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Residual Energy Based Adaptive Routing Protocol for Cluster-Based Wireless Sensor Networks

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Abstract*: *One of the important issue in Wireless sensor network is to extend the lifetime of the network by using the energy efficiently that are offered in each node of the network. An Adaptive routing protocol for a wireless sensor system is acquainted which enhances the survivability of the system by adequately utilizing the vitality of the sensor network. The Dynamic clustering approach provides a scalable and energy efficient solution for data transmission in Wireless Sensor Network. In this paper, a residual energy based adaptive routing protocol for a cluster-based wireless sensor network is proposed to adjust the energy utilization of inter-cluster communication and improve the lifetime of wireless sensor network. The Simulation results of the proposed work shows that adaptive routing protocol balances the energy utilization in inter-cluster communication, enhances the vitality productivity and increment the system lifetime.

Keywords: Wireless Sensor Networks, Adaptive Routing, Cluster based routing, WSN.

I. INTRODUCTION

Wireless Sensor Network comprises of an expansive number of battery worked sensor node with restricted capability and limited energy. The sensor nodes are the equipment gadget equipped for sending and accepting signals. These nodes accumulate information from the nearby condition and sent them to the base station utilizing some predefined routing protocol for further activity. The node communicates with each other and transmits data to an external base station through their cluster head. The topology of the network may be dynamic e.g. it may change due to some nodes failure and an addition of new nodes. In a cluster-based Wireless Sensor Networks, a network is divided into some cluster; each cluster contains some sensor nodes as cluster members [1] [2]. Among the cluster Members, a cluster head (CH) is chosen using some heuristic. Cluster members send the detected information from the environment to these cluster heads. Cluster head initially aggregate them and send aggregate information to the base station.CH, ought to be legitimately chosen, since the effect the system execution straightforwardly and devour more energy than cluster members. At the end of each round, the cluster-based topology breaks up, and the new cluster will be formed in the next round. The energy imbalance problem cannot be completely solved by the clustering of the network because the distance between source nodes to the base station has great impacts on its inter-cluster routing energy consumption. Basically, the inter-cluster communication can be categorized as single-hop routing and multi-hop routing. In single hop routing, all cluster head communicate directly with the base station. On the other hand, in multi-hop routing, cluster head transfer the data over several hops until the data each base. However, the energy imbalance problem is present in both single hop routing and multi-hop routing. In single-hop routing, the nodes that are deployed for away from the base station has to suffer long transmission range. In multi-hop routing, the nodes that are nearer to the base station has heavy relay burden [9]. The energy imbalance problem due to the location of the nodes can be solved by the adaptive routing protocol. The base idea of adaptive routing protocol is to adjust the inter-cluster routing modes for balancing the energy consumption.

II. RELATED WORK

A study of some recent review and literature available is carried out. It is revealed that main consideration was made on the energy efficiency. Hence, a variety of routing protocols has been developed to reduce the consumption of energy and extend the network lifetime of wireless sensor network. A close examination of literature shows that the cluster based routing algorithm has maximum energy utilization compared to non-cluster routing algorithm besides, there are many drawbacks exist in the cluster based routing algorithm. Some important and well known cluster-based routing protocols are (LEACH, PEGASIS, SEP, HEED, TEEN, and APTEEN).

1) *Low Energy Adaptive Clustering Hierarchy (LEACH):* LEACH protocol is an average portrayal of various hierarchical routing protocols. It is a self-adaptive and self-organized. Round as unit utilized by LEACH protocol and each round perform the set-up

stage to make the cluster and steady-state stage for lessening energy cost that is pointless. The steady state stage term is typically longer than set-up stage span. The set-up stage is more vital than steady state stage [14]. In set-up stage, sensor node chosen as a cluster head and the system is separated into cluster. Every node that turns into the cluster head (CH) will make a Time Division Multiple Access (TDMA) plan for the sensor nodes inside the cluster. The set-up permits each radio part of none cluster head to be turned off all the times. Radio segment of the node is on when it transmits information. The advantages of the LEACH protocol are that as scalability and energy efficiency of the sensor node is very low

2) *Hybrid Energy Efficient Distributed (HEED):* HEED (Hybrid Energy Efficient Distributed) routing is the cluster-based routing protocol. It utilizes remaining energy as a basic parameter and topology parameters like node degree and separation to neighbours are utilized as optional parameters when two cluster head have a similar energy [13]. The upside of the Hybrid Energy Efficient Distributed protocol is that it gives the higher cluster stability of the system. But the scalability, energy efficiency, load balancing, algorithm complexity of wireless sensor networks and delivery delay of the message is medium.
3) *Threshold Sensitive Energy Efficient Sensor Network (TEEN):* The standard protocol made for responsive frameworks is TEEN (Threshold touchy Energy Efficient Sensor Network Protocol). Adolescent relies on gathering based different leveled approach and uses data driven procedure. TEEN is a receptive protocol which is most appropriate for time basic application [5]. Threshold Sensitive Energy Efficient Sensor Networks transmit data in hard threshold and the soft threshold esteem. It utilizes an occasion driven strategy in which data is essential and requested in perspective of value administration. The use of this protocol is, for example, intrusion detection, explosion detection and so on. In TEEN protocol cluster head improvement technique relies on upon LEACH (Low Energy Adaptive Clustering in Hierarchy). In TEEN convention the vitality proficiency and load adjusting of the system are great however the adaptability of the system is low.
4) *Adaptive Threshold-sensitive Energy Efficient Sensor Network Protocol (APTEEN):* APTEEN is an extended version of TEEN and points of this protocol are to transmit the periodic information and responding to time basic occasions. The auxiliary outline of APTEEN is like TEEN. In APTEEN the clusters are shaped by the base station, now the cluster heads communicate the qualities, the transmission plan, and limit esteems to all nodes. Every node sense the environment constantly. If the detected esteem is equivalent to or pass HT, then the transmission is allowed. On the off chance that a node does not send information for a period interim equivalent to the CT, it must detect and transmit the information again [2]. Cluster heads accomplish information aggregate in APTEEN keeping in mind the end goal to spare energy. APTEEN protocol gives the better cluster strength of system; however versatility and vitality productivity is bad. Its advantage is that it has a little delivery time of message between sources to goal.
5) Power Efficient Gathering in Sensor Information System (PEGASIS): PEGASIS is an enhanced variant of LEACH protocol which is close for the information gathering application in wireless sensor systems. The fundamental idea of PEGASIS is to shape the chain between the sensor nodes then every node gets and exchanges the data to a closer neighbour. Accumulated information moves from node to node, get melded, and in the long run an assigned hub to the Base Station [15]. Hub show in the chain take turn just when it needs to exchange the data to the base station so the normal energy spends by a node is diminished. One of the advantages of this protocol is that it has better vitality effectiveness yet versatility and group solidness are low.

III. THE PROPOSED FRAMEWORK

In this section a simple analytical model is presented in which radio energy dissipation occur.

A. Network Model

Assume that N homogeneous sensor nodes are deployed in square area M*M. The features of this scenario are as follows:

1) The sensor nodes and base station are stationary and base station is located for away from sensing field.
2) The sensors nodes are periodically monitor the environment and information to base station.
3) All sensor nodes have equal ability for sensing area, data processing and data communication directly to base stations.
4) These sensor nodes are battery limited, non-rechargeable and non-replaceable.
5) All the sensor nodes are location aware.

B. Energy Consumption Model

The radio energy dissipation model for communication consists of two major components, the dissipated energy to run radio electronics and the power amplifier that depend on distance d and the radio propagation models, while the receiver dissipated energy

only to run the radio electronics [8] [10]. In order to transmit q-bit data message between two nodes separated by a distance of d meters, the energy consumption computed as follows:
Where Eelec is fixed dissipation energy to run the transmitter or receiver electronics Efs and Emp are the unit amplifier energy required for the transmitter in the free space and the multipath model that depends on the distance, respectively, and d0 is the distance calculated as
$d0=\sqrt{Efs/Emp}$
For receiving a data packet with q-bit the radio dissipates energy
ER*(k) = k.Eelec

C. Cluster Head Selectio

The group of active node divides into equal size cluster. For each round, the CH is selected by the BS for each cluster from the group of active nodes which generate random number between 0 and 1 and compare it with threshold value T [12]. Threshold value can be calculated as –

T (n) =q/1-q*[r mode (1/q)]

Where R is random number, p is probability distribution function is given as q= p*n*(1+a)*Er / (n+A)*(Ea)

Er= remaining energy of sensor node

Ea= average energy P= probability to become a CH

a = advance energy amount of active node

A= total advance energy amount of all active nodes.

IV. THE PROPOSED APPROACH

The primary goal of the protocol is to enhance the system life and efficient energy utilization in each of the node. In solitary protocol system, single and multi-hop, inter-cluster communication is done through cluster head. If the cluster head has its residual energy greater than a threshold value then it always follows the single hop communication and directly communicates with the base station. If the cluster head has its residual energy less or equal threshold then cluster head always transmits the information through the multiple hops and it will select the best path to communicate with the base station. We have calculated the threshold value through the experimentation. From all these, it can be concluded that the proposed adaptive routing protocol homogeneous nodes system can survive long than MS-LEACH routing protocol in a homogeneous system.

V. SIMULATION RESULT

In this section, the performance of adaptive routing protocol is compared with distance based Multi Single Hop-Low Energy Adaptive Cluster Hierarchy routing protocol via a simulator. The simulator MATLAB is used to find the benefits of adaptive routing architecture described here. Simulation parameters used are shown in Table 1.

TABLE1. SIMULATION PARAMETER

Number of deployed nodes	100
Area of Network	100m*100m
Position of Base station	(50, 175)
Maximum rounds in the network	100
Energy drained out or consumed by the amplifier to transmit at a short distance, Efs	10pJ/bit/m2
Energy drained out or consumed by the amplifier to transmit a longer distance, Emp	0.0013pJ/bit/m4
Data Aggregation Energy, EDA	5nJ/bit/signal
Message size	4000 bits
Initial energy	0.1J
Cost Function	0.04J

Figure 1 shows the initial set-up of the adaptive routing protocol with homogeneous sensor nodes.

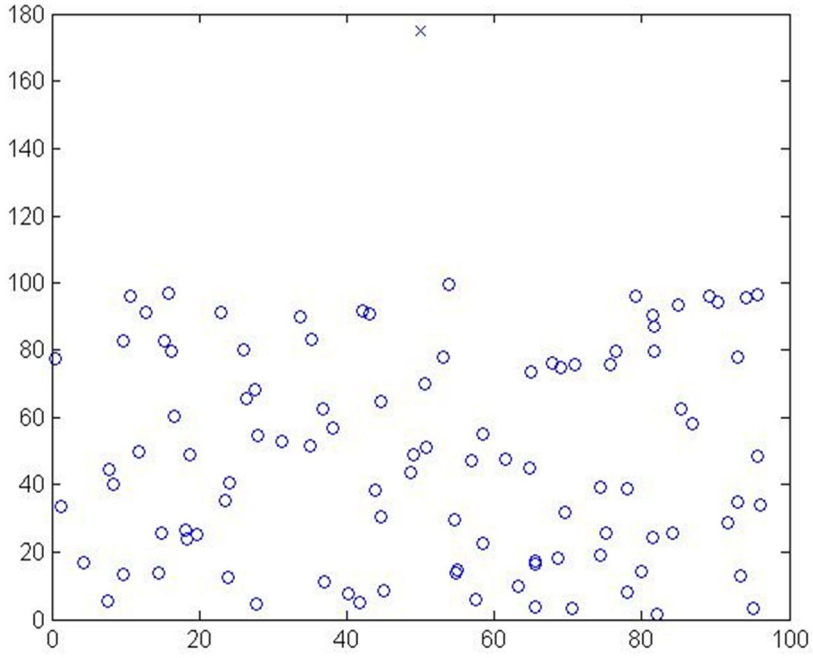

Figure 1: Initial set-up of proposed protocol

are measuring the network lifetime with accordance to death percentage rate of sensor node as shown in figure 2 and the average energy of the each sensor node as shown in fiure 3.

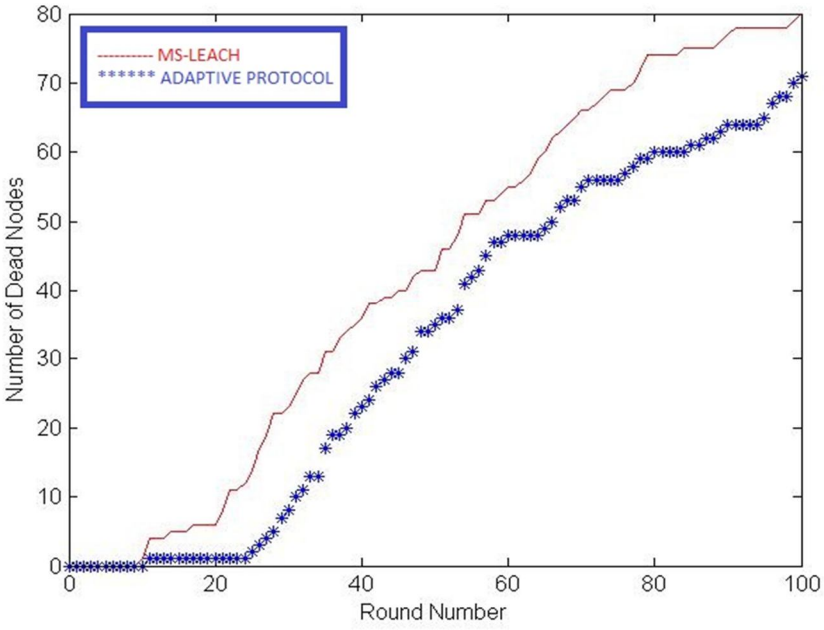

Figure 2: Number of Dead Nodes Vs round Number

As shown in figure 2 and figure 3, the proposed algorithm has longer network lifetime than Distance Based Multi Single Hop Low Energy Adaptive Clustering Hierarchy (MS-LEACH) routing protocol.

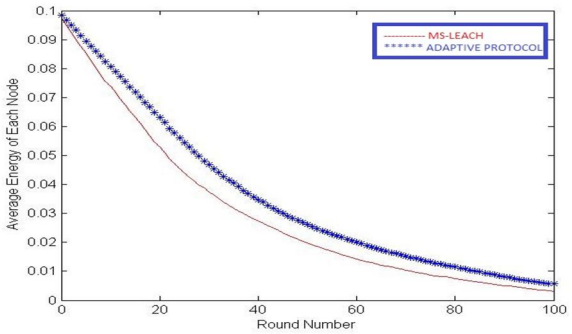

Figure 3: Average Energy of each node Vs Round Number

The improvement of proposed algorithm over the MS-LEACH algorithm is shown in terms of time when its first node die and last node die (1st node dies in the 12th round, 89 nodes die in the 100th round) and (1st node dies in the 19th round, 78 nodes die in the 100th round) respectively. We are also taking the account of average energy of each node. As shown in figure 3, it shows that in less number of rounds more energy is used in MS-LEACH as compared to proposed algorithm. The proposed algorithm is showing the better result.

VI. CONCLUSION AND FUTURE SCOPE

In this paper, a residual energy based adaptive routing protocol for a cluster-based wireless sensor network is proposed to adjust the energy utilization of inter-cluster communication and improve the lifetime of wireless sensor network. An Adaptive Routing Protocol utilizes an adaptive mode for choosing routing and a limit an incentive to tackle the issue of vitality lopsidedness because of the separation from the Base Station. In future, we might deal with intra-cluster communication and it consolidates inter-cluster communications. Therefore it may give better performance in energy utilization that lengthens the lifetime of wireless sensor network.

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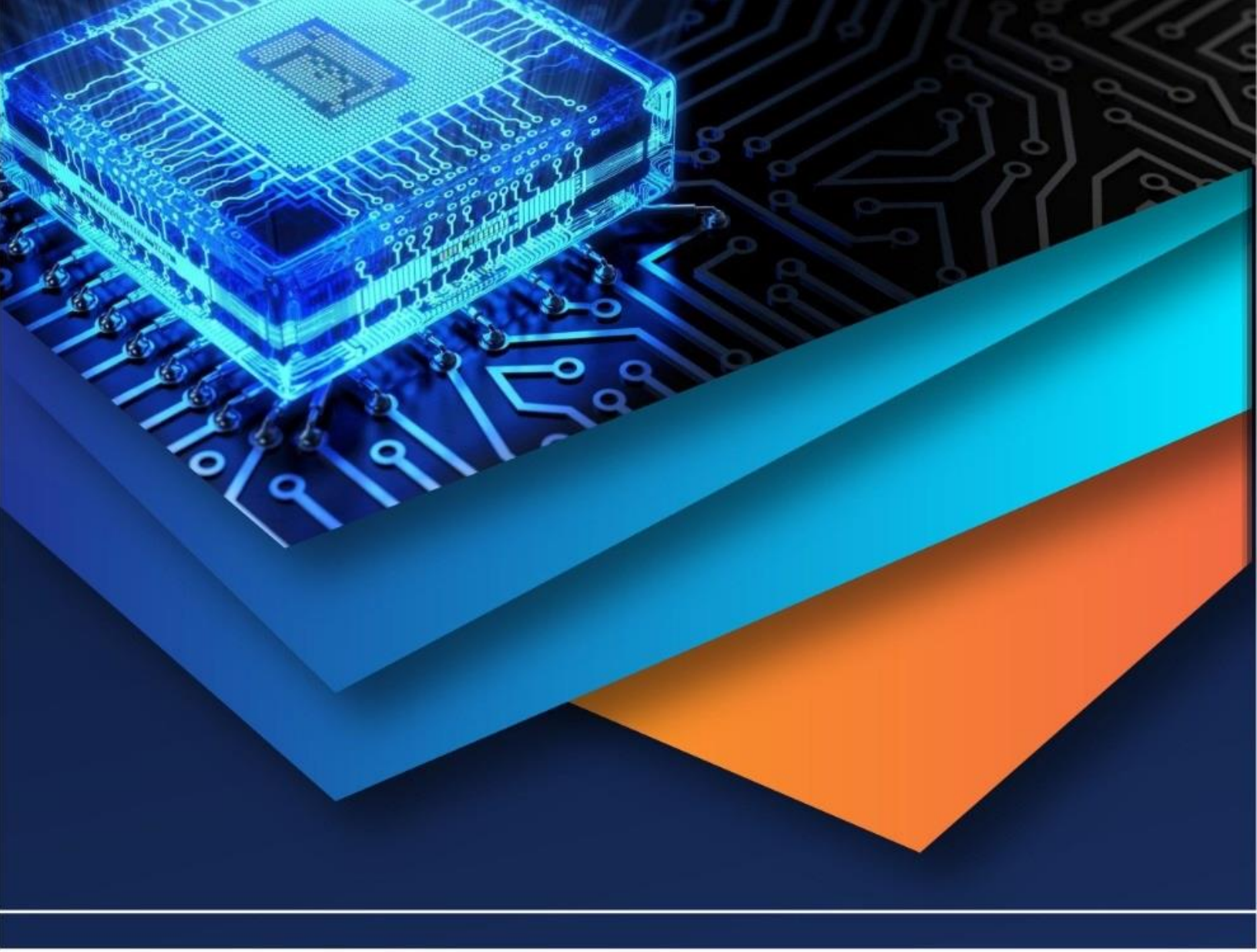

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