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IMPROVING THE LIFETIME OF WIRELESS SENSOR NETWORK USING ENERGY EFFICIENT CLUSTERING

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Abstract:

In the era of wireless communication the communication is possible to those area which was unreached. Hence the major constrain is of this communication is wireless sensor network. The wireless sensor network is developed by deploying the sensor node to that unreached area where it was gather the information . But when it will get work in a cluster we required number of node, the deployment cost of each node is very high Hence it is necessary to make efforts to reduce cost of deploying such technology. For wireless sensor network energy management is one of the challenges in design of WSN which is very important. Some protocols have been designed to reduce energy consumption. But still there is scope for saving energy In this paper the approach has been thaen in consideration that we will change the cluster head during the working of network by comparing the threshold of nearest node due to which the head will get alter and automatically the size of clster will get change . In this paper we consider 29 node therefore we will get 29 different cluster. With less consumption of energy and forming new clusters hence prolong the network lifetime and also achieves efficient transmission to the Base Station. Hence this is the attempt to reduce the deployment cost of node and improving the lifetime with energy efficient clustering

***Keywords*:** Cluster Head (CH), Base Station (BS), LEACH, wireless sensor network (WSN), Advertisement packet(ADV)

1. Introduction

When in remote or unreached area the sensors has been deployed , Then Sensor nodes are often left unattended e.g., in hostile environments, which makes it difficult or impossible to re-charge or replace their batteries. This necessitates devising novel energy-efficient solutions to some of the conventional wireless networking problems, such as medium access control, routing, self-organization, so as to prolong the network lifetime. In most of the applications sensors are required to detect events and then communicate the collected information to a distant base station (BS) where parameters characterizing these events are estimated. The cost of transmitting information is higher than computation and hence it is be advantageous to organize the sensors into clusters [1] [2], where the data gathered by the sensors is communicated to the BS through a hierarchy of cluster-heads. LEACH [1] is perhaps the first cluster based routing protocol for wireless sensor networks, which uses a stochastic model for cluster head selection. LEACH has motivated the design of several other protocols [3] [4] which try to improve upon the cluster-head selection process by considering the residual energy of the nodes. TL-LEACH [8] uses two levels of cluster heads instead of one in LEACH. EDAC [7] enables cluster heads to change status asynchronously and co-ordinate energy consumption. HEED [6] uses a hybrid approach based on residual energy and communication cost to select cluster heads. ANTICLUST [9] uses a two level cluster-head selection process involving local communication between neighboring nodes.

In above protocols load over CH for data processing and transmission is not considered. Therefore it may not give data transmission for longer duration due to fast consumption of energy by CH. Hence it is required to allow the even consumption of energy among the nodes in a cluster to prolong the lifetime of WSN. Here we designed a protocol using three approaches,

Energy aware CH rotation policy

Data aggregation

Tunneling data to nodes in sleep mode cluster.

2. Leach Protocol

In LEACH, nodes organize themselves into clusters and all non-cluster head nodes transmit to the cluster-head. The cluster head performs data aggregation and transmits the data to the remote base station. Therefore a cluster-head node is much more energy intensive than a non-cluster head node.

During the setup phase in LEACH [2] the cluster heads are selected based on the suggested percentage of them for the network and the number of times the node has been a cluster-head so far. This decision is made by each node n choosing a random number between 0 and 1. If the number is less than a threshold T(n), the node becomes a cluster-head for the current round. The threshold is set as follows:

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

where P is the desired cluster-head probability, r is the number of the current round and G is the set of nodes that have not been cluster-heads in the last 1/P rounds. Once a node has been elected to be the cluster head it will broadcast an advertisement message (ADV). Each non cluster-head node decides its cluster for this round by choosing the cluster head that requires minimum communication energy, based on the received signal strength of the advertisement from each cluster head. After each node decides to which cluster it belongs, it informs the cluster head by transmitting a join request message (Join-REQ) back to the cluster head. The cluster head node sets up a TDMA schedule and transmits this schedule to all the nodes in its cluster, completing the setup phase, which is then followed by a steady-state operation. This steady state operation is broken into frames, where nodes send their data to the cluster head at most once per frame during their allocated slot.

3. Protocol Architecture

In our protocol architecture we implemented three strategies i.e CH rotation, data aggregation and tunneling of data to sleep mode cluster node.

3.1 Motivation For CH Role Rotation Policy

In LEACH, a node becomes a cluster-head by a stochastic mechanism of tossing biased coins. This stochastic approach doesn't consider energy consumption of a cluster-heads. This will lead to more energy dissipation of cluster head and hence affect the reliability. Secondly, LEACH assumes that every time a node becomes a cluster-head, it dissipates an equal amount of energy. This is incorrect, as cluster-heads located far from the base station spend more energy in transmitting data to those located near the base station. Hence we need to focus of optimization of CH energy consumption to increase network lifetime.

3.2 Data Aggregation

In a typical sensor network scenario, different nodes collect data from the environment and then send it to some central node or sink which analyzes and processes the data and then send it to the required application center. But in many cases, data produced by different nodes can be jointly processed while being forwarded to the sink node. So in-network aggregation deals with this distributed processing of data within the network. Data aggregation techniques explore how the data is to be routed in the network as well as the processing method that are applied on the packets received by a node. They have a great impact on the energy consumption of nodes and thus on network efficiency by reducing number of transmission or length of packet. Elena Fosolo et al in [7] defines the in-network aggregation process as follows: "In-network aggregation is the global process of gathering and routing information through a multi-hop network, processing data at intermediate nodes with the objective of reducing the resource consumption (in particular energy), thereby increasing network lifetime."

3.3. Data Tunneling To Sleep Mode Cluster Node

As we discussed earlier WSN is divided into clusters for better performance. Not necessarily, each cluster is performing the same type of recording. It is also not necessary for the cluster to record and report information to BS all the time but information is to be reported at specific times. In such scenario keeping cluster in active mode is simply the wastage of energy. Hence in such scenario we may put the cluster in sleep mode during idle times to save energy. But sometimes it is required for the sleep mode cluster to receive/transmit the data. And hence the data to/from the nodes in sleep mode cluster must be tunneled. This can be implemented using a data tunneling protocol.

4. Protocol Algorithm

4.1 In our protocol there are 4 phases in each round.

Phase I: Cluster Head Selection

1. The BS broadcast an ADV packet type 1 to know all the sensor nodes in the range.
2. Then nodes respond to the BS with RES packet type 2 with their energy.
3. The base station now calculates the distance of each node and selects the node with shortest distance as cluster head using packet type 3.

Phase II : **Cluster Formation.**

1. CH now broadcast JOIN-REQ packet type 4 to form the cluster.
2. After receiving the packet type 4, the neighboring nodes within the range respond by sending JOIN RES packet type 5 to CH.

Phase III : Data Reporting

1. CH now multicast START REPORTING packet type 6 to nodes in the cluster.
2. Nodes now start reporting to CH on TDM basis as allotted by CH with packet type 7.
3. Data aggregation is achieved at CH by setting counter to 30 for each node.

4. Then aggregated data is processed separately and transmitted to BS with packet type 8.

Phase IV : CH Alteration

1. CH now checks it residual energy and compares with threshold energy.
2. If finds energy equal to or below threshold level. It takes initiative itself to find new CH.
3. Now CH send EREQ packet type 1 to all other node and gets their residual energy in RES packet type 2 from them.
4. Now CH selects the node with highest residual energy as CH and multicast packet type 3 to all nodes.
5. Nodes update their CH information and start reporting to new CH now while CH old continues as normal node reporting to new CH.
6. New threshold level is set and same process is repeated.

4.2 Data Tunneling To Nodes In Sleep Mode Cluster

1. When data is to be sent to nodes in sleep mode cluster, a wakeup call is sent by BS to CH of cluster. Then CH will communicate that to the nodes in the cluster using wakeup call.
2. After completing the required task it again goes into sleeping mode.

4. Simulation Environment

Parameters	**Normal Scenario**
No. of nodes	29
Topographical area	50 x 50 sq. m.
Topology	Star
Max. internode distance	6.5 m
Antenna	Omni directional
Initial energy of node	5.0j
Packet size	400 bytes
Energy consumption per packet	0.2mJ
Packet Delay	1 ms
Throughput	98.68 %

Table 1: Simulation parameters

We used network simulator ns-2 for evaluating our protocol. For our experiments, we used a 29-node network as in fig. 1 where nodes are randomly distributed between (*x=0*, *y=0*) and (*x=1000*, *y=1000*) with a single BS at location (*x=500*, *y=500*). We have four clusters each having 7 nodes including CH. The bandwidth for the channel was set to 1Mb/s, each message 500 bytes long, and the packet header for each type was 25 bytes long.

Simulation model

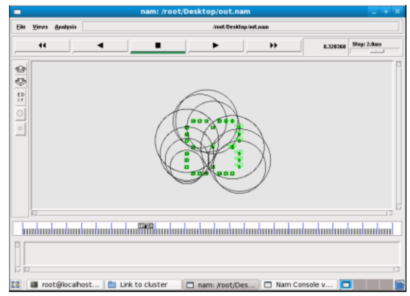

Figure 1 : Transmission & Reception scenario

Base station is located at the center of the network. Base station takes initiative towards CH selection and cluster formation by communicating appropriate packets. In our model we have used 9 different packets for proper WSN operation. Simulation model shows all 5 phases in the protocol. The above model is able to achieve systematic approach towards communication in WSN.

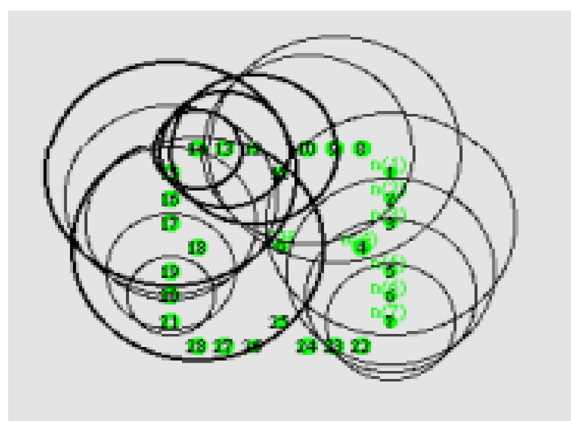

Fig. 2 Broadcasting of packets by BS

Figure 1 shows the snap shots of simulation process taken at different instants. Bubble in the figure shows the transmission and reception of packets taking place at the node. This model achieves increase in lifetime of the WSN by saving energy of nodes. The results reported in the next section are an aggregate of 30 simulations.

In Qualnet 6 server model has been taken intialy as a wsn out of which one is consider as a CH and other as a sensor node fig 3 shows confrugrable property fig 4 shows number of bytes sent to per connection fig 5 shows the throughput bits/s

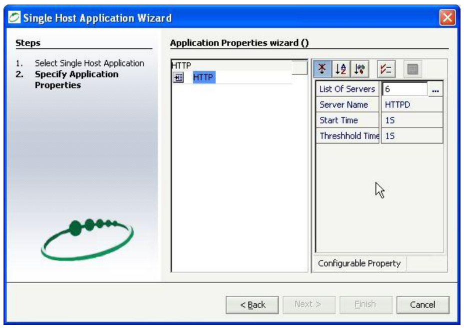

fig 3 confrugrable property

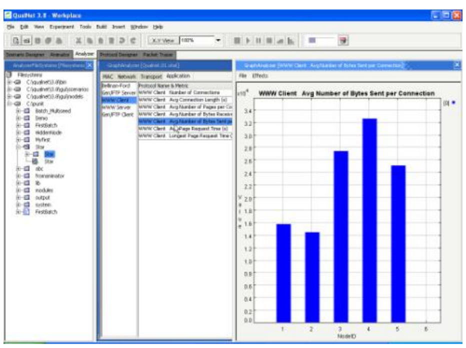

fig 4 number of bytes sent to per connection

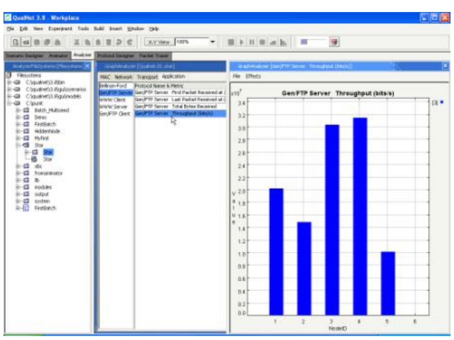

fig 5 the throughput bits/s

Results & Conclusions

In this paper, we describe a modification of the LEACH's stochastic cluster-head selection algorithm by combining three strategies i.e. energy aware rotation of CH, data aggregation and data tunneling to node in sleep mode cluster. Hence this approach will save energy, increase data transmission reliability and prolong the lifetime and reduce the cost of the using WSN.

This will be helpful for the state like Chhattisgarh in deploying wireless sensor network for controlling the legal or illegal activities in remote areas surrounded by forest. Fig. 2 shows the packets received by different nodes during simulation time. As the CH role is change regularly depending on the threshold energy the nodes are receiving almost same number of packet.

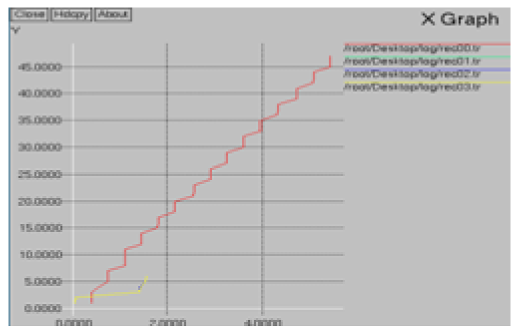

Fig. 6 : reception of packets by nodes

Fig. 7 shows the comparison of energy consumption by different nodes. The curve mark with CH_fix indicates the energy consumption by node 4 if we don't alter the CH role mean continue with the same CH. Other curves correspond to the energy consumption by nodes if the CH role is altered as a function of residual energy and threshold energy. From fig. 6 we can come to conclusion that alteration

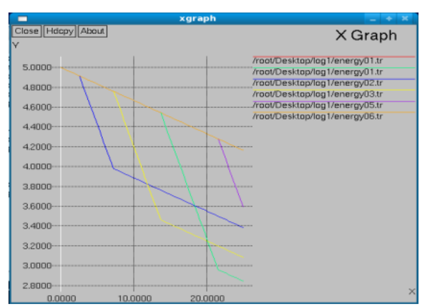

fig. 7: Energy of CH vs other nodes

of CH role cause less energy consumption of the cluster and hence network. This will definitely prolong the lifetime of the network.

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