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# Design and Implementation of a Protocol Based on Heuristic Algorithm to Routing Optimizing in Wireless Sensor Networks

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## ABSTRACT

The Wireless Sensor Network is a special type of ad hoc networks that due to their versatile including control over their physical environment, used in military and medical industries have attracted the attention of many researchers to itself.

Among the controversial challenges in such networks is delay of data delivery. The routing protocol proposed in this paper that is combination of directed diffusion and ant colony optimization method, to meet requirement listed, is designed and implement in two phase. In the first phase, Sink send a message to one´s hop of his, and them repeat this to latest node in the network. In this phase, the nodes are segmented and know his forward´s neighbors. In the second phase, nodes to find optimum route based on information that get them in previous phase, send forward ant to destination and in destination, from the path that found some of them that are more competence chosen using Genetic Algorithm. Then backward ants update pheromone of optimum routes to do routing via them. As we will see in the following this protocol provides better performance than many existing protocol in term of delay and energy efficiency.

**KEYWORDS**: wireless sensor network, routing, heuristic algorithm.

## 1. INTRODUCTION

Recently, new versions of networks introduced as wireless sensor networks. These networks contain some independent nodes, usually supplied by a battery. And communicate with physical environment via sensing and environment control parameters. Because of flexibility, these networks got important as critical tools of engineering and research. Thus, there isn't significant set of requirements in order to classify wireless sensor networks.

Due to features and specific structures of these networks like self-organizing and easy maintenance and carefree feature they are very popular. Due to complicated structure of wireless sensor networks, routing is one the big issues of this field. In this paper, routing of these networks was studied and it was attempt to deliver a routing protocol result in long life of network.

In wireless sensor networks, usually data belong to nodes must be delivered in specific destination called sink. Thus, data traffic always directly forward to sink. In the other words, due to limitations of nodes, usually each node data never delivered to sink directly. Thus, these nodes must deliver their data to sinks via nodes called intermediate nodes which direct and routed the data. Thus, intermediate nodes must be selected do that the packet destination with the minimum steps. This makes the data are delivered to the destination with low delay [9].

Most algorithms that aim to minimize the delay choose the shortest route to reach the sink. The problem of these algorithms is, the chosen shortest path for data delivery to sink, might not be a minimum energy cost route [2]. Some of other protocols concentrate on increasing network life time and balancing energy consumption and instead of choosing shortest path, select the nodes with highest energy that in this situation delay of data delivery is increased [3]. Some of protocols use geographical information of nodes to send data via shortest route to the sink [11]. In some of protocol such [5] and [6], sink send a query to network and nodes of network response to this query according data that sense form environment. Ant colony optimization technique is an approach that many of routing protocols use that for optimized routing. Examples of protocols that use this technique are present in [1], [4], [7], [8] and [10].

This paper presents an algorithm that between routes with minimum hop-count, selects the route that has maximum energy. Due to this, data delivered to sink with minimum delay on one hand and energy consumption is balanced and network lifetime is increased on the other hand.

The rest of the paper is organized as follows. Section 2 describes the materials and motivation for this work. In Section 3, we describe our proposed method. In section 4 simulation results have been shown and finally the conclusions have been given in section 5.

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## 2. MATERIALS

In Directed Diffusion protocol [5], sink sent a request toward within network nodes in order to receive required data. During propagation in network, this request learn the return route and deliver its data to sink through learned route of previous phase after receiving data from predetermined nodes. In other hand, in one of the other protocols called ACLR which acts as ant approach, whenever anode contain a data to send to destination, it sent it in multi routes to sink [8].The packet which reaches sooner than others to destination was returned to the transmitter node and updated intermediate nodes pheromone in return route. In this protocol, Intermediate node which located in shorter route to destination, receives more pheromone, and become candidate in next stage. In addition to shorter route, nodes energy is the other main criteria.

## 3. Proposed algorithm

Proposed method combined from above mentioned protocols which besides to positive features, also address topology diversity and nodes replacement and act so that nodes recognize their place network after replacement and continue their operation. This method called wireless sensor networks-distributed ant colony contain two phases. In first phase, nodes learn their position to sink and recognize forward neighbors. And in second phase, optimal routes identified based on their data and data routing to destination done via nodes energy and position. Thus, whenever, the node has data to send, if there is authorizes route to destination, send its data via the route. Otherwise, it was sent packets as forward ants in order to find optimal routes via its closer neighbors to destinations and send data to sink. Whenever a FANT reach to a node, if the node has authorized route to destination, the node send a BANT packet to a node which request for route. The optimal route is the one which created already. If nodes which receive FANT don't have authorized route to destination direct this packet to destination. This job continues until ant reach to the sink. Forward ants through their way to destinations collect the energy of all intermediate nodes. Some chromosomes created for routes forward ants come through after arrival of the forward nodes. These chromosomes contain some special gens depend on the nodes of what area they come from.

For example if an ant comes from k area, because it cross k-1 intermediate node then created chromosome in destination contains k-1 gens. Composed chromosome structure are as follow in the time forward ants reach to destination, each gen is the rate of intermediate nodes.

| **1thstep node number** | **2th step node number** | **….** | **Nth step node number** |
|---|---|---|---|
| **1th step energy** | 2th step node energy | ….. | Nth step node energy |

Figure1:Created chromosomes structure by reaching FANT.

Then using genetic algorithms and define fitness function as follow, computed chromosome fitness and optimal routes were recognized. In following function, because forward ants reach to destination via shortest route, number of movement steps was not addressed as a function parameters and intermediate nodes energy supposed as the only parameter of this function.

$$F(e) = \sum_{i=1}^{k-1} e_i \qquad (1)$$

Where, $e_i$ is the ith energy rate of the nodes in forward ant routes to destination. Due to forward ants which go to destination from a specific node, there are different choices in order to select as next step and this trend continues in following steps. Number of forward ants from special node might be n thus they are the original populations of the n chromosomes. Then half of initial population was selected for next generation using roulette wheel. In this algorithm, due to importance of sequence of intermediate nodes or in fact gens of chromosomes in order to make a route, it's difficult to use mutation and crossover integers. The above mentioned operation repeated until number of remaining chromosomes equal with number of node area which forward ants reached from. This job was done in order to maintain protocol multi routes features. In fact, for each node, there are number of optimal routes to destination equal with number of their area. Then, chromosomes contain optimal routes, returned to requested node in form of backward ant k. BANTs in the way back to requested node, deliver optimal recognized routes to intermediate nodes.

After return of backward ants to requested nodes, recognized routes registered in routing table of addressed node to send data toward destination through them. By arrival of backward nodes and registration of routes, their long life also added to routing table, so that after the routes life time termination, the node start to search to find new routes. Due to multiple routes of each node to send data to destination, after forwarding some packets from a route, other data forward through another routes to make balance in distribution network and prevent repeated usage of nodes exists in one special route.

Operation of first phase in order to recognize nodes place and their zoning are as follow:

1. Sink sends hello message to its one-hop nodes.

2. Nodes in one-hop distance neighbors of sink equalize their area with a special value. The value of this area number is equal for all one-hop nodes. One-hop nodes then send the message to two-hop nodes of sink.

3. Two-hop nodes of sink after receiving the message increase the number of the area one unit higher and assign it as their own numbers and repeat the previous step operation.

4. If a node receives the message from several nodes closer to sink, it assign the value due to the first message, but assign other received messages as neighbor in table of its neighbors.

5. This operation goes on until all nodes composing the network identify their area.

One-hop nodes of the sink assign number 1 to themselves as received the message from the sink, then these nodes send similar messages to all neighbor nodes without area number. Following figure shows this step. Green nodes assign 1 as their area numbers and forward the message to nodes away from sink.

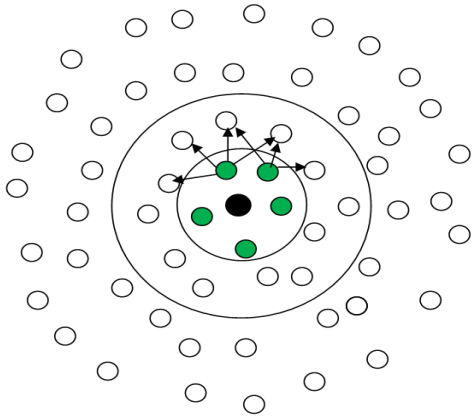

Figure2: Sending message from one-hop neighbors of sink to two-hop neighbors.

As seen in above figure, two-hop nodes of sink assign number2 as their area number after receive the message. Message sending operation in other areas continues till all nodes of the network recognize their area numbers. Second phase operation related to finding optimal routes to sending data to sink are as follow:

1. Whenever a node have data to send to destination, study its area number and if its 1 immediately send it to the sink.
2. If a node study its area number and recognize it none the 1, it also study its routing table in order to find if there is route to send data.
3. Ifthe node have route in its routing table, send its data through the route.
4. If it found no route in the routing table, the node sends forward ants to destination. Forward ants find the optimal route and put it in their routing table.
5. Among identified routes, one of the routed was selected by the node in order to send data to destination.

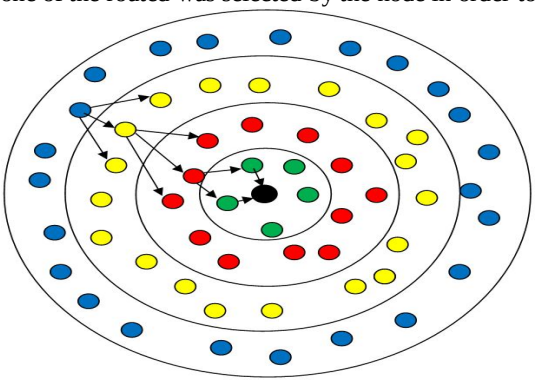

Figure3:FANT sending steps to find route toward destination.

When forward ants reach the sink, quality of the route crossed by ant was determined using genetic algorithm and a fitness function. Then in order to update route pheromone and in fact put the optimal routes in the routing tables of nodes, backward ants send from sink to requested nodes. Following figure shows the backward packet sending stages until reaching to the requested node.

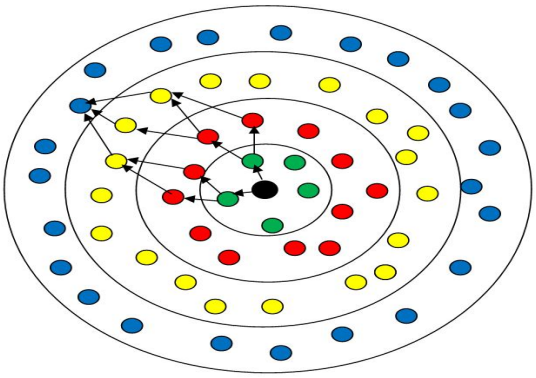

Figure4: BANT sending steps to requested node.

## 4. SIMULATION RESULTS

Some of the main metrics of the wireless sensor networks evaluated using NS2 simulation software. Obtained results of proposed method was evaluated and compared by one of the main protocols of Ad hoc network that is AODV.

**End to end delay**

One of the main needs of the computer networks is that all data of the network reach to destination at least delay. In most application that rapid delivery of data is not the main program, it's optimal that data delivered to destination at least delay.

In order to compute end to end delay it was measured the time spent to send data from source to destination.

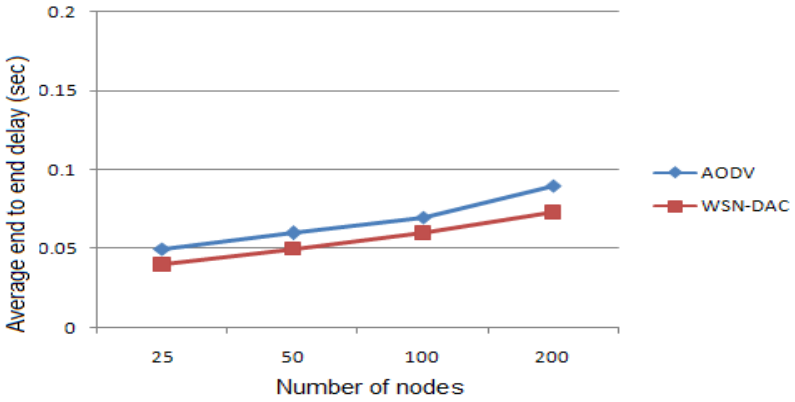


Figure5: average of end to end delay.

In proposed protocol, in order to deliver data to destination, nodes select another node as next step that is near to destination than themselves. In addition, the selected node has the highest rate of energy among all nodes. Then intermediate nodes send the data to destination through the shortest route that result in least delay in delivery of data in proposed protocol than other protocols.

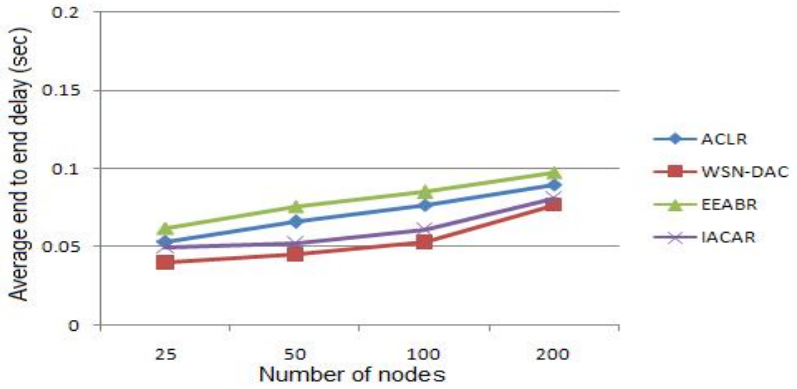


Figure6:Averageof end to end delay.

**Packet delivery rate to destination**

One of the other algorithm comparison measures is packet delivery rate to destination. It may not all sent data reach to destination because of many reasons. One of the main reasons is the wrong routing toward destination. In order to deliver the data to destination, it may data was given to a nodes which doesn't know any routes to destination and result in entrap in a circle,and due to short life long of packets, after passing some steps, packet life ended and it was removed from network. Due to the point that in proposed protocol, intermediate node have complex of neighbor nodes to give data to them, proposed model might be called multiple route protocol in which high percent of data reach to destination. Following figure shows the delivery rate of given packets.

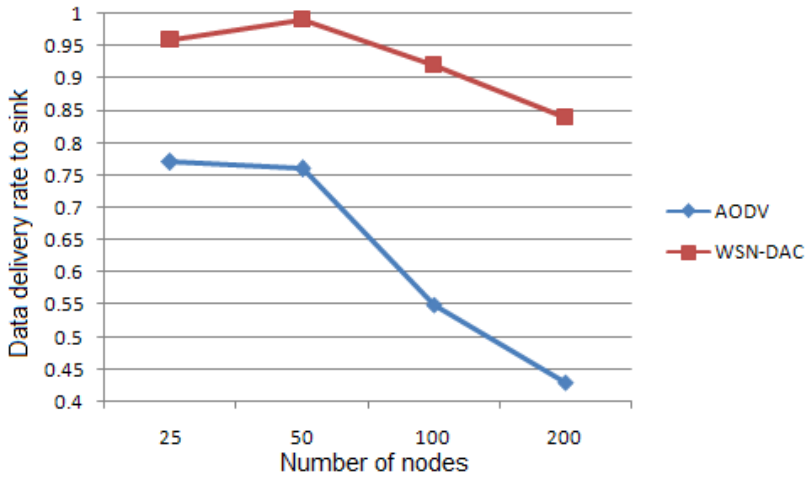


Figure7: Delivery rate of given packets with different node numbers.

**Network lifetime**

One of main goals of designing new protocol for wireless sensor networks is increasing network lifetime. In such networks, lifetime of network usually measured by destroying a percent of nodes. Due to in proposed protocol every time one node is selected, energy divide between nodes and accordingly network lifetime increased.

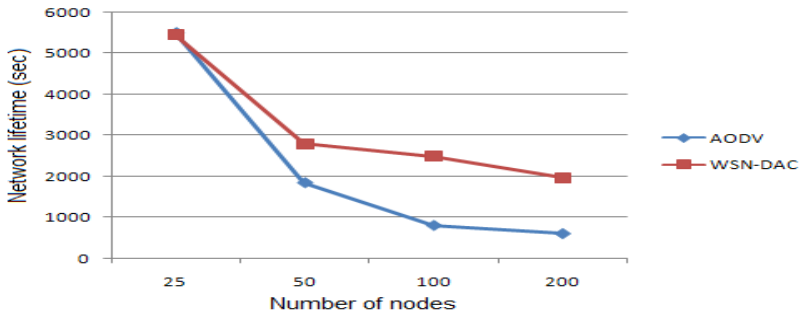


Figure8: Network lifetime.

In all modes, it was observed that the proposed protocol showed higher performance than AODV protocol.

## 5. Conclusion

In this paper, a new routing protocol based on ant approach and combination of multiple methods was introduced. In this protocol which designed in two phases, in the first phase of configuration, nodes specify their position in network due to their distance from sink and locate in anarea. In the second phase of data routing, each nodes sent forward ants to destination in order to find the optimal routes. After sending forward ants and reaching to destination, through information gathered by ants via energy rate of intermediate nodes and using genetic algorithms, optimal routes were found and delivered to intermediate to requested nodes via backward ants. Then routing and sending data to destination performed through found routes. Thus, this protocol not only delivers data with least delay and through shortest route to the sink, but also increases network life long. As seen before, proposed protocols in all modes showed better performance than AODV and other protocols based on ants.

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