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Quad Clustering Routing Protocol to Enhance the Stability in WSN

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ABSTRACT*:* A WSN (Wireless Sensor Network) can be used as effective tool for sensing and collecting data in various platforms using huge number of wireless sensor nodes. The main concern in wireless sensor networks is to develop the efficient energy routing protocol which increases the lifetime of the sensor nodes. This paper focuses on lessening the energy consumption and enhances the throughput and stability period of wireless sensor networks. Therefore, a communication protocol named Q-LEACH is modified. We propose that the network area is divided into four quadrants and each quadrant has equal number of sensor nodes (cluster), CH (Cluster Head) and Sub-CH (acts as CH when original CH expires before completion of round). We have simulation based results to compare the performance with existing protocol LEACH (Low Energy Adaptive Cluster Hierarchy) and proposed protocol Q-LEACH. The outcome of the experiment shows that Q-LEACH protocol has greater degree of NLT (Network Life Time) in the network against the LEACH protocol.

KEYWORDS—LEACH, Q-LEACH, routing protocols

I. INTRODUCTION

Wireless Sensor Networks (WSN) [1] is one of emerged technology that is being rapidly adopted due to their flexibility and use in a various environments. Networks protocols in WSN have to achieve fault tolerance whenever individual node is failed and energy consumption [5] as to be reduced. Moreover the routing protocols in WSN should have capability to perform local collaboration to reduce the bandwidth requirements, since the channel bandwidth is shared among all the sensor nodes in the network. WSN's are one of best technology for monitoring critical situations and remote fields which far away from the human perspective. Fig. 1 illustrates the Wireless Sensor Network.

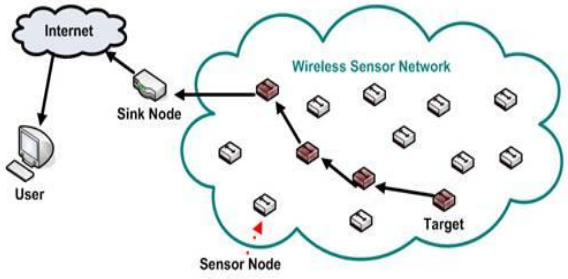

Fig. 1. Wireless Sensor Network

In WSN, the selection of CH (Cluster Head) is performed based on homogenous clustering protocol called Low Energy Adaptive Cluster Hierarchy (LEACH) [2, 4, 7].

II. RELATED WORK

LEACH (Low Energy Adaptive Cluster Hierarchy) [2, 4] is the first grade routing protocol in WSN. LEACH protocol is TDMA (Time Division Multiple Access) based protocol which is integrated with clustering and routing

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protocol [5] in WSN. The aim of LEACH protocol is to minimize the energy consumption for maintaining the sensor nodes in order to improvise the Network Life Time (NLT) in WSN's. Fig. 2 illustrates the LEACH protocol [2, 7], here CH (Cluster Head) are assigned based upon threshold T(n) value. Cluster (member) nodes forward the sense data to CH (Cluster Head) using allotted time slot. The CH gathers all the data received from clusters then aggregates the data and sends reduced data to Base Station (Sink).

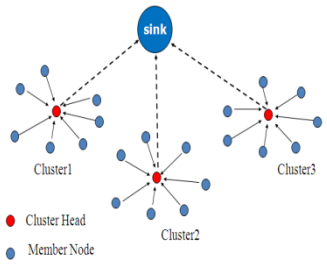

Fig. 2. LEACH Protocol

Q-LEACH (Quadrature LEACH) [1, 3] In order to obtain better cluster routing protocol the entire wireless sensor network is divided into 4 quadrants. Each quadrant has equal number of sensor nodes and among them one node will be the selected as Cluster Head (CH) based upon Threshold T(n) value. CH receives data from other nodes of same quadrant at allotted time slot and aggregates the data which reduces amount of information to be sent to base station. Q-LEACH with uniform clustering technique [5] improves the Network Life Time (NLT) than LEACH protocol [2, 4].

III. PROPOSED WORK

We propose concept called as Q-LEACH (Quadrature Low Energy Adaptive Cluster Hierarchy) [1]. In this section we discuss the charactertics and working principle of Q-LEACH to obtain optimum performance. Q-LEACH protocol is developed in order to exaggerate some parameters like NLT (Network Life Time), stability period and throughput for desirable performance of WSN's.

In this approach sensor nodes are deployed randomly in the territory. In order to acquire efficient clustering [5] we divide entire network into four quadrants. To achieve better coverage of entire network such partition is used.

Fig. 3 illustrates the load distribution within sensor nodes. The main goal is to acquire better clustering mechanism [5] which provides better coverage in the entire network. Random sensor nodes are deployed in 50mx50m area. Each node sends their position information to BS (Base Station) based on position information the entire network is divided

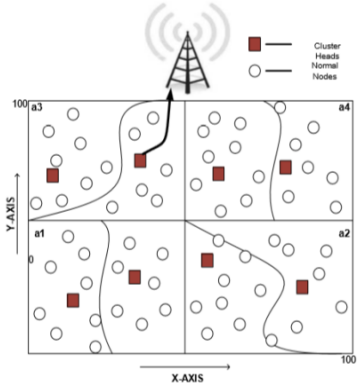

Fig. 3. Q-LEACH Protocol

into four quadrants i.e., (q1, q2, q3, q4).Where sensor nodes are equally disturbed in each quadrant. Overall network area is defined as [1, 6]:

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$$A = q_1 + q_2 + q_3 + q_4 \quad (1)$$

$$q_n = A(x_m, y_m)$$

Where, n=4 and m=24. Therefore area is divided as follows [1]:

$$\lim_{x_m \to 0:25}^{y_m \to 0:25} q_n + \lim_{x_m \to 26:50}^{y_m \to 0:25} q_n + \lim_{x_m \to 0:25}^{y_m \to 26:50} q_n + \lim_{x_m \to 26:50}^{y_m \to 26:50} q_n \quad (2)$$

Portioning of entire network in four quadrants is to enhance NLT and minimize energy utilization [5] of nodes. In existing model LEACH protocol [2, 4], the cluster is dynamically formed if cluster members are located far away from each other and hence energy consumption is too high. Whereas in proposed model Q-LEACH protocol [2], the entire is divided into sub-network and hence cluster are formed within the sub-network. Nodes are linked within one or other cluster and hence energy consumption is low.

Selection CH (Cluster Head) [1, 2] is performed using Probability (P) =0.05 and Threshold T(n). In each round nodes decides which node to become CH using P and T(n) [1, 2] as:

ALGORITHM 1 : *Setup Phase*
1 : *begin*
2 : if node $\in G \rightarrow G$ = nodes which did not become CHs in current EPOCH then
3 : if (NODE _ BELONGS _ TO=='area q_1')then
4 : if(NUMBEROFCHs<=($\frac{N}{K}$)then
5 : $TEMP = random\ number(0-1)$
6 : if ($temp <= \frac{P}{1 - P(r, \bmod 1/P)}$)*then*
7 : $node = CH\_q_1$
8 : $NUMBER\_OF\_CHs = NUMBER\_OF\_CHs + 1$
9 : *end* if
10: *else* if (NODE _ BELONGS _ TO=='area q_2')then
11: *REPEAT STEP* 4 : 8
12 : *else* if (NODE _ BELONGS _ TO=='area q_3')then
13: *REPEAT STEP* 4 : 8
14 : *else* if (NODE _ BELONGS _ TO=='area q_4')then
15: *REPEAT STEP* 4 : 8
16 : *end* if
17: *end* if
18:*end* if

Algorithm 1 describes CHs selection process [1] where entire network is divided into four sub-areas as: Area q1, q2, q3 and q4. Initially each node opt random number between 0 and 1. The random number of each node is compared with T(n) value and if random number of node is lesser than T(n) and if there is no other CH present in the sub-area then the node will be selected has CH. Similar CH selection process will be continued to select CH in other sub-areas. Clusters are selected based upon the RSSI (Received Signal Strength Indicator). Once the clusters are decided, nodes must

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inform about their association to CHs. The CHs receives nodes association information and assigns specific time slot to each node using TDMA.

Algorithm 2 describes association of nodes [1] with their suitable CHs. Once the cluster setup is completed (Algorithm 1). Each node communicates with CHs at its allotted time slot. Rest of interval node will remain off in order to minimize the energy utilization [5]. When all nodes information is received by CHs then, the information is aggregated and is sent to BS (Base Station). The round gets completed and new CHs will be selected for next round. Same idea is followed in all other sub-areas for optimize energy utilization and NLT (Network Life Time).

$$
\begin{aligned}
&ALGORITHM\ \ 2: Node\ Assocation\ \ in\ \ Q-LEACH\\
&1: N \in Groups\ of\ \ normal\ nodes\\
&2: GC \in Groups\ of\ \ CHs\\
&3: if\ \ N \in (A, q_1) then\\
&4: \quad Where\\
&5: \quad A = q_1, q_2, q_3, q_4\\
&6: \quad Check\ all\ \ possible\ q_1 CHs\\
&7: \quad Check\ RSSI\ of\ \ CHs\\
&8: \quad Associate\ with\ q_1 CHs\\
&9: \quad then\\
&10: \ transfer\ of\ \ data\ occurs\\
&11: \qquad if\ (battery\ of\ \ CHs == 0)\\
&12: \qquad\quad then\ select\ sub-CH\ to\ continue\\
&\qquad\qquad\qquad\qquad data\ transfer\\
&13: \qquad else\ if\ (continue\ with\ same\ CH)\\
&14: end\ if\\
&15: if\ \ N \in (A, q_2) then\\
&16: \quad REPEAT\ STEP5:8\ \ for\ q_2 CHs\\
&17: end\ if\\
&18: if\ \ N \in (A, q_3) then\\
&19: \quad REPEAT\ STEP5:8\ \ for\ q_3 CHs\\
&20: end\ if\\
&21: if\ \ N \in (A, q_4) then\\
&22: \quad REPEAT\ STEP5:8\ \ for\ q_4 CHs\\
&23: end\ if
\end{aligned}
$$

In proposed scheme, we implement Sub-CH (acts as CH when original CH dies before completion of round) with the above concept Q-LEACH to obtain better outcome compared to existing scheme. The Sub-CHs will be used whenever the original CHs energy exhaust without completion of round. Sub-CHs will be selected by the original CHs based on amount of energy remained. Sub-CHs gather all the information from original CHs before the energy of CHs is completely drained out. In Fig. 4 describes working principle of Q-LEACH [1], which works according to Algorithm1 and Algorithm2.

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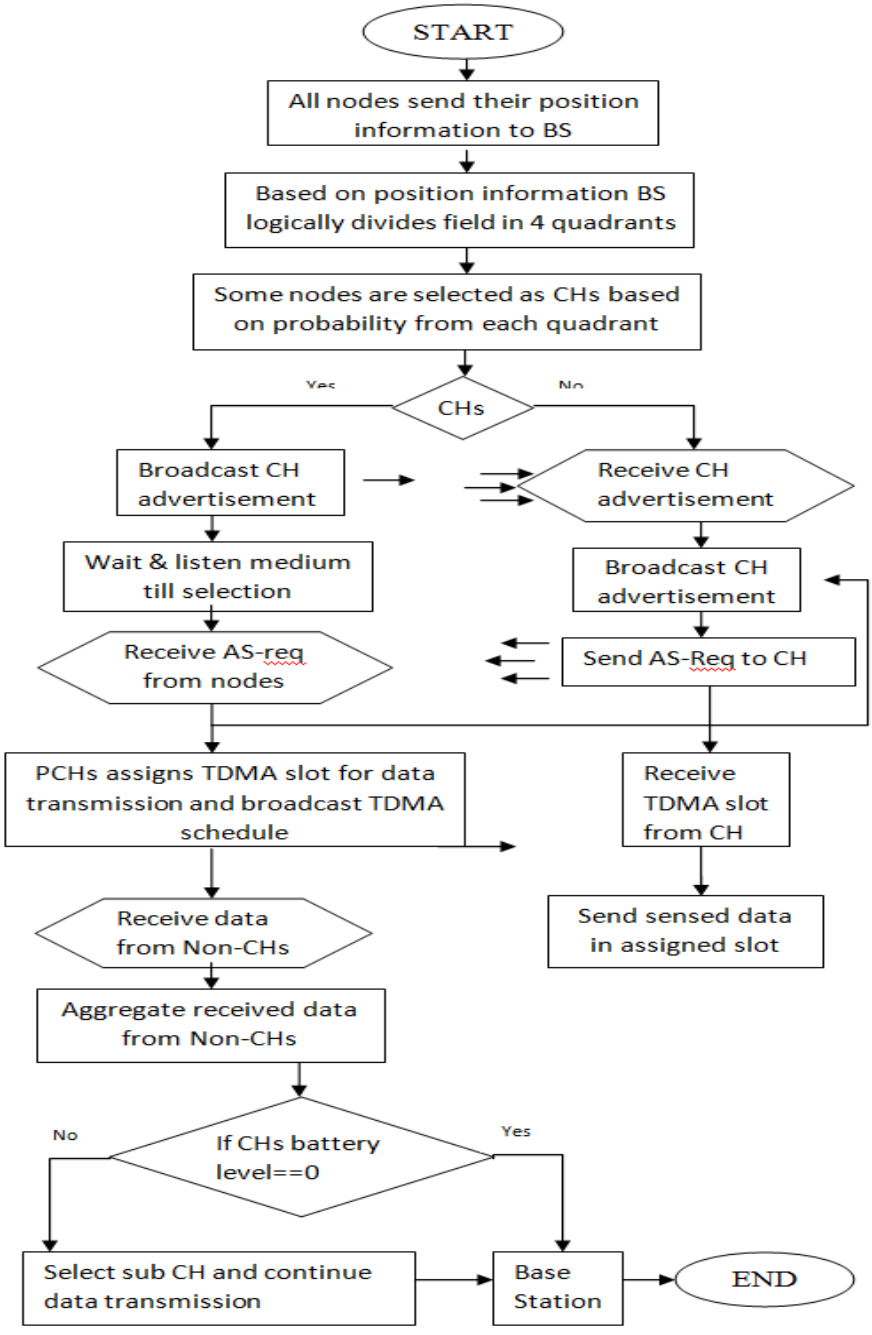

Fig. 4. Working principle of Q-LEACH [1]

IV. SIMULATION RESULTS

In this section, we validate the performance of proposed Q-LEACH protocol with existing LEACH protocol using Network Simulator-2(NS2) simulation tool.

We simulate the protocol and utilize a network with 24 nodes randomly deployed with initial energy (E) =10j in area with dimensions of 50mx50m. The BS is deployed far away from the network area. We measure the performance of the proposed scheme based upon certain parameter NLT (Network Life Time), SP (Stability Period) and TP (Throughput).

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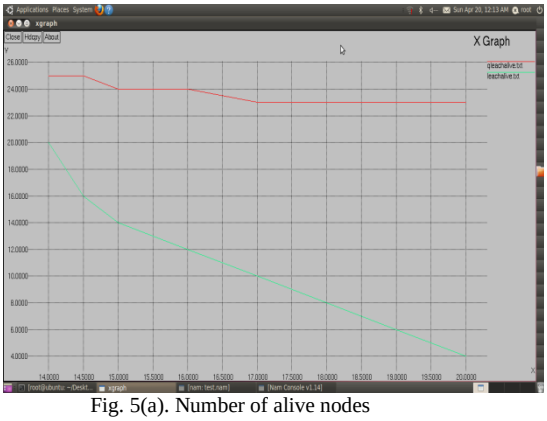

Fig. 5(a). Number of alive nodes

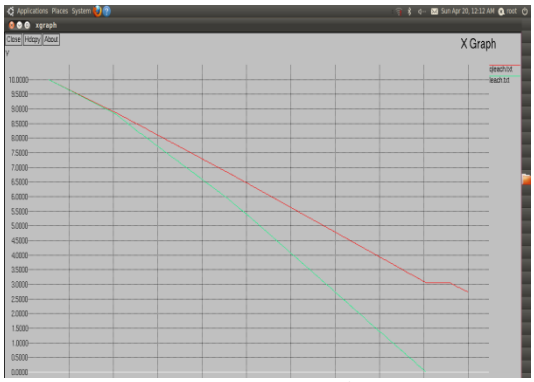

Fig. 5(c). Throughput factor

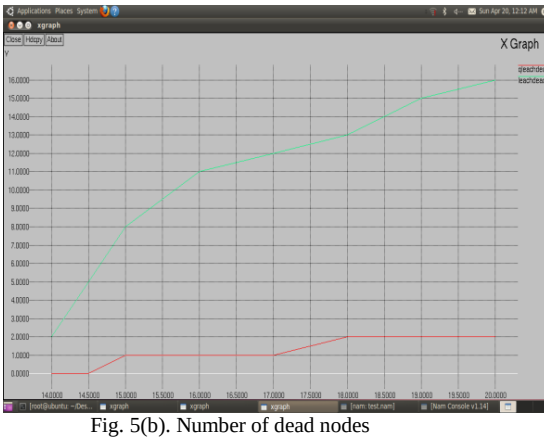

Fig. 5(b). Number of dead nodes

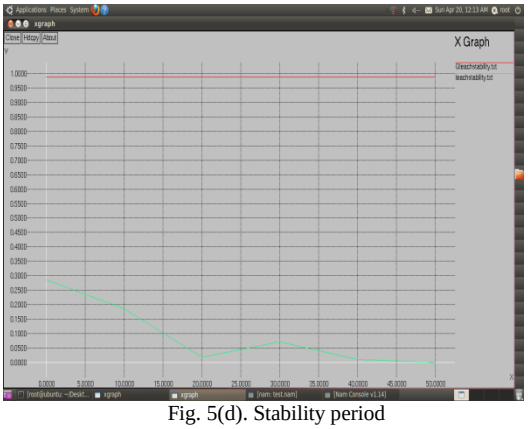

Fig. 5(d). Stability period

Fig. 5. Performance compared between LEACH and Q-LEACH.

In Fig. 5.(a) shows that in Q-LEACH protocol, number of alive nodes is too high whereas in LEACH protocol very few nodes are alive when the execution is completed hence, NLT(network life time) in Q-LEACH protocol to be more optimized when compared with LEACH protocol. In Fig. 5(b) shows that in Q-LEACH protocol, number of dead nodes are countable whereas in LEACH protocol almost all nodes are dead. In Fig. 5(c) represents the throughput of Q-LEACH protocol where the data is delivery accurately to the BS without any drop packets whereas in LEACH protocol there is no accuracy in delivering the packets. In Fig. 5(d) represents the stability period of Q-LEACH network, the Q-LEACH works stably for long time whereas the LEACH varies every round and network dies very soon.

V. CONCLUSION

Routing protocols in WSNs is still an area of research as sensor nodes are finding newer and newer applications with time. The growth in the fields of pervasive and ubiquitous computing coupled with the advances in the field of Nano technology have raised new routing challenges which the researcher community has to overcome. In this paper, we have defined Q-LEACH protocol on the basis of dividing entire network into four quadrants and each quadrant performs individually to enhance NLT, TP and SP. This gives an opportunity for researchers to further explore these algorithms in those domains where work has not been done. Also we presented an overview of various routing protocols with emphasis on Data aggregation, support for query and scalability of the network of which are important area of research.

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BIOGRAPHY

Mr. Sharath S.T is a Student of Computer Science and Engineering Department at Cambridge Institute of Technology-Bangalore, affiliated to VTU pursuing M.Tech in Computer Networking and Engg. He received his Bachelors of Engineering in Computer science and Engg. From AMC Engg College-Bangalore affiliated to VTU. He is working as a research assistant under the guidance of Asst. Prof**. Mrs. Veena N.** Her research interests are e-Learning through Cloud Environment with Special Focus on Indian Engineering Education System, Cloud Computing and Wirless Sensor Networks.

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