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Survey on Hierarchical Clustering Approaches in Wireless Sensor Networks

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Abstract: ***The energy constraints and dynamic topology of wireless sensor networks generates special requirements in routing protocols. Enhancement in lifetime is one of the main issues in the field of WSN. Some parameters like energy per packet, network lifetime, average energy dissipated, total number of nodes alive, average packet delay, packet delivery ratio, time until first node dies, energy spent per round, idle listening, packet size, total number of signals received at the base station are considered for measuring performance of routing protocols. In this research the proposed idea is to compare some hierarchical approaches of routing.***

Keywords: Wireless sensor networks, routing algorithms, LEACH

I. Introduction:

1) Wireless sensor networks: A wireless sensor network can be defined as a collection of tiny disposable low power sensor nodes that usually derive their energy from attached batteries. A sensor node consists of a sensing unit, a processor, a transceiver station and a power source. Major causes of energy wastage are following: Idle listening, Collision, Overhearing, Protocol overhead.
2) Power efficiency: The main issue in WSN is power efficiency which is obtained either by Dynamic power management (DPM) or Dynamic voltage scaling (DVS). In DPM the inactive nodes and the parts of active nodes which are not working at that time are shut down. In DVS the power levels depending on the non deterministic workload are varied by varying the voltage along with the frequency. Deploying the sensors densely gives better power lifetime but it is harder to manage them when deployed very densely.
3) Hierarchical routing and Clustering: In hierarchical routing the nodes are grouped into clusters and the each cluster head has a cluster head which communicates with other cluster heads and to sink and provides energy efficiency which can't be provided by flat protocols. Mainly this paper focuses on cluster based hierarchical routing protocols like LEACH, its improvements, DHAC and its hybrid improvement H-DHAC.

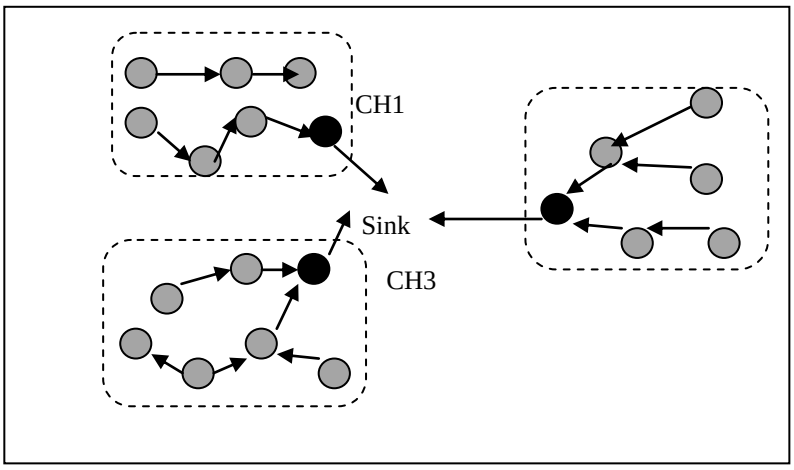

Fig.1 Clustering

II. Literature Survey:

Ashish Christian *et al* explained that LEACH (Low energy adaptive clustering Hierarchy) [1] is based on clustering and TDMA (Time division multiple access) plus routing protocol. All nodes are arranged in clusters and each cluster has a cluster head. All nodes in a cluster are communicated to their respective cluster head. Cluster head keeps the TDMA schedules and assign the time slots to all other nodes in the cluster. The data which is send by nodes to the cluster is aggregated and compressed at cluster head and then it is send to the sink node. In this protocol short distances are used to transmit the data. When the distance between the CH and sink is very high the delay caused is the main issue.

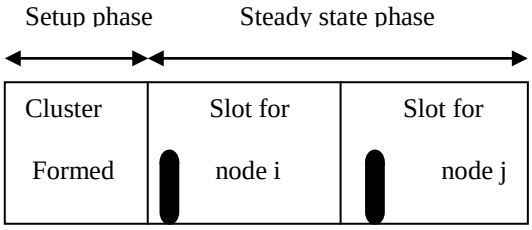

Fig 2-Concept of LEACH

Can Ma *et al* developed K-OCHE [2] protocol which is an overlapping clustering protocol for routing in wireless networks. This assumes that there may be three kinds of nodes: cluster heads, boundary nodes and the normal nodes. Cluster head consists of information about its own cluster members and its adjacent clusters. A boundary node may belong to more than one overlapping cluster. In this cluster heads are selected on the basis of remaining energy and sleep schedule mechanism is used to balance energy distribution and load distribution. Two tables one is CH-table and another is Boundary table is maintained at each of the nodes present. At least k nodes are being awakened for making the cluster k-connected.

Nikolas A. Pantazis *et al* [3] explained that LEACH-C is a centralized algorithm which uses extra features in setup phase. In this phase each node sends its energy level and location information to base station. Base station assigns the clusters and cluster heads to nodes according to their location and energy level. Steady phase is same as LEACH.

Ashish Christian *et al* [1] stated that concept of first node dies (FND) and the last node dies (Half of the node dies) are used to find out the reliability and the power efficiency. ILEACH is an improvement to ILEACH in terms of threshold value by multiplying En_current/En_max into the threshold equation. Also the modified energy level E' is computed by

$$E' = \frac{E_0 \times (1 - round / r_{max})}{n}$$

where E_0 is initial energy, round is current round and r_{max} is maximum number of such rounds preferred for data sensing and transmission to the base station. The modified probability is

$$Pnew = \frac{P \times n \times (node(i).E)}{E_0 \times E'}$$

This protocol gives approx 30% better results than LEACH.

Ali Norouzi et al [4] explained that PEGASIS (Power efficient Gathering in sensor information system) is the improvisation of LEACH in which a node is responsible to communicate with the base station in a round. Thus each node can communicate only with its nearest neighbor nodes and thus uses the chain based approach. One node in the chain is designated as the leader and it collect and aggregate all data it received and send to base station. In each round the leader is changed based on its remaining energy. Problems are the delay and the single leader.

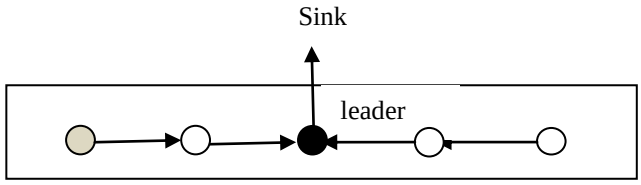

Fig 3- Chain based approach used in PEGASIS

J. Gnanmbigai *et al* [5] Q-LEACH follows the LEACH and the Q-DIR (Quadrant based directional routing protocol). In QDIR the location information is piggybacked in the route request packet generated from source and restricted flooding is used to transmit request and data. In Q-LEACH the distance and forwarding zone information are calculated at individual nodes and thus tracking their position towards the destination. It is both the location based and hierarchical protocol. (J. Gnanmbigai, 2012)

Zahra Taghikhaki *et al* [6] explored REC+ enhanced the REC by following the concept that the nodes near to relay send data to relay and the nodes near to CH send data to CH. It decreases the delay. There are four factors which are to be considered crucial for the WSN routing which are packet collision, overhearing, control messages and idle listening. REC+ provides a protocol for energy conservation, reliability, less intra-cluster delay, QOS requirements and scalability.

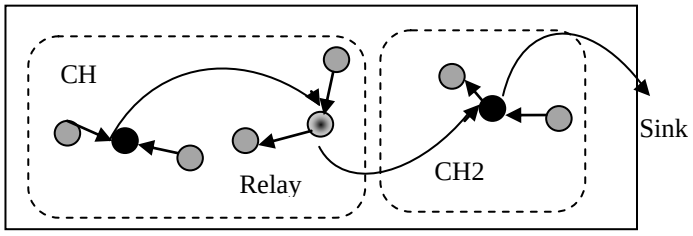

Fig 4-. Concept of REC+

R.U.Anitha *et al* [7] invented an enhanced cluster based routing protocol for mobile networks. It has five phases which are following: initiation, cluster formation, cluster head selection, data transmission, re-clustering and re-routing phase. DBSCAN is used for cluster formation. It gave better results in case of throughput, delay, packet delivery ratio and energy consumption than CBR-M and CBR-ME. Only it is costly in overhead than CBR.

Amulya Ratna Swain *et al* [8] proposed an Energy aware routing scheme with sleep scheduling is proposed for increasing the life time of the WSN. This routing is implemented by integrating a sleep scheduling with a tree and energy efficient routing protocol. The root of the tree is the sink node and the internal nodes in the tree remain awake and the leaf nodes are in sleep mode. Considering remaining energy of the nodes trees are periodically created after removing the dead nodes and there are always two paths from sink to a sensor node thus providing fault tolerance.

Chong-Horg Lung *et al* [9] explored a hierarchical routing protocol named DHAC. It consists of clustering at first step and then the resemblance factor is used to find similarities among nodes and the similar nodes are grouped together and automatic cluster head selection is used so there is no need of re-clustering at each round. DHAC is more efficient than LEACH and LEACH-C. Receiving energy dissipation, transmitting energy dissipation and computation energy dissipation are used for evaluating the performance of DHAC.

Receiving Energy Dissipation: $E_{RX}= L\times E_{elec}$

Transmitting Energy Dissipation: $E_{TX}=L\times E_{elec}+L\times \mathcal{E}_{mp}\times D^4$

Computation Energy Dissipation: $E_{com}=E_{fusion}\times Size_{Signal}\times Number_{Signal}$

Where L= Message size in bits

E_{elec} =Energy consumed by receiving one bit data

D= distance between transmitter and receiver

$\mathcal{E}_{mp}=0.0013pJ/Bit/m^4$

DHAC cannot deal with the missing location data. If location data is missing it uses the connectivity information based on the LSI matrix.

H-DHAC [10] is a hybrid approach which considers both the qualitative connectivity and quantitative location data using clustering. The qualitative connectivity is measured in binary form. In H-DHAC two additional parameters are being used which are the CL (confidence level) and the C_{MIN} (Minimum number of quantitative coefficients for estimation). The main w[illegible]one in this paper was on location data rather than the connectivity data.

$$CL= \frac{N_G}{N_C+N_N} \times 100$$

Here N_C=Total numb[illegible]its own cluster

N_N=Total number of [illegible]ighboring cluster

N_G=Total number of nodes which have location data available in N_C and N_N

The multi-hop mechanism that uses only the location or RSS information can also uses this hybrid approach to enhance their performance. The assumption in this approach was the symmetric links so the test of this approach on asymmetric links is still pending.

III. Comparison

Routing	Hop-Count	Mobility	Advantages	Drawbacks	Route Metric	Scalability
LEACH	Single-hop	Fixed BS	Consume low energy and distributed in nature	Not efficient in networks in which nodes ate at very long distance	Shortest path	good
LEACH-C	Multi-hop	Fixed BS	Consume lower energy than LEACH	Generate overheads	The best route	good
ILEACH	Multi-hop	Limited	Better network stability & minimal energy consumption	Threshold must be set after considering all parameters	Best route	good
QLEACH	Multi-hop	Limited	Restricted flooding and reduced overhead	Complex aggregation	Best route	limited
KOCHE	Multi-hop	Limited	Balance load to increase network lifetime	Generate overheads	Best route	good
PEGASIS	Single-Hop	Fixed BS	Chaining reduces the distance between node and sink	Base station's location and the node's energy is not considered while electing the cluster head	Greedy route selection	good
ECBR-M	Multi-hop	Yes	Support mobile nodes, better throughput	Complex protocol	Best route	Limited
REC+	Multi-hop	No	Reliability and energy	Reliabilty varies	Reliable	Limited

			efficiency	when cluster shape varies	route	
Sleep-Scheduling	Multi-hop	No	Extends network lifetime by replacing the expired nodes	Need of synchronization and management of extra nodes	Best route	Limited
DHAC	Multi-hop	No	Longer network lifetime by removing concept of re-clustering	Not perform well in high traffic case	Best route metric	Good
H-DHAC	Multi-hop	Yes	Can deal with missing location information	Works for only syymtric communications	Best and reliable route	Good

IV. Conclusion

LEACH is the first energy efficient cluster based routing approched which gave the better results in network lifetime than direct diffusion, flooding and gossiping. Then enhancements of LEACH gave better results in scalabilty, mobilty and network lifetime by improving the threshold formula or the cluster formation or cluster head selection method or employing extra nodes in sleep mode to replace failed nodes. PEGASIS is another hierarchical approach based on the chain-cluter method which gave better lifetime than LEACH and then some approaches use combination of chain based and clustering methods. DHAC is bottom up routing which gave better results in case of mobility,energy efficiency and scalabity than previous approaches. H- DHAC is a hybrid prtocol based on DHAC and in addition to DHAC advantages it also reduces the cost and reliabilty of WSN.

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