Path Optimization Using Ant Colony Based Multipath Routing Algorithm

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Abstract

Energy efficiency is always important in wireless sensor networks. In a sensor network the nodes are present with limited energy and in each transmission nodes loss some energy. It is required to minimize the rerouting to save the energy loss. Here An algorithm for energy efficient maximally covered sensor network is presented. The initial route will be identified by the Path Selection algorithm and as any path or node can get broken it would look for the alternate path but using simple Path Selection algorithm it requires rerouting so we need other way. Here other way used is Ant colony based multipath routing algorithm (ACMRA). As we know there are disjoint multipath between the source nodes and sink node. In multipath routing, multiple paths between source and destination are established. The algorithm generates two types of ants: search ant (SANT) and reinforcement ant (RANT). SANT is used to collect information about paths and the intermediate nodes local information as they travel along the path. RANT issued to update the pheromone table along the reverse path, and bring information of path to source node, such as residual energy of the sensor nodes, path length and energy consumed in the current path. In conclusion, a comparison between proposed work and literature proves the efficiency of our work.

Keywords: ACMRA, Energy Optimization, Path Selection Algorithm, Wireless Sensor Network (WSN).

I. Introduction

WSNs are a collection of self-organized sensor nodes that form a temporary network (figure 1). Neither pre-defined network infrastructure nor centralized network administration exists. Wireless nodes communicate with each other via radio links and since they have a limited transmission range, nodes wishing to communicate with other nodes employ a multi-hop strategy for communicating and each node simultaneously acts as a router and as a host. It should be noted that bandwidth available between communicating wireless nodes is restricted. This is because wireless networks have a significantly lower data transmission capacity compared to fixed-line data networks. Furthermore, wireless nodes only have a limited power supply available, as power supplied by batteries is easily exhausted. Lastly, wireless nodes may join or leave a network at any given time and frequently change their location in a network; this results in a highly dynamic network topology [1].

Figure 1

Energy efficiency is always important in wireless sensor networks. In a sensor network the nodes are present with limited energy and in each transmission nodes loss some energy. There are many protocols to tackle with and one of them is Ant colony based multipath routing algorithm (ACMRA).
In our proposed work we will be dealing with this protocol that is Ant colony based multipath routing algorithm (ACMRA).

II. Literature Review

In [2], Authors presented family of ant colony algorithms called DAACA for data aggregation which contains three phases: the initialization, packet transmission and operations on pheromones. After initialization, each node estimates the remaining energy and the amount of pheromones to compute the probabilities used for dynamically selecting the next hop. After certain rounds of transmissions, the pheromones adjustment is performed periodically, which combines the advantages of both global and local pheromones adjustment for evaporating or depositing pheromones. Four different pheromones adjustment strategies are designed to achieve the global optimal network lifetime, namely Basic-DAACA, ES-DAACA, MM-DAACA and ACS-DAACA. Compared with some other data aggregation algorithms, DAACA shows higher superiority on average degree of nodes, energy efficiency, prolonging the network lifetime, computation complexity and success ratio of one hop transmission. At last they analyzed the characteristic of DAACA in the aspects of robustness, fault tolerance and scalability.

In [3], Author presented a general overview of parallel ant colony optimization and an exhaustive survey of the proposed implementations. It includes a conceptual discussion of these methods, looking at different classification criteria and previous efforts to develop categories for parallel ACO algorithms. The survey has been the basis to develop a proposal for a new taxonomy, which is a helpful conceptual tool to both understand and organize the existing work, and to identify possible areas for future research. The work also includes an exhaustive review of the literature in the area, starting from the pioneering works in parallel ACO, up to the most recent proposals (up to December 31, 2010). The reviewed papers are organized according to the new taxonomy, and the main characteristics of the methods employed, as well as the application problems and results obtained, are presented. The discussion of each class concludes with a summary presenting its main features and a list of general conclusions about the efficacy of the corresponding methods. A comparative analysis regarding the computational efficiency and quality of results is also presented. The final section of the paper discusses some trends and perspectives about parallel ACO, including recommendations about the most effective parallel models and implementations. It also provides observations about the software issues and libraries, the employed parallel platforms and the application domains, which can be a source of inspiration for future research in the field.

In [4], Authors consider the problem of sensor deployment to achieve complete coverage and maximize the lifetime of the network. Author model the sensor deployment problem as the multiple knapsack problem. Based on ACO algorithm, their proposed sensor deployment strategy can prolong the network lifetime, while ensuring a full coverage. They have considered five deployment scenarios for performance evaluation and simulation results show that the network lifetime can be increased by increasing the energy and density of the sensors closer to the sink. In addition, their deployment scheme can perform better than the existing deployment schemes and can prolong the network lifetime significantly in any deployment scenario.

In [5], Authors Gave the importance of addressing ways to provide smart healthcare for the elderly, chronically ill and children, researchers have started to explore technological solutions to enhance health and social care provision in a way which complements existing services. In this study, they evaluated the examples of how people could benefit from living in homes that have wireless sensor technologies for improved quality of life and outlined issues to keep in mind during their development. They surveyed systems for acquiring and interpreting context information for the ubiquitous deployment of wireless sensor networks. Results from these works suggest a strong potential for wireless sensor networks to open new research perspectives for low-cost, energy-efficient ad hoc deployment of multimodal sensors for an improved quality of medical care.

In[6] author says that ACO is implemented in always all engineering applications like continuous casting of steel, data reconciliation and parameter estimation in dynamic systems, gaming theory, In-Core Fuel Management Optimization in Nuclear Engineering, target tracking problem in signal processing, design of automatic material handling devices, Mathematical and kinetic modeling of bio-film reactor, optimization of a rail vehicle floor sandwich panel, software design, Vehicle routing design, Quadratic Assignment problem, mutation problem. The various level of experimental in the computer network using ACO as routing protocol shows that the ACO outperforms than the existing research methodologies. A minute redefinition, updation and
or modification of the procedural steps of ACO also will raise the performance dramatically. The ACO remains open many research issues and the ACO are optimally suit many engineering domains.

III. Proposed Work

A. Path Selection Algorithm:

The energy should be under consideration when a routing protocol is designed for the wireless sensor networks. The reason is that energy retention of the network is directly related to the network efficiency. Therefore, minimizing the energy consumption is an important factor for the protocol design. In PSA, both minimization of the energy required for transmission, and available energy in the nodes are considered when deciding a “right path”. A “right path” means that among many possible paths, it is a path consisting of the nodes that have enough energy for transmission and it has the highest selectivity. The available energy $E_{a,pi}$ for a particular path $pi$ is defined as the sum of the available energy of all nodes on that path. Whenever a particular source sends a packet to the same destination, a path is required from the source to the destination. Therefore, the concept of round can be brought in. A “right path” among many paths is found by considering all the factors such as node energy and the number of times this path has been selected. This is a round 1 and it continues to go on whenever the source needs a path to the same destination for transmission. MTE protocol: $\min (E_{c,p1}, E_{c, pn})$ $E_{c,pi}$ denotes the energy consumed for transmission in a certain path $pi$. Available energy: $E_{a,p1}$, $E_{a,p2}$, $E_{a,p3}$, ... $E_{a,pn}$. There are two requirements on how a particular path $pi$ is selected: $E_{a,pi} > E_{c,pi}$

\begin{equation}
S_{pi} = P(pi)/(1 - P(pi) \times (k \text{ mod } 1/P(pi))) \times E_{a,pi}/E_{m,pi}
\end{equation}

In the first requirement, it shows that the available energy in a certain path should be larger than the energy consumed for transmission. This is an obvious condition that must be satisfied; otherwise the transmission would be aborted on the way before the destination. In the second requirement, $S_{pi}$ stands for selectivity of the path $pi$ being selected as a right path. Among all the values of the selectivity, the path that has the largest value will be selected as a right path. The maximum value of the selectivity is 1. $P(pi)$ is the desired probability for the path $pi$. Normally, it is determined depending on the number of paths, $n$ found by the route discovery procedure. In this case, the desired probability is set to $1/n$ for each path, so that all the discovered paths can be used equally, thereby maximizing the network lifetime in terms of energy. On the other hand, it is possible to give priority to some path by increasing the desired probability. For example, if the traffic type is delay-sensitive (e.g., urgent event), priority is given to the path with shortest delay, so that this path can be a Dynamic Network Reconstruction Approach using ACO chosen first. Also, if a certain path retains the available energy close to the consumption energy, the desired probability is lowered enough to prevent this particular path from being selected, because it would cause an energy drain of the path once used. Besides the desired probability, the other factor that affects the path selectivity $S$ is the round $k$ in the first term of the equation above. If a source has discovered $n$ paths to a given destination, one cycle is formed with $n$ rounds between these two nodes, and the desired probability is also determined at this point. Normally, the value of the desired probability is changed on a cycle basis. Each cycle starts from round 0 and ends with round $n-1$. Whenever one of $n$ paths is used to send a packet to the destination, the round value increases by one until the last round $n-1$. Once a certain path is chosen, the selectivity of that path is set to 0 so that it cannot be used again during this cycle. For any other path, the selectivity continues to increase according to the increment of the round value, as long as it is not chosen. Finally, the first term of the selectivity equation approaches to one so that it will be chosen during this cycle. The reason why a certain path even with the higher available energy is used only once at each cycle is because the environment of wireless sensor networks is changing fast in time due to the wireless links, mobility, or node energy consumption for local processing and so on. Therefore, if the source has another data to send to the same destination after one cycle ends, it executes the route discovery procedure again to find new paths and start a new cycle by reflecting the updated network environment. In the second term of Eq. (2), $E_{m,pi}$ represents the maximum energy for the path $pi$. Therefore, if nodes have low available energy, then the value of this fraction will be small (i.e. close to 0); because the value of $E_{a,pi}$ is small and the value of $E_{m,pi}$ is large. This means if there is not enough available energy, then such a path will not be chosen due to the small value of the selectivity. In contrast, if nodes have full energy, then the value of this fraction will be very large (i.e. close to 1), because the value of $E_{a,pi}$ approaches to the maximum energy. As a result, such a path is likely to be chosen as a right path unless there is any larger value than this.
Energy efficiency is always important in wireless sensor networks. In a sensor network the nodes are present with limited energy and in each transmission nodes lose some energy. It is required to minimize the rerouting to save the energy loss. Here an algorithm for energy efficient maximally covered sensor network is presented. The initial route will be identified by the Path Selection algorithm and as any path or node can get broken it would look for the alternate path but using simple Path Selection algorithm it requires rerouting so we need other way. Here other way used is Ant colony based multipath routing algorithm (ACMRA).

**B. Ant colony based multipath routing algorithm (ACMRA) ACMRA:**
As we know there are disjoint multipath between the source nodes and sink node. In multipath routing, multiple paths between source and destination are established. The algorithm generates two types of ants: search ant (SANT) and reinforcement ant (RANT). SANT is used to collect information about paths and the intermediate nodes local information as they travel along the path. RANT is used to update the pheromone table along the reverse path, and bring information of path to source node, such as residual energy of the sensor nodes, path length and energy consumed in the current path. In the constructing routing phase, cluster head in the event region generates SANTs according to the number of neighbor nodes, and chooses then extnode to move to according to probability of selection. While in the data transmission phase, the network life time relates to hopcount, energy consumption and the minimum energy at a path. The algorithm was compared with primary and replication mode of multipath routing and found to perform better in terms of energy consumption and standard deviation of node energy. The environment of simulation of the protocol is not stated, and the network nodes not properly distributed, while also not considering quality of service metrics in its design.

**C. Proposed Approach:**
In the present work we have improved the path selection algorithm by using the concept of ACMRA.
1. Define N Number of Sensor Nodes in the WSN with specific parameters in terms of energy, transmission rate etc.
2. Each Node Ni start Moving in Direction of Specific Direction
3. Find M Neighbor Nodes of Nodes Ni and maintains the respective Information For (j=1 to M) {Maintain Formation (Ni, Nj)}
4. if Data Loss(Ni)> Threshold and Time Delay > Threshold1 /*If Bad Node or Congested Node Occur on Node i*/ { For i=1 to Mi {Collect Information (Ni, Neighbor (Ni))}}
5. Implement SANT to find the alternate path in each Direction of Neighbor (N (i)).
6. Implement RANT to update pheromone table.
7. Trace the Pheromones and Communication of New Path
8. Perform the Normal Communication
The first step is to setup the network with specific parameters.
IV. Results and Discussion

A. Snapshots:

Initially Simple Path Optimization Algorithm is used to find the optimized path. We have assumed 10 paths from source to destination and show 5 cycles to be ok.

![Figure 2](image)

After 5 cycles path is broken and there is limitation of the simple path routing that rerouting is needed if path is broken. Packet gets lost at the broken node.

![Figure 3](image)

After path breakage rerouting is shown. But we can preserve it using another algorithm ACMRA.

![Figure 4](image)

First SANT are sent from source to destination. SANT is used to collect information about paths and the intermediate nodes local information as they travel along the path.

![Figure 5](image)

We can see another SANT is gone from source to destination from a path where only one from another.
Now RANT is send on backward path. RANT is used to update the pheromone table along the reverse path, and bring information of path to source node, such residual energy of the sensor nodes, path length and energy consumed in the current path.

As we discussed that two SANT were gone from a path so two RANT would also come depositing pheromone on the path so this deposition is more on this path. So we would choose this path.
B. Graph:

**Fig. 10: Packet Transmitted (literature work)**

**Fig. 11: Packet Transmitted (proposed work)**

**Fig. 12: Energy Dissipated (literature work)**

**Fig. 13: Energy Dissipated (Proposed work)**
V. Conclusion

By simulation, we have found that the energy in our work is consumed is less. By default the route is chosen on the basis of Path Selection formula i.e. lowest energy path is chosen. In case there is problem in the selection of the path (in case of any fault node) then ACMRA Algorithm is applied, the purpose of which is to continue sending data without re-routting. This ensures the reliability of the network communication i.e. data exchange will not stop even in case of failure of any node. Hence we achieved efficiency in terms of energy by applying path selection whereas ACMRA. Algorithm gives the required reliability. Implementation is done in MATLAB.

References