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A Survey on Network Lifetime Expanding And Energy Efficient Hierarchial Routing Protocols In Wireless Sensor Networks

Saranya S
Vel Tech Multi Tech Dr.Rangarajan
Dr. Sankunthala Engineering College
Chennai, Tamil Nadu, India

Vimal R*
Department of CSE, Vel Tech Multi Tech
Dr.Rangarajan Dr. Sankunthala Engineering College.
Chennai, Tamil Nadu, India

ABSTRACT

In recent researches wireless sensor network (WSN) is measured as most vital, complex and interesting new technology in data communication and gathering various kind of information which is not possible for human. In WSN a large number of small sensing self-powered nodes which gather information or detect special events and communicate in a wireless fashion, with the end goal of handing their processed data to a Base Station (BS). Major challenges in WSN are lifetime and energy consumption; to overcome this many protocols have been constructed for better performance by parameters like latency, throughput, fairness, energy consumption in WSN. In this paper, we give a comparative study of hierarchical routing protocols and also evaluating a performance of protocols that concludes with the recommendations and guide to the future enhancement in network lifetime and the energy efficient for the wireless sensor networks.

Keywords *–Base Station, network lifetime, energy consumption, sensor nodes, routing protocols, performance.*

I. INTRODUCTION

WSN provide a bridge between the real physical and virtual worlds. Wireless sensor and actuator networks (WSNs) make Internet of Things possible Computing, transmitting and receiving nodes, wirelessly networked for communication, control, sensing and actuation purposes.WSN is built of “nodes” from a few to hundreds or several thousand ,where each node is connected to different sensor nodes. Sensor nodes might vary in size from that of shoebox down to the size of grain of dust. Each sensor network node has several parts as a radio transceiver with an internal antenna or connected to an external antenna. One of the major challenges in a WSN is to produce low cost and tiny sensor nodes. An additional distinctive characteristic of sensor networks is the cooperative effort of sensor nodes. Sensor nodes are fixed with an onboard processor. As a replacement for transfer the unprocessed data to the nodes responsible for the fusion, they use their dispensation abilities to nearby carry out uncomplicated computations and transmit the required and partially processed data. These sensor nodes converse over short distance using a wireless medium and work together to accomplish a common task, for example, environment monitoring, military surveillance, and industrial process control.

ISSN 2348 – 7968

A. Characteristics of WSNs

- Battery-operated nodes
- Inadequate wireless communication
- Reduced coordination
- Ability to withstand harsh environmental conditions
- Mobility of nodes
- Lifetime
- Cross-layer design
- Data collection

B. Major Issues In WSN:

- Limited Range
- Inadequate Power
- Limited Processing power / memory
- Cost

C. Categorization of Protocols In WSN:

In general many routing algorithms were developed to overcome from issues in sensor networks. WSN protocols strongly impact on system performance .Choosing the wrong protocol may cause severe inefficiency and prevent the WSN to accomplish user need. Wireless sensor networks routing are differs from conventional routing in various ways.WSN protocols are divided into seven categories. They are

- Hierarchical protocols
- Location-based Protocols
- Data-centric Protocols
- Mobility-based Protocols
- Multipath-based Protocols
- Heterogeneity-based Protocols
- QoS-based protocols

In this paper we are going to discuss about hierarchical protocols with their working principle, characteristics and comparative study with some parameters.

II. HIERARCHICAL ROUTING PROTOCOLS

The main intension of hierarchical routing is to proficiently maintain the energy consumption of sensor nodes by connecting them in multi-hop communication within an exacting cluster and by performing data aggregation and also data fusion in order to decrease the number of transmitted messages to the sink. Among

ISSN 2348 – 7968

numerous numbers of hierarchical routing protocols we are going to discuss LEACH, HEED, PEGASIS and GSTEB briefly.

1.1. Low Energy Adaptive clustering hierarchy (LEACH) :

LEACH is said to be a first hierarchical routing protocol which is used for Wireless sensor network. It uses adaptive clustering scheme for the communication between nodes. In this protocol nodes are divided into only two types of categories; normal sensor nodes and cluster heads (CH).At first the normal sensor nodes are grouped together and form clusters and among all the sensor nodes in a cluster one node are selected as a CH node. The nodes cannot communicate directly with each other but they can communicate via cluster heads (CH). The basic idea of LEACH is to form the clusters of the sensor nodes depend on the received signal strength and it uses local cluster head as routers to base station.

In LEACH, each round includes two phases: a setup phase and steady-state phase. In set up phase, each node will decide whether to be a cluster head or not. After CHs are chosen, each of other nodes will select its own CH and join the cluster according to the power of many received broadcast messages. Each node will choose the nearest CH. In Steady state CHs fuse the data received from their cluster members and send the fused data to BS by single-hop communication. The cluster heads will change randomly according to the time in order to balance the energy over nodes. The selection of cluster heads is done by following equation:

$$T(n) = \frac{p}{1-p*\left(rmod\frac{1}{p}\right)} \quad \text{if n} \in \text{G}$$

Where r=the current round
G= set of nodes that haven't been cluster heads in the last 1/P rounds.
n = given number of nodes.
p = the priori probability of a node being elected as a cluster-head.

LEACH works, at first normal sensor nodes transmit their data to their respective CHs. On receiving these data, the CHs aggregated them in a compacted form and transmit them to the BS. Finally BS will receive all compressed data from different CHs present in the network. LEACH is fully distributed and it doesn't need global knowledge of network and also it uses single-hop to transmit the data from node directly to the cluster head.

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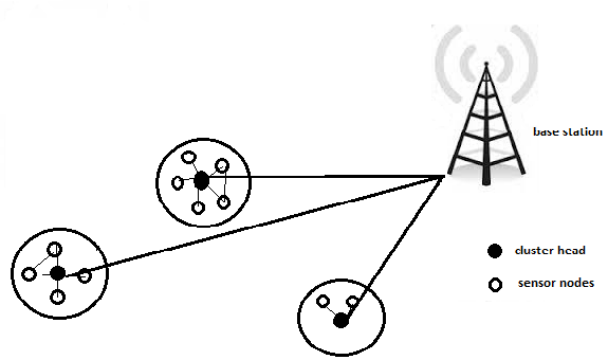

Fig: 1 Architecture of LEACH protocol

1.2. Power efficient gathering in sensor information systems (PEGASIS) :

PEGASIS protocol is an enhanced protocol from LEACH. It is a multi-hop routing protocol. In PEGASIS it selects only one node as cluster head node and sends the fused data to the base station in each round. When compared to LEACH protocol it achieves factor of 2 improvements because PEGASIS is a near optimal chain based protocol. It communicates with closely located neighbor nodes and transmits the data, in this way the chain will be created. In sensor networks, data fusion and aggregation helps to reduce the amount of data transmitted. Last node in the chain is called leader node this node will transmit all fused data to the base station. Data fusion means combining one or more data packets from different sensor nodes with some measurements to produce as a single packet.

In PEGASIS, if a node dead means a chain formation must be rebuilt which increases the energy consumption. This approach reduces the overhead and lowers the bandwidth requirements from the BS. PEGASIS has two phases: chain construction and gathering data. In chain construction phase it starts with farther node from the base station and in this protocol greedy algorithm were used to construct the chain. In data gathering phase the leader node will be selected randomly for each round. If N is a number of nodes (i mod n) node is selected as head node for i round.

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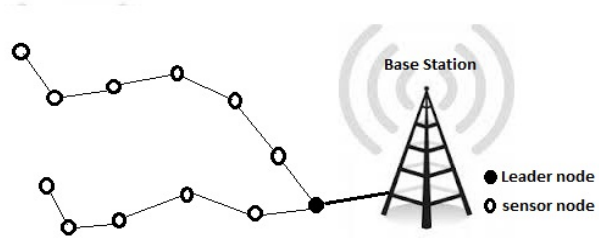

Fig: 2 Architecture of PEGASIS

1.3. *Hybrid Energy Efficient Distributed Protocol* (HEED):

HEED protocol is enhanced from LEACH protocol scheme. It is used for constructing energy-efficient hierarchies for routing protocol, in which higher level nodes should have more residual energy. In HEED, for cluster selection they are using two metric they are node degree or density to reach power balancing. It is a multi-hop routing protocol which uses an adaptive transmission power in the inter-clustering communication. In HEED, proposed method periodically selects the CHs depend on two parameters : primary clustering parameter to probabilistically select an initial set of cluster heads and secondary parameter to "break ties" among them ,secondary clustering parameters are function of cluster properties ,such as cluster size and whether or not variable power levels are permissible for intercluster communication.

HEED has four main goals to achieve they are

1) Prolonging network lifetime by distributing energy consumption.
2) Terminating the clustering process within a constant number of iterations.
3) Minimizing control overhead and
4) Producing well-distributed CHs and compact clusters.

In HEED, clustering is triggered every $T_{CP} + T_{NO}$ second to select new cluster heads, here T_{CP} is clustering process duration and T_{NO} is network operation interval. Before a node starts executing HEED, it sets its probability of becoming cluster head, CH_{prob} as follows:

$$CH_{prob} = C_{prob} \times E_{\frac{residual}{E_{max}}}$$

Where, $E_{residual}$ = estimated current residual energy in the node

E_{max} = reference maximum energy

CH_{prob} = value of a node

ISSN 2348 – 7968

HEED selects better cluster head than the original LEACH and thus, prolongs the network life time and in this protocol it terminates the constant number of iterations, independent of network diameter. This protocol can be applied for the sensor networks which require scalability, prolonged network lifetime, load balancing and fault tolerance.

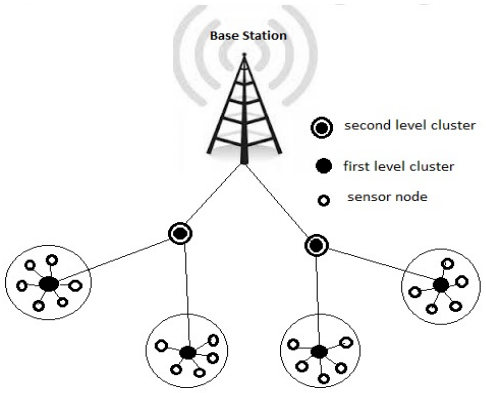

Fig 3: Architecture of HEED protocol

1.4. General Self-Organized Tree-Based Energy-Balance Protocol(GSTEB):

GSTEB outperforms LEACH, PEGASIS, TREEPSI and TBC. Reason is GSTEB is a self-organized protocol; it only consumes a small amount of energy in each round to modify the topography for the point of balancing the energy consumption. When lifetime is distinct as the time from the start of the network operation to the death of the first node in the network, this protocol prolongs the lifetime by 100% to 300% compared with PEGASIS.

GSTEB is to achieve a longer network life- time for different applications. In each round, BS assigns a root node and broadcasts its ID and its coordinates to all sensor Nodes. Then the network computes the path either by transmitting the path information from BS to sensor nodes or by having the same tree structure being dynamically and individually built by each node. For both cases, GSTEB can change the root and reconstruct the routing tree with short delay and low energy consumption.

The operation of GSTEB is divided into Initial Phase, Tree Constructing, Self-Organized Data Collecting and Transmitting Phase, Information Exchanging.

ISSN 2348 – 7968

Initial Phase:

BS broadcasts a packet to all the nodes. Then All Sensors sends its packet in a circle and sends a packet which contains its entire neighbor's information.

Tree Constructing Phase:

BS assigns a node as root and coordinates to all sensor nodes. Each node tries to select parent in neighbors using Energy Level. Parent nodes are computing every Node neighbors' Record.

Self-Organized Data Collecting and Transmitting Phase:

Leaf Node (L) Sends Beacon. Parent Node (P) and tries to receive Beacon from Leaf Node. More than one (L) need to send data. (P) Monitor channel one which is chosen send the data others keep sleep

Information Exchanging:

Each node needs transmit data in each round; it may exhaust its energy and die. The dying of any sensor node can influence the topography. So nodes that are going need to inform others.

Even though GSTEB needs BS to compute the topography, which leads to an increase in energy waste and a longer delay, this kind of energy waste and longer delay are acceptable when compared with the energy consumption and the time delay for data transmitting.

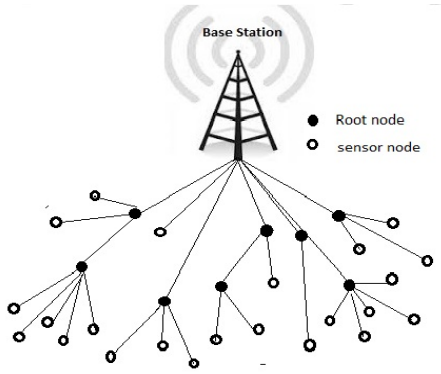

Fig 4: Architecture of GSTEB protocol

Table 1 shows a comparison between LEACH, PEGASIS, HEED and GSTEB routing protocol according to their characteristics.

Table 1. Comparison and Classification of routing protocols in Hierarchical protocols in WSN

Routing Protocols	**Category**	**Data Transmission Model**	**Data Aggregation**	**Power Consumption**	**Scalability**
LEACH	Hierarchical/ node centric	Cluster head	Yes	High	Good
PEGASIS	Hierarchical	Chain based	No	High	Good
HEED	Hierarchical	Cluster head	yes	Medium	Better when compare to LEACH
GSTEB	Hierarchical/ mobility-based	Tree based	yes	Low	Good

III. Simulation and metrics

The network simulator tool is used to generate the graph with evaluated metrics of network lifetime. Two scenarios are used to measure the performance, as follows:

A) When the value of transmission range is 30m

B) When the value of transmission range is 70m

These two scenarios are used according to the Loss of network connectivity. Simulation will report the network life time at the round when a sensor node is isolated (all its neighbours run out of energy), i.e. the network is not fully connected.

Table 2 Parameter metrics

Parameters	**Values**
Transmission bandwidth	4500bits/sec
Speed	100 bits/sec
Protocols category	Hierarchical routing protocols
No. of nodes	807
Initial energy	0.5J
processing delay	0.1 s
Network area	40×40 meter
channel	Wireless channel

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IV. RESULTS AND DISCUSSION

(I) The following graphs show the calculated value when the value of transmission range is 20m:

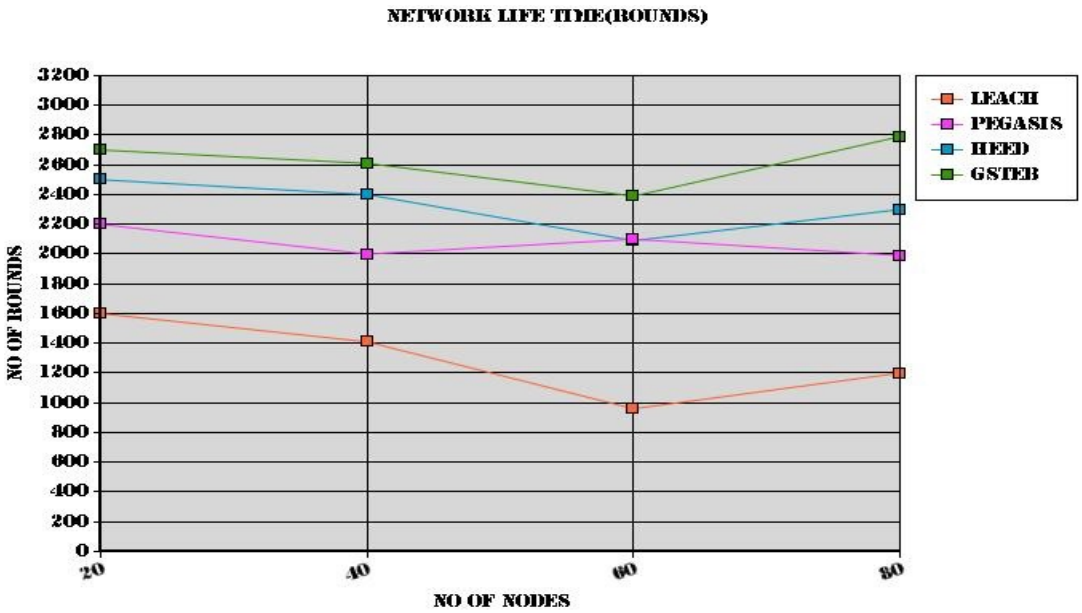

Fig: 5 network life time range of 30m

In this graph, simulation results shows that LEACH protocol was least in prolonging network lifetime because numbers of rounds were reduced when compare to other three protocols and GSTEB was highest among other protocols.

(II) The following graphs show the calculated value when the value of transmission range is 20m:

ISSN 2348 – 7968

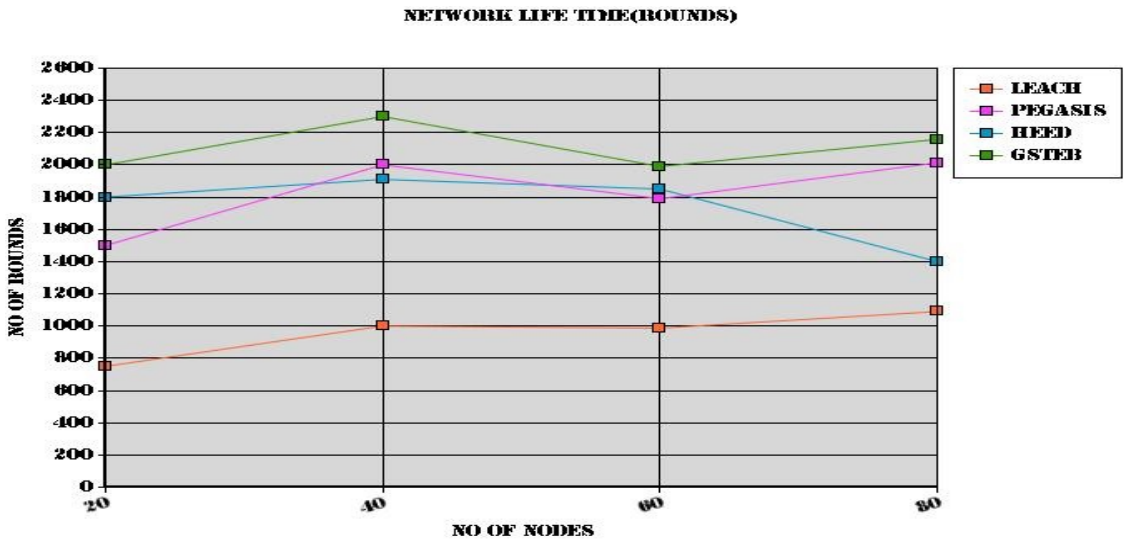

Fig: 6 network lifetime range of 70m

In this simulation result the HEED protocol performance were reduced while the transmission distance were extended. PEGASIS protocol improved by increasing the rounds with its mechanism than HEED.

V. CONCLUSION

The main goal of WSN is prolonging network life time by reducing the energy consumption among nodes. Design of every routing protocol is based on reducing a quick death of sensor nodes due to power consumption. In this paper we surveyed and simulated some hierarchical routing protocols LEACH, PEGASIS, HEED and GSTEB in wireless sensor network. Using some parameters of network lifetime evaluation i.e., some performance metrics were used to compare these protocols performance. LEACH and HEED, these two protocols reduce the total energy consumption but these two consume more energy from head nodes which leads to the death of that node quickly. When LEACH is compared to PEGASIS it reduces the total amount of data transmission and gives better performance. Our simulation results show that GSTEB protocol outperforms than PEGASIS. So we conclude that GSTEB protocol gives better performance when compare to LEACH, PEGASIS, HEED.WSN needs even more reduction in energy consumption to extend the lifetime of network.

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