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Hierarchical Routing Protocols in Wireless Sensor Networks: A Survey.

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***Abstract*— The ultimate aim of the survey is to outline characters of popular hierarchical (clustering) protocols and compare their performances. Clustering technique is used to conserve energy using multi hop communication of sensor nodes within the same cluster and performing data aggregation and fusion to reduce the amount of transmitted data to the base station. Cluster formation used to collect information more efficiently and provides an effective way to prolong the lifetime of the network. Cluster based routing protocols is a hot issue in research area so it is intend to analyze the features and issues of selected cluster based routing protocols LEACH, TEEN, DEEC and DSBCA. The simulation results indicate the efficiency in terms of network lifetime, stability period, throughput and number of clusters formed.**

***Index Terms*— routing protocols, wireless sensor networks, Cluster head, Leach, Teen, Deec, DSBCA.**

I. INTRODUCTION

A Wireless Sensor Network (WSN) is a collection of sensor nodes. Sensor nodes [1] are used to sense the environment in different locations like pressure, temperature, sound, motion. WSNs are widely used in different applications as like fire detection, flood detection, military surveillance [2], movement of animals, traffic control, home security system, health related applications [3] and so on.

In WSN the energy of the sensor node is limited, so the efficient usage of the energy is very important. Sensor nodes can't recharge it frequently so the energy is considered as important resource. At the same time there is more number of nodes presented in WSNs. The energy is spent to sent the data from sensor nodes. So we need a specialized energy aware routing protocols with scalability.

Normally grouping sensor nodes is satisfied the scalability issue and increase the network lifetime. In clustering protocols data aggregation and fusion [4] are available, this leads reduced energy consumption. The sensor nodes periodically transmit their data to cluster head and eventually change the cluster heads because of distributed energy usage. The cluster head acts as like a sink and collects data from the cluster members those data are sent to the base station. An example of the cluster based data communication within a network using single hop intra cluster communication and multi-hop inter cluster communication is further illustrated in Figure 1.

Routing protocols plays an important role in cluster formation process. On what basis they form the cluster and transmit their data to base station is considered by the routing protocols. Moreover the cluster formation and cluster head election can be repeated as many times as it is needed. To overcome these problems various clustering algorithms were proposed.

The LEACH [5], TEEN [6], DEEC [7] & DSBCA [8] are selected and undergone for performance evaluation process. The rest of the paper is organized as follows. In section 2 there is a review on selected cluster based routing protocols. Section 3 contains simulation results and performance analysis. Finally section 4 concludes the comparison work.

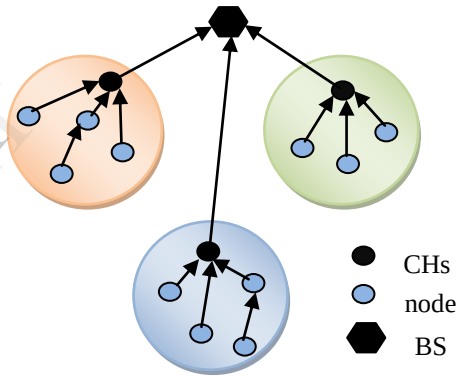


Fig. 1. Hierarchical Clustering Technique.

II. HIERARCHICAL PROTOCOLS REVIEW

A. LEACH

Heinzelman et al. [5] proposed a Low-Energy Adaptive Clustering Hierarchical algorithm. LEACH is a cluster based protocol that utilizes the randomized rotation of cluster heads to evenly distribute the energy load among the sensors in the network. This randomized approach does not drain the battery of a individual nodes. In this protocol the cluster heads have the responsibility of collecting data from their clusters and also aggregate the collected data for reducing the amount of data sent to the sink or Base Station, which enhance the network life time. LEACH uses cluster head rotation to enable scalability and robustness for dynamic networks. Data fusion is used here to reduce the amount of same information repeatedly transmitted to the base station. The sensor nodes elect themselves to be CHs at regular time interval with a given probability. The probability threshold function is defined as-

$$T(n)=\begin{cases}\dfrac{P}{1-P*(r \bmod \frac{1}{P})} & \text{if } n \in G \\ 0 & \text{otherwise}\end{cases}$$

Where P is the percent of cluster head nodes in all nodes, n is the number of the node, and r is the number of rounds for the election. r mod (1/ p) is the number of nodes elected as cluster head in a cycle, and G is the set of nodes not elected as a cluster head in previous rounds. Nodes are elected as the cluster head by its randomly generated value is less than probability threshold value T(n). Thus the above process can guarantee that the nodes are equally elected as the cluster head. Architectural design of LEACH is showned in Fig 2..

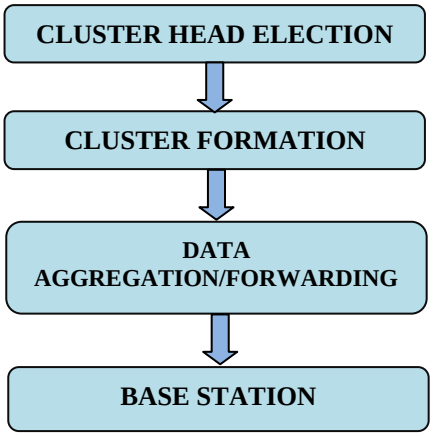


Fig. 2. LEACH Architectural design.

B. TEEN

Arati Manjeshwar and Dharma P. Agarwal [6] have introduced Threshold sensitive Energy Efficient sensor Network protocol to enhance efficiency for Wireless Sensor Networks. It is the first protocol developed for reactive networks. Energy consumption in this technique is lower than the proactive protocols because it does not frequently update the sensed information to cluster heads. There are two more thresholds available to conserve the energy

Hard Threshold (HT): This is a threshold value for the sensed attribute. If the amount of sensed information beyond the threshold value then automatically switch on its transmitter and report to its cluster head.

Soft Threshold (ST): This is a threshold value of the changes in sensed attribute. If the changes of sensed value is more than ST then triggers the node to switch on its transmitter and transmit the information.

The nodes sense their environment continuously but it does not transmit the sensed data. The sensed value is stored in an internal memory of the node. The nodes will transmit data only when any one of the following conditions is true:

1. The amount of the sensed value is greater than the hard threshold.

2. The current SV of the sensed attribute differs from previously SV is equal to or greater than the soft threshold.

Thus, the hard threshold and soft threshold reduce number of data transmissions but it does not support periodic reports application. Architectural design of TEEN is showned in Fig 3.

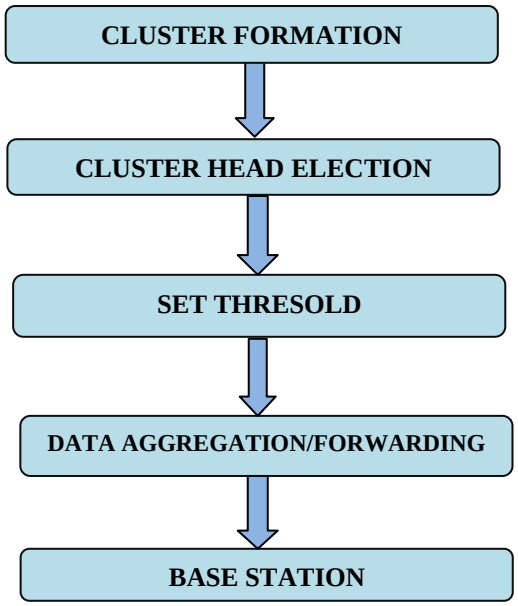


Fig. 3. TEEN Architectural design.

C. DEEC

Li Qing, Qingxin Zhu and Mingwen Wang [7], proposed a design of a distributed energy-efficient clustering algorithm for heterogeneous wireless sensor networks. In DEEC the election of cluster head done by taking probability on ratio of each nodes residual energy and average energy of the network. The probability threshold is used to elect the cluster head. The nodes with higher initial and residual energy will have more chances to be the cluster-heads than the other low energy-nodes.So it is more suitable, effective and achieves better results in heterogeneous environment.

DEEC is a variant of LEACH protocol which is suitable for both homogeneous and heterogeneous WSNs. The selection of the cluster head is based upon the ratio of initial and residual energy. To control the energy outflow of nodes DEEC uses the reference energy. DEEC calculates the average energy of the network by using the reference energy. So there is no requirement of global knowledge of energy at every round. Architectural design of DEEC is showned in Fig 4.

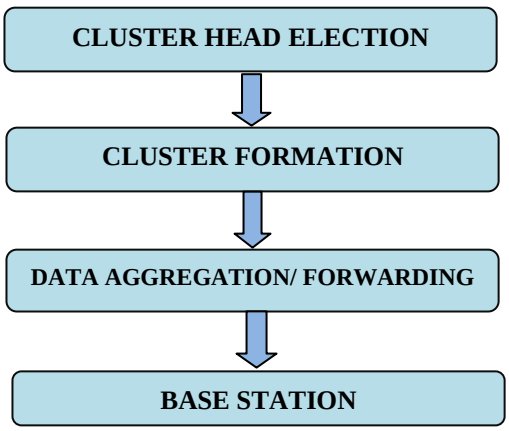


Fig.4. DEEC Architectural design.

D. DSBC ALGORITHM

Load-balanced Clustering Algorithm with Distributed Self-Organization for Wireless Sensor Networks was proposed by Liao et al [8]. The previously proposed clustering algorithms are uniformly distributed WSNs without considering the distance from the base station. In WSNs, the nodes are usually randomly arranged. If the clustering algorithm doesn't consider the distribution of nodes then it may leads to unbalanced topological structure, and some nodes die rapidly because of excessive energy decline. Architectural design of DSBCA is showned below.

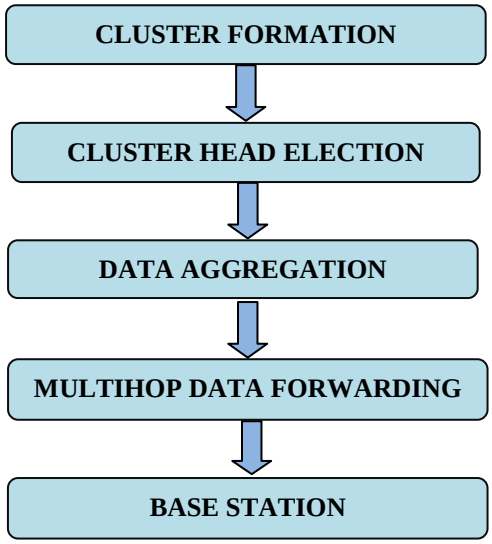


Fig. 5. DSBCA Architectural design.

DSBCA generates more balanced clusters and avoid creating excessive clusters with many nodes. All clusters need to communicate with BS so the long-distance clusters send the data through the nearest one. Energy dissipation based on the distance between the cluster head and base station and also there are too many members in a cluster may lead excessive energy consumption. From the above concerns, DSBCA consider the connectivity density, location of the node to build a more balanced clustering structure.

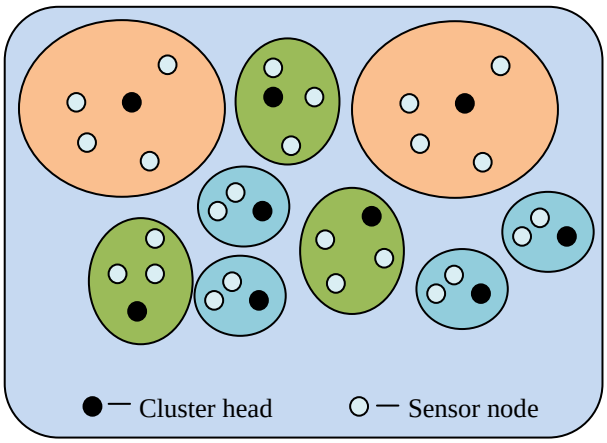


Fig. 6. DSBCA clustering non uniform distribution.

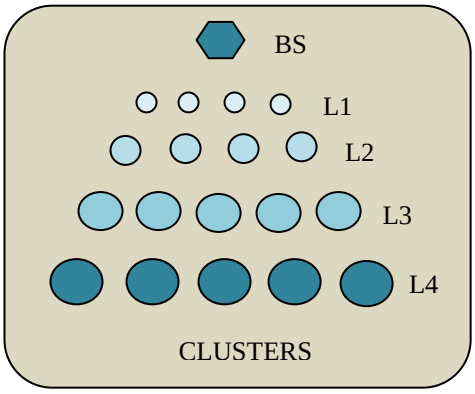


Fig. 7. DSBCA clustering in uniform distribution.

DSBCA calculate the clustering radius on the basis of connectivity density and the distance from the base station. If any two clusters have the same connectivity density, then long-distance cluster has larger cluster radius. Any two clusters having the same distance from the base station, then high dense cluster has smaller cluster radius.

DSBCA supports both uniform and non uniform distribution. Fig.6 shows DSBCA clustering in uniform distribution. Fig.7 shows DSBCA clustering in non-uniform distribution.

III. SIMULATION RESULTS

Here 100 x100 area used to deploy the sensor nodes. Deployment takes place on different amount of nodes such that 150, 200, 250, 300 to check the protocol efficiency under various numbers of nodes. The Parameters of the network settings are followed

TABLE. I. SIMULATION PARAMETERS

PARAMETERS	VALUES
Sink Position	50*50
Efs(Amplifier type)	$10*10^{-12}$ j
Emp(Amplifier type)	$0.0013*10^{-12}$ j
EDA(Aggregation Energy)	$5*10^{-9}$ j
Initial Energy Eo	0.5 j
PacketLength	2000bits
CtrPacketLength	100bits
Probability of CHs	0.1
Maximum rounds	8000
Ghama	0.2
Phi	0.3
Psi	0.4
Beta	0.5

In this section there are number of experiments carried out and used them for the comparison of LEACH, DEEC, TEEN and DSBCA for various performance metrics. Simulation results on MATLAB depict that DSBCA has better network lifetime and more packet delivery to Base station.

Figure 8 shows that the TEEN has more alive nodes for long time because TEEN is reactive protocol

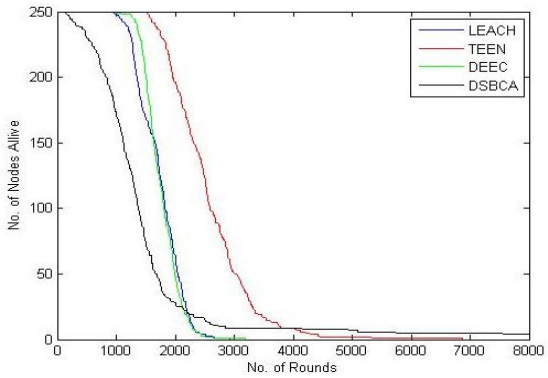


Fig. 8. Allive nodes vs rounds.

Figure.9 shows the number of CHs which are selected in each round. DSBCA mostly generate required average amount of CHs. But DEEC generate excess of cluster head than others. It seems not good because more number of CHs for every round can disturb performance of network. Optimal numbers of CHs are necessary to enhance network's life time then only size of the cluster is medium.

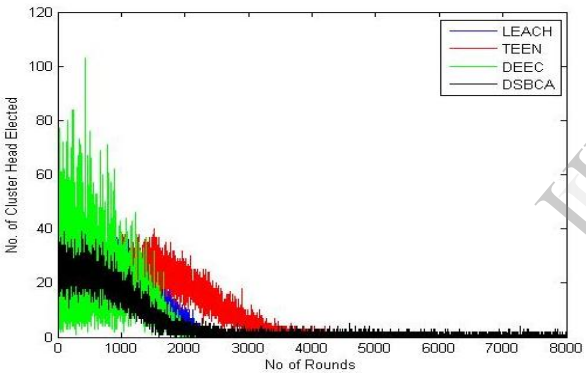
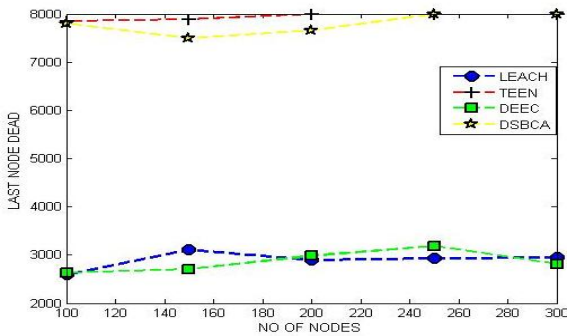


Fig. 9. Cluster Head vs Rounds.

From the figure 10 it is clear that the network lifetime of TEEN and DSBCA are better than others but TEEN is a



reactive protocol so DSBCA is better than others

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Fig. 10. Network Lifetime.

Figure 11 shows that the throughput of DSBCA is comparatively higher than the DEEC and LEACH because DSBCA send more data through the cluster head.

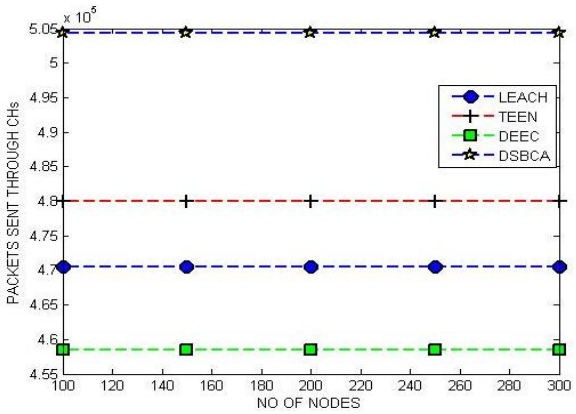

Fig. 11. Throughput.

From the figure 12 it is clear that the TEEN is more stable than the DEEC and LEACH as the first node dead in DEEC shows stability period of DEEC is prolong than others.

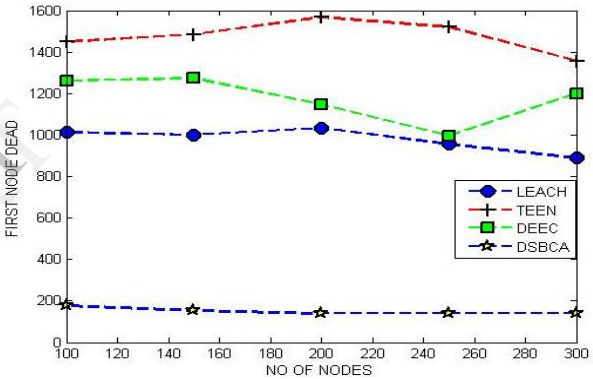

Fig. 12. Stability Period.

Table 2. Shows that comparison of protocols LEACH, TEEN, DEEC, DSBCA on the basis of simulation results under various performance metrics through simulation.

TABLE. II. COMPARISON OF PROTOCOLS

Performance Criteria	LEACH	TEEN	DEEC	DSBCA
Heterogeneity	No	No	Multi Level	No
Cluster stability	Moderate	Low	Low	High
Energy efficient	Moderate	High	High	High
Network lifetime	Moderate	High	Moderate	High
Routing type	Proactive	Reactive	Proactive	Proactive
Mobility	Fixed BS	FixedBS	Fixed BS	Fixed BS

IV.CONCLUSION

In this paper hierarchical routing protocols for WSNs have compared and summarized. As this is a broad area this paper has covered only few samples of routing protocols. This survey discuss the individual advantages and disadvantages of the four routing protocols under various number of sensor nodes. The factors affecting cluster formation, CH election and communication between nodes are open issue for future research.

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