

Environmental Monitoring Using Wireless Sensor Networks(WSN) based on IOT.

Aarti Rao Jaladi¹, Karishma Khithani², Pankaja Pawar³, Kiran Malvi⁴, Gauri Sahoo⁵

¹ Student, Dept. of Electronics, Vivekanand Education Society's Institute of Technology, Affiliated to University of Mumbai, India.

² Student, Dept. of Electronics, Vivekanand Education Society's Institute of Technology, Affiliated to University of Mumbai, India.

³ Student, Dept. of Electronics, Vivekanand Education Society's Institute of Technology, Affiliated to University of Mumbai, India.

⁴ Student, Dept. of Electronics, Vivekanand Education Society's Institute of Technology, Affiliated to University of Mumbai, India.

⁵ Assistant Professor, Dept. of Electronics, Vivekanand Education Society's Institute of Technology, Mumbai, India.

Abstract - In recent years, we have seen a new era of short range wireless technologies like Wi-Fi, Bluetooth [7], ZigBee [6], emerging in front of us. The project aims at building a system which can be used on universally at any scale to monitor the parameters in each environment. Raspberry-pi and sensors collect all the real-time data from environment and this real-time data is fetched by the web server and display it. User can access this data from anywhere through Internet. Raspberry Pi works as a base station which connects the number of distributed sensor nodes via zigbee protocol. Wireless Sensor Networks (WSN) has been employed to collect data about physical phenomenon in various applications such as habitat monitoring. The Internet of Things (IoT) can be described as connecting everyday objects like smart-phones, Internet TVs, sensors and actuators to the Internet where the devices are intelligently linked together enabling new forms of communication between things and people, and between things themselves. In wireless sensor network system, the sensor node sense the data from the sensor and that data collects the end tags, end tags send its data to the router and router to coordinator and supply multi-clients services including data display, the whole data will be stored in base station and the stored data will send to the cloud (Ethernet) and the client can visit the base station remotely via (website) Ethernet. Such a sensor are temperature, vibration, pressure, moisture, light, and pollution.

Key Words: (Raspberry pi; Zigbee; Sensor node; Sensors)

1.INTRODUCTION

The development in wireless sensor networks can be used in monitoring and controlling various parameters in the agriculture field, weather station field. The sensor network hardware platforms are basically low-power embedded systems with some different sensors such as onboard sensors and analog I/O ports to connect sensors. Like hardware, software should also be developed, including OS, sensor/hardware drivers, networking protocols and application-specific sensing and processing algorithms. The purpose or objective of environmental monitoring is different in different situations, but important aims to environmental monitoring to find risks to human and wildlife, scope to population migration from high density areas to low density areas and to restrict emission of gases. Wireless sensor network (WSN) [1] is a low cost, low power wireless network made up of thousands of smart sensor nodes which monitor physical or environmental conditions, such as temperature, pressure, moisture, etc. at different area or different location. The Internet of Things (IoT) is an emerging key technology for future industries, and environmental monitoring. The Internet of Things (IoT) can be described as connecting everyday objects like smart-phones, Internet TVs, sensors and actuators to the Internet where the devices are intelligently linked together enabling new forms of communication between things and people, and between things themselves. Building IoT has advanced significantly in the last couple of years since it has added a new dimension to the world of information and communication technologies.

2.INTERNET of THINGS (IOT)

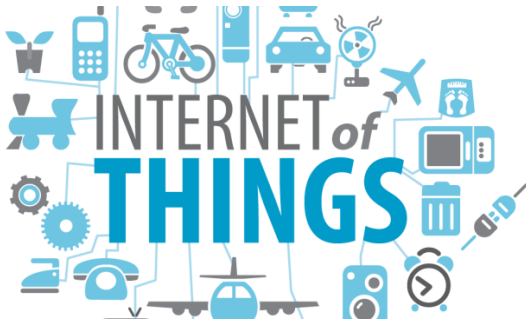


Fig-2: IOT

The Internet of things (stylized Internet of Things or IoT) is the internetworking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings, and other items—embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. In 2013 the Global Standards Initiative on Internet of Things (IoT-GSI) defined the IoT as "the infrastructure of the information society. "The IoT allows objects to be sensed and/or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. Typically, IoT is expected to offer advanced connectivity of devices, systems, and services that goes beyond machine-to-machine (M2M) communications and covers a variety of protocols, domains, and applications. the vision of the Internet of things has evolved due to a convergence of multiple technologies, including ubiquitous wireless communication, real-time analytics, machine learning, commodity sensors, and embedded systems.

3.WIRELESS SENSOR NODE (WSN)

The figure 4 shows design of sensor node. The main components of a sensor node are a microcontroller, transceiver, external memory, power source and one or more sensors. The controller performs tasks, processes data

and controls the functionality of other components in the sensor node.

Node Architecture (Components of Node)

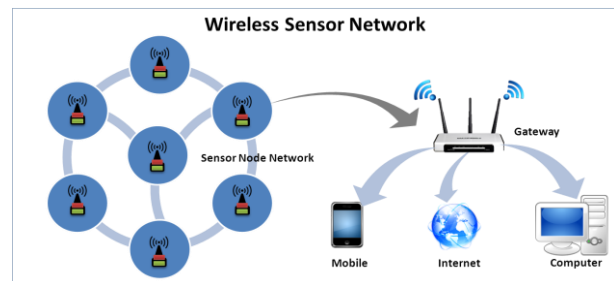
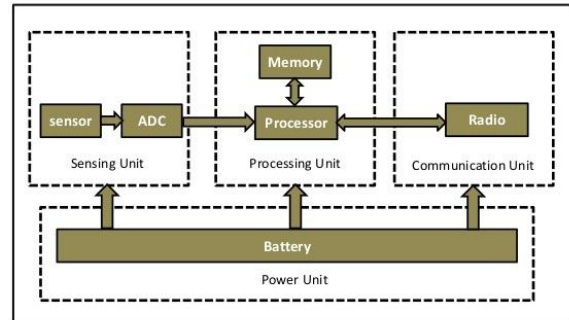


Fig-3: Architecture of WSN

While the most common controller is a microcontroller, other alternatives that can be used as a controller are: a general-purpose desktop microprocessor, digital signal processors, FPGAs and ASICs. A microcontroller is often used in many embedded systems such as sensor nodes because of its low cost, flexibility to connect to other devices, ease of programming, and low power consumption. Transceiver Sensor nodes often make use of ISM band, which gives free radio, spectrum allocation and global availability. The possible choices of wireless transmission media are radio frequency (RF), optical communication (laser) and infrared. Radio frequency-based communication is the most relevant that fits most of the WSN applications. WSNs tend to use license-free communication frequencies: 173, 433, 868, and 915 MHz; and 2.4 GHz. The functionality of both transmitter and receiver are combined into a single device known as a transceiver. From an energy perspective, the most relevant kinds of memory are the on-chip memory of a microcontroller and Flash memory—off-chip RAM is rarely, if ever, used. Flash memories are used due to their cost and storage capacity. Memory requirements are very much application dependent. A wireless sensor node is a popular solution when it is difficult or impossible to run a mains supply to the sensor node. A wireless sensor node is a popular solution when it is difficult or impossible to run a mains supply to the sensor node. However, since the wireless sensor node is often placed in a hard-to-reach location, changing the battery regularly can be costly and

inconvenient. An important aspect in the development of a wireless sensor node is ensuring that there is always adequate energy available to power the system. The sensor node consumes power for sensing, communicating and data processing. More energy is required for data communication than any other process.

4.OVERALL ARCHITECTURE

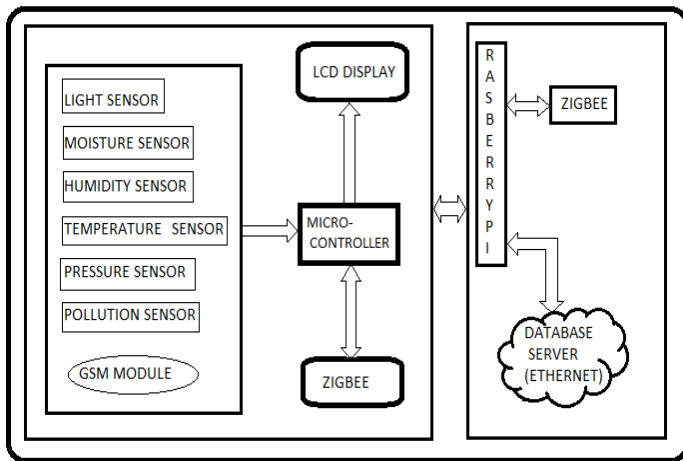


Fig-4: The overall system architecture

The figure 4 shows the overall system architecture of environmental monitoring wireless sensor network system [3]. Sensor node is a major part in this system it is responsible for information or sensor data. Raspberry pi manages multiple sensor nodes. Design and Implementation of Environment monitoring system using Raspberry-Pi which contains interfacing with various sensors (temperature, Humidity, CO₂, Vibration). Real time data will be collected by all the sensors and will be fetched by the Webserver. the gateway node of wireless sensor network, that is raspberry pi (base station) consist of database server and web server in one single-board computer hardware platform, it reduces the cost and complexity of deployment. Sensor node sense the data from the sensor and that data receives the end tag, end tag search the nearest router if router in its range it immediately sends the data to the router, next router to coordinator, here coordinator is directly communicating with the base station. Base station sends all data to the cloud or Ethernet (Database server). The WSN is built using a coordinator node and several sensor nodes, a workstation and a database.

4.1 Raspberry PI

The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. The raspberry pi is the cheapest ARM11 powered Linux operating system single board computer board. This board runs an ARM11

microcontroller @1GHz and comes with a 1GB of RAM memory [16,17], as this model has better specifications as compared to other raspberry pi models such as raspberry pi B and B+ model [4]. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. It's capable of doing everything you'd expect a desktop computer to do, from browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games. It supports 32GB external SD or micro SD card, the device consists a 4USB ports.



Fig-4.1: Raspberry Pi

2.2 Arduino

The Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila. Arduino Mega, etc. I used Arduino Uno in this development. Arduino is based on ATmega328. The package contains a 16 MHz ceramic resonator, a USB connection, a power jack and ICSP header and a reset button. Instead of using the FTDI USB-to-serial driver chip our Arduino features the Atmega16U2 chip programmed as a USB-to-serial converter.



Fig-4.2: Arduino Mega

4.3 XBee Module

Zigbee is a high-level communication protocols used to create wireless networks. Transmission distances to 10–100 meters depending on power output and environmental characteristics, ZigBee devices can transmit data over long distances by passing data through a mesh network topology. The Zigbee transmission data rate is 250 Kbit/s [6]. Zigbee is an established set of specifications for wireless personal area networking (WPAN), i.e. digital radio connections between computers and related devices. For the wireless communication between sensor nodes and the gateway node ZigBee RF modules were used. All the ZigBee devices are based on ZigBee standard which has adopted IEEE 802.15.4 for its physical layer and MAC protocols. The wireless devices based on this standard operate in 868 MHz, 915 MHz and 2.4 GHz frequency bands having a maximum data rate 250Kbps. ZigBee protocol layers are based on OSI model. When the pan is to use ZigBee, it is necessary to mention IEEE 802.15.4 standard. One of the finest characteristics about this standard is it allows user to use PHY and MAC layer defined by IEEE 802.15.4 and lets user to define the upper layers of the OSI model. Similarly, ZigBee also use the MAC and PHY layer of IEEE 802.15.14 standard.



Fig-4.3.1: XBee Module

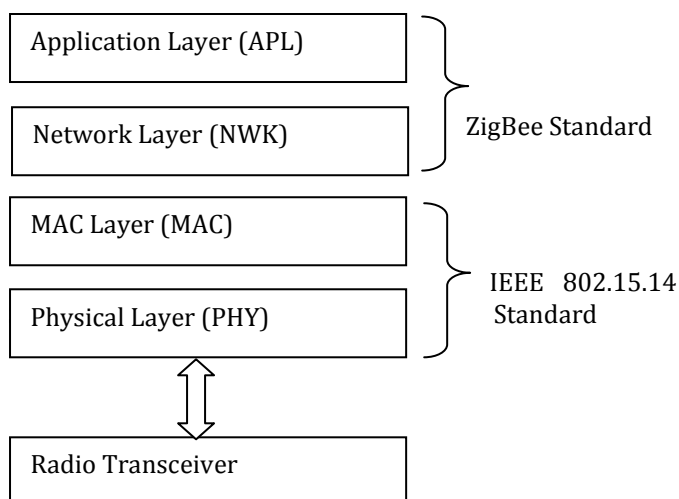


Fig-4.3.2: ZigBee Protocol Stack

5. SENSORS AND Its CHARACTERISTICS

5.1 MQ2 Sensor



Fig-5.1.1: Mq2 arduino gas sensor

Sensitive material of MQ-2 gas sensor is SnO₂, which with lower conductivity in clean air. When the target combustible gas exists, the sensor's conductivity is higher along with the gas concentration rising. MQ-2 gas sensor has high sensitivity to LPG, Propane and Hydrogen, also could be used to Methane and other combustible steam, it is with low cost and suitable for different application.

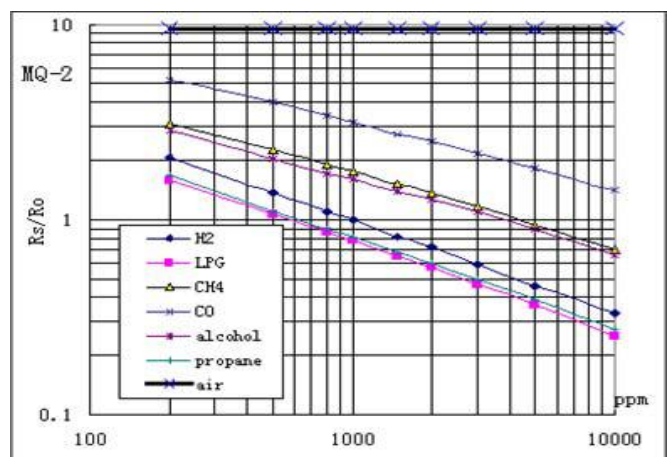


Fig-5.1.2: Sensitivity Characteristics

Fig-5.1.2 shows the typical sensitivity characteristics of Fig.2 shows the typical temperature and humidity the MQ-2, ordinate means resistance ratio of the sensor characteristics. Ordinate means resistance ratio (R_s/R_o), abscissa is concentration of gases. R_s means of the sensor (R_s/R_o), R_s means resistance of sensor resistance in different gases, R_o means resistance of in 1000ppm Butane under different term. and humidity. sensor in 1000ppm Hydrogen. All test is under standard R_o means resistance of the sensor in environment of test conditions.

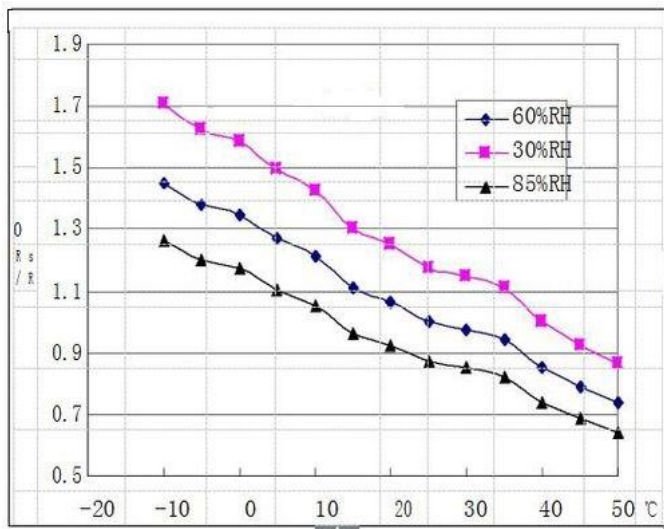


Fig-5.1.3: Influence of Temperature/Humidity

Fig-5.1.1 shows the typical temperature and humidity characteristics. Ordinate means resistance ratio of the sensor (R_s/R_o), R_s means resistance of sensor in 1000ppm Butane under different term. and humidity. R_o means resistance of the sensor in environment of 1000ppm Methane, 20°C/65%RH.

5.2 MQ7 Sensor

MQ-7 gas sensor composed by micro AL₂O₃ ceramic tube, Tin Dioxide (SnO₂) sensitive layer, measuring electrode and heater are fixed into a crust made by plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive components. The enveloped MQ-7 have 6 pin, 4 of them are used to fetch signals, and other 2 are used for providing heating current.



Fig-5.2.1: Mq2 arduino gas sensor

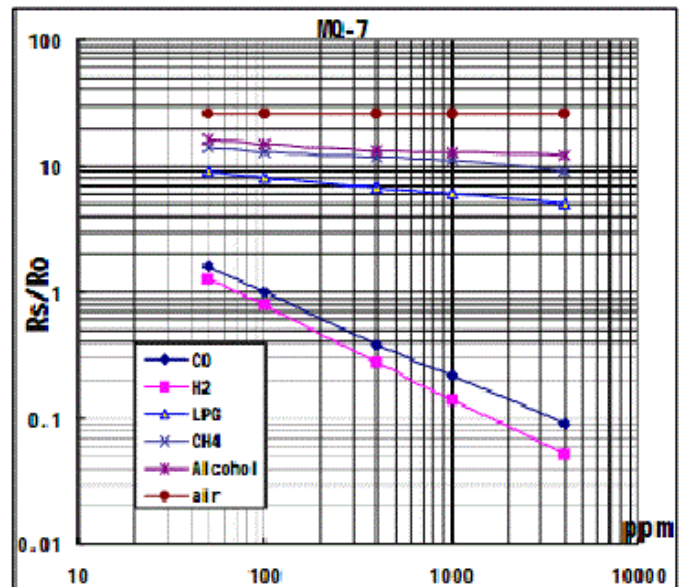


Fig-5.2.2: Sensitivity Characteristics

Fig-5.2.2: is shows the typical sensitivity characteristics of the MQ-7 for several gases. in their: Temp: 20°C Humidity: 65% O₂ concentration 21%, RL=10kΩ, R_o : sensor resistance at 100ppm CO in the clean air. R_s : sensor resistance at various concentrations of gases.

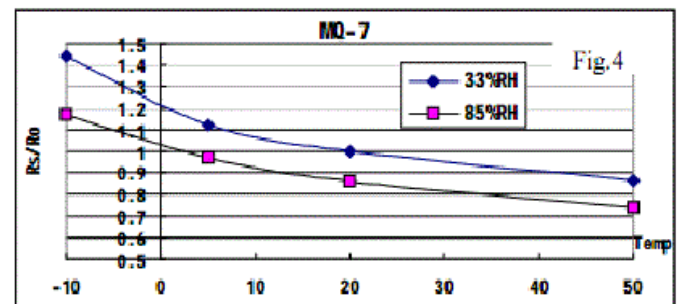


Fig-5.2.3: Mq2 arduino gas sensor

Fig-5.2.3 is shows the typical dependence of the MQ-7 on temperature and humidity. R_o : sensor resistance at 100ppm Co in air at 33%RH and 20degree. R_s : sensor resistance at 100ppm CO at different temperatures and humidities.

6. INTERFACING BETWEEN RASPBERRY PI AND XBEE

XBee module is configured as coordinator on the raspberry pi. Raspberry pi can be connected to XBee module directly through USB cable and by UART serial communication interface [3]. The base station also acts as a gateway in this application. The data collected or detected by sensor node sends to the base station and inserts the data received from sensor nodes into database of raspberry pi. Raspberry pi acts as a base station which connects to sensor nodes by zigbee

communication protocol and clients by external network (internet etc.). Python is a widely used general-purpose, high-level programming language, its syntax allows programmers to express concepts in fewer lines of code than would be possible in languages such as C++ or Java. For wireless communication and multi-hop networking protocol, we used XBee series module S2 from Digi international. Multiple users can access the raspberry pi through Ethernet or Wi-Fi connection within local area network or from anywhere on the internet [11]

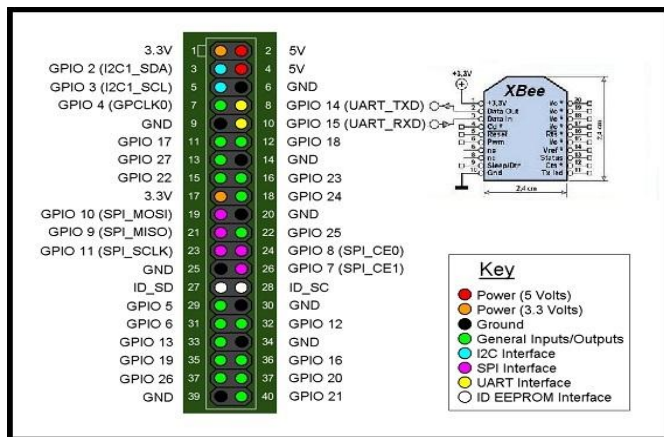


Fig-6: Interfacing between raspberry pi

7. RESULTS

In wireless sensor network, there are three types of devices: coordinator, router and end tags shows in figure 8. Open source data platform for the Internet of Things provides access to a broad range of embedded devices and web services. So, here one XBee is configured as a coordinator, which is connected with the raspberry pi using UART protocol shows in figure 9,10. Here sensor node is configured as router (R1 and R2) and end tag (E52), it will send its real-time data to the nearest router. There is only

one coordinator in the network, which communicates with the base station (raspberry pi).

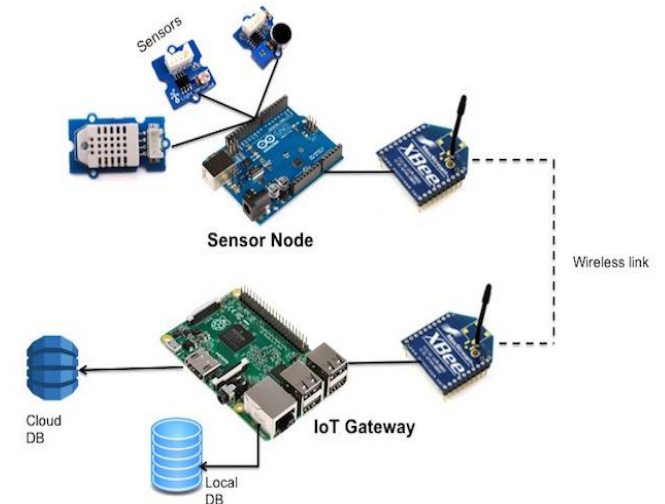


Fig-7.1: Overall system design

Step1: In WSN system the sensor node sense the data from the sensor.

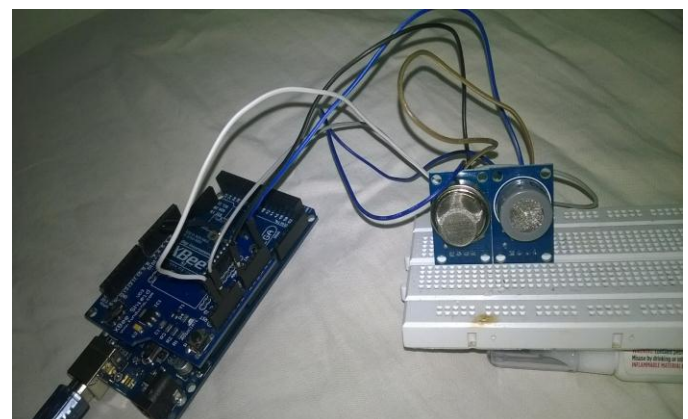


Fig-7.2: Interfacing sensors with arduino

Step2: Sense data receives the end tags and end tag search the nearest router.

Step3: If router it in range than end tag sends the data to the router.

Step4: router to coordinator and coordinator directly communicate with base station.

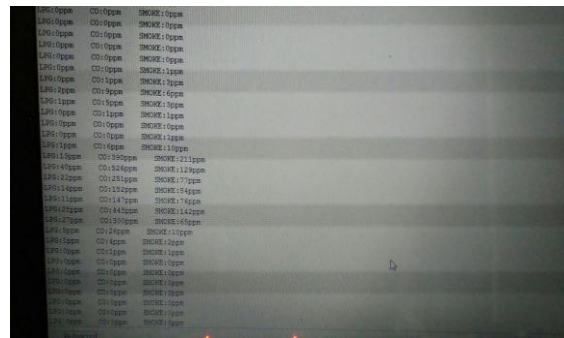


Fig-7.3: XBee is configured with raspberry p
Step5: In base station stored the all data, the client can visit directly to the base station.



Fig-7.4 Raspberry pi connected with UART

Step6: Base station sends all data to the cloud or Ethernet (Database server) shows in figure 11, end Users or clients can interact with the web application within the local area network.

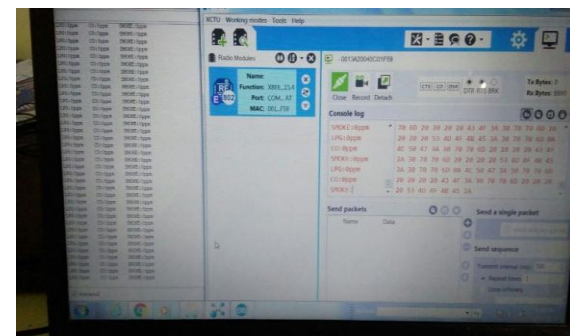


Fig.-7.6: Received output

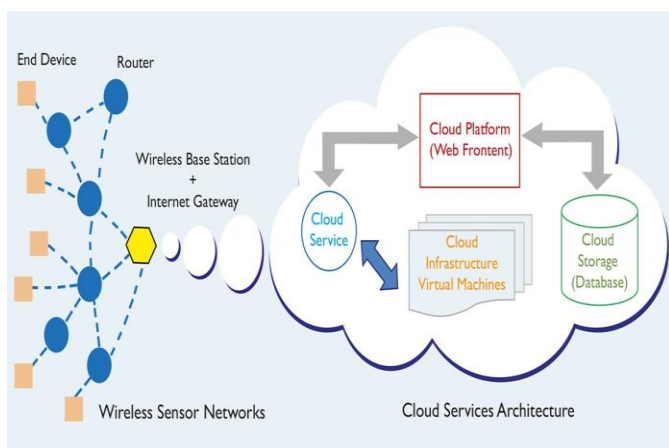


Fig-7.5 WSN integrated with cloud of IOT

Step7: In wireless sensor network, there are three types of devices, each device sending and receiving data display on the screen.

8. CONCLUSIONS

Comparing with collection and forwarding information or data of traditional base station (gateway), this system has low-cost, low power consumption, and easy to maintain. This paper designs a wireless sensor network system using Raspberry Pi as a base station, XBee as a networking protocol, sensor node as combination of sensors, controller and zigbee. Hence, we can create sensor-logging application, location-tracking applications, and a social network of things with status updates, so that you could have your location parameter control itself based on your current location. One major advantage of the system lies in the integration of the gateway node of wireless sensor network, database server, and web server into one single compact, low-power, credit-card-sized computer Raspberry Pi, which can be easily configured to run without monitor, keyboard, and mouse. Such a system is very useful in many environmental monitoring and data collection

REFERENCES

- [1] Kochlan, M.; Hodon, M.; Cechovic, L.; Kapitulik, J.; Jurecka, M., "WSN for traffic monitoring using Raspberry Pi board," Computer Science and Information Systems (FedCSIS), 2014 Federated Conference on, vol., no., pp.1023,1026, 7-10 Sept. 2014 C. Pfister, Getting Started with the Internet of Things. Sebastopol, CA: O'Reilly Media Inc., 2011.

- [2] Nikhade, Sudhir G.; Agashe, A.A., "Wireless sensor network communication terminal based on embedded Linux and Xbee," Circuit, Power and Computing Technologies (ICCPCT), 2014 International Conference on, vol., no., pp.1468, 1473, 20-21 March 2014. Matt Richardson and Shawn Wallace Getting Started with Raspberry Pi, 2011
- [3] Sheikh Ferdoush, Xinrong Li "Wireless Sensor Network System Design using Raspberry Pi and Arduino for Environmental Monitoring Applications", Elsevier The 9th International Conference on Future Networks and Communications (FNC-2014)
- [4] Raspberry Pi, webpage: http://en.wikipedia.org/wiki/Raspberry_Pi [April 20, 2014]
- [5] K Vujovic, V.; Maksimovic, M., "Raspberry Pi as a Wireless Sensor node: Performances and constraints," Information and Communication Technology, Electronics and Microelectronics (MIPRO), 2014 37th International Convention on, vol., no., pp.1013,1018, 26-30 May 2014.
- [6] ZigBee Specification. ZigBee Alliance 2006. <http://www.zigbee.org/>.
- [7] Jin-Shyan Lee, Yu-Wei Su, and Chung-Chou Shen "A Comparative Study of Wireless Protocols: Bluetooth, UWB, ZigBee, and Wi-Fi" The 33rd Annual Conference of the IEEE Industrial Electronics Society (IECON) Nov. 5-8, 2007, Taipei, Taiwan ZigBee Specification. ZigBee Alliance 2006. <http://www.zigbee.org/>.
- [8] Xbee module: [Online] <http://www.digi.com/>
- [9] Andrew N Sloss, Dominic Symes, Cris Wright "ARM system developer's guide designing and optimizing system software" 2004
- [10] Ya-lin Miaoi", Xiang-lin Miao, Zheng-Zhong Bian, Yongjie Zhang Xi'an Jiaotong University, Xi'an 710049, China "Design and application of Embedded System based on ARM7 LPC2148" Proceedings of the 2005 IEEE.
- [11] Srinivasa, R.V, Nageswara, R and Kumari, E.K. (2009). Cloud computing: An overview. Journal of Theoretical and Applied Information Technology, 9(1), 71-76.
- [12]] J. Yang, C. Zhang, X. Li, Y. Huang, S. Fu, M.F. Acevedo. "Integration of wireless sensor networks in environmental monitoring cyber infrastructure", Wireless Networks, Springer/ACM, Volume 16, Issue 4, pp. 1091- 1108, May 2010
- [13] Jin-Shyan Lee, Yu-Wei Su, and Chung-Chou Shen "A Comparative Study of Wireless Protocols: Bluetooth, UWB, ZigBee, and Wi-Fi" The 33rd Annual Conference of the IEEE Industrial Electronics Society (IECON) Nov. 5-8, 2007, Taipei, Taiwan
- [14] Xiaohui Cheng; Fanfan Shen, "Design of the wireless sensor network communication terminal based on embedded Linux," Software Engineering and Service Science (ICSESS), 2011 IEEE 2nd International Conference on, vol., no., pp.598, 601, 15-17 July 2011
- [15] www.nxp.com/documents/data_sheets/LPC2148.pdf
- [16]] J. Yang, C. Zhang, X. Li, Y. Huang, S. Fu, M.F. Acevedo. "Integration of wireless sensor networks in environmental monitoring cyber infrastructure", Wireless Networks, Springer/ACM, Volume 16, Issue 4, pp. 1091- 1108, May 2010
- [17]] Matt Richardson and Shawn Wallace Getting Started with Raspberry Pi, 2011
- [18] C. Pfister, Getting Started with the Internet of Things. Sebastopol, CA: O'Reilly Media Inc., 2011.