Maximization of Energy Efficiency in WSN using ACO-MNCC

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Abstract- *The use of wireless sensor networks (WSNs) is very common and frequently required for diverse set of applications such remote monitoring, forecasting, security etc. Since from the last two decades, the most widely studied research problem in WSNs is network lifetime performance due to the limitations on battery of sensor nodes. There are some recent techniques presented to solve problem of maximizing the WSNs lifetime under the different domains. However, energy efficiency is still the open research problem for WSNs. The optimization method called ant colony optimization (ACO) shown the promising performance for improving the energy efficiency in WSNs recently. With this motivation, in this paper, we are presenting the modified ACO based routing method with goal of maximizing network lifetime of WSNs and energy efficiency. The proposed application is based on technique of two contributions, first is searching maximum disjoint connective covers in order to satisfy the requirement of network connectivity as well as sensing coverage. This solves the problem of searching and network connectivity and hence improves the energy efficiency using ACO. Secondly, we contributed by using optimum path selection for data transmission by considering the energy constraints of sensor nodes based on set of pre-defined rules. This helps to improve the network lifetime of WSNs. The results show that performance of proposed ACO method is better as compared to previous variants of ACO.*

Keywords- Network Lifetime, Energy Efficiency, Sensor Networks, ACO, Routing Protocols, WSN

I. INTRODUCTION

Wireless Sensor Networks (WSNs) contains higher number of sensor nodes, it collects all data and route it from source to destination(one or more external sinks) with some transmission regulation. The transmission strategy should give minimum energy consumption and due to this it gives higher network lifetime due to limitations of bandwidth, energy and memory of nodes[2]. Data transmission takes place between multiple as well as single nodes. This many to one and one to many leads non uniformality of result and gives non uniform energy consumption in the network. Therefore, designing a network to get maximum energy efficiency plays an important role in WSNs.

An energy-efficient ant-based routing algorithm (EEABR) gives energy quality and number of nodes are use to choose paths. Camilo et al.[5] presented this paper. A dynamic and reliable routing protocol (DRRP) [6] was advanced performance of routing, its path is decided as best path depending upon energy level and length of the path. Depending upon distance and energy loss, an ACO algorithm was designed to decrease energy consumption, it is stated in [7]. An energy-aware ant colony algorithm [8] was proposed, and the path is selected depending upon three factors namely residual energy, distance and average energy. The residual energy is the parameter which is considered in some of above methods, the energy consumption, balancing, especially the energy depletion equilibrium.

Different from general transmission methods has following characteristics: First, considering energy consumption in different areas and various parameters of energy decreases energy consumption and finally increases network lifetime. Second, it considers maximum possible energy balancing, but also advances two strategies of it. Compared with other ACO-based transmission, it is performed by unconventional features.

Firstly, every ant needs to move from source to destination and complete the path and full transmission of data, we get reduced computation complexity by default. Second, in the ransition probability of the ant heuristic information is removed. This gives decreased computation complexity.

There are various types of ant systems Some are listed below:

1) Elitist ant system:The pheromone deposited quantity is same for each iteration with all other ants.
2) Max-min ant system(MMAS):There are two quantity of pheromone are decided and added on the route as maximum and minimum pheromone amounts [τmax,τmin]. First max quantity is added on route. As

pheromone has quality to evaporate therefore when it reaches to min value it is updated again to maximum quantity.

3) Ant colony system(ACO):The algorithm was designed to search shortest path depending upon behaviour of travelling ants from source to destination.
4) Rank-based ant system (Asrank): The amount of pheromone is deposite on the route depending upon length, such a that solutions it has higher quantity for longer path and lower for shorter paths.
5) Continuous orthogonal ant colony (COAC): It is very practical method and uses orthogonal system design. It searches solution effectively and collaboratively. It is more accurate method as compare to other methods.
6) Recursive ant colony optimization
7) It divides the whole area into sub parts named as sub domains and then it solves th problem of subdomains and then add all results and then it finds best path for transmission of data. Then the desired data is lowest level of energy consumption.

- **THE DOUBLE BRIDGE EXPERIMENT**

The ants begin by walking randomly. They cannot see the ground and have a very limited view of what is around them. Therefore, if the ground has not been explored yet, they will just wander and take random decision at each crossroads.

After a while, the places around the nest will be all explored. The ants will get to know that by the marking done by the previous ants. Indeed, they will leave behind them the famous pheromones and inform the other ants that the way is already explored.

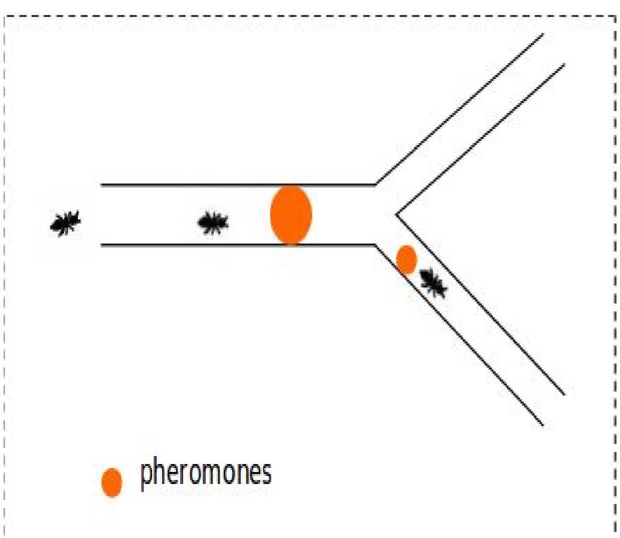

Figure 1. Ants and pheromones

The concentration of pheromones depends on the number of ants who took the way, the more ants taking the way, the more pheromones. The configuration is as shown in figure 1 : the nest of a colony of ants is connected to the food via two bridges of the same length. In such a setting, ants start to explore the surroundings of the nest and eventually reach the food source. Along their path between food source and nest, ants deposit pheromones. Initially, each ant randomly chooses one of the two bridges. However, due to random fluctuations, after some time one of the two bridges presents a higher concentration of pheromones than the other and, therefore, attracts more ants. This brings a further amount of pheromone on that bridge making it more attractive with the result that after some time the whole colony converges toward the use of the same bridge.

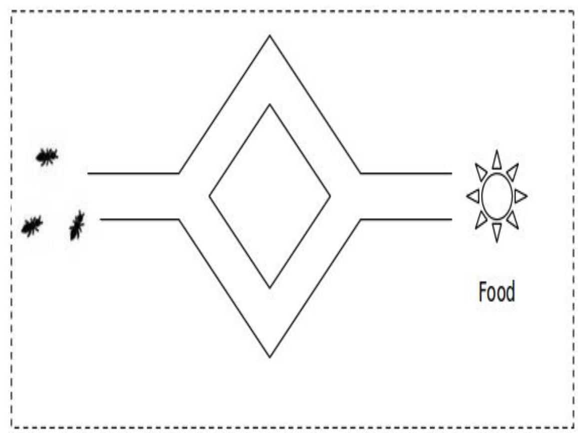

Figure 2. The Double Bridge Experiment

The second experimentation, figure 3 gives also two paths to the food source, but one of them is twice longer than the other one. Here again the ants will start to move randomly and explore the ground. Probabilistically, 50% of the ants will take the short way while the 50% others will take the long way, as they have no clue about the ground configuration.

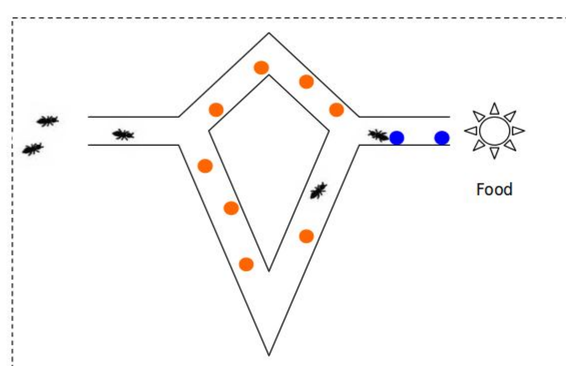

Figure 3. Ants coming back to the nest

The ants taking the shorter path will reach the food source before the others, and leave behind them the trail of pheromones. After reaching the food, they will turn back and try to find the nest. At the cross, one of the paths will contain pheromones although the other one will be not explored. Hence the ant which carries the food will take the path already explored, as it means it is the way to the nest.

As the ant is choosing the shortest way and will continue to deposit pheromones, the path will therefore become more attractive for others. The ants who took the long way will have more probability to come back using the shortest way, and after some time, they will all converge toward using it. Consequently, the ants will find the shortest path by themselves, without having a global view of the ground. By taking decision at each cross according to the pheromones amount, they will manage to explore, find the food, and bring it back to the nest, in an optimized way.

II. SYSTEM MODEL

Our goal is to get shortest path depending upn transmission distance for all nodes present in the network. By using ACO algorithm best path is detected. There is an ant present on each sector of the network initially. Depending upon probability every ant moves from sector to its destination using multiple hop system, as shown in Fig. 4. With discending order of sector these ants move one after another. The ant on outer sector moves first and then the inner sector. After any ant moves only one hop, it has completed its full task. This moving mechanism is similar to that in [11]

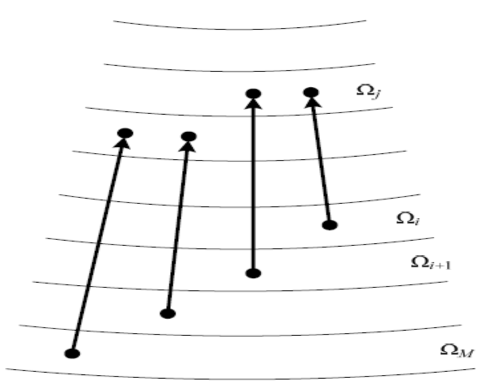

Figure 4. The moving mode of the ant

In moving rule, when the ant on sector Ωi wants to travel to the candidate sector Ωj , it must have visit all the Direct Source Sector(DSSs) of sector Ωi , and informed of Φi(the total volume of its received data). The per node average energy consumption of sector Ωi is calculated as follows:

$$\overline{E}_i = \frac{E_{\mathrm{Rx}}(\Phi_i) + E_{\mathrm{Tx}}(\Gamma_i, d_{ij})}{Q_i} = \frac{\Phi_i e_{elec} + (\Phi_i + \xi_i) e_{elec} + (\Phi_i + \xi_i)\varepsilon_{amp}[(i-j)\omega]^{\gamma}}{Q_i}$$ ..1

Energy efficiency:

For multi-hop transmission, optimal disatance is different for each hop and it is found in [10]. The ptimal distance is important to minimize the total energy usage between the transmission path. The communication route R is divided into x hops by (x − 1) intervening relay nodes. The overall energy usage is given by

$$d = D/\ x$$

for given distance D and the number of hops x.

It achieves the minimum when each hop shares the same transmission distance. In this case, we can get

$$x = D/d$$

$$\begin{aligned} E_{\mathrm{Total}} &= (x-1)E_{\mathrm{Rx}}(1) + x \times E_{\mathrm{Tx}}(1) \\ &= (x-1)e_{elec} + x(e_{elec} + \varepsilon_{amp} d^{\gamma}) \\ &= \left(\frac{2D}{d} - 1\right)e_{elec} + \frac{D}{d} \times \varepsilon_{amp} d^{\gamma} \\ &= \varepsilon_{amp} D d^{\gamma-1} + \frac{2e_{elec}D}{d} - e_{elec} \end{aligned}$$

III. RESULTS

1. Average Energy Consumption

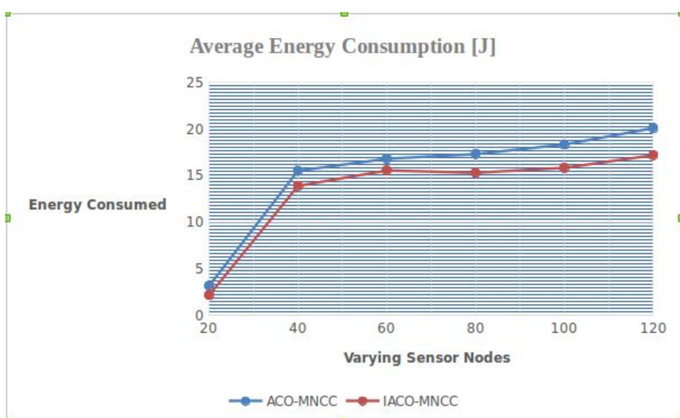

Figure 5.

2. Network Lifetime

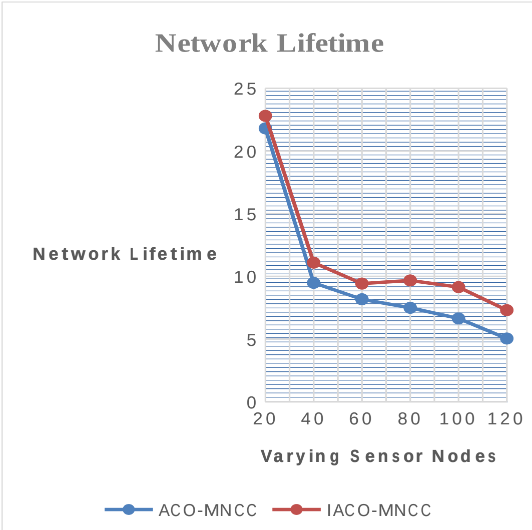

Figure 6.

3. Residual Energy

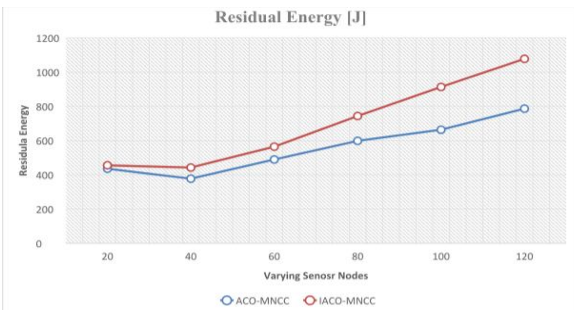

Figure7.

4. Packet Delivery Ratio

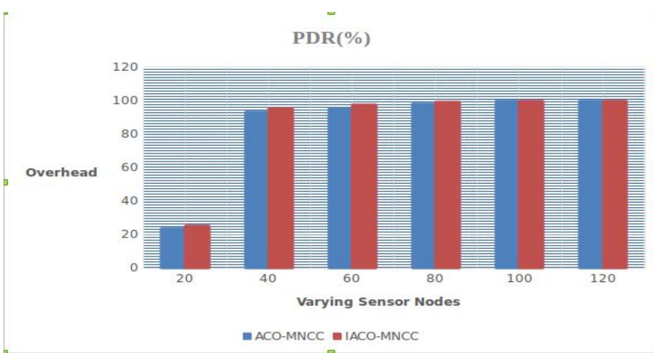

Figure 8.

The results showing that proposed IACO-MNCC (Improved ACO-Maximizing the Number of Connected Covers) as compare the existing ACO-MNCC in terms of energy consumption, network lifetime, and residual energy. These three energy related performance metrics claims that proposed approach achieved better energy efficiency for WSNs. Along with the energy efficiency, proposed method improves the performance.

IV. CONCLUSION

We achieve high energy efficiency and load balancing. These three energy related performance metrics claims that proposed approach achieved better energy efficiency for WSNs. Along with the energy efficiency, proposed method improves the performance.

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