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Hierarchical and Power Proficient Routing Protocol for Wireless Sensor Networks

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ABSTRACT
Wireless sensor networks consist of small battery powered devices with limited energy resources. Once deployed, the small sensor nodes are usually inaccessible to the user, and thus replacement of the energy source is not possible. So, the energy consciousness issue is the primary concern within the domain of Wireless Sensor Networks (WSNs). Most power dissipation occurs during communication and path selection, thus routing protocols in WSNs mainly aim at energy conservation. Moreover, a routing protocol should be flexible, so that its effectiveness does not degrade as the network size increases. In response to these issues, this work describes the development of a data centric and efficient routing protocol, named HPPRP.
***Keywords*:-** wireless sensor networks; routing protocols; clustering; energy efficiency; hierarchical routing;

I. INTRODUCTION

Wireless sensor networks (WSNs) are becoming increasingly popular in many spheres of life. Application [3] domains include monitoring of the environment (e.g. temperature, humidity, and seismic activity) as well as numerous other ecological, law enforcement, and military settings. Regardless of the application, most WSNs have two notable properties in common: the network's overall goal is typically to reach a collective conclusion regarding the outside environment, which requires detection and coordination at the sensor level, and WSNs act under severe technological constraints: individual sensors have severely limited computation, communication and power (battery) resources while operating in settings with great spatial and temporal variability. Wireless sensor networks (WSNs) are becoming increasingly popular in many spheres of life. Many researches concerning protocols for wireless sensor networks have been studied to improve the energy consumption and the network lifetime. Those protocols can be categorized into three classes: routing protocols, sleep-and awake scheduling protocols, and clustering protocols. The routing protocols determine the energy-efficient multi-hop paths [2] from each node to the sink node. In sleep-and-awake scheduling protocols, every node in the schedule can sleep, in order to minimize energy consumption. In clustering protocols, data aggregation can be used for reducing energy consumption. Data aggregation, also known as data fusion, can combine multiple data packets received from different sensor nodes. It reduces the size of the data packet by eliminating the redundancy. Wireless communication cost is also decreased by the reduction in the data packets. Therefore, clustering protocols improve the energy consumption and the network lifetime of the wireless sensor networks. LEACH, PEGASIS, SHPER, BCDCP [1], [6-7] are representative clustering protocols of wireless sensor networks. However, the unsolved problem of considerable energy consumption on the cluster formation still exists. The cluster formation overhead of the clustering protocols includes packet transmission cost of the advertisement, announcement, joining, and scheduling messages from sensor nodes. Also, these protocols do not support adaptive multi-level clustering [8], [9] in which the clustering level cannot be changed until the new configuration is made by the network director. Therefore, the existing protocols are not adaptable to the various node distributions or the various sensing area. If the sensing area is changed by dynamic circumstances of the networks, the fixed-level clustering protocols may operate inefficiently in terms of energy consumption.

In this paper, we present a new protocol, which is data centric and energy-efficient clustering hierarchy protocol for wireless sensor networks where Base-Station is assumed to have energy and computing power in abundance and also it is assumed to know all the node locations. The proposed HPPRP protocols were evaluated by computer simulations and compared with BCDCP. In this paper, the energy consumption, standard deviation of the energy consumption, residual energy distribution, and the network lifetime of the clustering protocols are evaluated. The simulation results demonstrate that HPPRP significantly minimizes the energy consumption and extends the network lifetime of the wireless sensor networks over existing clustering protocol BCDCP.

II. RELATED WORK

In BCDCP every node has similar clustering like [5] LEACH. We can see that BCDCP is more efficient than LEACH in two aspects; first by introducing Minimal Spanning Tree (MST) to connect to CH which randomly chooses a leader to send data to sink. Second, BCDCP makes the best use of high energy BS to choose CHs and form cluster by interactive cluster splitting algorithm [8], [9]. Thus BCDCP has work well to route data energy efficiently in small-scale network but their network topology constrains them to do so in a large scale network.

Because the club topology [4] in clusters is a one-hop route scheme, it is not appropriated for long distance wireless communication. First in BCDCP, one cluster head is randomly chosen to forward data the Base Station. Because the CH in each cluster will send data to the CH closest to it based on minimum spanning tree, this burdens the routing to the Base Station (BS). All the Cluster Heads sends data to one specifically chosen Cluster Head that will finally send the aggregated data to the Base Station. Thus, BCDCP[3] is at disadvantage when there is a large number of sensor node and cluster heads. Due to the large number, sensor nodes need more energy for intra and inter cluster data transmission. This creates an unbalance in energy consumption and decreases network lifetime.

So the CH closet to BS has not sufficient energy for the further rounds. Whereas the SHPER [4] protocol specifies that the election of the cluster heads is not randomized. More precisely, the node elected to be the cluster head within each cluster is the one having the maximum residual energy. Furthermore, the route selection policy proposed takes into consideration both the residual energy of nodes and the energy consumption for all possible paths. In its allocated transmission time, each node sends to its cluster head quantitative data concerning the sensed events. In a way similar to that proposed in TEEN [5] hard and soft thresholds are utilized in the SHPER protocol too. So in this paper we proposed a new protocol which is based on BCDCP and SHPER.

III. THE RADIO MODEL FOR HPPRP

The radio model consists of three parts: transmitter, the power amplifier and the receiver. There are two propagation models: free space model and two-gray ground propagation model. Both the free space (d2 power loss) and (two gray propagating) the multipath fading (d4 power loss) channel models are used depending on the distance between transmitter and receiver. The energy spent for transmission of an l-bit packet from the transmitter to the receiver at a distance (d) is defined as:

$$ETx(l,d) = l*Eelec + l*\varepsilon*d\alpha = l*Eelec + l*\varepsilon fs* d^2,\ d < d0 = l*Eelec + l*\varepsilon mp* d^4,\ d \geq d0 \ldots\ldots\ (1)$$

ETx is the energy dissipated in the transmitter of source node. The electronic energy Eelec is the per bit energy dissipation for running the transceiver circuitry. Here the amplifier energy, $\varepsilon fs*d2$ or $\varepsilon mp*d4$, depend on transmission distance and acceptable bit-error rate. The cross over distance *d0* can be obtained from:

$$d0 = \sqrt{(\varepsilon fs / \varepsilon mp)} \ldots\ldots\ (2)$$

*ERx*is the energy expanded to receive message

$$ERx(l) = l*Eelec \ldots\ldots\ldots\ (3)$$

The distance (d) of node from one node another node is:

$$d = \sqrt{((x1-x2)2 + (y1-y2)2)} \ldots\ldots\ldots\ldots\ (4)$$

In formula (4) d indicates distance node, (x, y, z) indicates variables as node position in field area network Energy cluster (Ecluster) is the sum of energy in Cluster Heads;

Ecluster=ki*ETx(l,d)+ ERx(l) +EDA ----(5)

In formula (5) ki indicates the number of member nodes in the Cluster Heads; ETx(l,d) indicates energy transmission; ERx(l)indicate energy receiver and EDA indicates energy of data aggregation.

IV. TERMINOLOGY USED

1. The terminology used to explain the routing protocol and the elements implemented on it are described here to make easy to follow the detailed description provided in the following sections.
2. START is the message used by base station. Initially, Base station broadcast this message to all the sensor nodes in the field to indicate that all nodes should start their task.
3. HELLO is the message broadcasts by all the nodes after receiving START message, in order to find their neighbors. This HELLO message will reach to those nodes only that are within range of that node.
4. REPLY is the message send by a node when it receives HELLO message. This message contain the node id. After receving the REPLY message, each node makes it neibhbor list. Initially a node has empty neighbor list. When a node replies with its ID, then node receiving REPLY message retrives the ID and make entry in its neighbor list.
5. STATUS is the message send to base station either directly or via gateway. It contains neighbor list, residual energy of the node. After collecting the neighbor information, each node send STATUS message to the base station.
6. ACK is the acknowlegement send by the base station and those nodes which receives STATUS message. That means when base station receives STATUS message directly it send back an ACK message. Or when a node (Gate Way) have STATUS message, It also sends back an ACK message to acknowldge them that STATUS has been succesfully received.
7. GW_ADV is the message used to advertise the nodes themselves as a Gate Way. Actually, if the base

station is in the range of nodes then those nodes can send their STATUS to base station directly. But in the case if it is not within their range, then nodes needs to have their gateway (or gateways) to send their STATUS up to base station.

8. When a node receive ACK message, then it advertise itself as a Gate Way by sending GW_ADV message. A node receiving GW_ADV, sends their STATUS to gate way advertising node. In this case, a node can receive GW_ADV message from many nodes. But it send their STATUS to only that node from where it has received GW_ADV message early.

V. PROPOSED ALGORITHM

Initially, base station is centralized and 150 nodes are setup in a particular region 100 x 100m and each node has equal energy 2 joules.

- The base station creates a TDMA (Time Division Multiple Access) schedule and requests the nodes to advertise themselves i.e. their geographical location in the network field. The size of this schedule is equal to the number of the existing network nodes.
- In round 1, the iterative cluster splitting algorithm is followed such as the selected cluster heads are uniformly placed throughout the whole sensor field by maximizing the distance between cluster heads in each splitting step.
- Cluster Head from all the clusters will be created according to probability condition as well as the distance parameter. (i.e. distance from the BS). Rest of the nodes sends the sensed data to their respective cluster heads in its TDMA slot and energy consumption will be calculated.
- Each Cluster Head will aggregate the data and send it to the base station according to its time slot and energy consumption will be calculated for each node and cluster heads.
- In round 2, protocol specifies that the election of the cluster heads is not randomized. More precisely, the node elected to be the cluster head within each cluster is the one having the maximum residual energy.
- The route selection procedure proposed takes into consideration both the residual energy of nodes and the energy consumption for all possible paths.
- After selection of cluster heads, nodes sends the sensed data in its TDMA slot to their respective cluster heads, that will be selected according to the minimum distance of a particular node from cluster heads and energy consumption will be calculated.
- Cluster Head will aggregate the data and send it to the base station in its time slot and energy consumption will be calculated.
- Steps 4 to 7 will be repeated until the whole network gets down or number of rounds finished.
- Performance will be evaluated according to parameters like network lifetime, energy dissipation, no. of data packets sent etc.

VI. PARAMETERS AND RESULTS

Parameter	**Value**
Network field:	100x100m
N (Number of nodes):	150
Initial energy:	2 J
Eelec (E.Dissipation for ETx&ERx):	50 nJ/bit
ε fs (free space):	10 pJ/bit/m2
εmp (Multipath fading):	0.0013 pJ/bit/m4
EDA (Energy Aggregation Data):	5 nJ/bit/signal
Data packet size:	4000 bits

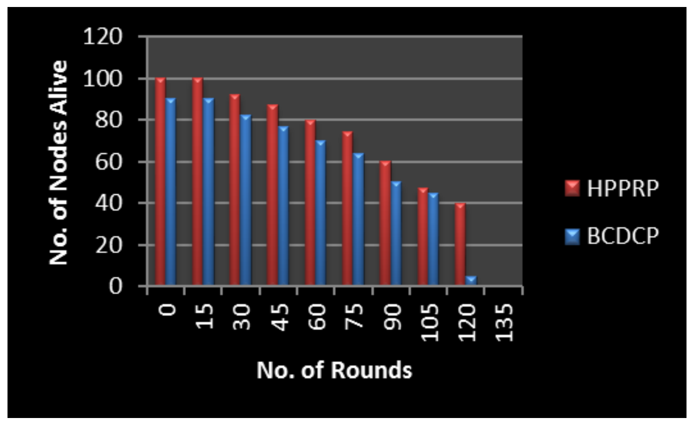

Figure 1.1: No. of Rounds vs Network Lifetime

Figure 1.1 shows the comparison of BCDCP and HPPRP protocol according to number of nodes died. All nodes of BCDCP protocol are died very earlier as compared to HPPRP.

Table -1.1 shows the Comparative analysis BCDCP and HPPRP in terms of Network Lifetime (in Rounds). It can be observed from table 1 that the HPPRP performs well as compare to BCDCP. The first node of HPPRP is dead around 3330 rounds whereas BCDCP first node dead around 3099 rounds. As the nodes starts communicating, they will lose their energy. So, the whole network is dead around 4767 in case of BCDCP, but in HPPRP the network is dead around 5711 rounds.

Table -1.1 Comparative analysis BCDCP and HPPRP in terms of Network Lifetime (in Rounds)

	First Node Dead (in Rounds)	Ten Nodes Dead (in Rounds)	Half Network Dead (in Rounds)	Whole Network Dead (in Rounds)
BCDCP	3099	3370	3693	4767
HPPRP	3330	3482	3834	5711

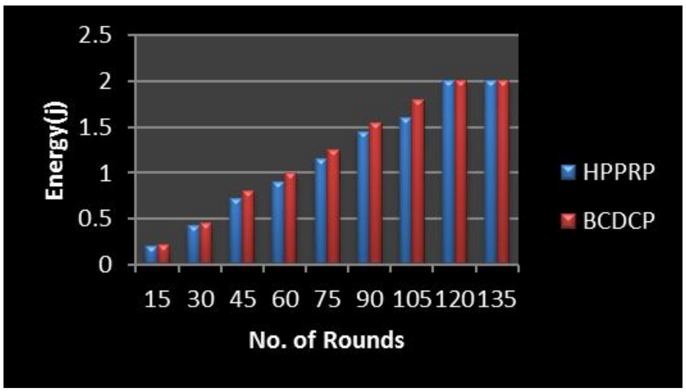

Figure 1.2: No. of Rounds Vs Energy Consumption

Figure 1.2 shows the lifetime of the network. It shows that how energy of the network consumes step by step and finally whole network goes down. It can be observed from the figure that, HPPRP consumes less energy and sustain more number of rounds as compare to BCDCP protocol.

VII.CONCLUSION AND FUTURE WORK

In this paper we propose a centralized clustering-based routing protocol, HPPRP that utilizes the high-energy CH to perform most energy-intensive tasks. By using the base station, the sensor nodes are relieved of performing energy intensive computational tasks such as cluster setup, cluster head selection, routing path formation, and TDMA schedule creation. Performance of the proposed HPPRP protocol is assessed by simulation and compared to other clustering-based protocol BCDCP. The simulation results show that HPPRP outperforms its comparatives by uniformly placing cluster heads throughout the whole sensor field, performing balanced clustering, and using a CH-to-CH routing scheme to transfer aggregated data to the base station. It is also observed that the performance gain of HPPRP over its counterparts increases with the area of the sensor field. Therefore, it is concluded that HPPRP provides an energy efficient routing scheme suitable for a vast range of sensing applications.

As future aspects we can think over other task scheduling methods like CDMA and FDMA. We can also think over security constraint during transmission Phase.

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