A Review paper on improving power consumption in Wireless Sensor Network

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Abstract:-Networking together hundreds or thousands of cheap micro sensor nodes allows users to accurately monitor a remote environment by intelligently combining the data from the individual nodes. These networks require robust wireless communication protocols that are energy efficient and provide low latency. The communication or message passing process must be designed to conserve the limited energy resources of the sensors. Clustering sensors into groups, so that sensors communicate information only to cluster heads and then the cluster heads communicate the aggregated information to the processing center, may save energy. Clustering provide an effective method for prolonging the life time of a wsn. Current clustering algorithms utilize two techniques: Selecting cluster head with more energy and Rotating cluster head periodically to distribute energy consumption among cluster.

The objective of this paper is to present a survey on clustering parameters and clustering algorithms reported in the literature of WSNs.

Index Items:-Clustering, Cluster head selection, Cluster parameters, Energy Awareness, Hetrogeneous nodes, Leach protocol, Residual energy

I. Introduction

A WSN consists of a large number of low cost, low–power sensor nodes that are deployed in a area of interest.

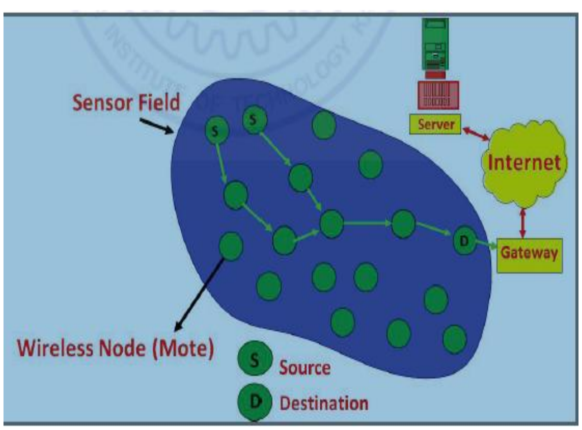

Figure-1 wireless sensor network[1]

Sensors have computation, communication, sensing capabilities. Sensor communicates via a short range radio signals and collaborate to accomplish the common tasks as shown in Fig. 1[1]. The nodes communicate wirelessly and often self organize after being deployed in an adhoc fashioned. Source node transmit their data to destination nodes through intermediate nodes. The destination node is connected to a central gateway , known as base station.

Sensor networks must support power saving modes for the sensor node. For example means of power conservation is to turn the transceiver off when it is not required. In fact, if we blindly turn the radio off during each idling slot, over a period of time we might end up expending more energy than if the radio had been left on.

Table 1. Sleep States for the sensor nodes

Sleep State	Processor	Memory	Radio	Sensor, Analog To Digital Convertor
S0	Active	Active	Tx,Rx	On
S1	Idle	Sleep	Rx	On
S2	Sleep	Sleep	Rx	On
S3	Sleep	Sleep	Off	On
S4	Sleep	Sleep	Off	Off

As a result, operation in a power-saving mode is energy-efficient only if the time spent in that mode is greater than a certain threshold. There can be a number of such useful modes of operation for the wireless sensor node, depending on the number of states of the microprocessor, memory, A/D converter, and transceiver. A dynamic power management scheme for wireless sensor networks is used where five power-saving modes are used as shown in table 1[2] .

II. Clustering in WSN

Cluster structure can prolong the lifetime of the sensor network by making the cluster head aggregate data from the nodes in the cluster and send it to the base station. A randomly deployed sensor network requires a cluster formation protocol to partition the network into clusters. The cluster heads should also be selected. There are two approaches used in this process

ISSN: 2278 – 7798

the leader first and the cluster first approach. In the leader first approach the cluster head is selected first and then cluster is formed. In the cluster first approach the cluster is formed first and then the cluster head is selected. Clustering has numerous advantages like it reduces the size of the routing table , conserve communication bandwidth, prolong network lifetime, decrease the redundancy of data packets, reduces the rate of energy consumption etc

A. Cluster properties

Quite often, clustering schemes strive to achieve some characteristics for the generated clusters. Such characteristics can be related to the internal structure of the cluster or how it relates to others. The following are the relevant attributes:

*1). **Cluster Count**:*

Cluster heads are predetermined thus, the number of clusters is preset. Cluster head selection algorithms generally pick randomly cluster heads from the deployed sensors hence yields variable number of clusters.

*2). **Intra-cluster Topology**:*

Some clustering schemes are based on direct communication between a sensor and its designated cluster head, but sometimes multi hop sensor to CH connectivity is required.

3).***Connectivity of cluster head to base station*:**

Cluster heads send the aggregated data to the base station directly or indirectly with help of other cluster head nodes. It means, there exists a direct link or a multi hop link.

*B).**Cluster head Capabilities***

The following attributes of the CH node are differentiating factors among clustering schemes

***1).Mobility*:**

Cluster head may be stationary or mobile. In most cases, they are stationary. But sometimes, cluster head can move within a limited region to reposition themselves for better network performance.

***2).Node Types*:**

Generally sensor nodes among the deployed sensors are designated as CHs, but sometimes sensor nodes equipped with significantly more computation and communication resources are selected as CHs. Nodes may be in homogeneous or heterogeneous nature. In homogeneous, all sensor nodes have same capabilities such as same energy level, configurations. In heterogeneous, nodes are varied in configurations.

***3).Role*:**

Some of the main roles of the CHs are simply relaying the traffic, aggregation or fusion of the sensed data.

C). Cluster head selection criteria

Following are some of the parameter used for selecting the cluster head

***1).Initial Energy*:**

In wsn nodes are deployed once, which are placed with variable energy level. So whenever energy consumed completely, node does not work further. This is an important parameter to select the CH. When any algorithm starts it generally considers the initial energy.

***2).Residual Energy*:**

After some of the rounds are completed, the cluster head selection should be based on the energy remaining in the sensors.

***3).Energy Consumption Rate*:**

This is another important parameter that considers the energy consumption rate.

***4).Average Energy of the Network*:**

The average energy is used as the reference energy for each node. It is the ideal energy that each node should own in current round to keep the network alive.

III. Clustering Algorithm For Energy Efficient Clustering In WSN :-

i. LEACH Protocol [Low Energy Adaptive Clustering Hierarchy]

LEACH protocol organizes the nodes by themselves. Regular nodes in cluster send data to Cluster Head (CH). Cluster Head aggregates the data and sends to base Station. In LEACH[3] Cluster Head Selection is based on the desired percentage of CHs for the network and number of times the node has been a CH so far. Each node should select a random number between the interval 0 &1. If the generated random number is less than threshold then the node becomes a CH for current round. Threshold is obtained by using the following formula: T(n) = { P/1-P*(r mod 1/P) , if n ε G

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Where, P is the desired percentage of clusters; r denotes the current round; G denotes set of nodes that have not been CHs in the last 1/P rounds. Cluster Head Selection, Cluster Formation and Data Communication are taken place at a time sending instant is known as rounds. Each round has two phases: Set-up Phase & Steady State Phase. During Set-up Phase, Cluster Head announces its election by advertisement message to all other nodes in order to form the cluster. During Steady State Phase each CH creates TDMA schedule for their members to transmit their data and it also tells when it to transmit. Nodes can send data during their allocated period. Thus the energy is saved. Finally CH aggregates all data and sends to Base Station..

ii. *Energy Residue Aware (ERA) Algorithm*

In this algorithm[4], CH election is same as that of LEACH. But it differs from cluster formation that is association between cluster head and other nodes. After the CH is elected according to LEACH, CH estimates their residual energy and broadcast this information to all other nodes. Residual energy[5] of CH is calculated by subtracting the remaining energy of CH in current round from energy requirement for transmitting data to base station. All other regular nodes calculate their residual energy by subtracting their remaining energy in current round from energy requirement for transferring data to every CH. After this they associate with one CH according to the sum of maximum energy residue path. Thus it maximizes the network lifetime by balancing the energy consumption of the network. In LEACH, regular nodes choose their cluster head according to shortest distance; due to this there will be a chance for dying CH in earlier. Compared to LEACH, ERA prolongs network life time by balancing the energy consumption of nodes. ERA ensures optimal CH selection, prolongs network life time but it does not focus on predictability of network.

iii. *LEACH – C Algorithm [LEACH-Centralized]*

In this, Cluster Head Selection depends on the current location of the node and residual energy.During setup phase, each node sends its current location and residual energy to base station. Base station estimates the average energy from the collected energy information. It finds that which node's energy level is higher than average energy level; and those nodes will be selected as Cluster Head. After selection, base station broadcasts the message along with selected Cluster Head's ID to all nodes. Node whose ID is matched with the ID containing in the message becomes CH. In LEACH –C[6], CHs are dispersed throughout the network because it is based on location & residual energy. Here the problem is, base station is responsible for calculating average energy level; in case any one of the node fails to communicate with base station due to far away from base station then the successful probability of CH selection is less.

LEACH – C considers the energy level of network but not focuses on predictability of network.

iv. *Efficient Cluster Head Selection Scheme For Data Aggregation [EECHSSDA]*

EECHSSDA[7] overcomes the problem of LEACH- C. Cluster Head Selection is same as that of LEACH-C. With decrease in energy level at CH, it selects Associate CH (ACH). If CHs energy is going to drain, ACH acts as a CH. For ACH selection, the node which has higher energy level after the energy of CH is less than average energy acts as an ACH. Due to this ACH,, no need to select the CH periodically .Hence it reduces load overhead, energy consumption and no need to select CH periodically. EECHSSDA ensures to obtain optimal cluster head, energy efficiency, but not addresses any schedulability bounds of network; hence it does not focus on predictability.

v. PEGASIS Protocol

The protocol, called Power- Efficient Gathering in Sensor Information Systems (PEGASIS)[8] is a near optimal chain-based protocol for extending the lifetime of network. The key idea in PEGASIS is to form a chain among the sensor nodes so that each node will receive from and transmit to a close neighbor. Gathered data moves from node to node, get fused, and eventually a designated node transmits to the BS. Nodes take turns transmitting to the BS so that the average energy spent by each node per round is reduced. It allows only cluster head to

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transmit their aggregated data to the sink in each round.

A sensor has to transmit to its local neighbors in the data fusion phase instead of sending directly to its cluster head as In case of LEACH. It works by forming a chain first as shown in figure2[9].

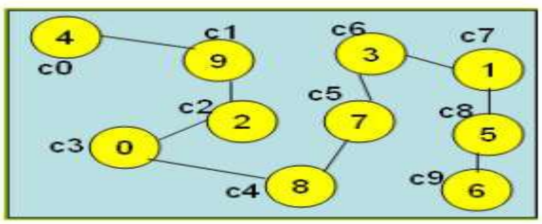

Figure2[9] showing pegasis data transmission

PEGASIS improves on LEACH by saving energy in several stages. First, in the local gathering, the distances that most of the nodes transmit are much less compared to transmitting to a cluster-head in LEACH. Second, the amount of data for the leader to receive is at most two messages.

vi. Stable Cluster Election Protocol (SCEP)

LEACH protocol is not heterogeneity aware, in the sense that when there is an energy imbalance between these nodes in the network, the sensors die out faster than they normally should have if they were to maintain their energy uniformly. In real life situation it is difficult for the sensors to maintain their energy uniformly, thus, introducing energy imbalances. LEACH assumes that the energy usage of each node with respect to the overall energy of the system or network is homogeneous. Stable Cluster Election Protocol (SCEP)[10], is proposed, which is a heterogeneous aware protocol, based on weighted election probabilities of each node to become cluster head according to their respective energy. In the SCEP, two types of nodes (two tier in-clustering) and two level hierarchies were considered. SCEP improves the stable region of the clustering hierarchy process using the characteristic parameters of heterogeneity. In the SCEP, two types of nodes are considered, Normal nodes and Advanced nodes. Advanced nodes have more energy than normal nodes by a factor α.

vii. SPIN (Sensor Protocols for Information via Negotiation)

SPIN [11] is a family of adaptive protocols that use data negotiation and resource-adaptive algorithms. SPIN is a data centric routing protocol. It assumes:

- All nodes in the network are base stations.
- Nodes in close proximity have similar data.

The key idea behind SPIN is to name the data using high-level descriptors or meta-data. Since all nodes can be assumed as base stations all information is broadcasted to each node in the network. So user can query to any node and can get the information immediately. Nodes in this network use a high level name to describe their collected data called meta-data. Figure 3[12] shows how SPIN works.

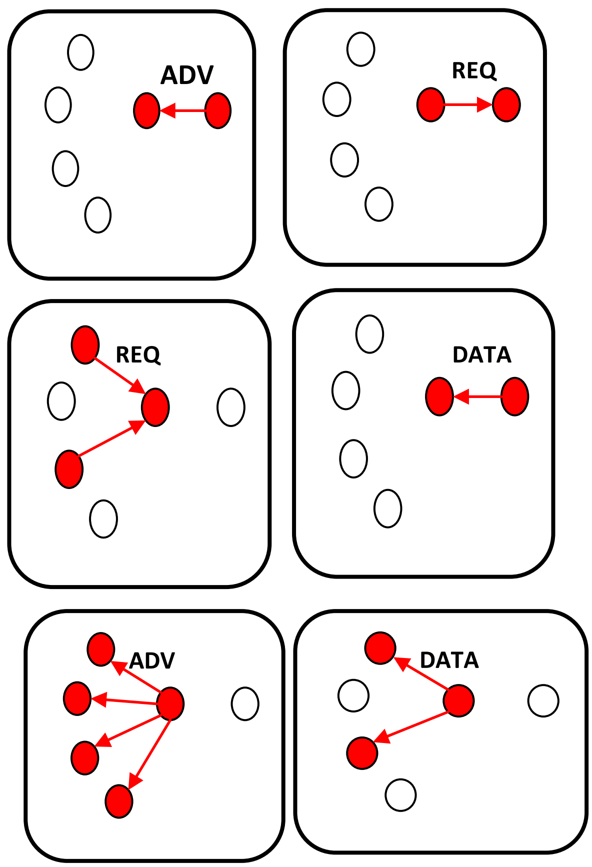

Figure 3. Data Transmission in SPIN.

Before transmission, meta-data are exchanged among sensors nodes (meta-data negotiation) via a data advertisement procedure, thus avoiding transmission of redundant data in the network. After receiving the data each node advertises it to its neighbors and interested

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neighbors get this data by sending a request message. The format of this meta-data is not specified in SPIN and it depends on the used applications. SPIN uses three types of messages: ADV, REQ, and DATA for communication with each other. ADV is used for adverting new data, REQ is used for requesting for data and DATA is the actual message. According to this protocol first a node gets some new data and the node wants to distribute that data throughout the network, so it broadcasts an ADV message containing meta-data. The interested nodes request that data by sending a REQ message and the data is sent to the requesting nodes. The neighboring node repeats this process until the entire network gets the new data.

viii. SPEED

SPEED is another QoS routing protocol for sensor networks that provides soft real time end-to-end guarantees. SPEED [13] performs better in terms of end-to-end delay and miss ratio. Moreover, the total transmission energy is less due to the simplicity of the routing algorithm, i.e. control packet overhead is less, and to the even traffic distribution. Such load balancing is achieved through the SNGF mechanism of dispersing packets into a large relay area .SPEED does not consider any further energy metric in its routing protocol. Therefore, for more realistic understanding of SPEED's energy consumption, there is a need for comparing it to a routing protocol, which is energy-aware.

ix. Geographic Adaptive Fidelity (GAF)

The state transition diagram of GAF [14] has three states name discovery, active, and sleeping. When a sensor enters the sleeping state, it turns off its radio for energy savings. In the discovery state, a sensor exchanges discovery messages to learn about other sensors in the same grid. Even in the active state, a sensor periodically broadcasts its discovery message to inform equivalent sensors about its state. GAF aims to maximize the network lifetime by reaching a state where each grid has only one active sensor based sensors is on sensor ranking rules. The ranking of based on their residual energy levels. Thus, a sensor with a higher rank will be able to handle routing within their corresponding grids. For example, a sensor in the active state has a higher rank than a sensor in the discovery state. A sensor with longer expected lifetime has a higher rank.

x. Geographic and Energy-Aware Routing (GEAR)

Location based routing protocols for sensor network need location information of all the sensor nodes to calculate the distance between any two nodes. GEAR [15] is a location based routing protocol which uses GIS (Geographical Information System) to find the location of sensor nodes in the network. According to this protocol, each node stores two types of cost of reaching the destination: estimated cost and learning cost. The estimated cost is a combination of residual energy and distance to destination. The learned cost is a modified estimated cost and it accounts the routing around holes in the network. When a node does not have any closure neighbors' towards the target region, a hole occurs. In case where no holes exit, the estimated cost is equal to the learned cost. The GEAR Protocol only considers a certain region rather than sending the interests to the whole network as happens in Directed Diffusion and thus restricting the number of interests.

IV. Comparison of Algorithms:

From this survey, it is observed that , Clustering algorithms without energy awareness, CH can not be rotated and loads can not be shared**.** Classification of Routing Protocols is necessary to evaluate and decide which protocol is applicable for a particular situation. The study of routing protocols in detail made it easy to evaluate and compare each protocol depending upon the factors that are mentioned above. Now we compare the above mentioned routing protocols according to their performance depending on the different parameters. Table-2[16][17] shows the operability of protocols with regard to Latency, Heterogeneity, Cluster head selection, Connectivity adaption and Energy Awareness.

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Protocol	Principle of working	Heterogeneity	Connectivity Adaption	Energy param--eter	Energy awareness	Latency
Leach	Cluster head selected on basis of prob./random	not present	Cluster head leads communication	No	High	Low when the network is small
Leach-C	Average energy based CH	Not	CH leads	Yes	Higher	Low when network is small
ERA	Prob. Based cluster head	Not	Ch leads	Yes	Higher	Moderate
EECHSDA	Average energy CH	Not	Ch leads	Yes	High	Low
PEGASIS	Average energy CH	Not	Chain based	Yes	Max	Moderate
SCEP	Prob. Based CH	Yes	Ch leads	No	High	Low when the network is small
SPIN	Interested nodes group	Not	Data shared with interested nodes, to reach sink	No	Moderate,	Moderate if the network is large
GAF	State based nodes with priority	Moderate	One node from the grid is used remaining go to sleep state	No	High, Node use sleep, discovery, awake states	Moderate, uses limited nodes
SPEED	Path based transmission and cost is proceeded	Not	Paths are built using least cost algorithms	No	High, Always uses multiple paths to transmit data	Low, always tries to reduce congestions
GEAR	Drain node estimation	Not	Calculate least cost paths to reach sink	No	Moderate, same path used until new path is calculated	Moderate, Checks for drained nodes

Table2[16][17] Comparison of various existing algorithm in wireless sensor network for improving power

ISSN: 2278 – 7798

V . Conclusion:- To maximize the network life time optimal cluster head selection is important. CHs require more energy than all other nodes because they perform processing, sensing, communication and aggregation. In case, the cluster head dies in earlier, then the entire network becomes useless; since the CH cannot communicate with Base Station. To obtain optimal cluster head, CH should be elected based on the various parameters of nodes in a cluster like energy etc. Therefore energy efficiency is maximized & network lifetime is also prolonged.

VI. Future Scope:

In this review paper we have seen various algorithm which are improving network lifetime somewhere. Most of these works on homogeneous nodes and does not provide consistent performances . So we have to develop a technique that have different types of nodes like (heterogeneous resources of energy, computational heterogeneity, link heterogeneity) and provide stability in network lifetime.

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Enhanced Clusterhead Selection Algorithm Using LEACH Protocol for Wireless Sensor Networks Rudranath Mitra1, Anurupa Biswas2 1,2Department of Information Technology Heritage Institute of Technology Anandapur, Kolkata – 700107.INDIA.

ISSN: 2278 – 7798