

IoT Based Home & Industrial Automation With Real-Time Energy Metering & Monitoring

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Abstract— Advancement in automation systems is making life simple and easy with respect to all the aspects. In the modern era, automated systems are being favored over conventional systems. Over the past decade, the brisk increase in the number of internet users has made Internet a essential component of life. With such influence of Internet in our day-to-day life, the present generation is seeing a emergence of a new technology known as the 'IoT: Internet of Things'. Internet of things is creating plexus of everyday objects ranging from industrial machine to consumer home appliances that share information and complete tasks while you are managing other activities. A Home Automation System uses computers or mobile devices to control basic home functions and features automatically through internet from anywhere around the world leading to the smart home concept, which is meant to save the electric power and human energy. The prime focus in developing such a system is to provide comfort for human life with a high efficiency, along with reduced power consumption. Real time monitoring of energy consumption is main objective of the system. This paper reviews different techniques of designing, developing and implementing IoT based Home Automation System.

Keywords—Internet of Things; automation; smart home; real-time; energy consumption.

I. INTRODUCTION

The process of controlling or operating various equipments, machineries, industrial processes, and other applications using various control systems, with less or no human intervention is termed as automation. Based on the application, automation can be further categorized as home automation, industrial automation, building automation, etc. Home automation is the process of controlling home appliances automatically using various control system techniques. The electrical and electronic appliances in the home such as fan, lights, outdoor lights, fire alarm, kitchen timer, etc., can be controlled using various control techniques.

Technology is a continuously evolving and developing process, which requires upgrading of the system according to the technology. Nowadays, all the system data is available on internet and the web technology is growing very fast. Embedded system with web technology provides remote management and controlling of embedded device via network interface following the Internet of Things technology.

The Internet of Things is a technology in which the actual physical entities (electronic devices) with data sensing, processing and self adoption capacity are used to interact with similar devices and process the data to take an intelligent decision which eases our day to day life. In IoT environment, the devices are given unique identifiers, giving them the ability to transfer data over a network without having human-to-human or human-to-machine interaction.

IoT is a combination two words: internet and things which means that any object or person which can be distinguished by the real world can be connected to global system of interconnected computer networks, governed by standard protocols. IoT can be defined as "An open and comprehensive network of intelligent objects that have the capacity to auto-organize, share information, data and resources, reacting and acting to environmental changes in real time". IoT is a world, where real, virtual and digital environments combine to generate a smart environment which makes life easy. This new technology has unlimited potential to improve our lives by using a "command-and-control" strategy. It is a revolution of the Internet in which objects make themselves recognizable.[16]

IoT is a new era of intelligence computing and it is providing a privilege to communicate around the world. The objective of IoT is anything, anyone, anytime, anyplace, any service and any network. The ultimate goal of IoT applications is to automate systems rather than using manual systems, to improve the quality of living.

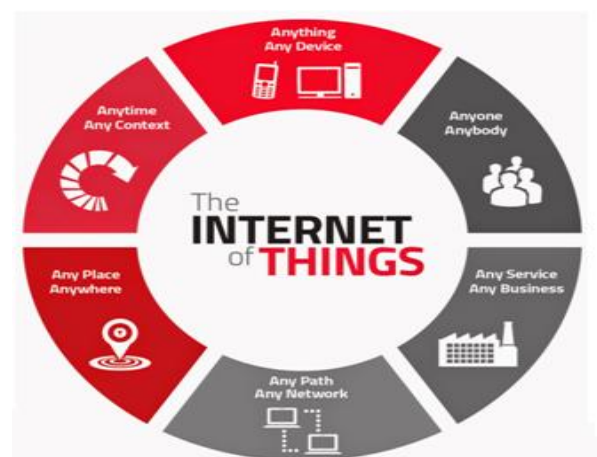


Fig.1 Internet of Things Concept

IoT includes variety of objects like smart phones, tablets, digital cameras and different sensors. When all these devices are connected together, they enable additional smart processes and services that support our basic needs, environment and health. Massive number of devices connected to internet provides enormous kinds of services and also produces huge amount of data and information.

Home automation is a forward step in “Internet of Things”, where everything is configured with an Internet Protocol (IP) address, which monitors, controls and remotely accesses the system the help of web technology. From the end user’s point of view, Internet based Home Automation System is very convenient, easy flexible and cheap. Nowadays, most of the devices have local area network (LAN) connectivity via Ethernet and / or are Wi-Fi enabled, which can connect them to smart phones or computers. But these devices cannot communicate with each other or else need additional devices to do so. Thus, these devices need to be unified, such that they can be monitored and controlled using one single program or device, e.g. controlling lights, fans, air-conditioners, oven, refrigerator, TV etc. by using an application on the Smartphone. This gives the user more control of their home and can simplify many manual actions.[17]



Fig.2 Home Automation

Internet on Things devices are controlled by web controller which is a package of embedded system and software stack. This is the most popular practice for Web development using in the world. Remote login and monitoring can be done by building a distributed web control system with the help of a web application instead of using big servers systems for managing and handling data. This kind of Web control system with IoT has characteristics of (1) Energy Conservation, (2) Comfort, and (3) Efficiency. Our objective is to apply the web control system to the web of things, so that people can remotely access the application from anywhere with the help of internet facility.

II. LITERATURE REVIEW

The Internet of Things (IoT) is the interconnection of uniquely identifiable embedded computing devices within the existing Internet framework. Typically, IoT is expected to offer advanced connectivity of devices and systems, and services that goes beyond M2M i.e. machine-to-machine communications and covers a variety of protocols, various domains, and applications. The interconnection of all these

embedded devices which also includes smart objects, is expected to lead in automation in nearly all fields enabling advanced applications like a Smart Grid. According to ABI Research, there will be nearly 26 billion devices on the Internet of Things by 2020. ABI Research has estimated that more than 30 billion devices will be wirelessly connected to the Internet of Things by 2020. According to the recent survey and study done by Pew Research Internet Project, a huge majority of the technology experts and engaged Internet users who responded 83 percent agreed with the conception that the Internet of Things, embedded, wearable computing will have widespread and beneficial effects by 2025. It is clear that the IoT will consist of a very large number of devices being connected to the Internet. [15]

The Internet of Things (IoT) refers to uniquely recognizable objects and their virtual representations in an Internet-like structure. Internet of Things refer to day-to-day objects, that are understandable, distinguishable, locatable, addressable, and or controllable via the Internet using either RFID, wireless LAN, wide-area network, or other means. These objects include not only the day to day usable electronic devices or the products of higher technological development such as vehicles and equipment, but also include various things like food, clothing, shelter; materials, their parts, and sub-assemblies; commodities and luxury items; boundaries, landmarks, and monuments; and all the miscellany of commerce and culture. Ubiquitous computing refers to a new genre of computing in which the computer completely permeates the life of the user. Internet of Things (IoT) will comprise of billions of devices that can sense, communicate, calculate and potentially actuate. Data streams coming from these devices will challenge the traditional approaches to data management and contribute to the emerging paradigm of Big Data. IoT has burst onto the stage, interconnecting everyday objects over the Internet, which acts as everlasting sources of information.

The term “Internet of Things” was first coined by Kevin Ashton, a British entrepreneur in 1999 while working at Auto-ID Labs (originally called Auto-ID centers, referring to a global network of objects connected to radio-frequency identification or RFID). Typically, IoT is expected to offer advanced connectivity of devices, systems, and services that goes beyond M2M communications and covers a variety of protocols, domains, and applications. Several researches have been previously done in this domain.

Sriskanthan N. and Karand T. have presented an application of Bluetooth Technology for Home Automation. The Bluetooth technology which emerged in late 1990's is used for implementing the wireless home automation system. Various appliances such as air conditioners, home theatres, cellular phones etc., are interconnected, thus creating a Personal Area Network in Home Environment. Communication between several client modules and host server takes place through Bluetooth module. A Home Automation Protocol has been developed to enhance communication between host server and client modules. The system also allows integration or removal of devices to the

network which makes the system scalable. The wireless system aims at reducing the cost of Home Automation. But, system does not use trending mobile technology. [1]

Buhur U. and Alkar A. have developed an internet based wireless home automation system for multifunctional devices. A flexible, low cost, wireless solution to the home automation is introduced. The transformation of the initial simple functionality control mechanism of devices to more complex devices has been discussed. The home appliances are connected through a server to a central node. The system is secured from meters in a concrete building. [2]

Mohd Ramli and Mohd Wahab developed a prototype electrical device control system using Web. They have developed a web based controller, for controlling electrical devices. Whenever the condition of server is down they also set their server with auto restart. The system does not use mobile technology. Being a web based system; this application is less effective since the use of headphones and Smart phones is increasing rapidly. [3]

Hasan B. and Serkan I. have designed and implemented a telephone and PIC remote controlled device for controlling the home electrical devices. In this Pin check algorithm has been introduced where it was with cable network and not wireless communication. The system ensures safety as it cannot be used by unauthorized users as the system uses Pin-check system. The architecture is very complex, but it gives an idea of remote handling of home automation system. [4]

Hoque S. E., Akbar M. M., Sohan S., and Naim I. presented a GSM based communication and control for home appliances. Different AT commands are sent to the Home Mobile for controlling different appliances. The drawback of this system is that a Graphical User Interface (GUI) is not provided to the user. Different AT commands have to be remembered by the users to control the connected devices. Also, the system supports Java enabled mobile phones. The system thus becomes less functional as now-a-days the use of Java enables phones are reducing and the use of Android phones are increasing tremendously. [5]

Rana J. R. and Pawar S. N. have implemented a Zigbee based home automation system. Zigbee is a high-level communication protocol used to create personal area network. It supports any kind of micro-controller. The system eliminates the complications of wiring. Considerable amount of power saving is also possible. Operating range is more than Bluetooth. But the system does not allow remote monitoring and controlling of appliances. [6]

Piyare R. and Tazil M. have presented design and implementation of a low cost, flexible and wireless solution to the home automation. The system uses Bluetooth technology where cell phone is used for interaction between the host server and the client modules. This system can be used by any appliances that require On-off switching applications without any internet connection. The drawback of this system was that the wireless communication system was found to be limited to

a range less than 50m in a concreted building and maximum of 100m range in an open range. The system supported only the symbian OS cell phones. [7]

Jadhav A., Anand S., Dhangare N., and Wagh K. S. developed a system which uses operating systems for implementation of the Home Automation System. An XML document is created and placed over the server, which can be used by any other mobile device without any platform issue. The layout of the screen is controlled by a common XML format. Downloading of XML file from the server and its parsing needs to be coded on every platform. As the design part is coded only once, a lot of coding effort is reduced. The same file is used by every other platform. The main objective of the paper was to develop a system without operating system platform limitations for Universal Mobile Applications. [8]

Javale D. and Nandanwar S. have used Android ADK for implementing a home automation and security system. In this system, the devices are connected to a Bluetooth sub-controller physically. It does not require internet connectivity. Smart phone is used to access and control the devices using built-in Bluetooth connectivity. Communication is established between android mobile device and the ADK. However, the system restricts mobility and can only be controlled within the specified boundary due to limited range of operation up to 100 m. Thus, the system does not support remote monitoring and controlling of appliances. [9]

Syed Anwaarullah presents the design and implementation of a low cost, compact and secure Android smart phone based home automation system. A single chip microcontroller real time operating system is integrated to the system, to improve the responsiveness of the system and make it more dynamic. The system uses Bluetooth technology. The Bluetooth module that is used is based on the Bluetooth V2.0 protocol and has a range of 10m operating at frequency of 2.4GHz with a maximum data exchange rate of 2.1Mbps. Similar to most of the existing systems, this system also does not support remote monitoring and controlling of devices. [10]

Sirsath N. S, Dhole P. S, Mohire N. P, Naik S. C and Ratnaparkhi N.S developed a Home Automation system that employs the integration of multi-touch mobile devices, cloud networking, wireless communication, and power-line communication to provide the user with remote control of various lights and appliances within their home. This system uses a consolidation of a mobile phone application, handheld wireless remote, and PC based program to provide a means of user interface to the consumer. [11]

Basil Hamed designed and implemented a control and monitor system for smart house. Smart house system consists of many systems that controlled by LabVIEW software as the main controlling system in this paper. Also, the smart house system was supported by remote control system as a sub controlling system. The system is also connected to the internet to monitor and control the house equipment's from anywhere in the world using LabVIEW. [12]

Basma M. Mohd, Sherine M., Abd El-kader and Fakhreldin M. A. proposed a new design for the smart home using the wireless sensor network and the biometric technologies. The proposed system employs the biometric in the authentication for home entrance which enhances home security as well as easiness of home entering process. The structure of the system is described and the incorporated communications are analyzed, also an estimation for the whole system cost is given which is something lacking in a lot of other smart home designs offers. WB-SH is designed to be capable of incorporating in a building automation system and it can be applied to offices, clinics, and other places. The paper ends with an imagination for the future of the smart home when employs the biometric technology in a larger and more comprehensive form. The paper ends with an imagination for the future of the smart home when employs the biometric technology in a larger and more comprehensive form. [13]

Delgado A. R, Picking R. and Grout V. in their paper, describe an investigation into the potential for remote controlled operation of home automation systems. It considers problems with their implementation, discusses possible solutions through various network technologies and indicates how to optimize the use of such systems. The home is a heterogeneous and distributed computing environment which certainly requires a careful study before developing any suitable Home Automation System (HAS) that will accomplish its requirements. Nevertheless the latest attempts at introducing Home Automation Systems in actual homes for all kinds of users are starting to be successful thanks to the continuous standardization process that is lowering the prices and making devices more useful and easier to use for the end user. Even so several important issues are always to be handled strictly before developing and installing a Home Automation System; factors like security, reliability, usefulness, robustness and price are critical to determine if the final product will accomplish the expected requirements. [14]

Thus, there are various techniques to control home appliances such as IOT based home automation over the cloud, home automation under Wi-Fi through android apps from any smartphone, Arduino based home automation, home automation by android application based remote control, home automation using digital control, RF based home automation system and touch screen based home automation. Wireless home automation using IOT is an innovative application of internet of things developed to control home appliances remotely over the cloud.

III. PROBLEM STATEMENT

The concept of Home Automation aims to bring the control of operating your every day home electrical appliances to the tip of your finger, thus giving user affordable lighting solutions, better energy conservation with optimum use of energy. Apart from just lighting solutions, the concept also further extends to have an overall control over your home security as well as build a centralised home entertainment system and much more. The IoT based Home Automation system, as the name suggests aims to control all the devices of

your smart home through internet protocols or cloud based computing.

Home automation systems face four main challenges. These are high cost of ownership, inflexibility, poor manageability, and difficulty in achieving security. There are a few more key challenges that need to be considered while design & developing the system:

- i. *Standards*
- ii. *Identification*
- iii. *Network Self-Organization*
- iv. *Integration*
- v. *Data Storage*
- vi. *Authentication*

The IoT based Home Automation system consists of a servers and sensors. These remote servers located on Internet which help you to manage and process the data without the need of personalised computers. The internet based servers can be configured to control and monitor multiple sensors installed at the desired location.

Power consumption of servers is becoming a huge issue in the server operation community. The maintenance cost of servers is considerably high, as it also requires a cooling system. Hence, energy consumption and cost offered has become a major issue for large data centers and servers. A controller with low power consumption can solve this issue, thus enhancing the performance.

Electrical energy or power is an important factor for human being survival nowadays. Apart from these efforts, automation is necessary in energy distribution for enhancing need of the people. Nowadays, human meter reading is providing insufficient to cope up with future residential need. So, the demand for Automatic Meter Reading (AMR) systems is increasing rapidly, which measures power consumption readings electronically. [17]

IV. SYSTEM IMPLEMENTATION OBJECTIVES

The main objectives of this research work is to design and implement a home automation system using IoT that is capable of controlling and automating most of the house appliances through an easy manageable web interface. The system can attain great flexibility by using Wi-Fi technology to interconnect its distributed sensors to home automation server. This will definitely decrease the deployment cost and will increase the ability of upgrading, and system reconfiguration. The objectives of implementing an IoT based home automation system can be defined as follows:

- To reduce power consumption in the web applications.
- To make energy metering easy by creating web application.
- To make an automated and intelligent home, and provide comfort to every consumer.
- Also the application is real time means the user can monitor real-time data and takes a particular action.

V. PROPOSED SYSTEM

This paper proposes a smart home with intelligence and provides e-metering system as a smart grid to overcome the discussed issues. The web application enabled system controls smart devices in home and also, all billing features from web

application work as a cloud application. The main objective of this project is to design energy consumption metering and control system for all service providers. As per this technology, a user can login and check usage of electricity in real time, while controlling various devices. Most of the energy providers can use same application for service management or controlling. No need to use separate application. Figure 3 shows a block diagram of the proposed system.

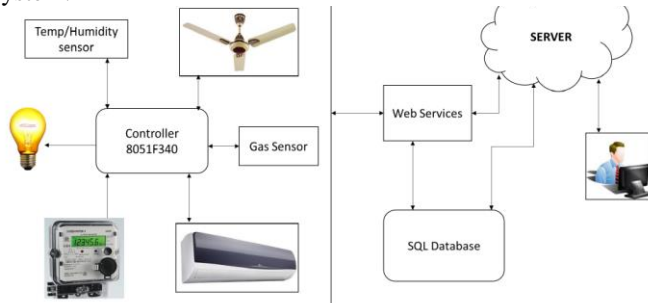


Fig.3 Block Diagram

Microcontroller is the heart of the system, being a high speed SMD. It contains a server which is having a web application working as a cloud application, where we can monitor or control the devices connected to the microcontroller. Temperature and humidity is measured by the sensor and displayed on web application. The gas sensor detects of leakage of gas. The SQL database contains all the data and values and these values are provided to application by web services.

The system actually works on the principal of “Tri-Level Context making Model”[12]. The role of this model is to generate context after data acquisition. To maintain a quality of service in different service domains, the models consist of three levels of working: Simple monitoring, Automatic controlling and user centric services. Data acquisition and signal processing are the low level context, whereas high level context is used to generate situation awareness.

Hardware contains main controller board with various sensors. Firstly all the sensors detect its current status and this status is sent towards the main controller. The current status values are stored into the database and these values are fetched and displayed on application. If status is updated by consumer, exact opposite procedure takes place. Updated values are stored in database and are also forwarded to the controller via internet connectivity by http request. Finally, the controller sends the updated value to transducers and they start working accordingly. Figure 4 shows flowchart of the proposed system.

VI. ADVANTAGES OF HOME AUTOMATION SYSTEMS

There are many advantages of incorporating IoT into our lives, which can help individuals, businesses, and society on a daily basis. For individuals this new concept can come in many forms including health, safety, financially and every day planning. In recent years, wireless systems like Wi-Fi have become more and more common in home networking. In home and building automation systems, the use of wireless technologies gives several advantages that could not be achieved using a wired network only.

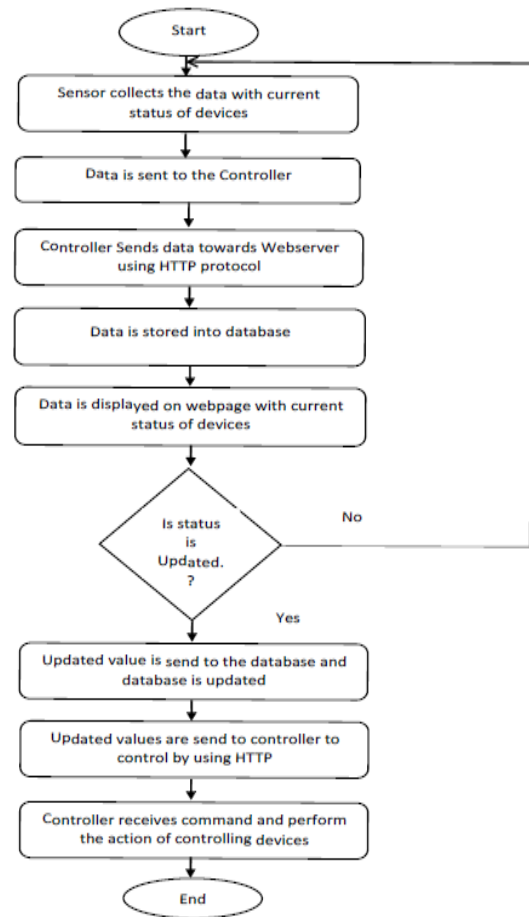


Fig.4 Flowchart

The home automation systems possess the advantages as described below:

- 1) System Scalability and Straightforward Expansion:** Deploying a wireless network is especially advantageous when, due to new or changed requirements, extension of the network is necessary. In contrast to wired installations, in which cabling extension is tedious. This makes wireless installations a seminal investment.
- 2) Integration of Mobile Devices:** With wireless networks, associating mobile devices such as PDAs and Smartphones, automation system becomes possible everywhere and at any time, as the devices’ exact physical location is no longer crucial for a connection (as long as the device is in reach of the network). For all these reasons, wireless technology is not only an attractive choice in renovation and refurbishment, but also for new installations.
- 3) Aesthetical Benefits:** Apart from covering a larger area, this attribute helps to full aesthetical requirements as well. Examples include representative buildings with all-glass architecture and historical buildings where design or conservatory reasons do not allow laying of cables.
- 4) Reduced Installation Overheads:** First and foremost, installation costs are significantly reduced since no cabling is necessary. Wired solutions require cabling, where material as well as the professional laying of cables (e.g. into walls) is expensive.

Another advantage of IoT is the ability to track individual consumers and targeting these consumers based on the information supplied by the devices. In a way, it provides a more “personalized” system that could potentially increase business sales and increases their demographic. Additionally, with the increased amount of devices connected to the Internet the Smart Grid expands, conserving more energy. Devices can make decisions and adapt without human guidance to reduce their energy usage.

IoT can also function as a tool that can save people money within their households. If their home appliances are able to communicate, they can operate in an energy efficient way. Finally, IoT can assist people with their everyday plans. Thus, IoT is certainly advantageous to businesses, individuals, consumers, the environment, and society.

VII. CONCLUSION

Internet is a means of Communication which is easily available and affordable nowadays. Android Phones and Android applications are already a part of human life. Thus, a combination of these technologies will make life more simple and easy to live. The paper reviews various techniques and systems having both, the facilities of Home automation and Real Time Energy controlling and monitoring, which is available in single web application. Multiple Energy service providers can use same web application by changing admin login and it depends upon the size of database. The potential of the system can be improved to a greater extent by combining technologies such as cloud computing, big data, robotics etc. Even though these technologies are not new to the Industry, combination of these technologies with the Internet of Things (IoT) will do miracles in human life.

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