A REVIEW: ENERGY EFFICIENT CLUSTERING PROTOCOLS FOR WIRELESS SENSOR NETWORK

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ABSTRACT

Now a day's Wireless sensor network (WSN) has various applications like disaster management, animal tracking and monitoring, volcano monitoring etc. Energy efficiency is resent issue in wireless sensor network. Hierarchical routing or Clustering is best solution for reducing energy consumption in WSN. LEACH (Low energy adaptive clustering hierarchy) is good hierarchical protocol. There are many protocols introduced based on LEACH but still have issue of energy efficiency. Lots of research is going on CH (cluster head) election, data aggregation, different power levels, Quality of service and reducing number of transmission. This paper introduces various clustering protocols; also their advantages and disadvantages.

Keywords: ***Clustering, Energy Efficiency, LEACH, Lifetime, Stability Period, WSN***

I. INTRODUCTION

Wireless sensor networks consist of several nodes. Each node has computation capability like sensing, control function and transmission. Every node sends their sensed data to sink using wireless communication. Sink receives sensed data; aggregate that data and takes decision about action for particular application. So there are various application based on WSN like disaster management, animal tracking and monitoring, volcano monitoring etc. In these kind of application, sensor has require energy for various operation; but at such place battery cannot be recharged or replace; so taking care of energy consumption is issue now a days. Every node transmits same kind of data directly to sink (Single hop) it is not efficient way because it consumes more energy; nodes far away from sink dry earlier because they have required more energy to transmit their data directly to sink; so lifetime decreases. Later they introduce multi hop communication between nodes; in this approach most of data transmit through node nearer to sink; so node nearer to sink die earlier and network fails.

To solve above problems of energy consumption hierarchical routing (clustering) is best approach. In this approach cluster has been formed; each cluster has several nodes and one cluster head. Every node sends their sensed data to CH; CH aggregates that data and sends data to sink. This paper introduces various clustering protocols; also their advantages and disadvantages. Out of them some of protocols for homogeneous network, some of protocols for heterogeneous network, some of protocols for proactive network and some of protocols for reactive network.

II. PROTOCOLS BASED ON CLUSTERING

There were various protocol based on clustering has been developed from 2001 to 2014. We introduce some of them including LEACH protocol. Some of protocols based on clustering are as follows,

2.1 leach [1]

LEACH (Low Energy Adaptive Clustering Hierarchy) was proposed by [1] W. Heinzelman. It was first clustering approach introduce for WSN. It is for homogeneous and dense sensor network. It is TDMA based MAC protocol integrated with clustering and uses simple routing. It is working in 2 phase. 1) Set up phase: cluster has been formed, CHs selected and CH send TDMA schedule to nodes which want to join that particular cluster. 2) Steady state phase: nodes transmit sensed data to CH in their time slot; CH aggregates that data and transmit to sink. In every round this 2 phase are worked and new CHs are selected.

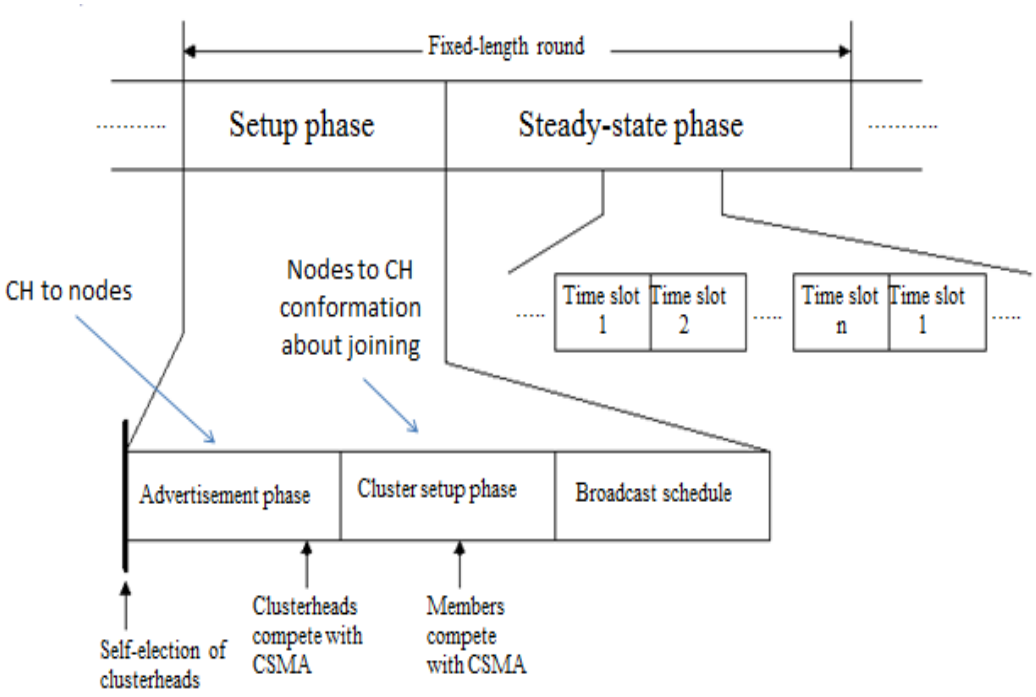

Fig.1: Organization of LEACH Rounds [2]

CHs are selected by below equation,

$$T(n) = p / (1-p (r \bmod (1/p))) \qquad n \text{ belongs to } G \qquad (1)$$

P = probability to become CH r = number of round

n= total number of nodes G= number of node which not become CH for last 1/p round

If T (n) is zero then node not became CH otherwise it became CH

2.1.1 Advantages of LEACH [3]

(1) Each node has an equal chance to become a cluster head but cannot be selected as cluster head in a subsequent round so the load is shared between nodes.

(2) Because LEACH uses Time Division Multiple Access (TDMA), it keeps cluster heads from unnecessary collisions.

(3) LEACH can avoid a lot of energy dissipation by opening and closing members' communication interfaces in conformity with their allocated time slots.

2.1.2 Limitations of LEACH [3]

(1) Because LEACH uses single-hop communication, it cannot be deployed in networks spread over large distances.

(2) Because cluster heads are elected only on the basis of probability, not taking energy into consideration, LEACH cannot provide actual load balancing.

(3) Because cluster heads are elected on the basis of probability, uniform distribution cannot be ensured. So, there is a chance that the elected cluster heads are concentrated in one part of the network and some nodes might not have any cluster heads in their vicinity.

(4) The idea of dynamic clustering brings extra overhead.

2.2 Teen [4] [3]

Threshold-sensitive Energy Efficient sensor Network (TEEN) was proposed by Anjeshwar *et al.* and is a hierarchical scheme for reactive networks. Its main use is in time-critical applications. TEEN is a combination hierarchical and data-centric approach. TEEN has a two-tier clustering topology. TEEN operation uses two thresholds: hard threshold (HT) and soft threshold (ST). HT is used for the sensed attribute. ST is used to show small changes in the value of the sensed attribute. In TEEN, a cluster head sends its members its HT and ST values. The hard threshold and soft threshold try to reduce data communications.

2.2.1 Advantages of TEEN [3]

(1) By varying the two thresholds, data transmission can be controlled.

(2) TEEN is well suited to time-critical applications.

2.2.2 Limitations of TEEN [3]

(1) The main drawback is that, whenever the thresholds are not met, the node will not communicate, and if the node dies, the network will not be able to sense it.

(2) Data may be lost if cluster heads are not able to communicate with each other if they are out of range from one another.

2.3 Heed [5][3]

Hybrid Energy-Efficient Distributed (HEED) clustering was introduced by Younis and Fahmy. The main goal of HEED is to prolong network life. The main difference between HEED and LEACH is cluster head election; cluster head election in HEED is not random. The construction of clusters is based on residual energy of the node and intra-cluster communication cost. Cluster heads have higher average residual energy than the member nodes. The communication technique of HEED is the same as LEACH. CH elected by below equation,

$$CHprob = Cprob*(Er/Em) \quad (2)$$

Er *is* the estimated current energy of the node, and Em is a reference maximum energy, *C*prob is set to assume that an optimal percentage cannot be computed a prior.

2.3.1 Advantages of HEED [3]

(1) HEED is a fully distributed cluster-based routing technique.

(2) HEED achieves load balancing and uniform cluster head distribution due to lower power levels of clusters.

(3) HEED achieves high energy efficiency and scalability by communicating in a multi-hop fashion.

2.3.2 Limitations of HEED [3]

(1) Energy consumption is not balanced because more cluster heads are generated than the expected number.

(2) As with LEACH, massive overhead is created due to multiple rounds.

(3) HEED also has additional overhead owing to several iterations being done to form clusters.

2.4 Deec [6][7]

Distributed Energy Efficient Clustering Protocol (DEEC) protocol proposed by L. Qing. DEEC protocol is a cluster based method for multi-level and 2 level energy heterogeneous wireless sensor networks. In this scheme, the cluster heads are chosen using the probability based on the ratio between residual energy of every node and the average energy of the network. The era of being cluster-heads for nodes are entirely different according to their initial and residual energy. The nodes with more initial and remaining energy have greater chances of the becoming cluster heads compared to nodes with low energy.

2.4.1 Advantages of DEEC [6]

(1) It avoid each node needs to know the global knowledge of the networks; DEEC estimates the ideal value of network life-time.

(2) It controls the energy expenditure of nodes.

2.4.2 Limitations of DEEC [7]

(1) Advanced nodes always punish in the DEEC, particularly when their residual energy reduced and when they come in the range of the normal nodes. During this position, the advanced nodes die rapidly than the others.

2.5 Mclb [8]

Multi-hop Clustering for Load Balancing Algorithm (MCLB) proposed by, N. Israr. It is a new cluster based routing algorithm that exploits the redundancy properties of the sensor networks in order to address the traditional problem of load balancing and energy efficiency in the WSNs. The algorithm makes use of the nodes in a sensor network of which area coverage is covered by the neighbors of the nodes and marks them as temporary cluster heads. The algorithm then forms two layers of multi hop communication. The bottom layer which involves intra cluster communication and the top layer which involves inter cluster communication involving the temporary cluster heads. Performance studies indicate that the proposed algorithm solves effectively the problem of load balancing and is also more efficient in terms of energy consumption from Leach and the enhanced version of Leach.

2.5.1 Advantages of MCLB

(1) Selects best path with minimum hop-count between first cluster-head and base station.

(2) Use full for longer distance.

2.5.2 Limitations of MCLB

(1) Calculating distance from CH to sink and routing introduces more iteration so overhead increases.

(2) Multiple transmission and reception consume more energy.

2.6 E-Horm [9][10]

Energy Efficient Hole Removing Mechanism (E-HORM) was proposed by M. B. Rasheed. In this technique, they use sleep and awake mechanism for sensor nodes to save energy. This approach finds the maximum distance node to calculate the maximum energy for data transmission. They considered it as a threshold energy Eth. Every node first checks its energy level for data transmission. If the energy level is less than Eth, it cannot transmit data. When numbers of sleep nodes are greater than 10 then put sleep node one by one into active mode. They also explain mathematically the energy consumption and average energy saving of sensor nodes in each round.

2.6.1 Advantages of E-HORM

(1) Increase stability period and remove energy holes.

(2) Significantly helps to extend the network lifetime.

2.6.2 Limitations of E-HORM

(1) Continuous sleep and awakening of node puts complexity in algorithm.

(2) Change in number of sleep node (10) for putting into active which change performance based on application.

2.7 A-Leach [11]

Assisted LEACH (A-LEACH) proposed by S. V. Kumar. It achieves lessened and uniform distribution of dissipated energy by separating the tasks of Routing and Data Aggregation; CH aggregates data and transferred to Helper node; Helper node sends aggregated data to sink. A new algorithm has been formulated to facilitate energy efficient Multi-hop Route Setup for helper nodes to reach base station. CH same as LEACH and Helper node selected by below Equation,

$$T(n) = 0.5 * (p / (1 - p(r \bmod (1/p)))) \quad n \text{ belongs to } H \quad (3)$$

H= set of node which not become helper node for last 1/p round

2.7.1 Advantages of A-LEACH

(1) It extends the lifetime of the network, minimizes overall energy dissipation in the network

(2) It distributes dissipation among Cluster Heads, Sensor Nodes and Helper Nodes.

2.7.2 Limitations of A-LEACH

(1) They used same equation same as LEACH rather than HEED/DEEC.

(2) They reduce overhead but significantly.

2.8 Modleach [12]

Modified LEACH (MODLEACH) proposed by D. Mahmood, N. Javaid. They introduce efficient cluster head replacement scheme and dual transmitting power levels. IT is for homogeneous network. They use different

power level for transmission from node to CH, CH to CH, CH to sink. They use CH selection method such that if CH has more energy than it remains as CH for next round. Also they introduce soft threshold and hard threshold; so energy consumption reduces.

2.8.1 Advantages of MODLEACH

(1) It minimizing routing load of protocol and increase energy efficiency.

(2) It distributes dissipation among Cluster Heads, Sensor Nodes.

2.8.2 Limitations of MODLEACH

(1) If cluster head has less energy than required threshold, it will be replaced according to LEACH algorithm. They used same equation same as LEACH rather than HEED/DEEC.

2.9 O-Leach [13]

Optimize LEACH (O-LEACH) proposed by S. El Khediri and N. Nasri. In which Election of cluster-head in each round with energy value greater than ten percent of the residual value at each sensor. So node which has low energy not become CH; so it consumes less energy and remain alive for next few round for communication.

2.9.1 Advantages of O-LEACH

(1) It achieves longer stability.

(2) It was improve energy efficiency as well as lifetime.

2.9.2 Limitations of O-LEACH

(1) If any nodes have not remaining energy greater than required then no CH selected network fails.

(2) They used same equation same as LEACH rather than HEED/DEEC.

III. COMPARISON OF PROTOCOLS [1, 13]

We learned various protocols based on LEACH. We summarize these protocols using TABLE 1.

Protocol	Cluster Stability	Energy Efficiency	Delivery Delay	Algorithm Complexity
LEACH	Small	Very Poor	Very Small	Low
TEEN	Medium	Good	Small	Very High
HEED	High	Medium	Medium	High
DEEC	High	Medium	Medium	Medium
MCLB	Medium	Medium	Very High	High
E-HORM	High	Good	High	Very High
A-LEACH	Medium	Medium	Very High	Very High
MODLEACH	High	Very Good	High	High
O-LEACH	High	Good	High	High

Table 1: Comparison of Clustering Protocols

Each of these has an advantages and disadvantages, out of which E-HORM, MODLEACH and O-LEACH has good energy efficiency for proactive network and TEEN for reactive network and also MCLB for very large network.

IV. CONCLUSION

We see clustering reduces energy consumption in Wireless Sensor Network. LEACH was first clustering protocol. Also DEEC protocol for heterogeneous network. Sleep and awake schedule prolongs network lifetime. Also different power levels introduced for reduce energy consumption so energy efficiency and lifetime increases and also stability period increases. Different cluster head algorithm changes value of all parameters. Protocols based on LEACH introduces in this paper with their advantages and disadvantages. Mostly all protocols for homogeneous and proactive network. TEEN, MODLEACH with Hard Threshold and MODLEACH with Soft Threshold protocols for homogeneous and reactive network. Reactive network has long lifetime than proactive network. Also Heterogeneous network has long lifetime than Homogeneous network.

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