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The Routing Control in Mobile Ad hoc Network Using Intelligent Optimization Algorithms

Khulood Moosa Omran
Electrical Engineering department
University of Basrah
Basrah, Iraq
khuloodmo@yahoo.com

***Abstract*—MANET (Mobile Ad hoc Network) made up of a combination of nodes that are randomly moving with a certain speed in any direction without relying on the communication infrastructure. It is useful for creating a low-cost network and communication during a disaster and to avoid the failure of communication. It is necessary to improve many of the criteria metrics that affect performance. In the traditional the protocol of routing AODV (Ad hoc On-Demand Distance Vector), the data packets are sent toward the adjacent node only by the shortest path method and cannot meet the multi-objective approach. This article utilized the FOA (Fruit fly Optimized Algorithm) to control the problem and find a suitable routing instead of the shortest method. The results found is compared with the particle swarm optimization (PSO) approach and traditional AODV routing protocol, the proposed (FOA) method offers the fastest and most accurate pathway. The numerical simulations indicate that the suggested approach achieved better performances in the case of delay time and improve the efficiency of the system.**

***Keywords*— AODV, MANET, PSO, FOA**

I. Introduction

MANET is one of the wireless communications fields, which consists of a set of mobile nodes or a collection of communicated devices without using a specified and central infrastructure [1]. This type of network has many research interests for use in the military field and in emergency and natural disasters, these networks need to implement routing protocols that ensure that messages reach the desired destination and achieve the goal of the application. In this paper, it was expanded a dissection of the routing performance for a number of the most important routing protocols used in these networks, namely AODV, Quality of Servic**e** (QoS). Static routing protocols don't give efficiently achievements when it works in the dynamic environment of MANET networks. So, the requirement of dynamic routing protocols is needed. The key purpose is finding the better route which can provide the various requirement of QoS constraint. This analysis relies on distinct elements such as PDR (packet delivery ratio), the throughput of data sent and E2E (end-to-end) delay to reach the best protocol that can be used if the network is low density [2].To achieve this purpose the fruit fly algorithm (FOA) was proposed and it was used to simulate in Mat lab program, the simulation results obtained for classical AODV, PSO and the proposed FOA methods and by analyzing and comparing these protocols at different low -density nodes it was found that the FOA protocol is the best among the protocols studied within the conditions specified in this study.

II. Literature Review

Several researchers have investigated algorithms for routing protocols in MANET to find the suitable route between nodes of wireless linked. The authors in [3] study the performance and efficiency of MANET Network and it has been improved by integrating the heuristic approach with AODV. The simulated was under a different node condition. The work yields better results compared to the ACO and GA models. In [4] the authors proposed a genetic algorithm that finds the optimal path between nodes in MANET, using NS2 network simulation and the NAM tool based on two different routing methods conventional AODV and GA that yielded better results.

In [5] a comparative study between DSDV, AODV and DSR is achieved. The study focused on proposing an extension of classic routing protocols that would be preferable in the form of safety, the productivity of network, the effective utilized of restricted purses, and the service quality. In the study of [6], Another interesting article is to be proposed where the authors tested and compared the multiple routing of Ad hoc protocols that included the OLSR protocol, the DSDV protocol, the AODV protocol, DSR, protocol ZRP protocol and TORA protocol, which were capable to work in an efficient manner. Then the study of [7] included the classified of the MANET routing protocols as proactive, interactive, and hybrid protocols. The study of the simulation was done to find a comparison between the rendering of two routing protocols DSR protocol and AODV protocol on demand and the single routing protocol DSDV gave by utilizing a performance table with different parameters.

In this article, the approach of Fruit Fly was proposed and accomplished to deal with the case of optimized routing for the MANET network from the deliver node toward the node of destination. It included study the influence of the nodes of mobile and its random movement in the MANET network. The performance comparison of the proposed protocols such as PSO-AODV and traditional AODV would be made on the base of quantitative measures, which included the throughput of data packets, (PDR) packet delivery ratio and the delay of time.

III. ROUTING

The Internet is a very large network that connects to the entire world so that it is not possible to know the location of all the links to all computers connected. The routing specifies the communication path from the message transmitting station to the receiving station. In an ad hoc wireless network, each node may move or be unable to connect, and the connection path may suddenly be interrupted. It is necessary to design a routing protocol that can handle these dynamic changes [8]. Computer networks use the information to arrange data destinations (packets) that are continuously transmitted. It is called the routing table. It is utilized to record the routes for each node, and it includes the transfer destinations that are used to send the deliver packets to destinations nodes. If the data packet reaches its target node, it will receive it while it is directed to itself, but with the routing table is routes and it refers to the adjacent nodes for the destination node. This is called routing as illustrated in Figure 1. To send the package from node A to node E, utilizing the table of routing for the node A, the node E will send to destination node D, so that the package is sent to node D. then in the routing table for the node D, it is included a destination E which will be sent to node E, so the package is received in node E because the destination is the same. So, the packet will successfully receive to the destination node E. This is the "routing protocol" role. In the MANET network, the nodes move frequently, the links may continue and stop, and the nodes may stop suddenly. Since the protocol of optimal routing changes depending on the different variations of environment included the characteristics of node movement and the frequency of nodes.

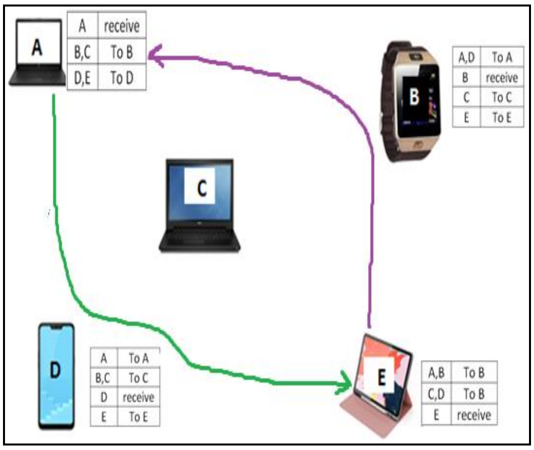

Fig.1. Routing illustration.

IV. AD HOC ON-DEMAND DISTANCE VECTOR (AODV)

It is one of MANET's most popular routing algorithms and it is an interactive type routing protocol that only specifies paths upon request. The basic strategy is as follows [10]: The node that wants to send a transmission request is transferred to all neighboring nodes. The node receiving the transfer request redirects it one by one and eventually arrived the target node. The target node sends a response message in a reverse order to which the transfer request message was transferred, and a communication path has been created from the delivered nodes and the received nodes. Since each node has the sequence number and actively uses it for routing, each node contains information about the next transmission location and a valid routing table for a very short period and the package are forwarded using it, and each routing table entry has a foreground list that is used when a link failure occurs [7]. When a road to a new destination is needed, RREQ a Route Request Message is created to the network to discover the route of packets. Finally, when the RREQ message reaches the target transmission destination, the sending destination node returns RREP a Route Reply message is the return to the transmission node by unicast. As a result of this exchange, a two-way path to the source and destination is created on the node path table in the middle, after which, the data can be sent and received using this routing table.

V. QUALITY OF SERVICE

QoS (Quality of Service) is a desired quality for MANET as the result of the development of multimedia applications. A process for directing traffic from network devices, such as routers and adapters, to the behavior required by an application that creates traffic. In other words, QoS allows network devices to distinguish traffic and then apply different measures to traffic [9]. It is necessary for traffic management in package based networks. QoS is a collective influence of service characteristics which provide the degree of contentment of the services of the users [10]. Features of QoS are types of requirements services to be satisfied by the network by sending the data packet from delivering node towards the destination node. Multiple QoS parameters were determined and observed to indicate if the requested or received a level of service is achieved. The routing of QoS is efficient for MANET and needs not only to implement a route from a deliver node toward the destination node of the destination but furthermore the route may achieve the E2E delay of QoS demands. For achieve QoS (the bandwidth and delay warranty), the stream of the packet (route detection) and the structure of the routing table is revised to implement the demands of service that should be achieved by the data nodes with forwarding RREQ and RREP package[11].

VI. THE PSO APPROACH

Particle swarm optimization approach was defined as a population depended on the computational technique. It is depended on the behaviour of flocks in nature such as bird swarm and fish flocks that was proposed in 1995 by Kennedy and Eberhart [12]. It is used in different applications to find the required parameters for minimizing or maximizing. In each iteration, the posi and spin vector of a particle is updated in each dimension i utilizing (1) and (2). Each particle of i represented by the vector posi. The fitness function is utilized to find the activity for each particle. Each particle will fly depend on the experience and from the social environment and the current position and the particle. The experience of the particle i represented as ptbest of the best position found by these particles[13]. Each member has a memory that saved the best previously searching locations with the fitness function in that position that is updated through time. The information taken from the environment was represented by particles that have the best position gt in the flock of the particles, with the current position of particle i is expressed by posi(t). The first step in PSO is initialization includes the number of iterations, the number of population n and the inertia weight W [14]. The coefficients of acceleration c_1 and c_2 are cognitive learning which two positive constants are. Moreover, the next step has utilized the population in the form of a random matrix with a range [0,1] of values. After that, the initialization of speed and position is achieved in this step, so that we will make the values of the velocity and position for each particle equal to zero, and then calculate the error. To determine the variation into speed and position of the particle (sp_i, pos_i) the following equations are utilized as indicated below [13]:

$$sp_i(t+1) = W*sp_i(t) + \mu1 *c_1 (pt_{Best} - pos_i(t)) + \mu2 * c_2(gt_{Best} - pos_i(t)) \quad (1)$$

with *pos* is $pos_i(t+1) = pos_i(t) + sp_i(t+1) \quad (2)$

The variable µ vector is a random value with a range value [0,1]. The speed of each particle is limited between [spmin, spmax]. W is the inertia weight provides the balance between global exploration and local exploration of PSO. posi and spi is the current position and velocity of a particle. gtBest represents the global best position of the best particle element. PSO needs a large number of iterations in searching for the optimum solution, W approximately ranging from 0.9 to 0.4 for the calculations. General inertia weight W is set below [14].

$$W = W_{max} - ((W_{max} - W_{WIN})/ ITER_{max})* ITER_{NO} \quad (3)$$

The PSO approach work as shown in Fig. the particles elements are distributed randomly for each initial position in the environment of the workspace at first, then the value of velocity of each particle is randomly assigned and it will continue updating itself depends on the particle's own and adjacent experience or the expert of the entire flock[14].

VII. THE FAO APPROACH

Fruit Fly is an evolutionary computation approach, it was first proposed by Wen T. Pan in 2011[15]. Fruit fly flock in natural includes the behaviour of social which utilizing the intelligence of the collective to achieve bases activities. FOA was depended on the behaviour of food searching of the fruit fly flock [16]. FOA utilizes osphresis and vision superior to other species. Fruit flies capable to smell the food source from far away distance and then fly fast toward that direction. The fruit fly has two phases for food research process [16, 17]:

1. In the first phase, the fruit fly utilizes the sense of smell capability to fly through the food area to search the food source then moves to the specified direction.

2. The vision capability of flies is utilized to get closer in the second phase after it approaches the location of food. When flies become near the source of food, the vision sensitive of the flies utilized to locate food position then flying in that direction.

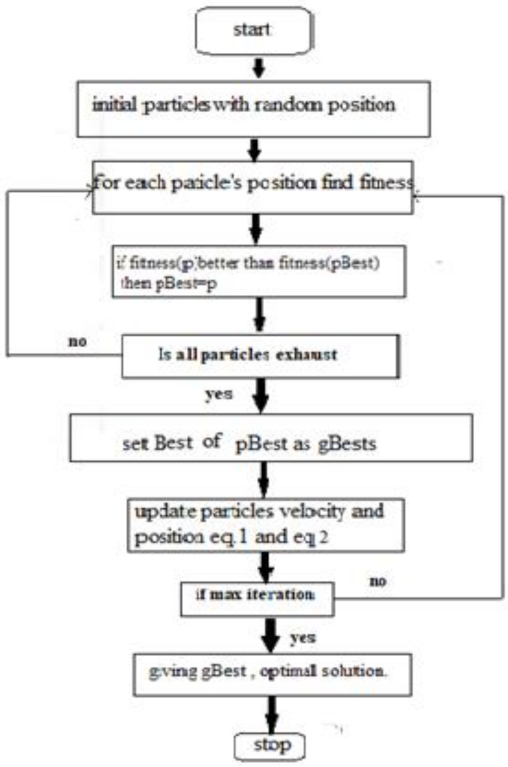

Fig.2. the PSO structure

The fruit flies have a superior smell and seeing capabilities compared with other flies sorts. The flies are able to smell the food even for a distance of 40 km away [16]. The food searching behaviour of fruit flies was indicating in Fig.3. The steps of the FOA algorithm flowchart are given in fig.4 to show its action. The algorithm steps can be shown that the smell phase of the algorithm is short compared with the vision phase.

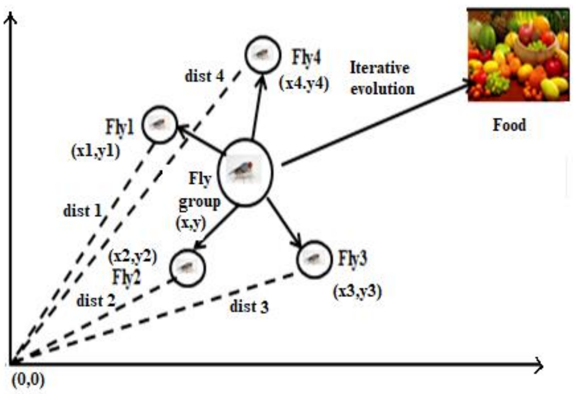

Fig.3. Food searching of fruit flies.

The food-finding steps of FOA [17] are as indicated below:

1. Adjust the parameters; a flock of n flies is located initially into the source node Si.

2. Locate the fruit flies in random positions.

3. Each fruit fly will move from the source node towards the neighbour location of next node randomly; the searching operation to the source of food by applying (4)

$$xp_i = x_{axis} + rand \quad (4)$$
$$ypi = y_{axis} + rand\ value$$

4. The value of fruit fly smell concentration was calculated as shown below:

$$Dis_i = \sqrt{xpi^2 + ypi^2} \quad (5)$$
$$Sp_i = 1/Dis_i\ ,\ smll = function\ (S_i)$$

5. To find the location of fly that gives the best smell concentration value and the value of best position of the flock in that location, the next iterations is found utilizing (6)

$$[Best\ smll \quad Best\ Indx] = MAX\ (smll) \quad (6)$$
$$x_{axis} = xp(Best\ Indx)\ ,\ y_{axis} = \mathrm{yp(Best\ Indx)}$$

6. The iterations are repeated until the fruit fly discovers the food location for the destination node.

7. When the number of maximum iteration is reached, the FOA algorithm method will report the best solution value, otherwise, it will return back to step number 3.

The distribution mechanism and development of the individual for the flock of fruit flies has been improved to increase research speed and accuracy [17].

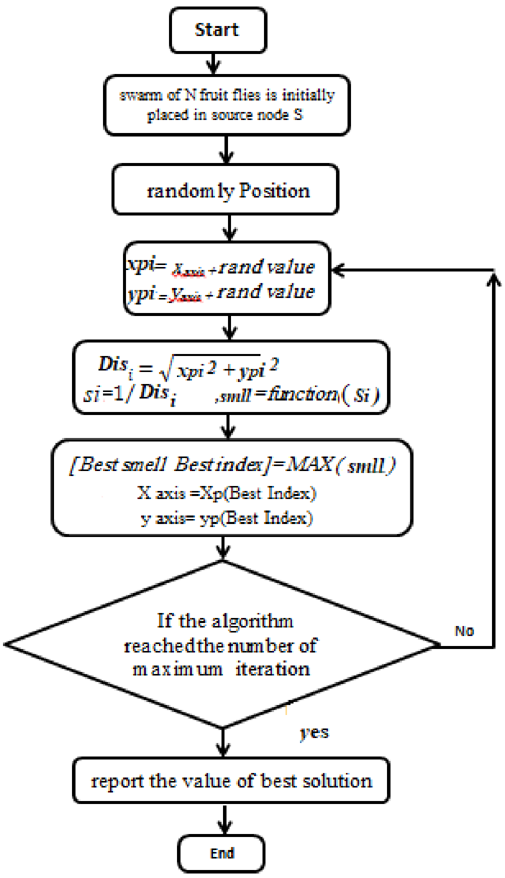

Fig.4. FOA algorithm

To apply the suggested routing protocol, we prepare a network workspace of the environment first, after that we implement and make a comparison between FOA proposed approach with the multiple scenarios. The simulation results in this study were done utilizing Mat lab program. The network simulation having two parts as indicated below:

1. Performing the MANET network utilizing the protocol of AODV: In that scenario of the network, it was achieved a network using AODV as a routing protocol with different nodes number in the network.

2. In this part, the network protocol was achieved utilizing the traditional AODV protocol and supported with optimized approach PSO and FOA algorithms.

TABLE I. SIMULATION PARAMETERS

Parameters	Description
Number of nodes	5,10, 20,40, 60
The type of channel	Channel is wireless
The type of network interface	Wireless Phy
Mac type	Mac/802_11
Simulation time	60 seconds
protocol of Routing	AODV protocol
The size of Simulation	1000 x 1000

IIIV. PERFORMANCE METRICS

This section of our simulation study gives the analysis and metrics of the suggested routing concerning traditional AODV as routing protocol. For performance analysis, we utilized different parameters, different scenarios and metrics. The metrics elements which are utilizing in our study are shown in Table I [4].

A. The packet delivery ratio

The ratio between the data delivered to the node of the destination to the data transmitted packets generated by the deliver source node [18]. PDR Packet Delivery Ratio gives the necessary information required about the performance of any routing protocols. Where PDR is evaluated utilizing the following equation:

PDR= (delivered of data packets)/ (sent data packet)∗100 (7)

The comparison of packet delivery ratio with a different number of nodes is indicated in fig.5.

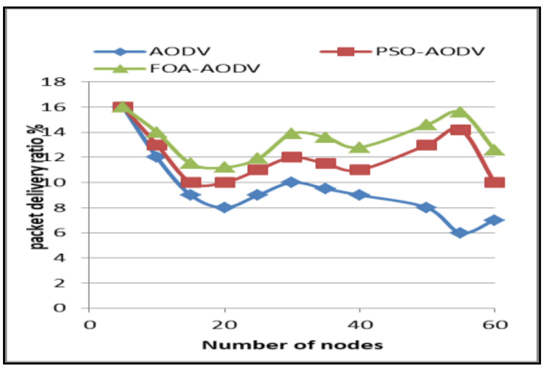

Fig.5. Comparison of no. of nodes and packet delivery ratio PDR%

B. E2E Time delay

The term E2E refers to the average time of the end to end delay of the data packets which is needed to transmit the data packet from delivering node to the node of destination [19]. The lower is the end to end delay, the better the application performs. This metric indicates the time duration for the transferring of the data packet from delivering a node to the node of destination. Total time difference between send and receiving of any data.

$$\text{E2E delay} = \frac{\sum_{i=1}^{n} \Delta t}{n} \quad (8)$$

The E2E time delay comparison is indicated in fig.6.

C. Throughput (TP) data

This metric is equal to the number of bytes which the destination has received.

$$\text{TP} = \left(\frac{\sum \textit{the number of byte received}) * 8}{\textit{time of simulation}} \right) * 1000\,kps \quad (9)$$

Throughput data provides the efficiency of the system, after evaluation of the performance parameters, we can see that the overall performance of the proposed FOA-AODV algorithm is much efficient than the traditional routing protocol AODV and PSO-AODV as shown in Fig.7. The FOA algorithm is faster and stable approach compared with other methods in solving the optimized problems, it is also an easy in implementation and application for the optimized problems.

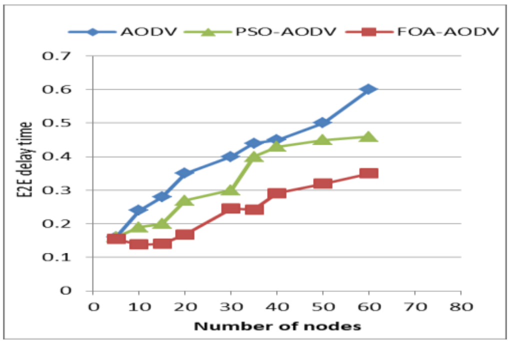

Fig .6. E2E delay time of the three protocols

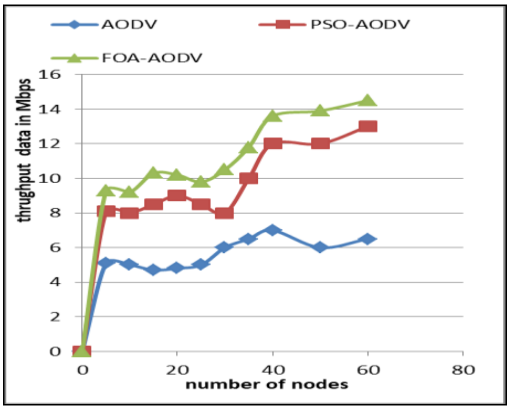

Fig.7. the throughput of data (TP)

IX. FOA Algorithm with Different Network Topologies

In this section, the routing problem was optimized by using the fruit fly approach with multiple network topologies [18], by adjusting the nodes number, the edges and the configurations of links. The simulations experiments are implemented in different topologies are named problem cases a, b, c, d and e. Each case provides a topology contains a different nodes number and different numbers of links as indicated on table II. Fig. 8 indicates the network topology of case .a with five nodes. Then, the proposed approach of FOA-AODV was applied to get the routing objective function, and the complexity time and Fruit flies numbers: 5, 10, 20, 40 and 60 as indicated in Fig.9 and Fig.10.

TABLE II. The Problems for the Cases

Cases	No. of nodes	No. of edges
Case a	5	8
Case b	10	22
Case c	20	99
Case d	40	158
Case e	60	302

Moreover, by applying the proposed FOA-AODV approach, it was found that the ability to achieve the optimal solution to the problem will increase if the size of the flock increases. It was observed that the minimum routing objective function results are similar in the small size network regardless of the size of the flock as indicated in Fig.9.That implies the FOA-AODV optimization approach can get the optimal solution in the network of small size by utilizing a small flock size. The average complexity time as a function of five cases of the proposed fruit fly optimization approach is indicated in fig.10. The ACT (Average Complexity Time) of the FOA-AODV approach will be increased when the number of the flock size increased for all problems. The ACT for the routing problem is founded by adjusting the number of nodes and links in the experiments, and in terms of the comparison results indicated that the FOA-AODV overcome the classical method in terms of ACT and it is efficient for the routing optimization problem.

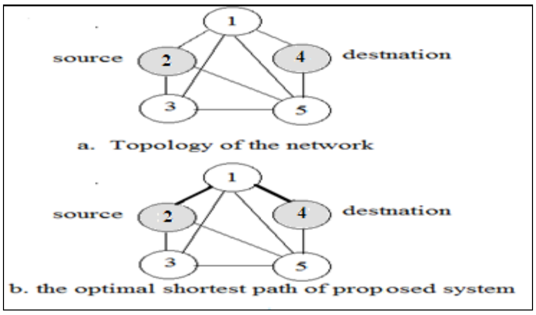

Fig.8. Network topology of case a with five nodes

X. CONCLUSION

The application of FOA optimization approach was achieved in this study, which is the typical meta-heuristic optimization method. The fruit fly optimization approach is a global optimization algorithm depended on the behavior of the fruit fly flock to foraging the food. The suggested optimized approach was applied effectively for routing to discover the optimal shortest route path between the source nodes toward the destination node. The proposed scheme for FOA-AODV algorithm to get the shortest optimal route shows efficient results compared with traditional AODV and PSO-AODV. The performance of the FOA-AODV algorithm was determined by implementing the experiments with distinct numbers of nodes and links, and by applied ACT in the MANET routing network, with classic test functions, simulation improvement results show that the proposed FOA algorithm offers the fastest and most accurate pathway and more reliable optimization ability. The compared results indicated that the FOA-AOD approach overcomes the conventional methods in the average complexity time state and it is adequate for solving the routing optimization problem.

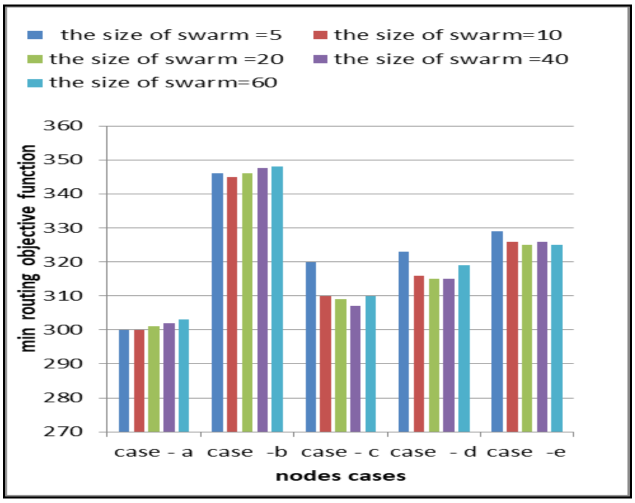

Fig.9.the min routing objective function

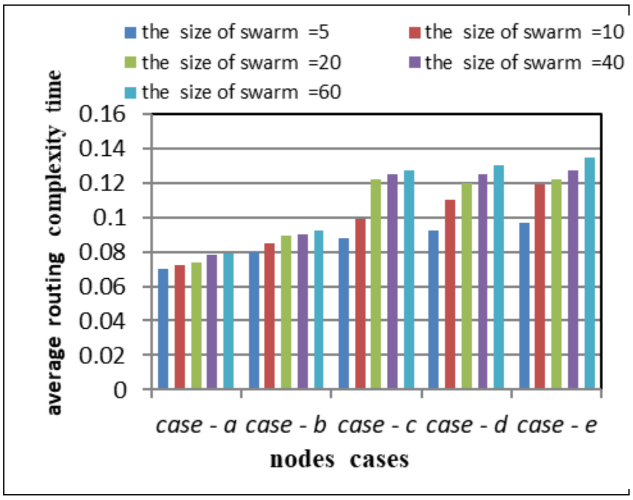

Fig.10. The average complexity time of routing

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