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IoT based Smart Home Monitoring and Controlling System

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ABSTRACT
The purpose of our work is to bridge the gap between physical devices (such as vehicles, home appliances and other embedded devices) and the Internet. Recent advancement in Internet of Things (IoT) technology has given rise to the network of physical devices such as vehicles, home appliances, and other things embedded with electronics, software, sensors, actuators and network connectivity which enables this devices to connect and exchange data over the existing Internet infrastructure. Our work aims at providing cheap IoT solution that needs no hard work from the end-user as all the home appliances and sensors can be easily controlled by a ATmega2560 microcontroller. An ESP8266 based Wi-Fi module is connected to the ATmega2560 through I2C communication protocol so that data from the ATmega2560 can be transferred to and from the ESP8266. The ESP8266 connects to the internet via a WLAN and a wireless access point(or mobile hotspot) and quickly sends data (i.e. sensors data and appliances states) to our customized web server hosted under 000webhost.com cloud hosting through the HTTP protocol. The web server is designed in such a way that it is capable of storing the data coming from the ESP8266 within itself and also serves the data in response to request made by ESP8266 as well as storing the switching states of the appliances when requested through a user interactive webpage hosted under the same web server. As embedded system runs on an infinite loop, so upon next subsequent requests made by ESP8266 to the web server, any changes in the previous switching states of the appliances will also get reflected too. Thus the home appliances and the sensors can be controlled and monitored respectively from a remote location just by the touch of internet. The main advantage of our system is that logging sensors data or appliances states is not done in the microchip device during run-time rather all the sensors data and appliances states are stored and served by the web server. As a result the risk of overloading of the device's memory during standby time is greatly reduced. Also there is no worry about the device failing to load memory during next startup as it retrieves the previous states of the appliances by establishing a HTTP communication automatically with the web server. This designed module is tested under slow, moderate and high speed internet and is found to be working efficiently under moderate and high speed internet connection while the responses get delay under slow speed internet connection. This can be implemented in our homes, thereby transforming our conventional home to smarter home, and making it a better place to live in. Also this designed module will help in saving energy in the long run of global energy crisis.
KEYWORDS- Internet of Things (IoT), Smart Home, Home monitoring and Controlling,

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I. INTRODUCTION

The Internet of Things (IoT) is a network of physical objects – vehicles, machines, home appliances, and more that use sensors and APIs to connect and exchange data over the Internet, often using the same Internet Protocol (IP) that connects the Internet [1]. The currently designed system is capable of alerting the owner over E-mails if there is someone waiting outside the door when the owner or user is out for work. A simple visitor name logging system can be implemented near the entrance and the owner will get the list of his visitors/guests by the end of the day. This system is also capable of alerting the owner/user over e-mails if there is any kind of fire or gas leakage or in case of adverse situations can send emergency e-mails to the fire and emergency personnel [2].

The system also sends information about temperature and humidity to the web server hosted under 000webhost cloud hosting which can be viewed by the user/owner through the interactive webpage built under the same domain [3]. In our proposed system, the complete hardware system is implemented inside the house using two units : the Appliance Controller and Sensing Unit and the Digital Switching Assistance Unit. The Appliance Controller and Sensing Unit (ACSU) mainly reads the sensors data, sends these to the web server and controls the domestic home appliances by requesting the appliances states from the web server. On the other hand the Digital Switching Assistance Unit (DSAU) is designed to replace the traditional switch board mounted on the wall of our home with a simple digital switching unit that uses a touch screen TFT display for user-end input and output. The DSAU acts as a dedicated switch that performs just the basic operation of switching ON/OFF the appliances and the working algorithm is very similar to ACSU. The only difference in case of DSAU is that the ATmega2560 used here drives the TFT display. The web server is designed with PHP which acts as a intermediary agent for both the Appliance Controller and Sensing Unit (ACSU) and Digital Switching Assistance Unit (DSAU). Both the ACSU and DSAU communicates with the web server through HTTP request and follows the Client-Server network architecture as shown in Fig. 1.

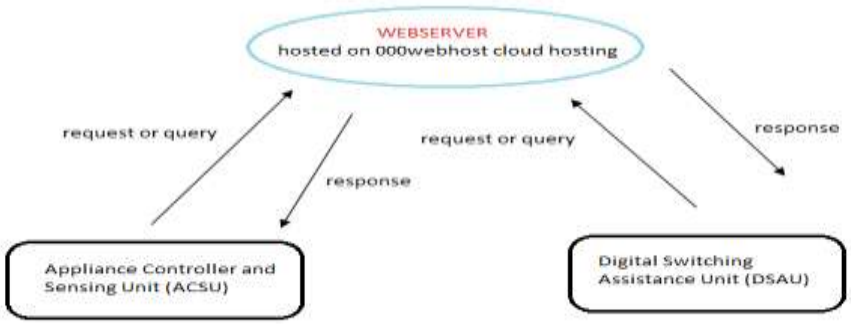


Fig. 1 Communication architecture of ACSU and DSAU with the web server hosted under 000webhost cloud hosting

The ACSU sends data coming from the sensors to the web server through GET request specified by the URL of that PHP script stored on the web server. The PHP script contains some code for processing and storing the arriving data and gets executed every time when each request made by the ACSU is acknowledged. Similarly when the ACSU requests the web server for the stored appliances' state then the request is acknowledged in the similar manner and a copy of response regarding the appliance's state (i.e. either ON or OFF) is sent back and accordingly the ACSU switches the appliances as either ON or OFF . While the DSAU is only responsible for sending and receiving the appliances states to the web server in the similar way as discussed above as the user operates the appliances with it. A webpage built on the same web server is used for interacting with the home. So any changes made from one system (i.e. either webpage, DSAU) will get reflected on all the three units. This is how the Appliance Controller and Sensing Unit (ACSU), Digital Switching Assistance Unit (DSAU), Webpage and the Web server are binded together to achieve the desired result.

II. COMPONENTS USED

For designing the whole system we have used some hardware as well as web technologies which will be discussed in brief below.

2.1 Hardware Components

A. ESP8266 Wi-Fi Module

ESP8266 is an impressive, low cost Wi-Fi module suitable for adding Wi-Fi functionality to an existing microcontroller project via a UART or I^2C communication protocol [3]. The main features are:

- 802.11 b/g/n
- Integrated TCP/IP protocol stack
- Wi-Fi Direct (P2P), soft-AP
- Integrated low power 32-bit CPU could be used as application processor
- Wake up and transmit packets in < 2ms

B. ATmega2560 microcontroller

ATmega2560 is a high-performance, low-power Microchip 8-bit AVR RISC-based microcontroller [4]. The main features are:

- 256KB ISP flash memory

- 8KB SRAM
- 4KB EEPROM
- 86 general purpose I/O lines
- 32 general purpose working registers
- 4 USARTs
- Byte oriented 2-wire serial interface
- Throughput of 16 MIPS at 16 MHz

C. DHT11 Temperature and Humidity sensor

The DHT sensors are made of two parts, a capacitive humidity sensor and a thermistor. There is also a very basic chip inside that does some analog to digital conversion and spits out a digital signal with the temperature and humidity. The digital signal is fairly easy to read using any microcontroller [5].

D. PIR Motion Sensor

PIR Motion Sensor is basically made of a pyroelectric sensor which can be used to sense motion, almost always used to detect whether a human has moved in or out of the sensors range. They are small, inexpensive, low-power and easy to use [6].

E. MQ-2 Gas Sensor

MQ-2 Gas sensor is used to measure or detect LPG, Alcohol, Propane, Hydrogen, CO and even methane. It can be used as a Digital or analog sensor. The Sensitivity of Digital pin can be varied using the potentiometer [7].

F. TFT LCD display

TFT display is big (2.8" diagonal) bright (4 white-LED backlight) and colorful! 240x320 pixels with individual RGB pixel control and has a resistive touch screen attached to it already. It has 8 bit digital interface, 4 or 5 control lines (12 pins minimum) or SPI mode with 4 or 5 SPI data/control lines (4 pins minimum) not including the touchscreen [8].

2.2 Web Technologies

A. PHP

PHP is an acronym for "PHP: Hypertext Preprocessor" and is widely-used, open source server-side scripting language. PHP code are executed on the server, and the result is returned to the browser as plain HTML. PHP can create, open, read, write, delete, and close files on the server [9].

B. HTML

HTML (Hypertext Markup Language) is the standard markup language for creating web pages and web applications. Hypertext means that the document contains links that allow the reader to jump to other places in the document or to another document altogether [10].

C. CSS

CSS (Cascading Style Sheets) is a style sheet language used for describing the presentation of a document written in a markup language like HTML [11]. CSS is designed to enable the separation of presentation and content, including layout, colors, and fonts.

D. JavaScript

JavaScript (JS) is a lightweight, interpreted or JIT compiled programming language [12]. It is used to add client-side behavior to HTML pages.

E. JSON

JSON (JavaScript Object Notation) is a lightweight data-interchange format. It is easy for humans to read and write. It is easy for machines to parse and generate. It is based on a subset of the JavaScript Programming Language, Standard ECMA-262 3rd Edition - December 1999. JSON is built on two structures:

- A collection of name/value pairs.
- An ordered list of values. [13]

III. DESIGN AND IMPLEMENTATION

The design and implementation of the complete system includes hardware as well as software design which is explained part by part below.

3.1 Designing the Appliance Controller and Sensing Unit (ACSU)

The Appliance Controller and Sensing Unit (ACSU) is designed by implementing ATmega2560 microcontroller, ES8266 Wi-Fi module and a 8-channel relay module in a single casing unit as shown in Fig. 2. The Wi-Fi module provides Internet functionality to the ATmega2560 microcontroller. The Wi-Fi module and the ATmega2560 are interfaced through I^2C communication protocol. The three sensors DHT11, PIR Motion and MQ-2 Gas sensors are interfaced with the ATmega2560 microcontroller. The raw data from the three sensors are first processed by the ATmega2560 and transmitted serially to the Wi-Fi module via Serial Data (SDA) line.

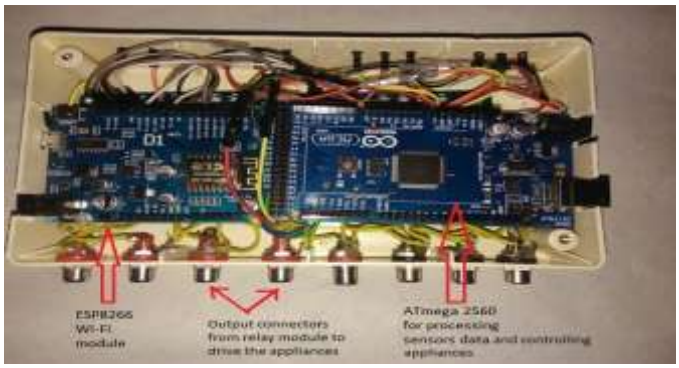


Fig. 2 Internal view of the ACSU housing the ATmega2560, ESP8266 Wi-Fi module and relay module

The data coming from the web server is routed to the ESP8266 module first and after that controlling action takes place. Since the ATmega2560 takes some time to process the sensors' data therefore in order to minimize the delay effect we have used the ESP8266 module to control the appliances through relay module which is under the two microchip board. The output connectors are taken from the relay module to drive any kind of electrical appliances as shown above in Fig. 2. We have tested the module by driving some DC appliances such as bulbs and DC Fan. The same result is obtained if AC source is used instead of DC for driving the connected appliances.

Fig. 3 Ports for interfacing sensors

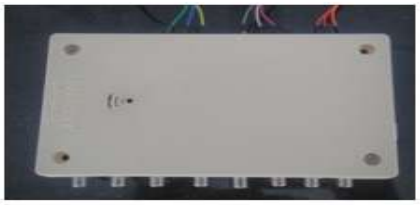
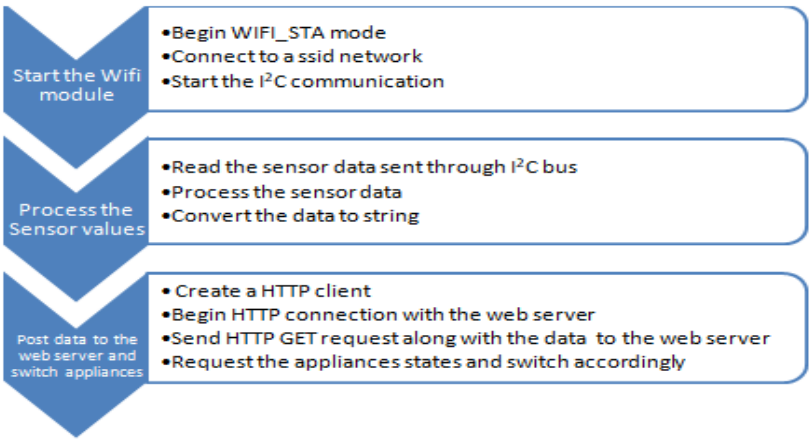
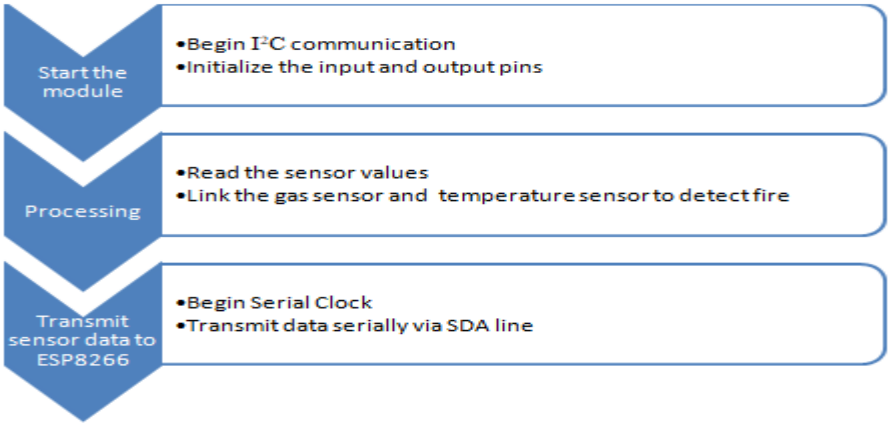


Fig. 4 Top view of Appliance Controller and Sensing Unit (ACSU)

A. Programming methodology for the ESP8266 module



B. Programming methodology for the ATmega2560 microcontroller



3.2 Designing the Digital Switching Assistance Unit (DSAU)

The Digital Switching Assistance Unit (DSAU) can be realized as a replacement for conventional switches used in our home today. The owner can control the appliances through it. It uses a simple TFT LCD to display the output to the user and also has a resistive touchscreen to take input from the user. The complete DSAU is implemented with a ES8266 Wi-Fi module and a ATmega2560 driving the LCD which is mounted on a single casing unit as shown in Fig. 5. The user can control as well as view the appliances' states too through this unit. The working of the Wi-Fi module and the ATmega2560 is similar to the Appliance Controller and Sensing Unit (ACSU) as discussed above. The only difference is that the ESP8266 and the ATmega2560 are interfaced through the UART serial communication protocol. The ATmega2560 drives the TFT display and as well as receives the input when the user makes any changes. After receiving the current appliances state, it is then forwarded to the ESP8266 module through UART communication prtocol. The ESP8266 send the data to the web server. The ACSU receives the current appliances' states from the web server and switches them accordingly.

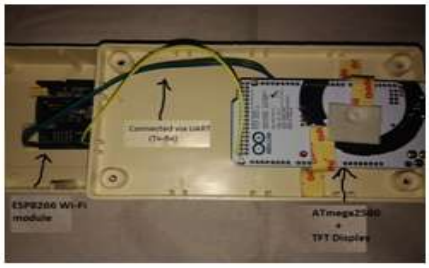
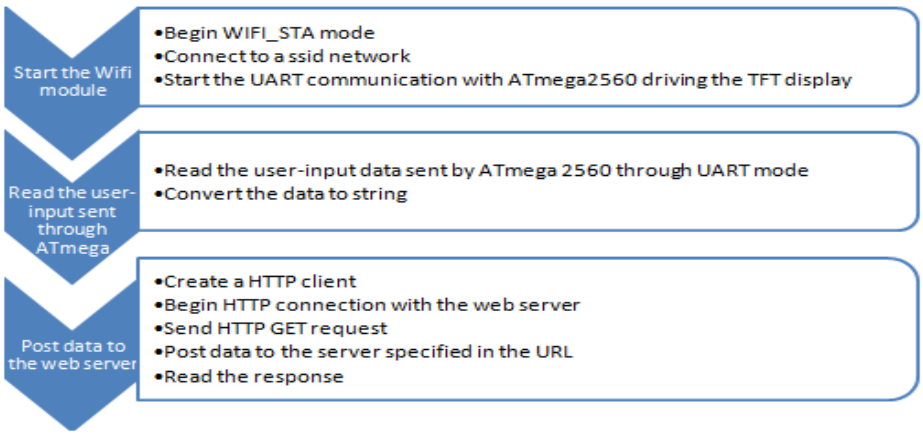


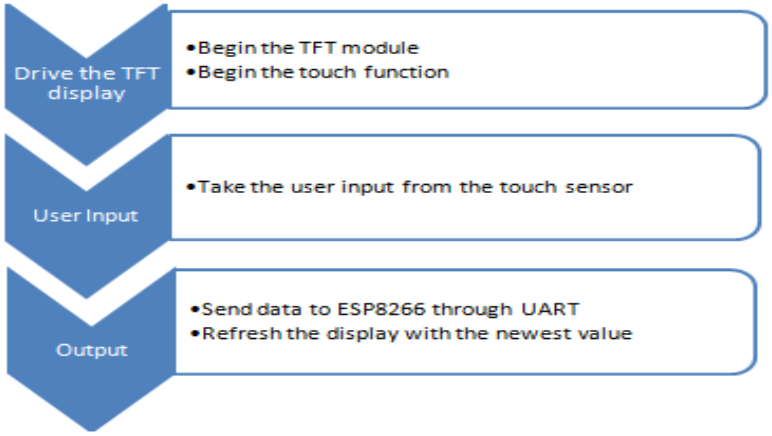
Fig. 5 Internal view of the DSAU housing the ESP8266, ATmega2560 and the TFT Display

Fig. 6 Top view of the DSAU along with the TFT display

A. Programming methodology for the ESP8266 Wi-Fi module



B. Programming methodology for the ATmega2560



3.3 Designing the web server

The web server is one of the most crucial part of the system. It is responsible for handling the request made by the Appliance Controller and Sensing Unit, Digital Switching Assistance Unit as well as from the user interactive web page. The web server is hosted under 000webhost.com cloud hosting. The web server is configured with PHP and mainly deals with json file and txt file. The PHP script contains some code which does some basic processing and storing the data collected by PHP $_GET super global variables contained within the PHP script. The PHP script is implemented for each appliances and sensors as shown in Fig. 7 and the appliances' as well as sensors' parameters are sent only to that specific script specified in the URL.

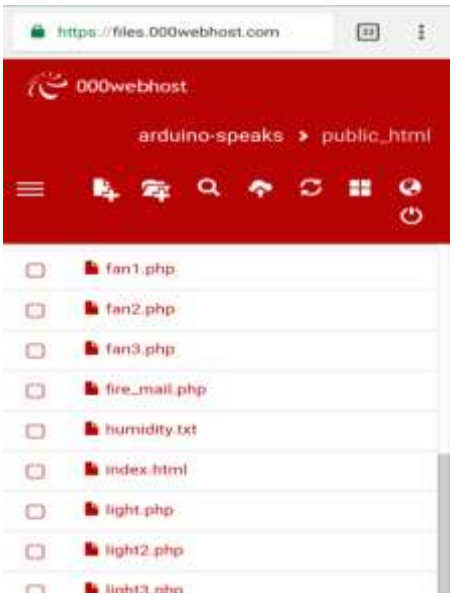


Fig. 7 Web server running under 000webhost.com

The web server collects the relevant data from the query string added with the URL as shown in Fig. 8 when request is made by the Appliance Controller and Sensing Unit or Digital Switching Assistance Unit or webpage ;when the user interacts from a Web browser and saves it on a json or txt file created at the web server by the php scripts. Data is retrived from the web server by sending HTTP GET request to the json or txt file located at the web server.This is how the web server is configured or built to achieve the expected result.

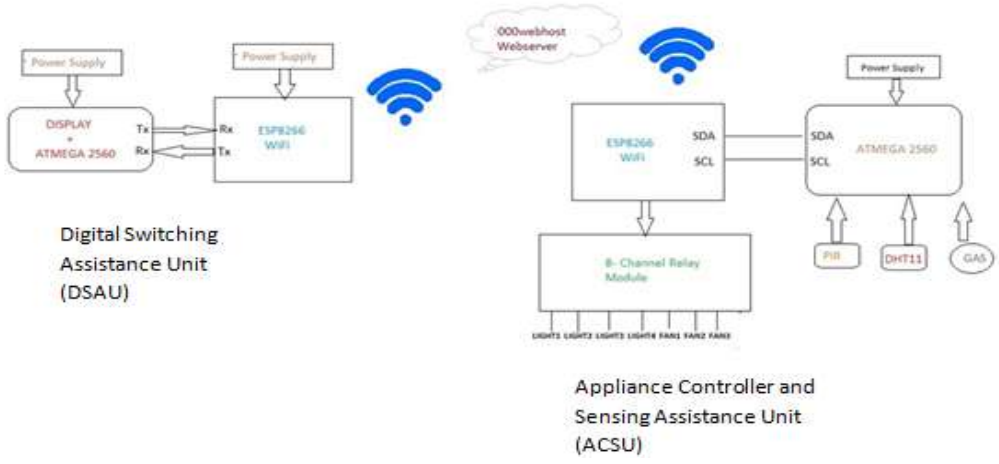
3.4 Designing the user interactive Webpage

The Webpage is built using HTML, CSS and JavaScript. HTML is used to define the content of web page, CSS is used to specify the layout of web page and JavaScript is used to program the behavior of web pages. We have defined four rooms namely Living room, two Bedrooms and one Kitchen in the webpage as shown in Fig. 8. The webpage can be accesed through http://arduino-speaks.000webhostapp.com. Services provided by the webpage:

- Display Temperature and Humidity
- Control Lights and Fan of your home through buttons provided

Fig. 8 HTML Web Interface for control and monitoring

3.5 Block diagram of the entire system



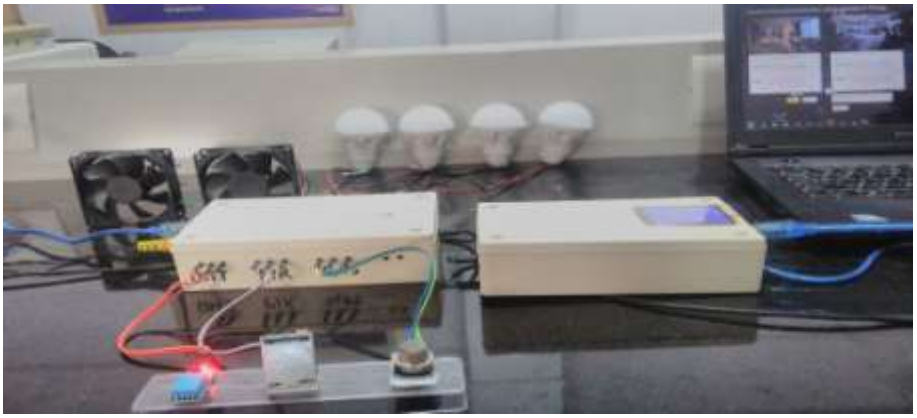


Fig. 9 Setting up the entire system

IV. CONCLUSION

The system is found to be working satisfactorily with simple appliances and sensors connected to it and can be controlled and monitored from a remote location over the Internet. This system is not just confined to control and monitoring but also gives alerts to the owner about visitors and emergency case such a fire through E-mails. With this system it will be easy for the owner to analyze various parameters of home anytime from anywhere.With further modification in the system, it can be implemented for any type of organization, big or small. With Make in India and Digital India initiatives, our project will help towards growing a better and smarter India.

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