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Active Cluster Node Aggregation Scheme in Wireless Sensor Network Using Neural Network

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Abstract

Recent wireless communication technologies enable the deployment of large scale sensor network. Sensor node has limited power energy constraints act as the critical issue in the deployment. Hence, we must developed energy efficient methods to facilitate efficient data transmission between the nodes. In this paper we compare currently available energy efficient clustering methods. Also we propose a dynamic clustering node method using neural network. In Neural Network (NN) each node has to send data to all the nodes in the next layer, which in turns requires lots of energy. Instead of that we form a clusters, in each cluster elect cluster node. Cluster node processes the data and send directly to the base station or through other cluster node. We periodically change the cluster and cluster node in order to balance the energy constraints.

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*Keywords:*Wireless Sensor Network ; Artifical Neural Network ; Data Aggregation ;

1. Introduction

Wireless Sensor Networks (WSN)[1] are spatially distributed, collection of nodes in order to make a large network. These sensor nodes are capable to sense, process and communicate information among the nodes. The main popularity of sensor node is, they are small in size and minimal design constraints.

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They can be deployed in any place without any installation. These make the WSN more popular. Now days the application area includes smart space, homeland defence and crisis management. The deployment of WSN is distributed so we need a proper data aggregation scheme to combine the data from different nodes and to produce the final result.

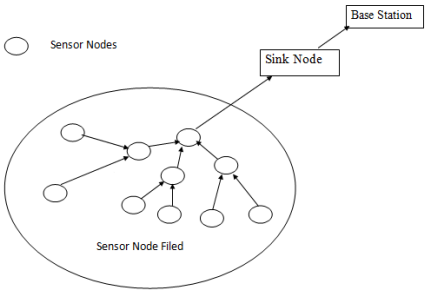

Fig 1. A Typical WSN

Some of the earliest methods suggested for data aggregation was one-bit fusion rule[2] ,it uses performance indices for the decision fusion. But it is difficult because it requires the knowledge about performance indices (pd, pf) Also it is applicable only for star topology or single hop networks. Secondly, B G Jagyasi proposed a Weighted Aggregation Scheme (WAS) [4] for multihop networks. But the main design issue is, it requires the knowledge about number of descendant. In [5] Bhushan G Jagyasi again proposes a novel Adaptive Weighted Aggregation Scheme (AdWAS) for both star and tree topology. They first introduced a Least Mean Square (LMS) based AdWAS for star topology later extended it to tree topology. Above methods reduces the power consumption to a reasonable value but it is not optimal.

In this paper we propose a new technique to reduce battery consumption based on the Artificial Neural Networks (ANN). The idea is to train the network to produce data fusion in a reliable manner by reducing the unwanted flooding of information. NN are mainly a data mining tool for classification and clustering.

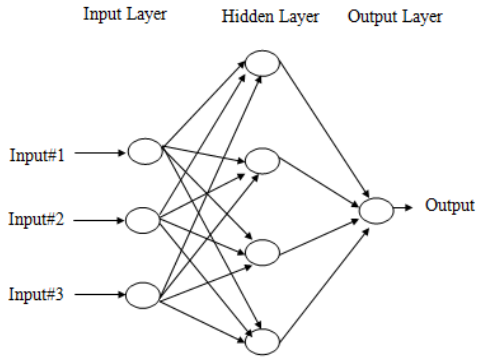

Fig. 2. A Typical Neural Network

The generic NN is composed of three layers, input layer,output layer and several hidden layers. All nodes in one layer are connected to the nodes in the next layer via weighted links. Input layers to receive inputs, an output

layer to receive information from the hidden layers and process it to produce final results, finally hidden layers to connect both input and output layers and also forward data from one layer to another. The NN usually learns by examples. The output is compared with the pre-defined output.. If there is any difference it indicates an error. This error is used to alter the weight to reduce the error small enough

2. Existing data aggregation methods

In this Section we re-visit all the data fusion methods in details.

2.1. One-bit CV rule

Varshney et al.proposed a Bayesian based one-bit CV rule mainly for an efficient data aggregation in single hop network(star topology)for binary event detection. In 1-bit CV data fusion rules, some prior knowledge about the performance indices. In the case of sensor node it is probability of detection(pd) and probability of false (pf) alarm. Data fusion is carried out in each sensor node to produce an optimal result at the fusion centre. B J Jagyasi extends the one-bit CV rule into multi bit. It also requires prerequisites knowledge about the performance indices.

2.2. Adaptive Weighted Aggregation Scheme (AdWAS)

In order to overcome the disadvantage of one-bit CV rule, Adwas was introduced. It does not require the computation of performance indices. However periodic updated weights required.

(1) Adwas for star topology: The main drawback of CV rule is the knowledge of pd and pf.In order to overcome these B J Jagyasi propose Adwas it does not require the knowledge about the performance indices. As per [5] , at any instant we use the input x(n) and corresponding weight w(n) made by
node S_i.The fusion centre produces the final result y (n).

$$y(n) = \sum_{i=1} x(n)w(n) \tag{1}$$

Where k is the number of neighbour nodes. The new weight ws(n) done by the Least Mean Square (LMS) based algorithm. Next step is to calculate the error. Here H (n) denotes the desired output and y (n) represents the actual output.

$$e(n) = H(n) - y(n) \tag{2}$$

So finally weight updated , by the equation

$$W(n+1) = W(n) + \mu X(n)e(n) \tag{3}$$

where μ is the step size. After weights are updated final decision is made.

(2) Adwas for tree topology: Deployment of sensor nodes not always single- hop it can be multi-hop .The data fusion is more difficult in tree topology compared to star because every node acts as a fusion centre .Each node in the network is allowed to change the received data and propagate this data to the immediate nodes to reach the base station. In this method data is aggregated into a single one bit result and transmit it to sink node.

2.3. Multihop Wireless Sensor Neural Network (MWSNN)

In this method we re-visit the problem of binary event detection in WSN and also introduced a new method which is based on neural networks. In NN the main computational elements are neurons. It has the capability to process various inputs received from different input links and produce an output. Links are associated with some weights. Input layer function is to feed the desired raw information to the network. The hidden layers receive the information from input layer, process the input values and sent to the output layer. Output layer combines the various hidden layer values and generates the final results. Next step is to compare the desired output with the generated output, if there is any mismatch it's named as error. Error is back propagated to the hidden layer. These steps are repeated until we get a reliable error value.

The training of NN is usually by examples. We feed the network with a set of sample inputs and output values. We will train the NN to produce the desired output for particular input. In MWSNN neurons in the NN are replaced with our sensor. Assume that every node detect a binary event with some precision P . The data is transmitted to a single node on the next layer to reduce the practical constraints like deployment and energy. Additional hardware component embedded is an aggregator. Its main role is to combine the results which came from the previous layer and forward it to next layer.

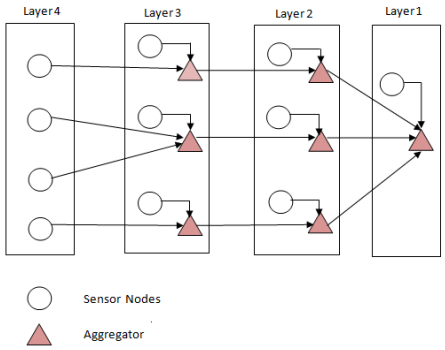

Fig. 3.Neural Network based WSN

Each node process the information in the following manner, As per JabalRaval et al. consider the node s let y(n) be the observation made by the node and w(n) is the corresponding weight. We compute the decision X (n) as

$$X(n) = y(n)W(n) + \sum_{i=1 to k} y_i(n) w_i(n) \tag{4}$$

Where k is the set of child node Indies. One additional function applying to X(n) is sigmoid function to make the binary decision.

$$Y = 1/\left(1 + e^{-x}\right) \tag{5}$$

This binary decision y made by each node is transmitting to sink node. As the usual error detection, calculate the error by subtracting actual desired output H (n) from estimated output Hest (n).

$$e(n) = H(n) - H_{est}(n) \tag{6}$$

In NN error is back propagated to leaf nodes in multihop manner to reduce the error .In order to get the error at each node use the following equation

$$e_j(n) = eParent_j(n) w_j(n) Y_j(n)(1 - Y_j(n)) \quad (7)$$

After all this process final weight updated as,

$$w_j(n+1) = w_j(n) - grad_j(n) \quad (8)$$

The next training sequence uses the new weights for training the algorithm.

3. Comparison

Table 1.Comparison table

Method Name	Efficiency	Energy Consumption	Fault Tolerance	Complexity of Design
CV Rule	High	Medium	Low	Low
AdWAS	Between CV Rule and NN	Lower than AdWAS	Low	High
Neural Network(NN)	High	Low	High	High

Main design concern in WSN is the power consumption;table shows it is low in neural network because it works intelligently .Efficiency is almost same for both CV rule andneural networks. NN requires a large data set for the network training so the design complexity is high as compared to other methods.

4. Proposed active cluster node aggregation method

In the proposed method instead of sending data from each node to every other node in the next layer, the nodes themselves construct a group in such a way that adjacent sensors form a cluster. Within the cluster one node in nominated as Cluster Head (CH).Sensor nodes periodically send data to cluster node. The data aggregation process is performed by CH. The result can be send straight to base station or through other cluster nodes in the intermediate layers.

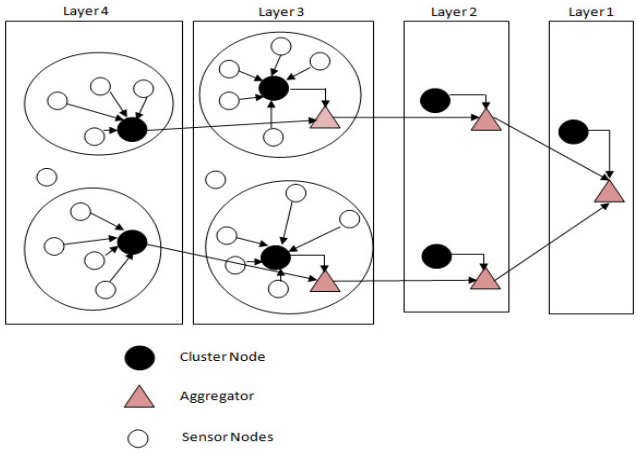

Fig. 4.Neural Network based WSN

Cluster nodes changes frequently in order to balance the energy consumption. The advantage of using neural network is that it learns from the previous experience and responds like a human. After the successful learning of NN, if we want to send a data from leaf to sink node NN will find a reliable energy efficient path.

5. Conclusion

In this paper we discuss various data aggregation methods, and how they reduce the data transmission power. We compare all the methods like CV rule, Adwas, finally using neural network. Neural Network is new technique of machine learning .We train the NN to make reliable energy efficient data propagation by using the past experiences. The results of the comparison prove that NN based data aggregation method is efficient as well as power consumption is minimum.Also proposed a dynamic data aggregation method based on clustering via Neural Network.

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