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Performance Analysis of LEACH-SCH Protocol for Wireless Sensor Network in Heterogeneous and Homogeneous Region Considering Variable Length of Packet

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Abstract- Wireless Sensor Network are networks of large number of small, battery powered sensor nodes having limited on-board storage, processing and radio capabilities .The transmission and reception between source and sink consumes lots of energy as compare to data processing. Designing protocols and applications for such has to be energy aware in order to prolong the lifetime of the network. For this purpose clustering routing protocol is the most common technique used for energy aware routing in WSNs. In this paper, we firstly completely analyzes the basic distributed clustering routing protocol LEACH-SCH (Low Energy Adaptive Clustering Hierarchy- Supporting Cluster Head), then we study the impact of heterogeneity in order to prolong the lifetime of WSN. The simulation results of proposed protocols are compared for its network life time in MATLAB with LEACH protocol**.**

Key Terms - Clustering, Energy efficiency, Routing protocol, Wireless sensor network, LEACH-SCH, Homogeneous, Heterogeneous.

I. INTRODUCTION

WIRELESS sensor network is collection of sensor nodes having limited resources. Sensor nodes are used to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. Sensor nodes communicate the information gathered through wireless links; the data is forwarded, possibly via multiple hops relaying, to a sink (sometimes denoted as controller or monitor) that can use it locally, or is connected to other networks (e.g., the Internet). The nodes are may be stationary or moving. They can be aware of their location or not. They can be homogeneous or not.

These nodes are small in size, but are equipped with embedded microprocessors, radio receivers, and power components to enable sensing, computing, communication, and actuation. These components are integrated on a single or multiple boards, and packaged in a few cubic inches. These sensor nodes sense the information and transmit it to the base station. Base station analyzes the received data and computation is performed, which gives the human understandable result. The Base station is having unlimited battery power. So it should implement the algorithm and protocols by which it can enhance the life time of the sensor node as well as save the battery power.

II. LITERATURE SURVEY

A. Routing protocols selection for WSN is very important while designing wireless sensor network.

Any routing strategy design is generally based on some criteria which can be described are stated as below:

B. Optimality: To achieve minimum cost forwarding, while design of the most data forwarding protocol is based on a chosen optimality criteria.

C. Simplicity: To reduce the minimum number of performed operations as well as the states those are maintained at each sensor node participating in data forwarding process.

D. Scalability: The solution has to scale to large network size with some constrained may be there or routing strategy has to give some constrain to use that algorithm with some range of no. of node deployment for acceptable performance. Here we expand the classification proposed by Nikolas into four main schemes: Network Structure Scheme, Communication Model Scheme, Topology Based Scheme and Reliable Routing Scheme. The presented classifications can be viewed as four different approaches to classify the protocols, rather than four parallel classes.

LEACH (low energy adaptive clustering hierarchy) is the kind of hierarchical routing protocol.

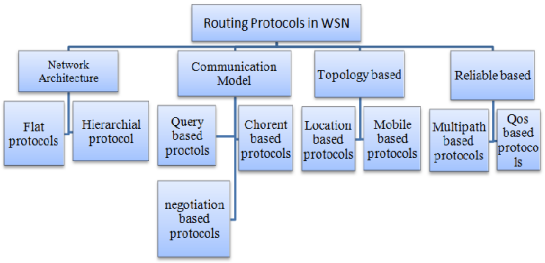

Fig 1: Classification of routing protocols

III. LEACH PROTOCOL

LEACH is a kind of cluster-based routing protocols, which uses distributed cluster formation. LEACH randomly selects a few sensor nodes as cluster heads (CHs) and rotates this role to evenly distribute the energy load among the sensors in the network. The idea is to form clusters of

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the sensor nodes based on the received signal strength and use local cluster heads as routers to the sink. The major characteristics of this Protocol are as follow: The cluster heads are rotated in a randomized fashion to achieve balanced energy consumption. It is assumed that all the sensors have synchronized clocks so that they know the beginning of a new cycle. LEACH adopts a hierarchical approach to organize the network into a set of clusters. Each cluster is managed by a selected cluster head. In LEACH, the Cluster Heads compress data arriving from member nodes and send an aggregated packet to the BS in order to reduce the amount of information that must be transmitted to the BS.

In order to reduce inter & intra cluster interference LEACH uses a TDMA/code division multiple access (CDMA) MAC.

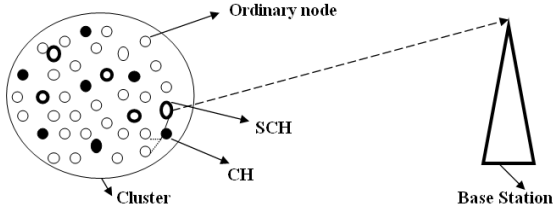

Fig2 : network formation

The basic operations of LEACH are organized in two distinct phases, setup phase and steady state phase. The duration of the setup is assumed to be relatively shorter than the steady-state phase to minimize the protocol overhead.

A. The first setup phase:

- For organizing the network into clusters
- Advertisements of the cluster heads
- Transmission schedule creation

B. The second steady state phase:

- The data aggregation
- Compression
- Transmission to the sink

At the beginning of the setup phase, a round of cluster-head selection starts. The cluster-head selection process ensures that this role rotates among sensor nodes, thereby distributing energy consumption evenly across all network nodes. To determine if it is its turn to become a cluster head, a node, n, generates a random number, v, between 0 and 1 and compares it to the cluster-head selection threshold, T(n). The node becomes a cluster head if its generated value, v, is less than T(n). The cluster-head selection threshold is designed to ensure with high probability that a predetermined fraction of nodes, P, is elected cluster heads at each round. Further, the threshold ensures that nodes which served in the last 1/P rounds are not selected in the current round. To meet these requirements, the threshold T(n) of a competing node n can be expressed as follows:

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

The variable G represents the set of nodes that have not been selected to become cluster heads in the last 1/P rounds and r denotes the current round. The predefined parameter, P, represents the cluster-head probability. It is clear that if a node has served as a cluster head in the last 'P' rounds, it will not be elected in this round. Upon cluster formation, each cluster head creates and distributes the TDMA schedule, which specifies the time slots allocated for each member of the cluster. Each cluster head also selects a CDMA code, which is then distributed to all members of its cluster. The code is selected carefully so as to reduce inter cluster interference. The completion of the setup phase signals the beginning of the steady-state phase. During this phase, nodes collect information and use their allocated slots to transmit to the cluster head the data collected. This data collection is performed periodically.

IV. LEACH-SCH PROTOCOL

A new proposed algorithm LEACH with supporting cluster heads (LEACH-SCH) is considered here, which is very helpfull for long distance communication. In this scheme after selecting the cluster heads (CHs) the supporting cluter heads (SCHs) are calculated. These suporting cluster heads recieved data from the cluster heads and transmit data to the base station. In this process the energy efficency of cluster heads and lifetime of cluter heads increase and network too.In the algorithm of LEACH-SCH 'sch_th' is the threshold value for generation of supporting cluster head. For example if total no. of nodes are 100 and if the percentage of becoming CHs is set as 10% then 10 number of node will become CHs. Out of that 10 nodes supporting cluster heads will be depends on 'sch_th'. Approximate no. of supporting cluster head is given by below:

no.of supporting cluster head = n × P × sch_th
Where, 0 < sch_th < 1

So according to above equation if 'sch_th=0.5' then approximately 5 nodes are able to become supporting cluster heads.

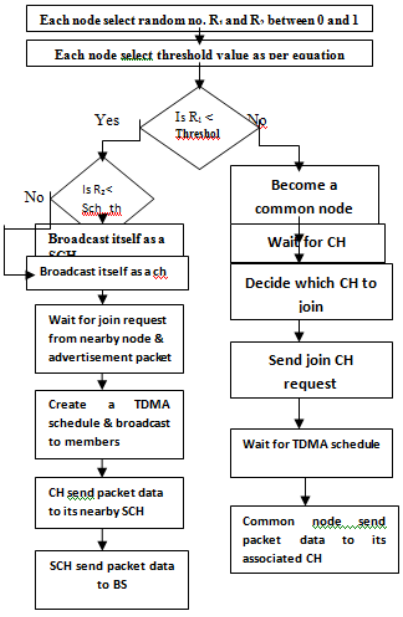

Fig 3: Algorithm for LEACH-SCH

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V. ENERGY MODEL FOR LEACH-SCH

Parameters	Values
Initial energy of each node	2J
Percentage of cluster head	8%
Packet length of each node per round	2000 bits
Packet generated per round by each node	2
Ctrpacket length	200 bits
Transmission & Receiving energy(E_{elec})	50 nJ/bit
Free space Transmitter amplifier energy(E_{fs})	10PJ/bit/ m^2
Multipath Fading Transmitter amplifier energy(E_{mp})	0.0013PJ/ bit/m^2
Data aggregation energy(E_{DA})	5nJ
Type of Distribution	Random
Energy level of node to be a alive	0.009J
Threshold for SCH(sch_th)	0.5

Table I

We use the first order radio model for wireless sensor networks. Here are some assumptions for these networks. All sensors are within the wireless communication range when they communicate with each other or with the BS. Sensors should have homogeneous sensing, computing and communication capabilities. BS is located in the center of the sensor networks and BS has infinity energy resource. Both the energy dissipation of sensing data and the energy dissipation for clustering are neglected. Also, we suppose that all the clustering algorithms are run on the BS. The energy dissipation of fusing one bit data is a constant value. Thus, to transmit a k-bit message a distance d, the radio uses:

$$E_{Tx}(k,d) = k*E_{elec} + k*E_{fs}*d^2 \quad < d_0$$
$$k*E_{elec} + k*E_{mp}* d^4 \quad \geq d_0$$

The first term represents the energy consumption of radio dissipation, while the second represents the energy consumption for amplifying radio. The use of free space E_{fs} and the multi-path fading E_{mp} channel models depends upon the transmission distance. By equating the two expressions at $d = d_0$,
We have $d_0=\sqrt{(E_{fs} / E_{mp})}$
When receiving this data, the radio expends:
$E_{Rx}(k) = k * E_{elec}$

Additionally, data aggregation operation will consume the energy E_{DA}.
Now we introduce our new heterogeneous aware protocol whose goal is to increase the lifetime and stability of the network in the presence of heterogeneous nodes. Let us assume the case where a percentage of the population of sensor nodes is equipped with more energy resources than the normal sensor nodes in the network.

VI. SIMULATION

Some common simulation parameters used for developing LEACH-SCH protocol shown in TableI.
Results:

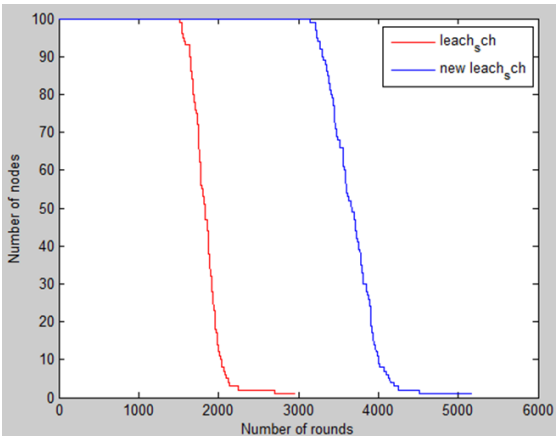

Fig4: Comparison graph of traditional LEACH-SCH and LEACH-SCH with variable packet length

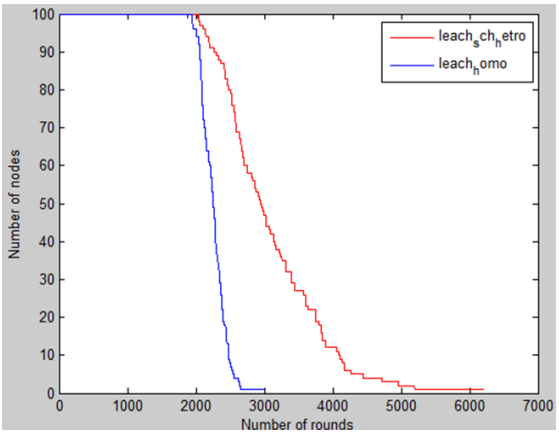

Fig5: Comparison graph of LEACH-SCH (Homo) Vs LEACH-SCH (Hetero).

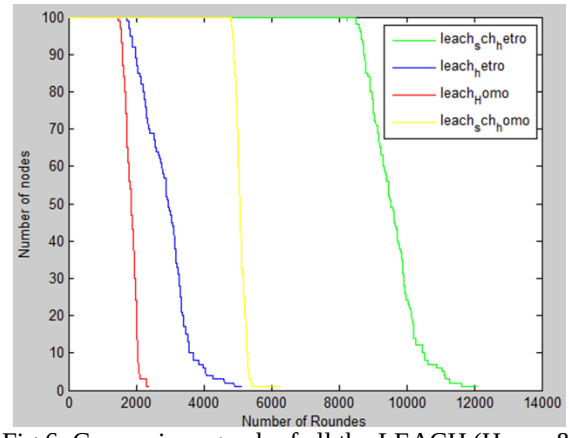

Fig 6: Comparison graph of all the LEACH (Homo & Hetero) and LEACH-SCH (Homo & Hetero).

VII. CONCLUSION

It is evaluated that LEACH-SCH homogeneous systems improve network performance over traditional LEACH protocol in order to increase network lifetime and energy efficiency increment. Another new concept of LEACH-SCH with variable packet length also upgrades the system

in order to contribute in the improvement of system performance. It is concluded through simulation results (Fig.4) that nodes in the network (considering variable packet length) remain alive for a longer times than the traditional LEACH-SCH. On the other hand LEACH-heterogeneous system significantly reduces energy consumption and increase the total lifetime of the wireless sensor network compared to the homogeneous LEACH protocol. This performance of LEACH-heterogeneous system is enhanced by considering the concept of LEACH-SCH with variable packet length in the heterogeneous region. It can be seen that nodes remains alive for a longer time (rounds) in LEACH-SCH-Heterogeneous system than LEACH-SCH- Homogeneous system (Shown in Fig:5). Note that further increasing of the number of nodes in the heterogeneous system and the area does improve the network lifetime considerably.LEACH-SCH-Heterogeneous System provides better performance in energy efficiency and increasing level in lifetime of the wireless sensor networks. We conclude that the heterogeneous wireless sensor networks are more suitable for real life applications as compared to the homogeneous counterpart.

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