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Wireless Sensor Network Design by using Energy Aware Artificial Bee Colony and Duty Cycled Sleep Scheduling Algorithm

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Abstract: ***Wireless Sensor Networks helps in disaster management system to learn about the phenomena of natural disaster and providing the information to make early warning. This work proposed energy aware clustering using artificial bee colony and duty cycled sleep scheduling algorithm (EASSABC) to develop wireless sensor network for landslide forecasting. In EASSABC Clustering formation and cluster head selection is determined according to the residual energy of the node for strong connectivity and nodes in the cluster are duty cycled to sleep or wakeup to improve the node life time. Network performance parameters such as packet received rate, node residual energy, throughput, end to end delay and loss rate were analyzed***
Keywords: WSN for landslide forecasting, Energy aware clustering, artificial bee colony, sleep scheduling algorithms

I. INTRODUCTION

The requirements for the long term environmental monitoring applications are long life time, low cost, large number of sensors and high quality of service. These specifications are consider for the design of wireless sensor network (WSN) for wide range of environmental monitoring[1],[2].

WSN technology widely used for many applications, particularly in the disaster management kind of applications and need to provide timely and valid information about the field during environmental monitoring. Failures of the sensing device are highly possible for during the emergency periods. Therefore in this scenario connectivity of the network is one of the critical issues to ensure accurate monitoring.[3]

Network discovery playing the vital role in the disaster predictions, for the disaster relief operation structure less network deployment is required to adapt the changing environment due to the disaster occurrence. However for the ad hoc routing protocols are developed to maintain strong connectivity[4]. In this ad-hoc network management protocol and services respectively is used to manage the network, Low Power Mode algorithm (LMP) and power-aware routing (PAR) are implemented in the dynamic source routing (DSR) protocol to analysis the performance[5]. Various types of ad hoc routing protocols are available such that AODV, DSR, DSDV, TORA, among that DSR uses source routing instead of hop-by-hop routing therefore it discover the route by the packets which contains the source information. Periodic advertisements of the route discover is not required. Packet delivery ration is high than other protocols[6],[7] . Honey bee colony routing algorithm is developed from the honey bees forage behavior and it as strong connectivity and strong network life time[8][9].

Hop based energy aware routing to improve the network life time by taking the relationship between hop number and energy consumption between the nodes. Hop number is selected for the transmission by considering the distance threshold between the nodes to base station[10].

II. RELATED WORK

Huadong Wang et al. (2016) proposed an efficient and reliable clustering algorithm based on swarm based quantum artificial bee colony (QABC) approach. In the view of this approach, energy conception of the network is reduced by load balancing analysis and results are compared with the LEACH and HEED algorithms. 1000 network polling times increased in this proposed algorithm than LEACH and HEED and network reliability is improved without considering node energy and position[11].

Energy aware clustering and data transmission of an individual node makes the network to be prolonged. The cluster head selection is depending on the residual energy of a node and average energy of nodes in the cluster. The cluster head selection process is keep on changing according to the residual energy condition of the cluster head [12].

Duty cycled sleep scheduling geographical routing algorithm makes network connection and conserve node residual energy. However two concepts, Geographic- distance based connected-k neighborhood for first path (GCK- NF) sleep scheduling algorithm and geographic-distance based connected-k neighborhood for all paths (GCKNA) sleep scheduling algorithm in duty cycle sensor network are proposed to make the topology depends on the active and sleep nodes[13].

III. PROPOSED WORK

This work proposes a reference network model for landslide forecasting application using Swarm based artificial bee colony energy aware clustering, duty cycled active/sleep geographical routing algorithm.

A. Energy Aware Routing

In landslide disaster condition the objective of the sensor network is to identify the threshold values of landslide trigging factors and send the information with minimum delay to give the warning, in this kind of applications strong connectivity of the network should be ensured. Artificial bee colony algorithm is implemented in dynamic source routing to achieve strong connectivity, data transfer with minimum delay, packet loss and to optimize the network life period.

Swarm intelligence is a division of bio-inspired algorithm is used insects behavior in scientific problems for optimization. Artificial Bee Colony (ABC) belongs to the swarm intelligence algorithm it adapt the foraging behavior of honey bees for the optimization technique. Handling of huge amount of data from the sensor network is required for the landslide forecasting application. Therefore maintain its accuracy and reliability and ensuring minimum delay during the transmission of the sensed data with efficient utilization of energy[2].ABC algorithm is adapts changing conditions in the environment and able to take an action when needed by self-organization, by implementing this ABC algorithm in WSN to solve the complex problems like topology problems, energy optimization and improve network life time[14]. In the ABC model, the colony consists of three groups of bees: employed bees, onlookers and scouts. While this may be a correct math model, it neglects the male drone population. It is assumed that there is only one artificial employed bee for each food source. Employed bees go to their food source and come back to hive and dance on this area. The employed bee whose food source has been abandoned becomes a scout and starts to search for finding a new food source. Onlookers watch the dances of employed bees and choose food sources depending on dances.

The ABC initially create a randomly distributed swarm group size denoted as N, the i^{th} location of the food source is given as $A_i = \{A_{i1}. A_{i2}\ldots A_{in}\}$, each employed bee A_i generates new candidate solution V_i in the neighborhood of its present position $V_{ik} = A_{ik} + \varphi_{ik}(A_{ik} - A_{jk})$. Where, $A_i \neq A_j$ K: {1, 2, 3……n} number of employed bees φ_{ik}: Random number [-1,+1] A_j: Randomly selected food source. If the fitness value of V_i is better than A_i, then A_i is updated with V_i, otherwise A_i keep unchanged. A greedy selection mechanism is employed as a selection operation between the old and the current food source.

In a network, cluster head (CH) uses more energy than the other nodes. The network performance gets affected when the energy of the CH decrease. To conquer this problem the CH remain changing in a cluster based upon its residual energy. An onlooker bees select the food source depending upon its probability value is given in Eq.(1), energy consideration of the node given in (2) and the fitness value is evaluated by the Eq. (3).

$$P_i = \frac{fit_i}{\sum_{n=1}^{N} fit_n} \quad (1)$$

$$E_j \geq \left(n_j E^{R_x} + E^{T_x}\right) \quad (2)$$

Fitness of the food source given in the Eq. (3)

$$fit_i = \sum_j^m (\sum_i^{n_j} D_{ij}^2 + B_j^2) \quad (3)$$

energy consumption model is adapted from author [10]

E_{tx} is amount of energy to transmit a k-bit message

$$E_{Tx}(k,d) = \begin{cases} kE_{elec} + k\,\varepsilon_{fs} d^2, & \text{if } d < d_0 \\ kE_{elec} + k\,\varepsilon_{mp}\, d^4, & \text{if } d \geq d_0 \end{cases} \quad (4)$$

E_{Rx} is amount of energy to receive message

$$E_{Rx}(k) = k\,E_{elec} \quad (5)$$

E_{fx} is the amount of energy to forward the message

$$E_{Fx}(k,d) = E_{Tx}(k,d) + E_{Rx}(k) \begin{cases} 2kE_{elec} + k\,\varepsilon_{fs} d^2, & \text{if } d < d_0 \\ 2kE_{elec} + k\,\varepsilon_{mp}\, d^4, & \text{if } d \geq d_0 \end{cases} \quad (6)$$

Where, E_{elec} is Energy dissipation rate to run radio in 50 nJ/bit, ε_{fs} is Free space model of transmitter amplifier in 10 pJ/bit/m^2, ε_{mp} is multi-path model of transmitter amplifier in 0.0013 pJ/bit/m^4, k is packet size 450 bits, d - source-sink distance is in meters, d_0 -

distance threshold is $\sqrt{\varepsilon_{fs}/\varepsilon_{mp}}$ meters, Direct transmission is taken place when $d<d_o$ and d will be divided into several d_i when $d>d_o$. BS will choose its neighbours with distance $d_i \in (d/n, d/n+\Delta)$ as the next hop candidates, where n is the hop number [10].

B. Cluster head selection

Step1: Generate initial population $A_i = \{A_{i1}, A_{i2} \ldots A_{in}\}$,

Step2: Evaluate the population

For each employed bee

Step3: produce new solution V_i by $V_{ik} = A_{ik} + \varphi_{ik}(A_{ik} - A_{jk})$,

Step4: calculate the fitness by (2),

Step5: Apply greedy selection process,

Step6: Repeat step 2 to 5 until maximum number of cycle is reached.

Each sensor node transmits its sensed data to the base station via cluster head periodically. Base station continuously monitors the energy of the cluster head. If the energy of the cluster head becomes lower than its members then base station reelect the cluster head from its members by using Cluster head selection method until requirements are met.

Therefore from equation (2) and (3) the node which is containing highest energy and minimum distance from the Sink node is selected as the CH from the network. Initially the employee node in the network search for the cluster head and form a cluster when the cluster head residual energy is less than the residual energy of employee node it again starts is reclustering process. All nodes in the cluster having the probability to be a cluster head.

C. Geographical Routing based Sleep/Wake Scheduling

Sensors in the network are sleep scheduled to reduce energy consumption, duty cycled sleep scheduling based on geographical routing is adapted [13] . A subset of nodes is being awake in a given period of time while the remaining nodes are in the sleep state. At least k neighbors (k-connected) remain awake for a node to go sleep in the subset. Let R*u* be the set of these ranks, it broadcast R*u* and receive R*v* from each $v \in N_u$. If $|N_u| < k$ or $|N_v| < k$ for any $v \in N_u$, node *u* remain awake were N*u* currently awake neighbor. The node could change the state depending upon the requirement and the shortest routing path of a node for multipath transmission is identified.

IV. RESULT AND DISCUSSION

The evaluation of the proposed EASSABC network protocol scheme is experimented with in Dynamic Source Routing (DSR) by using the network simulator Ns-2. The details of the network scenario are shown in the Table. 1. The cluster formation of the network is take place by the concept of swarm based bee colony technique. In this the selection of cluster head should satisfy the two conditions, that are the node should have the high residual energy than the other nodes in the cluster and the distance between the cluster head and sink node should be minimum than the other nodes.

A. Experiment Setup

The main aspect for the simulation is the total energy consumption of the network, delay, throughput, packet delivery rate, packet loss rate.

Simulation Parameter	Value
Simulation area	800×800m
Number of nodes	41
Simulation Time	50 s
Packet Size	512bytes
Initial Energy	0.5 J
Communication protocol	User Datagram Protocol (UDP)
Traffic Model	Constant Bit Rate (CBR)
Propagation model	Two ray ground
Antenna Type	Omni Antenna
MAC type	IEEE 802.11
Communication Range	150m

Table.1 Evaluation Setup

The cluster formation and head selection is shown in the figure. 1. The every node in the network are scheduled by the sleep/awake algorithm was shown in Figure 2. In this, subset of nodes are selected to be awake in a given time period by random duty cycle sleep scheduling approach while remaining nodes are in the sleep mode. This will reduce the power consumption and the overall energy consumption to be reduced.

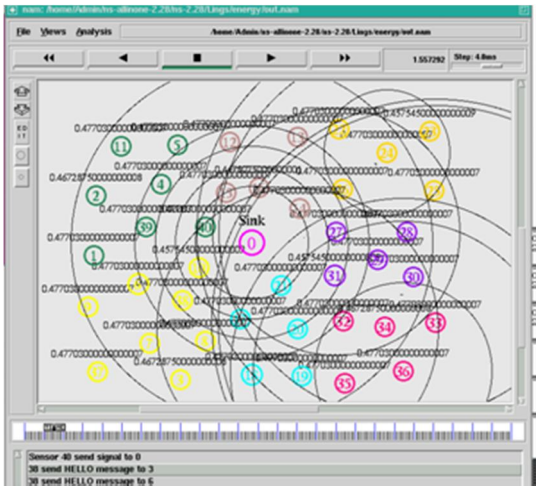

Figure 1: Energy Aware Cluster Head Selection

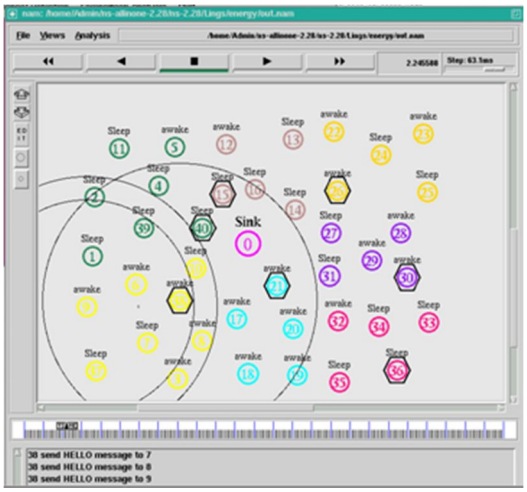

Figure 2: Sleep Scheduling In Eassabc

B. Performance Analysis

The proposed EASSABC algorithm is compared with the QABC algorithm [11], the node average residual energy is increased into 12%, throughput is also improved into 30.9%, packet loss rate is reduced into 62.68% and end to end delay also reduced into 52.9% The network performance is shown in the table.4 and the comparative analysis of the EASSABC algorithm is shown in the figure.3.

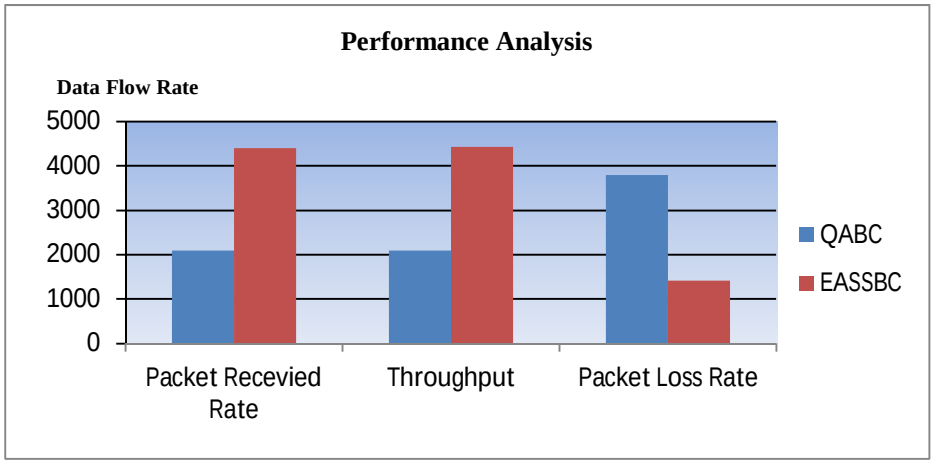

Fig.3. Performance Analysis

V. CONCLUSION

With the consideration of sensor node residual energy and duty cycled sleep/awake theory an Energy efficient swarm based clustering algorithm is applied into DSR protocol to optimize the network routing and to improve the network efficiency and reliability, which increase the network life time. Cluster formation and cluster head selection of the network by EASSBC is analyzed and the node average residual energy is increased into 12%. Therefore the node dead ratio could reduced and it makes the nodes be connected.

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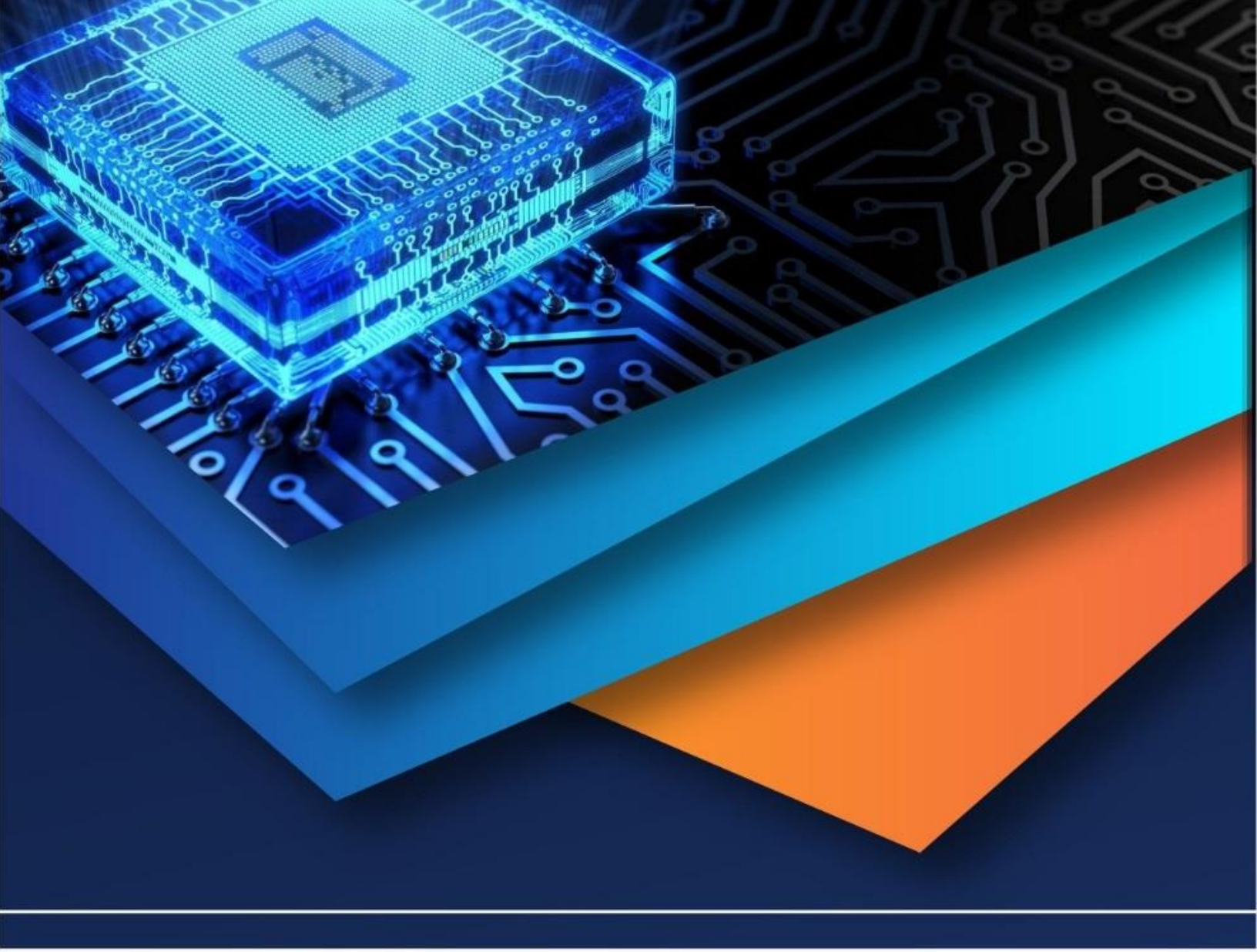

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