



Research Article

IMPROVED NETWORK LIFETIME MAXIMIZATION IN WIRELESS SENSOR NETWORKS USING ACO ALGORITHM FOR ENERGY CONSERVATION

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ABSTRACT

The use of Network Lifetime Maximization while disseminating queries to appropriate regions since data queries often include geographic attributes and apply Ant Colony Optimization clustering is proposed here. The protocol, uses energy aware and geographically-informed neighbor selection heuristics to route a packet towards the destination region to improve the link stability during data transfer and by applying the clustering algorithm, all the nodes are divided into clusters and a cluster head is selected in each cluster, which collects the information from all the nodes and creates a log about the sender, receiver and data to be sent, later while the cluster head starts navigating the entire data.

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INTRODUCTION

Recent advances in integrated electronic devices motivated the use of Wireless Sensor Networks (WSNs) in many applications including target surveillance and tracking. A number of sensor nodes are scattered within a sensitive region to detect the presence of intruders and forward subsequent events to the analysis center(s). Obviously, the sensor deployment should guarantee an optimal event detection rate. This paper proposes a network lifetime maximization using Ant Colony Optimization based on clustering. Two mobility models are proposed to control the coverage degree according to target presence and cross layer and interference tolerant WSN. The objective is to set a non-uniform coverage within the monitored zone to allow detecting the target(s) by multiple sensor nodes. We show how the proposed algorithm adapts to the situation where multiple targets move in the monitored zone. Moreover, we introduce an algorithm to discover redundant nodes (which do not provide additional information about target position).

This algorithm is shown to be effective in reducing the energy consumption using an activity scheduling approach. Simulations are carried out to underline the efficiency of the proposed models.

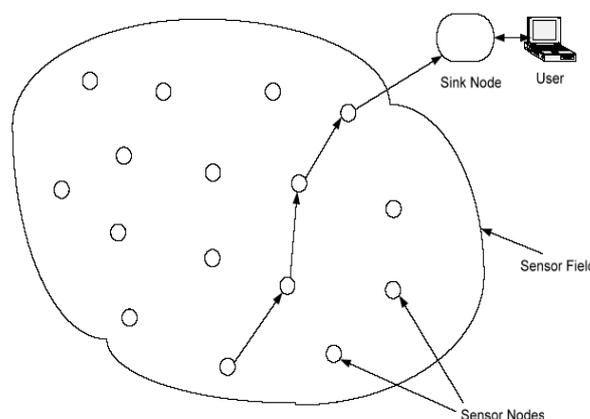


Fig 1.1. The basic structure of Wireless Sensor Networks

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Introduction about WSN

The wireless sensor networks of the near future are envisioned to consist of hundreds to thousands of inexpensive wireless nodes, each with some computational power and sensing capability, operating in an unattended mode. They are intended for a broad range of environmental sensing applications from vehicle tracking to habitat monitoring. The hardware technologies for these networks – low cost processors, miniature sensing and radio modules – are available today, with further improvements in cost and capabilities expected within the next decade. The applications, networking principles and protocols for these systems are just beginning to be developed. Sensor networks are quintessentially event-based systems. A sensor network consists of one or more “sinks” which subscribe to specific data streams by expressing interests or queries. The sensors in the network act as “sources” which detect environmental events and push relevant data to the appropriate subscriber sinks. Because of the requirement of unattended operation in remote or even potentially hostile locations, sensor networks are extremely energy-limited. However since various sensor nodes often detect common phenomena, there is likely to be some redundancy in the data the various sources communicate to a particular sink. In-network filtering and processing techniques can help to conserve the scarce energy resources. A Wireless Sensor Network is comprised solely of wireless stations. The communication between source and destination nodes may require traversal of multiple hops because of limited radio range. Existing routing algorithms can be broadly classified into topology-based and position-based routing protocols. Topology-based routing determines a route based on network topology as state information, which needs to be collected globally on demand as in routing protocols Dynamic Source Routing and Ad hoc On-Demand Distance Vector or proactively maintained at nodes as in Destination-Sequenced Distance Vector. The scope of this paper is focused on position-based routing, also called geometric or geographic routing. Position-based routing protocols are based on knowing the location of the destination in the source plus the location of neighbors in each node.

Most position-based routing protocols use greedy forwarding as their basic operation. In greedy forwarding, a forwarding node makes a locally optimal greedy choice in choosing the next hop for a message. Specifically, if a node knows its neighbors' positions, the locally optimal choice of next hop is the neighbor geographically closest to the destination of the message. Greedy forwarding, however, fails in the presence of a void (also called a local minimum or a dead end) where the only route to the destination requires a packet move temporarily farther in geometric distance from the destination. In order to recover from a local minimum, most existing protocols switch to a less efficient mode, such as the face routing mode. Face routing (also called perimeter routing or planar graph traversal) on a connected network theoretically guarantees the delivery of packets. Face routing runs on a planar graph, in which the message is routed around the perimeter of the void (face) surrounded by the edges using the right-hand rule.

Problem Definition

Here considering a network of linearly connected sensor nodes, where a single node's failure may destroy the entire topology of

nodes and, hence, the information of the source cannot be relayed to the sink. When considering the energy dissipated at a sensor node, the battery life is predominantly related to the node's communication activity, where the transmission rate and power must be optimized, while taking into account the battery capacity, the efficiency of the power amplifiers, the receiver and transmitter circuit energy consumption, and other physical layer parameters, including the modulation and coding schemes, the attainable coding gain, the path loss, and so on. It is widely recognized that transmission at a high transmission rate requires the use of high transmit power, which potentially leads to strong interference among the transmission links. Therefore, the battery depletion of an individual sensor node may become inevitable; hence, the NL may be reduced. However, in large networks, spatial reuse may be adopted for improving the attainable transmission rates at the cost of imposing interference on the network.

In this case, link scheduling and multiple-access schemes play a significant role in coordinating the resultant interference. More explicitly, here demonstrating that scheduling weakly interfering links simultaneously allows the network to maintain a given sum rate at a reduced per-node transmit power, which hence extends the battery life of the nodes and the Network Lifetime. This is one of the methods routinely employed for taking advantage of spatial reuse to control the level of interference imposed on the network. This method extends the Network Lifetime since mitigating the interference imposed implies that each transmission requires less power. Therefore, intelligent scheduling should carefully balance the number of simultaneous active links and their transmission duration to keep the required transmit power at a minimum. Furthermore, multihop relaying is capable of conserving the energy of the source node (SN) since intermediate nodes may be employed for reducing the transmission power necessary for maintaining a given end-to-end rate. Hence, here considering the joint optimal design of the transmission rate, transmission power, and scheduling to maximize the Network Lifetime of energy-constrained WSNs.

MATERIALS AND METHODS

Forwarding the packets towards the target region

Upon receiving a packet, a node checks its neighbors to see if there is one neighbor, which is closer to the target region than itself. If there is more than one, the nearest neighbor to the target region is selected as the next hop. If they are all further than the node itself, this means there is a hole. In this case, one of the neighbors is picked to forward the packet based on the learning cost function. This choice can then be updated according to the convergence of the learned cost during the delivery of packets.

Forwarding the packets within the region

If the packet has reached the region, it can be diffused in that region by either recursive geographic forwarding or restricted flooding. Restricted flooding is good when the sensors are not densely deployed. In high density networks, recursive geographic flooding is more energy efficient than restricted flooding. In that case, the region is divided into four sub regions and four copies of the packet are created. This splitting

and forwarding process continues until the regions with only one node are left. Ant Colony Optimization is an evolutionary algorithm. It uses a meta-heuristic approach. It is inspired by the foraging behavior of ants. The ants release chemical called pheromones on the path while moving along the path. As more number of ants moves along the path, the pheromone concentration increases. The more the pheromone concentration, more is the chance for a new ant to choose that path to reach the food from the colony. The path chosen by the ants will be the shortest path from nest to food. The process is a kind of distributed optimization mechanism, in which they find the shortest distance from the food to colony. Every single ant contributes to the solution, cooperating in the work. Artificial ants are used to find the solution of difficult optimization problems. Artificial ants use an incremental constructive approach to search for a feasible solution.

As discussed earlier, the peer-to-peer network can be considered in the form of a graph. In the graph, each node's location is represented using its x and y co-ordinate values and is identified by its unique node number. A node is said to be in the range of another node, if the Euclidian distance between the two nodes is within the range of each other. A hierarchical routing is done using clustering in which paths are recorded between clusters instead of between nodes. This reduces the amount of routing control overhead. Ant Colony Optimization finds the minimal set of cluster heads. This is an iterative process and the output obtained is a local solution. In the implementation of the routing protocol simulation, there are three parameters to be compared: throughput, average end-to-end delay and routing overhead. Throughput is the ratio between the numbers of data packets that successfully sent to the destination node with the number of data packets sent by the sender node. Average end-to-end delay states all the possible time delay caused by buffering during route exploration process, the process of lining up in the interface queue, retransmission of data packets or routing packet (retransmission), propagation of information and transfer time. In routing overhead parameter, there are two types of overhead on these parameters, namely packet overhead and byte overhead. In this study, we use the concept of packet overhead. Packet overhead is the ratio between the numbers of routing packets transmitted with a packet of data sent to the destination. In the simulation scenarios, each parameter has 64 pieces of scenario comparison. There are two routing protocols used to compare the performance of ACBRP routing protocol, those routing protocol are the Ad-hoc On Demand Distance Vector (AODV) and Dynamic Source Routing (DSR). Those three routing protocols will be tested within the same scenario and simulator, and the result of performance will be fetched later at the end of simulation.

There are two variables involved in the process of data collection by the implementation of the Ant Colony Optimization: number of nodes and number of ants. Variables involved and variations in the scenario of implementation of Ant Colony Optimization can be seen in table. After Ant Colony Optimization takes place, the process of comparing this method and the conventional one is conducted. Parameter used as comparison factor is percentage of coverage of the cluster to the overall number of nodes in the network. There are two methods to be compared; those are the selection of cluster head by using Ant Colony Optimization and election of cluster head

using a conventional manner, where the cluster head selection is done by selecting the cluster head with the largest number of neighbors. Neighboring nodes of node i is a node that is directly related to the node i and is located within range of the sensor node i . After the cluster head selection process is done, each selected cluster head will expand to create a cluster in the region. The percentage of coverage will be obtained from the ratio of the number of node that becomes a cluster head or being a member of a cluster by the number of nodes as a whole. the experimental results, we can conclude that the routing protocol ACBRP has the best throughput among the three routing protocols tested. On average end-to-end delay, a routing protocol will have a better delay if the value is getting closer to 0 millisecond, which means there is no delay at all. The results of the data average end-to-end delay from the three routing protocols can be seen. From the experimental results, ACBRP routing protocol has the lowest delay among the three routing protocols tested. Routing protocol will have a better routing overhead when the value is closer to 1, which means that there is no routing packet is lost in transmission process. The results of the routing overhead from the three routing protocols can be. From the experimental results, obtained data that the routing protocol ACBRP has the best efficiency with the lowest routing overhead, compared to AODV and DSR routing protocol. On the implementation of Ant Colony Optimization, data collection is done by running the simulation cluster formation and compare it with conventional methods. Coverage percentage of the cluster is later compared. It appears that Ant Colony Optimization method has better cluster coverage percentage than conventional methods at the beginning of the scenario with a small number of nodes with less than 40 nodes.

Ants moving rule

Ants move from one city to another city according to probability. Firstly, cities accessed must be placed in taboo table. Define a set of cities never accessed of the k th ant as *allowed_k*. Secondly, define a visible degree n_{ij} , $n_{ij} = 1/d_{ij}$. The probability of the k th ant choosing city is given by

$$P_{ij}^k = \begin{cases} \frac{[\tau_{ij}(t)]^\alpha [n_{ij}]^\beta}{\sum [T_{ik}(t)]^\alpha [n_{ik}]^\beta} & j \in \text{allowed}_k \\ 0 & \text{else} \end{cases}$$

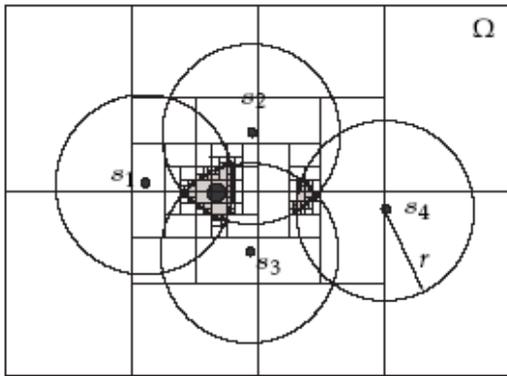
where α and β are important parameters which determine the relative influence of the trail pheromone and the heuristic information. The pseudo-random proportional rule is adopted as in ACO and modified MMAS

$$j = \begin{cases} \arg \max_{k \in \text{allowed}_k} \{ \tau_{ik}(t) [\eta_{ik}]^\beta \} & \text{if } p \leq p_0 \\ J & \text{else} \end{cases}$$

where p is a random number uniformly distributed in $[0,1]$. Thus, the best possible move, as indicated by the pheromone trail and the heuristic information, is made with probability $0 \leq p_0 < 1$ (exploitation); with probability $1-p_0$ a move is made

based on the random variable J with distribution (biased exploration).

Solving the tracking problem at a given time t consists of finding the set of positions that are consistent with at least $nq(t) = (|I(t)| - q)$ constraints. This paper uses interval analysis for that purpose Moore (1979); Jaulin et al. (2001). In other words, the computed solution consists of a set of non-overlapping boxes covering the solution set. In this section, a description of the approach is first proposed, then two different algorithms are presented for solving the problem. Note that in the proposed approach, the estimation process is performed at a central processing unit where all measurements are collected. For this purpose, all sensors detecting the target send their measurements and their positions at each time step to the central unit where computation is then processed.



Algorithm 1: Estimation algorithm

Input: Indices of sensors observing the target I ;

Output: Target coordinates $[x_1](t)$ and $[x_2](t)$;

Initialization: $[x_1](t)=[X_1]$, $[x_2](t)=[X_2]$,

$A=W([x_1](t)).W([x_2](t))$, $A_{dd}=A+I$;

While $A < A_{dd}$ **do**

$A_{dd}=A$;

For $i \in I$ **do**

$[b_{i,1}] = \sqrt{r^2 - ([x_2](t) - s_{i,2}(t))^2}$;

$[x_1](t) = [x_1](t) \cap [s_{i,1}(t) - b_{i,1}, s_{i,1}(t) + b_{i,1}]$;

$[b_{i,2}] = \sqrt{r^2 - ([x_1](t) - s_{i,1}(t))^2}$;

$[x_2](t) = [x_2](t) \cap [s_{i,2}(t) - b_{i,2}, s_{i,2}(t) + b_{i,2}]$;

End

$A = W([x_1](t)).W([x_2](t))$;

End

SIMULATION ANALYSIS

The selection of the cluster by the nodes and the attributes for the selection of cluster head is very important and a hot topic among the researchers. The different factors for clustering techniques. The important factors that contribute towards the formation of a clustering technique include the Network model, Clustering objectives and Clustering attributes. The network

model consists of the architecture and design of the underlying sensor network. There can be further sub factors in network model. First is the network dynamics like the node, cluster head and base station can be static or mobile. The sensor nodes are static normally with a few exceptions, the mobility of cluster head or base station can cause serious problems in clustering process. The events sensed by the nodes can be irregular or continual depending on the situation, and effect in selection of reactive or adaptive clustering. Second is the in-network data processing. The sensor nodes in the same area can generate a lot of redundant data, so there is need for techniques like data aggregation and fusion to eliminate this redundancy. Third one is the node deployment and node features. The nodes can be deployed manually or randomly.

In the first case, routing becomes easier as all routes are predefined. Whereas, the nodes self-organize in case of random deployment, so the clustering process is difficult and thought consuming. The nodes can have different features and selection of proper nodes for the application, the selection of cluster head nodes is also of importance in the clustering process. The clustering objectives vary a great deal from application to application. Different objectives of clustering include the following: load balancing is needed in clustering to divide and allocate the work load among different nodes in the cluster. Fault tolerance is especially required in the networks where the nodes are placed in harsh locations, the nodes are more prone to failures and hence efficient fault tolerance mechanisms are desirable. Improved connectivity and reduced delay is also a desirable feature. The cluster heads usually remain interconnected with few exceptions, so that timely information without much delay keeps flowing through the network. Another objective in clustering is the minimal cluster count, especially when the sensor nodes are resource rich and big sized, there is need to keep the cluster count to the minimum. The prime objective of clustering is the energy efficient use of the scarce node resources, to achieve the maximum network lifetime. Clustering attributes are the factors on the basis of which different clustering algorithms can be classified. These can be broadly the cluster properties, cluster head capabilities and clustering process. The cluster properties include cluster count i.e. the number of clusters can be pre-fixed or variable, the stability of the clusters formed can be provisioned or assumed, intra-cluster topology i.e. the communication between the sensor nodes and the cluster head can be direct link or multi-hop and inter-cluster head connectivity which is required when the cluster head does not have direct communication capacity with the BS, so it has to be connected with other cluster heads in the network. Cluster head capabilities include: it can be static or mobile, in case it is mobile the clusters are formed dynamically and cause problems. The cluster head can either be sane as a member sensor node or may be a node with more computation and energy resources.

The role of cluster head can be simple forwarding of the data received from sensor nodes or they can perform data aggregation and fusion function, while sometimes it can also act as BS. Clustering process and characteristics of different clustering algorithms presented in literature vary a great deal. The methodology of clustering process can be distributed, centralized or hybrid of the earlier two approaches. The objectives of clustering as discussed earlier include load

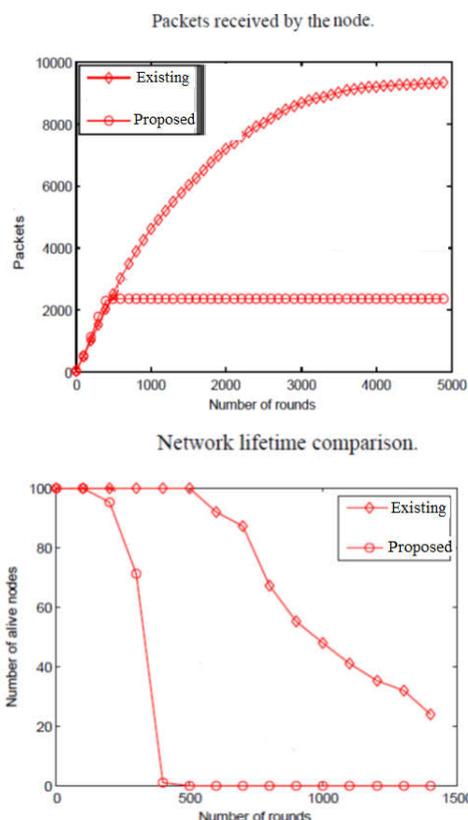
balancing, fault tolerance, increased connectivity and reduced delay, minimal cluster count and maximal network lifetime.

Table 1. Simulation parameters

Table 1. Simulation parameters.		
Simulation Parameters	Representation	Unit
N	Number of sensor nodes	100
E_0	Initial energy of sensor nodes	0.2 J
E_{DA}	Data aggregation	5 nJ/bit/signal
E_{elec}	Energy dissipation to run the radio device	50 nJ/bit
ϵ_{fs}	Free space model of transmitter amplifier	10 pJ/bit/m ²
ϵ_{mp}	Multi-path model of transmitter amplifier	0.0013 pJ/bit/m ²
l	Packet length	4,000 bits
d_0	Distance threshold	$\sqrt{\epsilon_{fs}/\epsilon_{mp}}$ m

Comparison Analysis

Ant colony optimization ACO due to its distributed nature becomes alternate to GA, in order to determine the optimal route it needs that the base station already has the required information. For fusion process neural networks are well suited because neural networks can learn and dynamically adapt to the changing scenarios. Reinforcement learning is fully distributed and it can adapt quickly to network topology change or any node failure. It has been used efficiently for finding the optimal path for aggregation. GAF based distributed approach using sleep state switching numbers and weighted average operators to perform energy efficient flooding-based aggregation has also been proposed and the system outperforms the previous results. In wireless sensor networks many situations demand aggregating data at a central node e.g. monitoring events.



In fixed sink node networks, as sinks are always away from sources, the transmission paths from areas of interest to a sink node often form certain multihop routing paths. However, in this kind of routing path, the sensors close to the sink exhaust

their energy very fast. In the calculation, sensors nodes located the furthest from the sink have 90% residual energy when the one-hop neighbor nodes drain their energy out. Finally, this uneven energy consumption will lead to energy holes, area isolation, high transmission latency, and data inaccuracy. With the aim to improve network performance, recent research has exploited mobile sinks. By introducing mobile sinks into sensor networks, optimization of energy efficiency, lifetime, and peer-to-peer delay can be achieved. Besides, with implemented mobile sinks, network isolation can be effectively mitigated. To realize mobile sinks in real-world implementation, special devices like gateways can be attached on taxis, animals, and humans. In this paper, one mobile sink with a trajectory along the central line of a rectangular region is proposed.

In real-world implementation, there is a chance that a mobile sink cannot move along the original trajectory due to some blocks ahead. In this scenario, a suboptimal trajectory should be established immediately. For instance, if a barrier blocks part of the trajectory and holds-up the mobile sink from moving on, the main idea of our solution is to make a cross-over. Once the mobile sink discovers the block ahead, it will soon scan from left to right and choose a direction with no barrier. A mobile sink moves on with previously stated method, however in every round the chosen direction should with the priority of moving back to the original trajectory. In the meantime, the location of the mobile sink should be updated to every sensor node.

Conclusion

This paper, evaluated the performance of network lifetime maximization in cross layered WSN and Interference tolerant transmission, where nodes in a sending cluster are synchronized to communicate a packet to nodes in a receiving cluster using Ant Colony Optimization. In this communication model, the power of the received signal at each node of the receiving cluster is a sum of the powers of the transmitted independent signals of the nodes in the sending cluster. The increased power of the received signal, leads to overall saving in network energy and to end-to-end robustness to data loss.

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