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A Collaborative Approach Based On Ant Colony Algorithm for Data Aggregation in Wireless Sensor Networks

R.Renganayaki[1], Dr.K.Vimala Devi[2]

P.G.Scholar, Department of CSE, PSR Engineering College, Sivakasi-626140, Tamilnadu, India[1]

Professor, Department of CSE, PSR Engineering College, Sivakasi-626140, Tamilnadu, India[2]

ABSTRACT: Wireless sensor networks are energy constrained devices. In a large sensor network, data aggregation significantly reduces the amount of communication and energy consumption. To balance the energy consumption and to prolong the network life time a family of ant colony algorithm for data aggregation is proposed. DAACA consists of three phases: 1) initialization 2) packet transmission 3) operation on pheromones. It has four different pheromone adjustment strategies. Basic-DAACA selects the route based on distance between nodes and ES-DAACA selects the route based on distance and energy consumption to send the packet. MM-DAACA includes both the features in above algorithm and also set the range to select the route. Finally the ACS-DAACA includes all the above features and also capability to deliver the packet to the destination without ant data loss and as soon as possible. It also utilizes the minimum number of nodes on the path to reach the destination. In ACS-DAACA, the additional enhancement of node's link level is also considered before selecting the optimal route. This can be done by using fuzzy sets.

KEYWORDS: Data Aggregation, DAACA, ES-DAACA, MM-DAACA, ACS-DAACA, Fuzzy sets

I. INTRODUCTION

The main task of wireless sensor network (WSN) is to detect and report the events of the physical world. In most cases, nodes are battery powered with limited energy resources. Suppose that when a node runs out of power and stops working, the original transmission paths will be changed. Nodes nearby will suffer from heavier work, because of sharing responsibility of the exhausted node which casts heavy burden of them. The energy dissipating rate of these nodes will become faster. This process spreads which will cause the packets loss or even network congestion. Moreover, the performance of the network depends on the persistence of the sensors to a large extent. Hence, the main challenge for the energy-constrained network is to design energy-efficient routing protocols which guarantees the persistence and balances the energy consumption of the network.

In recent years, methods of data aggregation are attracting the attentions of the researchers. A large number of works of data aggregation protocols in wireless sensor networks for energy preservation have been published. To begin with, we will provide a brief background of the data aggregation methods of WSN. The key idea is to combine the data coming from different sources which eliminates redundancy, minimizes the number of transmissions and thus saves energy. This method shifts the focus from the traditional address centric approaches for networking to a data centric approach.

Some existing methods utilize the Minimum Spanning Tree by implementing Prim's algorithm to construct and maintain the data aggregation tree in network topology. This algorithm consumes high energy to obtain the local information about the nodes in the network. So this not considered as much energy efficient algorithm. The drawbacks of existing systems are:

1. The energy consumptions of constructing and maintaining network topologies are high.

2. Issues of balancing energy consumption are not considered.

The ant colony optimization (ACO) is one of the most useful swarm intelligence which has been successfully applied in many optimization problems such as TSP, CVRP, Assignment Problem, Set Problems as well as routing in wireless sensor networks. This algorithm also consumes more power in case of pheromone concentration calculation. To eliminate this drawback it can be combined with data aggregation method, which will help us to save the battery power and to choose the best optimal path in the network topology.

II. LITERATURE SURVEY

A lot of research work is done in wireless sensor networks to reduce the energy consumption and to prolong the network life time.

- In the work [1], presents a new Wireless Sensor Network routing protocol, which is based on the Ant Colony Optimization Meta heuristic. The protocol was studied by simulation for several Wireless Sensor Network scenarios. It minimizes communication load and maximizes energy savings.

- In the work [2], describes many potential power sources for wireless sensor nodes. Well established power sources, such as batteries, are reviewed along with emerging technologies and currently untapped sources. Here the batteries create a substantial roadblock to the widespread deployment of wireless sensor networks because the replacement of batteries is cost prohibitive. But the main limitation in this paper is no single alternative power source will solve the problem for all or even a large majority of cases.

- In the work [3], propose a centralized routing protocol called Base-station controlled Dynamic Clustering Protocol (BCDCP), which distributes the energy dissipation evenly among all sensor nodes to improve network lifetime and average energy savings. The advantage of BCDCP reduces overall energy consumption and improves network lifetime. The drawback is the performance gain of BCDCP over the other clustering-based protocols decreases as the sensor field area becomes small.

- In the work [4], a protocol, HEED (Hybrid Energy-Efficient Distributed clustering) is proposed. That periodically selects cluster heads according to a hybrid of the node residual energy and a secondary parameter, such as node proximity to its neighbors or node degree. The advantages are: HEED prolongs network lifetime and increases scalability, fault tolerance, load balancing and the clusters it produces exhibit several appealing characteristics. It is limited only for two tier hierarchy.

- In the work [5], says that Data aggregation is an essential paradigm for energy efficient routing in energy constraint wireless sensor networks. The complexity of optimal data aggregation is NPhard. Optimal aggregation saves the energy upto 45% for moderate number of source nodes.

III. PROPOSED SYSTEM

3.1OBJECTIVE

The main objective of this work is

- To reduce the energy consumption in wireless sensor networks and

- To prolong the life time of the nodes in the network topology.

In this work expanded the ant colony algorithms by proposing a family of energy-efficient Data Aggregation Ant Colony Algorithms (DAACA), which is based on Basic-DAACA (Basic algorithm of DAACA), ES-DAACA

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(Elitist Strategy based DAACA), MM-DAACA (Max–Min based DAACA) and ACS-DAACA (Ant Colony System based DAACA). DAACA include three phases: 1) the initialization, 2) packets transmissions and 3) operations on pheromones. Initially, all the sensors are deployed at random they set up their routing tables in a self-organization manner. Each node is considered as an artificial ant which is raised in ant colony optimization for solving the global optimization problem. The packets transmitted between nodes are considered as tools for updating or adjusting the pheromones. Each node estimates the remaining energy and the amount of pheromones to compute the probabilities for dynamically selecting the next hop. After certain rounds of transmissions, the adjustments of pheromones are performed, which originally combine the advantages of global and local adjustments for evaporating or depositing the pheromones. Four different pheromones adjustment strategies are designed to achieve the global optimal in prolonging network lifetime.

The contributions of the paper can be summarized as follows:

1. Proposed a family of ant colony algorithms for data aggregation which aims at saving energy and prolonging network lifetime.
2. Devised the evaporating and the depositing pheromones approaches which take advantages of global and local merits.
3. Designed three heuristic methods (i.e. ES-DAACA, MM-DAACA, ACS-DAACA) for improving the performance of the basic algorithm (i.e. Basic-DAACA) which specialize the way of evaporating and depositing pheromones.
4. Developed a platform to compare the characteristics (e.g. average energy cost, network lifetime, average degree and so on) of DAACA family with other data aggregation methods (e.g. PEDAP, PEDAP-PA, L-PEDAP and so on).

IV. SYSTEM ARCHITECTURE

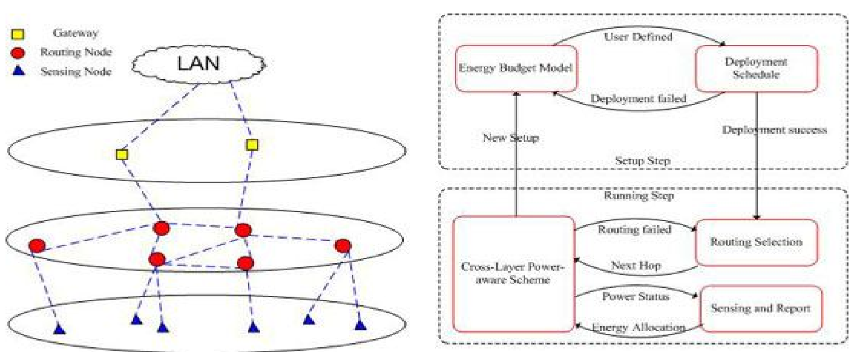

Fig. Components and Architecture of System

It contains various components of sensor devices and shows the routing strategy, deployment of nodes and next hop selection and path reestablishment at any stage on node failure.

4.1 DATA FLOW DIAGRAM

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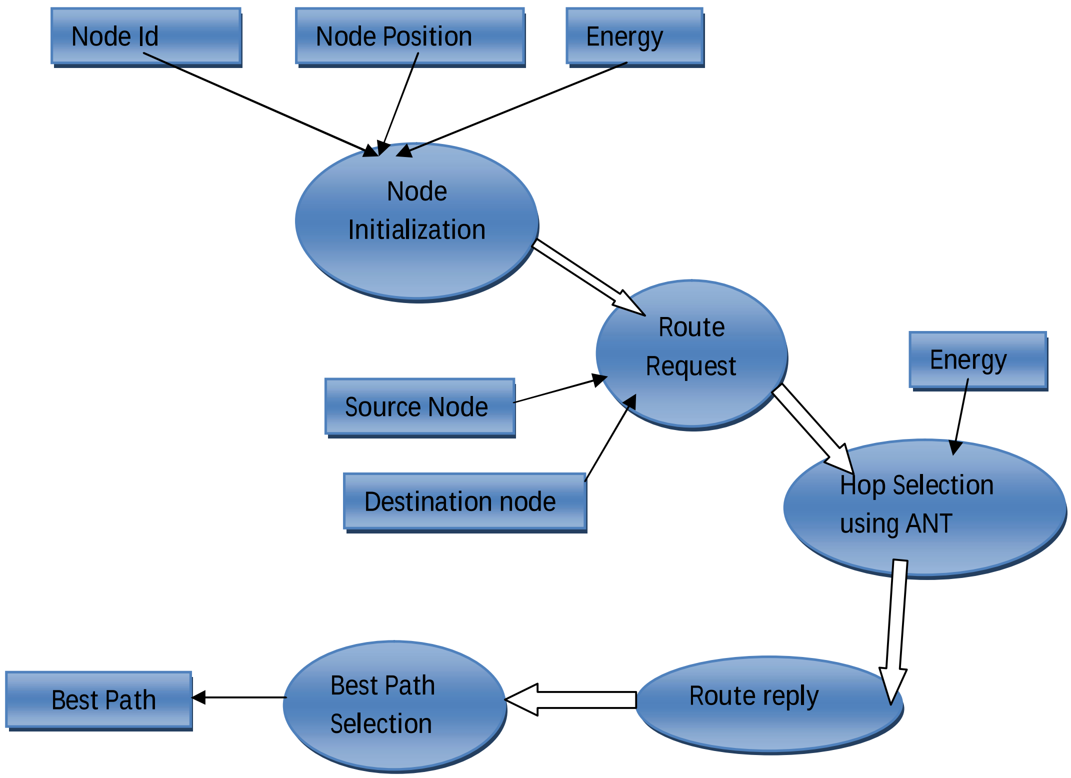

4.2MODULES DESCRIPTION

The proposed system contains the following five modules:

- Network Setup
- Path Traversal
- Pheromones Updation
- Pheromones Evaporation
- Optimal Route Procedure

4.2.1 Network Setup:

- Set up of nodes in the infrastructure involves a set of ordinary nodes, intermediate or relay nodes and a sink or destination node.
- Transmission infrastructure involves a source nodes to one definite destination or sink.
- Each node is labeled with the node name, its positioning in the network, energy and distance measure along with pheromone content.

4.2.2 Path Traversal:

- Traversal is set to begin at the source node and traverses through its consequent neighbors to the sink
- Each node estimates the remaining energy and distance between two nodes to compute the probabilities for dynamically selecting the next hop.
- select the next hop node:

$$pk(i, j) = \tau (i, j)\times\eta(i, j)\beta / \sum_{u\in Ni} \tau (i, u)\times\eta(i, u)\beta$$

τ (i, j)- pheromones level from node i to node j.

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η(i, j) -inverse of the hop count from node j to the sink node adding one.

Ni -number of neighbours of the node i .

4.2.3 Pheromones Updation:

- Pheromone is considered to be the balancing factor to prolong the network lifetime.
- Best optimal path in a network is identified by high pheromone concentration.
- Pheromone updation:

$$\tau_{xy} \leftarrow (1-\rho)\tau_{xy} + \sum_k \Delta\tau^k_{xy}$$

τ_{xy} - amount of pheromone deposited.

ρ - pheromone evaporation coefficient.

$\Delta\tau^k_{xy}$-amount of pheromone deposited by k th ant.

4.2.4 Pheromones Evaporation:

- Once the concentration along the traversal path reaches certain limiting range, in that case the pheromone concentration is reverted back to the original state.
- This is formulated to balance network load, thereby achieving energy optimization.
- When the round is equal to RoundtoUpdate ,the pheromone evaporation will start.

$$\eta(i, j) = (1 - \rho)\times\eta(i, j)$$

P-fraction of pheromones not evaporated.

4.2.5 Optimal Route Procedure:

- Regular procedure of pheromone deposition, updating and evaporation continues.
- Based on the frequency of pheromone updating, single optimal route is decided from multiple paths.

V. IMPLEMENTATION

5.1 Ant colony algorithms for data aggregation

The design of the system architecture starts with a basic algorithm, which is continued by three heuristic algorithms are proposed to enhance the performance of the basic algorithm. Since each algorithm in DAACA family has the same algorithm structure, the differences exist only in the process of evaporating and depositing pheromones. The algorithm structure of DAACA family is illustrated here and then it is explained in detail.

5.2 Basic-DAACA

Basic-DAACA is the basic algorithm of DAACA family. The pheromone is the most critical part in adjusting the probabilities in the routing table, the constitution of the routing table is illustrated.

5.2.1 Basic DAACA algorithm

1: Network Initialization
Node Initialization
Neighbour Initialization
Routing Table Initialization
2: The source node begin to send its data packets to the destination hop-by-hop.
3: for all t ∈ Nbr(s) do
4: s evaluates the energy of t.
5: s calculates p(s, t).
6: s selects the next hop node n based on p(s, t).
7: end for
8: s −→n // s sends the packets to n
9: while s _= d do
10: c =n
11: c aggregates data packets

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```
for all t ∈ Nbr(c) do
c evaluates the energy of t.
c calculates p(c, t).
c selects the next hop node n based on p(c, t).
end for
c −→n
end while
round = round +1
if round = roundToUpdate then
Evaporating Pheromones.
Depositing Pheromones.
Updating Routing Table.
Energy Broadcasting.
end if
```

VI. CONCLUSION AND FUTURE ENCHANCEMENTS

Compared with some other data aggregation algorithms, collaborative DAACA shows higher superiority on average degree of nodes, energy efficiency, prolonging the network lifetime, computation complexity and success ratio of one hop transmission. In future battery energy level ,distance between two nodes and Nodes Link Level also considered to select the best optimal path.

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