MANTECH Publications

Journal of Current Trends in Electrical Engineering
Volume 4, Issue 1, January-April, 2019

Implementation of Weighted Compressive Data Aggregation in Wireless Sensor Networks

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Abstract

Wireless Sensor Networks consists of sensor nodes continuously monitoring environment data and then transmitting to the Base Station (BS). If data is not processed before sending to BS, it consumes more energy since energy required for transmission is more compared to energy required for processing. Therefore a Traditional Compressive Sampling (CS) data aggregation method is used. This CS method for each CS measurement more number of sensors are involved leads to ineffective consumption of energy in the Wireless Sensor Networks (WSNs). To resolve the issue a new method in the network layer called Weighted Compressive Data Aggregation (WCDA) is implemented in this project. These algorithm sensor nodes are able to control the power to forming energy efficient routing trees and to minimize the consumption of energy by use the sparse random measurement matrix. Another data aggregation method called as Cluster-based Weighted Compressive Data Aggregation (CWCDA) is implemented in this project. CWCDA is the improved version of WCDA and it significantly reduces the energy consumption in WSN model. CWCDA algorithm at each cluster runs the WCDA algorithm to decrease number of sensor nodes participated throughout Compressive sensing. In the algorithm, for each cluster candidate nodes are selected to each collector node forms the collection tree have little structure than the WCDA algorithm. The WCDA and the CWCDA algorithms are compared and an analysis of energy consumption and life time of the network in terms of sink

location, CS measurement samples and number of sensor nodes and clusters.

Keywords: *Wireless Sensor Networks, Compressive Sampling, Wireless Sensor Networks (WSNs), Cluster-based Weighted Compressive Data Aggregation (CWCDA)*

INTRODUCTION

WSNs consist of spatially allocated self-controlled sensors to monitor environment Physical conditions such as pressure, temperature and sound, and to co-operatively pass their data to the base station.

MOTIVATION

Wireless Sensor Network applications like natural environment monitoring consists of independent, stationary, location-aware wireless sensor nodes which are battery operated. Continuous monitoring of data consumes more energy and because of the limited energy the network becomes less energy efficient. Therefore compressed data is transmitted, which reduces the transmission power and increases the network lifetime. With this purpose two Compression techniques are implemented and compared.

METHODOLOGY

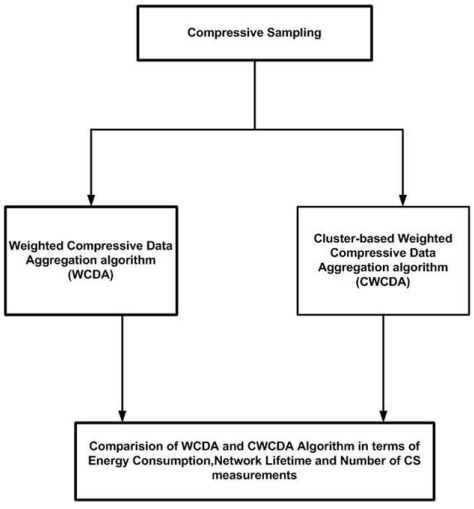


Figure 1: Flow of the dissertation work

Flow of the dissertation work is shown in Figure 1.

In this project the compression sensed data is aggregated using WCDA and CWCDA algorithms

- Compressed sensed data is obtained after loading environment data into each node.

- WCDA algorithm is used for aggregation of the compressed data.

- The sink node receives the combined data and is recovered, same procedure is repeated using CWCDA algorithm.

- The outputs of the two algorithms are compared with respect to energy consumption and network lifetime.

Wireless Sensor Networks

In the present third generation of the computer evolution termed as Ubiquitous computing era, people are unknowingly interacting with the computers in their daily-life activities. WSNs are one among those key technologies which supports Ubiquitous computing. WSNs are comprised of various types of sensors which consist of minute micro-controller boards called as sensor nodes. Wireless sensor networks can perform well in Ocean Pollution Detection, Medical Services, environment Monitoring, surveillance and information collection thus they represent a highly demanding research area. The concept of WSNs comprises of sensing, computation and communication into a small device [7].

Energy consumption can be carried out following steps:

Data Processing, Data Transmission and Sensing. Data Transmission Consumes more Energy than the Sensing and Data Processing. Sensor nodes are communicated with a BS by using wireless radios and also with each other.

Sensor Node Structure

The Block diagram shows the sensor node Architecture consisting of processing unit, sensing unit, power unit and communication unit.

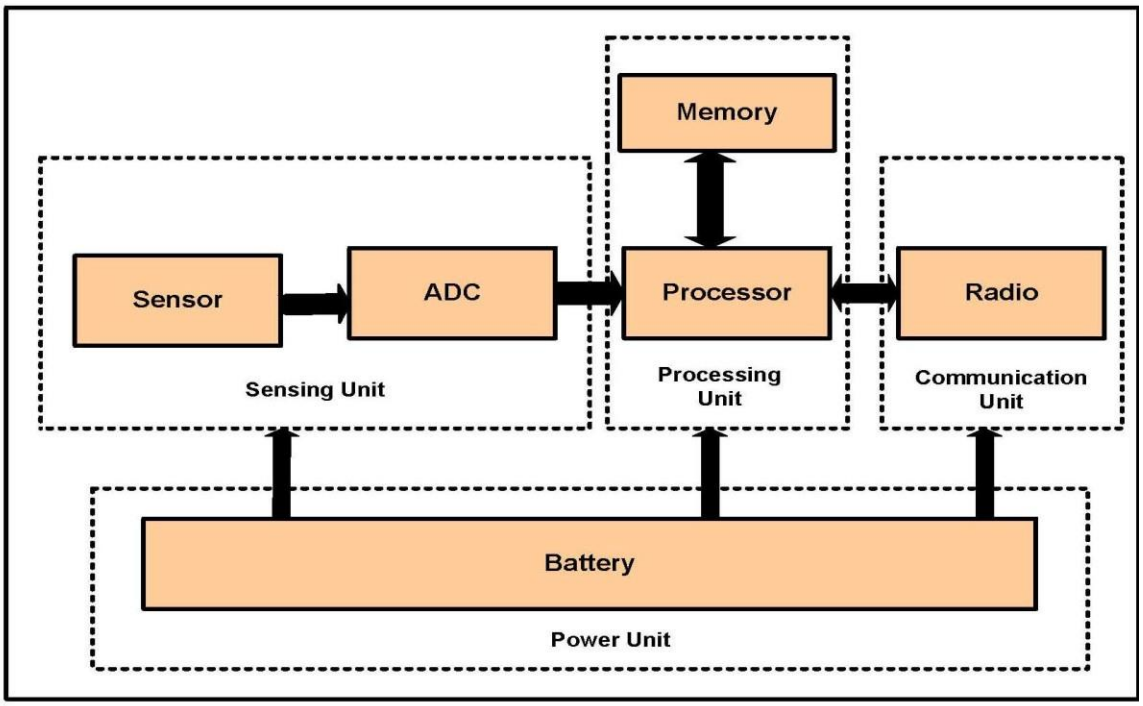
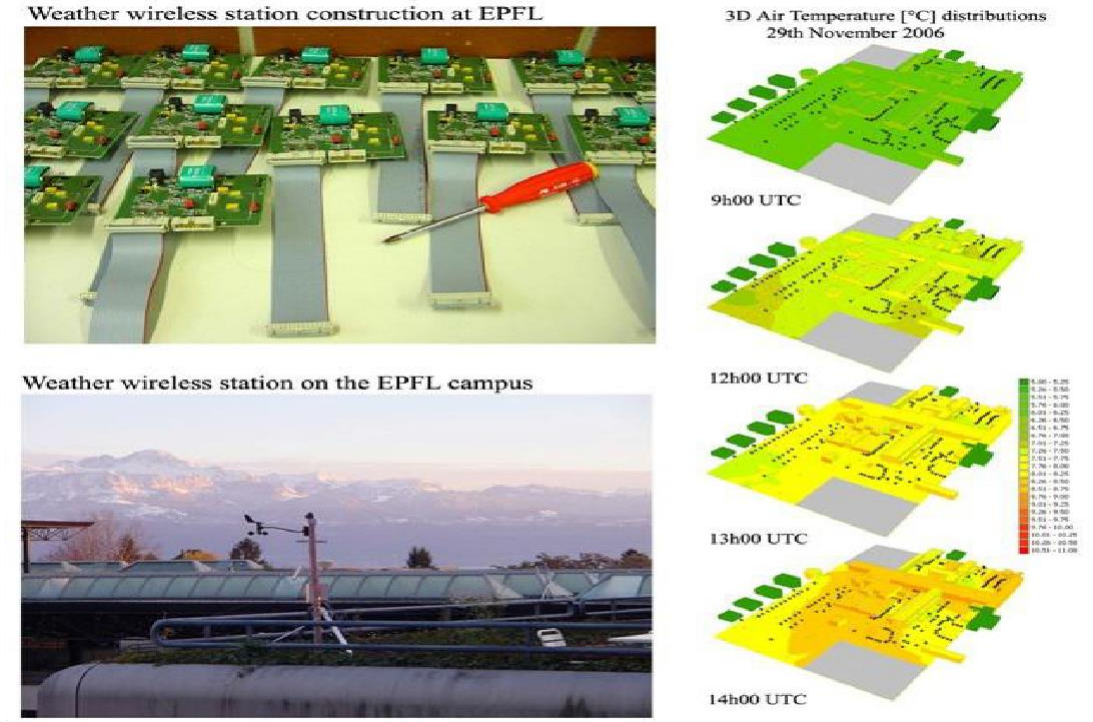


Figure 2: Sensor Node Architecture



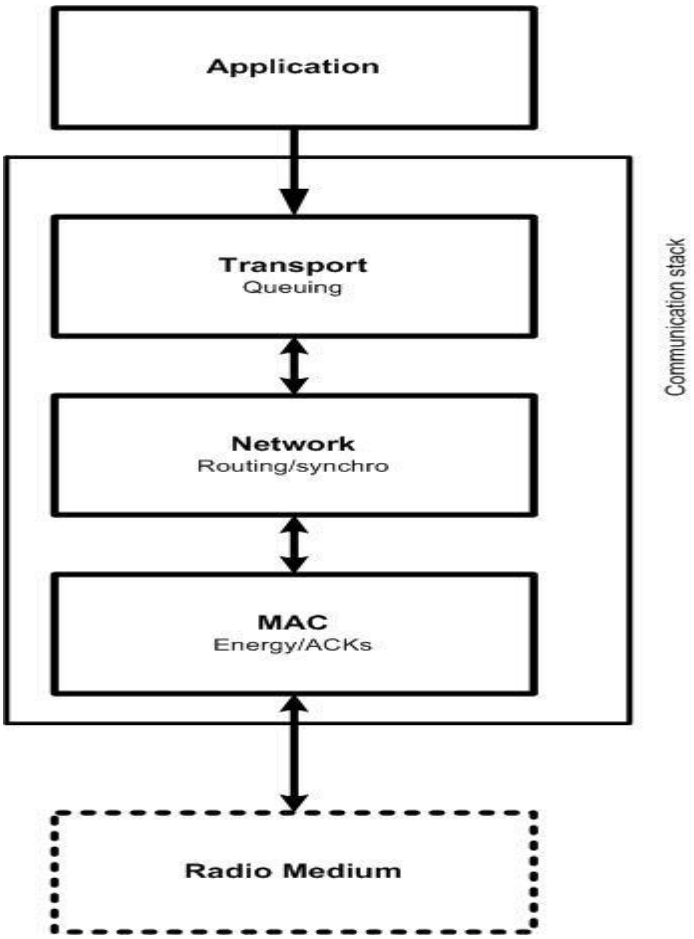


Figure 3: The Stack

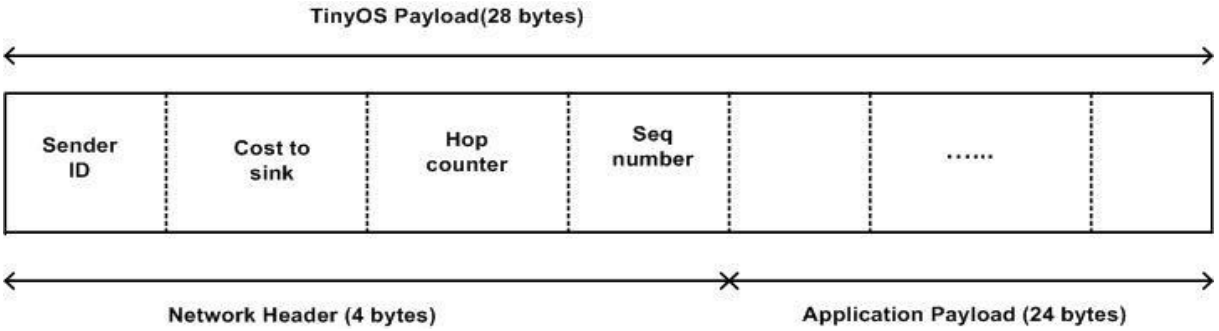


Figure 4: Packet format

Applications of Wireless Sensor Network

1. Structural Health Monitoring
2. Traffic Control
3. Health Care
4. Pipeline Monitoring
5. Precision Agriculture
6. Active Volcano
7. Underground Mining

Sensor scope

Communication stack consists of 4 layers:

Application: Application layer is responsible for collect measured data then transmitto the sink.

Transport: Transport layer creates and receiving the packets there is need queues them depends on their data type. Sink node reply to routed the data packets particular neighbor by controls like Acknowledgements. When traffic is low no need of congestion control mechanism. Two fields of the header are fill up they are number of hops executed by each packet and also sequence number.

Network: Network layer packets are given to the MAC layer, choose a next hop the data packets fills the fields contains the sender identifier and cost of the route towards a sink. At this level all routing decisions are taken with a new protocol in the network layer.

MAC: when the radio is turned on sending the data packets and also acknowledged the early data packet otherwise the radio is turned off to saves the energy. Radio driver fails to carrier sense a simple back-off mechanism is used for reducing the collisions.

Compressive Sensing:

which is below the classical Nyquist rate".

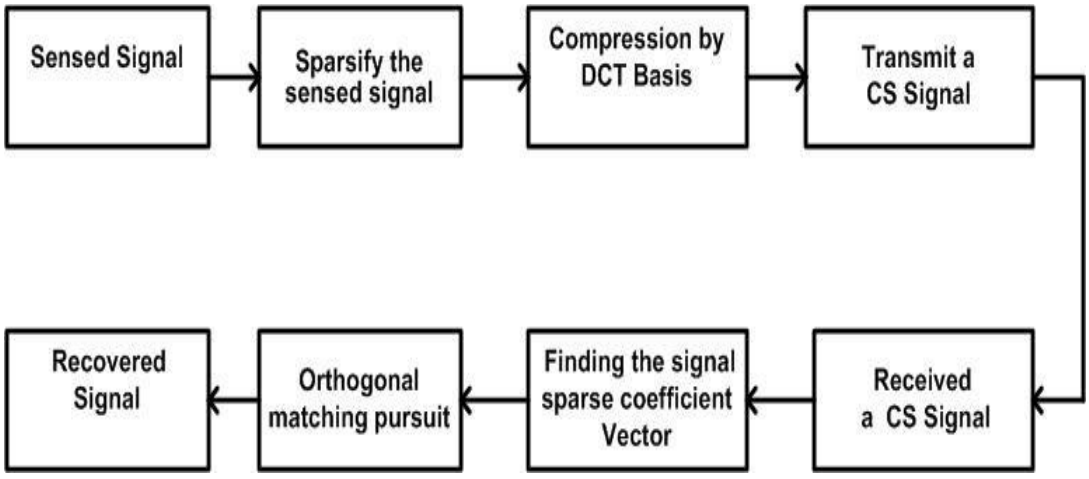


Figure 5: Compressed sensing method.

The Block Diagram shows the compressive Sensing or Sampling. Compressive Sensing is very useful concept when dealing with the limited and

redundant data. Processing of data is of two stages are acquisition and compression stages [9]. Shannon sampling has been 2 major drawbacks i.e. they rate generate a huge and extreme number of samples by the application of large bandwidth and a abundant of unnecessary digital samples for low bandwidth signals. Sparse signal consists of nonzero elements, General linear measurement process computes the inner product between original signal and a random Gaussian sensing matrix [6].

Data Aggregation

In the WSNs data transmission take place either by single hop or by multi hop fashion. Single hop process basically involves direct transmission, where each node sends data to the sink directly and it requires more energy for transmitting the data over longer distance.

Multi hop process each sensor node forwards its data to the neighbouring node, again this nodes retransmitting the data to BS, but near nodes are senses the same data which leads to data redundancy. Transmitting the redundant data to the sink consumes more energy, to transmit the data in energy efficient manner called "Data aggregation".

Data Aggregation Techniques:

Data aggregation techniques are of four types which are mentioned below:

1. Centralized Approach
2. In-Network Aggregation
3. Tree-Based Approach
4. Cluster-Based Approach

1. Centralized Approach

In centralized approach sensor nodes are transmitting the data to central node through the shortest possible path. Central node in turn sends the collected data to the leader node, which aggregates the data which needs to be queried. Centralized approach is represented in the Figure shown below.

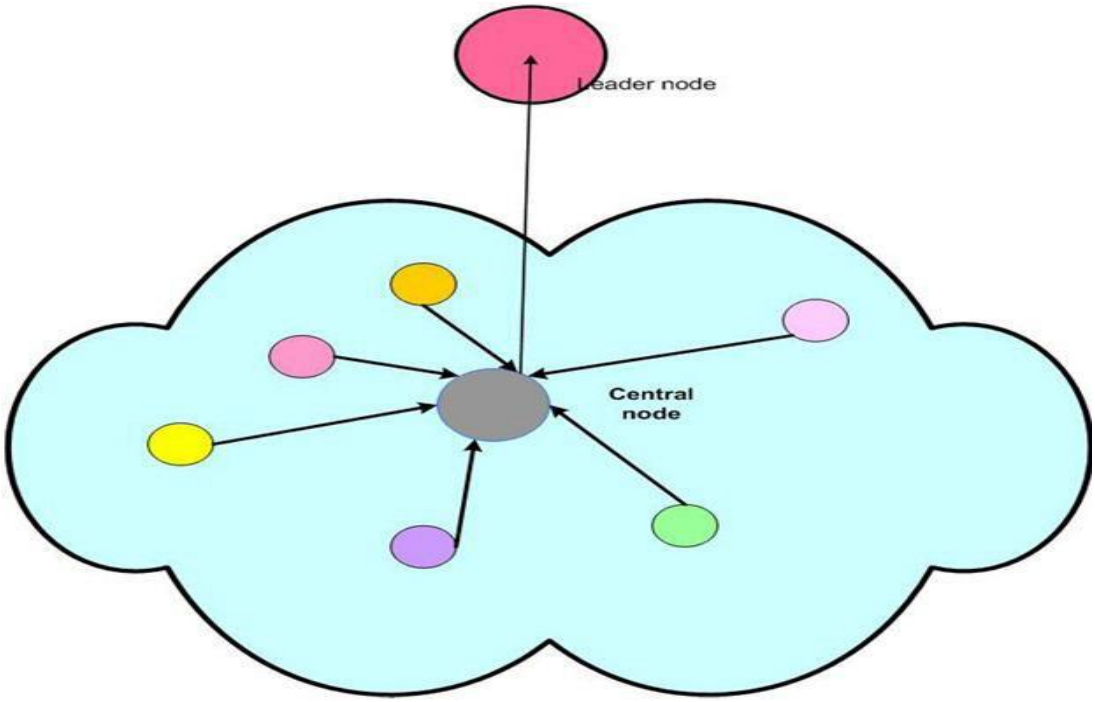


Figure 6: Centralized Approach

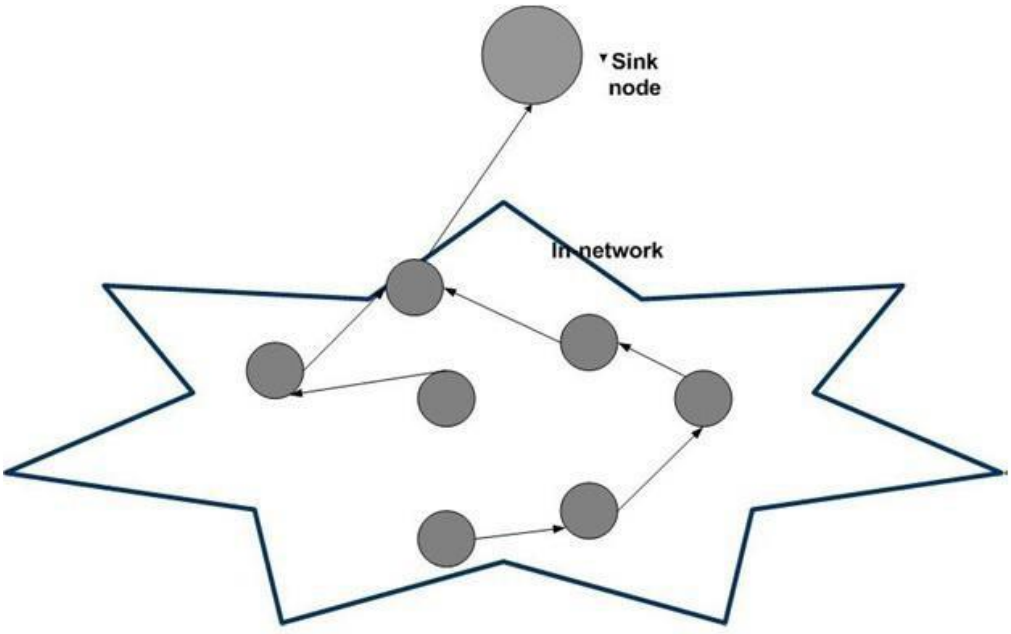


Figure 7: In-Network Aggregation.

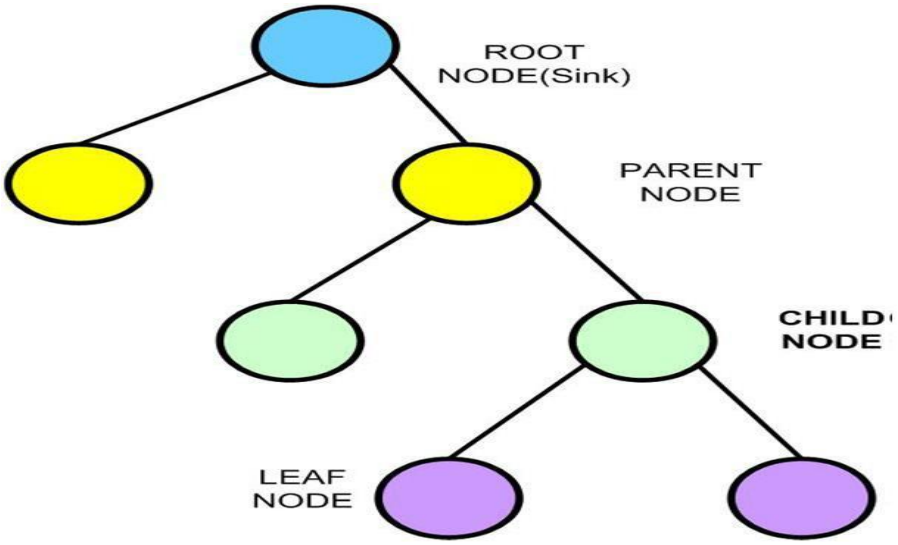


Figure 8: Tree-Based Approach

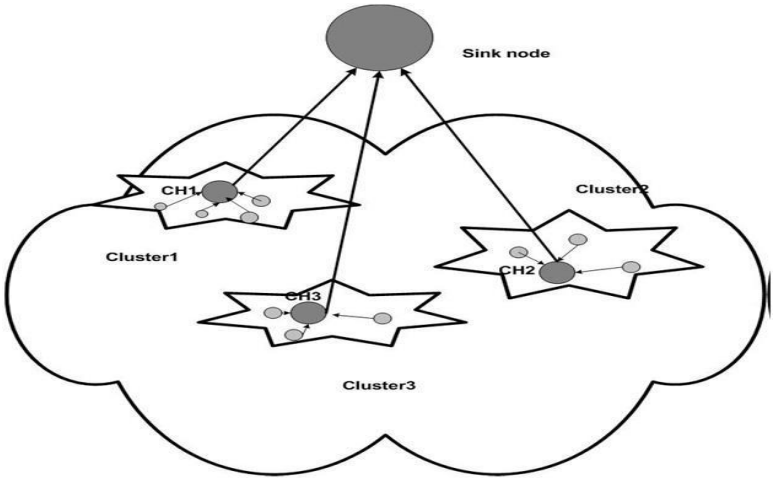


Figure 9: Cluster-Based Approach

In Network Aggregation Approach:

In network aggregation is the routing and gathering data through a multi-hop network .The data is processed at the intermediate nodes in order to reduce the resources to save the battery power, thereby increasing network lifetime. In-Network Aggregation is represented in the Figure shown above.

Tree Based Approach:

In tree based approach aggregation is executed by making the aggregation tree called as spanning tree. Each spanning tree

consist of four types of nodes they are sink node, parent node, child node and the leaf node as shown in the Figure.

Cluster Based Approach:

In cluster based approach Entire network is divided into many clusters. Among the Clusters CH is selected among the cluster, each CH acts as aggregator which combines the data received from cluster members and then transmits to sink. Cluster-Based Approach is represented in the Figure 9.

Cluster-based Weighted Compressive Data Aggregation algorithm

The WCDA algorithm candidate nodes are randomly selected from the routing trees, some of them far away from each other collection tree is formed with a lot of links. The above challenges to motivate an another energy efficient data aggregation method over the network called as CWCDA.

K-mean algorithm

The CWCDA divides the WSN into nc local non-overlapping clusters by using the K means Algorithm is denoted by C = c1; :::; cnc , sink node aggregate the data of all clusters, maximum communication range of each node in cluster ck indicated by Rck .

Step1: Number of Clusters(k) must be known to be previously.

Step2: K number of cluster center such that they are furthest distinct from each other.

Step3: Assign node to the each cluster which is closest.

Step4: Recalculate cluster center by finding mean of nodes belongs to the same cluster.

Step5: Repeat the step 3 and 4 till shifting of cluster center are observed. The Outcome of CWCDA algorithm in this ways:

Collection tree: denoted by _i;k; i = 1; ::::;mk, tree is formed between the collector nodes and candidate nodes in cluster ck using the WCDA algorithm.

Cluster head tree: The cluster head tree is indicated by _k; k = 1; ::::; nc, corresponding to the kth cluster head, tree formed between the CH and collector nodes in each cluster.

Backbone tree: backbone tree is denoted by BT tree is formed between the sink and CHs

4.1 CWCDA algorithm steps

1. Initialization:
2. Cluster Head election:
3. Intra-cluster data aggregation:
4. Inter-cluster data aggregation:
5. Terminate:

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Initialization

- Deploying the 24 sensor node at an 1200 _ 700 area and also define the specification of each node its location, energy consumption for link, range for transmission, size of bits.
- Weight is assigned for each node based on its weight in a Time division multiple access
- Tree cost of the node is equal to 0 then treated as sink
- Divide the all sensor nodes into clusters nc using the k means algorithm.

Cluster Head election

- For clustering the network k mean algorithm is used. The first iteration of the Communication midpoint of each cluster is identified, node nearer to the center elected as a Cluster Head (CH). This type of selection of CH decreases the intra cluster energy.
- The next iteration of communication, the node having more energy is chosen as a Cluster Head in each cluster.

Intra cluster data aggregation

- Calculate distance between each node to cluster head in each cluster, if the distance is less than 30m within this node is chosen as a collector node.
- Finding the distance between remaining nodes to collector nodes which is having distance is less than 30 is selected as a single hop node, and then connects to their corresponding collector node. Otherwise node is treated as multi hop node forms multi hop connection.
- To build collection tree in each cluster dijkstra algorithm is used.
- Formation of cluster head tree is the shortest path between collector nodes in eachcluster ck and their corresponding CH by using dijkstra algorithm.
- In each cluster, collector nodes transmit the compressed data to cluster head _tk, k = 1; ….nc.

Terminate

Energy of the node (Ei; i = 1; ::; n)is equal to 0 the algorithm is stop.

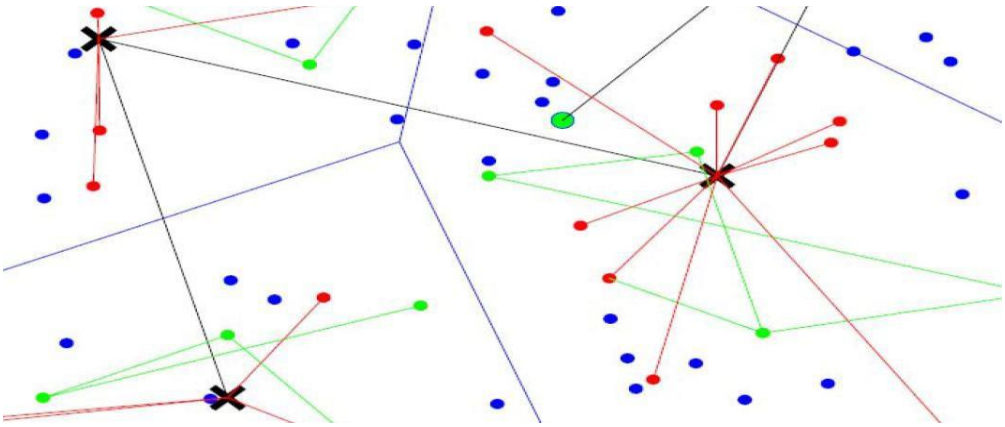

Figure: 10

CONCLUDING REMARKS

In this chapter CWCDA algorithm has been studied and implemented. Entire network divided into number of clusters by using K-mean algorithm, in each cluster select the cluster head and collector nodes. In each cluster collection tree formed by using WCDA algorithm, cluster head tree is formed by dijkstra algorithm and backbone tree formed is consists of all the cluster heads and sink node. Clusters heads aggregates its own cs measured data and transmit to sink through backbone tree, sink receives cs measurements of cluster heads and recover the sensed data.

Conclusion and Scope for Further Work

Data aggregation finds its importance in monitoring applications in general and in particular weather monitoring applications where the environment data such as temperature or pressure of a particular region will be sensed and transmitted to the sink node. In this dissertation work, WCDA and CWCDA compressive data aggregation algorithms have been studied and implemented. Further results obtained and analyzed by taking energy consumption, network lifetime and number of CS measurements into consideration.

Based on the qualitative and quantitative analysis of the results obtained from the implementations of WCDA and CWCDA algorithms the following conclusions are drawn:

- In Compressive sampling method, sampling rate is less than shannon/Nyquist sampling theorem thus the reduces memory for storage unit in each sensor node and also sparse random measurements in sensor nodes have power control ability fora large distance of nodes.

- Tree based data aggregation (WCDA) is suitable for less amount of data to be transmitted towards sink node. In this algorithm collection trees are used to aggregate the data. Cluster based data aggregation(CWCDA) clusters are formed, in cluster WCDA is applied to minimize the energy consumed and hence the network lifetime

These two algorithm are compared on the energy consumption and network lifetime with respect to sink location, CS measurements, sensor nodes which is based on this CWCDA data aggregation algorithm consumes 52 percent less than WCDA, therefore CWCDA algorithm is better.

Future Work

- In the work carried out Gaussian sensing matrix is used as matrix. Instead of this, Bernouli matrix can be used and network efficiency can be compared.
- In the present work immobile node have considered. Network performance can be analyzed with mobile CH.
- The Packet loss during the transmission and consumption of routing energy are discarded for the simplified approach.

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