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An Energy Efficient Unequal Clustered Based Multi-Hop Routing Protocol for WSN

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Abstract: Wireless Sensor Network has been one of the most promising fields in the technological advancement of sensors that explores the various applications. Limited battery resource is the one concerning issue in handling the sensor nodes for the large scale applications. It's almost impossible to replace their batteries once they are deployed in the remote areas or areas which are not in the domain of common people. Development of various routing protocols is being carried out to make the appropriate use of the limited battery. Among them hierarchical routing has been one of the most dominant one to enhance network lifetime. Clustering performs really significantly in terms of handling the scalability of the network. Here in this paper, the research work is focused to enhance the network lifetime of UCMR protocol by applying dual cluster head approach. UCMR has shown much improvement over the UCR Protocol which was the first protocol to mitigate the Hot Spot Problem. The proposed protocol D-UCMR introduces the two cluster heads; Main Cluster Head (MCH) and VCH (Vice Cluster Head) in the single cluster making it energy and load balanced protocol. VCH collects data from all the nodes and after aggregation, it forwards collected data to the MCH thereafter, MCH forwards it to Base Station. Simulation results show that network lifetime is enhancement by a good margin as compare to UCMR protocol.

Keywords: MCH (Master Cluster Head); VCH (Vice Cluster Head); WSN (Wireless Sensor Network); UCR (Unequal Clustering Routing); UCMR (Unequal Clustering Multi Hop Routing); LEACH (Low Energy Adaptive Clustering Hierarchy).

I. Introduction to WSN

A wireless sensor network (WSN) extends human's capability to explore, monitor and to control the physical world with its multi task handling capabilities. It is basically useful in catastrophic or emergency scenario where human intervention is not possible the sensor networks have evolved over a period of time [1]. The failures are inevitable in wireless sensor networks due to hostile environment; therefore sensor nodes must operate potentially in large numbers. The latest generation of sensors encompasses self organizing, flexible and scalable networks. The energy is a critical factor in order to extend the lifetime of the network as nodes once deployed cannot be recharged. Clustering is generally used in WSN to reduce energy consumption of sensor nodes. In an efficient clustering approach, radio communication distance should be as minimum as possible [2-3]. In applications based on large scale WSNs that requires scalability to hundreds or thousands of nodes, hierarchical clustering will be extremely useful.

The architecture of WSN is shown as in the figure 1.1 which shows the process of data collection that is followed by the nodes, so as to send data to the Base Station.

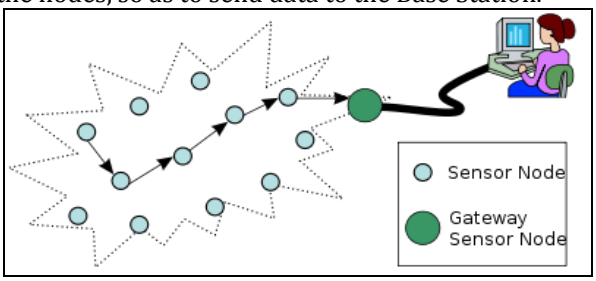

Figure 1.1 Wireless sensor network architecture [3]

WSN consist of various small numbers of nodes which send their data to the leader node which is cluster head in the clustering protocols. Thereafter it is sent to the Base Station. These nodes are wirelessly connected with each other. The sensor nodes are small in size, easy to use and are of low cost. These nodes are having the main components of sensors, ADC, Microcontroller, Transceiver and Antenna. There are also other subunits, which are application dependent and work according to the situtation. Most of the sensor network routing techniques require knowledge of location with much accuracy.

Various routing strategies as being employed in the enhancement of network lifetime [4-5].

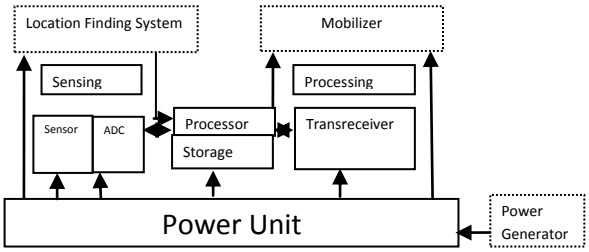

Figure 1.2 Components of sensor node

This paper is organized further as follows: section 2 covers the introduction to Unequal Clustering Protocols, then the proposed protocol is explained in section 3. Conclusion and Future scope are given in section 4 along with references in section 5.

II. Introduction to Unequal Clustering Protocols

While dealing with the clustering protocols, size of clusters really makes a huge impact on the energy balancing in the network. Earlier there use to be same size clusters, when the Base Station use to be at the center of the network. That scenario of network would not have created any problem with the same size. When the Base Station is located outside the network the multi hop transmission takes place. This multi hop transmission would put a lot of burden on the nodes which are cluster heads and are nearby to the Base Station. As they are supposed to relay a lot of data coming from the other clusters present in the network.

So with equal sized clusters the energy consumption of the clusters relaying the data gets on the higher side and it leads to the early die of those clusters.

I. UCR Protocol

It is the first protocol to mitigate the Hot Spot Problem by keeping the size of clusters with unequal size.

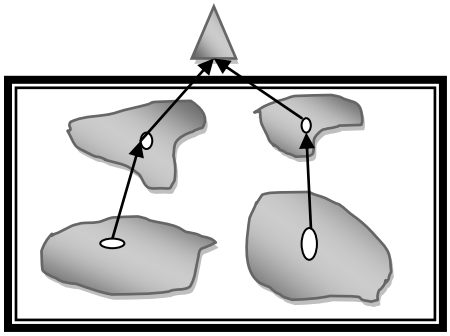

Figure 1.3 Unequal Clustering in UCR

The clusters nearer to the Base Station are kept small in size to preserve energy for forwarding of data to the Base Station.

With small size clusters near to the Base Station let them consume very little energy and as the distance increases from the Base Station, the size of clusters increases so that they can communicate from that far distance [6].

II. UCMR

UCMR protocol has different cluster size based on its distance with reference to base station. In this unequal clustering protocol the selection of cluster head is based on remaining energy, node degree and distance from the centroid [7].

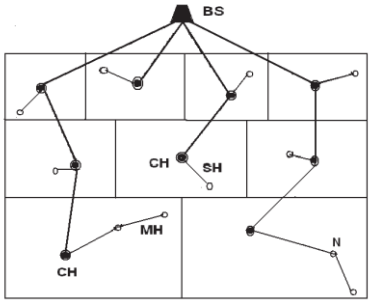

Figure1.4 UCMR Protocol [7]

This is a simple multi-hop unequal clustering algorithm which provides balanced energy consumption among the cluster heads. The multi-hop transmission in this protocol can improve QoS parameters like error rate and data rate. Simulation results shows that UCMR extends the network life time by 40% and 75% over UCR and LEACH protocols respectively.

III. The Proposed Protocol Dual Cluster Head UCMR

The proposed protocol aims to enhance the network lifetime. It follows these steps to implement the proposed technique of incorporating the two cluster heads in a cluster.

a) Initialization of parameters
b) Network Formation
c) Selection of Cluster head on the Basis of HBO technique. Data Transmission
d) Simulated Results

I. Initialization of parameters :

Network parameters are initialized for the network formation. Number of nodes to be considered are 100. All nodes are given initial energy of 1 Joule. Data packet used in the network is taken with size of 4096 bits.

Table 1: Simulation parameters

Parameters	Value
Network size	200×200m^2
Number of nodes	100
Base station	(100,220)
Initial energy of node	1J
E_{elec}	50 n J/bit
E_{fs}	100 p J/bit/m^2
E_{mp}	0.0013 p J/bit/m^4
Data packet	4096 bits
E_{DA}	5 n J/bit

II. Network Formation

Network is formed with randomly placed nodes and sink fixed at the location of (100,220). Size of network is taken to be 200m X 200m.
This network is random network and it is being included in large area network.

III. Selection of Main Cluster Head (MCH) and Vice Cluster Head (VCH)

MCH is selected on the basis of residual energy and the distance between the cluster head and the base station. The node on the top of the routing table list is selected as MCH. The node at the second position on the routing table list is selected as VCH.

This routing table is updated after each round. The MCH and VCH selection is updated accordingly. In this way routing is made efficient.

Role of MCH and VCH

VCH: It collects the data from all the nodes in the cluster and then it forwards the data to the MCH of the cluster. VCH also performs the task of data aggregation despite of data forwarding. Thereafter **MCH** forwards the data to the Base Station which is the only task it has to perform. It may transmit data to the MCH so it depends upon the distance from the Base Station. On the way to the Base Station, the intermediate nodes are used. Those are not other than MCH of another cluster.

IV. Simulated Results

The figure in the represents the graph between alive nodes and rounds.

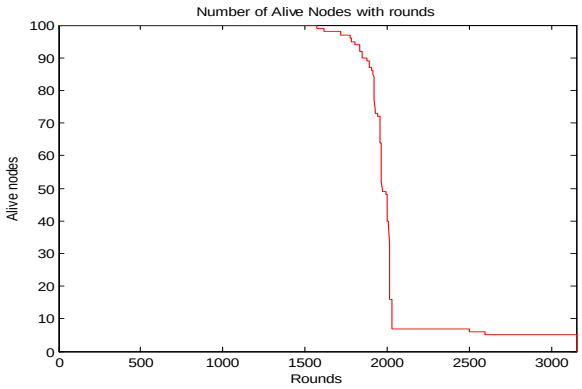

Figure 4.1 Alive nodes vs Rounds of proposed DC-UCMR

The first node dead is found to be after 1500 rounds and the Last node dead is found to be 3100 rounds. This is really the significant number of rounds that the proposed technique covers.

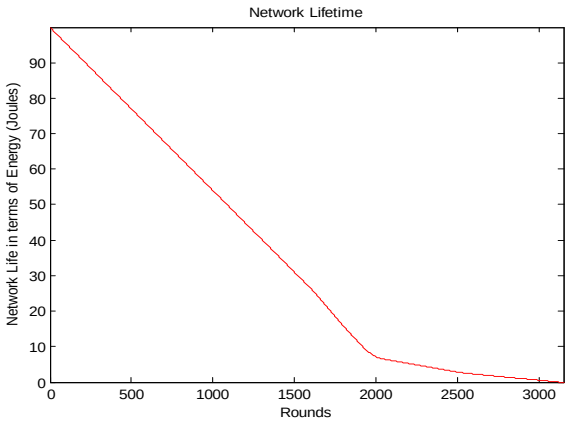

Figure 4.2 Network lifetime of proposed DC-UCMR

The figure represents the graph between the energy in Joules and number of rounds. The network lifetime that the proposed technique covers are more than 3000 rounds. The energy of rounds decreases till it gets the nodes fully depleted with energy after 3000 rounds.
The figure in represents the graph between the number of alive nodes and number of rounds. It is the comparison between the UCMR, LEACH and proposed DC-UCMR. It can be clearly seen that number of rounds are way more than that of LEACH. The first node dead is found to be 1569 rounds in the proposed technique where as it was 1050 rounds in UCMR with the increase of 49.4%.

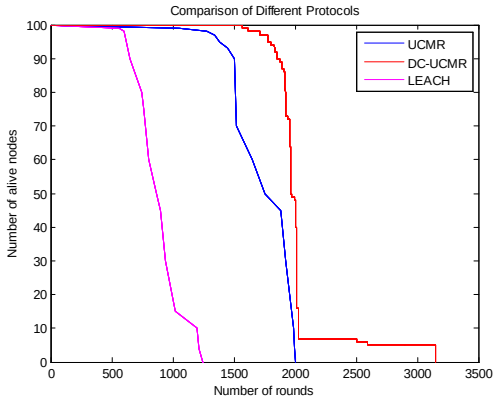

Figure 4.3 Comparison of LEACH, UCMR and proposed DC-UCMR

In case of improvement to the comparison with LEACH it is 563 rounds with 178.6% improvement. For the 50% node dead time it is found that proposed technique covers 1973 rounds where as it was just 1750 rounds in case of UCMR. This shows improvement in the 50% node dead time by 12.74%.Last node dead is found to be at 3151 rounds in case of proposed technique of DC-UCMR. It was only 2000 in case of UCMR giving 57.5% enhancement in the proposed technique.

V. Conclusion

Clustering has been in the spotlight since the development of various cluster based routing protocols. The selection of Cluster Head has been the crucial parameter to be considered for data collection for the Base Station. UCR performed very inefficiently as far as the selection of optimum number of cluster head is concerned. The UCMR uses Dijkstra's shortest path algorithm in the network for intra cluster communication between CH and member nodes as well as for inter cluster communication between CHs for multi-hop transmission of data to the base station. But the load balancing among the nodes has still being the issue. So D-UCMR balances the load among the cluster heads and makes it possible for sensor network to run for much more number of rounds. It shows the that 1st node dies at rounds showing an improvement of, 50 nodes die at rounds with the improvement, it is being observed that all nodes are died at rounds with an improvement of on UCMR protocol.

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