An Energy Efficient Quadrant based Clustering Approach for Wireless Sensor Networks

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Abstract: Wireless Sensor Networks is an promising epitome of correlating and calculating, where a node may be self-powered and discrete node have the proficiency to intellect and interconnect. Because sensors have restricted battery power, energy efficient routing is vital. A new sensor routing scheme Q-LEACH that conglomerates the Q-DIR protocol and clustering model in LEACH protocol has been represented in this paper. Quadrant Based Directional Routing Protocol (Q-DIR) mixes contradictory methods viz location based routing, restricted flooding. Q-DIR brims the broadcasting region to a quadrant where the destination node and source node sited. The location information of the target node, the source node and the current node is used by the Q-DIR. With Q-DIR as a reactive routing protocol routing overhead will be reduced and successively reduces total network power consumption through limited flooding. For hindering the energy consumed in gathering and distributing data, LEACH protocol which is one of the clustering based hierarchical routing protocols has been used. The paper will be concluded by mentioning the interpretations made from scrutiny of results about these protocols.

Index terms: Wireless Sensor Networks, Quadrant Based Directional Routing Protocol, location based routing, restricted flooding LEACH.

I. INTRODUCTION

Wireless Sensor Network, consists of immense number of sensor nodes having the proficiency of wireless communication, limited computation and sensing. The striking features in Wireless Sensor Network styles it different from other network; self-organize, low power, low memory, low bandwidth for communication, large-scale nodes, self-configurable, wireless, substructure less. Therefore, WSN design must encounter these features in order to afford a consistent network. However Sensor nodes are inhibited by energy supply and bandwidth. Such constraints pooled with the positioning of a large number of nodes are tasks to the design and conservation of the network.

II. RELATED WORK

The Routing protocol considered the characteristics of the sensor nodes along with the application and architecture requirements. Cataloguing of almost all of routing protocol can be according to network structure as data centric, hierarchical, location based[9].

In data centric, sink ask for particular node data by broadcasting message. After this message is reached to

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the specific node which sink is interested in its data. It will send the information back to sink. Several replicas of the packet is created by each sensor node which in turn forward it to all its neighbours in flooding. Directed Diffusion is a characteristic routing protocol of data centric which is based on the request[5]. In hierarchical routing protocols, clusters are created and a head node is assigned to each clusters.

![Clustering Process](image)

The LEACH will casually selects a few sensor nodes which is known to be the cluster heads (CHs) and this role will be rotated in order to evenly issue the energy load among the sensors in the network[19]. Figure 1 shows the clustering process in LEACH protocol. PEGASIS is an extension of the LEACH protocol. This implicates the creation of chain structures that is comprised of all nodes and recurrently data wholes across the chain rather than forming multiple clusters[4].

III. LOCATION BASED ROUTING

The sensor nodes in the location based routing protocols are addressed by means of their locations[3]. In order to save energy, some of the location based schemes will demand that nodes should go to sleep if there is no activity. By having as many as sleeping nodes in the network as possible, more energy savings will be achieved[2].

IV. RESTRICTED FLOODING

In this module, node that are located nearer to the destination or in a forwarding zone, will broadcast packet[1]. It can be implemented whereby limited nodes will participate in the flooding and not network – wide participation and also reduce the number of routing packets.

V. QUADRANT BASED DIRECTIONAL ROUTING PROTOCOL

Q-DIR is a restricted flooding routing protocol that focuses on a quantified zone using location information provided by a location service. In Q-DIR process, the location information of the source and destination nodes is piggy-backed in the route request (RREQ) packet and then publicized. Figure 2 shows the participating nodes in total flooding algorithm. Upon receiving the RREQ, destination node will send a route reply message (RREP) back to source via the path taken to reach the destination that was appended in the RREQ as it criss-crosses across the network[2]. By applying restricted flooding on the quadrant, and the path accumulation feature in AODV, the number of nodes contributing in the route discovery will be condensed and hence eases the routing overhead[3]. The final result is that the amount of energy used between the source and destination is limited thereby increasing the energy proficiency of the network.

Figure 3 shows less participating nodes if restricted flooding is employed based on the same quadrant an intermediate is located compared to source and destination[2]. It reduces the number of routing packets that traverse through the network.
VI. LEACH

Leach was proposed for the lessening of the power consumption.

Figure 2: Participating nodes in total flooding algorithm

Figure 3: Less participating nodes in Q-DIR algorithm
Leach involves the data aggregation (fusion) process which chains the original data into a smaller sized data. The data contains only the meaningful information to all the individual sensors [4,6]. Leach uses the clustering technique in order to reduce the amount of data that are transmitted to the sink, to make the routing and data dissemination mountable and forceful. Leach is completely distributed which requires the global knowledge about the network [7]. Figure 4 shows the overall process taking place in LEACH protocol.

The cluster heads can be chosen stochastically (randomly based) in Leach protocol. An example of LEACH model is shown in Figure 5. The Leach operation is classified into round each of which has mainly two phases namely:
A. Setup phase
- for forming the network into clusters
- announcements of the cluster heads
- transmission schedule creation

B. Steady state phase involves
- the data aggregation
- compression
- transmission to the sink

The energy consumption in Leach can be reduced by the reduction of the communication cost between the sensors and their cluster heads. The non-head nodes can be turned off as much as possible. The sensors used in the Leach do not use the location or the distance information.

VII. Q-LEACH
Q-LEACH is a fusion routing protocol which chains the advantage of both location based routing protocol and hierarchical based routing protocol. Restricted flooding concept is exploited in which nodes that are located closer to the destination or in a promoting zone broadcasts the packet. The Q-LEACH model is depicted in figure 6. Distance and forwarding zone information are calculated at the individual nodes to decide their advancement towards destination[10].

A. Cluster-Head Characteristics
The various cluster head characteristics are existence, difference of capability, mobility and its role in the network.

![Figure 6: Q-LEACH model](image)

Existence
Based on whether there exist cluster-heads within a cluster, clustering schemes can be grouped:
- cluster-head based clustering
- non-cluster-head based clustering
In the former schemes, there exist at least one CH within a cluster, but there aren’t any CHs within a cluster in the latter schemes.

B. Difference of capabilities
Based on uniformity of energy assignment for sensor nodes, clustering schemes in WSNs can be classified:
- homogeneous
- heterogeneous
In homogeneous schemes, all the sensor nodes are assigned with equal energy, computation, and communication resources and CHs are designated according to a random way or other criteria. However, sensor nodes are assigned with unequal capabilities in heterogeneous environment, in which the roles of CHs are pre-assigned to sensor nodes with more capabilities[8]. Figure 7 shows the basic work done by each cluster head in LEACH.

According to the mobility attributes of CHs, clustering approaches in WSNs also can be grouped:

- **Mobile**
- **Stationary**

In the former manners, CHs are mobile and membership dynamically change, thus a cluster would need to be continuously maintained. Contrary to it, CHs are stationary and can keep a stable cluster, which is easier to be managed. Sometimes, a CH can travel for limited distances to reposition itself for better network performance.

C. Role

A CH can simply act as a relay for the traffic generated by the sensor nodes in its cluster or perform aggregation/fusion of collected information from sensor nodes in its cluster. Sometime, a cluster head acts as a sink/BS that takes actions based on the detected phenomena or targets. It is worth mentioning, sometimes a CH acts in more than one role. These nodes will show the packets and the process is repeated at each midway node until it reaches the destination and also uses clustering procedures in which nodes are convened into cluster and cluster head is dispensed to each cluster to execute the data combination and blending in order to diminish the energy consumed by nodes within the cluster.

VIII. SIMULATION SETTINGS

Results were obtained using network simulator. Table I summarizes the parameters used in the simulation.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor deployment area</td>
<td>150x150m</td>
</tr>
<tr>
<td>Number of nodes</td>
<td>154</td>
</tr>
<tr>
<td>Data packet size</td>
<td>100 bytes</td>
</tr>
<tr>
<td>Control packet size</td>
<td>25 bytes</td>
</tr>
<tr>
<td>Initial energy of sensor</td>
<td>5 J</td>
</tr>
<tr>
<td>Aggregated packet size from cluster head</td>
<td>500 bytes</td>
</tr>
<tr>
<td>Processing delay</td>
<td>100µs</td>
</tr>
<tr>
<td>Radio speed</td>
<td>1 Mbps</td>
</tr>
</tbody>
</table>

IX. RESULTS

Two scenarios were simulated. The two protocols that were simulated are LEACH and Q-LEACH.

A. Routing Overhead:
Routing Overhead measures by the total number of control packets sent divided by the number of data packets delivered successfully. Figure 8 provides the comparison of Q-LEACH and LEACH in terms of routing overhead.

It is observed that about 33% of more routing packets are transmitted in LEACH compared to Q-LEACH due to the participations of large number of nodes in the network.

B. Energy consumption

Figure 9 shows the effective energy consumption graph for LEACH and Q-LEACH. As the number of nodes increases, the energy consumption also increases. It is 1.0012 J in LEACH and 0.423 J in Q-LEACH. Q-LEACH consumes about 57% less energy for sending the packets than the LEACH.

C. Average end-end delay

Figure 10 shows the average end-end delay for the two cases. Q-LEACH is better than the LEACH because of less number of nodes participating in the transmission.
D. Throughput

Figure 11 shows the throughput for the two cases. In Q-LEACH, the throughput increases with respect to number of nodes whereas in LEACH the throughput is very low but increases with increase in network size[20].

E. Packet Delivery Ratio

Packet delivery ratio is the ratio between the number of packets that are received and the number of packets sent. Figure 12 shows the comparison graph of packet delivery ratio. In WSN’s it is not possible to say clearly that the PDR in Q-LEACH are decreases or increases with respect to the number of nodes, because at the network size 25 to 50 there is increase but at the network size 50 to 75 there is decrease and for the network size 75 to 100 again increase, but PDR are higher than LEACH, but LEACH shows stability as compared to others.

X. CONCLUSION

This paper has proposed a unification routing protocol, Q-LEACH for wireless sensor networks. The network is alienated into four quadrants. Clusters are formed within each of these quadrants and cluster head is allotted to each cluster. These cluster heads show an central role of updating and forwarding the node locations and pointing the Route Request Packets (RREQ) to the next cluster. The shortest route is determined by using the RREQ which limits the announcement region to the relevant quadrants where source and destination nodes are sited. The simulation results spectaculars the integrating of LEACH and Q-DIR as Q-LEACH reduces the energy consumption and lengthen the network lifetime. The restricted flooding, location based and clustering techniques reduces the number of participating nodes as the RREQ navigates in the network towards the destination node and hence reduced overhead and energy intake are attained in Q-LEACH.
REFERENCES


