Smart Home Application using Internet of Things

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Abstract - *In the recent years the Internet of Things (IoT) has become ubiquitous technology and has made human life more secured, convenient and comfortable. It has enhanced quality of life by providing intelligence feature in the physical objects (sensors and actuators). It has made the connectivity pervasive and has affected the human life in unimaginable way. IoT is being used in many applications which includes smart home, smart city, healthcare, retail management, smart grid, etc. In the present paper IoT has been used for smart home application with the help of Arduino Uno board, Bluetooth, android based smart phone application, sensors, relays, motors and actuators. It has been used to control lights, heating ventilation and air conditioning (HVAC) system, door bell, water pump, garage door and garden management system.*

Key Words*: Internet of Things, Lighting Control, Smart Home Appliances, Garden Management Systems.*

1. INTRODUCTION

Internet of Things have made physical objects intelligent and smart by embedding in them the sensing, computing and communication capabilities. IoT has enabled physical objects as if they can see, hear and talk to each other without any human intervention. The sensors and actuators can share information and coordinate decisions among themselves. IoT has become ubiquitous and has made the connectivity almost pervasive [1]. It has eliminated the physical distance barrier and human interventions by enabling the physical objects with computing and networking capabilities. Figure 1 gives the broad definition of internet of things [2].

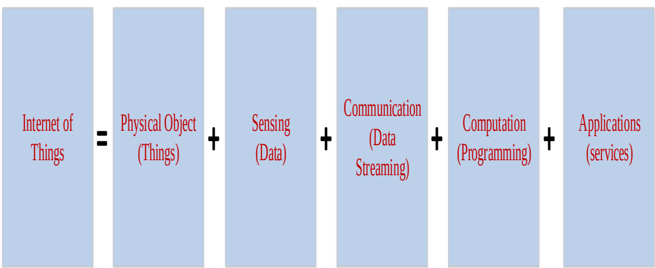

Fig – 1: Definition of Internet of Things

Small microcontrollers (sensors) embedded with energy efficient operating systems, communication and transceiver capabilities are connected to the web through a robust network architecture and provides plethora of reliable services with minimum time delay and cost [3].

2. INTERNET OF THINGS ARCHITECTURE

The traditional Internet architecture uses standard protocols and have predefined protocol layers in them. As in the case of international standard organization (ISO) standard open systems interconnection (OSI) model is a seven layered framework. Each of these layers are related to each other with a set of protocols for moving information across the network [4]. These layers are physical, data link, network, transport, session, presentation and application [5]. Similarly in the case of transmission control protocol/internet protocol (TCP/IP) protocol suite, it consists of five layers, such as physical, data link, network, transport and applications layer. It is well known that TCP/IP protocol suite has become a standard internet protocol suite because of its compactness than the OSI model [6]. Figure 2 represents one of the possible 5 layer architecture of IoT.

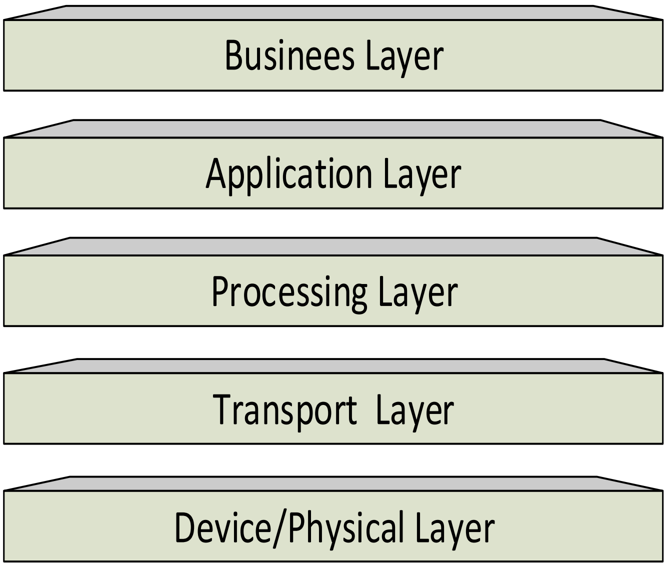

Fig – 2: Five Layers architecture of IoT

To meet the growing IoT challenges and create a competitive environment its architectural standard can be seen as the revised version of traditional internet architecture. The number of protocol layers are not fixed in the case of internet of things. It could be a very robust and simple architecture with only three layers: perception/device layer, network layer and application layer which defines the main idea of IoT [7]. But the three layer architecture does not specify the finer aspects of working requirements of IoT. More layers need to be included to elaborate its functionality. One such architecture might have five layered protocol which includes perception/device layer, transport layer, processing layer, application layer and business layer [8]. The processing layer acts as a middleware layer to provide additional facilities like storage, analysis and processing. Similarly, the business layer provides business, application and profit model management.

Apart from the two architectures described in the above paragraph, Cisco has suggested seven layer reference model for IoT applications. The seven layers have been termed as seven levels. First level has been specified for physical devices including sensors, machines and devices. Second level has been used for connectivity of communication and processing unit and third level for edge computing for the major focus on data analysis and transformation [9]. The work of data accumulation and storage has been defined in the fourth level, whereas level five performs the job of data aggregation and access. The job of application layer defined in sixth layer is of data analysis, reporting and control. The last and final, seventh level performs the work of collaboration and business process [10].

Similarly, internet engineering task force (IETF) has suggested IoT architecture based on 6 layers: Physical cum data link layer, data adaptation layer, network layer, transport layer, application support layer and application layer. International telecommunications union - telecommunications (ITU-T) reference model has only four layers: device, network, service and application and application layer. Last but not the least, European telecommunication standard institute (ETSI) has developed a set of standard for the network, devices and gateway for machine to machine (M2M) domain architecture based on only two domains: first as device and gateway and the second as application and network domain [11].

3. FOG/ EDGE AND CLOUD COMPUTING FOR IOT

Cloud computing offers services, infrastructure and computational capabilities for on demand network access to a shared pool of configurable resources. But the sensors used in IoT applications generate huge amount of data which requires large computational capabilities and storages resources for the purpose of processing and analysis. Apart from the huge data generated, most of the IoT devices are mobile, requires reliable and real time actuation, power constraint and scalable in nature and hence its dependency on cloud based computing is not reliable and sufficient. The solution of this problem could be to provide computing, analysis and data storage facilities at local level, close to the edge of the network (devices). Figure three represents the overview of fog/edge computing. The data sent to cloud is barely essential data. Most of the computing is done at the fog/edge level itself.

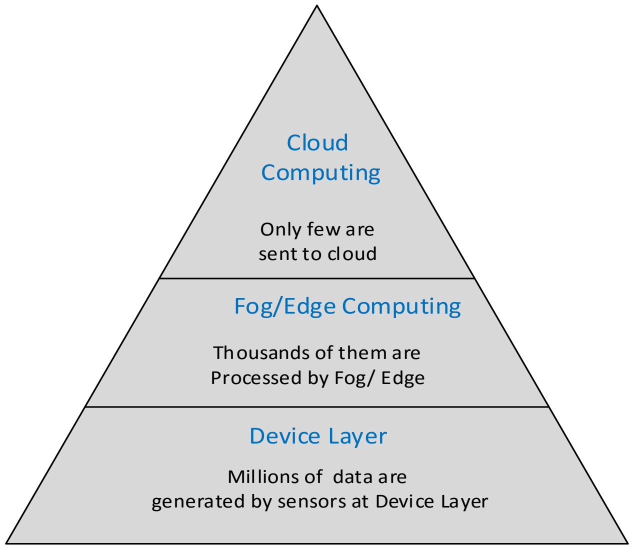

Fig – 3: Fog/ Edge and Cloud Computing

The fog/edge has features of low latency, location awareness, distributed nodes, mobility and real time response. Apart from these features it can interact with the cloud and send only those data which is required by the cloud. In other words, at one hand it reduces the burden of data handling by cloud and on the other hand it improves the efficiency of services provided by the IoT with enhanced security features and privacy of data [12]. Figure 4 depicts the work of IoT gateway services.

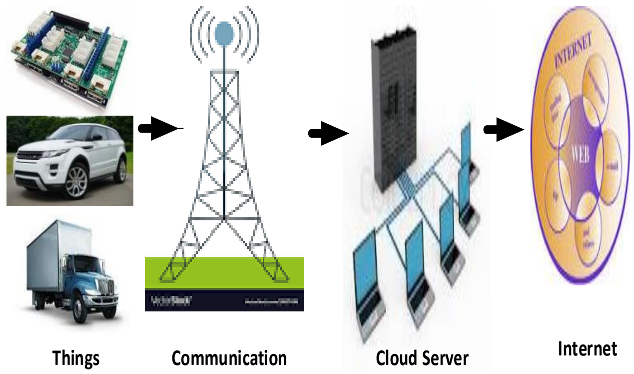

Fig – 4: IoT Gateway services

4. SMART HOME APPLICATION USING IOT

In the present scenario the Internet of Things are being used for many smart applications [13]. The important applications of IoT are in the field of smart grid, industrial automation, building automation, smart energy, mechanized agriculture, wearable devices, retail management, gaming, augmented reality, virtual reality, mixed reality, autonomous vehicles, health care, smart city, smart transport, social life and entertainment, health and fitness, smart chain and logistics management and smart home, etc. [14]. In figure 5 Arduino Uno board model R3 is shown. This board uses AVR ATmega328, 32 bit microprocessor at 16 MHz clock speed and operates on 5 Volt DC power. It has 14 digital input/output pins, 6 analog input pins, 32 KB flash memory, 2 KB SRAM and 1 KB EEPROM. It has the provision of a USB, power jack, ICSP header and also has one onboard reset button. It has all the essential requirement for small IoT project requirements embedded on the printed circuit board itself [15].

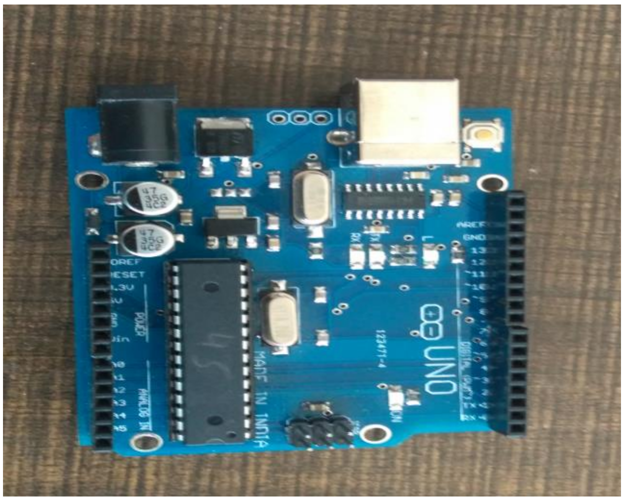

Fig – 5: Arduino Uno Board Model R3

In the present paper, smart home applications have been developed to resolve the basic needs of a home using internet of things. This application have been used to control lights, heating ventilation and air conditioning (HVAC) system, door bell, water pump, garage door and garden management systems, etc. [16]. The major equipment used for this application includes Arduino Uno board, Bluetooth model, android based smart phone application, driver, sensor, relay, motor, actuator and other accessories like transistors, resistors, etc. Figure 6 shows the blue tooth model HC 05. It operates at 2.4 GHz frequency in the ISM band and the modulation technique used is Gaussian Frequency Shift Keying. Its speed in the asynchronous mode is 2.1 Mbps and in the ssynchronous mode the maximum speed is 1 Mbps [17].

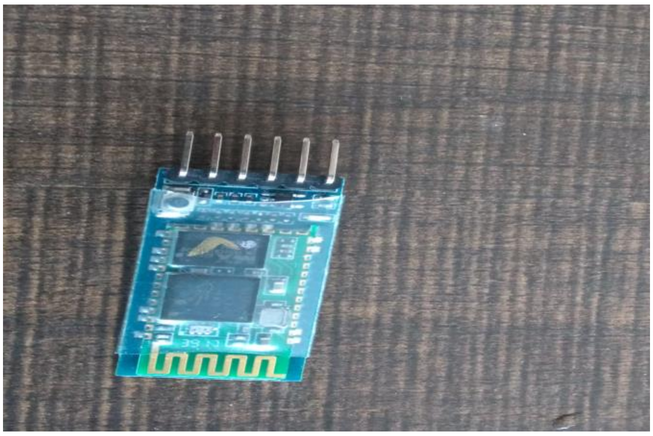

Fig – 6: Blue Tooth Model HC 05

In this work Arduino Uno Board model R3 along with Blue Tooth model HC 05 have been used. Ten number of different applications have been switched on from a distance of 10 meters wirelessly using android based smart phone applications [18]. The distance can be further increased up to 100 meters using Zig bee in place of blue tooth. The Zig bee and low energy blue tooth are low rate personal area network (Low rate PAN) devices, are not based on internet protocols (IP) and operates in the industrial, scientific and medicine (ISM) band with 2.4 GHz and 5.0 GHz frequency and follows the IEEE 802. 15. 4 and IEEE 802. 15. 1 standards respectively [19].

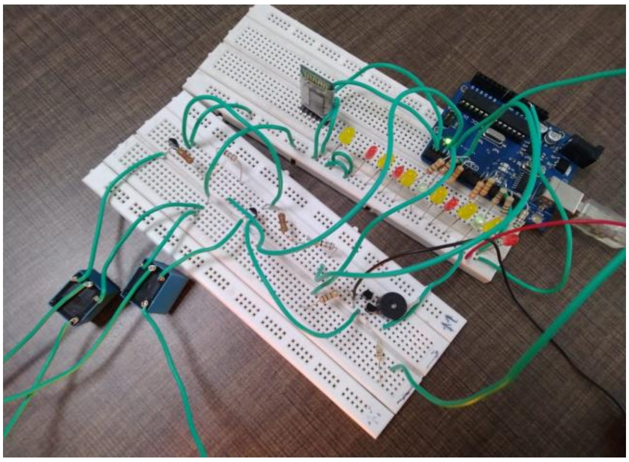

Fig – 7: Set up for 12 different applications

Figure 7 shows the laboratory set up of the project [20]. The wireless operating distance can be further increased using low energy wireless fidelity (Wi-Fi) system which operates on 900 MHz frequency that uses IEEE 802.11 protocol and comes under wireless local area network (wireless LAN). Its coverage area can be further increased up to a distance of 1 KM by further lowering the operating frequency [21]. Figure 8 shows few application such as switching on lights, motor, doorbell, etc.

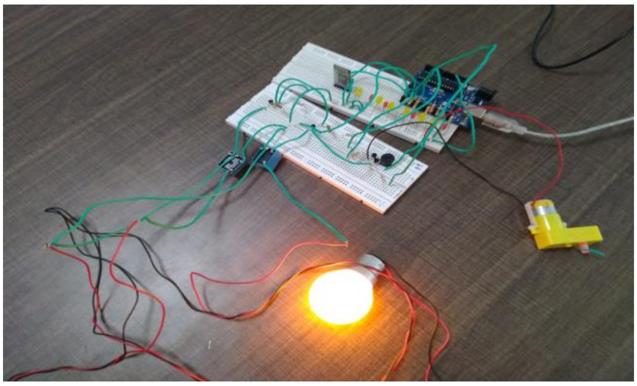

Fig – 8: Remote Switching of motor, doorbell and lights

The operating range can be further increased using IP based network protocols such as worldwide interoperability of microwave access (WiMax) which uses IEEE 802.16 standard, mobile broadband wireless access system (MBWA) using IEEE 802.20 standard and wireless regional area network (WRAN) based on IEEE 802.22 standard with data rate up to 1 Mbps constituting wireless metropolitan area network (WMAN) and wireless wide area network (WWAN) respectively [22].

5. CONCLUSION

Apart from enhancing quality of life, IoT has made human life more secured, convenient and comfortable. Due to the pervasive connectivity it has affected the human life in unimaginable way. It has wide area of applications such as smart home, smart city, healthcare, retail management, smart grid, etc. The present paper demonstrates the application of IoT for smart home. It has been operated wirelessly from the distance of 10 meters using android based smart phone applications and operating distance can be further increased using IP based network protocols. The devices which has been operated includes lights, heating ventilation and air conditioning (HVAC) system, door bell, water pump, garage door and garden management system.

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