An Effective Energy and Robust Routing Methods for Air Pollution Data Monitoring in WSN

Ekta Dixit, Vandana Jindal

Abstract*: *The world is facing major challenges due to the progress in technology. Usually, science has also both advantages and disadvantages. The emerged technology creates environment monitoring systems that assisted for the detection and verification of harmful objects. The automatic system is also being cause of pollution in several ways. So, the requirements have been increased to introduce a system to control the pollution. AP (Air pollution) is one of the most pivotal issues that is affecting the living souls. The wireless sensor networks have found a great application in the area of air quality monitoring. In simple terms, a WN (wireless network) is a collection of sensor nodes that communicate by radio signals or waves and detects crucial data which is used to detect the pollutants from the air. WSN routing protocols are specifically accessed for this purpose, such as EEUC, LEACH, DESCA and so on. In this paper, the focus is to bring forth the basic concepts of air pollution detection and some relevant data mining techniques that helped to make a successful air pollution detection system. In this paper, define an artificial intelligence field-based energy-efficient and novel protocol method for the network called Energy-Efficient and Robust Routing Method for air pollution monitoring in WSNs. In this method, sensor network is trained a large database comprising almost all scenes to create the system more efficient, reliable and effective in the atmosphere. In this method, works to increase the lifespan of the network and improve the energy consumption parameter. In experimental result shows that it output ELDC and some other routing protocols such as LEACH and E-LEACH etc.

Keywords* : *WSN, EEMDC, LEACH, HEED, ANN and EEUC.

I. INTRODUCTION

The emergence of technology has observed a rapid growth in urbanization and industrialization, technology breeds pollution. Pollution is one of the most essential issues that is required to be managed as it affects the people globally spreading its wings in areas like air, water, noise, soil, etc. The basic extended gases that result into pollution are CO, CO_2, NO_2, SO_2 and O_3 (Ozones) [1]. Air pollution has become a huge challenge with the high industrial emission and a rise of urbanization leading to increase in the traffic, heating and cooling of large buildings, etc. Therefore, the need to manage and control the air pollution becomes a chief task to save the environment with the increase in pollution, health issues due to bad pollution are also on the increase [2].

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From a survey [4][5], depicts that around 12 million people have been affected. Under such circumstances, the minimization of pollutants is a big challenge for the developers and researchers to make city smart. The quality of air in both indoor and outdoor is affected. Various factors are considered for managing the air pollutants [3].

Indoor pollution is a cause of worry regarding health of people and internal atmosphere of huge buildings. To preserve this problem and effective system was designed to gain a control over the raised air pollution monitoring system. It managed and controlled the pollutants generating the pollution. Detection procedure is easy to manage and balanced the air condition. But the monitoring systems are expensive and time consuming. WSNs have increased a lot of consideration in this field for monitoring the environment conditions. The basic components of WSN are: SNs (Sensor nodes), BS (base station), database and a WS (web server). Generally, a sensor node is organized by the processing unit (PU), a wireless link and connected networking nodes [4].

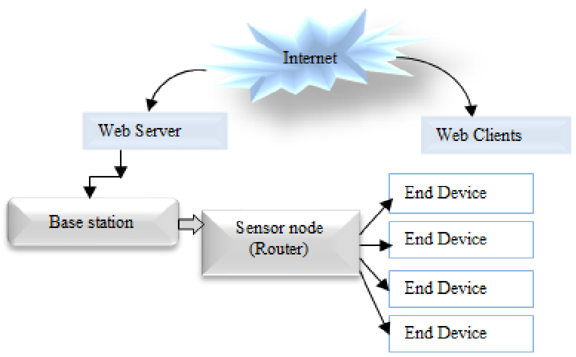

Fig 1 Basic Architecture of WSN In air pollution monitoring System[4].

A wireless sensor network for air quality consists of web servers and web clients along with the access to the internet and the base stations and wireless nodes are linked to the base station with service to end devices.

In Eindhoven, [5] the air quality was discovered in the AREAS in 2016. It was the first resolution for the air quality sensor networks in Netherland, which was executed in 2013 and operated gradually. It was a collaboration of air boxes of size 43X33X20 cm. In Netherland, the city Eindhoven is mapped showing the urban background in circles and the traffic positions in triangles. The air boxes placed determined the particulate matters, O_3, NO_2, temperature and humidity levels as air flew from one direction to another.

Fig 2. The Position of air boxes in Eindhoven [5]

For the power supply, the air boxes were connected to the lamp posts [5]. The outlier detection relies on the determination to observe a concentration value if falling under the condition or not.

$$\mu_1 \pm z_1 X \sigma_1 \quad \text{….. (i)}$$

In the above equation (i), μ_1 is considered as a mean, σ_1 taken as standard deviation and z_1 is the size of the confidence interval. The Nitrogen oxide concentration is a solution in the urbanization arrangement and basically depends upon the proximity of busy areas. Hence, the higher rate of noise in concentration is easy to track.

$$y_b = \sqrt{NO_{2b}} + \sqrt{(1 - minimum\ (NO_{2b}))} \text{…..(ii)}$$

In the equation (ii), NO_{2b} is the comment and y_b is the distorted determination in the spatio temporal class R. b is the determination index and Y_b has the co-ordinate values in both space and time. Where R= $\cup_{b \in B}$ and B = {1……. N_B}.For each transformation of NO_2 observation Y_b, the purpose is to exclude the jth determination through the NO_2 concentration data sets to expel the influence of the observation, an outlets and standard deviation (SD) with a mean. The remaining dataset mean and standard deviation are as below-

$$Nr^{-j} = \frac{\sum_b (y_b) - y_{b,j}}{(y_b - 1)} \quad \text{…………(iii)}$$

$$S_r^{-1} = \sqrt{\frac{\sum_b (y_b - Nr^{-j})^2 - (y_{b,j} - Nr^{-j})^2}{(y_b - 2)}} \quad \text{……(iv)}$$

In this way, the simulation extends all over the NO_2 observation where spatio-class is R, Nr^{-j} and the S_r^{-1} which are considered as the mean and SD (standard deviation). The ND (normal distribution) is expressed by Qr and Tr, that gives thresholds.

$$Qr \pm z_1 \text{ x } Tr \quad \text{….. (v)}$$

The same process is followed up to monitor NO_2 (Nitrogen) in city Eindhoven which is part of Netherland [5].

The overall review work is partitioned into several sections. Section I gives the overview of the air pollution and the wireless sensor network. Section II is all about the literature studies. It has the previous techniques and methods that were used for monitoring air pollutants. Section III is the preferred techniques and methods used by WSN for the monitoring and controlling air quality. Section IV has the conclusion and future scope in it.

II. RELATED WORK

Mehmood, A., et al., [6] researched on pollution monitoring in WSN with the use of An ANN, an energy-efficient and robust routing protocol method. The proposed technique was referred as ELDC, an ANN based on the energy-efficient routing scheme that described load balancing and enhancing network life. This technique alleviates the energy consumption and delay. WSN applications were extremely inclined towards the stream of processing, storage, communication and energy **Gautam, N., [7]** started a collection of small sensor nodes, which aimed to extract the environmental information as data. **Mehmood, A., et al., [8]** found its application in monitoring and control system, surveillance, disaster management, weather applications, pollution and indoor temperature. In this research work, the main focus was on monitoring air pollution. The system collaborated with WSN was upgraded with reduced cost, time and quick procedure. **Mehmood, A., et al., [9]** proposed an approach named ELDC, an arithmetic algorithm that had the capability to read and learn complex mapping in both input and output in terms of supervision. The results demonstrated the characteristics of both an EMDC(energy efficient multilevel and distance aware clustering) and an energy efficient unequal clustering(EEUC) approaches. It enhanced the lifeline of sensor nodes and made it more efficient. **Vieira, M. A. M., et al., [10]** proposed a system that involved numerous monitoring systems which worked wirelessly on the back end servers. The communication between sensor nodes was linked to machine learning. It consisted of the stations and each station associated with gaseous and meteorological sensors had communication capabilities. The main motive behind the back end server was to fetch the valuable data and transfer the data to end users. The research on air quality monitoring system was executed into pilot phase and in four dissimilar solar powers in the area of 1 km^2. Its outcomes were highly preferable in terms of reduction of connections of base stations and improved the ability to be operated sophisticated. To control the indoor air quality, several methods had been described along with the capability to enhance the energy efficiency and potential to occupant driven demands control. The routing methods were accessed to attempt fine grained occupancy. The characteristics of this technique were segmented into two categories: Spatial Temporal and Behavior Properties. The spatial-temporal gave access to the information related to the physical information of the occupant like presence, number, position and identity. This information facilitated to adapt Heating, Ventilation and Air Conditioning (HVAC) operation as per the architecture of occupancy. On the contrast, the behavioral characteristics contributed to the information nearby the activities performed by the occupant. It included walking, sitting, running. The occupancy measurements were difficult tasks and required various sensing approaches which are shown in the figure 3 below :

The current research demonstrated that the collaboration and correlation data occupied from the sensor techniques must improve the occupants and the building context. The main purpose of the occupants was to manage different approaches. There were enormous sensor techniques in the Spatial Temporal characteristics such as CO_2, Power meter, image sensors, sound sensors, computer algorithms etc. [11] [12].

Pavani, M., et al., [13] described a solution to monitor the real-time pollution with the use of WSN.

Generally, WSNs were used almost in every field. It had enormous applications. To control the environment pollution, several sensors were associated that captured the pollutants.

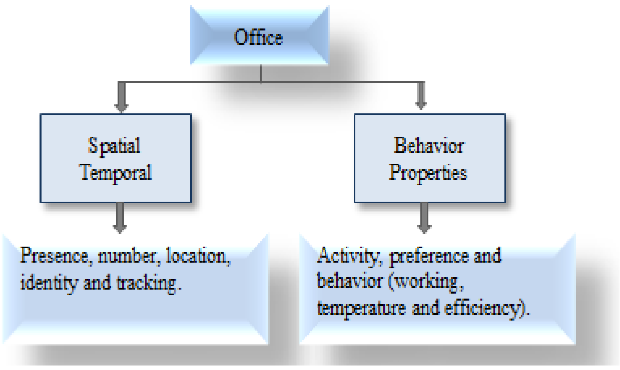

Fig 3. Occupancy Characteristics [3]

Gas sensors were newly introduced sensor networks that gained attention due to the extraction of the harmful pollutants from the air. The gas sensors were combined through the exposure to various concentrations of gas priors on a Water quality analysis simulation program (WASP) mote. It was performed to enhance the results and to improve the accuracy. In gas sensors, each sensor obtained an output, and its readings were allotted on the calibration equation in Parts Per Million (PPM). The output generated by these sensors was of low magnitude. The use of signal conditioning circuit strengthened the output signals. Gas sensors were an effective and improved method for the discovery of Aps (air pollutants). It was cheap , compatible and could handle versatile applications.

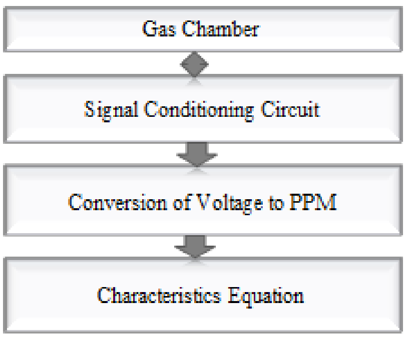

Fig 4. Gas Sensor Procedure [13].

Figure 4. Represents the procedure of gas sensor to monitor the air quality. Firstly, the sensors were combined into a gas chamber. Then, the signal circuit was included in which the voltage of data collection converted in the PPM and the curve fitting was performed on it. Lastly, the characteristic equation was considered to obtain the desired results to track the quality of air in the environment.

Boubrima, A., et al., [14] proposed a deep research for air pollution monitoring on the basis of WSNs. In this research work, two optimization techniques were utilized to cover the pollutants efficiently. The primitive approach employed to demonstrate adequate modeling and well planned strategy in the real pollution detection. The main focus was on atmospheric dispersion, and a lot of techniques were accessed for this work. These models were specifically for the weather forecasting, assessment of contamination, poisoning, etc. It generally relied on fluid mechanism theory. Simultaneously, the other focus was on the state dispersion and Gaussian dispersion. Assuming that the direction of the wind was along the X axis and the pollutants were at the location (0, 0, H_r) in the free space. It was assisted to determine the pollutant concentration at the point of (X, Y, Z) using the following equation.

$$P\,(X,Y,Z) = \frac{G}{2\pi v\,\sigma_i\,\sigma_j} E^{i^2} \left(E^{\frac{-(Z-h)^2}{2\sigma_i}} + E^{\frac{-(Z+h)^2}{2\sigma_i}}\right) \ldots\ldots(i)$$

In the above equation, P was the pollution concentration, σ_i *and* σ_j was the dispersion coefficients which were in vertical and horizontal direction. G was the emission rate at the source point, h was the pollutant effective height and v was the wind speed. It was predicted that the H described the pollution effect height, which was similar to the pollutant source height.

Khedo, K. K et al., [15] investigated research on the use of WSN for the air pollution monitoring in Mauritius region. The issue of the health has become a major area of concern in industrial activities with the growing population. They proposed an innovative method for the WSN air pollution monitoring method (WAPMS) in Mauritius by the deployment of the nodes around the island. The proposed method used air quality index that was not available in Mauritius. A recursive converging quartiles methods were implemented to enhance the efficiency of the WAPMS. The method was used to combine the information to delete the double data, filter out unacceptable readings and reviewed the data in a simple way which decreases the amount of information transferred to sink and save energy. The energy was maintained by the hierarchical routing protocol in WAPMS. **Luo, X et al.,[16**] surveyed on pollution monitoring using sensor network in protection of the environment. In addition, the sensor and pollution method was studied. Along with that, the detection techniques were observed and compared. Moreover, a summary of the resource localization was also given. **Bathiya, B et al., [17]**aimed to examine the minimum cost multi sensor hop for measurement of the pollution and establish air protocol for collecting information and aggregation protocol. The goal of this research was to establish a minimum price node for air. They had established a board to manage the accuracy of every sensor by comparing transferring data of multiple radio frequency. **Boubrima, A et al [18]** focused on supplementary method with minimum price and automated wireless sensors . The wireless sensors aimed at better spatio-temporal sensing. The general deployment method was adapted to determine the behavior of the pollution sensing. The main goal of this research was to project the integer linear programming method that calculates deployment of the sensor catching both regions of pollution under time varying weather situations and the connection of the structure design. They compute deployed dataset of London. They analyzed the performance of the planned method at a given execution time. Lastly, the simulation behavior of the urban environment was analyzed by deployment of the air pollution sensors.

III. ROUTING PROTOCOLS

The WSNs gave a better, simpler execution and a low cost solution for the real time monitoring applications. The sensor nodes are open hardware and open software that gained attention from majority of developers [19] as the data recovery from sensors is easy. Its automatic operations allowed to develop the major applications to monitor the air quality. It mainly consists of sensor nodes, a router, a wireless gateway and monitoring station [20]. Routing protocols are essential parts of WSNs that are described below : -

A. LEACH Protocol

The WSN is created more efficiently with the use of LEACH. The process of communication is easy, moving from Cluster Head (CH) to nodes and nodes to the hop. Each route makes a new structure of clusters and it has a new CH. The count of CH is based on the energy-consumption of the network [21]. CH contains a lot of energy as compared to its members. The processing criteria are segmented into phases.

i. *Setup:* First phase involves creation of CH.

$$S(m) = \frac{R}{1-R} \quad \text{if } M \in H$$

$$S(m) = 0 \quad \text{if } M \notin H$$

In the above, equation the CH is evaluated as S where R is the percentage and H is considered the number of nodes.

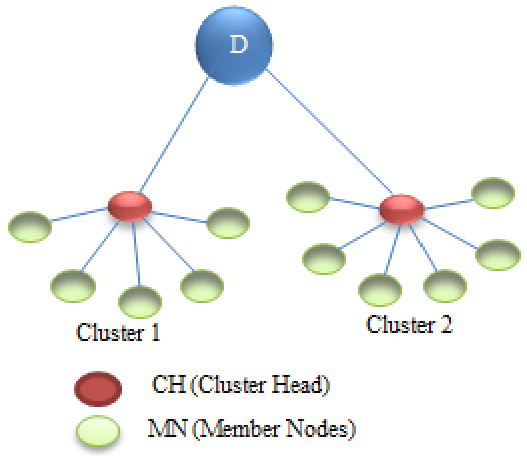

Fig 5. Leach protocol in WSN [22].

In above Figure 5. the nodes are organized in local clusters and one out of the node acts as a base station. All the MN and CH in association transmit the data to the destination.

The overall process of LEACH passed through several rounds where each round had the capability to transmit the sensed data at the nearest CH. CH gathered the data and accumulated the information to the Base station (BS) [23].

ii. Steady State: In this stage, the data are sensed in the field and then transferred to CH. When all the data is gathered by CH, it then sends to BS. Later, the setup phase is initialized again and moves the data in another round. In this way, the rounds are generated.

iii. Types of Leach Protocol: LEACH protocols are available as Two Levels LEACH, V LEACH, MR LEACH and Far Zone LEACH. Two levels LEACH basically combined the two CH in WSN. Vice LEACH (V LEACH) mainly used an alternative CH by using active CH. It expelled the isolation in the cluster nodes when CH was dead. Multi hop routing with leach (MR LEACH) used the multi hop connectivity to transmit the data from CH to BS. In this process, at initial stage a table was created having the cluster nodes which extracted and stored the information like ID, energy level and status of the node. Far Zone LEACH considered as an extension of LEACH protocol. It was mainly required to work on the extremely large sensor networks where nodes were located at far off distances from the base station, thus reducing the threshold energy level to send the data [24].

B. HEED Protocol

HEED stands for hybrid energy efficient distribution protocol. It is an extension of LEACH protocol. The communication route is Multi-hop in which CH is linked to BS and the selection criteria was based on the determination of intra cluster cost. The fundamental use of HEED was to outspread the processing period of the network through the spread of power consumptions. The cluster procedure was limited in the count of iterations (Rounds) and diminished the routing challenges to build an optimized cluster with dynamic cluster heads. The focus was on the residual energy of sensor nodes (SN) and the communication cost as the function of cluster density.

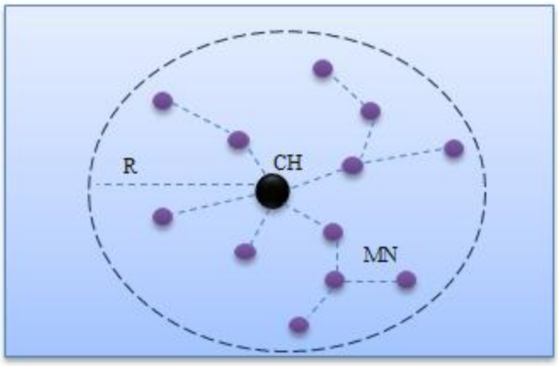

Fig 6. HEED Protocol in WSN [25].

C. DESCA (Distance energy cluster structure) Protocol

DSCA algorithm was developed with both distance and residual energy of the nodes. From the multi-hop communication between base stations and cluster heads, the algorithm expelled the energy consumed by the cluster head. The main components of a network were partitioned into three basic levels, each level having its own CH. The third level CH associated to the second level CH and after that, it connected to the first level CH. The process proceeded in the rounds DESCA rounds were classified into two forms as initial stage and stable working stage. To expel the consumption of energy, the working stage was considered longer rather than initial stage.

i. Initial stage: In the initial phases of DESCA process, the time slots were spread to the common MNs using CH. The common MNs were combined with the appropriate clusters. The process of selection basically followed 2 steps : Election of common CH and the election of BS.

*ii. Stable working stage: T*he other stage of DESCA is where the BS, transmits the message into the overall network. After receiving messages, the BS and CH chosen of the maximum CH sensor node as a next hop . The other CH nodes are selected as the previous sensor node until all the CH nodes are linked together.

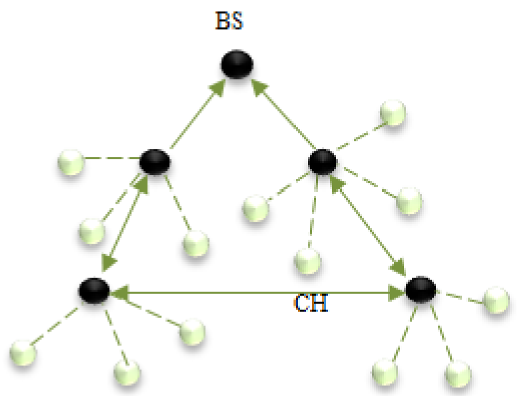

Fig 7. DESCA in WSN [26].

D. EEUC Protocol

EEUC is an energy efficient unequal clustering, based on the cluster size and the count of the nodes of a cluster. It condensed the energy consumed by the nodes. Its main motive was to balance the energy consumption of all the nodes in a network.

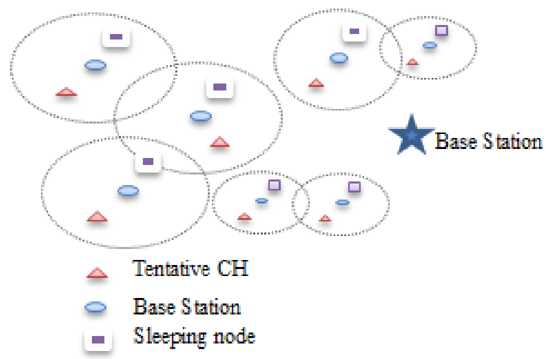

Fig 8. Entire Structure of EEUC [27].

Figure 8. shows set of cluster heads, which are tentative and common along with sleeping nodes and base stations which helps to communicate in the network. It contains un-equal clusters in the network. The chances of becoming a tentative CH are based on the probability of a node processing the residual energy. Sleeping node was initialized when the waiting time is raised on the network. The function is used to determine the distance to the BS. It is composed of count of neighborhood nodes and the residual energy of CH. The competition radius is organized as-

$$P_{competition} = \left[1 - xi\left(\frac{trj}{tr_{maximum}}\right) - xi'\left(1 - \frac{fx}{f_{maximum}}\right) - \frac{xi''Gx}{G_{maximum}}\right] P_{maximum}$$

In the above equation, trj is the distance between node j and the BS. $tr_{maximum}$ is the maximum distance of sensor node and BS. Fx is the residual energy and $f_{maximum}$ is considered as the maximum energy of node. $P_{maximum}$ is maximum size of cluster and xi,xi' and xi'' is the constant coefficients between 0 and 1. Table 1 symbolizes classification and comparison of various routing protocols in WSNs.

Table 1:- Several Routing Protocols in WSN [28]

Classification	**Protocol Representative**
Quality of Services, Protocols	SAR SPEED Energy Aware Routing Protocol
Heterogeneity Protocol	IDSQ CADR CHR
Hierarchical Protocol	LEACH PEGASIS HEED TEEN APTEEN
Data centers Protocol	SPIN DD RR EAD Energy Aware Routing Protocol Home Agent Based Information Dissemination
Location Based Routing Protocol	MECN SMECN GAF SPAN TBF, GERAF and BVGF

Table 2 defines routing protocols in WSNs. This table depends on the survey of references [27,28] and adapted according to presentation requirements.

Table 2: Comparison of Routing Protocols in WSNs

Routing Protocols	**Category**	**Aggregate Data**	**Scalability**	**Query**	**Overhead**	**Quality of Services**
LEACH	Hierarchical	✓	Good	X	High	X
TEEN and APTEEN	Hierarchical	✓	Good	X	High	X
VGA	Hierarchical	✓	Good	X	High	X
DD	Flat	✓	Limited	✓	Low	X
RR	Flat	✓	Good	✓	Low	X
PEGASIS	Hierarchical	X	Good	X	Low	X
SPEED	Location	X	Limited	✓	Les	✓
SAR	Data center	✓	Limited	✓	High	✓

IV. RESULT AND DISCUSSIONS

In this section, ELDC protocol performed using MATLAB 2016a as a simulation tool scripting language used in the WSN environment. Table 3. defines the performance parameters used to make the simulation (MATLAB). Assume that detailed the performance parameters utilized in the model. Firstly, the network created an area of 200m *200m or 100m*100m. Assigned each sensor node initial energy (IE) of 12 (j), packet size is 25(bytes) and packet size value is initialized for data interchanging and manage information among the sensor nodes. Signal Broadcasting and broadcast packet size metric reveals the network size of the data packet. The final experimental result, show that proposed protocol outputs most significant CH based rules suggested for WSNs. Experiments are happening with attractive 100 sensor nodes with different layers.

Table 3. Simulation Performance Metrics

Metrics	Simulation Values
WSN Area	100*100m or 200*200m
Start_energy	12 (j)
Packet_Size	25(bytes)
Sensor_nodes	30,40,50,60,70,80,90,100…. .
Length of rounds	20 (s)

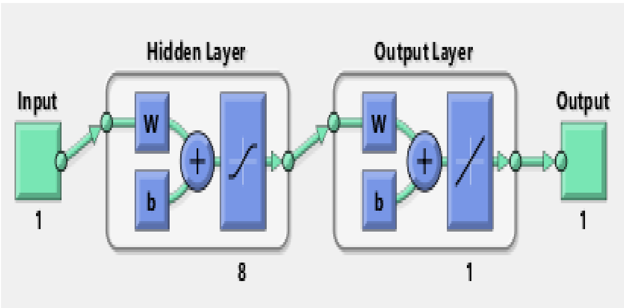

Fig 9. Neural Network Architecture

Above fig 9, show to create the WSN network is more reliable, adaptive and energy efficient. WSN is trained for almost all possible situations. Train WSNs, the most famous category of ANN architecture is called Back Propagation (BP) with 3 different layers are used. It works knowledge based or train nodes towards the design, validation and selection of sensor nodes having the most valuable resource design. Firstly, train procedure outcomes the record of sensor nodes, which verify the energy parameter phase. The complete network is enclosed by utilizing this procedure in an efficient manner. Mitigate the data redundancy only Adjacent Nodes (AN) are screened and signed. Training Phase is enabling the chosen sensor nodes to search for a set of their AN that they considered. In the last complete procedure, the two most valuable sensor nodes with their values are chosen. Below Fig 10 shows the best validation performance evaluated by the total sum of error rate. Means Square Error Rate is calculated by the average of the error. It computes the train,validate, test and best validation check w.r.t 50 epochs in the WSNs.

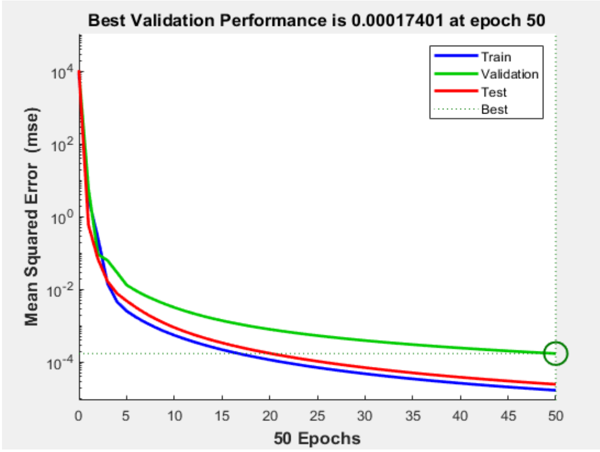

Fig 10. Best Validation Performance

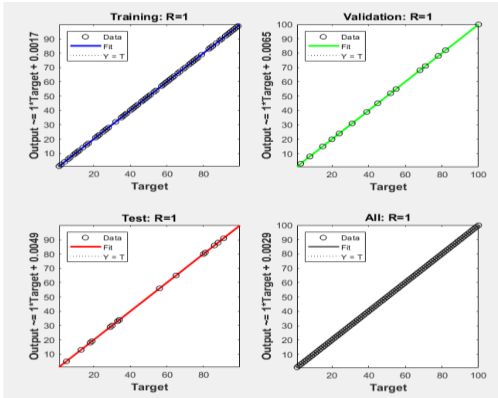

Fig 11. Regression

Above figure 11 shows the total average rate is equal to the regression. Training R = 1 w.r.t. Target, validation R =1 w.r.t Target, Test R=1 w.r.t. Target and Average of all Section Regrssion value are equal to 1 w.r.t calculated by the target.

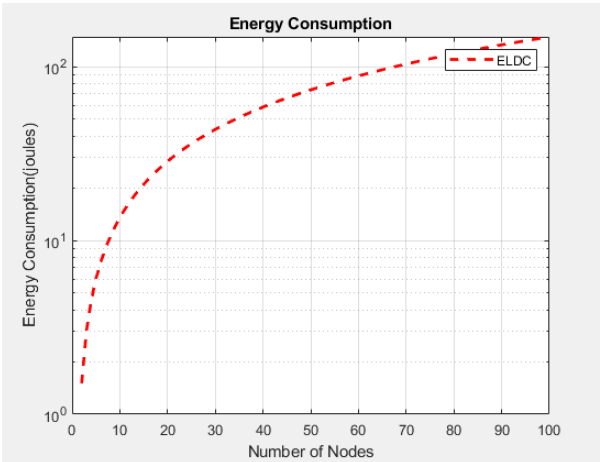

Fig. 12. Energy Consumption in ELDC Protocol

Fig 12 defines the energy consumption of the analyzed routing protocols along the interval of time. Experiment result define that ELDC consumed 23 per cent minimum energy as compared to other routing protocols such as LEACH, HEED, DDAR, EEMDC and EEUC results the predictable rules.

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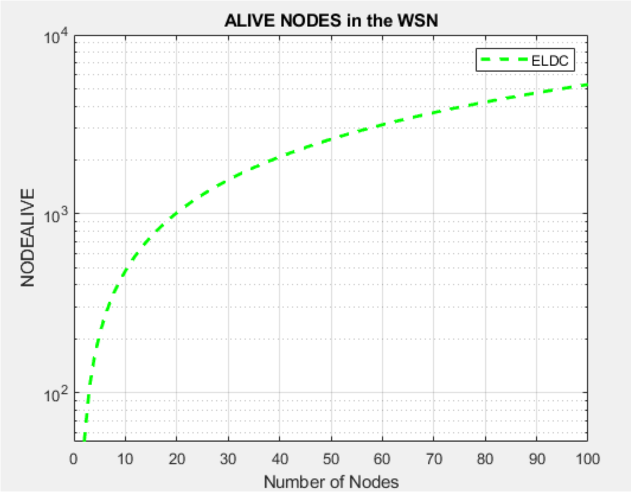

Fig 13. Alive Nodes in ELDC Protocol

Above figure 13 defines the network performance based on number of nodes alive along with nodes. This proposed result shows that the ELDC routing protocol has 50 nodes alive after 100 numbers of sensor nodes in WSN. Then, cluster-based routing protocol performance like LEACH, HEED, DDAR, EEUC and PEGASIS performance analysis w.r.t ELDC protocol in an air monitoring system in the environment.

Table 4. Experiment Result with Energy Comsunption using ELDC

Rounds	Energy (j)
250	30
500	46
750	58
890	67

Table 1. Shows the energy consumption amount of protocol (ELDC) w.r.t its comparison various protocols or a session/Uni_id's 1000 rounds. It defines that protocol (ELDC) consumes less energy consumed as compared with other protocols.

V. CONCLUSION AND FUTURE SCOPE

In this conclusion is calculated by WSN are accessed for the detection and prevention from harmful air pollutants. The system based on WSN is of low cost and, which easily collect data from anywhere due to the fact of fewer requirements of wireless network. In this survey paper, a brief description of air pollution and relevant approaches have been discussed that must be enhanced in the coming time period. The main focus is to be laid on the routing protocol approaches and the process of air pollution monitoring system to track and detect the weather and the environment related issues. It has implemented a novel artificial intelligence (AI) protocol is known as ELDC protocol. The major routing protocol avoids its problems and joins the characteristics of clustered based routing protocol. It develops ANN classification method to train the rules by taking into number of metrics like CN or BS (Base Station/Chief Node), D of CH (Distance of Cluster-Head), Residual Energy and Assumption of health status of the each route. In performance computations of this rule define that all sensor nodes minimize their energy factor at the similar time span. In case few sensor nodes consume their energy speedily, but the other sensor nodes care them and suppose in another case sleep node by sending sleep commands after every round and nodes.

In further work, will implement an optimization method with the help of the GA-BFOA algorithm used WSN in air pollution monitoring. It may emphasis on the deployment of the maximum amount of nodes in monitoring real time testing of the sensors. Moreover, the detection of the air quality monitoring will record the health of people in real time environment. Moreover, an approach should be developed for computing the sensors at minimum cost. The computing method will help in measuring the air factor and sensor quality and throughput rate.

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