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Wireless Gas Monitoring and Alerting System (WGMAS) for Warehouse using Arduino and Raspberry Pi

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Abstract

Objectives: To devise a gas leakage monitoring and alerting systems for LPG warehouse. Methods/Statistical Analysis: One of the prime areas to monitor the leakages is LPG warehouse. A Wireless Gas Monitoring and Alerting System (WGMAS) is proposed for detecting, monitoring and thereby to provide alerts about the emissions and leakage at the target area of interest inside a warehouse.MQ-2 and MQ-5 LPG gas sensors interfaced with the Arduino sensor nodes are used. The Raspberry Pi gateway uses a hypertext transport protocol to send the data to the Xively cloud. **Findings:** The developed WGMAS provides an efficient, periodical monitoring and alerting framework for the plants to prevent the explosion due to the leakage. A mobile relay node is designed for the fault tolerance purpose. **Improvements:** The designed prototype enables the admin of the warehouse to monitor and analyze the status of emission inside the warehouse remotely by utilizing the Io T services and thereby the supervisor of warehouse can have a control over it.

Keywords: Gas warehouse monitoring, IoT, WGMAS, WSN, Xively

1. Introduction

The requisites for monitoring the gas leakages inside the industries, mainly in the gas warehouses are getting increased owing to the problems like explosion due to excessive emissions of harmful gas. The emanations of gases are due to reasons like the cracks in pipes; gaps in welding joints, flange joints, loose fittings[1]. Apart from this the improper maintenance of the warehouse has led to major emanation of gases in the warehouses. The gas leaks in industries are posing major threats in India and so before the end of 2020, India needs to build nearly 32,737 km of gas pipelines across the length and breadth of the country[2] and proper monitoring facility has to be enabled. The major accidents due to gas emissions are reported mainly in steel plants[3] and gas processing plants[4].

The LPG and flammable gases are the most widely used across the country and there are more number of warehouses and refilling centers for the same. On considering the safety aspect for the LPG warehouses an effective monitoring platform needs to be installed. The yesteryear works reported are of using different methods for monitoring of the leakages and emissions. The usage of carbon monoxide (CO) gas sensorsis reported[5] for detection of distinguishes rising levels of CO gas at the coal power plants. The regions regularly checked are coal heap transport burrows, tipper rooms, coal shelters, containers also, storehouses. Usage of WSN for indoor natural gas leakage detection is proposed[6], where the enhancement of the lifetime of the WSN was considered as a prime factor alongside the leakage detection. There are more methods for detecting the gas leakages through monitoring as stated in[7].This method can also be used in underground mine monitoring as in[8]. As in[9] the structure is formed and relay node is replaced with moving relay node. The nodes are randomly placed at different locations and monitoring takes place when the leakage of gas is present at that place. But integration of WSN with

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the internet will produce efficient services for real time monitoring as portrayed in[10].

The principal intention in this work is to detect the emission of gas from the probable areas of leakages and to prevent the explosion by alerting the consumers or the warehouse admin. The detection of leakages is mostly inside a LPG cylinders warehouse or along the pipelines. For this purpose, a sensor network is formed using multiple sensor nodes which are connected to the gateway and the gateway is connected to the internet and thereby makes integration with IoT possible. The authors[11] reports about the integration of cloud services called Xively for power monitoring and control in home automation. Also the usage of smart sensors is discussed in [12]for monitoring the gas emissions in the power industry boilers.

In WSN, it is mandatory to keep up the inter node communication and network connection established at any moment. So a fault tolerant scheme is always required for any effective system. One way of achieving a fault tolerant is by introducing a mobile relay node MRN for collecting the data at time of node failures. For the purpose of overcoming these difficulties, an effective method called WGMAS is proposed for detecting the leakages or emissions in the warehouses from remote & online and thereby alerting the warehouse in-charge. The same work can also be deployed at gas processing & refilling plants and along the pipelines.

In this work Arduino based sensor nodes are used along with MQ5 and MQ2 LPG gas sensors with XBEEs series2 transceiver. The sensor nodes transmit the data to the gateway. The gateway is made up of single board computer called Raspberry Pi. The gateway handles all the other storing of data, publishing the data to the cloud services for online remote monitoring, decision making and alert generating process.

The remaining of the paper is organized into four sections, where sections 2 and 3 hashes out with proposed system architecture and system methodology. The section 4 gives the details about the results of the implementations of the intended work and finally the section 5 concludes the work alongside possible future works.

2. Proposed System Architecture

The proposed system consists of Arduino UNO R3 based end nodes deployed at the area of interest for the leakage data acquisition called as source nodes, a mobile relay node for the redundancy, and monitoring station called gateway. The gateway is made up of miniature low cost single board computer called Raspberry Pi. This gateway also acts as alerting system for the admin who is overlooker for monitoring the godowns. Each node is interfaced with the MQ5 and MQ2 LPG gas sensors with XBEE radio modules, a relay circuit for alerting purpose and powered with battery source. The end nodes are placed in different sub areas of same location where leakages will occur. In the intended method prototype three end nodes are located at the areas of interest inside the LPG cylinder warehouse.

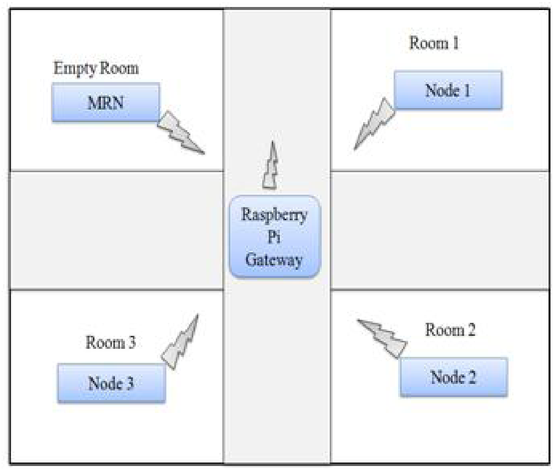


Figure 1. Proposed system architecture – warehouses.

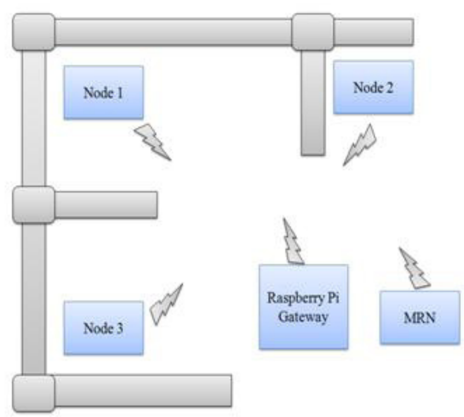


Figure 2. Proposed system architecture – pipelines.

However, the same can be applied for the detection at the pipelines as shown in Figures 1 and 2. The concentrations of emission of gases are estimated through the respective node and the data packets are passed on to the gateway node via XBEE. The gateway node publishes the processed data to the open source cloud services called xively. In both cases the fault tolerance is achieved by the MRN where it increases the communication range and also act as backup when the end nodes are in failed state. MRN is directed manually to the area of the failure node and takeovers the job of the failed node.

3. System Methodology

In a gas plant, the gas sensors are placed alongside the joints and valves of the pipelines. Inside the warehouses containing gas cylinders the sensor nodes are placed in the similar fashioni.e., deployed at multiple places or locations of interestas showed in figure1 and figure2. In this proposed system the sensor nodes are placed along the joints and flanges of pipelines for detecting the gas leakages inside the plant and at the rooms inside the warehouse. The concentration of gases is measured in terms of parts per million (PPM). With the evolution of open source cloud services for IoT integration, the job of online and remote monitoring becomes easy. Usage cloud services also reduces the burden of the gateway nodes by running analytics and GUI based application online for monitoring. Hence the power and resource consumption of gatgeway node is also reduced significantly. For this purpose, a single board computer called Raspberry Pi is configured as gateway node. The data acquired at end nodes are sent to the Raspberry Pi gateway through zigbee communication protocol. The gateway node runs on OS called as Raspbian which is a Debian based Linux. A database is created for storing the sensor data from different nodes deployed. The gateway node is associated with XBEE S2 module for receiving the data from the end nodes and also has facility to connect to the internet via Ethernet port so that it can be accessed securely from any remote place. All the decision making process are carried out at the gateway node.

After the processing of data from different nodes from the environment, the data are published to the Xively cloud for online monitoring. Before publishing the data, the required access to the Xively cloud services are obtained. The Xively provides a real time graphical representation of the sensor node values. An application is written and made to run periodically on the gateway node for detecting and alerting the plant or the warehouse overlooker. And thus continuous monitoring of the warehouse and gas plant is made possible. The alerts are in the form of buzzer sounds and to minimize or to prevent the harm that can be caused due to over emission inside the warehouses, a relay circuit is triggered, so that the operation of exhaust fans connected to it are automated. Whenever the emission level is higher than the threshold, the relay is turned on by the sensor node and at the same time any control command can be issued through the gateway based on the situation. A periodical health checking is made by the gateway node and whichever nodes fail the check will be identified and the corresponding report is shown to the admin. This makes the task of admin easier to direct the MRN node to the corresponding area. The MRN is made up of a PIC microcontroller and has a complete set of sensor node deployed at the location. This MRN can be directed to the location of failure by giving commands to it.

4. Results and Discussion

The designed prototype is deployed and tested inside the lab condition with three end nodes and one gateway node and the results obtained are displayed in the at the raspberry pi gateway. Figure 3 shows about the Arduino based end node implementation with Raspberry Pi based gateway node.

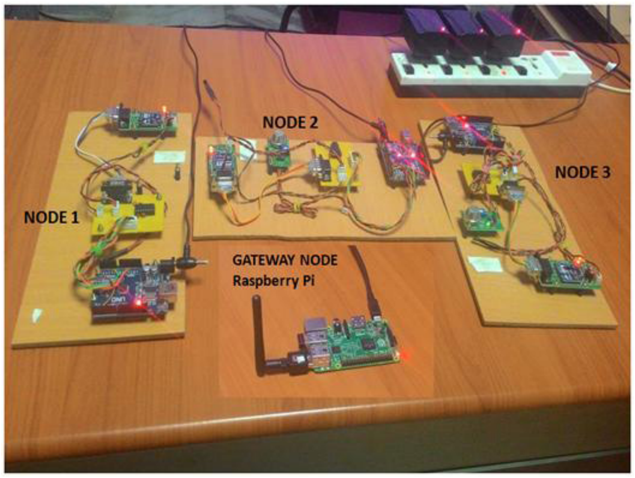
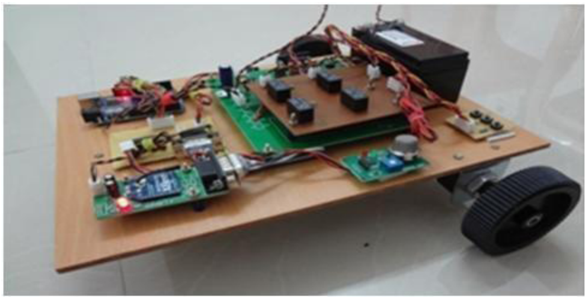


Figure 3. Three end nodes with gateway node.

Figure 4 shows the MRN setup for fault tolerance. Also the Figure 5 shows the database entries of the node data. Figure 6 shows the Xively dashboard for gas warehouse monitoring and figure 7shows the graphical representation of sensor values from each node and the location for online remote monitoring of the gas warehouse through Xively cloud services which makes the admin works easy.



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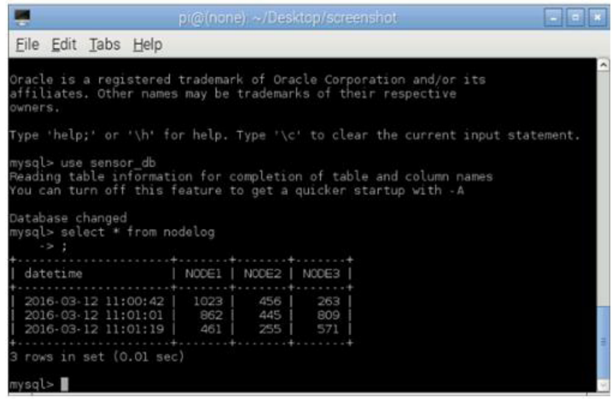

Figure 5. Database entries of sensor node data – last three timestamps.

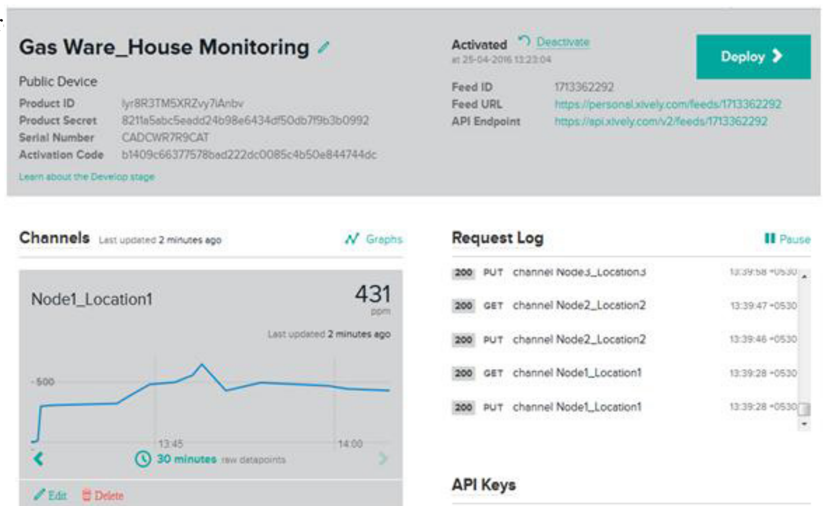

Figure 6. Xively dashboard..

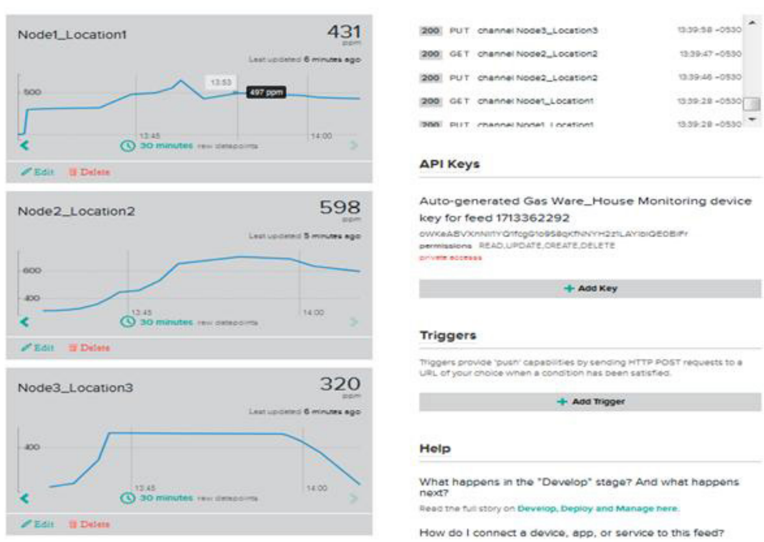

Figure 7. Graphical representation of data at Xively.

5. Conclusion

The over emission of the gases may be possible due to the leakages. This emission may sometimes lead to the explosions when not monitored and stopped immediately. The proposed method WGMAS will be helpful in detecting and alerting about the leakages and thereby preventing or reducing these kinds of explosions. The proposed method also has a strategy to inform the admin regarding the fault of the node and to activate the MRN. And thus the main agenda of ensuring the safety can satisfy by deploying the prototype model along with the add-ons that satisfies future requirements. The same prototype can be enhanced in future with effective decision making algorithms based on the criticality of the application and scalable for tomorrow.

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7. References

1. Toxic gas detectors[Internet]. [cited 2013 Apr 27]. Available from: http://abhisam.com/downloads/white-papers/how-toxic-gas-detectors-work/.
2. Industrial gas leaks threats in India[Internet]. [cited 2013 Apr 27]. Available from:http://www.rediff.com/news/column/rashme=sehgal-be-warned-industrial-gas-leaks-pose-a-major-threat-in-india/20140718.htm.
3. Steel plant leakages [Internet]. [cited 2013 Apr 27]. Available from:http://timesofindia.indiatimes.com/city/hyderabad/Gas-leakage-kills-two-engineers-at-Vizag-Steel-Plant/articleshow/36686565.cms.
4. Methane leakage in gas processing plants [Internet]. [cited 2013 Apr 27]. Available from:http://thinkprogress.org/climate/2015/08/18/3692660/methane-leaks-in-processing/.
5. Power Plant Gas leakage detection applications[Internet]. [cited 2013 Apr 27]. Available from:http://www.avensys-solutions.com/data_AS/File/Solutions/Sensidyne/Applications%20Notes/Power_Plant_Gas_Detection_Applications.pdf.
6. Brunelli D, Rossi M. Enhancing lifetime of WSN for natural gas leakages detection. Microelectronics Journal. 2014; 45:1665–70.
7. Bhuiyan MAS.A computational model of thermal monitoring at a leakage in pipelines. International Journal of Heat and Mass Transfer. 2016; 92:330–8.
8. Ali MM.Development of underground mine monitoring and communication system integrated ZigBee and GIS. International Journal of Mining Science and Technology. 2015; 25:811–18.
9. Somov A.Developmentofwirelesssensornetworkforcombustiblegasmonitoring, SensorsandActuatorsA. 2011; 171:398–405.
10. SomovA.Deploymentandevaluationofawirelesssensornetworkformethane leakdetection. SensorsandActuatorsA. 2012; 202:17–225.
11. Sindhujaand P, Balamurugan MS. Smart power monitoring and control system through Internet of things using Cloud Data Storage. Indian Journal of Science and Technology. 2015Aug; 8(19):1–6.
12. Sujatha K, Bhavani NPG, Godhavari T, Cao RSPS.Smart Sensor for NOx and SO2 Emissions in Power Station Boilers (SSEPSB). Indian Journal of Science and Technology. 2015 Oct; 8(27):1–10.