Design Approach for Increased Lifetime of WSN using Artificial Neural Network Based Data Aggregation

Manomi K S, Vinutha C B, M Z Kurian
Department of ECE, SSIT, Tumkur, Karnataka
ksmanomi@gmail.com, cbvinutha@gmail.com, mzkurianvc@yahoo.com

ABSTRACT-In recent years, wireless sensor network (WSN) is finding its applications in agriculture, military, health care, environmental monitoring and industries. In wireless sensor networking energy resource of battery is very important and it has to be utilized in an efficient way. Energy resource of WSNs cannot be recharged or replaced in most of the time. So, the lifetime of the WSN is an important aspect in the design of WSN. Data aggregation is a crucial task in WSNs. This paper focuses on data aggregation using artificial neural network (ANN) to maximize the throughput of the network. The faulty sensor nodes in the network send the wrong data to cluster head (CH) by leaf nodes. This paper applies the neural network for wireless sensor network to detect the faulty sensor nodes and faulty nodes are eliminated. This increases the throughput and lifetime of sensor networks.

Keywords - Artificial Neural network (ANN), Cluster formation, Cluster head (CH), Data aggregation, Wireless sensor network (WSNs).

I. INTRODUCTION

Wireless sensor networks are composed of several sensor nodes. These sensor nodes senses the physical or environmental conditions like pressure, temperature, moisture, sound etc, and process the acquired data. Sensor nodes are connected wirelessly using sensor and actuators, passes the sensor node data through network to main location [1].

In WSN data aggregation is the process of accumulating and routing the information through a multi-hop network, processing the data at intermediate nodes to reduce energy consumption thereby increases the network lifetime.

Artificial Neural Network is an arithmetic algorithm to learn the complicated mapping between input and output. Data aggregation is the process of collecting and processing the sensor data in order to reduce the amount of data transmission in the network. Neural network based data aggregation increases the network lifetime and throughput.

A. Architecture of wireless sensor networks

Sensor nodes are placed in the sensor field as shown in the Fig 1. Each wireless sensor node has memory, communication device, controller, sensors/actuators and power supply [1]. These sensor nodes collect the data. The collected data is transferred to the base station through multi-hop path. Base station communicates with the user through the internet.

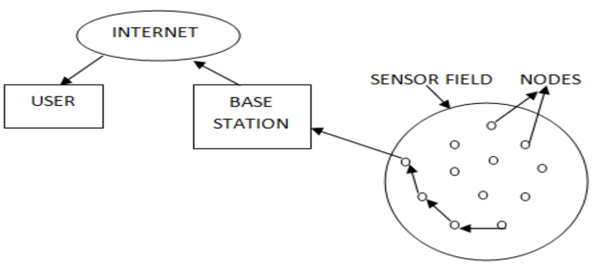

Fig. 1. Wireless sensor network architecture

II. ARTIFICIAL NEURAL NETWORK

The artificial neural network has processing units. These processing units are similar to biological neurons. Signals are transmitted through the connecting links [2]. Each links poses associated weights. Neural network may be single layer or multi layer network. Single layer ANN is shown in Fig.2. Here X_1, X_2 are inputs, W_1, W_2 are weights and Y is the output. The weights are multiplied with their incoming signals to get the output.

$$Y=X_1W_1+X_2W_2 \quad \ldots\ldots\ldots\ldots (1)$$

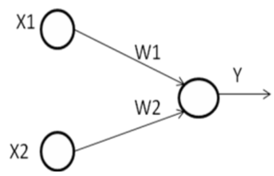

Fig. 2. Single layer ANN

Multi layer ANN has input layer, hidden layer and output layer as shown in Fig.3. Raw data is fed to the input neuron. Neurons in the hidden layer are found out by the activities of input neuron and associated weights between the input and hidden units. Neurons in the output layer depends on the activity of neurons in the hidden layer and connectiong weights between the hidden and output layer [2].

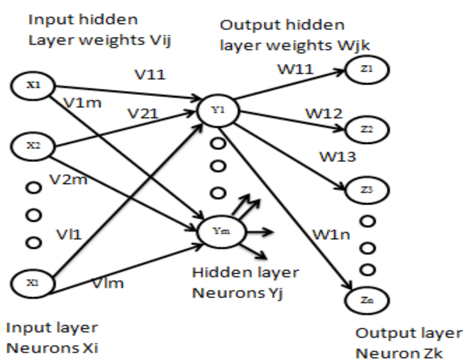

Fig. 3. Multi layer ANN

III. Proposed Method

A. Data aggregation

Data aggregation is a key technology in WSNs. Data aggregation is a process of dealing with the several data to obtain the data that must satisfy user needs. The sensor nodes are distributed in the specified sensor field. The sensor nodes are clustered using the clustering technique. We have mentioned the cluster heads for each cluster. The sensor nodes send their collected data from the environment to the cluster head and cluster head transfers the data to the base station using the data aggregation technique. In this paper ANN based data aggregation technique is used to increase the throughput and network lifetime.

The faulty sensor node data to the CH is the main drawback of the existing system [4]. The existing system is a sensor network without neural network. The data transfer in the existing system is shown in Fig.4. Fault tolerance is the ability of the sensor network to provide the correct results when the sensor nodes fail. The ANN for sensor network eliminates the faulty sensor node that avoids the false information processing.

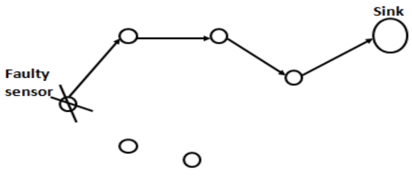

Fig. 4. WSN without artificial neural network

This paper presents an idea of the neural network for sensor network. The collected data from the sensors are input to the neural network. The neural network trains the sensed data and then output the neural network data. The neural network data are compared with the initial sensed data and the difference is α.

Artificial neural network data - Sensor data= α

α must be greater than β (β is the accuracy of production of data) otherwise the sensor is defective and that sensor is removed. The defected sensor node elimination is shown in Fig.5. This prevents the energy consumption for the transfer of false data.

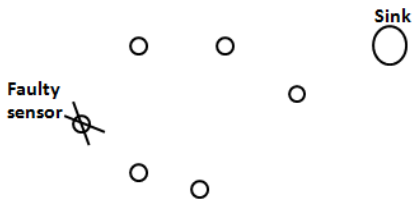

Fig. 5. WSN artificial neural network

The failure of sensor node within the neural network does not cause the network failure because of the faulty sensor node elimination using artificial neural network. Therefore the network death doesn't happen with the faulty sensor.

B. Back propagation neural network for data aggregation

In this paper back propagation neural network (BPNN) training is used for the data aggregation. Back propagation neural network for data aggregation is as shown in Fig.6. BPNN is a multi layer feed forward neural network [2]. The input layer is located in the leaf nodes (cluster members) and hidden and output layer is in the cluster head (CH).This neural network involves supervised learning [8]. Back propagation network have:

1. Input layer consists of the back propagation network inputs.

2. Hidden layer consists of neurons; these neurons are responsible for adjusting the weights to determine the correct weights.

3. Output layer consists of back propagation network outputs and represents the final decision of training operation.

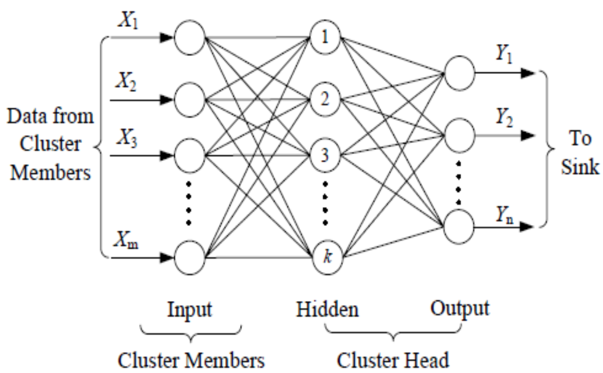

Fig. 6. Data aggregation using back propogation neural network.

In a feed forward neural network the information flows from leaf nodes to cluster head. Every node processes the data in following manner. The flowchart for data aggregation using BPNN is as shown in Fig.7. First initialize the weights for all nodes. Leaf node data are the input to the neural network. Then transfer the data to the cluster head for training or processing.

The aggregated data $X_j(n)$ of node C_j is given by

$$X_j(n) = y_j(n)w_j(n) + \sum_{K=k} Y_k(n)w_k(n) \quad \text{... (2)}$$

Where,

C_j = Cluster head

$w_j(n)$ =Associated weight of cluster head

$y_j(n)$ = Observation made by Cj

K = set of indices of all leaf nodes of node C_j.

$w_k(n)$ = Weights of leaf nodes

$Y_j(n)$= output after applying sigmoid function to $X_j(n)$

The sigmoid function is defined as $Y=1/(1+e^{-X})$ is used at intermediate nodes to get the binary decision. The decision $Y_j(n)$ of node C_j is given by,

$$Y_j(n)=1/(1+e^{-X_j(n)}) \qquad \ldots\ldots. (3)$$

The binary decision $Y_j(n)$ of each node is propagated to cluster head. The binary decision made by CH estimates the event hypothesis $H_{est}(n)=Y_{CH}(n)$.

The error at the CH is the error between the actual desired output H(n) and estimated output $H_{est}(n)$ is calculated as,

$$e(n)=H(n)-H_{est}(n) \qquad \ldots\ldots..(4)$$

The error $e_j(n)$ at the node C_j is given by,

$$e_j(n)=e(n)w_j(n)Y_j(n)(1-Y_j(n)) \qquad \ldots\ldots. (5)$$

The gradient $grad_j$ is calculated to update the weight.

$$grad_j(n)=\alpha e_j(n)X_j(n)+\mu grad_j(n-1) \qquad \ldots\ldots. (6)$$

The value of step size α and acceleration factor μ are carefully selected to avoid algorithm divergence.

Finally the weights are updated as,

$$w_j(n+1)=w_j(n)+grad_j(n) \qquad \ldots\ldots\ldots.(7)$$

Use the updated weights for the next training sequence to train the algorithm which uses forward and back propagation till the convergence reaches [10].

If the error is more, then the node is defective. Eliminate the faulty node. When the leaf nodes fail or submit the faulty data, then reduce the nodes weight thereby resulting in the no impact of faulty data on aggregation. This reduces the energy consumption for the transfer of faulty data, thereby increases the network lifetime.

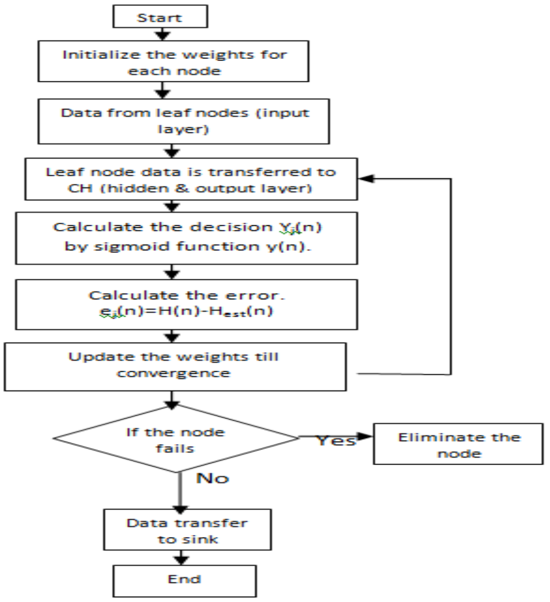

Fig. 7. Flowchart for data aggregation using back propogation neural network.

IV. Results

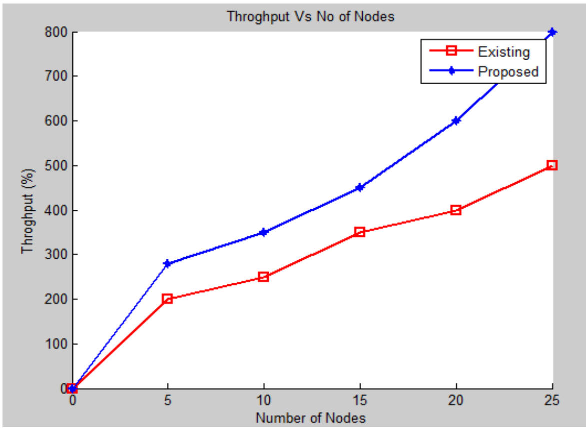

Fig. 8. Throughput Vs No of nodes

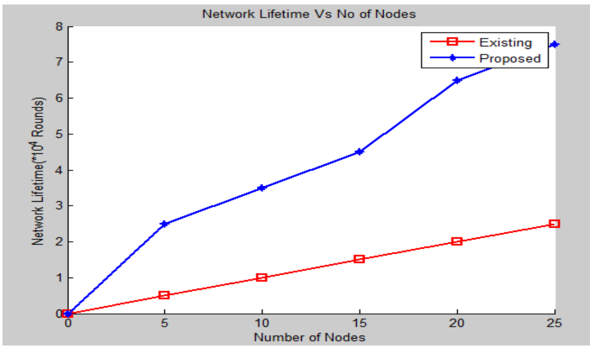

Fig. 9. Throughput Vs No of nodes

Due to the elimination of faulty sensor only real data is transferred. The throughput of the proposed system (with neural network) is more compared to the existing system (without neural network) as shown in Fig.8. The network lifetime increase in a proposed system as shown in Fig.9. Comparison of the throughput and lifetime of existing system Vs proposed system is shown in the TABLE1.

TABLE 1: THROUGHPUT & LIFETIME COMPARISONS

NO OF NODES	WITHOUT NEURAL NETWORK		WITH NEURAL NETWORK	
	THROUGHPUT	LIFETIME *10^4 ROUNDS	THROUGHPUT	LIFETIME *10^4 rounds
05	200	0.5	300	2.5
10	240	1.0	350	3.5
15	330	1.5	440	4.5
20	400	2.0	600	6.5
25	500	2.5	800	7.5

V. CONCLUSION

Wireless Sensor Network is finding its application in various fields and is becoming very popular. Data communication in WSN should be supported by the limited resources of the nodes. Clustering of nodes in wireless sensor networks increases the scalability of the network and energy conservation. Data aggregation using ANN technique increases the network lifetime and throughput by eliminating the defected node. More efficient energy balancing technique should be devised to conserve nodes battery energy and result with improved network lifetime.

REFERENCES

[32] I. Akylidiz, W. Su, Sankarasubramaniam, and E.Cayrici, ―A survey on sensor networks‖, IEEE Communications Magazine, Volume: 40 Issue: 8, August 2002, pp.102-114. Broadband and Wireless Networking Laboratory, School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, GA 30332, USA. Received 12 December 2001; accepted 20 December 2001.

[33] Neda Enami, Reza Askari Moghadam, Kourosh Dadashtabar & Mojtaba Hoseini proposed ―NEURAL NETWORK BASED ENERGY EFFICIENCY IN WIRELESS SENSOR NETWORKS: A SURVEY‖. International Journal of Computer Science & Engineering Survey (IJCSES) Vol.1, No.1, August 2010.

[34] Shruti Prabha Shaktawat ,O.P Sharma, ―Node Deployment Models and their Performance Parameters for Wireless Sensor Network: A Perspective‖ International Journal of Computer Applications (0975 – 8887) Volume 88 – No.9, February 2014.

[35] Krishanamachari B., D. Krishanamachari B., D. Estrin and S. Estrin and S. Wicker "The Impact of Data Aggregation in Wireless Sensor Networks", Distributed Event Based Systems (DEBS), Vienna, Austria, Jul. 2002

[36] Saeid Bahanfa, Helia Kousha[2] and Ladan Darougaran, ―Neural networks for error detection and data aggregation in wireless sensor network‖, IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 5, No 3, September 2011

[37] Vipin Pal, *Student Member, IEEE*, Girdhari Singh, and R. P. Yadav, "Balanced Cluster Size Solution to Extend Lifetime of Wireless Sensor Networks, IEEE INTERNET OF THINGS JOURNAL, VOL. 2, NO. 5, OCTOBER 2015

[38] Sang-Hyun Lee , Sang-Joon Lee , Kyung-Il Moon,― Life-Environmental Sensor Data Aggregation Based on Neural Network‖, Advanced Science and Technology Letters Vol.47, ISSN: 2287-1233 ASTL Copyright © 2014 SERSC.

[39] Ling-Yi SuN, Wei CAI, Xian-Xiang HUANG ―Data aggregation scheme using neural networks in w.ireless sensor networks‖, 978-1-4244-5824-0/$26.00 _c 2010 IEEE

[40] Jabal Raval, Bhushan Jagyasi ―Distributed Detection in Neural Network based Multihop Wireless Sensor Network‖, 978-1-4799-2179-9/14/$31.00 ©2014 IEEE.

[41] Bin Zhang, Guolong Chen, ―A Prediction-Based Fault-Tolerant Aggregation Algorithm in Wireless Sensor Networks‖ 2013 International Conference on Cloud Computing and Big Data.

Bhushan Jagyasi, Jabal Raval, ―Data Aggregation in Multihop Wireless Mesh Sensor Neural Networks‖, 2015 ninth international conference on sensing technology.