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Energy management system for smart home using IoT

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ABSTRACT

One of the major attribute of the Smart home automation and energy management systems integrate IOT and renewable energy resources at the consumption premises. With advancement of Automation technology, today's world prefers Automatic systems over manual systems. This paper presents the design, implementation and testing of an embedded system using arduino that integrates solar energy resources and energy management to a smart home incorporated with IOT. The proposed system provides and manages a smart home energy requirement by installing renewable energy and scheduling the power flow during peak and off-peak period. IOT (Internet of things) is the latest and emerging internet technology. Internet of things is a growing network of everyday object-from industrial machine to consumer goods that can share the sensors information to the Automation system using WIFI communication. IoT is a system that uses computers or mobile devices to control all home functions and features automatically through internet. In addition to that, a two-ways is developed to enable the home owner and the utility provider to better optimization of the energy flow and the consumption efficiency. A prototype for the proposed system was designed, implemented and tested using a controlled load bank to simulate a scaled random real house consumption behavior.

Keywords: *Smart home automation, Arduino, WIFI communication, IoT (Internet of things), Energy management system, Smart home, Solar energy.*

1. INTRODUCTION

The Internet of Things (IOT) is the recent advancement in tele-communication that is the future, in which the devices of everyday life will be equipped with microcontrollers, transceivers for digital communication, and suitable protocol that will make them able to communicate with one another and with the users, becoming an integral part of the Internet. The IOT concept, aims in making the Internet more reliable and pervasive. Thus by enabling easy access and interaction with a wide variety of devices such as, for instance, home appliances, surveillance cameras, monitoring sensors, actuators, displays, vehicles, and so on, the IOT will help in the development of various applications that make use of the potentially enormous amount and variety of data generated by such objects to provide new services to citizens, companies, and public administrations.

This paper presents the design of home energy management system that integrates the power resources from the traditional grid and renewable energy sources namely; solar energy and storage energy. A single chip microcontroller is used to multiplex the three power sources to supply the house with its required power based on a communication between the utility and the house owner. In this regard, Low Cost Automation is a technology that promises to be very useful for any kind of manufacturing organization. With the advent of liberalization and globalization, it is necessary that industries explore methods of enhancing automation and productivity to acquire greater competitiveness.

Therefore, from a system perspective, the realization of an IOT network, together with the required backend network services and devices, still lacks an established best practice because of its novelty and complexity. In addition to the technical difficulties, the adoption of the IOT paradigm is also hindered by the lack of a clear and widely accepted business model that can attract investments to promote the deployment of these technologies.

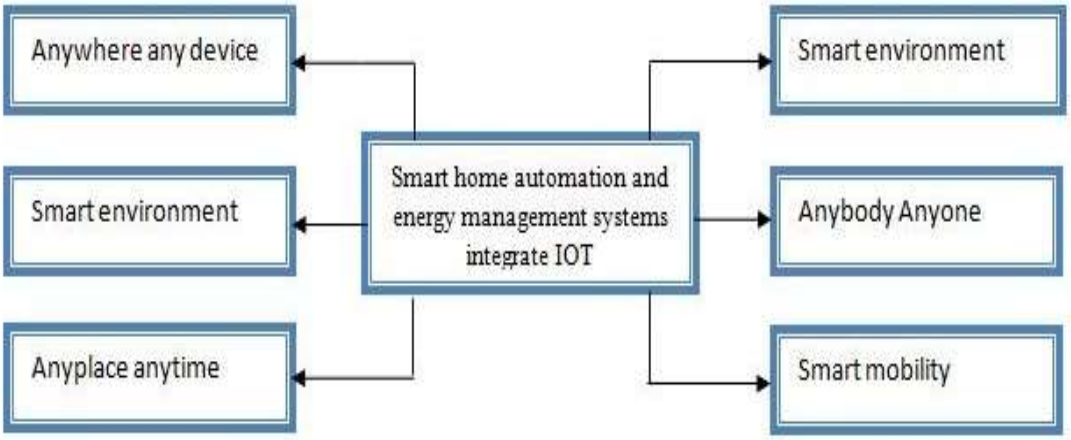

Fig 1. Relation with various phases

2. INTERNET OF THINGS

The figure (1) shows the various advantages of the internet of things like the different methods for connecting our devices and appliance to the internet from any place anywhere in this world and integrating this connectivity with our home and the devices connected. IOT technology is the connection of various networks in embedded devices used in the everyday life integrated into the Internet. It aims to automate the operation of different domains such as home appliances, health care systems, security and surveillance systems, industrial systems, transportation systems, military systems, electrical systems, and many others. In order to achieve a fully automated process, devices in the different domains must be equipped with micro-controllers, transceivers, and protocols to facilitate and standardize their communication with each other and with external entities. Sensors, Global Positioning Systems (GPS), cameras, and Radio Frequency Identification Devices (RFID) are examples of devices that exist at perception layer.

IoT systems use a combination of Internet and short-range networks based on the communicated parties. Short-range communication technologies such as Bluetooth and ZigBee are used to carry the information from perception devices to a nearby gateway. Other technologies such as Wi-Fi, 2G, 3G and 4G carry the information for long distances based on the application. These systems and appliances include sensors and actuators that monitor the environment and send surveillance data to a control unit at home. The control unit enables the householders to continuously monitor and fully control the electrical appliances.

It also uses the surveillance data to predict future activities to be prepared in advance for a more convenient, comfortable, secure, and efficient living environment. Other applications of the smart community concept are in health care, managing shared resources, and enabling support social networking. The concept of a smart community is extended to develop a smart city.

This difficulty has led to the proliferation of different and, sometimes, incompatible proposals for the practical realization of IoT systems. Therefore, from a systems view, the visualization of an IoT network, together with the required backend network services and devices, still lacks an established best practice because of its novelty and complexity. In addition to the technical difficulties, the adoption of the IoT paradigm is also hindered by the lack of a clear and widely accepted business model that can attract investments to promote the deployment of these technologies.

In this complex situation, the application of the IoT to an urban context is of particular interest, as it responds to the data of many national governments to adopt ICT solutions in the management of public affairs, thus realizing the so-called Smart City concept. Although there is not yet a formal and widely accepted definition of "Smart City," the final aim is to make a better use of the public resources, increasing the quality of the services offered to the citizens, while reducing the operational costs of the public administrations. This purpose can be done by the implementation of an IoT that will give a simple, and easy access to multiple platforms of public services. A multi-level IoT, may bring a number of benefits to the management and optimize the traditional public services, such as transport and parking, lighting, surveillance and maintenance of public areas, preservation of cultural heritage, garbage collection, hospitals, and school. Furthermore, the availability of different types of data, collected by Arduino with IoT, may also be exploited to increase the transparency and promote the actions of the home owners enhance the awareness of people about the status of their home, stimulate the active participation in the management of energy consumption, and also stimulate the creation of new services upon those provided by the IoT.

IoT ELEMENTS

We present an idea that will aid in defining the components required for Internet of Things from a high level perspective. Specifics of each component can be found elsewhere. There are three IoT components which enables seamless efficiency
1) Hardware – these consist of sensors, actuators and embedded communication system 2) Middleware - storage and computing tools for data analysis and 3) Presentation - has visualization and interpretation software's which can be accessed on different platforms and can be designed for different applications. In this section, we discuss the technologies that categories the three components stated above.

The Arduino Mega 2560

Fig 2. Arduino mega 2560

The figure (2) is the pictorial representation of the ATmega2560. The Arduino Mega 2560 is an ATmega2560 microcontroller board. It has 54 digital input/output pins in which 14 PWM output pins, 16 input analog, 4 UART, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It has everything needed to support the ATmega2560 microcontroller. It can be simply connect to a computer with a USB cable, it can be powered up by an AC-to-DC adapter or battery.

The ESP8266 module

Fig 3. ESP8266 module

The figure (3) shows the ESP8266 module. The ESP8266 is a Wi-Fi module that is used for various applications which is because of it low cost and its compatibility. It as TCP/IP protocol that can make any microcontroller access to your WiFi network. The ESP8266 WIFI module has 1 MB of built-in flash, allowing for single-chip devices that get connected to Wi-Fi.

IR Sensors

The figure (4) represents the image of IR sensor .IR Sensor work by using specific light source as a medium to detect light wavelength in the Infra-Red spectrum. Using LED which produces light at same wavelength which the sensor is looking. When the object is coming close to the sensor, the light from the LED bounces off from the object and into the light sensor. This results in a large jump of the intensity, which will be detected using a threshold signal.

Fig 4. IR sensor

Radio Frequency Identification (RFID)

RFID is the latest trend in communication which uses specially designed microchips with wireless data communication. They help in automatic identification of anything they are attached to acting as an electronic barcode.

Fig 5. RFID reader

The figure (5) represents the passive RFID tags which is not battery powered and they use the power of the reader‘s interrogation signal to communicate the ID to the RFID reader. This has resulted in many applications particularly in retail and supply chain management. The applications can be found in transportation (replacement of tickets, registration stickers) and access control applications as well. The passive tags are currently being used in many bank cards and road toll tags which is among the first global deployments. Active RFID tags have their own inbuilt battery supply and can easily communicate. Of the several applications, the main application of active RFID tags is in port containers for monitoring cargo.

DHT11 Temperature and Humidity Sensor

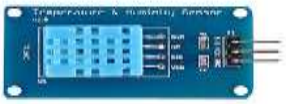

Fig 6. DHT11 sensor

The figure (6) represents the DHT11 sensor. This DHT11 is a Temperature and Humidity Sensor with a calibrated digital output with the temperature and humidity reading. this technology ensures the high reliability and a long-term usability. It has a 8-bit microcontroller. This sensor includes a resistive element and a sense of wet NTC temperature measuring devices. It has excellent quality, fast response, anti-interference ability and high cost performance advantages.

Each DHT11sensors has an accurate calibration for humidity chamber. The calibration coefficients stored in the OTP program memory, internal sensors detect signals in the process, and we should call these calibration coefficients. The serial interface system is integrated to become quick and easy. Small size, low power, signal can be transmitted up to 20 meters, making it a variety of applications and even the most demanding applications. This has 4-pin single row pin. The connection has special variants that can be provided according to users need.

Gas sensor

Fig 7. Gas sensor

The figure (7) shows the gas sensor .A gas sensor is a device that detects the presence of gas in an specific area. This sensor interacts with a gas using chemicals to measure its concentration. Each gas has a unique breakdown voltage Sensor identifies gases by measuring these voltages. The concentration of the gas can be determined by measuring the current discharge in the device. The MQ5 gas sensor detects the presence of various gases such as hydrogen, carbon monoxide, methane and LPG ranging from 100ppm to 3,000ppm.When a gas interacts with the chemicals in the sensor, it is first ionized into constituents and is then adsorbed by the sensing materials. During this process the potential difference is given through the pins. The gas sensor module has a steel body under which a sensing element is housed. This sensing material is subjected to current through connecting leads. The gases coming close to the sensing material gets ionized and are absorbed by the sensing element. This changes the resistance of sensing material which alters the current going out.

3. BLOCK DIAGRAM

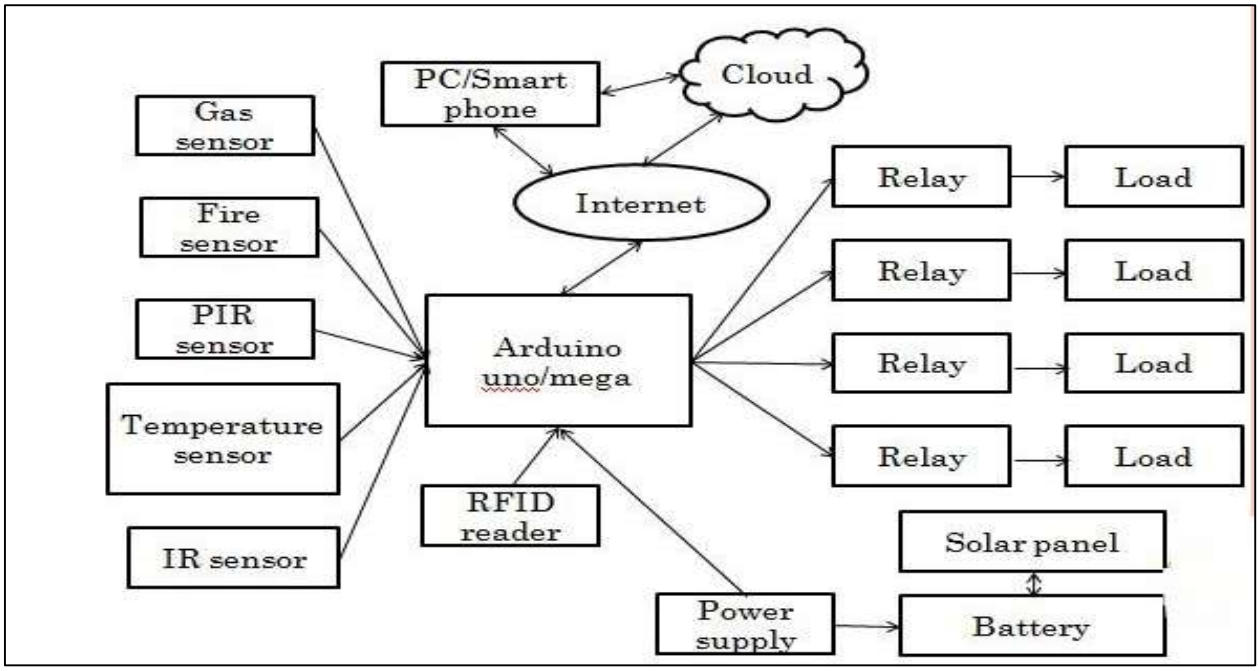

Fig 7. Block diagram of Smart home energy management systems using IOT

The figure (7) shows the block diagram of Smart home energy management systems using IOT. Here a various types of sensors are used inside the house like gas sensor, fire sensor, PIR sensor , temperature sensor,IR sensor for various purposes and all these are connected to the Arduino mega microcontroller and the loads are connected to the microcontroller through the relay circuit .this whole prototype is powered by solar energy and a 12v dc battery. The main advantage of this system is that it is connected to the internet so that the whole setup can be controlled from any place in the world if connected to the internet.

Smart home automation and energy management systems integrated with IOT is a work which emphasis on the smarter world. The aim of the work is to develop a smart home which can be controlled over internet from remote places. The application of IOT provides the user to view the status of his from anywhere through internet by using mobiles phones, computers. The figure (8) represents the prototype model. In smart phones by using applications we can control the loads in the home and at the same time we can get the sensor data simultaneously. This works on the platform known as arduino IDE which by serial communication, communicates with the sensors and actuators. The programming has been done in the arduino, using arduino software which is for programming.

Fig 8. Prototype of a smart home connected with IoT

This platform is used because of its low cost and easy accessibility. The arduino is connected to ESP6822 WIFI module which connects to the network allocated to it when powered ON. Various sensors like IR sensor which is used in parking to detect the presence of vehicle, temperature and humidity sensor is used detect the temperature and humidity of the house, gas sensor is used to detect the leakage of gases inside the cooking area, PIR sensor is used to detect the presence of humans inside the house, water level indicator is used to check the level of water in the water tank.

Day	Conventional energy consumption(kWh)	smart energy consumption(kWh)
1	10	8
2	14	11
3	16	14
4	11	9
5	13	10
6	13	9
7	13	10
8	14	12
9	15	12
10	13	10
11	12	9
12	15	11
Average	13	10

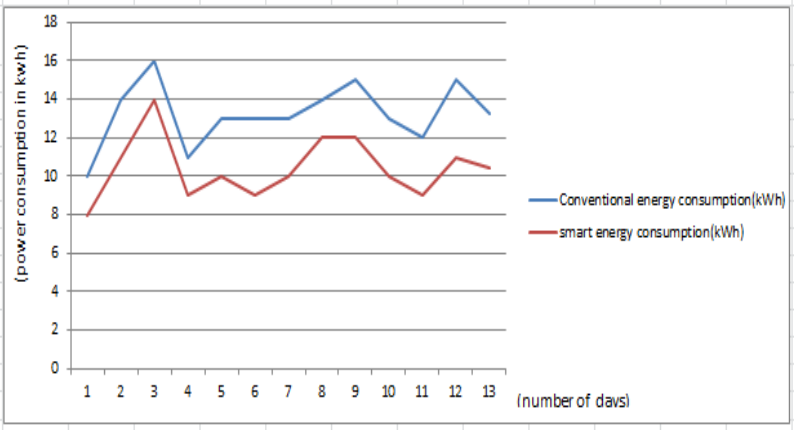

Fig 9. Graph on Energy Consumption

All these data's are sent to the arduino board which is processed there and the output signal is sent to the actuators like lights, fans, pumps servo motors, etc… By using the various sensor data's the appliances are made active or not. In order increase the efficiency renewable energy sources are used such as solar panel which provides energy to the house. The water heater in the house is turned on by the timer in the arduino which triggers output signal to switch ON the heater based on the daily usage which is programmed in the arduino after the usage time the heater is turned OFF automatically. This approach contributes to the energy management in households.

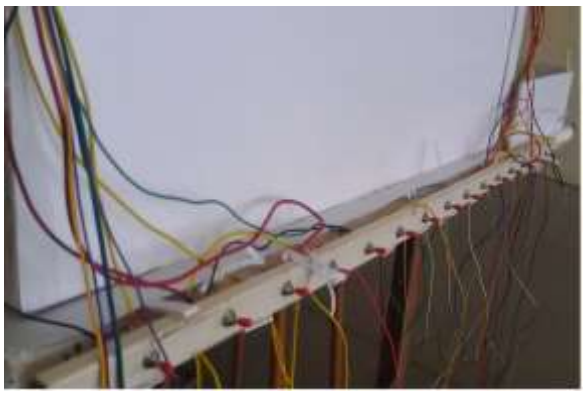

Fig 10. Manual toggle switches

The figure (10) shows the toggle switch setup which is provided to every appliance for the connivance of the user where he can swift each appliance either to manual or IOT operation. This gives the user a great advantage in case of any failure of IOT operation he can swift to manual operation instantly.

4. RESULT

The figure (9) represents the graph output of smart home automation with home energy management system in kWh for a period of 12 days. It has been compared and found that the smart energy system uses 37% less electricity has than the electricity consumed by the connected appliance and reduce cost of electricity.

5. CONCLUSION

The smart home automation and Energy Management Systems Integrated with IOT (Internet of Things) has been experimentally proven to work satisfactorily by connecting simple appliances to it which is successfully controlled by internet network. The designed system not only monitors the sensor data, like temperature, gas, light, motion sensors, but also actuates a process according to the requirement, for example switching on the light when it gets dark and saves energy consumption. It also stores the sensor parameters in the cloud in a timely manner. This will help the user to analyze the condition of various parameters in the home anytime anywhere. By using renewable energy sources which gives sustainable environment.

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