Internet of Things (IoT) Enabled Automation Systems

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Abstract— Internet of Things (IoT) is a technology which enables the computing devices, physical and virtual objects / devices to be connected to the internet so that users can control and monitor devices with greater ease. The Internet of Things has been considered as the third revolution in the digital technology after the computer and the Internet and it brings significant advantages in every field of Automation. The IoT offers huge potential for development of various applications namely - Industrial Automation, Home Automation, Agricultural Automation, Healthcare Monitoring, Military Applications, Infrastructural Management, e-governance, Environmental Monitoring, Energy Management, Transport Systems and numerous others. In this paper, brief overview of framework for development of IoT based Automation Systems are presented. The proposed new generic framework is helpful for controlling and monitoring the various fields like Industries, Smart Homes, Hospitals, Agricultural fields, Transportation system etc. and implemented based on Arduino and the IoT devices like ESP8266, X-bee, GSM SIM900,Bluetooth, RFID and various sensors.

Key words: IoT (Internet of Things), ESP8266 Wifi, X-bee, Bluetooth, GSM SIM900, RFID, Sensors, Arduino, Android, Controlling Devices & Computational Intelligence

I. INTRODUCTION

In recent years, Internet has grown exponentially and changed human's life providing anytime, anywhere connectivity with anyone. The Internet technology can be further extended to connect objects that we use in day to day life. This expansion of internet services is called Internet of Things (IoT). The term "Internet of Things" was coined by Peter T. Lewis in a 1985. In his speech he states that "The Internet of Things, or IoT, is the integration of people, processes and technology with connectable devices and sensors to enable remote monitoring, status view/manipulation and evaluation of trends of such devices". The global network of computing devices around the globe is termed as the Internet. The internet provides an open-ended perspective for generating connectivity among various devices while the Internet of things provides another open-ended prospective for generating connectivity as well as embedded computing capabilities among them. Today, each house, company, school, institute, private organization and government organization are connected to each other via the internet. More specifically every one individual is connected to every other via the internet. The full potential of this connectivity is now days exploited by interconnecting not only individuals but the devices also. This paradigm has been around for last decade and is conceived as the internet of things. Internet of things as a concept has been around for last decade, but it has been utilized and implemented in various walks of life for last few years

[1]. Now a days, the development of IoT based technology for automation is gaining lot of attention and many researchers are working in that direction. According to researchers, "The IoT is a system of interrelated computing devices, mechanical and digital machines, objects, animals, or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human- to-computer interaction" [2].While the last half century was dominated by the communication revolution, the next several decades will be dominated by Electric Power and Energy Systems (EPESs). Since the global economic crisis of 2008, energy has started to dominate the market landscape [3]. The transformation in EPESs emphasizes increasing efficiency and improving the reliability of electric power network operations, energy conservation, renewable sources of distributed power generation, and reduction of carbon emissions [4].Internet of Things and its Enabling Technologies, supported IoT platforms are also deliberated. IoT also imparts real-time feedback capabilities to the utilities which function to better serve customers through enhanced monitoring and control functionalities [4]. This is the reason that utilities are among the largest IoT market and will be the third-largest industry by expenditure in IoT products and services, with more than $69 billion already spent worldwide [5]. The adoption of IoT in EPESs is also favored by the significant reduction of costs associated with sensors, bandwidth, processing, and memory/storage [6].

II. LITERATURE REVIEW

The IoT empowers data assembling, transmitting, and storing be accessible for devices in numerous situations, which makes or quickens several applications, for example, mechanical control frameworks, retailing industry, social insurance, nourishment and hotel industry, strategic industry, travel and tourism industry, library applications, and so on. It can likewise anticipate that the IoT would significantly add to address the essential issues for example: plan of action, medical services checking frameworks, day by day living checking, and traffic control.

Implementaion of Some Key Technologies of IoT

A. Radio Frequency Identification (RFID)

The MF RC522 is a highly integrated transmission module for contactless communication at 13.56 MHz, it supports ISO 14443A/MIF ARE mode, this transmission module utilizes an outstanding modulation and demodulation concept completely integrated for different kinds of contactless communication methods and protocols at 13.56 MHz. This RF reader uses SPI to communicate with microcontroller such as Arduino. MF RC522 support MIFARE series of high-speed non-contact communication, two- way data transimission rate up to 424kbit/s. Low-voltage, low-cost, small size of the non-contact card chip to read and write [7].The RFID Module accepts only the fed Card or Tag Number. Here fig.1 shows the RFID is not accepting the Tag

which number is not mentioned in the programming code data base. Now in fig.2 The RFID has accepted the Card.

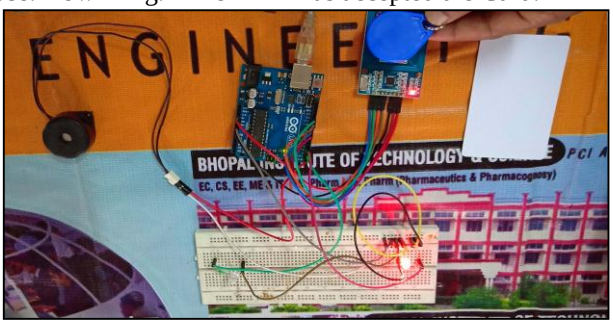

Fig. 1: RFID not accepted Card

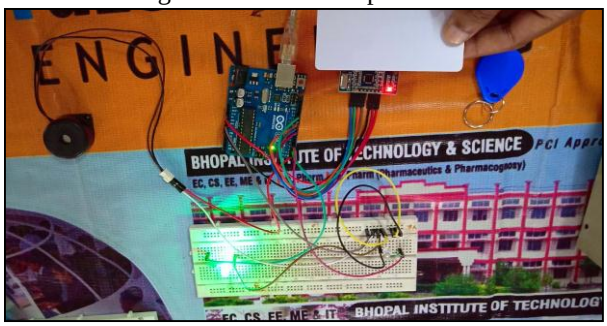

Fig. 2: RFID accepted Card

B. Bluetooth HC-05

Bluetooth is a low-power wireless communication which was designed and developed by Bluetooth Special Interest Group. Compared with conventional Bluetooth, BLE uses less power.

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature). It has the footprint as small as 12.7mmx27mm. Hope it will simplify your overall design/development cycle [7]. We have successfully implemented the Bluetooth HC-05 module in the Automation Systems with Arduino UNO in which fig.3 shows the operation of Bluetooth based Automation System. Also fig.4 shows the entire breadboard setup of the project.

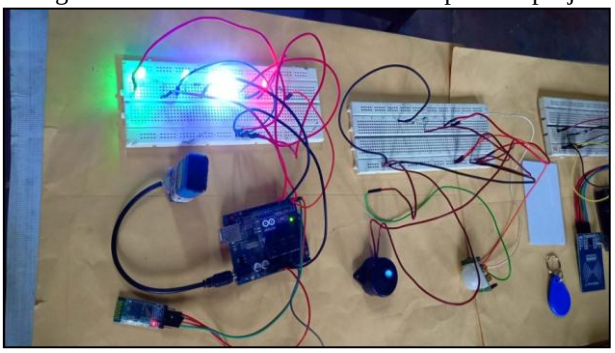

Fig. 3: Bluetooth HC-05 Operating at Breadboard

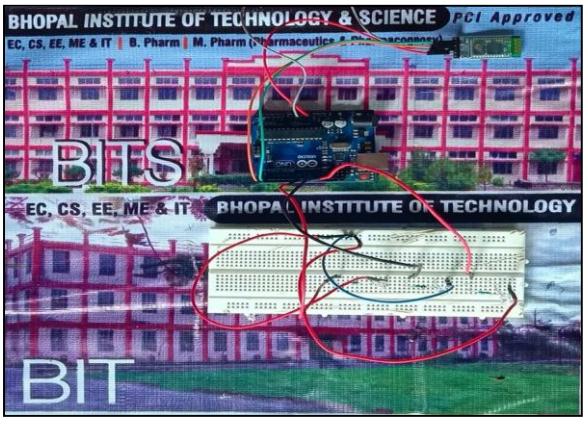

Fig. 4: Bluetooth HC-05 Breadboard Setup

C. GSM SIM900

The connection in this system is established by GSM module. This GSM module directly receive/ transmit commands from/to PC/Laptop with the help of Arduino UNO. GSM/GPRS Modem-RS232 is built with Dual Band GSM/GPRS engine- SIM900A, works on frequencies 900/ 1800 MHz. The Modem is coming with RS232 interface, which allows you connect PC as well as microcontroller with RS232 Chip(MAX232). The baud rate is configurable from 9600-115200 through AT command. The GSM/GPRS Modem is having internal TCP/IP stack to enable you to connect with internet via GPRS. It is suitable for SMS, Voice as well as DATA transfer application in M2M interface. The onboard Regulated Power supply allows you to connect wide range unregulated power supply . Using this modem, you can make audio calls, SMS, Read SMS, attend the incoming calls and internet act through simple AT commands.

Now you can proceed with sending the commands to the modem using any serial communication program like Hyperterminal, minicom etc. Ensure the serial parameters are configured to 8N1 and the baudrate is set to 9600bps.For each command you send the modem acknowledges with a message. Example: Just try sending "AT" to the modem. It sends back a result code "OK" which states that the modem is responding. If it's not working fine, it sends "ERROR".

Unlike mobile phones, a GSM modem doesn't have a keypad and display to interact with. It just accepts certain commands through a serial interface and acknowledges for those. These commands are called as AT commands. There are a list of AT commands to instruct the modem to perform its functions. Every command starts with "AT". That's why they are called as AT commands. AT stands for attention. In this project, the program waits for the mobile number to be entered through the keyboard. When a ten digit mobile number is provided, the program instructs the modem to send the text message using a sequence of AT commands [7].Here in our project fig.5&6 shows the setup of the GSM SIM900 with Arduino UNO.

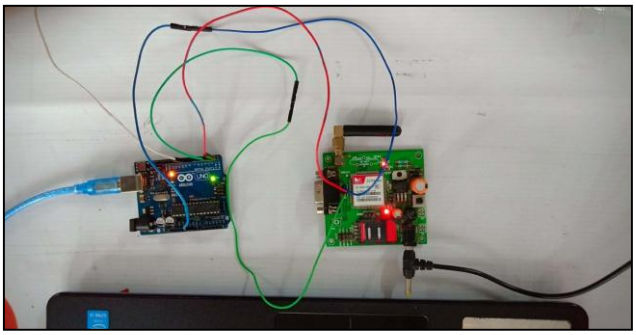

Fig. 5: GSM-Arduino UNO based Automation

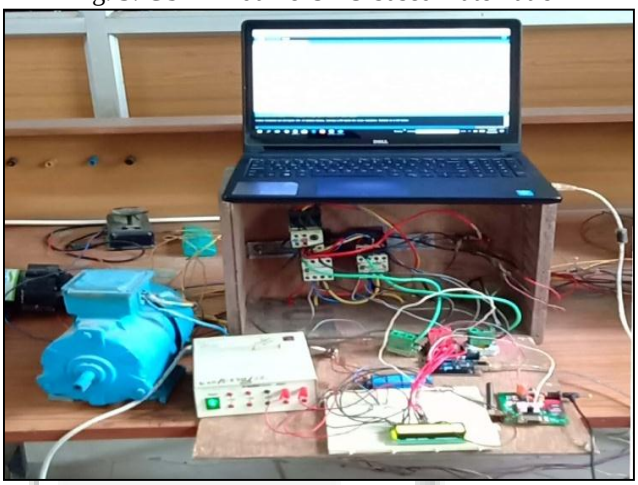

Fig. 6: Poly phase I.M.working with GSM Module

D. ESP8266

The ESP8266 is the most useful Wifi module module which gives the better connectivity of the devices by virtue of which Automation becomes more relevant. ESP8266 is very highly integrated SoC which encapsulates Trans-silica LX106 core processor, RAM, RF components and allow WiFi TCP/IP stack to be implemented on board with just few components beside ESP8266. The chipset also incorporates built-in self-calibration to compensate for performance errors, improving the modulation accuracy and stability of wireless communications. High integration level of this chipset tremendously decreases the number of components used in peripheral circuit design. Beside ESP8266 only a number of less than 10 resistors and capacitors, one crystal oscillator, and one SPI Flash is needed to make a complete module with wireless communication capability. A detailed description of ESP8266 schematics and layout design are illustrated here.Major fields of ESP8266 applications to Internet-of-Things include: Home Appliances , Home Automation , Smart Plug and lights Mesh Network , Industrial Wireless Control , Baby Monitors , IP Cameras , Sensor Networks , Wearable Electronics Wi-Fi Location-aware Devices , Security ID Tags Wi-Fi Position System Beacons .The NodeMCU combined with the ESP2866 was used as the main processing unit that collects the data from the sensors, processes it and then uploads it to the EmonCMS cloud server. The NodeMCU can also read data and commands from the same server and control switching devices. This constitutes a complete smart monitoring and automation system that is based on the IoT technology [7].

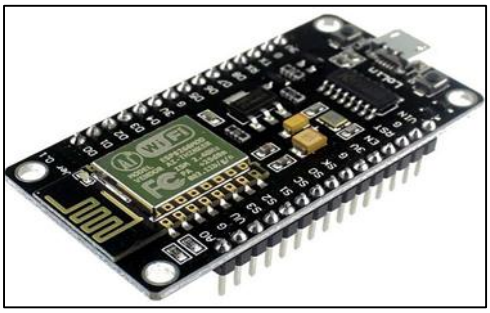

Fig. 7: ESP8266 (NodeMCU) Module

E. X-Bee

X-Bee is an alternative communication technology that offers short range, low transmission rate, and less expensive alternative for IoT system implementation. It is based on IEEE 802.15.4 protocol and works in physical and MAC layer of a network. X-bee operates on the unlicensed ISM bands. The estimated data rates are 250 kbps per channel in the 2.4 GHz band, 40 kbps per channel in the 915 MHz band and 20 kbps per channel in the 868 MHz band. Another appealing aspect is its low power consumption. Transmission limits of X-Bee range from 10 meters to 100 meters and therefore the principal relevance of X-Bee is over a personal area network. Its services may include wireless switches, medical device data collection, in-home displays, and much more milar domains. Its application ranges from home automation to traffic management systems. The IoT application areas where low data transmission rate is acceptable, but long battery life is a basic requirement, are the best suitable areas to use X-Bee as communication technology [1].In this project of Automation , we have operated the farming motors nearby our farm house which gives the greater ease in farming. fig.8 shows the signal transmitter of the X-Bee based Automation.

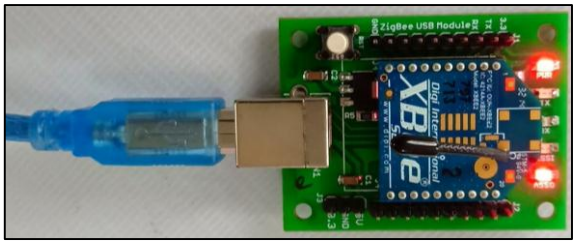

Fig. 8: X-Bee based Automation System

Successful Implementation of some Sensors

Sensors can be considered as the "sense organs" of the material world, and provide the raw information for information processing, transmitting, analyzing and feedback, including heat, power, light, electricity, sound and signals. Sensors can be divided into various types in terms of materials, output signal types, and manufacturing technologies, etc. Recently, nanotechnology has been utilized to provide high performance sensitive material and new sensor production methods, such as Micro Electro Mechanical Systems (MEMS) technology which greatly extends the application field of sensors and promotes the development of sensor industry [12].

A sensor forms an essential interface for the IoT implementation and therefore referred as the front end of the IoT environment. Sensor data collection acts as a stimulating event to perform any of the task offered by any IoT

implementation. In an IoT environment, every sensor has to write or generate, and implement a quite complex and heavy program code for appropriate and accurate data collection. Sensors may vary according to the application area. Many sensors and their interfaces are dedicated to some particular applications, while others are adaptable for different domains. With the increasing moment towards IoT is catching the attention of academicians, researchers and manufacturers towards Sensors, especially multi-sensory acquisition devices [9,10]. It is necessary to test IoT sensor performance at near-threshold or sub-threshold voltage levels to account for process variations and non-linear transistor characteristics. However, the sub-threshold voltage level tests may result in the sensor operation overshooting the process corners. One way to prevent this overshooting is by "over-designing" the IoT sensor with a very conservative design sign-off criteria. Alternatively, higher levels of manufacturing tests must be performed on the IoT sensor that would further increase the cost [11].

However, they are classified on the basis of data size, sampling rate, the number of connected devices, types of signals associated with the sensor. The sensors related to IoT are also identified as a PIR sensor, Temperature sensor, Gas sensor, LDR sensor, Ultrasonic Sensor, Pressure sensor , Touch sensor Accelerometer , Gyroscope etc. We have successfully implemented some of the IoT sensors which is mentioned below.

1) PIR Sensor

It is an associate electronic detector that is employed for motion detection. Human body generates a infrared heat which is picked up by the motion sensor and outputs a 5V signal for a period of one minute to the Arduino UNO through DIGITAL pins and the alarm triggers and message need to be displayed[8]. Arduino UNO based PIR sensor seup is shown in the fig.9

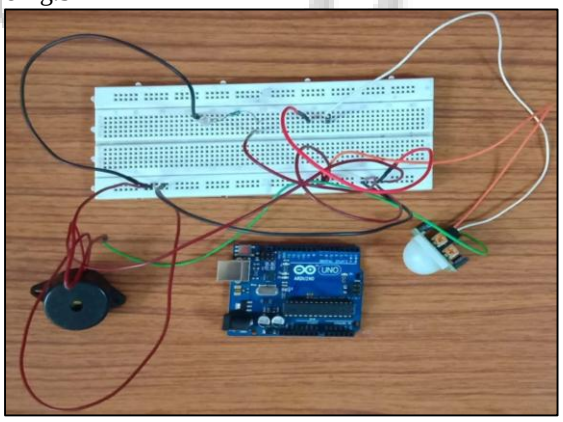

Fig. 9: PIR-Arduino based Automation Setup

2) Temperature Sensor (LM35)

LM35 may be an exactitude precision IC temperature sensor with its electrical output proportional to the temperature (in °C). All of that's work into the little package with 3 leads. One of the lead named as V_{cc} isconnected to power supply and another lead GND is connected to ground and one more lead V_{out} is connected to the DIGITAL pin of Arduino UNO which feds the temperature sensor output[8].

3) Gas Sensor (MQ-5)

The Grove-Gas detector (MQ5) module is beneficial for gas run detection. It's appropriate for sleuthing H2, LPG, CH4, CO, Alcohol, Smoke or fuel.Gas detector 3 pins which are connected to the power supply facility provide by the predefined pin and information pin is connected to Arduino UNO that feds digital information[8].

4) LDR (Light Dependant Resistor)

A photo resistor or Light Dependent Resistor or CdS (Cadmium Sulphide) Cell is a resistor whose resistance decreases with increasing incident light intensity. LDR is interfaced to Arduino UNO through DIGITAL pin to read the light data value[8].We have successfully implemented the lightning system by the help of LDR Sensor which provides the better operating mechanism.

5) Ultrasonic Sensor

Ultrasonic sensors use sound to determine the distance between the sensor and the closest object in its path. How do ultrasonic sensors do this? Ultrasonic sensors are essentially sound sensors, but they operate at a frequency above human hearing. Here in our project of Aotomation based on Arduino UNO is successfully implemented and the setup of project is shown in fig.10. The sensor sends out a sound wave at a specific frequency. It then listens for that specific sound wave to bounce off of an object and come back. The sensor keeps track of the time between sending the sound wave and the sound wave returning. If you know how fast something is going and how long it is traveling you can find the distance traveled with equation.

Equation $d = v \times t$

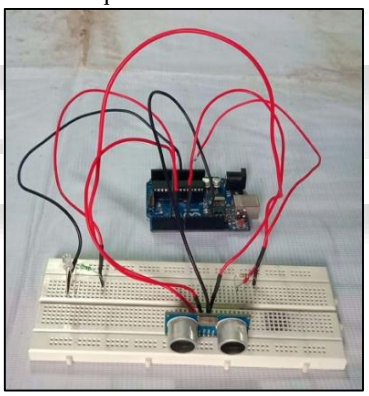

Fig. 10: Ultrasonic Sonic Sensor with Arduino

F. Temperature & Humidity Sensor

DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor. Complex with a calibrated digital signal output. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high-performance 8-bit microcontroller, off ering excellent quality, fast response, anti-interference ability and cost-eff ectiveness [7].

IR (Infrared Sensor)

The IR Sensor-Single is a general purpose proximity sensor. Here we use it for collision detection. The module consist of a IR emitter and IR receiver pair. The high precision IR receiver always detects a IR signal. The module consists of 358 comparator IC. The output of sensor is high whenever it IR frequency and low otherwise. The on- board LED

indicator helps user to check status of the sensor without using any additional hardware. The power consumption of this model is low. It gives a digital output.The output of IR receiver goes low when it receives IR signal. Hence the output pin is normally low because, though the IR LED is continuously transmitting, due to no obstacle, nothing is reflected back to the IR receiver. The indication LED is off. When an obstacle is encountered, the output of IR receiver goes low, IR signal is reflected from the obstacle surface. This drives the output of the comparator low. This output is connected to the cathode of the LED, which then turns ON [7]. The IR sensor is one of the most important sensors available till now. We have used this sensor to build the Counter. The IR sensor module is shown in fig.11.

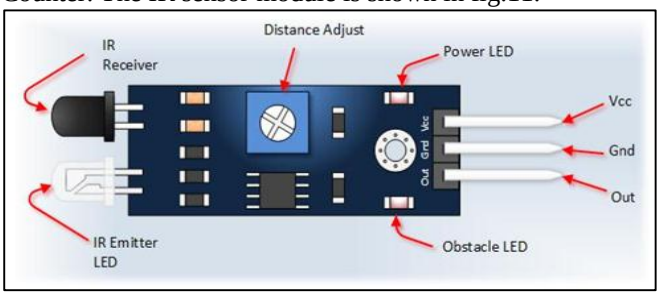

Fig. 11: IR Sensor based Counting System

III. Result & Future Scope

The main objective of doing this project is to disseminate and share knowledge of Automation among Engineering scholars and working professionals. The scope of the project is to use cut above the rest technology of IoT for Automation to full fil the educational objective and therefore in this paper we have successfully implemented some of the IoT technologies and operated them by interfacing devices using Programming codes. Our paper would help to understand the paradigm of Internet of Things and motivate them to further identify the appealing field for future perspectives. Finally, the work is concluded on applicability and in exploring open issues concerning the field of Internet of Things.

IV. Conclusion

As we all know about a wide range of platforms, enabling technologies, associated research projects, and immense extent of application domains of IoT. It is quite obvious to accept the inclination of the world towards the implementation of IoT in every field. It is also evident that the paradigm of IoT will make its own way into the marketplace over the coming years.

Hence IoT and its efficient implementation require a direct attention towards research. Moreover, the world looks forward to an ample amount of investment to be made in research and development towards the solutions and technologies supporting IoT. These solutions are definitely intended to make our life a "smart" life and therefore our world a "smarter" world. This paper mainly elaborates the IoT, its components, its correlation with other paradigms, enabling technologies, platforms, some solutions given by distinguished researchers. This paper, therefore, provides a comprehensive reference source for the researchers involved in the field of Internet of Things.

References

[1] Priya Matta, Bhaskar Pant, Minit Arora " All You Want To Know About Internet of Things (IoT) " ISBN: 978-1-5090-1666-2/16/$31.00 ©2017 IEEE
[2] Rouse, M. and Wigmore, I. (2018). "What is Internet of Things (IoT)? "[Online] IoT Agenda. Available at: https://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT
[3] B. Gokay, "The 2008 World Economic Crisis: Global Shifts and Faultlines," Global Research, February 2009, http://www.globalresearch.ca/the-2008-world-economic-crisis-global-shifts-and-faultlines/12283
[4] "Paris Agreement", PARIS2015 UN Climate Change Conference COP21 CMP11, December 2015, http://ec.europa.eu/clima/policies/international/negotiations/paris/index_ en.htm
[5] R. Bigliani, J-F. Segalotto and G. Gallotti, "Shaping a New Battleground in the IoT Era: Highlights from the 2016 IDC Pan–European Utilities Executive Summit," IDC Energy Insights, June 2016, https://www.ericsson.com/res/narratives/docs/industries/iot-utilities-era-new-battleground-idc-summit-report-2016.pdf
[6] S. Jankowski, J. Covello, H. Bellini, J. Ritchie, and D. Costa, "The Internet of Things: Making sense of the next mega-trend", Goldman Sachs IoT Primer Report, September 2014, http://www.goldmansachs.com/our-thinking/outlook/internet-of-things/iot-report.pdf
[7] Open Internet source using Google Chrome
[8] Dr. M. L. Ravi Chandra , B. Varun Kumar , B.Suresh Babu " IoT Enabled Home With Smart Secuirity " International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS-2017), 978-1-5386-1887-5/17/$31.00 ©2017 IEEE
[9] Z. Pang et al., "Ecosystem analysis in the design of open platform-based in-home healthcare terminals towards the internet-of-things," in Proc. IEEE 15th Int. Conf. Adv. Commun. Technol.(ICACT), 2013,pp. 529– 534.
[10] L. Benini,"Designing next-generation smart sensor hubs for the Internet-of-Things," in Proc. 5th IEEE Int. Workshop Adv. Sensors Interfaces (IWASI), 2013, p. 113
[11] Ed Korczynski, "IoT demands: Are we ready?", Solid State Technology, June 2016, pp. 19-23
[12] Qinghai Ou, Yan Zhen, Xiangzhen Li, Yiying Zhang, Lingkang Zeng " Application of Internet of Things in Smart Grid Power Transmission" 2012 Third FTRA International Conference on Mobile, Ubiquitous, and Intelligent Computing. 978-0-7695-4727-5/12 $26.00 © 2012 IEEE DOI 10.1109/MUSIC.2012.2

