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HETEROGENEOUS PROTOCOLS FOR INCREASING LIFETIME OF WIRELESS SENSOR NETWORKS

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***Abstract**:* In this paper, the heterogeneous energy-efficient data gathering protocols for lifetime of wireless sensor networks have been reported. The main requirements of wireless sensor network are to prolong the network lifetime and energy efficiency. Here, Heterogeneous - SEP: A Stable Election Protocol for clustered heterogeneous (H-SEP) for Wireless Sensor Network has been proposed to prolong the network lifetime. In this paper, the impacts of heterogeneity in terms of node energy in wireless sensor networks have been mentioned. Finally the simulation result demonstrates that H-SEP achieves longer lifetime and more effective data packets in comparison with the SEP and LEACH protocol.
***Keywords**:* Wireless Sensor Networks, Energy-Efficiency, Heterogeneity, maximize lifetime.

INTRODUCTION

A wireless sensor network (WSN) can be defined as a network consists of low-size and low-complex devices called as sensor nodes that can sense the environment and gather the information from the monitoring field and communicate through wireless links; the data collected is forwarded, via multiple hops relaying to a sink (also called as controller or monitor) that can use it locally, or is connected to other networks [1]. A sensor node usually consists of four sub-systems [2] i.e. sensing unit, processing unit, communication unit and power supply unit.

In WSN, the sensor nodes are deployed in a sensor field. The deployment of the sensor nodes can be random (i.e. dropped from the aircraft), regular (i.e. well planned or fixed) or mobile sensor nodes can be used. Sensor nodes coordinate among themselves to produce high-quality information about the physical environment.

Each sensor node bases its decisions on its mission, the information it currently has, and its knowledge of its computing, communication, and energy resources. Each sensor nodes collect the data and route the data to the base station. All of the nodes are not necessarily communicating at any particular time and nodes can only communicate with a few nearby nodes. The network has a routing protocol to control the routing of data messages between nodes. The routing protocol also attempts to get messages to the base station in an energy-efficient manner.

The base station is a master node. Data sensed by the network is routed back to a base station. The base station is a larger computer where data from the sensor network will be compiled and processed. The base station may communicate with the Remote Controller node via Internet or Satellite [2, 3]. Human operators controlling the sensor network send commands and receive responses through the base station.

HEED (Hybrid Energy Efficient Distributed) protocol [4] is the clustering protocol. It uses using residual energy as primary parameter and network topology features (e.g. node degree, distances to neighbors) are only used as secondary parameters to break tie between candidate cluster heads, as a metric for cluster selection to achieve load balancing. In this all nodes are assumed to be homogenous i.e. all sensor nodes are equipped with same initial energy. But, in this paper we study the impact of heterogeneity in terms of node energy. We assume that a percentage of the node population is equipped with more energy than the rest of the nodes in the same network - this is the case of heterogeneous sensor networks. As the lifetime of sensor networks is limited there is a need to re-energize the sensor network by adding more nodes. These nodes will be equipped with more energy than the nodes that are already in use, which creates heterogeneity in terms of node energy, leads to the introduction of H-SEP protocol.

The remainder of the paper is organized as follows. In Section 2, we briefly review related work. Section 3 describes the clusters formation in the SEP protocol. Section 4 describes heterogeneous H-SEP protocol and the network radio model for energy calculations. Section 5 shows the performance of H-SEP by simulations and compares it with SEP and LEACH. Finally, Section 6 gives concluding remarks.

RELATED WORK

Heinzelman et al. [5] propose LEACH, a substitute clustering based algorithm. In order to save energy, LEACH deals with the heterogeneous energy condition is the node with higher energy should have larger probability of becoming the cluster head. Each sensor node must have an approximation of the total energy of all nodes in the network to compute the probability of becoming a cluster head but it cannot make decision of becoming a cluster head only by its local information, so the scalability of this scheme will be influenced.

S. Lindsey and C. Raghavendra [6] introduced Power Efficient Gathering in Sensor Information Systems (PEGASIS) protocol in 2002. It is an improved version of

LEACH. Instead of forming clusters, it is based on forming chains of sensor nodes. One node is responsible for routing the aggregated data to the sink. Each node aggregates the collected data with its own data, and then passes the aggregated data to the next ring. The difference from LEACH is to employ multi hop transmission and selecting only one node to transmit to the sink or base station. Since the overhead caused by dynamic cluster formation is eliminated, multi hop transmission and data aggregation is employed, PEGASIS outperforms the LEACH. However excessive delay is introduced for distant nodes, especially for large networks and single leader can be a bottleneck.

In 2001, A. Manjeshwar and D. P. Agarwal [7] proposed Threshold sensitive Energy Efficient sensor Network Protocol (TEEN) protocol. Closer nodes form clusters, with a cluster heads to transmit the collected data to one upper layer. Forming the clusters, cluster heads broadcast two threshold values. First one is hard threshold; it is minimum possible value of an attribute to trigger a sensor node. Hard threshold allows nodes transmit the event, if the event occurs in the range of interest. Therefore a significant reduction of the transmission delay occurs. Unless a change of minimum soft threshold occurs, the nodes don’t send a new data packet.

A. Manjeshwar and D. P. Agarwal [8] proposed Adaptive Threshold sensitive Energy Efficient sensor Network Protocol (APTEEN) protocol in 2002. The protocol is an extension of TEEN aiming to capture both time-critical events and periodic data collections. The network architecture is same as TEEN. After forming clusters the cluster heads broadcast attributes, the threshold values, and the transmission schedule to all nodes. Cluster heads are also responsible for data aggregation in order to decrease the size data transmitted so energy consumed. According to energy dissipation and network lifetime, TEEN gives better performance than LEACH and APTEEN because of the decreased number of transmissions. The main drawbacks of TEEN and APTEEN are overhead and complexity of forming clusters in multiple levels, implementing threshold-based functions and dealing with attribute based naming of queries.

In 2004, G. Smaragdakis, I. Matta and A. Bestavros [9] proposed Stable Election Protocol (SEP) protocol. This protocol is an extension to the LEACH protocol. It is a heterogeneous aware protocol, based on weighted election probabilities of each node to become cluster head according to their respective energy. This approach ensures that the cluster head election is randomly selected and distributed based on the fraction of energy of each node assuring a uniform use of the nodes energy. In this protocol, two types of nodes (two tier in-clustering) and two level hierarchies were considered.

In 2005, M. Ye, C. Li, G. Chen and J. Wu [10] proposed Energy Efficient Clustering Scheme (EECS) protocol. It is novel clustering scheme for periodical data gathering applications for wireless sensor networks. It elects cluster heads with more residual energy through local radio communication. In the cluster head election phase, a constant number of candidate nodes are elected and compete for cluster heads according to the node residual energy. The competition process is localized and without iteration. The method also produces a near uniform distribution of cluster heads. Further in the cluster formation phase, a novel approach is introduced to balance the load among cluster heads. But on the other hand, it increases the requirement of global knowledge about the distances between the cluster-heads and the base station.

In 2006, Q. Li, Z. Qingxin and W. Mingwen [11] proposed Distributed Energy Efficient Clustering Protocol (DEEC) protocol. This protocol is a cluster based scheme for multi level and two level energy heterogeneous wireless sensor networks. In this scheme, the cluster heads are selected using the probability based on the ratio between residual energy of each node and the average energy of the network. The epochs of being cluster-heads for nodes are different according to their initial and residual energy. The nodes with high initial and residual energy have more chances of the becoming cluster heads compared to nodes with low energy.

O. Younis and S. Fahmy proposed [4] Hybrid Energy Efficient Distributed clustering Protocol (HEED) protocol in 2004. It extends the basic scheme of LEACH by using residual energy as primary parameter and network topology features (e.g. node degree, distances to neighbors) are only used as secondary parameters to break tie between candidate cluster heads, as a metric for cluster selection to achieve power balancing. The clustering process is divided into a number of iterations, and in each iterations, nodes which are not covered by any cluster head double their probability of becoming a cluster head. Since these energy-efficient clustering protocols enable every node to independently and probabilistically decide on its role in the clustered network, they cannot guarantee optimal elected set of cluster heads.

CLUSTER FORMATION OF SEP PROTOCOL

In this section, we describe the network model. Assume that there are N sensor nodes, which are randomly dispersed within a 100m*100m square region (Figure 1). Following assumptions are made regarding the network model is:

1. Nodes in the network are quasi-stationary.
2. Nodes locations are unaware i.e. it is not equipped by the GPS capable antenna.
3. Nodes have similar processing and communication capabilities and equal significance.
4. Nodes are left unattended after deployment.

Cluster head selection is primarily based on the residual energy of each node. Since the energy consumed per bit for sensing, processing, and communication is typically known, and hence residual energy can be estimated. Intra cluster communication cost is considered as the secondary parameter to break the ties. A tie means that a node might fall within the range of more than one cluster head.

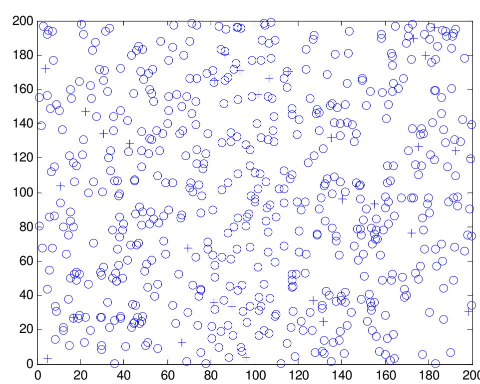

Figure 1. Random Deployment of Sensor Nodes

When there are multiple candidate cluster heads, the cluster head yielding lower intra-cluster communication cost are favored. The secondary clustering parameter, intra-cluster communication cost, is a function of (i) cluster properties, such as cluster size, and (ii) whether or not variable power levels are permissible for intra cluster communication.

HETROGENOUS MODEL FOR WSNs

In this section, we define the network model and wireless radio model which is used during the simulation of the protocols.

In 2-level H-HEED protocol, two types of sensor nodes, i.e., the advanced nodes and normal nodes are used. Let us assume there are 'N' numbers of sensor nodes deployed in a field. E_0 is the initial energy of the normal nodes, and *m* is the fraction of the advanced nodes, which own *a* times more energy than the normal ones. Thus there are *m* * *N* advanced nodes equipped with initial energy of $E_0 * (1 + a)$, and $(1 - m) * N$ normal nodes equipped with initial energy of E_0. The total initial energy of the network [19] is given by:

$$E_{total} = N * (1 - m) * E_0 + N * m * E_0 * (1 + a)$$
$$= N * E_0 * (1 + am)$$

So, this type of networks has *am* times more energy and virtually *am* more nodes.

Network Model

Assume *n* sensor nodes are randomly and uniformly distributed over the sensing field R and the sensor network has the following properties:

1. This network is a static compactly deployed network. It means *n* sensor nodes are compactly deployed in a two dimensional geographic space, forming a network and those nodes do not move any more after deployment.
2. All nodes should be approximately time coordinated on the order of seconds.
3. There is one base station, which is deployed at (50, 50) position.
4. There are two types of nodes normal and advance nodes. Advance nodes are equipped with more battery energy than normal node.
5. These nodes are uniformly distributed over the region R and they are not mobile.

Wireless Radio Model

We have used similar wireless radio dissipation model as proposed in [1] and illustrated in figure 2.

$$E_{TX}(L,d) = \begin{cases} L * E_{elec} + L * \epsilon_{fs} * d^2 & if\ d \le d_0 \\ L * E_{elec} + L * \epsilon_{fs} * d^4 & if\ d \ge d_0 \end{cases} \quad (1)$$

Where E_{elec} is the energy dissipated per bit to run the transmitter or the receiver circuit, ϵ_{fs} and ϵ_{mp} depend on the transmitter amplifier model used, and d is the distance between the sender and the receiver. By equating the two expressions at $d = d_0$, we have $d_0 = \sqrt{\frac{\epsilon_{fs}}{\epsilon_{mp}}}$. To receive an *L* bit message the radio expends

$$E_{Rx} = L * E_{elec} \quad (2)$$

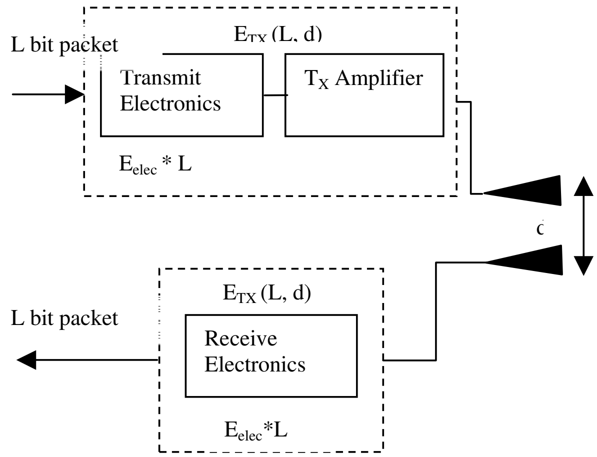

Figure 1 Radio Dissipation Model

Table 1 Communication energy parameter values of the radio model.

Description	Symbol	Value
Energy consumed by the amplifier to transmit at a shorter distance	ϵ_{fs}	*10nJ/bit/m²*
Energy consumed by the amplifier to transmit at a longer distance	ϵ_{mp}	*0.0013pJ/bit/m⁴*
Energy consumed in the electronics circuit to transmit or receive the signal	E_{elec}	*50nJ/bit*
Energy for data aggregation	E_{DA}	*5nJ/bit/signal*
Message Size	*L*	*4000 bits*

RESULTS AND DISCUSSIONS

The simulation is done in Matlab. Let us assume the heterogeneous sensor network with 100 sensor nodes are randomly distributed in the 100m*100m area.

The base station is located at the centre (50, 50). We have set the minimum probability for becoming a cluster head (*pmin*) to 0.0001 and initially the cluster head probability for all the nodes is 0.05.

The parameters used in our simulation are listed in the Table 1. This section discusses the simulation results of the comparative evaluation of the performance of LEACH, SEP and H-SEP in wireless sensor networks.

Let us consider the cases used as explained in the above section:

CASE 1:

(m=0.1 and a=3 or a=5 for 2-level)

It defines the values of the sensor nodes in the network for 2-level H-SEP.

We deploy the sensor nodes in the square field. In this type, we randomly deploy 100 sensor nodes in 100*100 m^2 field.

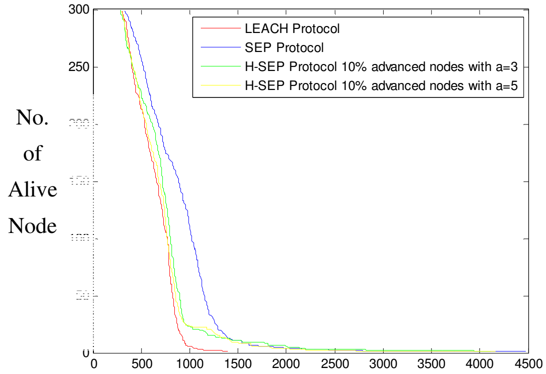

Figure 3 Number of alive nodes per round in random deployment in square field (LEACH; SEP; H-SEP with m=0.1 and a=3; H-SEP with m=0.1 and a=5 for 2-level)

Figure 3 shows the relationship between the number of alive nodes and number of rounds. In SEP Protocol, having homogenous nodes die very fast which will result in sparse network field. H-SEP, in 2-level, advance nodes die slowly as compared with normal nodes in SEP which help in prolonging the lifetime of the network. H-SEP, nodes die with relatively slow speed as all the sensor nodes are equipped with different energies. It has been observed that the death of the last node is around 4500 round.

CASE 2: *(m=0.2 and a=3 or a=5 for 2-level)*

In this, the percentage of number of advanced is increased. The value of the sensor nodes in the sensor networks for 2-level is defined. We deploy the sensor nodes in the square field. In this type, we randomly deploy 100 sensor nodes in 100*100 m^2 field.

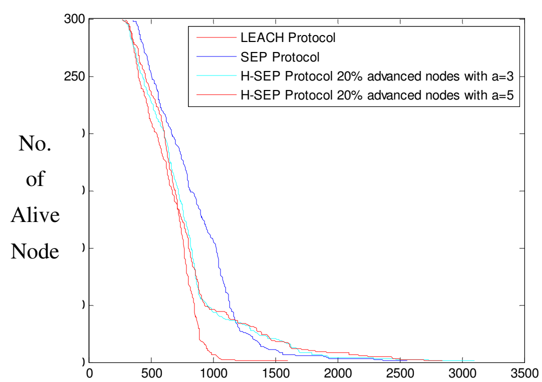

Figure 4 Number of alive nodes per round in random deployment in square field (LEACH; SEP; H-SEP with m=0.2 and a=3; H-SEP with m=0.2 and a=5 for 2-level)

Figure 4 shows the relationship between the number of alive nodes and number of rounds. In SEP Protocol, having homogenous nodes die very fast which will result in sparse network field. H-SEP, in 2-level, advance nodes die slowly as compared with normal nodes in SEP which help in prolonging the lifetime of the network. H-SEP, nodes die with relatively slow speed as all the sensor nodes are equipped with different energies. It has been observed that the death of the last node is around 3200 round.

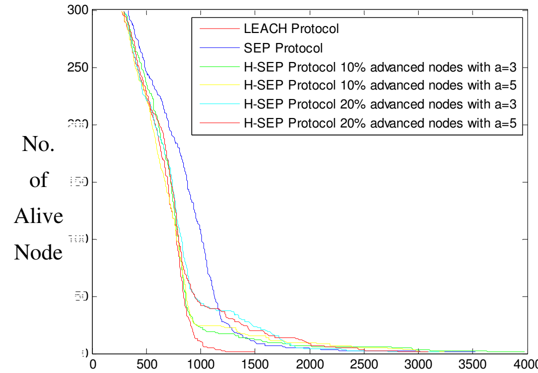

Figure 5 Number of alive nodes per round in random deployment in square field (LEACH; SEP; H-SEP with different different fractions)

Figure 5 depicts the number of alive nodes per round. In H-SEP, the last node dies around 4000 round. The lifetime of H-SEP is better than SEP and LEACH. As the number of advanced is increased the lifetime of the network also increases.

CONCLUSIONS

In this paper, we have introduced the H-SEP protocol for the heterogeneous wireless sensor network. We have discussed the two types of sensor nodes (normal and advanced) possible for the wireless sensor networks. We have evaluated the performance of LEACH, SEP and H-SEP protocol under these energy models using matlab. H-SEP prolongs the network lifetime and it is energy efficient than SEP. It sends more number of packets to the base station. In this, we introduced 2-level heterogeneity in terms of the node energy. It is observed that there is significant improvement in the lifetime in case of H-SEP protocol in comparison with SEP protocol because the number of rounds is maximum with 2-level H-SEP.

REFERENCES

[1] Marcos, Diogenes. 2003. Survey on Wireless Sensor Network Devices. IEEE.

[2] V. Raghunathan, C. Schurgers, Park. S, and M. B. Srivastava. 2002. Energy-aware wireless microsensor networks. IEEE Signal Processing Magazine, Volume: 19 Issue: 2, Page(s): 40 –50.

[3] I. Akyildiz et al. 2002. A Survey on Sensor Networks. IEEE Commun. Mag., vol. 40, no. 8, pp. 102–14.

[4] Ossama Younis and Sonia Fahmy. 2004. Distributed Clustering in Ad-hoc Sensor Networks: A Hybrid, Energy-Efficient Approach. In Proceedings of IEEE INFOCOM, Hong Kong, an extended version appeared in IEEE Transactions on Mobile Computing, 3(4).

[5] W. Heinzelman, A. Chandrakasan and H. Balakrishnan. 2000. Energy-Efficient Communication Protocol for Wireless

Microsensor Networks. Proceedings of the 33rd Hawaii International Conference on System Sciences (HICSS '00).

[6] S. Lindsey, C. Raghavendra. 2002. PEGASIS: Power-Efficient Gathering in Sensor Information Systems. IEEE Aerospace Conference Proceedings, Vol. 3, 9-16 pp. 1125-1130.

[7] A. Manjeshwar and D. P. Agarwal. 2001. TEEN: a routing protocol for enhanced efficiency in wireless sensor networks. In 1st International Workshop on Parallel and Distributed Computing Issues in Wireless Networks and Mobile Computing.

[8] A. Manjeshwar and D. P. Agarwal. 2002. APTEEN: A hybrid protocol for efficient routing and comprehensive information retrieval in wireless sensor networks. Parallel and Distributed Processing Symposium, Proceedings International, IPDPS, pp. 195-202.

[9] G. Smaragdakis, I. Matta, A. Bestavros. 2004. SEP: A Stable Election Protocol for clustered heterogeneous wireless sensor networks. In Second International Workshop on Sensor and Actor Network Protocols and Applications (SANPA).

[10] M. Ye, C. Li, G. Chen, J. Wu. 2005. EECS: an energy efficient cluster scheme in wireless sensor networks. In IEEE International Workshop on Strategies for Energy Efficiency in Ad Hoc and Sensor Networks (IEEE IWSEEASN-2005), Phoenix, Arizona, April 7–9.

[11] Q. Li, Z. Qingxin, and W. Mingwen. 2006. Design of adistributed energy efficient clustering algorithm for heterogeneous wireless sensor networks. Computer Communications, vol. 29, pp. 2230-7.

[12] W.R. Heinzelman, A.P. Chandrakasan, H. Balakrishnan. 2002. An application-specific protocol architecture for wireless microsensor networks. IEEE Transactions on Wireless Communications 1 (4) 660–670.

[13] R. B. Patel, T. S. Aseri, Dilip Kumar. 2009. EEHC: Energy efficient heterogeneous clustered scheme for wireless sensor networks. International Journal of Computer Communications, Elsevier, 32(4): 662-667.

[14] Yingcghi Mao, Zhen Liu, Lili Zhang and Xiaofang Li. 2009. An Effective Data Gathering Scheme in Heterogeneous Energy Wireless Sensor Network. In International Conference on Computational Science and Engineering.

