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Energy Efficient Clustering Algorithm in Wireless Sensor Network

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Abstract: - Wireless sensor networks have attracted much research attention in recent years and can be used in many different applications. That paper presents the several energy efficient clustering algorithms such as LEACH, PEGASIS and VGA. Energy Efficiency is a crucial factor for the performance of wireless sensor networks (WSN). Clustering is an efficient approach to capitalize the energy of energy constraint sensor nodes in wireless sensor networks (WSNs). LEACH is a major breakthrough for clustering technique by rotating the role of clusterhead among nodes. LEACH, PEGASIS and VGA is able to distribute energy dissipation evenly throughout the sensors, doubling the useful system lifetime for the networks. Clustering technique has been proven to be an effective approach for reducing energy consumption. It also can increase the scalability and lifetime of the network. Clustering facilitate the network self management and make it easy to devise the communication protocols.

Keywords: - Clustering Algorithm; Wireless sensor network; Energy efficiency; LEACH; PEGASIS and VGA

I. INTRODUCTION

Wireless sensor networks [1] [2] are typically characterized by denser levels of nodes deployment, higher unreliability of sensor nodes, asymmetric data transmission, and severe energy supply, computation, and memory constraints. These unique characteristics and constraints present many challenges for the development and eventual application of wireless sensor networks. Since the sensor nodes are [3] equipped with tiny, irreplaceable batteries with limited power supply, it is essential that the network be energy efficient in order to prolong the lifetime of the whole network Therefore, energy efficiency is a major design goal in WSNs. In addition, wireless sensor network design also demands other requirements such as fault tolerance, scalability, QoS, and reliability [2]. Sensor nodes [1] [2] are energy constrained because they carry a limited energy.

Because nodes are deployed randomly in a harsh environment so replacement or recharging of battery is not quite possible. Communications being the major energy consuming process, design of data centric wireless sensor networks [1] [2] [3] [4] focus on energy efficient data gathering. Recent [2] advances in micro-electro-mechanical system (MEMS) technology, wireless communications, and digital electronics have enabled the development of low-cost, low-power, multifunctional sensor nodes that are small in size and communicate undeterred in short distances.

These tiny sensor nodes, which consist of sensing, data processing and communicating component, leverage the idea of sensor networks based on collaborative effort of a large number of nodes. Sensor networks represent a significant improvement over traditional sensors. One of the most important constraints on sensor nodes is the low power consumption requirement. Sensor nodes carry limited, generally irreplaceable, power sources. Therefore, [2] [5] while traditional networks aim to achieve high quality of service (QoS) sensor network protocols must focus primarily on power conservation. They must have inbuilt trade-off mechanisms that give the end user the option of prolonging network lifetime at the cost of lower throughput or higher transmission delay [5].Low Energy Adaptive Cluster Hierarchy (LEACH) [2] [3] [5] suggests rotation of role of clusterhead among nodes randomly. A node will be a clusterhead for a round and after which re-clustering is done with a new clusterhead for each cluster. Every node has the possibility of being a clusterhead. The main idea in PEGASIS [9] [14] is for each node to receive from and transmit to close neighbors and take turns being the leader for transmission **to** the BS. This approach will distribute the energy load evenly among the sensor nodes in the network.

That paper described as follow, first one was described the WSN routing protocol, all routing protocol are hierarchical. Second section was the related work of hierarchical clustering algorithm. Last section was energy model of the LEACH and PEGASIS.

II. WSN ROUTING PROTOCOL

Hierarchical routing performs energy-efficient routing in WSNs, and contributes to overall system scalability and lifetime. There are some WSN routing protocol here we discussed.

A. Low Energy Adaptive Clustering Hierrchical Protocol (Leach):

LEACH [5] [7] protocol was a major breakthrough in clustering scheme. Now most of the clustering schemes proposed use LEACH as backbone. In LEACH, the nodes organize themselves into local clusters, with one node acting as the local base station or cluster-head. If the clusterheads [4] [5] were chosen a priori and fixed throughout the system lifetime, as in conventional clustering algorithms, it is easy to see that the unlucky sensors chosen to be cluster-heads would die quickly, ending the useful lifetime of all nodes belonging to those clusters. In LEACH [5] [6] scheme clusterhead selection is done randomly among the nodes during each round. Operation of LEACH is carried out in two phases during a round: set-up phase and steady phase.

During the set-up phase, a sensor node chooses a random number between 0 and 1.

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If this random number is less than the threshold T (n), the sensor node is a cluster-head. T (n) is calculated as in equation (1) [5].

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

Here P is the desired percentage to become a clusterhead; r, the current round; and G, the set of nodes that have not being selected as a clusterhead in the last 1/P rounds. After the cluster-heads are selected, the cluster-heads advertise to all sensor nodes in the network that they are the new cluster-heads [5]. During the steady phase [5], the sensor nodes transmit data to their respective clusterhead. Clusterhead aggregates data and sends to the base station. After a certain period of time spent on the steady phase, re-clustering is done.

a. Cluster Set up Phase:

After each node has decided to which cluster it belongs, it must inform the cluster-head node that it will be a member of the cluster. Each node transmits this information back to the cluster-head again using a CSMA MAC protocol. During this phase, all cluster-head nodes must keep their receivers on [5].

b. Schedule Creation:

The cluster-head node receives all the messages for nodes that would like to be included in the cluster. Based on the number of nodes in the cluster, the cluster-head node creates a TDMA schedule telling each node when it can transmit. This schedule is broadcast back to the nodes in the cluster [5].

c. Data Transmission:

Once the clusters are created and the TDMA [6] schedule is fixed, data transmission can begin. Assuming nodes always have data to send, they send it during their allocated transmission time to the cluster head. This transmission uses a minimal amount of energy (chosen based on the received strength of the cluster-head advertisement). The radio [4] of each non-cluster-head node can be turned off until the node's allocated transmission time, thus minimizing energy dissipation in these nodes. The cluster-head node must keep its receiver on to receive all the data from the nodes in the cluster. When all the data has been received, the cluster head node performs signal processing functions to compress the data into a single signal. For example, if the data are audio or seismic signals, the cluster-head node can beamform the individual signals to generate a composite signal. This composite signal is sent to the base station. Since the base station is far away, this is a high-energy transmission [5].

d. Hierarchical Clustering:

The cluster-head nodes would communicate with "super-cluster head" nodes and so on until the top layer of the hierarchy, at which point the data would be sent to the base station. For larger networks, this hierarchy could save a tremendous amount of energy. In future studies, we will explore the details of implementing this protocol without using any support from the base station, and determine, via simulation, exactly how much energy can be saved [5].

B. Power- Efficient Gathering In Sensor Informtion Systems (Pegasis):

An enhancement over LEACH protocol was proposed in [9]. The protocol, called Power- Efficient Gathering in Sensor Information Systems (PEGASIS). The protocol is a near optimal chain-based protocol for extending the lifetime of network.

In PEGASIS, each node communicates only with the closest neighbor by adjusting its power signal to be only heard by this closest neighbor. Each Nodes uses signal strength to measure the distance to neighborhood nodes in order to locate the closest nodes. After chain Formation PEGASIS elects a leader from the chain in terms of residual energy every round to be the one who collects data from the neighbors to be transmitted to the base station. As a result, the average energy spent by each node per round is reduced. Unlike LEACH, PEGASIS [9] avoids cluster formation and uses only one node in a chain to transmit to the Base station instead of multiple nodes. This approach reduces the overhead and lowers the bandwidth requirement from the BS. Figure 1 shows that only one cluster head leader node forward the data to the BS [13].

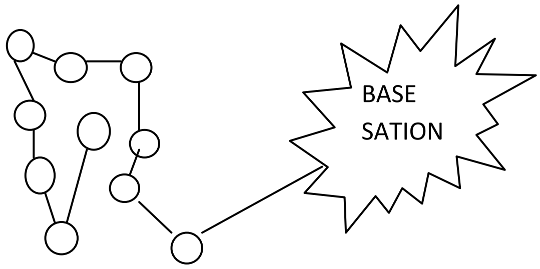

Figure1:- PEGASIS [10]

C. Virtual grid Architecture (VGA):

Virtual Grid Architecture (VGA) is an energy- efficient routing paradigm proposed in [10]. The protocol utilizes data aggregation and in-network processing to maximize the network lifetime. Due to the node stationary and extremely low mobility in many applications in WSNs, a reasonable approach is to arrange nodes in a fixed topology. A GPS-free approach is used to build clusters that are fixed, equal, adjacent, and non-overlapping with symmetric shapes. In [10], square clusters were used to obtain a fixed rectilinear virtual topology. Inside each zone, a node is optimally selected to act as CH. Data aggregation is performed at two levels: local and then global. The set of CHs, also called Local Aggregators (LAs), perform local aggregation, while a subset of these LAs are used to perform global aggregation. However, the determination of an optimal selection of global aggregation points, called Master Aggregators (MAs), is NP-hard. Figure 2 illustrates an example of fixed zoning and the resulting virtual grid architecture (VGA) used to perform two level data aggregation. Note that the location of the base station is not necessarily at the extreme corner of the grid; rather it can be located at any arbitrary place [13].

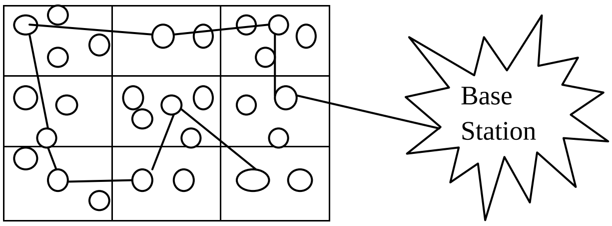

Figure: 2

III. RELATED WORK

LEACH [5], the nodes organize themselves into local clusters, with one node acting as the local base station or cluster-head. In LEACH [4] [5], the three type of phases i.e. cluster set up phase, data transmission phase and schedule creation phase. PEGASIS [10] is a near optimal chain-based protocol for extending the lifetime of network. In PEGASIS, each node communicates only with the closest neighbor by adjusting its power signal to be only heard by this closest neighbor. VGA [11] protocol utilizes data aggregation and in-network processing to maximize the network lifetime.

Due to the node stationary and extremely low mobility in many applications in WSNs, a reasonable approach is to arrange nodes in a fixed topology. O. Younis et al.[1] conclude that the clustering of node in wireless sensor network is important and its save the energy of every node and the network life time was increased. I.F. Akyildiz et al.[2] conclude the survey of wireless sensor network and it also described the application of WSN. Abbasi et al.[3] conclude the survey of all clustering algorithms i.e. LEACH, PEGASIS, VGA, HEED etc. All algorithms are hierarchical algorithm. W. Heinzelman et al.[5] conclude the LEACH energy efficient clustering algorithm. LEACH was hierarchical and scalable algorithm and data aggregation, data delivery was done by the cluster head selection. B.

Deosarkar et al.[7] conclude that the LEACH increased the network life time by using the steady phase and set up phase. P.Bhaskar et al.[8] conclude that the LEACH classification was hierarchical and node centric and the scalability was good then the other hierarchical clustering algorithm. S. Lindsay et al.[9] conclude the PEGASIS clustering algorithm i.e. chain based algorithm and the power uses was max but lower than the power uses by the LEACH. J.N. Alkaraki et al.[10] describd th data aggregation of WSN routing protocol, data aggregation was done by the LEACH and VGA routing protocol but PEGASIS can't performed the data aggregation because it was chain based protocol. R.V. Biradar et al.[11] conclude the classification and comparison of routing protocol of WSN i.e. show into the table. Lailali et al.[13] conclude the performance and evaluate the routing protocol of wireless sensor network. The performance of the LEACH protocol was good but the power uses by the LEACH was high then the other routing protocol. PEGASIS was the extension of the LEACH clustering algorithm it was removes all the drawbacks of the LEACH protocol.

Classification and Comparison of routing protocols in WSNs [11]

Table1.Comparision of routing protocol in WSN

Routing Protocols	LEACH	PEGASIS	VGA
Classification	Hierarchical / Node-centric	Hierarchical	Hierarchical
Power Usage	High	Max	Low
Data Aggregation	Yes	No	Yes
Scalability	Good	Good	Good
Query Based	No	No	No
Over Head	High	Low	High
Data delivery model	Cluster head	Chains based	Good
QoS	No	No	**No**

IV. ENERGY MODEL

There [5] have been several network routing protocols proposed for wireless networks that can be examined in the context of wireless sensor networks. Using a direct communication protocol, each sensor [4] [5] [7] sends its data directly to the base station. If the base station is far away from the nodes, direct communication will require a large amount of transmit power from each node (since d in Equation 1 is large). This will quickly drain the battery of the nodes and reduce the system lifetime [5]. Radio energy model [5] used for this study uses a 914 MHz radio. The node radio energy consumed in transmission is as in equation (2).

Table2. RadioTransmiter Characteristics

Operation	**Energy Dissipated**
Transmitter Electronics($E_{tx\text{-}elec}$) Receiver Electronics($E_{rx\text{-}elec}$) ($E_{tx\text{-}elec}=E_{rx\text{-}elec}=E_{elec}$)	50nJ/bits
Transmit Amplifier(Єamp)	100pJ/bit/m2

$$E_{Tx}(m,d) = \begin{cases} m\times E(elec) + (m\times E_{fs}\times d^2)\ \ d < d_0 \\ m\times E(elec) + (m\times E_{amp}\times d^4)\, d \geq d_0 \end{cases} \quad (2)$$

Where [5], *m* is the number of bits transmitted, *d* is the distance between transmitter and receiver and do is the distance constant referred as crossover distance. And for receiving the *m* bit message the node radio consumes as in equation (3).

$$E_{Rx}(m) = M \times E(elec) \quad (3)$$

As communication cost [5] is considered to be much larger than computational cost, the contribution of computations to the energy consumption is considered to be negligible in this analysis. The assumed energy required for running the transmitter and receiver electronic circuitry *E(elec)* is 50nJ/bit and for acceptable SNR required energy for transmitter amplifier for free space propagation E_{fs} is 100pJ/bit/m2 and for two ray ground E_{mp} is 0.0013pJ/bit/m4.

The crossover distance d_0 is assumed to be 87m [5].

Energy model for PEGASIS [14] a radio dissipates [9] [14] $\mathbf{E_{elec}}$ = 50 nj/bit to run the transmitter or receiver circuitry and $Є_{amp}$ = 50 pj/bit/m^2 for the transmitter amplifier. The radios have power control and can expend the minimum required energy to reach the intended recipients.The radios can be turned off to avoid receiving unintended transmissions. The equations used to calculate transmission costs and receiving costs for a k-bit message and a distance d are shown below:

Transmitting

$$E_{Tx}(k, d) = E_{Tx\text{-}elec}(k) + E_{Tx\text{-}amp}(k, d)$$

$$E_{Tx}(k, d) = E_{elec} * k * d^2$$

Receiving

$$E_{Rx}(k) = E_{Rx\text{-}elec}(k)$$

$$E_{Rx}(k) = E_{elec} * k$$

Receiving is also a high cost operation, therefore, the number of receives and transmissions should be minimal.

V. CONCLUSION

In the wireless sensor network (WSN), A clustering-based routing protocol that minimizes global energy usage by distributing the load to all the nodes at different points in time. LEACH, PEGASIS and VGA outperforms static clustering algorithms by requiring nodes to volunteer to be high-energy cluster-heads and adapting the corresponding clusters based on the nodes that choose to be cluster-heads at a given time. At different times, each node has the burden of acquiring data from the nodes in the cluster, fusing the data to obtain an aggregate signal, and transmitting this aggregate signal to the base station. LEACH is completely distributed, requiring no control information from the base station, and the nodes do not require knowledge of the global network in order for LEACH to operate. PEGASIS can greatly prolong sensor network's lifetime when the transmission range is limited. VGA saves more energy than other protocols when the transmission range is farther, since the early death of the nodes reduces the network's coverage badly.

VI. REFRENCE

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