices and is widely used on both indoor and outdoor lighting of commercial, industrial, and residential spaces and serves to provide the right amount of light where and when it is needed. The remote automation can produce power utilization by analyzing different patterns like motion detection, number of persons, day light availability, temperature, etc. The automated system is programmable, secure, economical and easily accessible through android devices. The automatic system, at given time or pattern at a specific intensity controls the lighting measures with power consumption, energy efficiency, optimum generation and execution [6].

Hardware implementation allows the components fit into system architecture and provides important information needed for software development and integration. It also provides identification of a system's physical components and their interrelationships [7], [8]. ESP8266 processor, low cost Wi-Fi module acts as a server, sends HTTP requests, read inputs and interrupts and handles all the requests. ESP8266 has self-contained SOC (System on chip) with TCP/IP stack that gives microcontroller access to Wi-Fi. The microprocessor is connected directly to the programming language LUA and provides ease [9].

Wi-Fi technology developed by IEEE 802.11 provides the liberty to connect to the internet from any place and a medium to smartphones to interact with the system. Designing and deploying a wireless network, takes into consideration several factors. The access points and routers indicate a typical range according to the equipment used. Depending on the type of antenna used and the physical location of the access point or router, the range may vary significantly. It is important to consider obstacles such as walls, ceilings, furniture, and electronic interference from machinery; power lines play an important role in wireless signal reception. In wireless transmissions, reflections and multipath (when wireless signals travel in multiple paths arriving at the receiver at different times) are as important as signal strength in determining the success of an installation. A signal will also exhibit peaks and nulls in its amplitude and alteration of its polarization (vertical or horizontal) when propagating through walls, ceilings and reflecting off metallic objects [10].

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The RISC processor that is a microprocessor design principle consists of a smaller and simpler set of instructions that all take same amount of time to execute and is used across a wide range of platforms from cellular phones to super-computers [11]. As in CISC approach, controller design becomes very complex and performance level is not up to the mark as multi clock cycle is used to execute instruction while the RISC processor is used where the instruction can be executed in one clock cycle [12]. It boosts computer speed by using simplified machine instructions for frequently used functions [13]. Apart from the hardware requirements, the software language used to integrate all components used is LUA which is an extensible, light-weight programming language written in C [14]. Server implementation in LUA makes it easy and efficient to use. Also, it is a specialized language where Wi-Fi connection is simple to process as server statements are available. It is portable, free, open, and readily available and integrates with other language with dynamic structures, no redundancies, ease of testing and debugging makes it efficient and unique. For this, LUA has a safe environment, automatic memory management, and good facilities for handling strings and other kinds of data with dynamic size [15].

This paper is organized in different sections as follows: In Section II, the system's general architecture and hardware implementation are discussed. It also describes the system's software implementation. Results and discussion is presented in Section III followed by application in Section IV and conclusion in Section V.

II. Methodology

This section comprises of three main segments. Design architecture is the main part of the system. It is followed by the hardware specification that consists of the detailed list of the components involved in the design including the sensors used. Last segment consists of the interface development that provides the flow of the system in accordance with the design pattern.

A. *Architectural Design*

First module of the system development is the design architecture of the proposed system. Detailed block diagram of the system is depicted in Fig. 1. It consists of the core component, main server that handles all the requests and stores the information about the system via Wi-Fi. The components used as input are voltage, clock, intensity sensor, and water or temperature sensor that are connected to different microprocessor like ArduinoNanoV3.0 or ESP8266. Ports like LUA, Bluetooth and switches are connected to controller. Two main outputs are identified as display and LED module.

Microprocessor is mainly used for light detection, temperature or water detection, pole pattern detection and some movement or emergency based on the input from the sensors used. Brightness of LED is controlled by the intensity port and status of the system is put on display. End users can control or give commands to the system via their android phones.

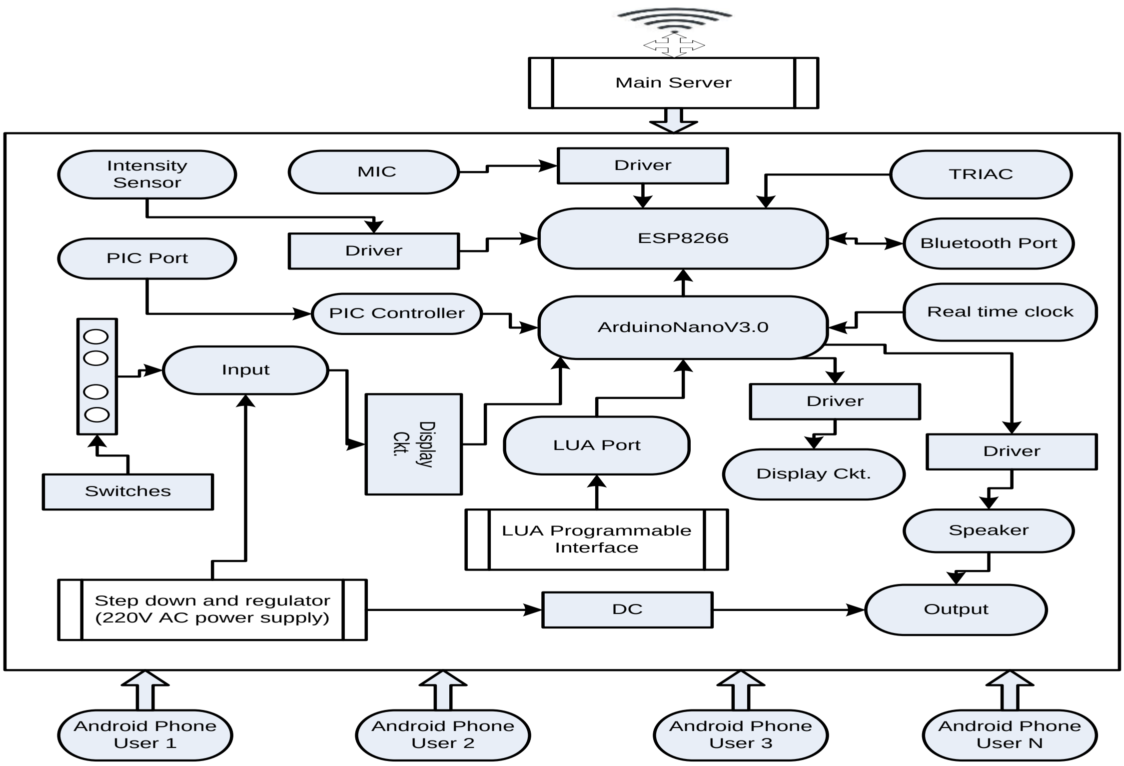

Fig. 1. Detailed model of the proposed system.

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B. Hardware Requirements

Hardware specification consists of the microprocessors, along with input and output. Main inputs used are clock, sensors and power supply. Tiny RTC i2c module is used as clock input and is based on the clock chip DS1307 that provides seconds, minutes, hours, day, date, month and year information. It works on either 24/12 hour format with am /pm indicator. Power supply provides voltage to the system with supply by the switch that turns power on/off.

Four sensors are used as input to the system. LDR, a semiconductor material having high resistance is used to detect the light emitted by the object and measure the surrounding intensity of light based on the principle of photo conductivity. Temperature sensor LM35 measures temperature of the surroundings with an electric output proportional to the temperature in Celsius. Current sensor measures AC/DC current up to 20A and operates from 5V. ArduinoNanoV3.0 is used as a microcontroller because of its reasonable cost, compact size, compatibility and efficient interfacing with other microprocessors like ESP8266 (Wi-Fi module), PIC (Peripheral Interface Controller). The GPIO (General Purpose Input Output Pins) are programmed to turn an LED (Light Emitting Diode) on/off through local Wi-Fi network or from the internet. It is also used for ADC (Analog to Digital conversion. The analog pins are arranged in the group of 8 pins where signals can be sent or received to and from other devices and running at low power consumption. Bluetooth module is connected with RX and TX serial pins i.e. digital 0 and 1 pin of the controller as input- output. Devices can be connected from a range of 10m to 100 m and can be increased by using piconet architecture.

The output is provided by the display and the intensity of light that are connected to the digital pins, group of 13 pins in the controller. LCD displays the power consumption, voltage or time. LED is used to display the intensity of light of the poles in the institution. The schematic representation of the hardware components specification is shown in Fig. 2.

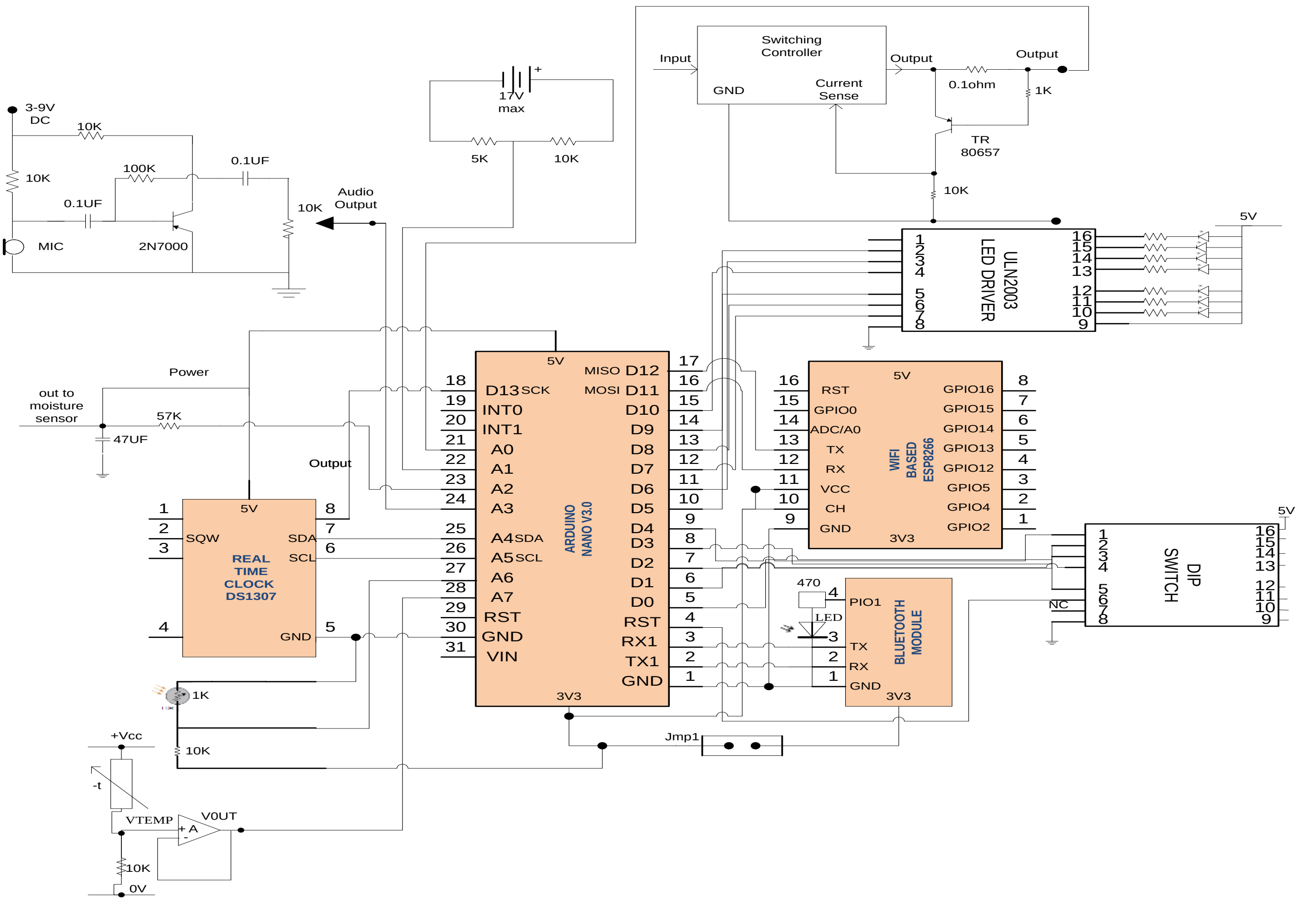

Fig. 2. Schematic representation of the hardware system.

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C. *Interface Development*

A programming language is required by microprocessor to work as interface and execute the process signified in the design. LUA based programming is used to manage and control algorithm that enables the user to access the appliances through the internet. It also communicates with the board via the parallel port to download and upload the control commands and appliance's status.

The system reflects the communication between the controller and various sensors that serve as input to the controller, controller integration with the clock, Bluetooth and other processors. It determines the intensity of light and the optimized patterns of surrounding light. The system prioritizes the poles light based on the cost function depending on the constraints like area covered by the poles, wattage of light, distance between the adjacent poles and energy consumption. During day light, energy is saved by switching off the lights. While at night time, system identifies the conditions, sub-conditions and based on that switches LED's on/off.

```
Establishing Wi-Fi connection:
wifi.setmode(wifi.STATION)
wifi.sta.config("username","password")
print(wifi.sta.getip())

Setting the LED on/off first, make it an output:
led1 = 3
led2 = 4
gpio.mode(led1, gpio.OUTPUT)
gpio.mode(led2, gpio.OUTPUT)

Conditional statements that is required to on/off the LED:
if(_GET.pin == "ON1")then
        gpio.write(led1, gpio.HIGH);
    elseif(_GET.pin == "OFF1")then
        gpio.write(led1, gpio.LOW);
    elseif(_GET.pin == "ON2")then
        gpio.write(led2, gpio.HIGH);
    elseif(_GET.pin == "OFF2")then
        gpio.write(led2, gpio.LOW);
 end
```

The above code segment represents the ESP8266 Wi-Fi program that enables the LED's blinking on/off based on various conditions. Users can control it and see the outcome in the android application.

III. Results and Discussion

The results and discussion includes the details and cost analysis of the hardware components, PCB layout of the design and smart applications that users can access.

A. *Cost and Components Analysis*

The research provides a low cost solution to design server hardware and LUA interface via wireless network. Using the Wi-Fi access, users can remotely control any appliance at any place. The microcontroller used is economical and efficient. While the wired controllable systems requires lot of cable connections for data transmission and communication thus increasing the cost of the system. Hence, maintenance and installation of the wired systems is a big challenge. The details of the components used are listed in Table I. The table shows the main components required to design the hardware circuit and their estimated quantity used.

TABLE I. Details of components.

S.No.	Component	Quantity
1.	ESP8266 Wi-Fi chip	1
2.	Bluetooth module	1
3.	ArduinoNanov3.0	1
4.	DS1307 Clock	1
5.	ULN2003(LED drivers)	1
6.	2N7000 MOSFET	3
7.	Speaker Amplifier	1
8.	Resistors 10ohm	6
9.	Resistors 360 ohm, 470 ohm, 39 ohm (all 5 volt)	1 each
10.	Capacitor 0.05 and 0.01 (400 volt both)	1 each
11.	Sensors: a. LDR b. Thermistors c. Microphones with amplifiers	1 each
12.	PCBs	1
13.	Small on/off switches	4
14.	SMPS (5 volt)	1
15.	Speaker (for sound signal)	1
16.	Optocoupler relay	1
17.	TRIAC	1

B. *PCB Layout*

Various tools and software are there to design the schematics and printed circuit board layout of the hardware circuit. Here, eagle software is used to design the circuit because of its good and reliable features. Although it consists of inbuilt libraries, but user defined libraries can also be made and kept saved in the default library folder. Once the routing has been done from one component to the other component as per the schematic flow using net connection, the design is tested using DRC (design rule check) for PCB and ERC (electrical rule check) for its schematic representation. Also, ratsnest feature is verified for PCB layout that signifies any missed air wire connections. Fig. 3 and Fig. 4 show the schematic and PCB layout of the hardware circuit respectively.

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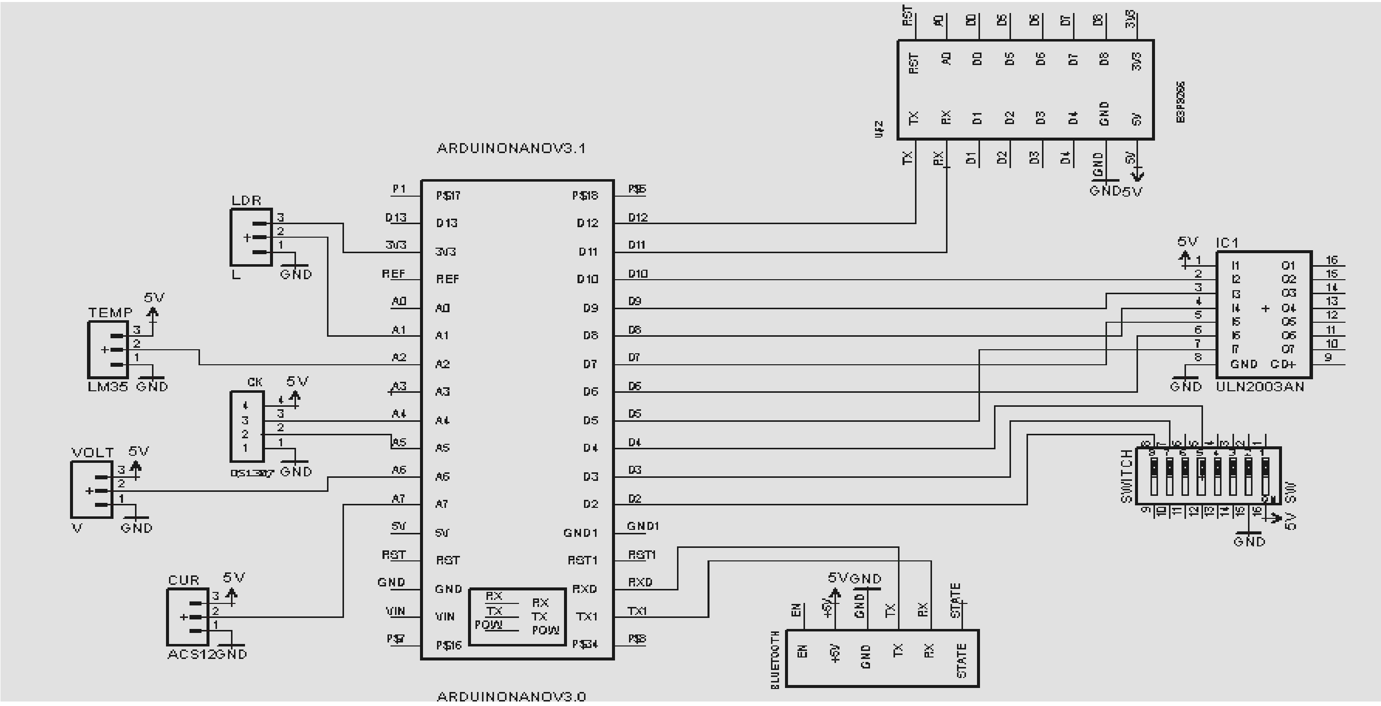

Fig. 3. Hardware system layout.

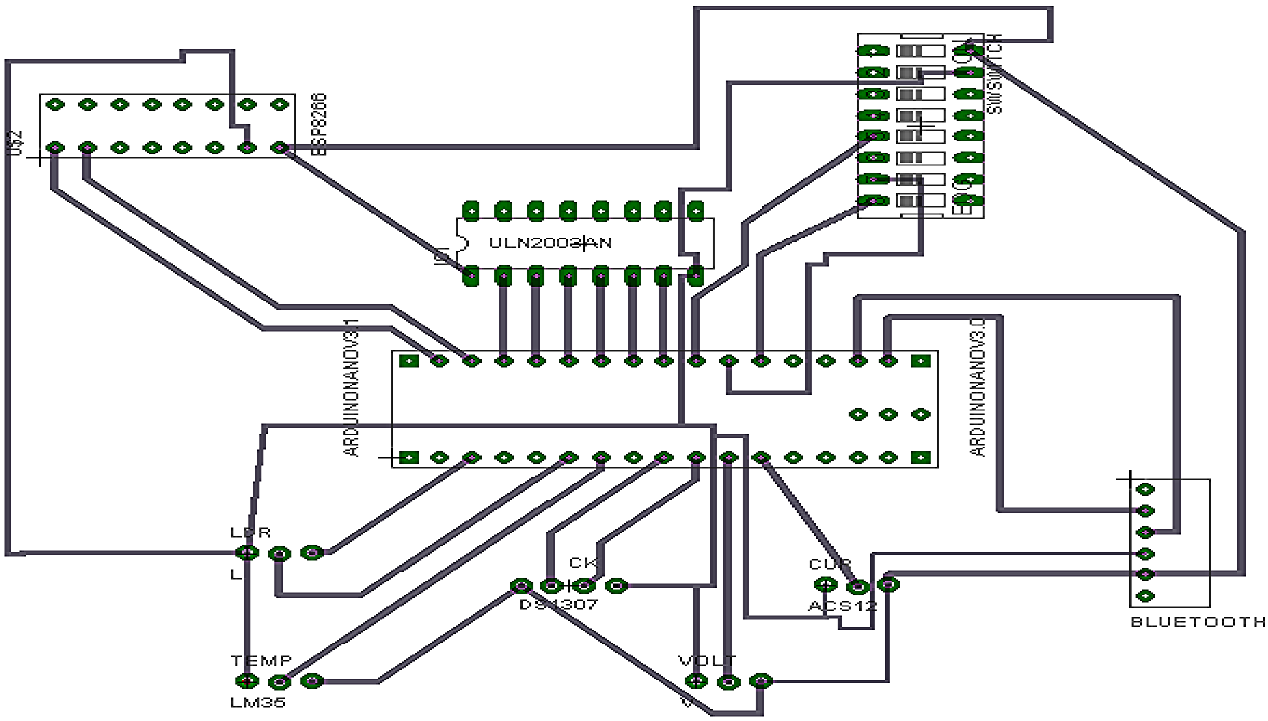

Fig. 4. Printed circuit board representation of the hardware system.

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C. *User end Application*

Users can control and operate the system via the web page application through android. Below Fig. 5 shows the general layout of the application. When user clicks on any pin on/off button, led's will turn on/off accordingly.

Fig. 5. Android layout of the system.

IV. Applications

The server hardware design is applied to automate lighting control system in order to maximize the energy savings from the lighting system, also called smart lighting. This may include sensors like LDR, thermistors and microphones with amplifiers, Wi-Fi server chips, switches, TRIAC and many more devices to complete the circuit that are hard-wired to control fixed groups of lights independently. Adjustment of the system occurs both at device locations and at central computer locations via software programs or other interface devices. The system is cost effective, economical, and portable, with reduced power consumption. The major advantage of a lighting control system over stand-alone lighting controls or conventional manual switching is the ability to control individual lights or groups of lights from a single user interface device. This ability to control multiple light sources from a user device allows complex lighting scenes to be created. Wireless lighting control systems provide additional benefits including reduced installation costs and increased flexibility over where switches and sensors may be placed.

V. Conclusion

In this paper, the design and implementation of the hardware system is presented that is controlled by the LUA interface based on the conditions and sub parameters. It consists of the main segments as the circuit design, smartphone running android application, sensors including LDR or photoelectric sensor, LUA based programming to connect the appliances and low cost controller. As a solution, 30%-40% of power consumption is reduced finally saving energy by using this system. Optimized hardware design is implemented and communicated through LUA framework upon which various optimized algorithms are applied like BFO (Bacterial foraging algorithm) or GA (Genetic algorithm) to generate various patterns using the cost function.

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