# Offering New Routing Method in Ad hoc Networks Using Ant Colony Algorithm

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# Offering New Routing Method in Ad hoc Networks Using Ant colony algorithm

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***Abstract*—The aim of this study is to provide a novel method routing in ad hoc networks using ant colony algorithm. Hence for this study the researcher attempts to discover and create routes with less number of crossings, nodes sustainable and less energy transfer, to reduce latency end-to-end, save bandwidth and to extend the life and increase the lifetime of the network nodes. Research methodology for simulation algorithm has been OPNET software. Therefore, the proposed algorithm`s performance was comparedwith one of the most routing algorithms in mobile ad hoc networks AntHocNet. The results showed that the proposed algorithm compared with AntHocNet has more end-to-end delay, more package shipping, and less routing overhead can reduce energy consumption and thus increasesthe lifetime of the network nodes. The results of this study indicate that the latency end-to-end, saving bandwidth and increasing lifetime of nodes and network lifetime can be predicted by the proposed algorithm.**

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***Keywords* —ant colony algorithm, ad hoc networks, simulation, routing.**

## I. INTRODUCTION

Routing as one of the core activities in ad hoc networks plays a key role in function of network.Therefore, routing algorithms in such networks should be compatible with the topology changes and traffic conditions.To accomplish this goal, the network design algorithms in addition to the robustness must have the ability to work in a distributed manner. This property exists in self-organizing natural systems such as ant colony.Resistance and impacting of collectivebehavior of ant carriers due to changes in environmental conditions are one of key aspects of their success. Based on optimization methods of ant colony, autonomous agents in a distributed environment using local data and indirect interactions can be a solution to achieve a given problem. Since there are a lot of similarities between ad hoc networks and ant colony environment of a mobile ad hoc network such as non-structured environment which is dynamic and distributed. Colony-based routing algorithm of ants in comparison with other algorithms is more efficient, stronger, and more consistent with the changes and is able to discover several routes to one target.In mobile ad hoc networks due to special circumstances and limitations such as shortage of energy andbandwidth, routing targets can be different. In some algorithms only sending packets with the lowest latency is vital and in others, criteria for successful delivery of packet is to increase network lifetime through lower power consumption or less bandwidth consumption which is significant.However, the continuously varying traffic conditions and network topology require that the routing algorithm notice such goals. Targets routing network status can help improve route quality according to condition change of network [6].

In this paper, a multi-objective routing algorithm based on multiple colony of ants is proposed. In the several colonies of ants, several colonies of ants are working together to obtain the best answer. The algorithm can be run in two ways:

Homogeneous and heterogeneous. In heterogeneous method each colony has a different behavior to other one. This method is used for solving multi-objective optimization problems where each colony is used to optimize each cluster with a different optimization criteria. In implementation of homogeneous, all colonies work together in parallel to optimize a same goal attempt. So far many algorithms were presented to solve multi-objectiveproblems such as colporteur in multi-colony method. Hence for route ad hoc network, our algorithm is the first one which uses heterogeneous colonies to support several different goals [5].

In the proposed algorithm there are three colonies withthree different colonies:

1) The least number of crossings
2) The most stable connection
3) The least energy consumption for transmitting to find the best route.

Each colony to obtain the best tracks only uses one of the goals. Sustainability of a node can be specified on the basis of level of participation. Since the probability of failure of routes including more sustainable nodes is less, selecting them as the optimal route can reduce the frequency of process of discovering route. Parameter of the leastenergy transfer is the amount of energy required to move from one node to the next. The less energy, the less energy consumption and consequently the lifetime of the network increases. Parameter of number of crossings is less and it can also find the shortest route. At each node, there is one factor that will decide when sending data packets in terms of condition available in order to use the right parameter to determine the optimal path [5]. Other elements of the algorithm, is exchange of information amongclones. At regular intervals, colony shares its information to have focus on promising areas of search space.

Thus, the possibility of finding routing with more quality increases. Another feature of the proposed algorithm is its combination which uses both active and passive components to be able to address the specific challenges of mobile ad hoc networks. This method is passive and nodes seek to collect routing to destinations that are currently active and communicate with them because by the time connection continues, the nodes maintain routing information and modify it. The algorithm uses a two-stage discovery and maintenance. In the discovery phase the mechanism is passive and carrier ants which are called passive forward ants start moving through source to find several paths and then return to source to establish paths.Directions are defined by local tables of pheromonesin nodes. In each node, there is one pheromonestable corresponding to each target.After making paths, data packets randomly select one of these paths. During data transmission, the path should be monitored, maintained and if possible improved. This is done by active ants ahead. When the path faces failure, local modifier ants are used to modify the route [4]

In addition, each of the detailed characteristics of the proposed algorithm are explained:

### *A. Model of Node Swapping*

Displacement models to describe the movement patterns of mobile nodes and changes of place, speed and their accelerations are designed in terms of timing. These models are four groups:

1) Random models
2) Models with time dependence
3) Models with spatial dependency
4) Models with geographical restrictions.

In this simulation Random Waypoint Model (RWP) was used [3].

### *B. Energy Model*

The process supervises energy consumption of a wireless node over time. At first, user Specifies primary energy amount for each node and the energy is consumed given to three operating modes of unemployment, packet transmission and package reception [3].

### *C. Selection Process of Routing Objective*

In the proposed algorithm, three different objectives are prioritized to optimize. When you run the discovery process route,decision is made on type of goal according to which routing that must be done. The remaining energy of nodes, crowding of current nodes, packet delivery ratio and routing overhead in the network are parameters that the decisions are made based on them.One of the decisions is residual energy node. If rate of decline in energy is high, then paths with minimum transmission energy must be selected. Thus, node lifetime and therefore the lifetime of the network increases. Current congestion in queue of nodes represents current congestion in the node. If congestion is high, or coefficient of delivering packages is low, then paths with less crossings must be selected, Then latency of end-to-end is reduced and packages are serviced in the least possible time. Network routing overhead is another parameter that plays a key role in selecting routing goal.The parameter is achieved by dividing total routing packages by data package which is delivered to target successfully and internal efficiency of the algorithm is assessed. One of the reasons for the increase of routing overhead is repeated execution of discovering route. In networks where speed is high, directions persistently can`t findroute discovery process. Therefore, we need to choose routes that are more stable and less likely to break down. If the current state of the source of node is ordinary, target routing is randomly selected [1].

### *D. Route discovery process*

The process of route discovery is a mechanism that enables us to obtain one or more routes from the source node in order to send data packages.When the source node S sends a package to target destination d, selection process aims at routing specifies route given to current state of network. If the path exists with this feature, data package is sent to target. Otherwise, the route discovery process should be done. In order to perform route discovery process, source node broadcasts one passive forward ant to all the adjacent nodes. The goal of ant is to find a path in which process of goal selection is specified. In each intermediate node, if there is information related to pheromonesthen we will face unicast Ant and otherwisebroadcasting (Donner et al, 2013, 119).

### *E. Random routing data*

In the contact phase, multiple paths were created from the source node to target and placed on tables pheromones. Then, the data according to the values in the routing tables were routed in pheromones. In each node, if there are several pathways to the destination d, one of them israndomly selected with probability Pnd. Pnd is achieved using Equation( 1).The difference is that α is higher than this part to increase the possibility of better routes. Using possible selection strategy several routes may be selectedautomatically for sending packages. And data load broadcast on each path is according to its quality. If table information is kept up to date, this strategy results in a load balancing(Donner et al., 2013: 119)

$$P_{nd} = \frac{\left(T_{nd}^{if}\right)^{\alpha}\left(\frac{1}{V_n}+\frac{1}{dist_{in}}+\frac{1}{E_{initial}-E_n}\right)^{\beta}}{\sum_{j\in N_d^i}\left(T_{jd}^{if}\right)^{\alpha}\left(\frac{1}{V_j}+\frac{1}{dist_{ij}}+\frac{1}{E_{initial}-E_j}\right)^{\beta}} \quad \alpha,\beta\geq 1 \tag{1}$$

### *F. Route Maintenance Phase*

During data transmission, the source node uses proactive forward to maintainthe route.

These factors are sent in terms of rate of sending data.(one factor for each n data package)

Ants areusuallybroadcast one by one and seek to calculate next crossing based on pheromone values and using the formula (1). But there is a small possibility too in which ants are broadcast in each node.(This probability is usually considered 0.1 ). Two goals are followed. If forward ant passes total path without even one broadcasting, in fact it samples path available and can update the information. If ant is broadcast, new paths will be discovered [2].

### *G. Failure to Connect*

In this algorithm, each node tries to keep information about adjacent nodesup-to-date at any moment to identify connection failures ASAP before it leads to transmission errors or package loss.Presence of a neighboring node is approved with one Hello message and if there is no message at a specified interval, it is assumed that the new node is disappeared [2].

### *H. Exchange of Information Among Colonies*

In the proposed algorithm, there are three different colonies that exchange information incertain intervals. Information exchange increasesthe possibility of exploring promising clones in the search space and it also increases the quality of path, therefore we need to maintain colonies ability in exploring new areas. The effort for calculation should not focus on one searching sector only. To achieve these two objectives and for balancing them,colonies use communication policy specifying type of information exchanged, the exchange time and colonies that exchange. The more communication, the more equal answers by all colonies. Meantime, algorithms are calculated more.Thus, we have a problem of multi-objective problem which is reduced to a single goal [6].

## II. Methodology

In this study, using simulation results, the performance of the algorithm is compared with one of the most prominent routing algorithms in mobile ad hoc networks AntHocNet.

### A. Simulation

To simulate the proposed algorithm simulation software OPNET version 14 is used and all tests were done based on basic adjustment. In this setting, 100 nodes were randomly placed in an environment with dimensions of 3000 * 1000 square meters. Each test runs about 900 seconds. 20 source nodes deal with data traffic generation source node with rate of 1 bps. Each source starts simulation from random timing between zero and 180 seconds after the beginning of the simulation and continues this by the end of simulation platform. There are 64-bit data packets. In layer MAC, IEEE 802.11 protocol is used andpropagationofradiowavesis300 meters.

RWP mobility model follows the movement model of RWP which has two adjustable parameters of speed and duration of stop for each node. In this study, the effects of increased mobility nodes, network size and turnover of human informed on algorithm function are addressed. Evaluation of algorithm is in terms of end-to-end average delay per packet and packet delivery coefficient. There two criteria are the most important criteria for evaluation criteria of routing algorithm in ad hoc networks.Also, the two other criteria of averageresidualenergynodeand routing overhead are used for evaluation.Routing overhead internal measures internal performance of algorithm and it is obtained by dividingtotal number of control packets sent on the number of packages that were successfully delivered. This criteria is significant regarding networks with limited bandwidth or their power is provided throughbattery. In order to address impact of information exchange among colonies in quality of obtained solution, two strategies of proposed algorithm without information exchange (Proposed Alg.NIE) and proposed algorithm with information exchange (Proposed Alg.IE)was applied in the algorithm suggested and its function is compared with each other and with AntHoccNet.

RWP model was applied to simulate the dynamics of nodes used. The speed of movement of each node in each random time was set between minimum and maximum amount. In these tests, the stop time of 50 seconds was considered. Minimum speed iszero meter per second and the maximum changes it step by step incremental 10 meters per second and up to 50 meters per second. Tests have been conducted for the proposed algorithm and AntHocNet. Each test was repeated ten times with random values and the average results were calculated. In the proposed algorithm, the exchange of information through parameter can be set in formula (2).

In order to investigate the effect of exchange of information on the performance of the algorithm, learning coefficient y changes in two various tests from zero to one in incremental step-by-step mode 0.3.

In these trials, 50 nodes were randomly placed in an environment with dimensions of 500 * 1000 square metersand 20 source nodes deal with generation of data traffic with constant bit rate. In the first test, the maximum movement speed of nodes is equal to 10 meters per second, and then in the second test, the movement level of nodes increases to 40 meters per second.

Each test is repeated 10 times with different random values and the mean results are calculated. Test execution time of each is 900seconds.

$$\tau_{nd}^{if(j+1)mod\ 3} = (1-\gamma)\tau_{nd}^{if(j+1)mod\ 3} + \gamma\tau_{nd}^{if\ j\ mod\ 3}, \gamma \in [0,1]$$
(2)

## III. Findings

### A. Node Movement Responses

The findings showed that high-speed packet delivery ratio does not have an impact in high speeds, since in high speeds process of discovering route occurs more. So credit of available routes is more and the possibility of packet transmission will be less. Fig 1

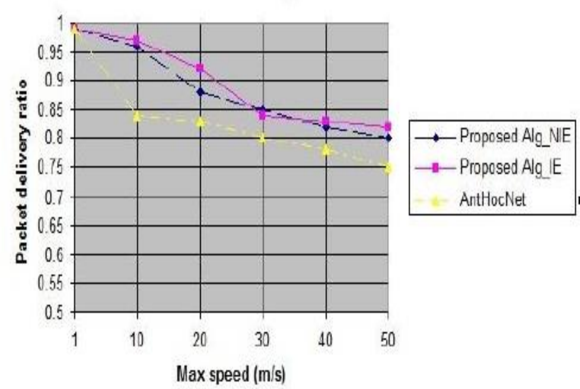


Fig 1, packet delivery ratio at different speeds

Results also show that the proposed algorithm compared with AntHocNethas more end-to-end average delay. In the proposed algorithms, increasing the dynamics of the nodes causes the decision-making to select more stable routes and the stable routesare not necessarily stable (see Fig 2). The routingoverhead rate in algorithms offered is much less than other algorithm. Fig3.

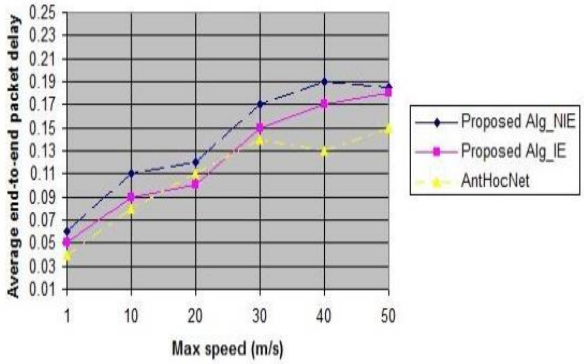


Fig 2. End-to-end delay average in maximum different speeds

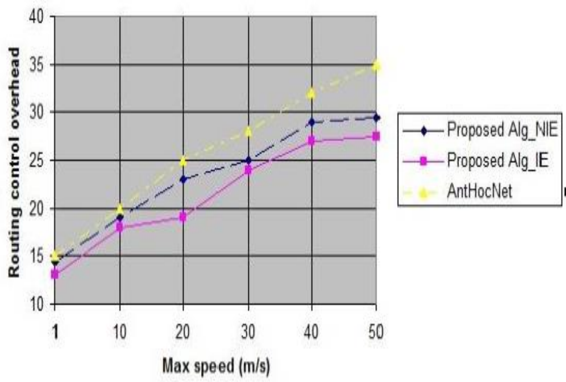


Fig 3.Monitoring overhead of routing in maximum different speeds

### *B. Response to changes in network size*

Forms (4), (5), (6) and (7) show the proposed algorithm performance compared with AntHocNet.Algorithms suggested can increase packet delivery ratio by development of network and can also reduce routing overhead. This function shows algorithm extensibility.

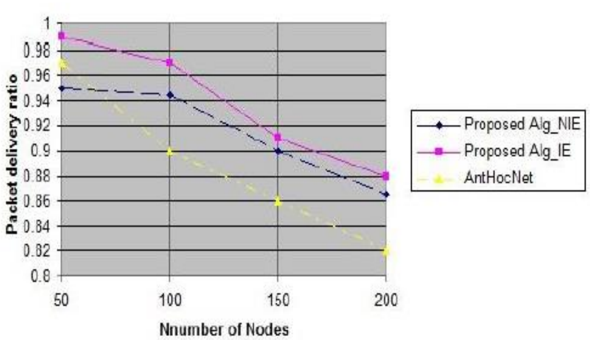


Fig 4. Packet delivery coefficient in networks with various sizes

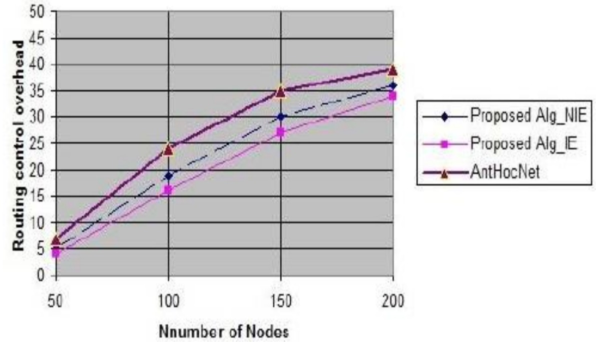


Fig 5. Monitored routing overhead in networks with various sizes

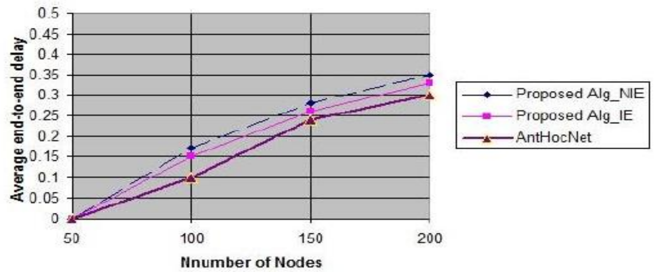


Fig 6. End-to-end delay average

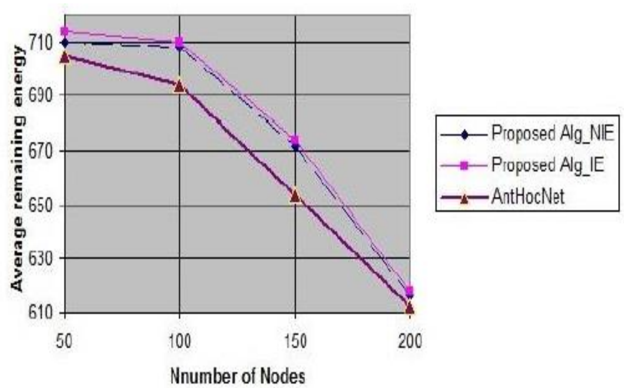


Fig 7. average energy left in nodes in networks wit various sizes

### *C. Responding to the exchange of information*

The results show that the lowest coefficient of packet delivery happens in an independent and parallel implementation of ClooniesY = 0 and when adjacent colony response vector replaces current colony response Y = 1.

In $0.3 \leq \gamma \leq 0.9$ mode with rise ofexchange of information among colonies on the quality routes obtained, more number of packages are delivered to destination. Fig 8.

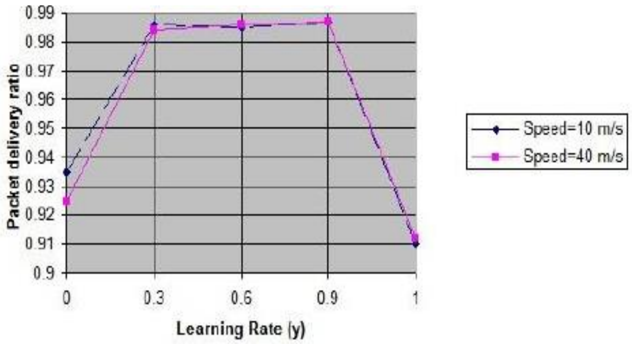


Fig 8. Effect of learning coefficient on packet delivery coefficient

The findings also show that the exchange of information in much movements of nodes can significantly reduce routing overhead rate and average end-to-end delay and can increaseaverage residual energy of nodes. Fig 9, 10 and 11

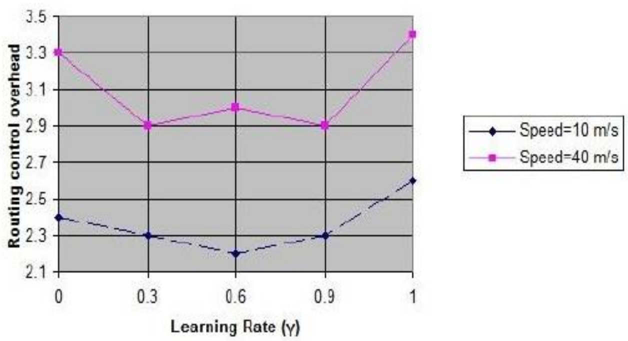


Fig 9. Effect of learning coefficient on routing overhead rate

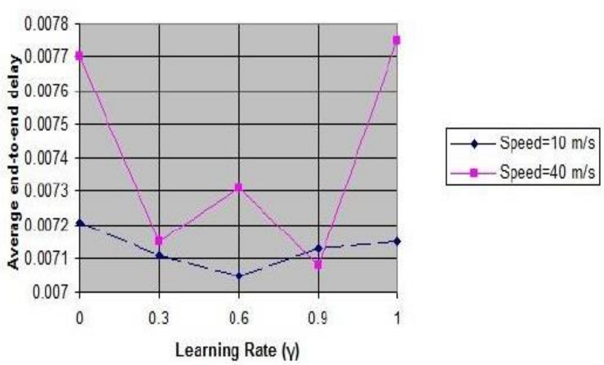


Fig 10 Effect of learning coefficient on average end-to-end delay

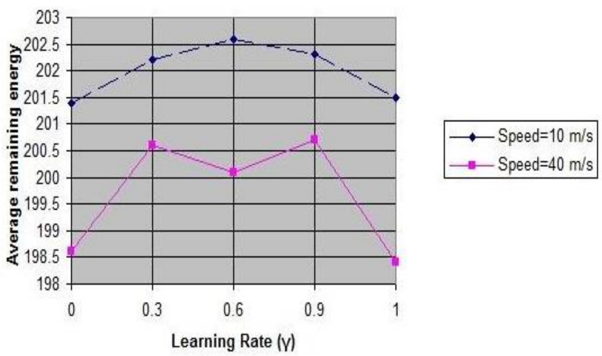


Fig 11. Effect of learning coefficient on average residual energy of nodes

## IV. CONCLUSION

The purpose of this research, was presentation and evaluation of a routing algorithm based on colony optimization method. Hence at first there was a review of existing routing algorithms in ad hoc network and the strengths and weaknesses of each were reviewed. Then mass intelligent technique was introduced indicating that this technique and in particular ant colony optimization can be fine for using in self-motivated routing algorithms because there are many similarities with the ad hoc networks. Charisma of optimization method is based on ant colonies in self-motivated ad hoc routing algorithms and it was approved with several routing protocols which applied this technique. Nearly in all tasks introduced more appropriate function was reported compared to other methods. Then, a new algorithm based on ant colony optimization and consistent with current changes of network were presented. The proposed algorithm is a hybrid algorithm of active and passive elements.In this algorithm routing is done based on the current situation. For this purpose, a decision-making function is added to algorithm, which selects target according to network conditions routing. The purpose of routing can be one of three parameters of crossing, node consistency and minimum energy transmission. Corresponding to each target there exists a clone and a table which maintains information of route for each goal.For better function of algorithm, colonies exchange information of pheromones in regular intervals. Using directional ring topology, each cluster colony transfers answer related to each goal colony in pheromones table for next one in circle so that new solutions will be based on exploring the next colony. In order to evaluate algorithm function the proposed algorithm became one of the most important self-motivated routing algorithms which was based on ant colony optimization AntHocNet.The results show that using multi-colony and routing target selection based on the current state of the network can be effective in improving performance routing algorithms. Topology is constantly changing in mobile ad hoc networks and on the other hand, energy nodes are restricted, so in this algorithm there was an effort to be notice condition and network limitations in selecting optimized routes. The proposed algorithm can have betterfunction compared to AntHocNet during delivering data package successfully, reducing route overhead and increasing energy left from nodes.

In this algorithm ant colony algorithm-based optimization method was used for routing. In ant colony optimization decision is made for choosing next crossing based on pheromones anddiscovering information and parameters $\alpha$and$\beta$ determine their significance level. Fine algorithm function depends on determining the exact performance. For improved performance, future works can deal with effect of these parameters. Also, the exchange of information in multi-colony methods happens using various topologies at regular intervals. Topology and policy information exchange can be effective in improving function. Therefore, in future work we can revieweffect of selecting any one of these topologies and the different timing of exchange of information among clones examined.

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