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A Survey on Hierarchical Energy Efficient Routing Protocols in Wireless Sensor Networks

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Abstract: Wireless sensor networks are energy-constrained networks. They have a limited lifetime which is determined by a non-replaceable and non-rechargeable battery equipped in the sensor nodes forming the network. Energy is consumed by a sensor node during transmission and reception of data. Even if a node is not transmitting or receiving data, energy is still consumed if it is active all the time. In this paper, we have studied various clustering based protocols available for wireless sensor networks and reviewed them in terms of their energy efficiency.

Keywords: Wireless sensor network, Energy-constrained, Sensor node, Clustering, Energy efficiency.

I. INTRODUCTION

Wireless sensor network may consist of hundreds or thousands of sensor nodes and can spread out as a mass or placed out one by one. The sensor nodes collaborate with each other over a wireless media to establish a sensing network, i.e. a wireless sensor network because of the potentially large scale of the wireless sensor network each individual sensor node must be small and of low cost. The availability of low cost sensor nodes has resulted in the development of many other potential application areas.The sensor network can provide access to information by collecting, processing, analysing and distributing data from the environment. A sensor node is a node in wireless sensor network [1] that is capable of performing some process gathering sensor information and communicating with other connected nodes in the network. These nodes form a typical wireless network system by combining with routers and gateways. Each node has the processing capability, contains multiple type of memory, have a RF transreceiver, power source and accommodate various sensors and actuators. The nodes communicate wirelessly and deployed in ad hoc fashion. Even 1000 to 10,000 nodes are scheduled. The wireless sensor network structure consist of sensor nodes and base station. Base station is located far away from sensor node, the data/information collected by the sensor node is transmitted to the base station. Sometimes the sensor node can send information directly to the base station or else via some intermediate sensor nodes. The location of the sensor nodes are pre-determined. Wireless sensor network is an emerging technology which attract researchers due to their potential applications in various field such as environment monitoring, radiation and nuclear threat detection systems, weapon sensors for ships, battlefield, reconnaissance and surveillance military command, control communication intelligence, biomedical application. In addition to this underwater surveillance, military sensing, physical security, process control, air traffic control, traffic surveillance, video surveillance, industrial and manufacturing,automation,distributed,robotics,weathersensing,environment monitoring, building and structure monitoring will also be the nature areas where Wireless sensor networks are very helpful.

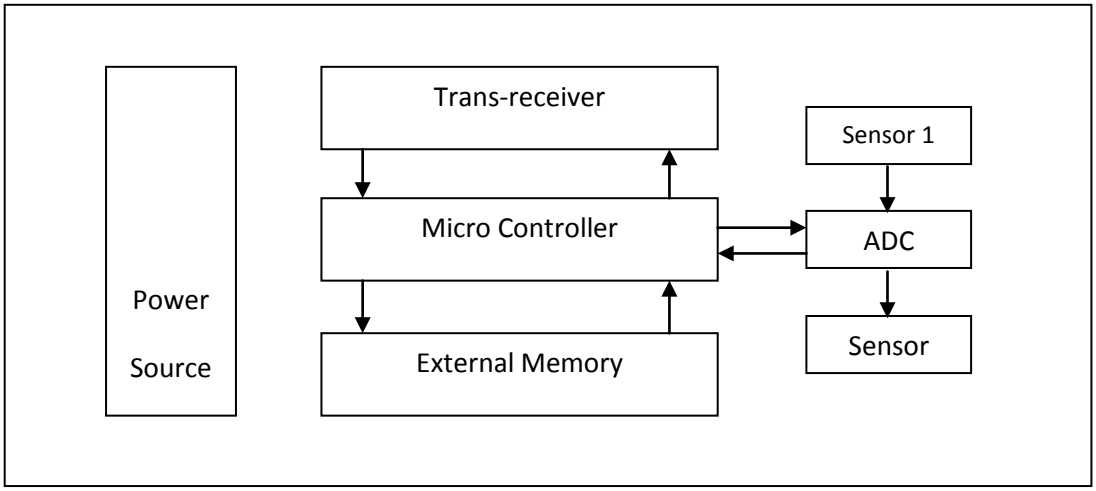

Figure 1 : Architecture of sensor node

Routing [2,3,4] in sensor networks is very challenging, due to several characteristics that distinguish them from contemporary communication and wireless ad-hoc networks. Many new goal and data-oriented algorithms have been proposed for the problem of routing data in sensor networks. The sensor mote is a small node with the capabilities of the sensing, computation, wireless communication, power(battery driven).The sensing unit consist of more than one sensor which senses the physical medium and transmits the signal. The transmitted signal is fed through ADC and then sends to the computation unit. The computation unit consist of micro controller and external memory. The wireless communication system consists of transreceiver for performing data transmission and reception and the power source is used for the supply of power to the requisite unit.

II. CONSTRAINTS IN WSN

A. Energy constraints

In wireless sensor network energy plays an important role as energy consumption in the sensor nodes are categorised as

- Energy for sensor transducer
- Energy for communication among sensor nodes.
- Energy for microprocessor computation

B. Limitations of memory

A sensor is a tiny device with small amount of memory and storage space. To run complicated algorithms in this sensor is very difficult as the space is very less.

C. Nodes unattended in network

The nodes that are deployed in distant region left unattended sometime. In this type of environment the probability that the nodes might be physically attacked is very high.

D. Poor reliability in communication

Packet based is very critical in security as some security mechanisms may rely on critical event reports and cryptographic key distribution. This is due to the broadcast nature of wireless communication, as the packets may collide in transit and may need retransmission.

E. High latency in communication

Synchronization is very complex to achieve due to network congestion and processing in the transitional nodes. At highly congested nodes the packets may get damaged or dropped.

III. CLUSTERING IN WSN

In the design of wireless sensor network, usage of energy plays a vital role and this supply of energy depend on portable energy sources like batteries foe power. A sensor technology called MEMS (micro electro mechanical system) has facilitated the development of smart sensors which are tiny devices with limited power, processing and computation and resources. Smart sensors are power constrained devices that have one or more sensors, memory unit, processor , power supply and actuator. In wireless sensor network, sensor nodes have certain constrains in terms of processing power, communication bandwidth and storage space which requires very efficient resource utilization.

In wireless sensor network, the sensor nodes are grouped to form a cluster. Clustering[5] provides network scalability ,resource sharing and efficient use of constraint use of resources which gives network topology, stability and energy saving attributes. The clustering skims reduces communication overheads and efficient resource allocations. Thus decreasing the interference among sensor nodes. Too many clusters will make the area congested with small size clusters and a very small number of cluster will exhaust the cluster head with large amount of messages transmitted from cluster member. In a cluster, the efficient way to lower energy consumption is the hierarchical routing, which performs data aggregation and fusion in order to decrease the number of transmitted messages to the BS. Indeed energy efficiency, clustering reduces channel contention and packet loss, avoids collision resulting, in better network throughput under high load. The improved network lifetime is shown by the method of clustering, It is a primary metric for evaluating the performance of sensor network. Clustering has numerous advantage in addition to support network scalability. within the cluster route can be localized which helps in reduction of the size of routing tables that are stored in the individual nodes. As clustering limits the scope of inter cluster interactions to CHs and avoids redundancy which conserves the communication bandwidth.

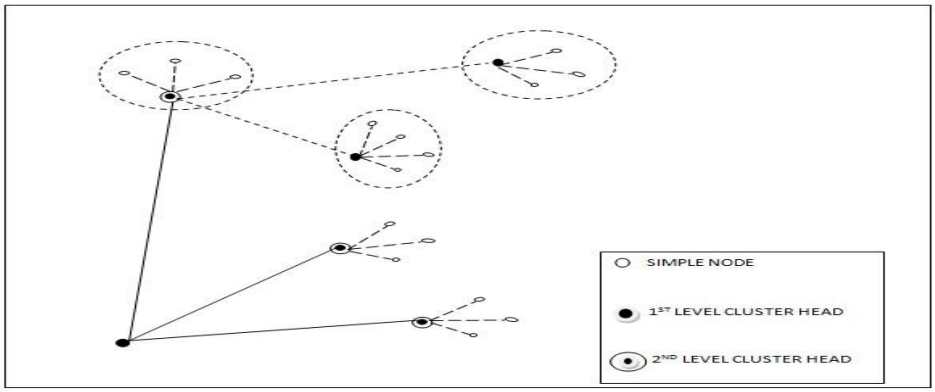

Figure 2: Clustering

Hierarchical routing or cluster based routing aims at maintain efficiently the energy usage of sensor nodes by involving them in multi-hop communication within a particular cluster. Formation of cluster is based on the reserved energy of sensors and proximity of the cluster head (CHs).

In WSNs, clustering plays a vital role for energy saving. Clustering in WSNs, energy consumption lifetime of the network and scalability can be improved. In a cluster, the cluster head requires to perform routing task and the other sensor node just forward their data to cluster head. High density sensor network is an important application of clustering because it is easy to manage a set of cluster head from each cluster and then to manage whole sensor node. In WSNs the nodes are resource constraint i.e. they limited energy, transmit power, memory and transmission capabilities. The crucial cause of energy depletion in sensor nodes is the energy consumed by the sensor nodes for communicating data from sensor nodes to the base station.

IV. ENERGY EFFICIENT PROTOCOLS

A. Low energy adaptive clustering hierarchy (LEACH)

LEACH[6,7,8] is the first hierarchical cluster based routing protocol for wireless sensor network. It partitions the nodes into clusters, in each cluster a cluster head (CH) is chosen which has extra privileges for creating and manipulating a TDMA (time division multiple access) schedule and sending aggregated data from nodes to the BS where these data is needed using CDMA(code division multiple access), remaining nodes are the members of the cluster. It has two phases

- Setup phase: In this phase the sensor node selects random number between 0 and 1. If the number selected is less than the threshold T(n) , then the node becomes the CH. T(n) is calculated as:-

$$T(n) = \left\{ \frac{p}{1-p} * \left(r \bmod \left(\frac{1}{p} \right) \right) \right\}, \quad if\ n\ \varepsilon\ G$$

$$T(n) = 0, \quad otherwise$$

Where, r - is the current round, p – the desired percentage for becoming CH and G – is the collection of nodes not elected as a CH in the last 1/p rounds.

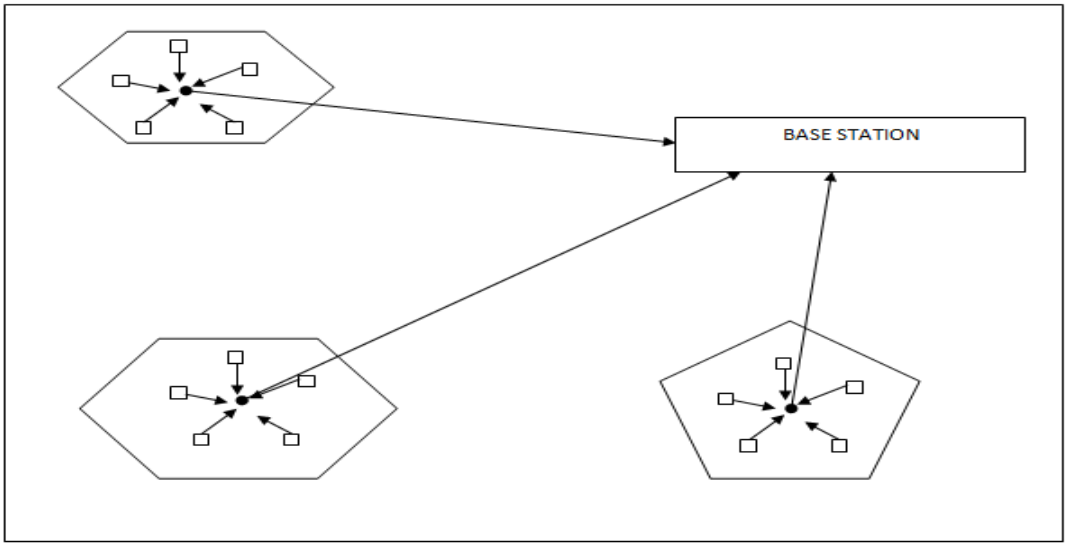

Figure 3: LEACH protocol

Each and every nodes decides itself to become a CH or not. The nodes which are not elected for CH from long time have the maximum probability of becoming CH. In the advertisement phase the CH advertise and broadcast the message to its neighbourhood nodes about the CH.

- Steady-state phase: In this phase data transmission begins. Nodes sends data in the allocated TDMA slot of the CH. The transmission takes minimal amount of energy. The radio of each non CH node is turned off to minimize energy dissipation of the nodes. When all the data is received the CH aggregate these data and sends to the base station.

B. Power efficient gathering is sensor information systems(PEGASIS)

PEGASIS[9] is a chain based protocol. It is the extension of LEACH protocol. PEGASIS protocol requires the formation of chain which is achieved in two steps

- Chain Construction: The sensor nodes forms chains with each other so that transmission and reception of data is done to transmit to the base station (sink). In a greedy way the chain construction is performed, the node at the farest end from the sink is selected first and second node is the node that is next to the first node is selected in the chain. A node can be in a chain at only single position. In each round the leader node is randomly selected. If the sensor node fails due to power dissipation the same greedy approach is used to construct the chain by bypassing the failed sensor.

- Gathering data : The data gathered moves from node to node aggregated and eventually sent to the base station. PEGASIS avoids cluster formation and uses only one node at the time of data fusion phase instead of sending directly to its CH as in the case of LEACH.

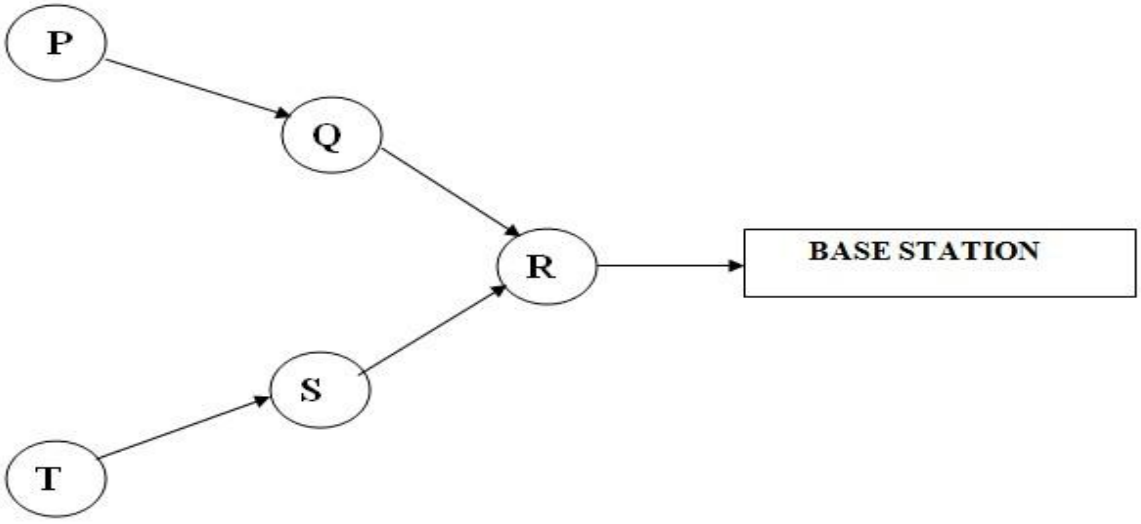

Figure 4: Chain formation and data gathering in PEGASIS

For example as shown in the figure 4 node P pass on its data to node Q and node Q along with the data of node P and its own data passes to the main node R. Similarly, the node T passes its data to node S and node S along its own data and T's data it passes to R and R aggregates all the messages from the neighbours and transmits to the base station.
Simulation results shows that PEGASIS is able to increase the lifetime of the network as compared to LEACH protocol. Performance gain is achieved by eliminating the overhead which is caused by dynamic cluster formation in LEACH and also decreasing number of transmission and reception and using data aggregation. Even though clustering overhead is avoided, PEGASIS requires dynamic topology adjustment since nodes needs to know about the energy status of its neighbours to route its data. PEGASIS reduces the energy spent per round. In many stages we can see that PEGASIS is more power saving than LEACH protocol. Firstly, in the local gathering, the distance between two nodes is much less as compared to LEACH in the case of transmission of the cluster head. Secondly, only a node transmits to the base station in each round of communication. Hence, LEACH is outperformed by PEGASIS by limiting number of transmissions, eliminating the dynamic overhead.

C. Hybrid energy efficiency protocol(HEEP)

HEEP[10,11] uses the principle of PEGASIS in its clusters. In this, a chain of nodes is arranged in each cluster to avoid energy loss. In each cluster the CH transmits the aggregated data to the base station

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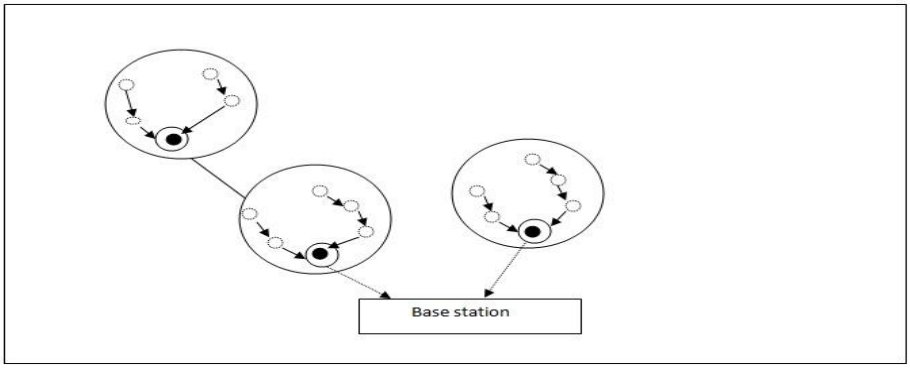

Figure 5: Chains cluster organization in HEEP

Figure 5, shows that the nodes within cluster forms a chain by transmitting its data to the neighbouring node and the neighbouring node with its own data along with the transmitted data from the neighbours passes on to the CH, the CH finally transmits the data to the BS. In this way the transmission distances and the number of nodes communicating with CH is reduced. Chain clustering implies better energy saving and even extends CHs lifetime. LEACH concept of random rotation of the CH is used by HEEP , which control energy dissipation and the nodes selected as CH does not die soon.
HEEP has two important phases, firstly the initialization phases where chain cluster are formed and CH is elected and Secondly is the transmission phase, where collected data is transmitted. As transmission distance is reduced, the total rounds of transmission is definitely improved.

D . Threshold sensitive energy efficient sensor network protocol(TEEN)

TEEN[12,13] is a hierarchical clustering protocol. Sensors are grouped to form a cluster and each cluster having a CH. The sensors transmits the sensed data to its CH and the CH transmits the data to the high level CH and the process of transmitting goes on till it reaches the base station. In this process of forming clusters every time, the cluster head along with the attributes broadcast two messages to its members. First is the hard threshold, it is the value of sensed attribute and is the absolute value of the attribute apart which the node sensing this value should switch on its transmitter and report to its CH. Secondly is the soft threshold, this happens when there's a small change in the value of the attribute when it triggers the node to switch on its transmitter and transmits.

The nodes senses the environment continuously, when it reaches the hard threshold it switches on the transmitter and transmits the sensed data. The sensed value is stored as "Sensed Value"(SV) in the internal variable of the node. Hence , the node transmits data in current cluster period when two conditions are fulfilled. Firstly , the current value is greater than the hard threshold and secondly, the current value of the sensed attribute differs from SV by an amount equal to or greater than the soft threshold.

TEEN uses data centric method with the concept of hierarchical approach. TEEN applications are used in time critical sensing, controlling trade-off between energy efficiency, data accuracy and response time dynamically. TEEN is not suitable for sensing applications where periodic reports are required because the user may not get any data at all if the threshold conditions are not met.

V. CONCLUSION

In this paper, we have examined the hierarchical cluster based routing protocols focusing on the energy efficiency of the protocol. In WSN, the energy dissipation of the nodes plays a vital role in the design of the protocols. The lifetime of each node is dependent on the battery. The more the nodes will be active throughout, the more is the loss of energy as transmission and reception goes on continuously. Hence, the chances of the node to die out are more. The aim of the energy efficient clustering based protocols is to maintain the usage of energy by each node in multi-hop communication within a particular cluster. Clustering plays a crucial role in WSN as network lifetime, energy consumption, scalability, reliability are improved. The existing protocols can be further enhanced to improve the energy efficiency.

REFERENCES

[1] C.Divya, N.Krishnan and P.Krishnapriya, *"Modified Distributed Energy-Efficient Cluster for Heterogeneous Wireless Sensor Networks"*, International Conference on Emerging Trends in Computing, Communication and Nanotechnology, IEEE, 2013.

[2] Adeel Akhtar, Abid Ali Minhas, and Sohail Jabbar, *"Energy Aware Intra Cluster Routing for Wireless Sensor Networks"*, International Journal of Hybrid Information Technology Vol.3, No.1, pp. 29-49, January, 2010.

[3] Hui Li, Jianghong Shi, Qi Yang and Dezhong Zhang, *"An Energy-Efficient Hierarchical Routing Protocol for Long Range Transmission in Wireless Sensor Networks"*, 2nd International Conference on Education Technology and Computer (ICETC), IEEE, 2010.

[4] K. Kishan Chand, P Vijaya Bharati and B. Seetha Ramanjaneyul, *"Optimized Energy Efficient Routing Protocol for Life-Time Improvement in Wireless Sensor Networks"*, IEEE-International Conference On Advances In Engineering, Science And Management (ICAESM -2012) March 30, 31, 2012.

[5] S. Mathapati Basavaraj, Siddarama R. Patil and V. D. Mytra, *"A cluster based energy efficient reliable routing protocol for wireless sensor networks"*,1st International Conference on Emerging Technology Trends in Electronics, Communication and Networking, IEEE, 2012.

[6] Nguyen Duy Tan, Longzhe Han, Nguyen Dinh Viet and Minho Jo, *"An Improved LEACH Routing Protocol for Energy-Efficiency of Wireless Sensor Networks"*, Smart Computing Review, vol. 2, no. 5, pp. 360-369, October, 2012.

[7] Nguyen Duy Tan, Longzhe Han, Nguyen Dinh Viet and Minho Jo, *"An Improved LEACH Routing Protocol for Energy-Efficiency of Wireless Sensor Networks"*, Smart Computing Review, vol. 2, no. 5, pp. 360-369, October, 2012.

[8] Mortaza Fahimi Khaton Abad and Mohammad Ali Jabraeil Jamali, *"Modify LEACH Algorithm for Wireless Sensor Network"*, IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 5, No 1, pp. 219-224, September, 2011.

[9] S. Lindsey, C. Raghavendra, *"PEGASIS: Power-Efficient Gathering in Sensor Information Systems"*, In Proceedings of IEEE Aerospace conference, pp 1125-1130, 2002.

[10] Osama Younis, Sonia Fahmy, *"HEED: A Hybrid, Energy-Efficient, Distributed Clustering Approach for Ad Hoc Sensor Networks"*, IEEE, vol. 3 no. 4 pp. 366-379, October 2004.

[11] Harneet Kour, Ajay K. Sharma, *"Hybrid Energy Efficient Distributed Protocol for Heterogeneous Wireless Sensor Network"*, International Journal of Computer Applications (0975 – 8887),Volume 4 – No.6, July 2010

[12] L. Savita, W. Gayatri, *"A Survey on Energy Efficient Routing Protocols in Wireless Sensor Network"*, In Proceedings of International Conference on Computational and Network Technologies, July 4-6, Tiruchengode, India, 2013

[13] Arati Manjeshwar and Dharma P. Agrawal, *"TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks"*, IEEE, 2001.

