Improved chain based cooperative routing protocol in wsn

1Awadhesh Kumar Maurya, 2Varsha, 3Neeraj, 4Ajay Kumar, 5Neeraj Kumar
Corresponding Author: ²barkhambright@gmail.com

Abstract - Energy preservation of the sensor become a prime objective of the routing protocols for prolong the period of sensor network and for efficient running of wireless sensor network applications. Taking this aspect into consideration, improved CBCCP approach has been developed that take energy, distance and node Density as parameter to choose cluster head (CH) and cluster-coordinator (CC). In Improved CBCCP, the network is partitioned into layers of fixed measurements and each cluster has one CH and varied no. of CC. Each CH and CC has the load of one cluster just to adjust the load. Data transmit to CH through normal nodes using single hop approach. Data transmitted to base station through cluster coordinator in type of chain. Communication distance is decreased by utilizing cluster coordinator for Intracluster communication and cluster head for inter-cluster communication. In comparison with CBCCP, Improved CBCCP balances the energy and prolongs the period of sensor network.

Index Terms - Cluster, cluster coordinator, communication distance, node density.

1. Introduction

A wireless sensor network comprises of an extensive number of low - cost, low - capability, and multi-purpose sensor nodes that are distributed in areas that are difficult to access, which requires sensors to be energetically autonomous and able to operate without manual intervention. A sensor node commonly comprises of sensors, actuators, memory, a processor and they do have communication capability. All the sensor nodes are permitted to communication through a wireless medium. The wireless medium may both of radio frequencies, infrared or whatever other medium, obviously, having no wired connection.

If the node is not capable to connect with other through direct connection, i.e. they are out of scope range of each other; the information can be sending to the next node by utilizing the node in the middle of them. This property is cited as multi-hopping. All sensor nodes work collectively to handle the requests. WSN gives adaptability of including nodes and removing the nodes as required. Yet, these offers ascend to numerous extreme changes to manage in the network topology, for example, updating the way, or the network tree, etc. In a WSN the node that collects the information relate to sink. The sink might be associated with the outside world through web where the data can be used inside time limitations.

The outstanding issue in utilizing these networks is restricted battery life. This is because of truth that the measure of a sensor node is relied upon to be little and this prompts limitations on size of its parts i.e. battery estimate, processors, information putting away memory, all are should have been little. So any improvement in these networks should concentrate on energy preservation. In WSN a ton of detected information and steering data must be sent which frequently have some time requirements with the goal that the data can be used before any accident happens, e.g. industrial monitoring, machinery monitoring, etc. The energy power consumption is significantly higher in information communication than internal processing. So energy preservation in WSN is should be tended to.

The traffic in Wireless Sensor Network relies upon number of inquiries produced per mean time. As expressed before the sink infuses the question into the Sensor network and sensor nodes react to the inquiry suitably. They either react as an inquiry answer or further floods the questions to the downstream nodes. Ultimately the sensor node having the result of the infused inquiry will answer to the sink node through some routing protocol. A sensor node also combines the answers to a single reply which rescues the quantity of packets to send back to the sink node.

Usually sensor nodes depend on a battery with restricted lifetime, and their replacement is impractical because of physical limitations. Also the design and convention of sensor network must have the capacity to scale up any number of sensor nodes. Since the battery lifetime can be extended if we figure out how to decrease amount of communication, caching the useful information for every sensor either in its local store or in the neighbourhood nodes can prolong the network period. In this paper, improved chain based cooperative clustering protocol is proposed. The main aim of this protocol is to prolong the network period. The performance of proposed approach will be compared against chain based cooperative clustering protocol (CBCCP)[17]. The paper is classify as follows. In section 2, reviews of previously proposed chain and cluster
based routing protocols. In section 3, the proposed M-CBCCP protocol is characterized. In section 4 Performance analyses of M-CBCCP protocol and comparison with CBCCP protocol is discussed. Finally, section 5 conveys the conclusion.

2. Related Work:

Heinzelman et al. [1] proposed LEACH (Low-Energy Adaptive Clustering Hierarchy), a clustering-based protocol that apply irregular revolution of cluster-heads to constantly spread the energy load among the sensor nodes in the network. LEACH uses localized arrangement to enable expandability and muscle for dynamic networks, and add to data fusion into the routing protocol to decreases the quantity of information that must be routed to the base station.

Younis et al. [3] proposed a novel distributed clustering approach for long-lived ad hoc sensor networks. Proposed approach does not frame any supposition about the presence of infrastructure or about node capacities, other than the availability of multiple capability levels in sensor nodes. Here presented a protocol, HEED (Hybrid Energy-Efficient Distributed clustering), that regularly choose cluster heads suitably to a node remaining energy and node proximity to its neighbors or node degree. HEED ends in O iterations, incurs low message overhead, and accomplish fairly uniform cluster head spreading across the network.

M. Ye et al. [5] proposed a novel clustering schema EECS for wireless sensor networks, which better suits the regular data collecting applications. This approach chooses cluster heads with more remaining energy through local radio communication while gaining well cluster head distribution; furthermore, it suggests a novel method to adjust the load among the cluster heads.

Chengfa Li et al. [7] proposed an Energy Efficient Unequal Clustering (EEUC) mechanism for regular data collecting in wireless sensor networks. It segments the nodes into clusters of unequal size, and clusters near to the base station have smaller sizes as compared to those that farther away from the base station. Thus cluster heads near to the base station can save some energy for the inter-cluster data transmitting and also suggests an energy-knowledgeable multi-hop routing protocol for the inter-cluster communication.

S. Jung et al. [9] proposed the enhanced PEGASIS protocol based on the concentric clustering scheme to solve the problem of duplicate data transmission and no reward of area of base station. The main idea of the concentric clustering scheme is to consider the area of the base station to improve its performance and to prolong the network period.

Muruganathan et al. [10] proposed a centralized routing protocol called Base-Station Controlled Dynamic Clustering Protocol (BCDCP), which divide the energy dissipation evenly among all sensor nodes to enhance network period and average energy preservation. The performance of BCDCP is then compared with Low Energy Adaptive Clustering Hierarchy (LEACH), LEACH centralized (LEACH-C), and Power-Efficient Gathering in Sensor Information Systems (PEGASIS).

Manjeshwar et al. [11] proposed a hybrid routing protocol (APTEEN) which allows for overall information recovery. The sensor nodes in such a network not only respond to time-critical situations, but also convey a whole picture of the network at regular time in a very energy efficient method. Such a network allows the user to inquiry past, present and future data from the network in the form of historical, one-time and persistent queries respectively.

Noroouzi et al. [13] proposed Genetic algorithm based algorithm to develop the optimum clusters. It used direct link to base station, cluster based distance, cluster based distance standard deviation, transfer energy and number of transmission as the fitness parameters. This algorithm perform best than LEACH and M-LEACH clustering protocol in term of network period and consistency in performance.

Shilpa et al. [15] proposed cluster chain weight metrics approach. This method reduce the energy dissipation and adjust the load by choosing cluster head nodes first, based on three parameters node degree, average energy and minimum path loss factor and then forming the well divided cluster. This method reduce the overhead of the network and communication cost and gaining higher energy efficiency, better load adjusting and extending network period.

Y Kang et al. [16] proposed a hybrid node scheduling approach. It adds sleep scheduling for periodically monitoring area of interest in time-driven modes and wakeup scheduling for tracking emergency events in event-driven modes. A failure rate is inserting to the sleep scheduling to improve the reliability of the sensor network. A wakeup sensor threshold and a sleep time threshold are inserting in the wakeup scheduling to decrease the energy consumption to the possible extent.

S. Rani et al. [17] proposed EEICCP (Energy Efficient Inter Cluster Co-ordination Protocol) which adopted grouped approach for the clusters and Communication between the clusters by using cluster heads and cluster coordinators. Here checked the impact of homogeneous densely deployed network with novel approach of grouping of clusters with inter cluster coordination in terms of energy, time, reliability and complexity in wireless sensor networks that are hierarchically clustered.

Shalli Rani et al. [18] proposed chain based cluster cooperative protocol, which divide the region into subarea and elect the cluster heads and cluster coordinators based on distance and energy. Organization and mutual efforts among local node
using relay nodes in local cluster. Routing was based on predefined path. Communication distance is reduced by using cluster coordinator for intra cluster communication and relay node inside cluster.

A. Energy Model

Radio model used to figure the measure of energy consumed by sensor node to transmit and get l bit message for distance d. this model use both channel models of free space with $d^2$ power loss and multipath fading with $d^4$ power loss. On the off chance that the distance is less limit at that point free space display is utilized generally multipath demonstrate is utilized [15].

$$E_{TX}(l, d) = lE_{lect} + lE_{mp}*d^4.$$ \hspace{1cm} (1)

$$E_{TX}(l, d) = lE_{lect} + lE_{fs}*d^2.$$ \hspace{1cm} (2)

Here threshold $d_0 = \sqrt{E_{mp}/E_{fs}}$.

$$E_{RX}(l) = lE_{lect} + lE_{bf}.$$ \hspace{1cm} (3)

Here energy consumed by transmitter amplifier for longer distance, $E_{mp} = 0.0013$pj/bit/m$^4$. Energy consumed by transmitter amplifier for shorter distance, $E_{fs} = 10$pj/bit/m$^2$. $E_{lect} = 50$nj is required to run transmitter and receiver circuitry.

3. Problem Identification

In paper [18], a chain based clustering protocol has been proposed. In this clustering performed by dividing the area into ten cluster with dimension of 200 by 20. the election of CH and CC is based on distance and energy, CH and CC can be selected which is further placed as compared to the other node in the cluster. The inter cluster communication is inefficient as it may lead to the overburdening the nodes which are intermediate.

4. Proposed technique

A. Overview

In this paper, we have proposed ICBCCP in WSN. Initially network is partition into ten sub network (cluster) with measurements of 200m by 20m. Each sub network has 100 nodes that are randomly deployed in the network. Every sub network has one CH and changing number of CCs. Number of CCs continues expanding from 0 to 9 with 1 number incremental at every level. It is done in such a way that every CCO handles the load of one sub network only. Selection of Cluster Head and cluster coordinator are done on the premise of residual energy of the nodes, node Density and distance parameter which is basically calculated from the sink. The sub network in the region 0–20 m is the primary level cluster which has one CH that got information from ordinary nodes and transmit that information to next level cluster (21–40 m) node which go about as the cluster coordinator (CC) for the primary level cluster. CC sent information to the following level CC in the following cluster (40–60 m). This procedure proceeds until the point that the information is transmitted to the Base station.

![Figure 1.intra-cluster communication](image-url)
B. ICBCCP Algorithm
Here are the following steps that are incorporated in the designed algorithm.

Begin
Randomly deploy nodes with randi () function.
Initialize all nodes with same level of energy.
Call cluster_creation procedure.
While (all nodes are not dead) do
    Call prediction of CH and CC procedures.
    Call intracluster_communication procedure.
    Call intercluster_communication procedure.
End while.
End.

C. Estimation Of metrics

1) Node Density: Node Density mean no. of nodes which is in its transmission range (tx_range). the value can be find out using $N_D$. Here is source node and $n$ are the neighboring nodes.

\[
N_D = \sum_{n \in N_s \cap S} \{\text{distance}(s,n) < \text{tx\_range}\}
\]

2) Total Distance: For each node, total the sum of distances with all its neighbors. Distance among sensor nodes has been calculated using Euclidean distance formula.

\[
\text{Distance}(s,n) = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}
\]

\[
T_p = \sum_{n \in N_s \cap S} \{\text{distance}(s,n)\}
\]

3) Residual Energy: the Residual energy (RE) of each sensor node ($N_i$) is estimated using the following formula.

\[
\text{RE} = E_i - (E_{t_{rx}} + E_{t_{tx}} + E_{r_{r}})
\]

$E_i$ is initial energy of node. $E_{t_{rx}}$ is Energy consumed during transmission. $E_{r_{r}}$ is energy consumed at the time of reception of data. $E_{act}$ is energy required to keep the node active.

4) CH selection (CHSI):- Cluster Head Selection Index (CHSI) is estimated for each node by using following formula.

\[
\text{CHSI} = \frac{(\text{RE}(i) + \text{ND}(i))}{D(i)}
\]

5) Path Prediction Cost Estimation (PPCE):- Path prediction cost calculated using following formula.

\[
\text{PPCE} = \frac{(W1 \times E) + (W2 \times \text{ND})}{W3 \times D}
\]

$W1$, $W2$ and $W3$ are the weights for the Energy, Node Density and Distance to the Base Station.

D. Description of ICBCCPP
The proposed protocol follows following steps in proposing energy efficient techniques.
1) **Network Initialization**: Network is initialized with network area 200 m X 200 m and network is segmented into ten clusters having 100 nodes in each cluster. These 100 nodes are randomly deployed in the network. Each node is equipped with equal level of energy of 0.5J. Every cluster has one CH and varying number of CCOs. Sink is located at (100,200) m. Number of CCs keep increasing from 0 to 9 with 1 number incremental at every level.

2) **Prediction of CH and CCOs**: Selection of Cluster Head and cluster coordinator are done according remaining energy of the nodes, node Density, distance parameter which is basically calculated from the sink.

```
Algorithm:-Prediction of CH and CCOs
/* CH->Cluster Head, CC->Cluster Coordinator, E_range -> Energy Range, Tx_Range-> Transmission Range */

1. If area is 200 m. by 200 m then election of CHs and CCOs is based on following criteria
2. For area_x=0:200
   For area_y=0:20
      If Node_energy > E_Range && Node_dist < Tx_Range
          Elect one CH
      End if
   End for
   For area_y=20:40
      If Node_energy > E_Range && Node_dist < Tx_Range
          Elect one CH and one CC.
      End if
   End for
   For area_y=40:60
      If Node_energy > E_Range && Node_dist < Tx_Range
          Elect one CH and two CC.
      End if
      End for.
   Repeat until the last cluster reached (x_axis=0-200, y_axis=180-200)
   For area_y=180:200
      If Node_energy > E_range && Node_dist < Tx_Range
          Elect one CH and nine CC.
      End if
   End for
3. For all node
   If node is not equal to CH or CC
      Then
         Node becomes a normal node.
      End if
   End for
Return to calling procedure.
```

3. **Data Transmission**: After the selection of CHs and CCOs in each cluster, the data transmission takes place. Data transmission process takes place in two ways, inter-cluster and intra cluster communication.

3.1) **Inter cluster communication**: In inter cluster communication, normal nodes send data to cluster head (CH).
3.2) Intra-cluster communication:-Cluster Head forwarded data to cluster coordinator (CC). CC forwarded data to the next level CC in the next cluster. This process continues until the data is transmitted to the Base station.

Algorithm:-Intra-cluster communication
/* CH->Cluster Head, CC->Cluster Coordinator, 1->True, 0->False, E_range -> Energy Range. */
1. CH, CC=1
2. For Z=1: total cluster
   If CH (Z).energy<E_Range or CC (Z).energy<E_Range
       Then
       CH, CC=0
       Call prediction of CH and CC.
       Else
       While (CH or CC!=0 & & cluster!= last cluster)
           If last_CH or Last_CC
               Then
                   Send data to base station
               Else
                   Send data to upper CC
               End if
           End while
   Else
   Send data to upper CC
End if
3. Continue with step 2nd till all nodes are dead.
4. Return to calling procedure.

4. Performance Analysis:

We evaluate our proposed approach using MATLAB. We compare the performance of ICBCCP with CBCCP by using two performance metrics Number of alive nodes over Number of rounds, Number of dead nodes over Number of rounds.
TABLE I: Simulation Parameters

| Parameter                                      | Value          |
|-----------------------------------------------|----------------|
| Area of simulation                            | $200 \times 200 \text{ m}^2$ |
| Number of nodes                               | 1055           |
| $E_f$ (energy used in short distant communication) | 10 pJ/bit/m$^2$ |
| $E_{mp}$ (energy used in long distant communication) | 0.0013 pJ/bit/m$^4$ |
| $l$ (length of data)                          | 4000 bit       |
| $E_e$ (Initial energy of the nodes)           | 0.5 J          |
| $E_T$ (Transmitting energy)                   | 50 nJ/bit      |
| $E_R$ (Reception Energy)                      | 50 nJ/bit      |
| $E_{bf}$ (Energy consumption in Beam Forming) | 5 nJ/bit       |

Number of alive nodes: Fig. 3 shows the number of alive nodes in CBCCP and ICBCCP, we can see that the number of alive node of our proposed approach is greater than the existing CBCCP approach.

![Figure 3: Number of alive nodes over number of rounds](image)

2) Number of dead nodes: - Fig. 4 shows the number of dead nodes in CBCCP and ICBCCP, we can see that the number of dead node of our proposed approach is less than the existing CBCCP approach.

![Figure 4: Number of dead nodes over number of rounds](image)

5. Conclusion

In this paper, we have proposed improved chain based cooperative clustering approach. Initially the network is partitioned into 10 sub networks and 100 nodes randomly deployed in these sub networks. Then from each sub networks, CHs, CCs are chosen based on energy, node Density and distance. Every sub network has one CH and varying number of CCs. It is done in such a way that every CCO handles the load of one sub-network only. Intracluster communication cost is decreased by using path prediction cost metrics. By results; we show that proposed approach decreased the energy dissipation and increase the network period.
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