

Energy Efficient Clustered-Chain Based Routing Protocol for Wireless Sensor Networks

Baranidharan V, Bharanidharan N, Preethi D

ABSTRACT--- *The Wireless Sensor Networks (WSN) consists of enormous amount of sensor nodes. These nodes sense the physical parameters from the environment and forward the information to the destination (or) sink node. The sensor nodes have limited sensing, computation and communication capabilities. Those sensor nodes are mostly battery operated devices. This restriction makes the sensor nodes may prone to failure because of the more energy is wasted for data transmission to longer distance. This is a main challenging task in WSN to increase the network lifetime by increasing the number of alive nodes and to decrease the end to end delay and increase the average energy consumption. To aggregate the collected data before transmission is an intelligent technique in WSN. This technique will reduce the number of packets sent across the networks. The existing cluster chain mobile agent routing (CCBRP) having high end to end delay and very high energy wasted for unnecessary transmission of data packets. To avoid this, the modified cluster chain based routing protocol are designed. It makes the advantage of very low energy consumption by using clustering hierarchy, improved network lifetime and very low end to end delay by using chain hierarchy. This protocol runs in two phases. This protocol is simulated and evaluated for the performance metrics has an energy consumed per node, end to end transmission delay, and network lifetime. Those results are demonstrated that the modified CCBRP outperforms than the existing routing protocols.*

Keywords – *Modified CCBRP, routing, Wireless Sensor Networks, Mobile Agent, Data Transmission.*

I. INTRODUCTION

The Wireless Sensor Networks (WSN) are a highly distributed or randomly scattered networks with embedded GPS, memory, sensing devices are called as sensors. These sensors are widely used to sense the physical quantity from the environmental conditions such as heat, humidity, pressure, oxygen, pH level from the different environment. The collected information from the environment is aggregated and transmitted from the nodes to sink or monitoring station the coordination among the all the sensor nodes are needed. The nodes consist of sensing unit, ADC, processor, storage unit, and transceiver etc [1].

The sensed information is a physical stimulus. These analogue values are converted into a digital form by using ADC. The data is processed by the processor and then

transmitted through the transceiver [2]. The received information is stored in the storage unit for further processing. The nodes are powered by the low capacity batteries but, the nodes are required to survive for very long time periods.

To increase the network coverage and data transmission reliability enhancement are need to be achieved. Those sensor nodes are having constraints in inadequate battery, low bandwidth, unattended to sensible environment, packet collision, overloading etc. [3] & [4]. Thus the energy efficient routing protocols are designed to overcome the constraints [5] & [6]. There must be a proper balance between the sensors and the good network lifetime and seamless network connectivity. There are N number of hierarchical based protocols are designed such as cluster based, grid based, chain based, area abased etc. The researchers are proposed the routing agent based routing protocols for WSN [7] & [8]. The data packets are forward based on their geographic coordinates. In this routing protocols, routing agents are used to transmit the information packets from the cluster heads to destination/monitoring sink.

The contribution of this paper are discussed as follows,

1. Cluster chain based routing may suit for high reliable and guaranteed less delay transmission of data packets.
2. Low time complexity and the effectiveness of the network is increased by routing agent.
3. The proposed method is widely used to manage the mobility agent/sink node by the cluster-chain head re-election.

The rest of the paper is summarised as follows in successive sections. Section II gives the related work. Section III explains the modified CCBRP routing protocol. Section IV analyses and examines the simulated results. Section V concludes the paper with future directions.

II. RELATED WORK

From the past decades, there are many authors are come up with their new energy improved efficient routing protocols for WSN. Some of these are given below.

CCBRP is a clustering based routing protocol [9]. This routing protocol used a randomized approach to balance the load of network evenly among all the sensors. This protocol runs in four phase. First, the voting of cluster heads is done and cluster heads are always elected based on their

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remaining residual energy and total count of remaining neighbouring sensor nodes. In second phase, the cluster heads are requesting their neighbouring sensor nodes to forward the data packets through broadcasting messages. After receiving the broadcasting information, the based on the received data packets contains signal strength of the sensor nodes are joined with the cluster heads and forward the data packets periodically. At finally, the aggregated data packets are forwarded to the destination by one cluster head to another.

The chain based routing algorithm was discussed in PEGASIS [10]. The data aggregation is done the sensor nodes are formed a chain. Any node in a single chain may act as head node. The header nodes are selected based on their energy expenditure. After, the chain formation, the sensor nodes are formation, the sensor nodes are formed the data packets by the greedy forwarding strategy.

The cluster based routing protocol is a widely distributed and energy efficient routing protocol. CBRP is a hybrid type of routing protocol. This protocol architecture is combining of cluster heads and tree [11]. In the first phase, the sensor nodes are elected for cluster heads based on their initial energy. Secondly, the aggregated data from the cluster heads to base station are used by the spanning tree method. The drawback of this routing protocol is that non-data message exchanging between the sensors leads a communication and data overhead.

Cluster-Chain Mixing (CCM) routing protocols [12] are having both chain and cluster mixed routing protocols. At initially, the sensor nodes are used to set chains which are placed horizontally and to assign the leader for chains which is having a longer length. Then only, the heads for the various chain groups are aligned together by the vertical and horizontal cluster heads. The fused or aggregated data are transmitted through the base station. The major drawback of the CCM is voting process is not optimized and messages overhead is more. The system level complexity is also high.

III. MODIFIED CHAIN-CLUSTER BASED ROUTING PROTOCOL

In this proposed system, the network routing protocol design combine chain and cluster based hierarchical networks. To improve the network lifetime, the networks have less latency and the high energy efficiency. This routing protocol will increase QOS of WSN. The existing systems the routing protocol is have a mobile Agents are very much useful to perform the aggregation of the data. Here, the Mobile agent is used to monitor the node mobility and data aggregation. The most important focus of the system is to design an energy efficient and improve the network lifetime for the routing protocols. This routing protocol is achieving both very less energy consumption and very less propagation and transmission delay over the entire network.

This routing protocol divides the entire network into a group of clusters. After forming the clusters heads, the chain is formed among the cluster heads and the nodes for data aggregation. After computation process, the aggregated data is collected by the cluster-chain heads based on the localization [13]. The mobile agent is used to collect the

data packets from the cluster-chain head. This will reduce the energy consumption of the nodes in the networks. So, the modified CCBRP protocol is overcome the issues in existing Cluster-Chain based routing protocol. In the existing routing protocol, the cluster-chain head energy drains very faster in collecting, aggregating, and data transmission to destination node.

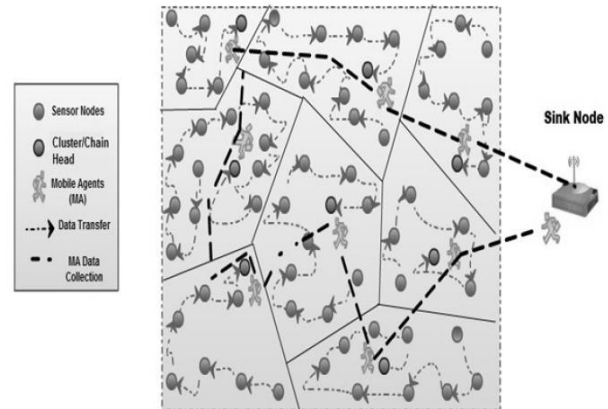


Fig 1.1 Modified Cluster-Chain based routing protocol

The assumptions of the Modified CCBRP routing protocol is given as,

1. All the sensors placed in a random manner are homogeneous in nature.
2. The initial energy of all the sensors are always equal (Before Simulation).
3. The energy consumption is based on the energy required by the node for data packets transmission and reception. Here, we assumed that the energy required for transmission and reception are same.

The figure 1.1 shows the modified CCBRP routing protocol based network model for wireless sensor networks. The networks are divided into few Cluster-Chain heads and clustered nodes. The collected information's are dispatched to the sink node/monitoring stations through the mobile agent. The modified CCBRP routing protocol design is classified into two phases. They are,

1. Cluster-Chain Heads Selection and Election (CCSE Algorithm)
2. Collecting the aggregated data through mobile agent. (CAMA Algorithm)

The chain-cluster heads are the most important nodes which is used to collect the data, process it and then it transmits the aggregated data packets to destination. The cluster-chain heads are formed with both equal and unequal energy balancing clusters. The pseudo code for the chain cluster forming is to be presented in given algorithm is given as,

Algorithm 1: Clustering ()

```

1   set node N, i=0, N(i) for N nodes
2   set Dest nodes
3   sets cluster partition ();
4   i nodes computes the distance  $d_i$  and
   update routing table
5   nodes update the average energy
    $E_{avg}(i)$ 
6   if ( $E_{avg} > E_r(Norm)$ )
7     kind(i) = CCH;
8   end if
9   sends CCH_Selects()
10  if ( $d_i < w_c$ ) // For each node
11  if  $N(i) == E_r(Norm)$ ;
12  kind(i)= CCH;
13  else
14  packets discarded;
15  end if
16  end if
17  each chain-cluster node (CCH) choose
   nearest CCH

```

At the beginning, the network gradient value $N(i)$, node kind are get initialized. Then the broadcasting message are transmitted to all other nodes with in x,y,z coordinates. After receiving the broadcasted messages, all the sensor nodes will update the neighboring information set. The clustered-chain head nodes are selected based on their remaining residual energy. The cluster-chain heads are always having high residual energy. The sensor nodes forming a group with its neighboring clusters. The chain nodes are also grouped under the cluster head. The pseudo code for data transmission is given as,

Algorithm 2: data transmission ()

```

1   CCH collect packets periodically
2   CCH checks  $E_{res}(i) > E_{avg}(i)$ 
3   if ( $E_{res}(i) > E_{avg}(i)$ )
4   CCH calculate  $E_{rx}(k,l)$ 
5   if ( $E_{avg}(i) > E_{TX}(k,l)$ )
6   CCH sends packets to destination
7   end if
8   else
9   CCH forward the packet to multi-hop
10  end if

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The above algorithm explains the Cluster-chain heads transmits the packets periodically from the sensor nodes. After CCH check whether the residual energy of sensor nodes and average residual energy. CCH residual energy is always higher than the E_{res} , then its calculates its destination distance. The distance (d) is greater than E_{TX} then it is sends the data packets or else its packets are routed through the multihop routing.

IV. SIMULATION RESULTS AND DISCUSSION

The Modified CCBRP routing protocol performances are evaluated by using Network Simulator-2 [NS-2]. The proposed CCBRP is comparing with existing CCMAR routing protocol. The important difference between the two

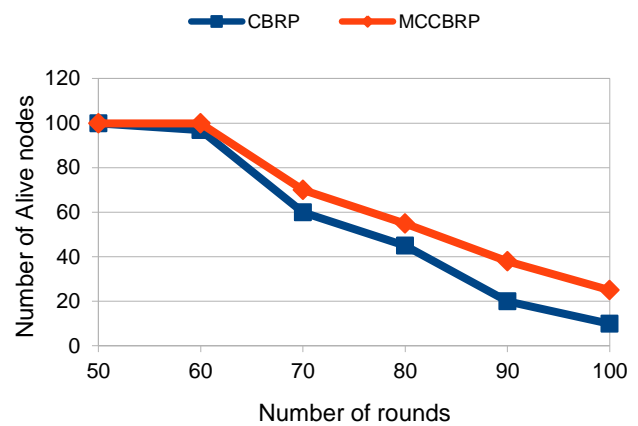
routing protocols is how the aggregated data is collected through the Mobile agent. In this simulation, the 100 sensor nodes are considered. The deployment region is 500m x 500m x 500m.

Table 5.1 Simulation parameters

| S.No | PARAMETER | DESCRIPTION |
|------|-----------------------------|--------------------|
| 1. | Sensor Nodes | 100 |
| 2. | Simulator | NS2 |
| 3. | Deploy region | 500m x 500m x 500m |
| 4. | Nodes transmission range | 250m |
| 5. | Data Packets payload size | 19 bytes |
| 6. | Average Node Initial Energy | 1500nJ |

Network Life time

The time duration required for the first node dies in the network is called as Network lifetime. The figure 1.2 shows that network lifetime of the modified CCBRP routing protocol.



The figure shows that the proposed protocols have the more numbers of the alive nodes than the existing protocol. This modified CCBRP routing is increase the network life time span. The results will demonstrate that the modified CBRP is having high network lifetime because the network routing protocol have very low transmission delay and high residual energy. The sensor nodes have a sufficient energy for the data transmission and reception.

Average energy consumption

The average energy consumed by the nodes for the efficient data packets transmission and reception. The below figure 1.3 illustrates that the energy consumption of the Modified CCBRP routing protocol is less compared with existing routing protocol.



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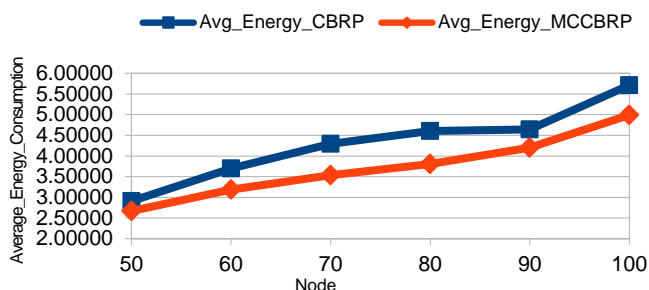


Fig 1.4 Average energy consumed in per node.

To avoid the flooding of the data packets at cluster-chain heads, the packets are collected by the mobile agent by the both Cluster-Chain methods. This will avoid the rerouting within the entire network. So, the nodes are consuming very less energy compares with existing routing protocols.

V. CONCLUSION AND FUTURE WORK

This paper, the modified Cluster-Chain based energy efficient routing protocol has been proposed. This routing is highly energy efficient and capable of increasing the network lifetime of the network, through the energy efficiency and very less propagation delay. The simulated results are compared with existing routing protocols. In this routing protocol, all cluster chain heads of each clusters are used to perform the data aggregation operation by received data packets from all other sensor nodes. In second phase, the Mobile agent collects the data packets from the Cluster-Chain heads. So this, proposed routing protocol has advantages in efficient routing protocol has advantages in efficient data dissemination and gathering. The major issues in their routing protocols are the fault tolerance and security. In future work, it is planned to explore the employment the secured algorithms for the sensor nodes for transmission and reception of the data packets to improve the efficient still more in routing algorithm.

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