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Co-operative Communication with Energy-Efficient in A Clustered Wireless Sensor Network

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Abstract— The concept of co-operative communication is one of the fastest growing areas of research in wireless sensor networks. Energy efficiency is the main issue in the Wireless Sensor Networks (WSN). The energy consumption is minimized using cooperative communication technique. Number of techniques has been proposed in minimizing the energy consumption in wireless sensor networks. In this paper, the two techniques proposed for minimizing the energy consumption have been discussed. During the route discovery process AODV (Ad hoc On demand distance vector) floods the entire network with large number of control packets, and hence it finds many unused routes between the source and destination. This becomes a major drawback to AODV since this causes routing overhead, consuming bandwidth and node power. The proposed enhancement to AODV optimizes CAODV (Cluster Based AODV) by reducing the number of control messages generated during the route discovery process. The optimization method uses the idea of clustering the nodes of the network and managing routing by cluster heads and gateway nodes. Routing using clusters effectively reduces the control messaged flooded during the route discovery process by replacing broadcasting of RREQ packets with forwarding of RREQ packets to Cluster Heads. The performance evaluation of CAODV is carried out through simulation tests, which evince the effectiveness of this protocol in terms of network energy efficiency when compared against other well-known protocols.

Keywords- Clustered wireless sensor networks, co-operative communication, energy efficiency. AODV, Routing, Gateway Node.

I. INTRODUCTION

A mobile ad hoc network (MANET) consists of a number of mobile nodes that jointly function as a router. A MANET can be created dynamically without any infrastructure. In this network type, the use of the clustering technique significantly reduces the routing traffic that occurs during the routing process. Clustering is used to divide an ad hoc network into small sets of nodes, with each cluster consisting of a cluster head, ordinary nodes, and gateway nodes. Clustering can be used for the effective utilization of resources for large ad hoc networks [1].

Most existing clustering algorithms use either geographical regions as clusters or form new clusters proactively even if their function is not needed [2, 3, and 4]. The algorithm by Chatterjee et al [5] creates clusters on demand. However, this algorithm does not use the information maintained by a routing protocol.

We argue that if the routing algorithm is used as a means of gathering clustering information, the clustering and routing overhead can be significantly reduced. The AODV is one of the reactive routing protocols most commonly used in MANETs. Although the AODV protocol performs well with mobile nodes, it incurs high overhead with an increase in the network's size, the nodal degree or the number of communicating source-destination pairs.

By using AODV route construction and maintenance mechanisms, clustering architecture can be constructed on demand. Clusters are maintained when data are to be sent. Such an integrated routing and clustering scheme can improve throughput and reduce routing overhead. The two main contributions of this paper are: (a) we propose a clustering architecture based on an extended AODV routing protocol for cluster formation, maintenance and purging operations; and (b) we propose an adaptive Cluster-AODV routing protocol that uses AODV and clustering information for quick route discovery, maintenance and packet delivery.

II. EXISTING SYSTEM

For clustering the main goal is that the information should flow among various nodes. Before the actual data transmission the control information between source and destination is exchanged and data information is routed by various nodes. If the network topology is large and dynamic then the overhead of information passing increases.

Cluster-based routing is based on the implementation of a hierarchical approach [6] in which the network is organized into subsets of nodes, known as Clusters. Every clustering algorithm consist of two mechanisms, cluster formation and cluster maintenance [7].

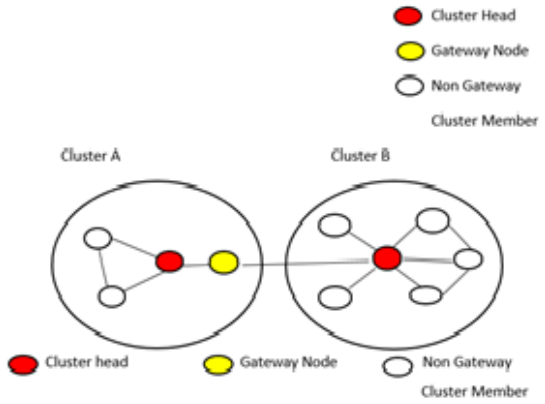

Figure 1. Clustering in MANET

A. *Cluster Formation*

The neighbor table is basically used for supporting the method of cluster formation. In neighbor table the information concerning its neighbor nodes is stored like their ID's, their role in the cluster (cluster-head or member node) and also the status of the link to it node (uni-directional/bi-directional). The Periodic broadcasting of HELLO messages is used for maintaining the neighbor table. The information concerning the one node state, its cluster adjacency table, its neighbor table etc. is maintained by the HELLO message [8].

B. *Cluster Maintenance*

Cluster maintenance is needed when there is a failure in an active link of the network. A link failure can be detected by the loss of HELLO messages from neighbours. If the cluster head doesn't receive HELLO message from its member within a time period, it will assume that the node is dead. The cluster head will delete the entry of the node from the members table. It also reduced its Degree by 1. If a node doesn't receive CLUSTER_STATUS message from its Cluster Head within a time period, it will do the Cluster Join Procedure [8].

C. *AODV (Ad-hoc On Demand Vector Routing)*

AODV is a reactive kind of protocol where the route from a source to a destination is created only when it is needed and it keeps these routes as long as they are desirable by the sources. AODV uses sequence numbers to ensure the freshness of routes and uses Hello messages to detect and monitor links to neighbours.

During the route discovery process AODV floods the entire network with large number of control packets, and hence it finds many unused routes between the source and destination. This becomes a major drawback to AODV since this causes routing overhead, consuming bandwidth and node power.

III. PURPOSED SYSTEM

In the Continues process it has proposed an algorithm in which node energy is considered as a one parameter for selecting a Cluster Head. So, most suitable node which has highest battery power will be elected as Cluster Head. After selecting CH node; this algorithm will form the Cluster by selecting all those nodes as Cluster Member which are nearer to CH. In the proposed algorithm, it works for maintenance of cluster, due to this lifetime of cluster will be increased. Condition for re-clustering is when Cluster Heads' energy will falls down to a predefined threshold value, this algorithm will select next suitable candidate node as CH based on energy parameter [9].

This proposed work will evaluate parameters like PER (Packet Error Rate), Throughput, Energy Consumption and also End to End Delay.

The CAODV reducing the number of control messages generated during the route discovery process. The optimization method uses the idea of clustering the nodes of the network and managing routing by cluster heads and gateway nodes. Routing using clusters effectively reduces the control messaged flooded during the route discovery process by replacing broadcasting of RREQ packets with forwarding of RREQ packets to Cluster Heads. Figure 2 shows the performance of CAODV routing protocols.

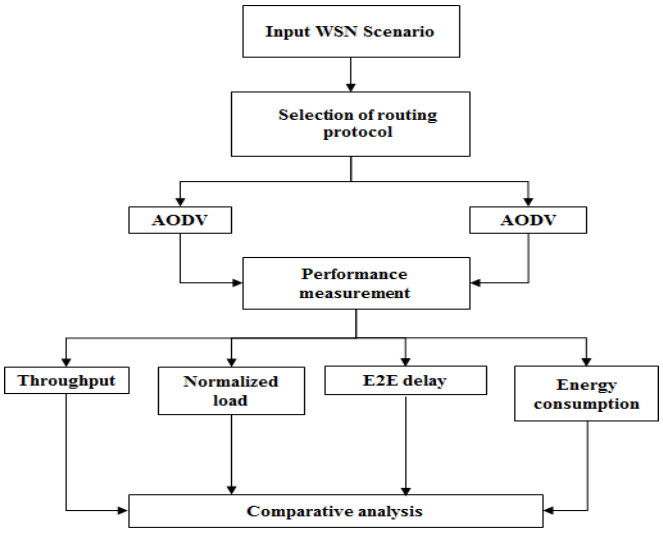

Figure 2. Performance of CAODV Routing Protocol

Proposed clustering algorithmic program can be divided into three phases.

- In Phase 1, the hop tree from the source nodes to the sink nodes is built. In this phase, the sink node starts building the hop tree that will be utilized by Coordinators for data forwarding functions.
- Phase 2 consists of cluster formation and cluster-head election among the nodes that detected the prevalence of a new event within the network.

- Finally, Phase 3 is accountable for each putting in place a new route for the reliable delivering of packets and updating the hop tree.

A. *Algorithm 1: Tree Formation Algorithm Notations*

HCM: Hop Configuration Message
HTT: Hop to Tree

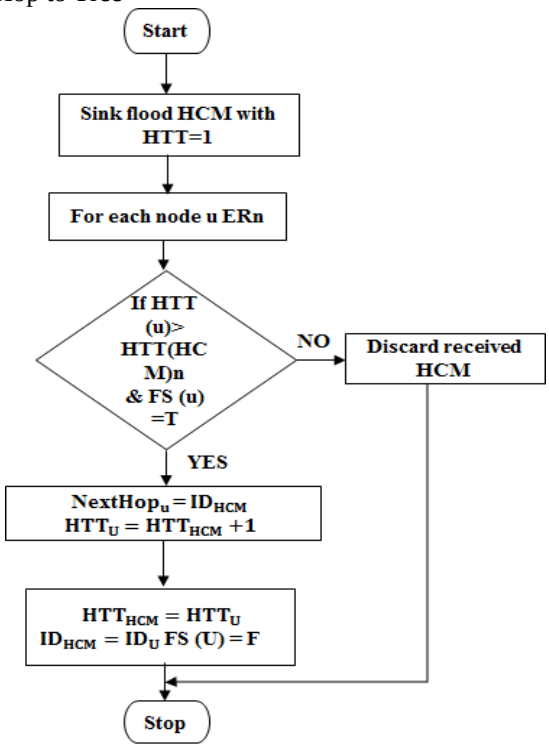

Figure 3. Tree Formation

Before the first event takes place, there is no established route and the Hop to Tree variable stores the smallest distance to the sink. On the first event occurs, Hop to Tree will still be the smallest distance; however, a new route will be established. After the first event, the Hop to Tree stores the smaller of two values: the distance to the sink or the distance to the closest already established route.

B. *Algorithm 2: Cluster Formation Algorithm Description*

When an event occurs, a cluster based on the nodes which detect it (we may call them event nodes) will beformed. The key process of the cluster formation phase election of the leader node (called Coordinator) for the cluster, and the information delivery in this phase is by means of Cluster Configuration Message (CCM). CCM is also a four-tuple:< Type, ID, HTT, State>, where ID is the identifier of the node that started the MCC message, HTT and State fields store the HTT and State value of the node with the identifier ID separately.

CCM: Cluster Configuration Message

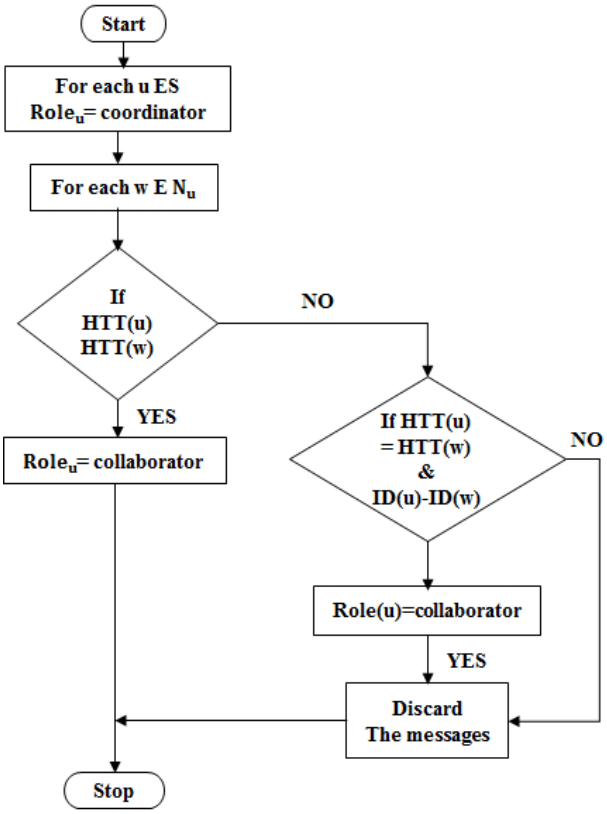

Figure 4. Cluster Formation

The elected group leader, as described in Algorithm 2, starts establishing the new route for the event dissemination. This process is described in Algorithm 3.

C. *Algorithm 3: Route Establishment and hop to Tree Update Algorithm*

The elected group leader, starts establishing the new route for the event dissemination. This process is described in this phase. For that, the Coordinator sends a route establishment message to its Next Hop node. When the Next Hop node receives a route establishment message, it retransmits the message to its Next Hop and starts the hop tree updating process. These steps are repeated until either the sink is reached or a node that is part of an already established route is found. The routes are created by choosing the best neighbour at each hop.

A route repair mechanism is used to send information in a reliable way. Sender nodes wait a predefined time period to receive a packet delivery confirmation. When the confirmation is not received by the sender node, a new destination node is selected and the message is retransmitted by that node [10].

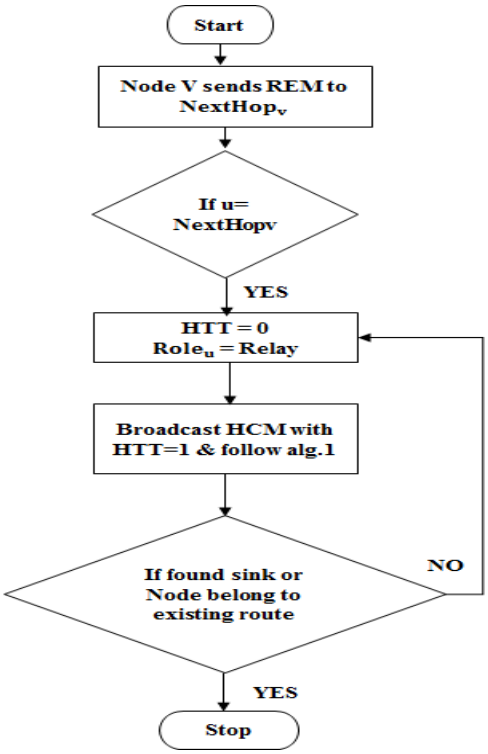

Figure 5. Route Establishment & HTT update

IV. SIMULATION RESULT

We use simulation to evaluate the performance of the protocol. Network simulator ns2 is used for simulating the results. All the simulations are conducted considering a WSN with 50, 100, 150, 200, 250, 300 nodes respectively.

TABLE I. Simulation parameters

Number of sensor nodes	50, 100, 150, 200, 250, 300
Network size	1000*1000
Mobility size	1 m/s
Simulation time	100 s
Transmission packet rate time	10 m/s
Pause time	1.0 s
Routing protocol	AODV/ CAODV
MAC protocol	802.11
Transmission protocol	CBR

V. PERFORMANCE EVALUATION

A. *Avg. Throughput*

Simulation results for Throughput is represented in table II with respective graph in fig. 6. The Avg. Throughput defined that the total amount of data, that the destination receives them from the source which is divided by the time, it takes for the destination to get the final packet.

TABLE II. Avg. Throughput

Sr No.	No. of Nodes	AODV	CAODV
1	50	8.29	9.61
2	100	16.41	18.21
3	150	23.24	23.94
4	200	28.64	29.15
5	250	32.28	34.83
6	300	40.41	40.93

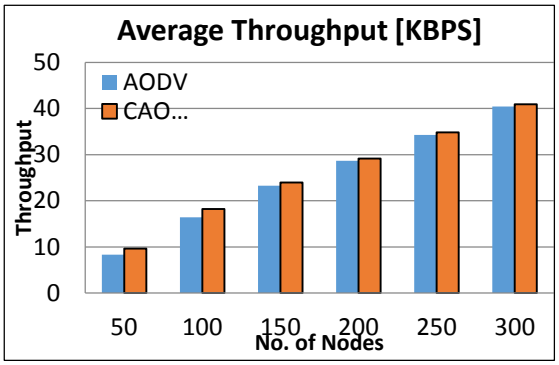

Figure 6:Average Throughput

B. *Avg. Delay*

Simulation results for Avg. Delay is represented in table III with respective graph in fig. 7. The Avg. Delay defined that the average time taken for a packet to be transmitted from the source to destination.

TABLE III. Avg. Delay

Sr No.	No. of Nodes	AODV	CAODV
1	50	0.04	0.039
2	100	0.03	0.028
3	150	0.011	0.01
4	200	0.085	0.063
5	250	0.102	0.07
6	300	0.111	0.078

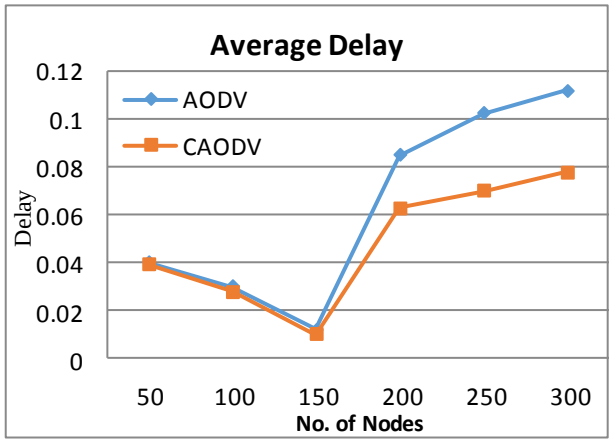

Figure 7: Average Delay.

C. *Avg. Energy Consumption*

Simulation results for Avg. Energy Consumption is represented in table IV with respective graph in fig. 8. The Avg. Energy Consumption defined that the percent of energy consumed by a node with respect to its initial energy.

TABLE IV. Avg. Energy Consumption

Sr No.	No. of Nodes	AODV	CAODV
1	50	1.92	1.34
2	100	1.84	1.41
3	150	5.66	4.64
4	200	10.01	7.5
5	250	11.98	11.19
6	300	9.66	6.65

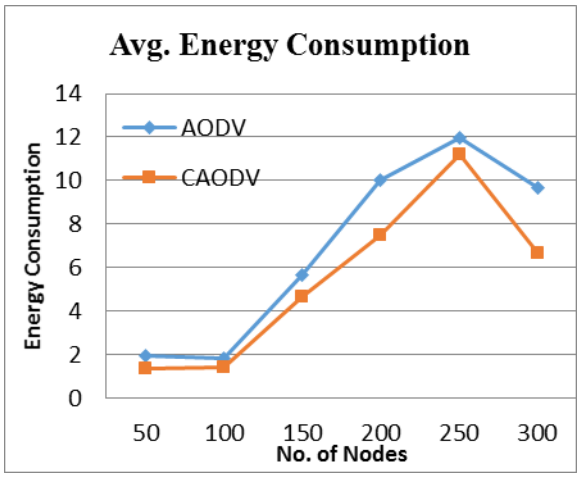

Figure 8: Average Energy Consumption.

D. *Normalized Routing Load*

Simulation results for Normalized Routing Load is represented in table V with respective graph in fig. 9. The Normalized Routing Load defined that the number of routing packets which are transmitting with the original data packet over the network. It is indicates the efficiency of routing protocol in the WSN.

TABLE V. Normalized Routing Load

Sr No.	No. of Nodes	AODV	CAODV
1	50	1.53	1.1
2	100	1.68	1.49
3	150	3.55	2.78
4	200	5.15	4.16
5	250	5.5	4.07
6	300	5.11	2.74

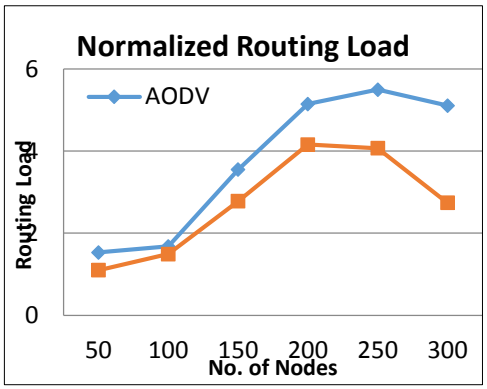

Figure 9: Normalized Routing Load

VI. CONCLUSION

In this paper, we have analyzed, how energy consumption is affected by the transmit power allocation, the total number of sensors in a cluster, the end-to-end packet error rate requirement, the relative magnitudes between the clusters, with the help of Network simulator ns2.

We have proposed a new protocol that is CAODV to find, decrease End to End Delay, increase Throughput also find decrease Packet error rate and decrease Energy Consumption.

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