Zigbee-Based Smart Sewer

N. Dinesh Kumar, Roja Ramanathapuram, Pragnya Rangi, Twinkle Sheoran

Abstract: One of the major problems we see today with regard to urban infrastructure is that of sewers, which are used as a pathway to underground waste management facilities. Sewers are a common sight in busy lanes and streets and pose a paramount threat to human, as well as animal life in case they are left open. This may happen due to various reasons (viz. manhole cover theft, negligence etc.). Several newspaper reports in the past year have indicated how open sewers jeopardized the lives of children who were seen playing in the nearby areas surrounding a manhole and ended up falling into it. In addition to this , it is important to monitor certain gas levels inside a sewer and keep a check on the water levels flowing through it. Our paper aims to curb these problems by bringing out a manageable and cost-effective Smart Sewer using what is today one of the most influential technologies - The Internet of Things. A simple, yet noteworthy answer has been proposed and concepts related to it are explained.

Index Terms: Urban infrastructure, open sewers, smart sewer, Internet of Things.

I. INTRODUCTION

1.1 OVERVIEW OF THE PAPER

We live in a world that is fast-paced and rapidly growing. Waste management facilities through underground networks have become an essential feature of today's infrastructure. However, it is important to check whether these systems are safe and work efficiently. What is the use of endlessly developing our cities if they take a toll on our very lives? Exponential growth in terms of technology has led us to achieve things that were never thought of before. A low-cost WPAN (Wireless Personal Area Network) technology known as the **ZIGBEE (IEEE 802.15.4)** standard is the central element of this work. A Zigbee device known as the **XBEE** is a microcontroller, which also serves as the brain of this research work. We make use of two Xbees , one connected to sensors (viz. Gas sensor - Methane (CH4) , Carbon-monoxide (CO) , water-level sensor , Light Dependent Resistor (LDR sensor) , flow rate sensor) and the other connected to a monitoring node - a computer that takes in the sensor data and analyses it through a web-based monitoring platform called ***Thingspeak***. Thingspeak allows us to connect devices to the internet, thereby implementing the ***Internet of Things (IoT)*** technology. The two xbees serially communicate with each other. The xbee connected to the sensors is called the Router; while the xbee connected to the monitoring node is called the Co-ordinator (A detailed description about the Xbee and its types is given in the subsequent sections.)

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Thingspeak reads the data from the sensors and gives a visual analysis of the derived data. It is open-source and connects devices over the internet. Once we obtain the output from the sensors, they can be easily studied and hence any prevailing abnormalities can be immediately looked into and taken care of. This is a quick solution to manhole woes and also reduces the need for continuous human intervention, which as it sounds, can be tedious and inefficient.

1.2 *STANDARDS* AND TECHNOLOGIES

1.2.1. XBEE - A Zigbee standard

Figure 1: Zigbee-based device (viz. Xbee by Digi)

The Zigbee (Figure 1) standard is an IEEE 802.15.4 WPAN (Wireless Personal Area Network) specification. Zigbee wireless devices operate in 868 MHz, 915 MHz and 2.4 GHz frequency bands. The maximum data rate is 250 K bits per second [1]. Its contemporary technologies include the popular WIFI and Bluetooth, both of which are used to establish a WPAN. However, Zigbee devices have an edge over WIFI and Bluetooth in terms of battery life and cost. Also, Zigbee can operate over a mesh topology, contrary to the star topology of WIFI [1-8].

A Zigbee device m ay be used as a -

1. ***Co-ordinator***- The WPAN has only one co- ordinator. It is the central element that establishes the network and also routes the traffic.
2. ***Router*** - It finds the most optimum route to direct the traffic.
3. ***End point*** - WPAN network can have several end points. They do not control traffic. They are connected to coordinator/router.

It has 2 modes of operation -

1. ***AT (Transparent) mode*** - It is a direct mode of operation. In this mode, information is passed on as it is received. It is generally used for single source transmission.

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2. ***API (Programming Interface) mode*** - In this mode, information is transferred in terms of packets. It is used for robust networks. It is useful for multiple source transmission and remote monitoring of devices.

Both the xbees (coordinator and router) are configured to work in the API mode since it involves remote monitoring of multiple sensors.

1.2.2. Internet of Things (IoT)

The Internet of Things (IoT) is a revolutionary concept that came around in the first decade of the 21st century. In simple terms, it is an expansion of the application of internet to

Figure 2: IOT (Image source: Google)

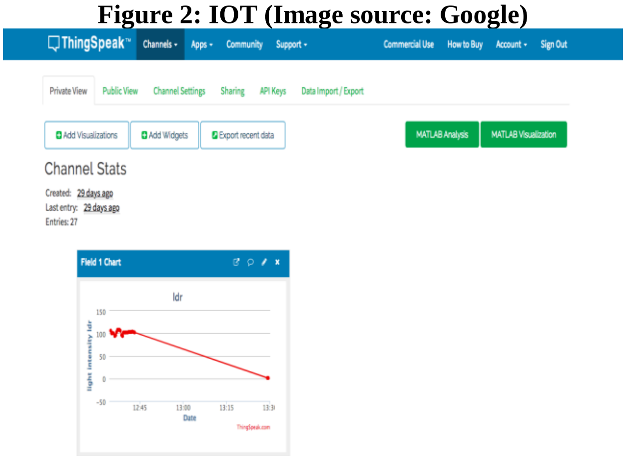

Figure 3: ThingSpeak (Source: www.thingspeak.com)

'things' around us. Nowadays, we find 'smart' devices such as smart air conditioners, smart televisions etc., all of which are based on the IoT. It is an interconnected network of devices, all connected to each other over the internet (Figure 2). The application of IoT is what makes this idea and work 'smart'. *Thingspeak* is a web-based IoT platform to which several sensors are connected to be analyzed (Figure 3).

II. DESIGN

2.1. BLOCK DIAGRAM

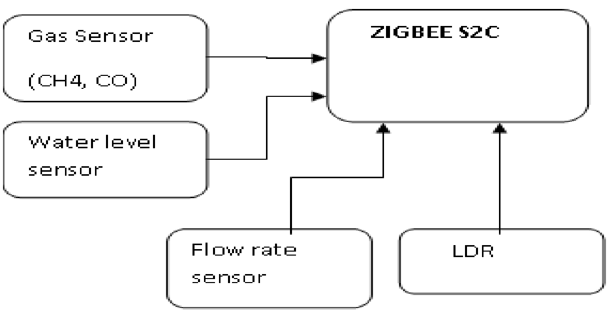

Figure 4 :**TRANSMITTER**

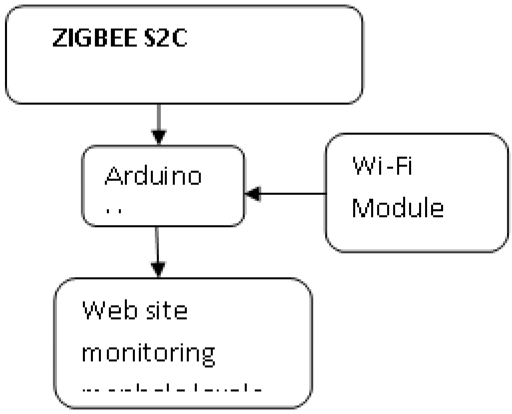

Figure 5: **RECEIVER**

2.2. WORKING

The working model consists of two main parts - The Transmitter and Receiver. The transmitter section (figure 4) consists of a circuit fabricated to fit a manhole. This circuit consists of multiple sensors (viz. LDR (Light dependent resistor), water level sensor, gas sensor and flow rate sensor) connected to the Xbee module (ROUTER).

2.2.1. TRANSMITTER

It consists of the following sensors:

LDR (Light Dependent Resistor) - It is basically a simple optical sensor, whose value changes depending on the amount of light falling on it. In the most common type of LDR sensor, the resistance value is inversely proportional to the intensity of light. When a sewer's lid is absent, it automatically implies an increase in the amount of light falling on this sensor, thereby indicating a steep fall in the resistance values, which is visually shown in the Thingspeak tool. Hence, immediate action can be taken and casualties can be avoided.

Water level sensor - A water level sensor (viz. ***Funduino***) is an analog sensor which is used to check the water levels inside a sewer. The Funduino consists of 3 pins - ground pin, power supply and an analog pin. It is a water-sensitive sensor. This water level sensor is connected to Thingspeak and values are shown graphically. As soon the water levels cross a certain threshold level, there is a steep increase in the output value of the sensor, thereby clearly indicating water overflow.

Gas sensor - MQ-9 is a gas-sensitive sensor that can detect the presence of Carbon Monoxide (CO) and methane (CH4) - both of which are toxic and may be present in sewers. Its output is analog voltage consistent with the concentration of gases. It can detect concentrations between 20 ppm-2000 ppm in case of CO and 500 ppm-10,000 ppm in case of methane [2].

Flow rate sensor - The amount of water that is pushed through system in a given amount of time. It consist of a impeller and a hall-effect sensor. There's a little magnet on impeller the magnet triggers a Hall-effect switch and that causes pulses. It can measure 1 to 30 liters per min. when we count total number of pulses we get time and total number of liters. output of the sensor is digital signal.

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2.2.2 RECEIVER

The receiver section (figure 5) consists of a *coordinator* Xbee that receives the sensor data sent by the *router* Xbee. The two Xbees serially communicate with each other via another microcontroller called ***ARDUINO UNO. (The programming is done using the Arduino IDE).*** Once communication is established between the 2 Xbee modules, the received sensor data is sent to the monitoring tool Thingspeak via a ***WIFI module*** (ESP8266). In this way, data can be easily sent and analyzed for further action.

III. CONFIGURING THE XBEE MODULES

Before any serial communication is established between the two Xbee modules, they must be configured in order to attain their respective functionalities. This configuration is done using software (figure 6) known as **XCTU** by **DIGI** [3] - it can be downloaded from their website. Connect the Xbees to your PC and configure them separately.

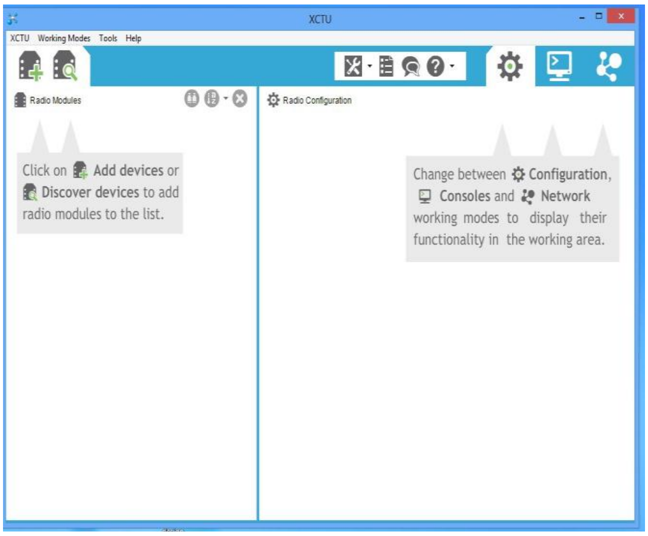

Figure 6: XCTU Software

IV. RESULT

Once we obtain sensor data on the Thingspeak platform, it is easy to analyze and immediate action can be taken by the concerned authority in order to curb the problem of open/overflowing sewers. The following tables summarize the practical values obtained from different sensors under different conditions.

Table-1: LDR sensor

Scenario	Range Value
Fully dark (Closed Sewer)	0-15
Open Sewer (3pm Afternoon)	540-1023

Table-2: Water level sensor (Funduino)

Scenario	Range Value
No Flow	0
Normal Flow	10-300
Above Normal Flow	>500

Table-3: Flow Rate sensor

Flow Rate (Liters/min.)	Output Liquid Quantity (mL)
0	0
1	562
1	662
2	1349
3	2865
4	3729
0*	4258

Table-4: MQ-9 Sensor Reading at Different Heating Time

Heating time (min)	CO Gas reading	
	Ratio RS/R0	PPM Values
O	0.6989	1109
2	0.9872	949
4	1.374	597
5	1.972	209
7	3.156	70

Red mark indicates DANGER

Note* : The flow meter values are cumulative. Therefore , for 0 Liters/min , we get a non-zero value

V. CONCLUSION

A basic Smart Sewer was fabricated in order to bring out a solution in response to the diminishing safety of sewers. In the current scope of this work, 4 sensors are connected to a WPAN module for relaying forward information about the status of a sewer and prompting concerned personnel to take action in case of a disruption with the help of an online monitoring tool that is paired to our sensors using the IoT Technology. However, this plan may be extended such that it incorporates several advanced features.

Several other sensors may be added to fine tune the monitoring process. Furthermore, the Wifi-module can be used to send alert text messages using the IFTTT Applet (https://ifttt.com/discover). A two-way relay can be established and the sewer may be programmed to close itself in case it is open (without any human intervention).

The main motive of this paper is to highlight the utilization of technology in order to encounter everyday problems and thus improve the quality of life. This is just one such example. Judicious utilization of the improvements being made in science and technology can be applied across a plethora of everyday entities. We live in a smart world where everything is technology-driven and this concept revolves around the same idea.

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