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IOT based control of Appliances

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***Abstract*—Owing to the rapid developments in automation technology, embedded systems and connectivity, the emerging technology 'Internet of Things' (IOT) is sky-rocketing. Number of devices that can be inter connected through IOT is shooting up day-by-day. Life is made simpler and more productive through IOT. IOT can be considered as the network of multiple things including inanimate things as well as living organisms. Deploying a sensor network to collect the sensor data in the surrounding environment and remotely actuate the necessary controls is possible through IOT. As the WiFi hotspots are increasingly becoming common in the recent times, the existing infrastructure can be used to develop a cost effective solution to enable the existing appliances with IOT. Most of the current solutions for home automation and industry control use GSM/GPRS for connectivity. An overview of IOT, its architecture and protocol suite is presented in this paper. This paper also aims to prototype a solution to enhance the old appliances and make them smart. Such a system can be used in a wide range of applications such as home automation, smart agriculture, smart industry.**

Keywords:Internet of Things, remote access, home automation

I. Introduction

Internet of things (IOT) refers to the inter-connection of multiple devices and providing them with the intelligence so as to make them smart. It allows the real world devices to communicate with each other and configure themselves independently [1]. Though IOT has been hyped about envisioning the future technology, it is not a recently born concept. The term Internet of Things was coined by Kevin Ashton in 1999 to describe the global network that can be created by connecting RFID to virtually monitor the P and GĂŹs supply chain [2]. With the wide accessibility of internet and booming automaton technology, the penetration of IOT enabled devices in human life is sky rocketing. Living organisms are also becoming a part of the IOT network. To include the living things along with the non-living things under this technology, Cisco has coined the term Internet of Everything (IOE) [3]. According to the estimates of Cisco Internet Business Solutions Group (CIBSG), by 2020 about 50 billion devices are to be connected to the internet as a part of IOT and on an average, 6.58 devices would be connected per person [4].

Most of the devices are being armed by necessary sensors, actuators, micro-controllers and transceivers which promote the deployment of this technology to create a smartly controlled environment. IOT extends a huge potential in many industries such as Transportation, Healthcare, manufacture and supply chain, infrastructure etc impacting the quality of work and life [5]. With the growing ease of wireless internet access, all the devices from heavy industrial machinery to everyday consumer goods are becoming smart devices. Smart homes, smart cities, smart metering, smart agriculture etc are the outcomes of this revolutionary technology.

Various wireless communications such as Bluetooth, Zigbee, RFID, GPRS, GSM etc. can be used to establish the network of IOT devices. However, as WiFi is widely being used everywhere, we can use the existing connectivity to link all the appliances in a neighborhood. Using the internet to control the home, agricultural, industrial and health care appliances automatically facilitates to make life easier, smarter, secure and to conserve the energy [6].

II. IOT architecture and protocol

Internet of things is not just a simple extension to the existing technology of inter-networking or communication. The current architecture and protocols suffice to meet the needs of Internet of People. They cannot support billions of smart devices in IOT network. There is a need to develop an architectural model for this emerging technology to facilitate the interoperability among various IOT systems [7]. Many multi-tier architectural reference models are proposed to standardize IOT [8] [9] [10]. However, there is a lack of unified agreement over the architectural framework of this new wave of computing and networking technology [11]. Moreover there are issues regarding interoperability, security and privacy.

A basic architectural reference model for IOT consists of three layers - Application layer, Transmission layer and Perception layer [12]. The perception layer deals with end devices that senses physical parameters such as light intensity, temperature, humidity etc. These devices can digitalize these signals for transmission and can actuate based on the received commands. Transmission layer deals with connectivity. It transmits the digital signals from perception layer to database or processing unit. Connectivity can be achieved by various protocols such as 2G, 3G, 4G, WiFi, Zigbee etc. In addition to this, the network or transmission layer is also responsible for providing secure inter modal communication. The application layer is accountable for data storage, analysis and processing. It consists of cloud services and abundant of user applications.

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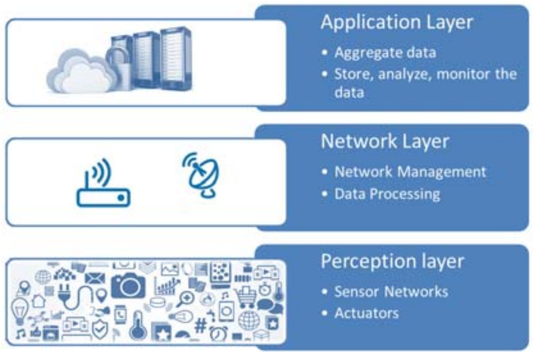

Fig. 1. Basic IOT architechture

However, this traditional architectural model of IOT can be modified to account scalability, QoS and flexibility [13].

Conventional internet protocols cannot be utilized for IOT as the IOT devices have constraints over their power consumption, memory usage and CPU processing capabilities. Protocols such as TCP, HTTP etc. add a lot of headers and redundant data to the actual data that is being transmitted which will be overburden the IOT devices. Moreover, IOT forms a dense stochastic network of millions of nodes [4] with variable transmission rates. In the recent past, focus is being laid to research and standardize protocols that support low power, reliable communications for IOT enabled devices. IEEE 802.15.4, 6LoWPAN, COAP, MQTT etc are the such IOT protocols. IEEE 802.15.4 defines a reliable and low power physical and MAC layer. [14]. 6LoWPAN stands for IPv6 over Low power Wireless Personal Area Networks. It describes a low power reliable wireless communication of devices that are addressed using IPv6. The revolutionary IPv6 addressing scheme has created nearly an unbounded address space capable of addressing about $340x10^{27}$ billion unique devices. 6LoWPAN is an emerging network protocol attributed to IPv6. UDP is used in IOT instead of TCP as the reliability is taken care of in the lower layers. CoAP, REST APIs, MQTT etc are the protocols used in the application layer. Existing protocols such as http can be used to connect to the internet through REST (Representaional State Transfer)APIs. CoAP or Constrained Application Protocol is a light weight web transfer protocol that reduce the complexity through header compression [14].

III. Related Work

Dongyu Wang, Dixon Lo, Janak Bhimani and Kazunori Sugiura [15] developed a home appliance controlling system using Raspberry Pi [16]. They used an IR controlled system to control TV, ACs etc. Websockets protocol was used and data is transmitted as JSON objects. S.Pandikumar, R.S. Vetrivel [17] proposed an architechural model for IOT customized for smart homes. It works on the lines of providing remote access of smart devices in the home through GSM and GPRS. This IOT home automation solution aims to prototype web servers, IOT agents and web user applications.Sensor data is transmitted

TABLE I
Comparision of TCP/IP and IOT protocols

	Internet Protocol (TCP/IP)	IOT protocol
Application Layer	HTTP/ FTP/ SMTP/ POP3 etc	CoAP/ MQTT/ REST API
Transport Layer	TCP/UDP	UDP
Network Layer	IPv4, IPv6	6LoWPAN
Link Layer	IEEE 802.3, IEEE 802.11	IEEE 802.11, IEEE 802.15.4 etc

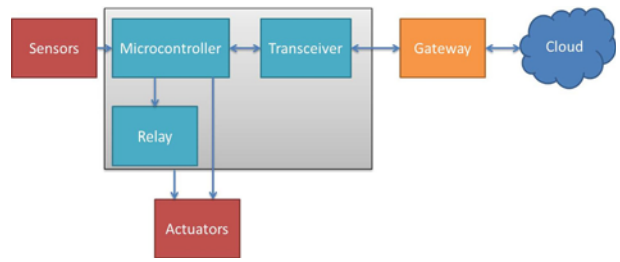

Fig. 2. Network Setup

through GSM and actuation command is obtained through an SMS.

A similar work is done by Sirsath N. S, Dhole P. S, Mohire N. P, Naik S. C & Ratnaparkhi N.S [18].They proposed a home automation solution through smart phones and cloud network. Android application is developed to access the home appliances from anywhere in the world.

Vishwajeet Hari Bhide, Dr, Sanjeev Wagh [15] proposed a self learning system for home automation. This system aims to provide the home appliances with the intelligence for automatic fault detection and correction. The data is monitored in a PC that is specific for this task. Naive Bayes Classifier Algorithm is used for data mining and automatically detect the faulty system.

IV. Network Setup and Implementation details

The existing automation solutions need to create a new infrastructure for communication of WSN and the cloud. However in the system that is being proposed, WiFi is used to interconnect the physical world devices keeping in the view of increased number of WiFi hotspots in the recent past.

Various sensors can be used to sense the environmental conditions and is transmitted to gateway through WiFi. This data is sent to the cloud. The sensed values can be remotely monitored and analyzed at the cloud platform. Necessary actuation can be performed from the server. A relay can be used to control high power appliances such as TV, AC, geyser etc.

A. Nebula Board

Nebula board developed by Radiostudio Inc [19] is used as a part of this project to IOT enable any home appliance.

Fig. 3. Nebula Board interfaced with sensors

The nebula board can be used to support up to three inputs and 4 outputs out of which one is connected to relay. Additional sensors or actuators can be programmed using UART. 16 bit PIC micro-controller with 16 Mb Flash, 1 Mb EEPROM, 3 UART, three 10- bit ADCs , one SPI and an I2C are the key features of Nebula board. Each Nebula board is assigned a unique hardware ID and power isolation feature.

B. Sensors

Three sensors namely temperature sensor, reed switch and photoresistor are used to monitor the parameters of the surrounding environment. These sensors are connected appropriately to the Nebula development board.

1) Temperature Sensor: LM35 IC [20] temperature sensor is used to measure the temperature of the room. LM35 is a three pin IC that is calibrated in celsius scale.

TABLE II
SPECIFICATIONS OF LM35A TEMPERATURE SENSOR

	LM35A
Range	-55C to 150C
Accuracy	+/- 0.2C at 25C
Non linearity	+/- 0.18C

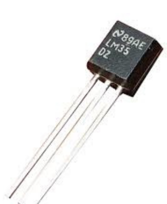

Fig. 4. LM35 temperature Sensor

Fig. 5. Reed Switch

Fig. 6. Photo Resistor

2) Reed switch : Reed switches are useful in multiple ways especially for fault detection in appliances [21]. Their low power consumption and ability to switch high loads make them extremely advantageous in ensuring the security of appliances driven by them. They have a wide range of applications such as proximity sensor, tamper detection, fluid level detection etc. Reed switches at doors and windows help to develop an intruder monitor system in home automation. They can be used to detect the door open condition in appliances such as washing machines, refrigerators etc. To demonstrate the response of reed switch during experimentation , magnetic field is varied to observe the changes in the data sensed by the reed switch.

3) Light Intensity Sensor: A photo-resistor (LDR) can be used to sense the intensity of light. As the light is incident on LDR, the electrons in the material are excited and conduction is increased. Thus higher the intensity of light incident on the sensor, lower is the voltage drop across it.

C. Actuators

The actuation can be performed based on automatically or manually by the user at the server side. A buzzer and a relay are used as actuators. Rules can be created on the cloud platform for auto triggering of a device. Through the Dataglen platform, rule is created such that if the reed switch crosses a particular threshold, then the buzzer is turned on. High power appliances such as geysers, water pumps, AC, TV etc can be connected to the micro-controller through a relay. GU-SH-112D relay from Good Sky relay manufacturers [22] is used to

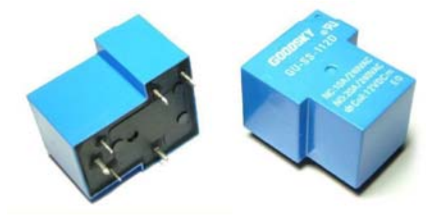

Fig. 7. GU-SH-112D Relay

control TV. It is a SPST type relay that can control a maximum load of 240V, 30A. It can drive the high power appliances that upto 900W [22].

D. Data transmission

A gateway is used to provide the nebula board with connectivity to Internet. A PC with internet connectivity is used as a gateway. The data sensed by the sensors is aggregated by the nebula board and transmitted to the gateway. Dataglen cloud is used to store, analyze and manage the data. The Dataglen platform is used to visualize the sensor data and perform actuation controlling. The gateway sends this data to the Dataglen cloud over http using REST APIs as json objects. The Dataglen platform can be accessed through web browsers, smart phones or programming interfaces.

Python programming can be done to update the sensor data or perform the actuation control through REST APIs. The data is transmitted as JavaScript Object Notation (JSON) array. A sample JSON array of data posting of the sensors' data is given below:

[
"name": "ADC1$_R$”,
"source": "4GUQiFovZtED3gA",
"streamDataType": "INTEGER",
"streamDataUnit": "995",
"streamDateTimeFormat": "19:57:02;17-01-2016",
"streamPositionInCSV": 3,
"multiplicationFactor": 1 ,
"name": "ADC2$_R$”,
"source": "4GUQiFovZtED3gA",
"streamDataType": "INTEGER",
"streamDataUnit": "32",
"streamDateTimeFormat": "19:57:02;17-01-2016",
"streamPositionInCSV": 4,
"multiplicationFactor": 1 ,
"name": "ADC3$_R$”,
"source": "4GUQiFovZtED3gA",
"streamDataType": "INTEGER",
"streamDataUnit": "53",
"streamDateTimeFormat": "19:57:02;17-01-2016",
"streamPositionInCSV": 5,
"multiplicationFactor": 1 ,
]

Fig. 8. Reed Switch readings

Fig. 9. Data sensed by LM35

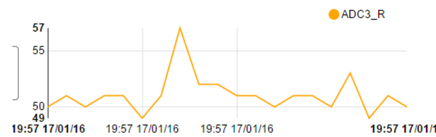

Fig. 10. Sensed values from LDR

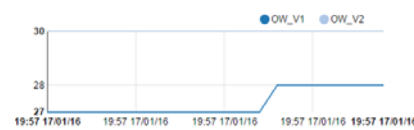

Fig. 11. Relay Output is triggered

Fig. 12. Dataglen Platform

V. Conclusions and Future Work

A brief discussion on the architecture and protocols of IOT gave a basic overview of this upcoming technology and provides the developer with necessary tools to deploy IOT to improve the quality of life and work. A prototype is developed to remotely monitor the environmental conditions and control the appliances through the existing WiFi infrastructure. Reaping the benefits of sensor technology and advancements in communication technology, it is possible to enhance the old appliances and making them smart through IOT. Using the Dataglen platform the data can be aggregated, analyzed and visualized. This kind of automation system can be useful for differently-abled people to control their home appliances remotely. In smart agriculture, sensor network can be setup using the soil moisture sensors and irrigation system can be automated. Industry processes can be automated and machine conditions can be remotely determined using this system. This prototype uses REST APIs for communication with the cloud. Verbose data due to the protocol overheads increase the power consumed by the device and may make it less efficient. Emerging protocols such as CoAP and 6LoWPAN can be considered to provide better performance.

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