PERFORMANCE COMPARISON OF DYNAMIC CLUSTERING PROTOCOLS FOR ENERGY EFFICIENT ROUTING IN WIRELESS SENSOR NETWORK

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ABSTRACT: Wireless sensor network (WSN) comprises of small nodes with detecting, calculation and remote correspondence abilities. Many routing protocols have been invented over the decade especially to utilize power with a specific end goal to amplify the chances of network survival**.** In this paper three protocols namely size Low energy adaptive clustering hierarchy (LEACH), Hotspot -aware uneven clustering based on Dynamic Path Selection (PHADPS) and Efficient and Secure Routing protocol for WSN through signal to noise ratio (SNR)-based Dynamic Clustering (ESRPSDC) are compared for the common network size. These are the clustering protocols in which data transmission to base station takes place through cluster head (CH). Platform used for simulation is NS2.The parameters evaluated shall be end to end delay, packet delivery ratio and total energy consumption in life time.

KEYWORDS: Wireless sensor network (wsn), routing, least energy adaptive clustering hierarchy (LEACH), Hotspot-aware uneven clustering and Dynamic Path Selection' (PHADPS), Efficient and Secure Routing protocol for WSN through SNR-based Dynamic Clustering (ESRPSDC), NS2.

INTRODUCTION

This wireless sensor network forms a wide network of sensor nodes which are conveyed in the detecting territory. These sensor nodes respond to the changes in their surrounding environment in which they are deployed. Applications of these WSNs are numerous based upon the area in which they are used. The principal commonsense utilization of WSNs can be found amidst 70s by military and protection commercial enterprises. They were additionally utilized as a part of Vietnam War keeping in mind the end goal to bolster the location of foes in remote wilderness area [5]. In any case, it is the main start of the applications.

Since then application range of WSN has grown rapidly. They can be seen in weather monitoring, intrusion detection, strategic observation, detecting ambient conditions such as temperature, movement, sound, light, disaster management [4]

Basically a sensor node is consists of sensing unit, processing unit, a transreceiver and the most important power supply which is generally a dc battery. GPS is an optional element. Various sensor nodes sense the surrounding behavior according to their application and send the sensed information through transreceiving unit to other nodes or to the base station. At base station this information is made global through internet. Each sensor node has capacity to gather and course information either to other sensor hub or to base station

The main drawback of these WSN is their limited power supply. Since they are generally deployed in remote areas charging their battery is not a suitable option. So we only left with the efficient utilization of accessible battery power in order to maximize the network lifetime. Out of various operations routing consumes majority of the battery power, hence routing the data form source to destination with the minimum energy consumption is the main task in any network. For this purpose various routing protocols are invented [1][3]. They effectively route the data from source to destination with efficient energy consumption. Clustering is a routing technique which some routing protocols used. In clustering nodes are split into clusters. These clusters have a cluster head (CH) which is in charge of sending the data to base station. This clustering can be static or dynamic. In static clustering cluster heads are constant throughout network lifetime whereas in later cluster heads or clusters are changed periodically according to their available energy [6].

This paper is constructed as per following sections: In section II energy utilization model for a single node is discussed; in section III, brief description of the protocols which are consider for comparison are presented; in section IV simulation parameters are discussed, in section V simulation results are plotted and discussed; in section VI conclusions are drawn.

DYNAMIC CLUSTERING MODELLING

Energy Utilization Model

In a sensor node transreceiver responsible for transmitting and receiving the data/packets form other sensor nodes. Such system is shown in Figure 1.

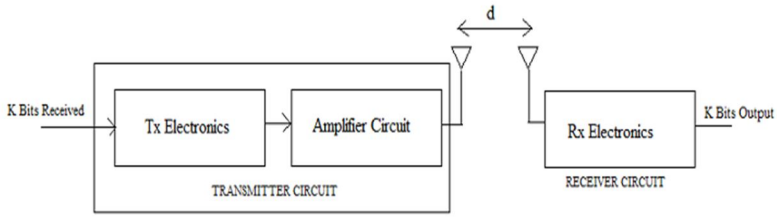

Figure. 1. Energy consumption model for a sensor node

Suppose K bits are at the input of transmitter circuit which will be transmitted through distance d through wireless channel and get received at receiver circuit of another node. Total energy required to transmit K bits is given as follows.

$$E_{TX}(K) = \begin{cases} KE_{elec} + K\varepsilon_{fs}d^2 & d < d_0 \\ KE_{elec} + K\varepsilon_{amp}d^4 & d > d_0 \end{cases} \quad (1)$$

Where d: Transmission distance, Ɛ: Amplification Factor, d_0: distance over which transmission factor changes, E_{elec}: Total energy required in Tx Electronic circuit, S: Total area of sensing field, D_{bs}: Distance between node and the base station

Total energy required to receive K bits is given as follows

$$E_{RX}(K) = K \times E_{elec} \quad (2)$$

Optimal number of clusters in a network is given by

$$K_{optml} = \frac{\sqrt{N}}{\sqrt{2\pi}} \frac{\sqrt{\varepsilon_{fs}}}{\sqrt{\varepsilon_{amp}}} \frac{S}{D_{bs}} \quad (3)$$

Here it can be seen that from equations (1) and (2) extra energy is required to amplify the signal in transmitter circuit as compared to receiver circuit.

Algorithm for Dynamic Clustering

Main purpose of dynamic clustering method is to assign different CHs at regular interval. The common steps of clustering are:

1. Find the optimal total number of clusters in the given sensor field as per equation (3)
2. Appoint each cluster a CH (generally a center node)
3. Assign various nodes to their respective CH
4. Repeat steps 1 to 3 after a fixed interval of time

ROUTING PROTOCOLS

In this segment we give you a brief portrayal of the routing protocols compared in our simulation.

LEACH

Least Energy Adaptive Clustering Hierarchy (LEACH) [3][5][6] is one of the first routing protocol which uses clustering technique. Its working is divided into two stages namely setup stage and communication stage. In setup stage clusters are organized and CHs are selected. Selection of CH is based on their residual energy. The node having the highest energy among the cluster nodes is selected as CH for that particular round. All the communication to the base station takes place through this CH only. CH receives all the information from its cluster nodes, removes similar information and forward aggregated data to the base station. In the next round new CH is selected based on energy while previous CH is not taken into account. In data communication stage data transfer takes place.

ESRPSDC

Efficient and Secure Routing Protocol for wireless sensor networks through signal to noise ratio (SNR) based Dynamic formation of Clusters (ESRPSDC) is a protocol based on dynamic clustering [1]. Its working is divided into five steps. In the initialization phase base station broadcasts REQ messages. As a result nodes are divided into clusters. Each cluster selects its own cluster head (CH) contingent upon the residual energy of the node. At the same instance next CH is also selected. In the second step CH is selected from each cluster. Node having the highest energy is selected as CH. The threshold for selecting the CH among the cluster nodes is given by

$$T(n) = \frac{(P \times C)\,(U_i - d(n,BS))}{(1-P)\,(r|^1/_P|)\,(U_i - L_i)} \left[\frac{E_{cur}(n)}{E_{min}(n)}\right] \quad (4)$$

Where P is the desired percentage of the CHs. r is the current round and Z is the set of nodes, which have not been CHs in the last 1/P rounds. C is the constant factor whose value is between 0 and 1. U_i is the upper limit of level-i and L_i is the lower limit of level-i. d(n,BS) is the distance between node n and the BS. $E_{cur}(n)$ is defined as the current energy of node n. $E_{min}(n)$ is the initial energy of node n and the value of K is between 0 and 3

In third step the non CH (NCH) nodes are connected to CH and serve as a 2-hope node. These NCH nodes are situated at the boundary of the network, hence they do not get CH message. In fourth step data forwarding is performed. Here TDMA scheduled is followed and after the completion of round same algorithm is followed.

PHADPS

An efficient routing protocol in terms of energy based on hotspot aware uneven clustering and path selection which performs dynamically (PHADPS) [2] cleverly deals with the hotspot issue in the wireless sensor networks. Nodes which lie very close to the base station are called hotspot nodes. Since they lie at one hop distance from BS most of the data from away CHs mandatorily forwarded through these nodes. As a result their battery gets more utilized and hence they die earlier. This creates a energy hole in the network near the BS.

This problem is effectively solved by this protocol by uneven clustering of sensor nodes and dynamically selecting path to the base station. Its working is divided into two parts. First is hotspot aware uneven clustering and second is routing algorithm. In the first part hotspot nodes are clustered into smaller groups than the normal nodes i.e. radius of clusters in hotspot zone is smaller than the normal cluster nodes. As a result there are more clusters in the hotspot zone and hence more CHs. So there are enough nodes to forward data to the BS. Hence energy of these nodes utilized effectively and their lifetime increases. In the later part routing of data is performed. Criterion for the selection of CH is given by following threshold.

$$E(T) = \sum_{i=1}^{m} P_i \times \frac{T_{data}}{n \times T_s} \times [E_{Tx}(k,d) + E_{Rx}(k)] \quad (5)$$

Where *n* represents the number of nodes in the cluster, P_i is the probability with which next path is selected , T_{data} time for sending the data packet, T_S time for one cluster round. CH sends the packet to the next hop node according to the probability saved in the rout table. Hence dynamic path selection is performed based on the probability and each time the path to the destination is changed.

SIMULATION PARAMETERS

NS2 (Network Simulator 2) is an open source free software in network technology. It is a discrete event simulator. NS2 is the pioneer software in the wireless and wired network simulations in academic field.

All the three protocols are implemented taken into the same above conditions. Also all the simulation parameters are tabulated in Table 1.

Table.1. Simulation Parameters

Parameter	Value
Protocols	LEACH, ESRPSDC, PHADPS
Area of sensing field(m2)	1000x1000
No. of sensor nodes	100
Simulation time(s)	50s
Frequency	2.3 GHz
Bandwidth	2 Mbps
Traffic type	CBR
Path loss model	Two ray model
No. of clusters	4
Initial energy of node(J)	10
Antenna type	Omni directional
MAC layer protocol	IEEE 802.11

SIMULATION RESULTS

Various simulation parameters which are studied are packet delivery ratio, end to end delay and total energy consumption. These parameters are studied under the total network lifetime and results are plotted as follows.
Packet delivery ratio is characterized as the ratio of total number of packets received by the destination node to the total number of packets transmitted by the source node. For the graph we can say that LEACH has least capacity to transfer packets to the destination node while ESRPSDC has the best ability to deliver packets to the destination as shown in Figure 2. We can more reliable on ESPRDC when we want more reliable transmission of data.

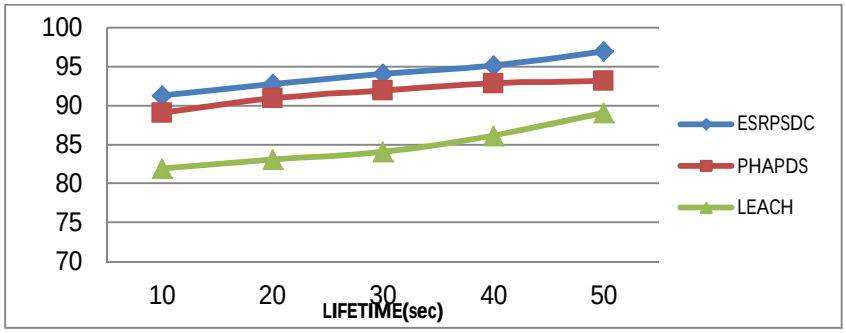

Figure. 2. Packet Delivery Ratio

End to end delay defined as the total time required reaching the packet from source to destination. Here ESRPSDC outperforms both LEACH and PHAPDS. On an average it is better than LEACH and PHAPDS by 21.05% and 18.32% respectively. It is stated in Figure. 3.

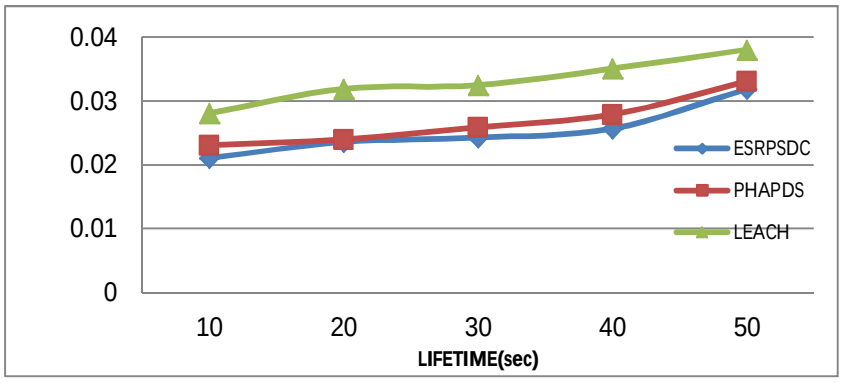

Figure.3. End to end delay

Total energy consumed during the network lifetime is given by following graph. It is an important parameter to predict the energy efficiency of the network. Here ESRPSDC consumes least energy as compared to LEACH and PHAPSDC. It means that the number of nodes alive in total lifetime is more in ESRPSDC when contrasted with other two protocols. Figure. 4 shows the comparison of three protocols based on energy utilization over the network lifetime.

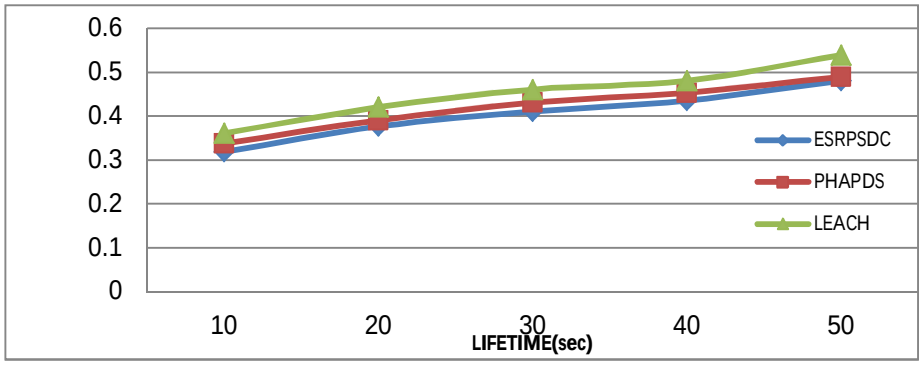

Figure.4. Total energy consumption in lifetime

CONCLUSION

Packet delivery ratio and energy consumption are the one the prominent characteristics to state the usefulness of a routing protocol. Here we can see that ESRPSDC clearly suits better than both the other protocols. Thus as the network lifetime increases we can say that ESPSRDC is more useful in a particular environment. But if the hotspot problem is to be considered one can select between ESPSRDC and PHADPS. We can also conclude that LEACH protocol has least performance on the basis of results but if the one hop distance is to be considered LEACH can also be more useful.
Although it is seen that ESRPSDC outperforms other two protocols, its ability to handle the hotspot problem is not verified. Hence in dense network it will found inefficient to sustain for a longer period. Also scalability issue is not discussed in above comparison. So there is a wide future scope of adding extra features such as scalability and hotspot issue in the above protocol.

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