ISSN (ONLINE): 2395-695X
ISSN (PRINT): 2395-695X

International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)
Vol. 2, Issue 8, August 2016

Ant Colony Optimization (ACO) Based Distributed Algorithm for Maximizing Life Time of Wireless Sensor Networks

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Abstract:

Wireless sensor network (WSN) consist of large number of sensor nodes with limited energy computational capability. It consists of three main components sensor nodes, gateway and base station (BS). Sensed information in sensors is transmitted to the base station using distributed routing. Power Aware Scheduling and Clustering algorithm based on Ant Colony Optimization (PASC-ACO) is the technique used to find the optimum path for transmitting the sensed data to BS. Residual energy, distance and pheromone are the parameters used to find the probability to select the optimum path.In our proposed system we are combining the node rotation concept with PASC-ACO for increasing the network life time.

Keywords—Wireless sensor networks, routing, ant colony optimization, energy consumption,clustering, scheduling.

I. INTRODUCTION:

Wireless Sensor Network (WSN) consists of number of sensors for computing the changes in the physical environmental conditions. A WSN is basically composed of a sink and several sensor nodes distributed over a certain geographical area. Sensor nodes monitor the environment collect information such as temperature, humidity, pressure, vibration, sound and so on. Each node in a WSN report the information it gathered to the base station directly or through multi hop wireless communication link[1].

Typically, sensor nodes are energy constrained, since rely on batteries asenergy source. Due to energy constraints, the life time of a WSN is also limited.Because of the nature of the applications in which WSNs are used, it is usually verydifficult to reach every node and replace their batteries.Therefore, to minimize the energy consumption in each node and prolong thelife time of the network, several methods have been proposed such as power efficientcomponents, energy aware protocols etc.

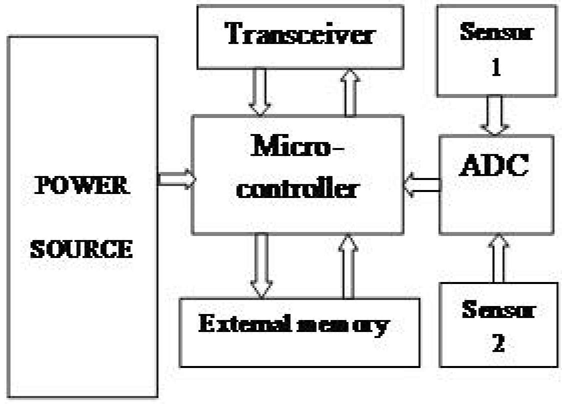

Fig 1: Components of sensor network

Figure 1 shows the main building blocks of a sensor node and their interactions. Sensor nodes monitor changes in the environment using their sensors.The components of a sensor node have various operation modes. Theprocessor can be either in active, idle or sleep mode. The sensors can operateeither in active or sleep mode. The transceiver can be either transmitting, listening, oroff .Each combination of these devices operational mode characterizes different states.Based on these components operation mode combination, sensor nodes mode ofoperation can be broadly categorized into four; active, listen, sense and sleep.

Diagnosis, refinement and data collection are the main activities of a sensor node, which causes energy depletion [2].Data communication accounts for consumingmost of the energy stored in the battery, but the energy consumed in sensing andprocessing cannot be neglected as well.

Challenging issues in WSN are scalability, reliability, lifetime, congestion, security etc. Comparing these issues lifetime is an important issue.To avoid this problem many techniques are available duty cycling, datareduction, topology control and controlled mobility. Comparing to these technique distributed algorithm gives good result.

Centralized network routing is default; if anyone of the node get fails then total network is collapsed [3].so that validity of the network is increased using the distributed network .Routing is formed during the data transmission only it will not be a permanent routing. Advantage of distributed network is sensor nodes are prone to failure, better collection of data; provide nodes with backup in case of failure of the central node.

In [9] authors,have proposed traditional wakeup scheduling, sensor nodes startup numerous times to communicate in a period, thus consuming extra energy due tostate transitions. To avoid that author have proposed that node wake up only once for transmitting as well as receiving the data.

In [17], authors have proposed a secure energy-efficient data aggregationprotocol called ESPDA (Energy-Efficient Secure Pattern based Data Aggregation). Data aggregation in wireless

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sensor networks eliminates redundancy to improve bandwidth utilization and energy-efficiency of sensor nodes. If sensor nodes sense the same data, ESPDA first putsall but one of them into sleep mode and generate pattern codes to represent thecharacteristics of data sensed by sensor nodes. Due to the use ofpattern codes, cluster heads do not need to know the sensor data to perform dataaggregation, which allows sensor nodes to establish secure end-to-end communication.

II.PROPOSED ALGORITHM

In order to avoid redundancy and increasing the network life time node rotation is combined with PASC-ACO algorithm. It has two phases:

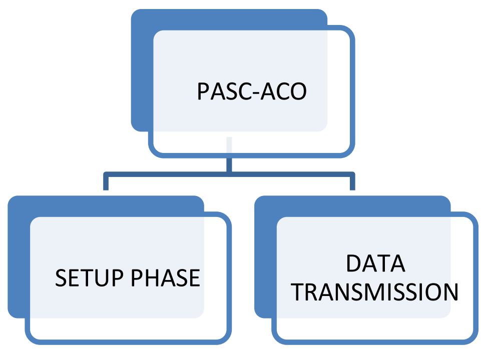

Fig 2: Classification of PASC_ACO

A.SETUP PHASE:

In setup phase two processes are there, one is cluster formation and another one is cluster head election. Cluster is formed using region based clustering .Hybrid energy efficient distributed (HEED) is a protocol used to select the cluster head based on the residual energy. If suppose cluster head energy is less than any one of the child nodes residual energy then that child node become a cluster head.

TDMA schedule will be setup by the CH,based on the cluster member's residual energy . Setup phase is completed and data communication phase is started, after all the nodes know the TDMA schedule.

B.DATA TRANSMISSION PHASE:

There are multiple paths between the source and the destination. The path between the source and the destination is graded and ready to be used in case of failure of the best path .The path information are collected using the (Forward Ant) FAs. Using those information paths from source to the destination is selected. Data structures of FA can be as shown in Table 1.

TABLE 1: Structure of forward ant

S
D
RID
ttl
Cluster ID
Node Type
recvNodeList

•**S-**source address;

•**D-**destination address;

• RID-request ID;

• **ttl-** time to live. The forward ant (FA) is forwarded, ttl value is decremented, and the FA message is discarded if ttl is decreased to zero before the destination is found.

• Cluster ID represents the ID of the cluster.

• Node Type records whether the node is a cluster head or an ordinary node. The rectangle area of Searched Area is decided by cluster ID of the source and destination nodes.

•**recvNodeList-** it contain list of cluster head ID that have already receive the packet. Using broadcast mechanism Packets are receive by all the nodes .the receiving node will check its own ID whether it is in recvNodeList or not. If it so then the node will not broadcast the packet ultimately it will drops it.If suppose the node not in the recvNodeList it will forward the packet to its neighbor. The forwarding node will check the neighbor nodes are in the recvNodeList.If this affirmative, the node will not broadcast the packet simply it will drop the packet. Redundant transmission in flooding is reduced due to this process

The new routes created with help of the FAs and BAs.FAs will search the usable paths using flooding process and the BAs used for routing development phase .Ant will deposit pheromone on the path when it walk on it .pheromone will decrease due to the diffusion .depends on the amount of pheromone deposited The probability of ants backing source to choosing a path back to the source. The larger the amount of pheromone is achieved threw more ants visit.

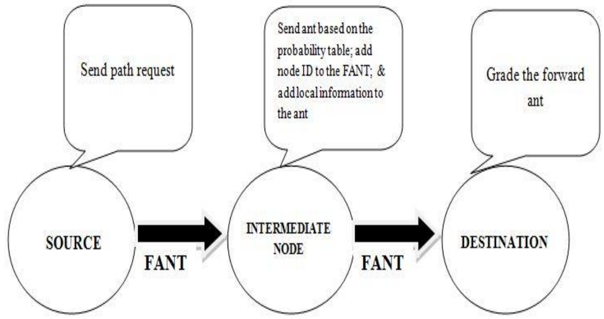

Fig 3: FORWARD ANT

Fig 3 shows that source node will send the path request; it will forward throw the intermediate nodes. Depend upon the probability value it will choose the path to reach the destination.

Initially routing information will not be available at that time suppose that host S wants to communicate with destination host D means ;it will send FA's to collect the routing information's. Control flooding is the process when an ordinary node receives an FA packet, it will discard the FA. When a cluster head receives an FA packet, it will first check whether the packet is within the cluster area defined by the range. If the received packet is not within its range the cluster head simply ignores this packet. Otherwise, the cluster head rebroadcasts the packet using control flooding.

Due to the flooding, ants can proliferate quickly over the network, following different paths to the destination. When an intermediate node receives several ants of the same generation, it will compare the previously received ant’s path traveled by each ant to that of this generation: only the path, which has minimum Sum of Link Cost, is selected, where Sum of Link Cost represents the sum of a link cost from the source to the current cluster head. Ant will forward after this process.Due to this policy, the overhead is limited. However, since only local minimum Sum of Link Cost paths are selected, other good paths are possibly rejected.

If pheromone information is available for d, the ant willchoose its next hop n with the probability P_{nd}:

$$\frac{\boldsymbol{P_{nd}} = \left[\boldsymbol{T^{i}_{nd}(t)}\right]^{\alpha}\ \left[{}^{\mathrm{n}}\boldsymbol{{}_{in}(t)}\right]^{\beta}}{\sum \boldsymbol{j} \rightarrow \boldsymbol{N^{i}_{d}}\left[\boldsymbol{T^{i}_{jd}(t)}\right]^{\alpha}\ \left[{}^{\mathrm{n}}\boldsymbol{{}_{ij}(t)}\right]^{\beta}} \qquad \textbf{(1)}$$

Where,

T^{i}_{nd} - The estimated of the pheromone value indicating going from i over neighbor n to reach destination d.

N_d^i - The set of neighbors of i over which a path to d is known, and

η_{ij}- The local heuristic value of the link(i, j) between nodes i and j energy consumption. The link cost can be calculated in the following way:

$$\eta_{ij}=\textbf{Link cost (i,j)} \qquad \textbf{(2)}$$

Link cost between the node i and j is calculated using equation 3

$$\textbf{Link cost (i,j)}=e_{ij}^{\alpha}R_i^{\beta} \qquad \textbf{(3)}$$

From equation 3, LinkCost(i, j) is the cost metric between nodes i and j, e_{ij} is the energy used to transmit and receive on the link, while R_i is the residual energy at node i. The path with high residual energy, the minimum energy path or combination of both calculated using the weighting factors α and β. Sum of Link Cost represents the sum of a link cost from the source to the current cluster head.

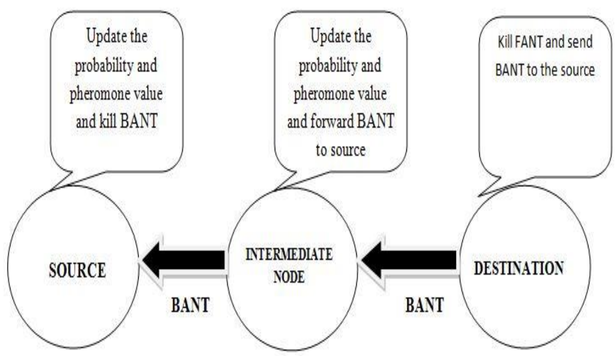

Fig 4: BACKWARD ANT

Fig 4 shows that When an FA reaches its destination, the information carried by this FA path will be graded .Then, the FA will be killed and a BA will be generated. A BA carries its corresponding FA's path grade and path's intermediate node ids and it will be sent back following the reverse path of its corresponding FA. The intermediate nodes modify their pheromone table based on the probability carried by the BA and accordingly update their probability routing tables while the BA moves in the reverse path. The source node receives the BA and finally updates its tables, and kills it. A data structure of BA can be as shown in Table 2.

TABLE 2: Structure of BA

S
D
RID
Reverse_ recvNodeList
Cluster ID
Node Type
Searched area
Path Grade

III.PERFORMANCE EVALUATION

The performance of the proposed system is evaluated using Ns2(Network simulator 2).The simulation parameter for this analysis is represent below:

The area taken for this process is 600m*600m.Totaly 100 nodes are used for the simulation .Nodes are all in the same transmission range .Drop tail queue is used and the queue size is 50.The type of propogation model used for the proposed system is two ray propogation model.Simulation results are compared with exsisting distributed algorithm .Cluster based routing protocol was used to discover the routing between the source and destination. The existing algorthm also having the same topology .

In exisisting method cluster formation is based on the region based clustering and cluster head election in done using Hybrid Energy Efficient Distributed algorithm (HEED).Routing protocal used for this concept is cluster based routing protocol (CBRP).In this process performance achivement is improved by combining the ACO.

The simultion network contaions 100 nodes eith 500 joules as initial energy for all the nodes ,in the distributed manner .Node will have the same transmission enrgyand they are distributed randomly .

The PASC-ACO algorithm is compared with existing system based on the following parameters:

- Life time improvement ratio-The reason life time represent in the ratio is the life time is measured as ratio between the lifetime of the network after applying the algorithm and lifetime without any algorithm to the network.
- Throughput-throughput is a parameter measured the ratio of successfully received packet to total number of transmitted packet.
- Packet drop-the difference between the total number of packet send to the destination to the number of packet received at the destination
- Delay-this parameter is depends upon the simulation time. It is measured by the difference between the starting simulations to the end of simulation.
- Energy consumption-amount of energy consumed by the transmission is consumed energy

These are the parameters used for the comparing the existing systems.

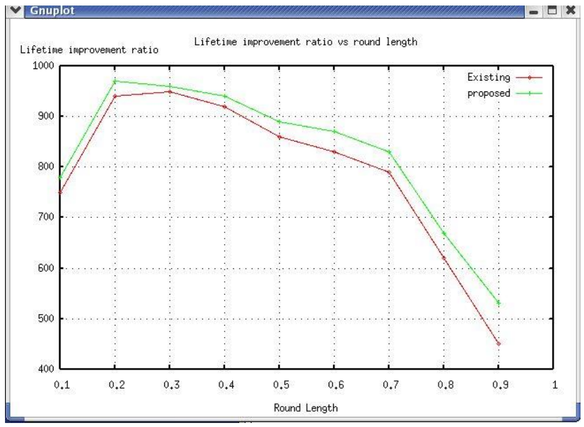

Fig 5: Life time improvement ratio vs. round length

In Fig 5 graph is plotted between the lifetime improvement ratio and round length. Lifetime improvement ratio of the PASC_ACO is compared with the existing distributed system. The result shows that the proposed system lifetime is high when we compare it to the existing system. Lifetime is increased with increasing the number of nodes.

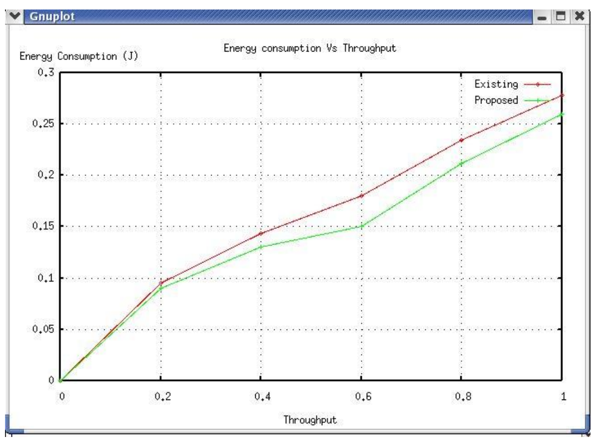

Fig 5: Energy consumptionVs.Throughput

Fig 5 illustrates the graph that is plot between the energy consumption and throughput. Energy is consumed for the data transmission. Throughput is increasing with increasing the energy consumption. Comparing to the existing system proposed method consume less energy .From this it is clearly proved when there is energy consumption is less then automatically life time will be increased .

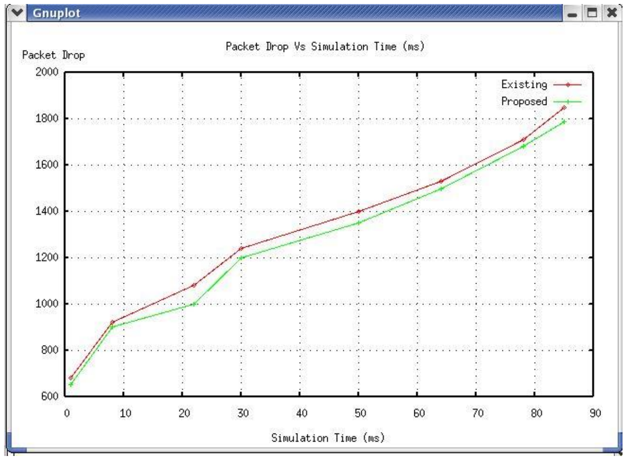

Fig 6: Packet drop Vs. Simulation Time

Fig 6 illustratesthe graph that is plotted between the packet drop and simulation time. Packet drop is high in the existing system where in the proposed system it is less. When packet loss is less then accuracy of information received in the base station will be more.

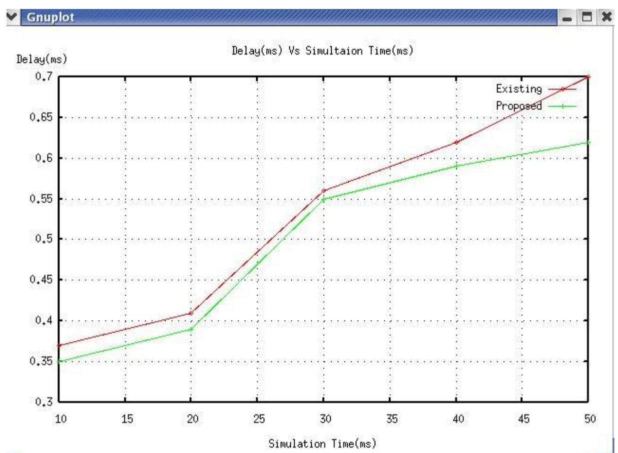

Fig 7: Delay Vs. Simulation time

Fig 7 illustrates the graph that is plotted between the delay and simulation time .Delay in proposed system is less compare to the existing system. From the graph we can understand that, when the simulation time is 45 delay of existing system is 0.67 where is in proposed system it is 0.6

TABLE 3:Comparison Table

PARAMETERS	DISTRIBUTED ALGORITHM	PASC-ACO
LIFE TIME IMPROVEMENT RATIO	850	900
ENERGY CONSUMPTION	0.19 J/S	0.15 J/S
PACKET DROP	1200	1000
DELAY	0.41	0.37

IV.CONCLUSION

The challenging issue in WSN isfinding optimal path in a dynamic changing environment. The main goal of the proposed system is increasing the life time of WSN. Transmitting the redundant data to the base station will waste the energy of the network. So that lifetime of the network will be reduced. To avoid this proposed method combines the clustering approach with the ant colony approaches.

Cluster head will combine the cluster member's sensed data. During the collection of data the redundant data will be avoided so that time will be increased. Ant colony approach will find the best path between the source and the destination. So that lifetime will be increased .Another advantage of this approach is it will have the list of graded path .If suppose the best path get failure means it will select the next path for the transmission.

The proposed system combines theclustering and ant colony system so that lifetime is increased.

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