Energy Efficient Home Automation Using IoT

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***Abstract*—India is the 4^{th} largest consumer of energy, so it has to strive relentlessly for alternative methods to achieve effective reduction in consumption of energy. Because of inadequate energy infrastructure and extensive energy usage, intelligent energy management systems need to be incorporated in order to use energy more efficiently and to make an effective safe environment not only in industries but also in other ways of our day to day lives. Smart home automation can manage and monitor household energy efficiently and it also ensures safety. In this paper, an intelligent home automation technique is implemented using Internet of Things which will overcome the existing energy usage problems to a great extent. IoT makes use of a combination of intelligent software applications along with electronic devices to build an effective data exchange network. To implement this, a low cost and low power consuming embedded Wi-Fi module ESP8266 is used to operate a relay channel, which acts as a switch to control household appliances. Here Thinger.io provides cloud infrastructure through which mobile and ESP8266 to communicate with each other via REST API.**

Index terms: Internet of things, smart home automation, ESP8266, Arduino IDE, REST.

I. Introduction

To make our day to day life simpler and easier, comfortable and convenient automation required in all aspects of life and smart home networked devices are extensively very important [1]. This can be achieved by Internet of Things with intelligent adaptive techniques, usage patterns. The proposed system can be modeled by a simple architecture as shown in Fig. 1 where ESP8266 and other devices are connected.

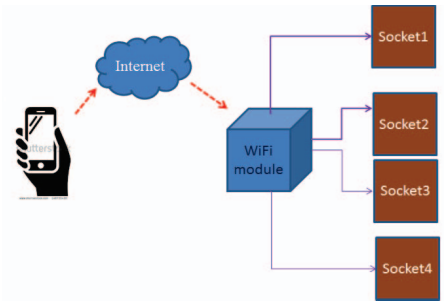

Fig. 1. Block diagram of the proposed scheme

A. Internet of Things

Among the existing technologies, the rapid improvement now revolves around Internet of Things. Many researchers are paying attention to find solutions related to design and architectural issues of IoT [2]. IoT will add $15 trillion to global GDP in next 20 years, this results in need of 4.5 million software developers trained for information technology and wireless sensor networks [3]. IoT can offer an automate solution for existing problems faced by various fields like energy, agriculture, health services, security and disaster management etc. via remotely controllable and operable devices [4]. IoT is all about low power connected embedded devices to design scalable connectivity infrastructure for sensing and analyzing data coming from billions of sources. In the present scenario, IoT is perfect representation of evolution of the Internet, by taking an extensive change in its ability to get and analyze the distributed data [5].

IoT makes use of devices or things to offer services to all desired applications and it reduces energy consumption efficiently by using smart edge devices. [6].

B. Smart home automation

The smart home automation is the technique which is nothing but the integration of appliances, security and communication equipments [7]. The living standards of people are improving day by day and people want high quality requirements for their living environment and they give more importance to each members comfort, safety and convenience in day to day lives [8]. This leads to a rapid improvement and development in information, communication, control and network technologies. The importance of Internet of things technology has increased for smart home automation system as per the demand of communication requirements between people and devices in home [9], [10].

Realizing the requirements and functions of smart home systems, the highly intelligent environment controlling mechanisms leads to a safe, comfortable family life and provide users a guarantee for improving their quality of living style as in the age of Internet of Things [1], [11]. Smart home automation using IoT devices will help reduce costs and conserve energy. For example, an air conditioner could run continuously at home for our comfort, but it is needed to be switched off when we are not at home. By this scheme we can turn off AC with mobile phone even though we are outside. The smart LED lights also works in similar way [9]. In this way we can reduce the use of energy so as the electricity bill. In smart home automation using IoT the first and foremost advantage is smart devices can be connected to a network through Wi-Fi,

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these devices assigned with IP address and can be operated or monitored remotely [10], [12].

II. Circuit connections and working

ESP8266 nodemcu board is powered with USB. Meanwhile the relay channel is interfaced with ESP8266 board. The GND and V_{CC} of the relay channel are connected to GND and 3.3V pins of ESP8266 board. The relay channel inputs i/p(1), i/p(2), i/p(3) and i/p(4) are given to general purpose I/O interface pins GPIO0(D3), GPIO2(D4), GPIO14(D5) and GPIO13(D7) respectively as shown in Fig. 2.

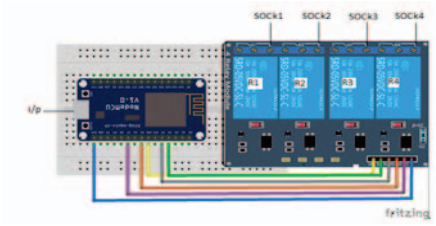

Fig. 2. ESP8266 and relay-board connections

As a part of programming in Aurdino IDE for the desired system, pin configurations for the relay channel are necessary. After initialization, the program logic is structured in such a way that ESP8266 module and the relay channel can be operated using a mobile phone.

III. Hardware

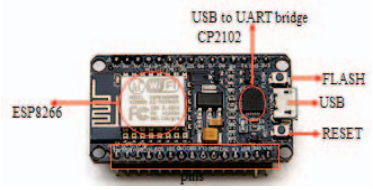

Fig. 3. ESP8266 nodemcu

1) ESP8266 nodemcu: ESP8266 nodemcu is a low cost Wi-Fi module among all other integrated Wi-Fi chips in the IoT industry. It is integrated with 32-bit Tensilica Xtensa L106 micro controller, power amplifier, RF balun, filters, low noise receive amplifier and power management modules. It requires minimal external circuitry, The total solution including front-end module is designed to occupy less PCB area [13]. This module is a self contained SoC with integrated TCP/IP protocol stack. ESP8266 operates in 5 following states, active, OFF, sleep mode, wakeup mode, deep sleep mode. Power saving algorithm to operate ESP8266 is explained in [13]. The application specific devices like sensors or any other device can be easily operated by programmable GPIO pins. These pins create an easy way to establish connection with outside world and ESP8266 board. These pins have other multiplexed functions with I2S, I2C, PWM, UART, IR Remote Control etc. A 10-bit precision SAR ADC is embedded in ESP8266 module. ESP8266 can serve as Wi-Fi adapter micro-controller is added with wireless Internet access using serial peripheral interface, UART and I2C. A cache is integrated in it for improved performance. It supports some link functions with android systems. ESP8266 is basically designed for applications like mobiles, basic electronic house hold appliances and IoT devices to achieve low power consumption [13].

TABLE I
ESP8266 features

CPU	Tensilica Xtensa LX106(80MHz) 32-bit
GPIO pins	16
WiFi	IEEE802.11 b/g/n
Operating voltage	3.0V-3.6V
Operating current	80mA
Network Protocols	IPv4, IPv6, TCP, UDP, HTTP, FTP
External QSPI flash	512KB to 4MB
Instruction RAM	64KB
Operating temperature	-40°C to 120°C
Output power	+20dBm
Antenna	PCB
Frequency range	2.4GHz-2.5GHz

This table is taken with reference to the documentation [13]

2) Relay: The major advantage of relay comes into picture when a low-power signal is used to operate a circuit. It can be used in places where control of many circuits is needed by using only one signal. Most of the industrial application

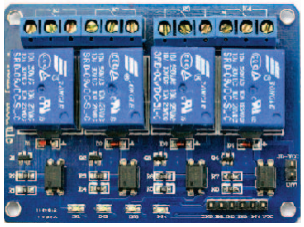

Fig. 4. Relay channel

devices need relays to work effectively. Relay is nothing but both electrically and mechanically operable switch. Relays consist of an electromagnetic coil and also a set of nodes. The switching action is carried out by an electromagnetic coil. When a small current flows through the electro magnetic coil a magnetic field is developed and the common node is shorted with normally closed terminal which is connected to external circuit which draws a larger current. If the current does not flow through the primary coil the common node is shorted it to normally open terminal.

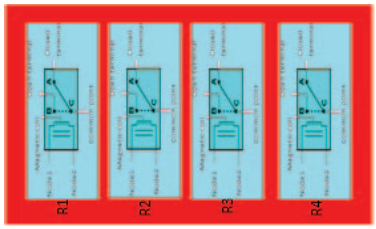

Fig. 5. Relay channel working

TABLE II
RELAY WORKING PRINCIPLE

primary current(i)	Normally open	Normally closed	Secondary current(I)
If flows	Open	Common short	Flows
If no flow	Common short	Open	No flow

IV. SOFTWARE

A. Aurdino IDE

ESP8266 is programmed by using an open-source Aurdino IDE. This provides easy way to write and upload the code onto ESP8266. This software is user-friendly language that runs on every windows, Linux and Mac OS X systems. It has a Java-based environment for processing and an easy installation procedure [14].

B. IoT protocols

TABLE III
DIFFERENT IOT DATA PROTOCOLS AND THEIR PROPERTIES

Property	**MQTT**	**COAP**	**REST**	**XMPP**
Transport	TCP/IP	UDP	TCP	TCP
Paradigm	Publish-Subscribe	Request-Reply	Point-to-Point Exchange	Publish-Subscribe Request-Reply
Scope	Device-to-Device	Device-to-Device	Device-to-Device, Device-to-Cloud	Device-to-Device, Device-to-Cloud
Low-power support	Excellent	Excellent	Fair	Fair
Security	TLS	DTLS	TLS	TLS
Use cases	IoT cloud based applications	Field area networks	Client-server applica-tions	Remote manage-ment of consumer white goods

MQTT is a light weight publish/subscribe utility protocol useful for cloud based applications [15], COAP offers semantics similar to HTTP and useful in resource constrained applications. XMPP is used for real time exchange of structured extensible data between more than one network. But REST is great option for cloud-app communication and server-client communication in a local network [16].
The comparison among different IoT data protocols are tabulated in TABLE III.

C. Thinger.io

Thinger.io which is an IoT platform to connect and manage smart devices in a network. It can offer a cloud infrastructure for connecting things. These smart devices can be integrated with REST API to use it as admin console. Here Thinger.io

Fig. 6. Console of Thinger.io platform

uses REST protocol [17]. Representational state transfer protocol allows communication among the devices. This is an application programming interface (API) which enable controlling and reading of smart devices. RESTful web services or REST provides interoperability among different computer systems on the Internet. RESTful Web service requests resource's URI and get a response in defined formats like XML, HTML, JSON. It is a stateless protocol. REST systems aim for fast performance, reliability. It has the features like client-server architecture, cache ability, layered system, uniform interface and fallows standard HTTP methods like OPTIONS, GET, PUT, POST, and DELETE.

V. EXPERIMENTAL RESULTS

As a part of smart home automation controlling of power sockets with mobile phone is done using ESP8266 module and the relay channel shown in Fig. 7. An IoT system has modeled and developed using all desired units and setting up a server for the home. After making all circuit connections, we have to install Thinger.io mobile app in android mobile properly. The user has to sign-up and register on server page of Thinger.io platform. After that user gets user ID and unique PASSWORD, then user can login from android app. After coding part is done in Aurdino IDE, the program is flashed onto ESP8266. After successful uploading, observe that mobile and ESP8266 are connected or not. In the device API, it is observed that four resources socket1, socket2, socket3, socket4 which are

used to monitor relay channel. This is shown in Fig. 8. In the

Fig. 7. Controllable power sockets

console screen user can keep track of electronic, and electrical devices which have server connectivity. The load here is not only a power socket board, it can be extended to control fans, lights and other basic home appliances as shown in Fig. 9. But make sure that take appropriate measures while connecting to the main.

Fig. 8. Sockets control using Thinger.io

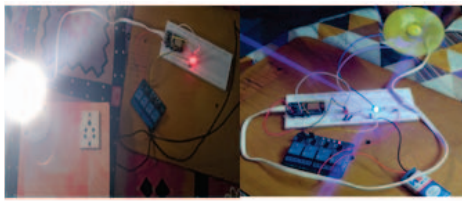

Fig. 9. Controlling home appliances

VI. Conclusion

In this paper main focus is about controlling and operating various smart home appliances remotely. This home automation technique provide more efficiency in utilization of energy. And it makes home as a smart place to live on, since ESP8266 board is very useful and desired which makes the IoT systems cost effective with required ultra-low power consumption capability.

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