# Implementation of WBTA for Detection of Hazardous Gas Leakage Source Localization using WSN

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***Abstract:*** This paper presents a method of Weighted Back Tracing Algorithm for localization of the Gas leakage source based on weighted back tracing algorithm (WBTA) adopted using star topology Wireless Sensor Network. The relative signal strength of gas concentration tested by modeling means of exhaust gas, from a diesel operated vehicle, exposed to TGS 2201 gas sensors. The sensor data was transmitted to the PC monitor in order to detect gas concentration in PPM calibration. The results were collected to calculate error in gas leakage source location experimentally for various positions. The error has been estimated by actual position of the gas leakage source and calculated and negligible.

***Keywords:*** **Error analysis, Source localization, Weighted Back Tracing Algorithm, TGS-2201 WSN, Zigbee.**

## I. INTRODUCTION

Wireless sensor networks are nowadays widely used. Many sensor nodes are to be deployed for variety of applications. But these sensed data is meaningless without proper knowledge of position where the data was sensed. Localization should be needed for less complexity, secure and accurate network. Localization to construct an improved algorithm for in-network detection of faulty readings [1]. Location information in addition to report incidents, but it also can be used for target tracking, the target trajectory prediction, to assist the routing and network topology management. Therefore, node localization problem has become a primary solution to the problem of wireless sensor network. Wireless sensor network, according to the location of the actual measurement of the distance between nodes, the positioning mechanism is divided into: range-based localization (range-based) and distance (range-free) positioning method [2].The reliable detection and localization of gas leaks is essential for ensuring safety and minimizing property damage [3].Over a large surface area, manual localization of such gas sources and remote monitoring of gas effusion rate would be highly Cumbersome and ineffectual. The three-step source localization strategy uses maximum likelihood (ML) estimation technique, simulation and limited directive mobility applied to the subset sensor nodes [4]. Passive source localization in wireless sensor networks (WSNs) is an important field of research with numerous applications in signal processing and wireless communications. The sensitivity of source location estimation accuracy with respect to the a priori sensor position information, the source location estimates obtained can vary significantly regardless of the localization method used. Therefore, the sensor position uncertainty should be considered to obtain accurate estimates [5]. Location technology is becoming more and more important in wireless sensor networks. The weighted centroid localization offers a fast and simple algorithm for the location equipment in wireless sensor networks. Wireless sensor nodes self-localization is a system determining its own position through estimating the distance between it to neighbor nodes and the number of neighbor nodes and utilizing the information exchange between nodes [6]. If the users cannot obtain the accurate location information, the related applications cannot be accomplished. The main idea in most localization methods is that some deployed nodes (landmarks) with known coordinates (e.g., GPS-equipped nodes) transmit beacons with their coordinates in order to help other nodes localize themselves.

In general, the main localization algorithms are classified into two categories: range-based and range-free [7]. In WSN, the location of nodes is significant to the detection. Location information also supports many fundamental network services, including network routing, topology control, coverage, boundary detection, and clustering [8]. Sensor data must be registered to its physical location to permit deployment of energy- efficient routing schemes, source localization algorithms, and distributed compression techniques. Devices estimate the distance to multiple known-location devices, using either a direct measurement, or if none exists, an estimate based on the shortest path to the known-location devices [9]. The presented work is localization of gas leakage source using received signal strength method based on weighted forward as well as back tracing algorithm using wireless sensor network. In this algorithm received signal strength with the positions of sensor nodes in order to find out the position of gas leakage source in a XY- plane Co-ordinate system as discussed in section II.

## II. METHODOLOGY

The following section presents methodology and geometrical deployment of gas sensing node and position of the gas source to be estimated with reference to 2D co-ordinates. This set up contains an arrangement of sensor node that are enclosed inside the developed chamber. Figure 1 show sensor nodes deployed coordinates and dashed line represent the distance between the source and sensor nodes with respect to XY coordinate system having set origin at (0,0).

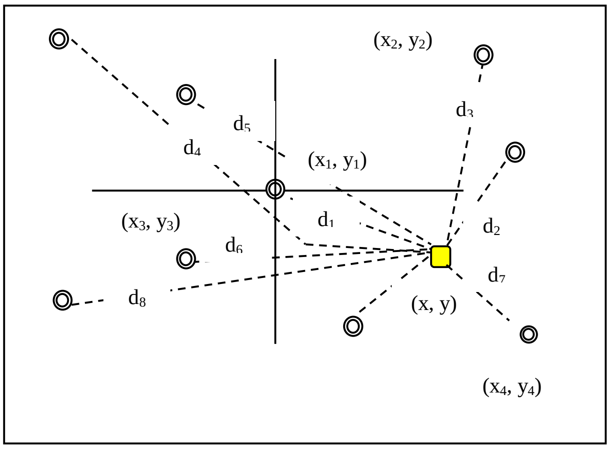


**Figure: 1 Sensor nodes and Source arrangement**

Wireless sensor network is configured and established for monitoring diesel exhaust gas leakage detection and monitoring based on star topology. We measure the distances between the nodes from the source position. The gas leakage signal sensed is fed as transmitting data for signal strength which needs to be measured. However, any error occurred thereby is then calculated between actual location and imaginary location of gas source. This was a simulation coded program written and tested using Turbo C. Figure 2 presents block diagram of configured wireless sensor network using Zigbee 802.15 and Figure 3 show a base station to transmit and receive the necessary signal serial data communication.

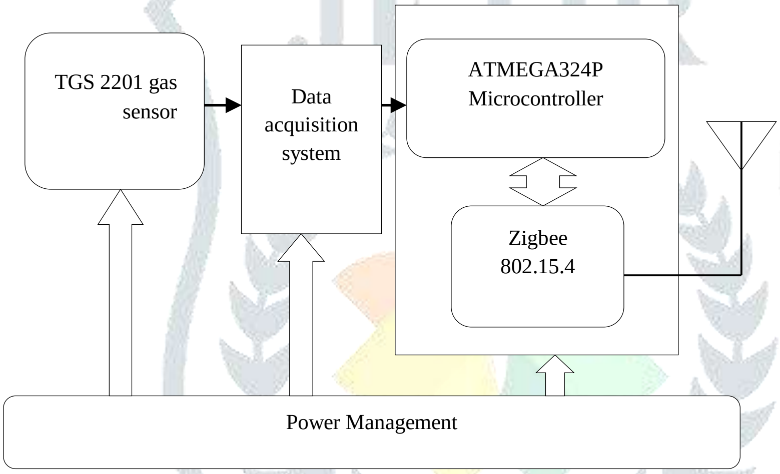


**Figure 2: Block Diagram of Wireless Sensor Node**

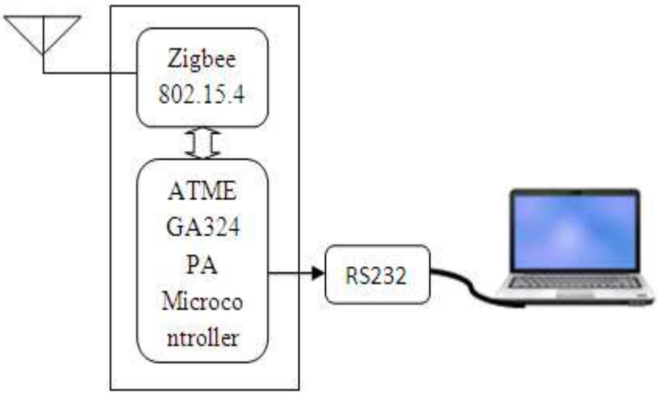


**Figure 3: Block diagram of Base Station.**

The block diagram consists of wireless sensor node TGS 2201 sensor for Diesel exhaust gas detection. It was then interfaced with ATMEGA324PA Microcontrollers followed by the PC monitor with IEEE standard 802.15.4 Zigbee module.

## III. WEIGHTED BACK TRACING ALGORITHM (WBTA)

1. Mark the position of nodes and fixed the inter nodes distances.
2. Setup the source position from the nodes using the following equations:

$$((x-x_1)^2)+((y-y_2)^2)={d_1}^2$$
$$((x-x_2)^2)+((y-y_2)^2)={d_2}^2$$
$$((x-x_3)^2)+((y-y_3)^2)={d_3}^2$$
$$((x-x_4)^2)+((y-y_4)^2)={d_4}^2$$

3. Deploy the sensor nodes as per the marked the position.
4. Monitor the received signal strength using wireless sensor network.
5. Estimate the source position using weighted backtracing algorithm.
6. Simulate the Location of the y. From y we get the x position of the gas source by using the following complex equations.

$$\mathbf{y}=\left\{\frac{\left[\left(\left(\left(\frac{2\times s_3\times x_3}{(s_3-s_1)}\right)-\left(\frac{2\times s_2\times x_2}{(s_2-s_1)}\right)\right)\times\left(\left(\frac{s_2\times({x_2}^2+{y_2}^2)}{(s_2-s_1)}\right)-\left(\frac{s_4\times({x_4}^2+{y_4}^2)}{(s_4-s_1)}\right)\right)\right)-\left(\left(\left(\frac{2\times s_4\times x_4}{(s_4-s_1)}\right)-\left(\frac{2\times s_2\times x_2}{(s_2-s_1)}\right)\right)\times\left(\left(\frac{s_2\times({x_2}^2+{y_2}^2)}{(s_2-s_1)}\right)-\left(\frac{s_4\times({x_4}^2+{y_4}^2)}{(s_4-s_1)}\right)\right)\right)\right]}{\left[\left(\left(\left(\left(\frac{2\times s_4\times x_4}{(s_4-s_1)}\right)-\left(\frac{2\times s_2\times x_2}{(s_2-s_1)}\right)\right)\times\left(\left(\frac{2\times s_3\times y_3}{(s_4-s_1)}\right)-\left(\frac{2\times s_2\times y_2}{(s_2-s_1)}\right)\right)\right)-\left(\left(\left(\frac{2\times s_3\times y_3}{(s_3-s_1)}\right)-\left(\frac{2\times s_2\times y_2}{(s_2-s_1)}\right)\right)\times\left(\left(\frac{2\times s_3\times y_3}{(s_4-s_1)}\right)-\left(\frac{2\times s_2\times y_2}{(s_2-s_1)}\right)\right)\right)\right)\right]}\right\}$$

$$\text{and}\quad x=\left\{\frac{-\left[\left(\left(\left(\frac{s_2\times({x_2}^2+{y_2}^2)}{(s_2-s_1)}\right)-\left(\frac{s_4\times({x_4}^2+{y_4}^2)}{(s_4-s_1)}\right)\right)\right)+\left(\left(\left(\frac{2\times s_3\times y_3}{(s_3-s_1)}\right)-\left(\frac{2\times s_2\times y_2}{(s_2-s_1)}\right)\right)\times y\right)\right]}{\left[\left(\left(\left(\frac{2\times s_3\times x_3}{(s_3-s_1)}\right)-\left(\frac{2\times s_2\times x_2}{(s_2-s_1)}\right)\right)\right)\right]}\right\}$$

7.Comapare the simulated and actual source location..
8.Calculate the error between estimated with actual source position.

The very purpose was of course the detection of gas leakage source localization with WSN experimentation. However, handling of gas is very difficult and requires sophisticated setup moreover the quantity of gas is wasted will be prohibitively large. It is well known gas leakage spread by following inverse square law of concentration. A light source also is known to exhibit similar square law of intensity, thus instead of gas leakage and gas sensor array a light source and light detector array is used for a gas distribution setup. The following section describes the detail experimental setup.

## III. EXPERIMENTAL SETUP

To locate the source position from received signal strength and distance between source and nodes using weighted back tracing method is used. In weighted back tracing method calculate the coordinate of source.

1. When used one sensor node it is impossible to calculate location of the source. It predicts the information of source location may likelihood in this plane or nearby; but not the guarantee of the exact location.
2. Two sensor nodes gives stereo type location of the source but again not guaranteed exact source location.
3. Using three sensor nodes it gives theoretical position however it yields very complex results but are found less accurate.
4.With four sensor nodes it gives accurate location of source. If we use more than four sensor nodes, then we can predict better redundancy in the results
5. Robust position of the gas leakage source can be determined. From this we can find out x and y coordinates of source at the end.

**Figure 4: Photograph of an experimental setup**

An actual WSN configuration setup photograph is shown in Figure 4. This is an experimental setup of localization of source with mounted number of sensor nodes on required distance deployed in different positions. The signal is in the form of measured the light intensity variations. In later stage The light source location was varied for possible measurements to be monitored. Monitoring of light intensity with the light sensor nodes, the received signal strength of light intensity is made possible on computer screen that is practical approach. The received light signal strength and nodes positions calculated the estimated source position using the above formulae to find the error between estimated source and actual source position.

## IV. RESULTS AND DISCUSSION

The Source position and Sensor distance plots are shown with respect to the variation (Δy) in gas source position coordinates versus y are plotted in figure 5 and Δx versus x in Figure 6 respectively. Basically Figure 5 represents the variation in y position of gas source. The error between actual source and estimated source position is analyzed by varying the source position y and figure 6 represents the graphical analysis of variation in source x position, the error between actual source and estimated source position shown in Δx, Δy, which is very less than or equal to 1. However, efforts are on to minimize the error be reduced to zero.

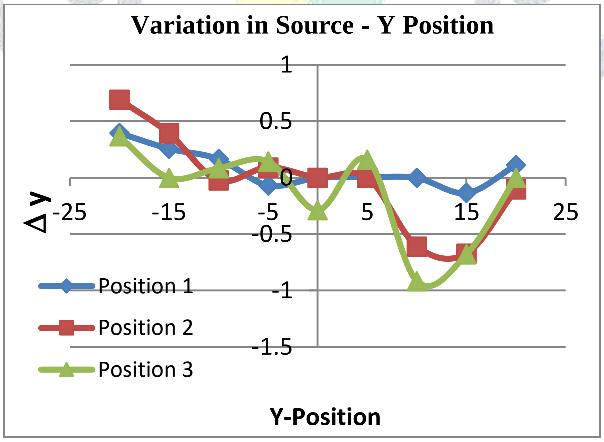


**Figure 5: Plot of variation in source Y-Position.**

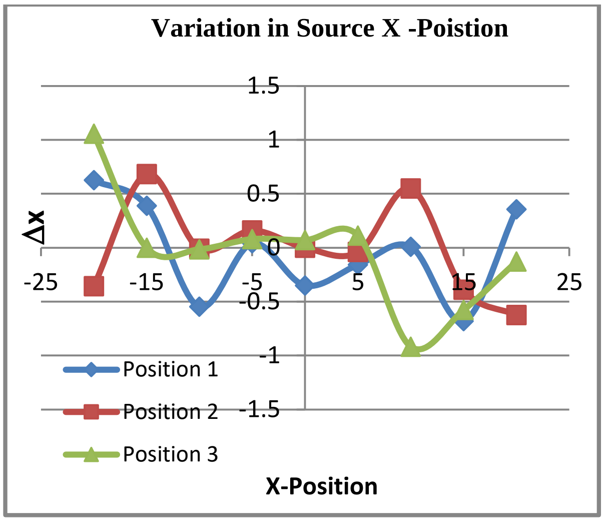


**Figure 6: Plot of variation in source X-Position.**

## V. CONCLUSION

Wireless sensor network using Zigbee IEEE standard 802.15.4 is designed and deployed successfully, for the localization of gas leakage source. On received signal strength using weighted back tracing algorithm it was possible to estimate source position and actual source position. An error was calculated which was found be minimal. A simulation study presented here can estimate the gas leakage position using complex formulae with C functions programs effectively. The results are obtained and estimated useful for majority of the different positions of gas leakage source detection.

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