Ant Colony Optimization Algorithm for Wireless Sensor Network

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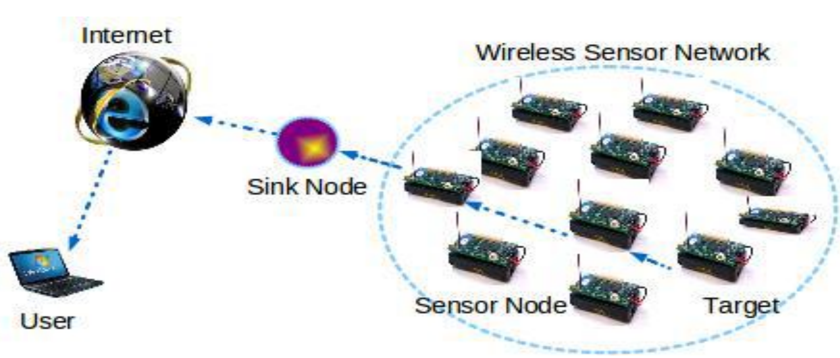
Abstract

Due to the inventions in technology, Wireless sensor networks have been growing rapidly. Sensor nodes are capable of performing some processing, gathering required information and communicating with other connected nodes in the network. Sensor nodes are of limited energy which is a drawback during peak times in a network. Always energy is of primary concern in a wireless sensor networks. There are various approaches used for optimizing energy conservation. Some of the methods include Ant Colony optimization, Particle Swarm optimization, Heuristic approach etc. For enhancement of network lifetime, ant colony optimization plays a significant role. We present here the various ant colony optimization algorithms.

I. INTRODUCTION

Wireless sensor network (WSN) is one of the most important technologies in this century. A WSN typically consists of a large number of low-cost, low-power, and multifunctional wireless sensor nodes. The number ranges from 100-1000 nodes. These sensor nodes are composed of sensors, transceiver, battery, and the processor for performing local processing. The processor converts the analog information which is sensed by the sensors about their environment into digital format [1]. These nodes have sensing, wireless communications and processing capabilities. These sensor nodes communicate over short distance via a wireless medium. Wireless sensor network (WSN) has a wide range of applications in military, environmental monitoring which includes agriculture monitoring, habitat monitoring, greenhouse monitoring and forest monitoring, health care monitoring, industrial monitoring, space exploration and so on.

Individual sensor node's capability is limited and hence all the nodes aggregate power is used to accomplish the task. Sensor nodes organize autonomously in the wireless network. Sensor nodes are battery-powered and are expected to operate for a relatively long period of time. Always power is a critical resources in the wireless network. It is very difficult to change or recharge batteries for the sensor nodes. WSNs are characterized with denser levels of sensor node deployment, higher unreliability of sensor nodes, and sever power, computation, and memory constraints. Thus, the unique characteristics and constraints present many new challenges for the development and application of

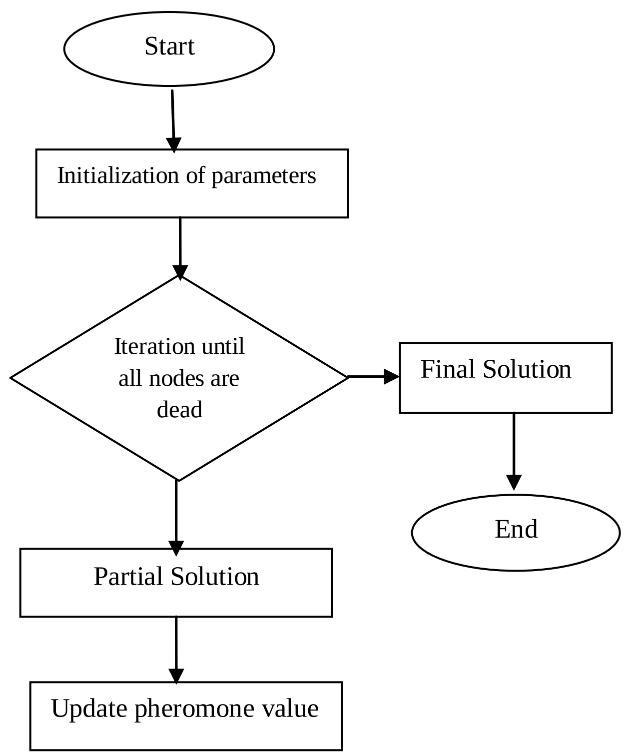


WSNs.

II. RELATED WORK

ACO (Ant Colony Optimization). Routing comes under the optimization problem for finding the shortest path from source to the destination. Ants have been there for millions of years and they detect shortest path between the food sources and nest. An ant secretes a volatile chemical substance called pheromone that helps in converging over the shortest path among multiple paths. Ants secrete pheromone on the ground while moving and follow the path with maximum pheromone concentration. This mechanism helps the ant to choose the best path and the same has been proved to be to generate optimal path from among multiple paths [2]. The ant behavior is mapped in electronic devices for solving various combinatorial problems. While traversing through the phases of the problem, asynchronous agents are included to produce partial results. Greedy approach is followed for arriving at the solution in incremental way in each phase. The same approach is used for routing the data packets from the source to destination in the wireless sensor networks. Amount of network packet transmission, energy efficiency and increasing the network lifetime are very important in a wireless sensor network.

An ACO algorithm has two phases where the capability of the algorithm is enhanced which is trail evaporation and daemon actions. To refrain the unlimited accumulation of trail over specific component trail evaporation is done. To implement the actions that cannot be performed by a single ant, the Daemon actions are used.



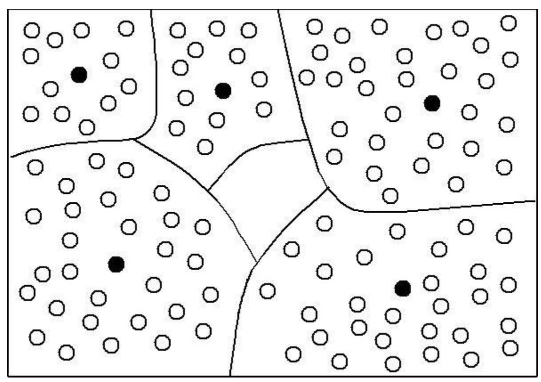
ACO (Ant Colony Optimization)

III. VARIOUS APPROACHES

3.1 LEACH Protocol.

LEACH is the first and most popular energy-efficient hierarchical clustering algorithm for WSNs that was proposed for reducing power consumption. Direct communication is used by each cluster head (CH) to forward the data to the base station (BS). It uses clusters to prolong the life of the wireless sensor network. LEACH is based on an *aggregation* technique that combines the original data into a smaller size of data that carry only meaningful information to all individual sensors. LEACH divides the network into several clusters of sensors, which are grouped by using localized coordination. Cluster head positions are chosen based on high energy rather than a static procedure. Because of this selection procedure every high energy sensor node has chances of becoming Cluster head and thus avoiding individual sensor dyeing quickly. The operation of LEACH is divided into rounds having two phases each namely (i) a setup phase to organize the network into clusters, CH advertisement, and transmission schedule creation and (ii) a steady-state phase for data aggregation, compression, and transmission to the sink.

LEACH is completely distributed and requires no global knowledge of network. It reduces energy consumption by (a) minimizing the communication cost between sensors and their cluster heads and (b) turning off non-head nodes as much as possible. LEACH uses single-hop routing where each node can transmit directly to the cluster-head and the sink. Furthermore, the idea of dynamic clustering brings extra overhead, e.g. head changes, advertisements etc., which may reduce the gain in energy consumption. While LEACH helps the sensors to diminish their energy slowly, the CHs consume a larger amount of energy when they are located farther away from the sink. Also, LEACH clustering terminates in a finite number of iterations, but does not guarantee good CH distribution and assumes uniform energy consumption for CHs.



Cluster formation in LEACH.

3.2 Basic Ant Based Routing Algorithm (BABR)

The simplest way to describe the Ant Colony concept in WSNs is to put the concept of Basic Ant Colony Algorithm (BABR).The implementation of this algorithm is as follows:

- A Forward ant is launched to source node with the aim of finding an optimal path from source to the destination.
- Each ant forwards to the destination node by using the neighbor nodes with minimum cost joining the source and sink.
- As the ants move forward to reach up to the destination, greedy stochastic policy is applied to choose the successive node.
- For every movement, the agents collect information regarding the network and update the routing table.
- On reaching the destination node, a backward ant is created to travel in the same path but in opposite direction.
- During the backward travel, the network status and the routing table of each node are updated related to the path they followed.

Thus in the Basic Ant Routing Algorithm the ant travels in both forward and reverse path to update the routing table periodically.

3.3 Sensor-driven and cost-aware ant routing (SC):

One of the problems of the basic ant-routing algorithm is that the forward ants normally take a long time to reach the destination, even when a table list is used. This happens since the ants initially do not have an idea where the destination is. Only when an ant reaches the destination and traverses back in the same link, probabilities of the path changes. In sensor driven method, we assume that ants have sensors to find the path to reach the destination even at the beginning. Something like that where ants smell the food at the very beginning. This approach is a realistic assumption in sensor networks, as the Feature-based routing dominates address-based routing in that space. If the destination is not clearly known, then pre-building the feature potential is sometimes very efficient. Cost awareness generalizes the objective of shortest path length so that ants can apply other routing metrics as well, e.g., energy-aware routing. This algorithm may produce misleading solution due to loss of visibility of the destination node. This is disadvantage of this algorithm.

3.4 Flooded Forward Ant Routing (FF)

This routing method is based on flooding of agents from source node to the sink node. In this method, even when the ants are equipped with sensors, they might get into wrong path due to obstacles or due to loss of visibility of nodes. There may also exist situations where sink or destination node may not be known to the agents and estimation of cost of the path also difficult. This leads to wandering of agents around the network to find the destination. Broadcast method is used for sending data packets in the wireless network to overcome this problem.

3.5 Flooded Piggyback Ant Routing (FP)

The basic functionality of this method is the same as flooded forward ant routing except that a new ant called data ant is used to carry the forward list. The energy dissipation of nodes during the sending of data packets in the network is reduced by coupling the data with the forward flooding ant. Two tasks are performed by the ants; one is forwarding the packets and second is keeping the identity of the nodes along the path to sink note. The same information can be used by the backward ants.

3.6 Many-to-One Improved Ant Routing (MO-IAR)

MO-IAR, a two-phase algorithm, The first phase establishes the shortest path and the second phase provides the procedure for actual data routing. For minimizing the packet loss, proactive congestion control mechanism is adopted by the second phase. It is presumed that the neighboring nodes as well as the destination are already known to the sensor.

3.7 ACO-Based Quality-of-Service Routing ACO-QoSR)

ACO-QoSR deals with the problem of limited energy and the delay requirements of the data packets. This algorithm uses a threshold bounding parameters for both end to end delay and the energy. Whenever a sensor node has its data to be sent to the sink, it checks its routing table. If such path doesn't exist, then the procedure for finding a new path is initiated. For finding these new paths, probabilistic approach is used by the forward ants are deployed which selects the next hop to traverse.

This algorithm stores the heuristic information in the form of a ration of residual energy and the summation of residual energy of all the nodes. This heuristic information which is defined as ACO-QoSR embeds one of the features of Max-Min Ant System. ACO-QoSR on comparison proves to be better on the grounds of higher packet delivery and time constraint applications.

3.8 Energy Efficient Ant Based Routing (EEABR)

EEABR is considered to be an improvised version of ant based routing. While selecting the node over the traversal path, this algorithm considers the energy level along with distance. In the basic ant algorithm, large amount of memory is required for storing identity of each neighboring node and their corresponding pheromone information in the routing table. By storing the information about only the last two nodes EEABR significantly reduces the memory requirement. Only drawback in this algorithm is the delay in packet delivery.

3.9 Self-Organizing Data Gathering for Multi-sink Sensor Networks (SDG)

In this protocol only backward ants are produced and that too by the sink node. These ants update the pheromone information of each node using a pheromone value. When the backward ant reaches a node, generating sink ID and the neighboring nodes and then that node stores the pheromone value,. The algorithm was able to achieve the reliability of 90% even in the presence of lossy channels. The main disadvantage of this algorithm is that significant amount of energy is wasted due to the packet exchange by hello ants and the proactive nature.

The table below shows the comparison of various routing protocols based on energy efficiency, , location awareness and data aggregation

	LEACH	BABR	SC	FF	FP	MOIAR	QoSR	EEABR	SDG
ENERGY EFFICIENCY	Strong	Weak	Strong	Weak	Weak	Moderate	Very Strong	Very Strong	Strong
LOCATION AWARENESS	No	No	No	No	No	No	No	No	No
DATA AGGREGATION	Yes	No	No	No	No	No	No	No	Yes

IV. Conclusion and Future Work

In a changing environment of wireless sensor network, finding an optimal path is a challenging issue. One of the primary goal in WSN environment would be to improve the lifetime of the network. Vitality will be wasted when all the nodes are live even when they are not participating in a communication. Redundant data transmission may also cause energy wastage in dense environment. Ant colony optimization approach can be used for finding the optimal path. In future work, cluster head selection mechanism can be applied along with ACO to get the optimal cluster head.

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