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Optimization of Energy Consumption for Hybrid Routing Protocol in WSNs

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ABSTRACT

Wireless sensor networks consist of thousands of inexpensive miniature devices capable of computation, communication and sensing. Clustering is one of the key techniques that can extend the lifetime of wireless sensor networks. Generally, lifetime extension is still considered to be the most dominant challenge for wireless sensor networks. In this paper, introduce a meta-heuristic population based soft computing algorithm as an optimization technique to increase the WSNs lifetime. It optimizes the network as a nonlinear problem to select the optimum cluster head nodes across number of generations. The proposed technique is QB-LEACH combines the merits of QB-LEACH and BAT Algorithm wireless sensor networks deployments and compared with the QB LEACH hierarchal clustering and routing protocol. Results show that proposed technique outputs the classical QB LEACH. It efficiently optimizes the selection of cluster head nodes that ensure optimum coverage and connectivity based on intra-cluster distances. This optimizes the energy consumption on each node level and hence increases the network lifetime for every node, causing increase in the wireless sensor network lifetime. The paper introduces a performance numerical analysis with the metrics of number of packets sent to base station, and number of dead nodes, sum of WSN energy and the network lifetime. . Bat algorithm was successfully used for many optimization problems and there is also a corresponding program in MATLAB.

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INTRODUCTION

Wireless sensor network in context of computing is defined as a complex efficient system consisting of small distributed constrained entities (Marwa sharawi, 2014). The extensive complexity of this system comes out of the system limitations and challenges. This is due to the fact that WSNs are multi constrained in terms of energy consumption, communication rage, links costs, low bandwidth, limited processing and storage. On the basis of energy distribution among sensor nodes, Wireless sensor networks are classified into heterogeneous and homogenous networks. Some clustering protocols such as LEACH, Power-Efficient Gathering in Sensor Information System (PEGASIS), and Hybrid Energy-Efficient Distributed Clustering (HEED) are defined for homogenous networks. Whereas, stable Election Protocol (SEP) and Distributed Energy-Efficient Clustering (DEEC) deal with heterogeneous networks.

Through geographical information and energy awareness of nodes, Geographic and Energy Aware Routing (GEAR) routes a packet towards targeted region. For such process either their exist a closer to neighbor are farther away from destination. For closer neighbors from the base station, GEAR picks a next-hope node among all neighbors closer to the destination. In case of distance neighbors there exists a hole and GEAR selects a next-hope node on the basis of minimum cost value (Manzoor, 2013). Moreover, Energy Aware Geographic Routing Protocol (EAGRP) is another technique used in wireless networks for routing packets. Sensor networks are deployed for long term monitoring of fields and are desired to continue working without abrupt changes (Manzoor, 2013). Moreover, it is also desired to obtain global knowledge continuously that is better coverage of area should be obtained by Considering above mentioned needs new approach QB-LEACH is designed which improves network efficiency.

Most of the ongoing researches in WSNs are done towards ensuring energy efficient operation. One of the important research arenas that could ensure energy efficient operation is the routing protocols. The routing protocols aids in determination of energy efficient multi-hop paths

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between each of the node to its sink. Also the clustering strategy ensures efficient energy usage profile by reducing the data packet size. Another important category of the wing is the one that combines the merits of two different classes. This is called as hybrid routing protocols. This work is also done towards developing a hybrid routing protocol called Quadrant based LEACH that combines the LEACH and Q-DIR. The forthcoming sessions of this paper are organized in the following ways: Section 2 presents the related works, Section 3 presents the protocol description, section 4 Bat algorithm and Section 5 gives the simulation results and discussion.

Related works:

A. Low Energy Adaptive Clustering Hierarchy (LEACH):

LEACH is a hierarchical clustering algorithm for Sensor networks. The cluster formation may either be centralized or decentralized. Arbitrarily confined number of sensor nodes are selected to be cluster heads utilizing cluster head selection algorithms and periodically rotates the role of cluster head to some other nodes in order to have even apportion of energy among the sensors. The limitation for the number of cluster heads is that 5% of total nodes could act as cluster head. There exists two important phases in LEACH.

1. Setup Phase:
- Cluster formation
- CH selection
- Scheduling

2. Steady state Phase:
- Data collection/Aggregation
- Data transmission

After cluster formation and cluster head election the cluster head nodes compression the data arrived from the nodes that is sent appropriately to the respective clusters and sends the aggregated packet to the Base Station (BS) to minimize the amount of information. The two communication modes in the Inter-Cluster communication (Among the different clusters) and Intra-Cluster communication (Within the cluster). To avoid the collisions TDMA and CDMA scheduling is provisioned. LEACH evidently is energy efficient.

B. Quadrant based Directional Routing (Q-DIR):

Q-DIR is hinged on the hypothesis of the restricted flooding that utilizes the position/area information that is provisioned by the location service. Q-DIR is constructed over the bases of ARP and restricted flooding (10). In Q-DIR mechanism the information of the location of source node is piggybacked along with route request (RREQ) packet and is broadcasted. The nodes that require the data packet from source node or in short the sink node replies through the Route reply packet (RREP) along with the piggybacked location of itself (Sink) through the same path followed by the RREQ packet. Then the overall network is divided into quadrants such that the source and destination falls under the same quadrant. This is followed by restricted flooding. The need for the routing table/one hop neighbor table is not essential in Q-DIR unlike ARP. The combined effects of reduction in overhead processing to maintain the table along with less participating nodes in forwarding accomplished by restricted flooding results in the energy efficiency.

C. Particle Swarm Optimization:

PSO (particle swarm optimization) is based on the swarm behavior of fish, and bird schooling in nature has a great optimization in energy aware clustering for WSNs (7). The contribution of applying PSO techniques in WSNs energy efficient clustering and routing, is that it is optimally select the cluster head nodes based on the maximum residual energy. Moreover, finding the optimal shortest route to the base stations that inspired form the nature of particle swarm will significantly extend the WSN`s lifetime. Equalizing the number of WSN`s nodes and nominating a proper cluster head objective to minimum energy based on PSO was firstly introduced in clustering method was effectively maximize the network lifetime and minimize the data transmission costs.an energy-aware clustering for wireless sensor networks using particle swarm optimization. It works by applying the Divided Range Particle Swarm Optimization (DRFSO) algorithm to the dense mobile nodes distribution. This restricts the selected number of cluster head nodes to provide efficient medium access control. The proposed objective function takes into account a combined effect of the ideal degree, transmission power, mobility, and battery power of the nodes. Results show a good optimization over the previous applied methods especially for the flexibility of assigning different weights to the nodes.

Quadrant Based LEACH (QB-LEACH):

The Quadrant Based LEACH is hybrid classes of Routing Protocol that admixes the ideologies of LEACH and Q-DIR. It roots the conglomerates of the above two postulations. This protocol holds good for the WSN's that have a great extension of good node numbers where the overall system tends to be homogeneous with node nature that adheres to static one. Once if the network initialization is done a procedure that is similar to that of LEACH is followed in-order to form the Clusters and to make out with the choice of Cluster Heads.

In sequence to it an Inter Gateway Node (IGN) is chosen to establish the communication between the Base Station and Cluster Heads. The grand choice of IGN is made by the base station with a consideration that, a node that is chosen to be an IGN must be at a position that is optimally nearer and approachable by all the Cluster Heads to reach the Base Station. Once

when an IGN is chosen the Base Station intimates the appropriate Cluster Head (that the IGN previously belongs to) to remove it from that particular Cluster. Then the Base Station also announces the other Cluster Heads about IGN. Claiming that the incorporation of Q-DIR (that bestows the location awareness) network has a knowledge of Source node and the quadrant is formed with respect to that source node.

This is done in such a way that the source and destination is made out under the same quadrant. After this setup is made data is forwarded to the destination by restricted flooding. If the source and destination could not be made under the same node then the vertices adjustments are made and they are brought forth under the quadrant and then restricted flooding is performed. These quadrant adjustments are made out under the care of Base station. In case if the source and destination could not be made under the same quadrant then LEACH based procedures is adapted to perform the data forwarding.

BAT Algorithm:

Bat Swarm Optimization Algorithm (BSO) is of the most recent invented and efficient meta-heuristic population based soft computing algorithms (7). It solves nonlinear optimization problems with single or multi-objective functions. It exposed as a meta-heuristic swarm intelligence optimization method developed for the optimal numerical optimization. This algorithm naturally inspired from the social behavior of bats. The capability of echolocations of these bats composed a great competent manner to detect prey, avoid obstacles, and to locate their roosting crevices in the dark based on sensing distances. In order to formalize the bat swarm algorithm optimally, the following approximated bats` echolocation characteristics should be idealized:

a. Objects distances are always perfectly sensed by the echolocation system on bats. This considers the ability to differentiate between different objects even in darkness.

b. Bats are flying randomly with velocity *vi*, fixed frequency *fmin* at position xi, and fluctuating wavelength λ, and loudness from *A0* to Amin to search for its prey. Wavelength or frequency can be changed spontaneously by adjusting the pulse emission rate $r \in [0, 1]$, based on the closeness of the bat`s objective.

c. Variation of the loudness parameter takes vales between large loudness *(A0)* and minimum loudness *(Amin).*

Steps of Bat algorithm:

1. Objective function $f(x)$, x=(x1 ... xn) T
2. Initialize the bat population xí= (í =1,2,3…d) and ví
3. Define Pulse frequency fí at xí
4. Initialize the rates rí and the
5. loudness Aí
6. While (t < Max number of iterations)
7. Generate new solutions by adjusting frequency and updating

velocities and locations/solutions

fi = fmin + (fmax-fmin) β,

vit+1 =vit+ (xit – x*) fi,

xit+1 = xit + vit,

8. If (rand > rí)
9. Select a solution among the best solutions
10. Generate a local solution around the selected best solution
11. End if
12. Generate a new solution by flying randomly
13. If (rand < Aí & f(xí) < f(x*))
14. Accept the new solutions
15. Increase rí and reduce Aí
16. End if
17. Rank the bats and find the current best x*
18. End while
19. Post process results and visualization

Simulation Results and Analysis:

In this section we are presented various results that explore the relationship between various WSN parameters and the network lifetime. In this section all simulation results are derived using MATLAB. The simulations assume the radio characteristics mentioned in table I. in table 2 assume to the bat parameters for simulations values. We have defined the homogeneous sensor network with 150 number of sensor nodes.

Table 1: Simulation Parameters.

Parameter	Value
Number of nodes	150
Network size	100m x 100m
Data packet size	100 bytes
Node deployment	Random
Network Type	1 Mbps
Radio speed	Homogeneous
Initial energy	2J/battery
Control packet Size	25 bytes

Table 2: Bat swarm algorithm parameters.

Parameter	Value
Population size	Number of nodes
Number of generations	100
Loudness	0.5
Pulse rate	0.4
Minimum frequency	0
Maximum frequency	1

The Fig 1 represents the wsn it traces the number of received packets to the base station node increasing number of these packets over the rounds in the efficiency optimization of network lifetime it should be increased.

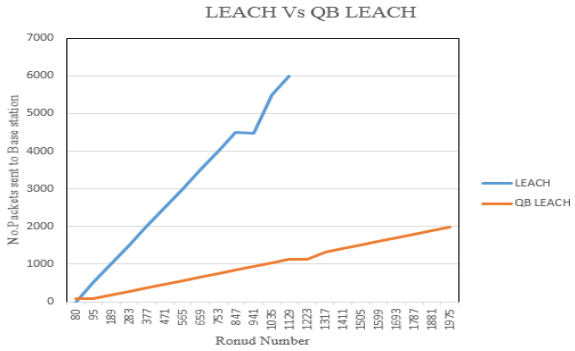

Fig. 1: No.of packets sent to BS Vs. No.of. Rounds.

The Fig 2. Represents the network lifetime by showing number of dead nodes respected to number of rounds. That nodes die out in LEACH quickly and in early rounds most of nodes die while the first node of the QB LEACH dies in latter rounds .death of first node this measures the start of the WSN coverage reliability degradation. The QB leach is efficiency and scalability of WSN.

Fig 3 the bat swarm technique for leach and QB leach wsn for sum of energy across to the all the rounds. The QB leach is reached global maximization of WSN lifetime based on applying optimal selection of CH nodes which effectively preserve the global energy.

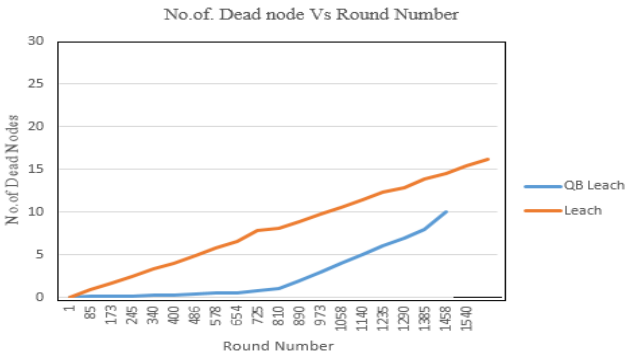

Fig. 2: Number of dead nodes vs. No.of rounds.

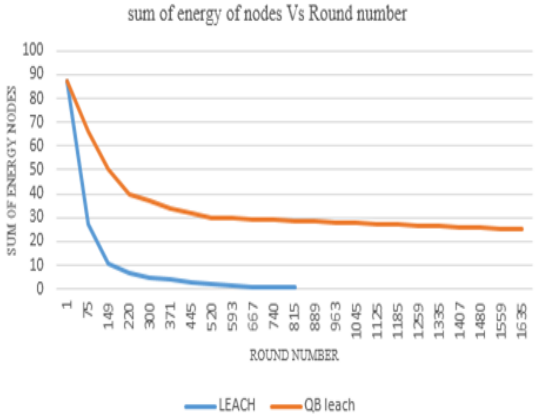

Fig. 3: Sum of energy nodes vs. No.of rounds.

The QB-LEACH ensures the packet delivery through the restricted flooding or through LEACH procedures. Hence the packet delivery ratio in QB-LEACH is comparatively best compared to the LEACH. The source and destination information is processed through the base station and provides immediate vertices formation followed by restricted flooding.

Conclusion:

In this Research paper Bat optimized algorithm Improved LEACH protocol, which provides Prolong network Life time. Also QB-LEACH gives very much improvement in Packet sent to the Base station and other. And also total energy consumption of the network is very much reduced than LEACH & QB LEACH. Thus QB-LEACH gives network stability and prolongs the lifetime of the network. The experimental results show how the QB-LEACH is superior to LEACH. Thus by the utilization of QB-LEACH protocol the network lifetime is enhanced in an organized way by effective utility of the available limited energy consumption.

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