On-line Monitoring of Green House gases Storage and Leakage Using Wireless Sensor Network

Mallakalva Aneelkumar Reddy[1], Prof.V.Natarajan[2]

[1] PG scholar, Embedded System Technology, SRM University, Tamilnadu, India
[2] Professor, ECE department, SRM University, Tamilnadu, India

---

Abstract - *Nowadays air pollution is increasing rapidly due to Human activities. These activities have* ***altered the chemical composition of the earth's*** *atmosphere through the buildup of greenhouse gases – primarily carbon dioxide, methane, and carbon monoxide. To avoid such effects an efficient green house gases monitoring system is necessary. In this paper, an on-line green house gases monitoring system based on wireless sensor network is implemented using X-bee Digi modules and open source hardware platform Arduino. This system consists of three nodes. Each node is equipped with Arduino micro controller and x-bee zig-bee seris2 mesh net module and a battery source. Sensors are interfaced to each node which senses the data and then the collected information is sent to the central monitoring unit which acts as a sink node, which is always attached to personal computer to update the data .Data are continuously transmitted from zig-bee sensor nodes to zig-bee coordinator node. Co-ordination is present between sensor nodes and base station for monitoring and detection of leakage. This system can be used anywhere in the atmosphere and especially useful in industries and some places such as CO_2 Capture and Storage (CCS) region. At the sink node arduino Ethernet shield is interfaced. Web-server is created using Ethernet shield which is used to make the entire system on-line. The sensed data can be accessible to user anywhere in the world using World Wide Web.*

Key Words: Arduino, X-bee, Wireless sensor network, sensors, Arduino Ethernet Shield, Web-server, On-line monitoring

1. INTRODUCTION

A greenhouse gas is any gaseous compound in the atmosphere that is capable of absorbing infrared radiation, thereby trapping and holding heat in the atmosphere. By increasing the heat in the atmosphere, greenhouse gases are responsible for the greenhouse effect, which ultimately leads to global warming. Many of the world's largest cities today have bad air quality. To avoid such effects an efficient green house gases monitoring system is necessary. Wireless sensor networks (WSN) have been deployed for green house gases monitoring. The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a micro-controller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery. We implemented the proposed green house gases monitoring system in different phases. The phases are sensors interfacing, Zig-bee network formation, web server creation, services on Internet.

2. SYSTEM OVERVIEW

The below figure shows the overall implementation of proposed system

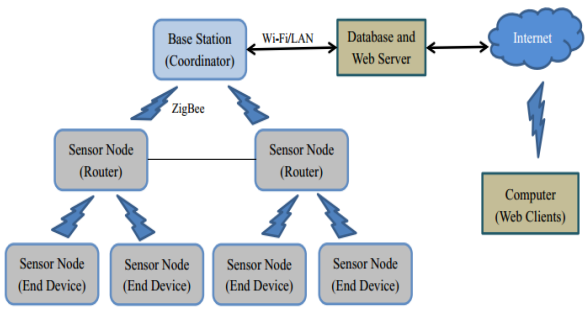

Fig-1: Block diagram of the entire system

The system consists of zig-bee coordinator, router and end device. Coordinators are the most capable of the three node types. There is exactly one coordinator in each network and it is the device that establishes the network originally. It is able to store information about the network, including security keys. Routers act as intermediate nodes, relaying data from other devices. End Device can be low-power / battery-powered devices. They have sufficient functionality to talk to their parents (either the coordinator or a router) and cannot relay data from

other devices. The data collected by the coordinator is updated into the web-page available on web server. This web-page can be accessed globally over the Internet.

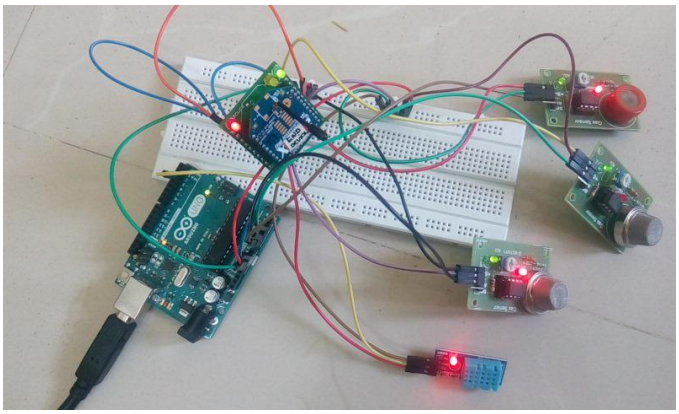

Fig-2: End Device node interfaced with gas sensors

3. SYSTEM IMPLEMENTATION

3.1 HARDWARE COMPONENTS USED

3.1.1 ARDUINO UNO R3 MICRO CONTROLLER

Arduino can be used to develop stand-alone interactive objects or can be connected to software on your computer (ex., Flash, Processing, MaxMSP).Arduino is an open-source physical computing platform based on a simple i/o board and a development environment that implements the Processing/Wiring language.

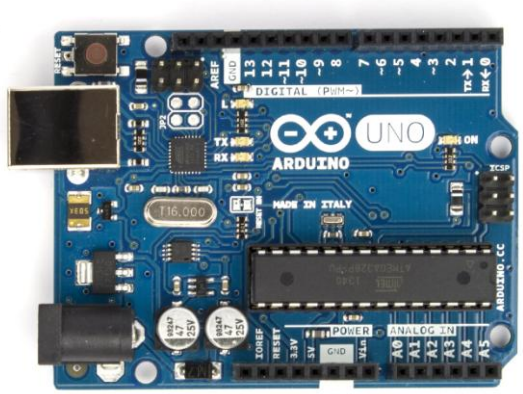

Fig-3: Arduino UNOR3 microcontroller board

The Arduino Uno Rev3 is a micro-controller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, 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 micro-controller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

3.1.2 X-bee Transceiver

The (XB24-Z7WIT-004) modules are part of the XBee ZB family which provides Zig-Bee level interoperability with Zig-Bee devices from other vendors. Zig-Bee is a protocol that uses the 802.15.4 standard as a baseline and adds additional routing and networking functionality. What Zig-Bee is designed to do is add mesh networking to the underlying 802.15.4 radio. It has various features like Wire antenna, Cross-compatibility with other ZB modules ,Low-power sleep modes,133 feet (40 m) indoor/urban range and 400 ft (120 m) outdoor line-of-sight range, Configured with API or AT commands, local or over the air,10 digital I/O and (4) 10-bit ADC inputs.

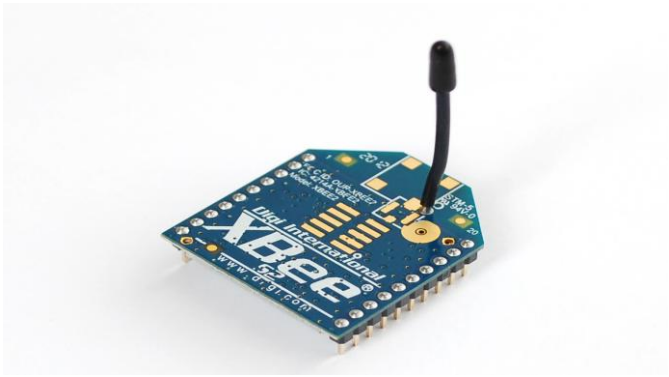

Fig-4: X-Bee Zig-bee family radio module by Digi INC

3.1.3 Wiznet W5100 Ethernet Shield

The Arduino Ethernet Shield allows an Arduino board to connect to the Internet. It is based on the Wiznet W5100 Ethernet chip. The Wiznet W5100 provides a network (IP)

Fig-5: Arduino compatible Wiznet W5100 Ethernet module

Stack capable of both TCP and UDP. It supports up to four simultaneous socket connections. Use the Ethernet library to write sketches which connect to the Internet. using the

shield. The Ethernet shield connects to an Arduino board using long wire-wrap headers which extend through the shield. This keeps the pin layout intact and allows another shield to be stacked on top. The Ethernet Shield has a standard RJ-45 connection, with an integrated line transformer and Power over Ethernet enabled. There is an on-board micro-SD card slot, which can be used to store files for serving over the network. It is compatible with the Arduino Uno and Mega (using the Ethernet library). The on-board micro-SD card reader is accessible through the SD Library.

4. SOFTWARE IMPLEMENTATION

4.1 SENSORS INTERFACING

The air quality sensors MQ-135, MQ-7, MQ-4, and DHT-11 temperature and humidity sensor are interfaced to the one of the node of arduino UNO R3 which acts as an end device. The code for sensors interfacing with arduino is written in embedded C using arduino IDE.

4.2 ZIGBEE NETWORK FORMATION

Zig-Bee defines three different device types: coordinator, router, and end devices

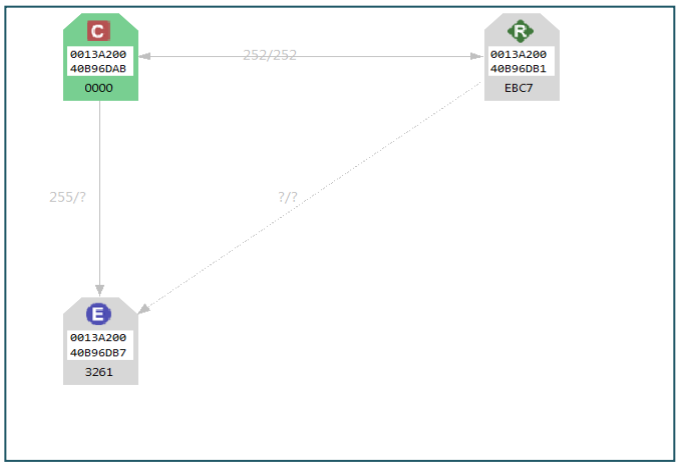

Fig-6: X-Bee modules GUI output after network formation

Xbee can be used for wireless communication with low power consumption. A 3.6V 600mA Lithium battery may last 6 - 12 months for powering up an Xbee while the wireless range can up to 1 mile. It talks with well known UART interface and makes it easy to use.
Coordinator: Start a new personal area network (PAN) by selecting the channel and PAN ID. Allow routers and end devices to join the PAN, transmit and receive RF data transmission and route the data through the mesh network.
Router: Transmit and receive RF data transmission, and route data packet through the network.
End Device: Cannot assist in routing the data transmission but transmit or receive RF data transmission and intended to be battery powered devices.
The X-Bee digi radio modules are configured using software which is made by Digi Corporation Inc. the software is named as X-CTU. First we have to select and load the appropriate function set which suits our application and then we can program the module by altering some parameters such as PANID, destination address low and destination address high, baud rate etc.
For a correct setting of a Zig-Bee Network, the following parameters must be set:

1. ID - PAN ID: must be all the same for each XBee on this network.
2. DL - Destination Address Low
   Coordinator set to FFFF (broadcast mode)
   Router set to 0 (The default Address Low for Coordinator)
3. BD - Baud Rate: must be the same for each XBee on this network.

4.3 WEB SERVER CREATION

Arduino Ethernet shield is used to create web-server. MYSQL is used as Data Base Management System.PHP is used as scripting language for serving dynamic web pages.

4.4 SERVICES ON INTERNET

The coordinator node is attached to personal computer. PC is hosted using Port Forwarding and DynDns features available in home routers. Port forwarding is a method of making a computer on network accessible to computers on the Internet, even the computer is behind a router. DDNS is a service that maps Internet domain names to IP addresses. DDNS serves a similar purpose to DNS: DDNS allows anyone hosting a Web or FTP server to advertise a public name to prospective users. Unlike DNS that only works with static IP addresses, DDNS is designed to also support dynamic IP addresses, such as those assigned by a DHCP server. That makes DDNS a good fit for home networks, which often receive dynamic public IP addresses from their Internet provider that occasionally change.

5. RESULTS

The below image indicates the results obtained after interfacing all the sensors to the end device. The readings are taken at the coordinator node which is always connected to personal computer. Below results are taken from coordinator node's COM port from the terminal software PuTTY.

Fig-7: Gases concentration levels which is received at coordinator node

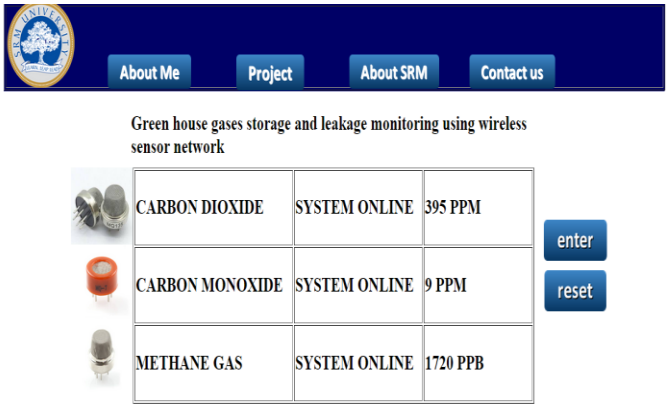

Fig-8: Web-page which displays the Gases concentration levels which are received at the coordinator node

6. CONCLUSION AND FUTURE SCOPE

In this paper, a cost efficient and highly reliable system is implemented using open source hardware platforms and technologies of wireless sensor network. This system detects the leakage and storage concentration of green house gases in real-time and sends those values to the central monitoring unit which always connected to PC. The collected values at the Base station is uploaded to web-page automatically .Hence user can access these values anywhere over the Internet. This system can be used effectively anywhere at the gases storage region and in industries. In the coming years with more advancement of technology in wireless sensor network domain will helps in improve the system with better features and by using best quality sensors the accuracy of the readings can be improved to meet the real-time needs.

REFERENCES

[1] M. Gao, F. Zhang, and J. Tian, "Environmental monitoring system with wireless mesh network based on Embedded System", *in proc. 5th IEEE Int. Symp. Embedded Computing, 2008, pp. 174-179.*

[2] Andrey Somov, Alexander Baranov, Alexey Savkinb, Denis Spirjakin, Andrey Spirjakin, Roberto Passerone" Development of wireless sensor network for combustible gas monitoring" Sensors and Actuators A 171 (2011) 398–405.

[3] A. Kumar, I.P. Singh, S.K. Sud, Indoor environment gas monitoring system based on the digital signal processor, in: Proceedings of the International Multimedia, Signal Processing and Communication Technologies (IMPACT'09), Aligarh, India, March 14–16, 2009, pp. 245–249.

[4] A. Somov, M. Ivanov, A. Baranov, A. Savkin, K. Sithamparanathan, Energy efficient trade-off between communication and sensing in wireless gas sensor node, in: Proceedings of the First International Workshop on Cognitive Radio and Cooperative Strategies for Power Saving, Lisbon, Portugal, September 8, 2010, pp. 1–11.

[5] Peter Reimann, Andreas Dausend, Andreas Schütze "A self- monitoring and self-diagnosis strategy for semiconductor gas sensor systems ".IEEE SENSORS 2008 Conference.

[6] Dipanjan bhattacharjee,Sushaban choudhury, Ajay kumar "Wireless intelligent smart sensor node for hazardous gas monitoring" international journal of Computer Science and Information Technology (IJCSIT), Vol 3, No 1, Pp. 53-57. june 2010.

[7] L.K.Hema, Dr. D. Murugan, M. Chitra "Wireless Sensor Networks' emergence and Growth- A survey" in the International Journal of Computational Engineering Research (IJCER) ISSN:2250-3005.

[8] QinghuaWang, Ilangko Balasingham"Wireless Sensor Networks- An Introduction", Wireless Sensor Networks: Application-Centric Design, Intech publishers.

[9] Xiao Liu , Sitian Cheng , Hong Liu , Sha Hu, Daqiang Zhang and Huansheng Ning "A Survey on Gas Sensing Technology" *sensors* ISSN 1424-8220.

