DOI: https://dx.doi.org/10.4314/gjpas.v24i2.12

GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES VOL. 24, 2018: 223-228
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PACKETS ROUTING AND BANDWIDTH SENSING IN A NETWORK TRAFFIC: ANT COLONY OPTIMIZATION TACTIC.

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(Received 24 September 2018; Revision Accepted 26 November 2018)

ABSTRACT

Packets routing and bandwidth sensing in a network platform remains an integral part of the study of signal flow.The algorithm to route packets in a network link called the AntNet algorithm was inspired by the behavior of real ant colonies. At each node in the network, a forward ant deposits some amount of pheromones at different links that responds to the node's queue length. In this paper, we propose the inclusion of the computation of paths to adapt with the Depth Search Ant Explorer Network (DS-ANTENet) algorithm for discrete problems as an IP based mechanism. This method is tested and the efficiency is compared to the original AntNet algorithm and the Link-State algorithm to check the transmission of computing traffic flows between the nodes. We then made comparison with the algorithms proposed in the literature. The protocols were sorted out in terms of average number of lost packets ranging from the higher priority queue to the lower priority queue which then resulted to the fact that; First, AntNetBW (loss ratios reduction of 9.6% when compared to the AntNet and the Link-State algorithm respectively. Secondly, DS-ANTENetBW (loss ratios reduction of 8.3% and 36.7% when compared to the AntNet and the Link-State algorithm respectively. Finally, DS-ANTENet (loss ratios reduction 0.7% and 33.2% when compared to the AntNet and the Link-State algorithm respectively.

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KEYWORDS: Packets Routing, Bandwidth Sensing, Network Traffic, Ant Colony Optimization Algorithm, AntNet,

INTRODUCTION

In recent years, there have been significant changes in the network traffics with rapid increase in peer-to-peer communication network. Peer-to-peer network applications for instance, do not only contribute to internet traffic but also introduces a dynamic behavior due to peer churn in the network by constant changing of congestion points in IP network.

In such scenarios, frequent monitoring of congestion level in connecting different nodes in a network link can potentially distribute load in different paths of the network. In trying to do this, feasible paths of the solutions can be identified. This can help in minimizing the end-to-end delay of packets and speed up the network route (Brendan and Ogban, 2015). The social behavior of insects, particularly Ant Colony Optimization has inspired such optimization techniques.

The first Ant Colony Optimization algorithm that was developed for network routing is called the AntNet algorithm. This algorithm was implemented in an adaptive routing of network packets in a wired network. In AntNet algorithm, packets are forwarded in an intelligent way, giving it a balance in the queue length of the quantity of pheromone deposited (Runka, 2009).

Furthermore, the AntNet algorithm does not directly consider the availability of the length of the network links, but mostly considers the forward packet based on the queue length and the values of the pheromone deposit which may contribute to the reduction of the end-to-end delay, but do not react to the available length in a set of an alternative path. (Dorigo and Stuzle, 2004)

In this paper, we propose a new Ant Colony Optimization (ACO) algorithm called the Depth Search Ant Explorer (DS-ANTE) algorithm to adapt as an IP routing mechanism together with the AntNet algorithm to instantly include bandwidth measurement which will result to two new protocols called the AntNet Bandwidth (AntNetBW) and the Depth Search Ant Explorer Network (DS-ANTENetwork) in these new network, the available bandwidth analysis is combined with the information that is gotten from the queue length and the value of the pheromone deposit to prevent congestion from occurring in the network traffic and effectively distribute network traffic among the nodes in the network. (Diosan and Oltean, 2009)

The paper is organized as follows: section (II) we present the AntNet algorithm and the DS-ANTE algorithm. In section (III), we will introduce our proposed algorithm. In section (IV), we will present the

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experimental results and compare the results with other algorithms. And finally, in section (v) we will conclude the paper and present some future work.

ANT COLONY BASED ROUTING METHOD

In order for us to describe the algorithm we developed, we will first, introduce the AntNet algorithm and also consider the adaptation of the DS-ANTE algorithm before obtaining our method which we call DS-ANTENet.

AntNet Algorithm

Ant net algorithm was created to find the minimum delay paths in a network link to forward packets. This behavior was inspired by the behavior of real ant colonies making it an active algorithm which depends on routing packets in network traffic in a specific path that can be measured in a periodic interval. (Brendan and Ogban, 2015)

To give a proper description of the AntNet algorithm, we first of all consider a network packet that is sent from a given origin to its destination in a network link(Diosan and Oltean, 2006). However, there are two types of ants that are used by this algorithm. These are:

(a) The forward ants. These areant agents that are represented by $F_{s\rightarrow d}$. their responsibility is to travel from the source node, s, to the destination node, d, seeking for the path with the minimum delay between the source node and the destination node.

(b) The backward ants. These are ant agents that are represented by $B_{s\rightarrow d}$. These ants are created at the destination node d, by the help of the forward ants $F_{s\rightarrow d}$and are made to travel backward from the destination node to the source node, directly opposite the path thatis created by ant and are made to update all the pheromone deposit and the routing tables in all the nodes that are seen on that path.

Furthermore, the forward ants $F_{s\rightarrow d}$ carries a set of information that allows the pseudo random finding of paths between the source node and the destination node in the algorithm (Poli, Langdon and McPhee, 2008). Whereas, the backward ants $B_{s\rightarrow d}$ ensures that the pheromone values and the routing tables are being updated correctly, at each point in the network, the source node, s, represented by agent $F_{s\rightarrow d}$ are lunched out toward a particular direction of the destination nodes; d, at a regular interval, $\triangle$t concurrently with the data traffic. Therefore, the destination node d, which is generated from the source node is chosen according to equation (1).

$$p_d = \frac{bits_{sd}}{\sum_{d \in N} bits_{sd}} \quad (1)$$

Where P_d – is the probability of choosing the destination node d

$bits_{sd}$ – is the number of bits that are being transmitted from the source node s, to the destination node d. also, the forward ants travel from one node to another adjacent node. While moving, the forward ants collect information about the delay time together with the node identifiers of the path that is followed. At every intermediate node k, a stochastic decision policy is applied to select the next node n, according to equation (2).

$$p_{nd} = \frac{T_{nd}^{k} + \eta_n}{1 + \alpha(|N_k| - 1)} \forall_n \in N_k \quad (2)$$

Where N_k – is a set of neighbor nodes of k

T_{nd}^{k} – represent the pheromone quantity that is deposited between node k and node n given as

$$\left(\sum_{n \in N_k} T_{nd} = 1\right)$$

with $\eta_n \in [0,1]$ representing the heuristic coefficient which is determined by equation (3)

$$\eta_n = 1 - \frac{q_n}{\sum_{n=1}^{|N_k|} q_n} \quad (3)$$

Whereq_n – represents the number of packets in the queue between node k and node n

$\boldsymbol{\alpha} \in [0.1]$ – is the parameter value

Finally, the backward ant uses a higher priority queue in the network route such that the pheromone information in the node is quickly updated.

Depth Search Ant Explorer Network (DS-ANTENet)

Depth Search Ant Explorer Network (DS-ANTENet) algorithm is a method that is used in routing network packets such that it combines Ant Colony Optimization method with the Depth Search method. DS-ANTENet is our proposed algorithm that is developed with the aim to further explore very good solution from the intermediate node k to destination node d, within the set of solutions obtained by the AntNet method. However, this is done with the need to further rebuild each solution completely from the source node. This will mean that at a certain node, the backward ant is given the ability to generate new forward ant that will use part of the solution that is built by the original forward ant.

To have a proper understanding of the concept of this algorithm, we introduce the following:

(i) Identical factors between the AntNet and the DS-ANTENet

Table 1: Identical factors between AntNet and the DS-ANTENet

AntNet	DS-ANTENet
Forward ant. These are ants agent represented $f_{s\rightarrow d}^{Ant}$ that are responsible for travelling from the source node s, to the destination node d, seeking for the minimum delay time in the path between the source node and the destination node.	**Forward ant.** These are ants agent represented by $f^{DS}_{k\rightarrow d}$ that are generated from the backward ant $B^{ant}_{s\rightarrow d}$ from an intermediate node k with the aim to implement depth searching. The forward ant of the DS-ANTEnet algorithm are made to travel from the

	intermediate node k to the destination node d, looking for an alternative path with minimum delay time that is deferent from the one found by the forward ant of the AntNet. However, the creation of this intermediate ant favors the exploration of the searching space without the need to rebuild the solution from the original source node, s, which per se will induce a small computational effort to obtain a different and very good solution.
Backward ant. These are ants agent represented by $B^{ant}_{s\rightarrow d}$ that are created at the destination node d, by the forward ant of the AntNet and are made to travel from the source node in the same path but in the opposite direction updating the pheromone table in all the nodes present in that path.	**Backward DS-ANTENet.** These are ants agent represented by $B^{DS}_{s\rightarrow d}$ that are created from the destination node, d, by the forward ant of the Depth Search Ant Explorer Network. The aim of this backward ant is to use information that is generated by the forward ant about the time and the node identifier to update the pheromone deposit and the routing tables from the destination node to the source node.

(ii) Difference between the AntNet and the DS-ANTENet

AntNet	DS-ANTENet
Backward ant ($B^{Ant}_{s\rightarrow d}$). Generates forward ant from the beginning of the algorithm	Backward ant ($B^{DS}_{s\rightarrow d}$). Generates the forward ant from the information that is gotten from the end point of the AntNet algorithm

The memory structure of the Depth Search Ant Explorer Network is the same as the memory structure of the Ant Colony System algorithm. The AntNet part of this algorithm uses the forward and backward ants represented by $F^{Ant}_{s\rightarrow d}$ and $B^{Ant}_{s\rightarrow d}$ while the DS-ANT part of the algorithm uses the forward ants created at the intermediate node (i.e., the forward ants of the DS-ANTENet are generated by the backward ants of the AntNet. The backward and forward ants of the DS-ANTENet are represented as $F^{DS\text{-}ANTE}_{k\rightarrow d}$ and $B^{DS\text{-}ANTENet}_{s\rightarrow d}$. but the condition to create the DS-ANTENet is that its next node that is calculated by equation (2) has to be different from the (k-1) and (k+1) nodes of the paths that are present in the memory of the AntNet algorithm. With this innovation, the DS-ANTENet ($F^{DS\text{-}ANTE}_{k\rightarrow d}$) is then forwarded in the same way that the AntNet ($F^{Ant}_{s\rightarrow d}$) is forwarded. This will enforce the production of new solutions that will further explore the searching space of our algorithm.

In conclusion, the forward ant of the AntNet ($F^{Ant}_{s\rightarrow d}$) transfers information about its traveling time and the node identifiers at the end point of the intermediate node on the algorithm to generate a new forward ant from the DS-ANTENet ($F^{DS\text{-}ANTE}_{k\rightarrow d}$). In the same way, the backward ant of the DS-ANTENet ($F^{DS\text{-}ANTE}_{k\rightarrow d}$) transfers information about its traveling time and the node identifiers to generate the backward of the ($F^{Ant}_{s\rightarrow d}$) algorithm.

$$P_{nd}=\left(\frac{\tau^{k}_{nd} + \alpha\eta_n}{1 + \alpha\ (|\ N_k\ | - 1)}\right).(1\text{-}util^{k}_{n}),\quad \forall_n\in N_k \qquad (4)$$

Where$Util^{k}_{n}$ represents used bandwidth of the link connected between different nodes connected along the path of k and n.

And the $1\text{-}util^{k}_{n}$ is the available bandwidth of the nodes. (see equation (2) for detailed explanation of the remaining parameters).

Also, following the decision rule in equation (4), the decision to route a packet in the DS-ANTENet ($F^{DS\text{-}ANTE}_{k\rightarrow d}$) now responds to the following: pheromone level, queue length and the available bandwidth. Hence, the use of the available bandwidth is to try to forward the ants of the DS-ANTENet ($F^{DS\text{-}ANTE}_{k\rightarrow d}$) through the links that have limited bandwidth.

(III) Combining the Ant Colony Network (Antnet) Algorithm and the Depth Search Ant Explorer Network (Ds-Antenet) Algorithm to Route Packets in a Network and Sense Bandwidth.

The purpose of the forward ant agent in the AntNet algorithm and the DS-ANTENet algorithm in anetwork route is to find the best optimal paths for routing of network packets. A stochastic decision rule is applied at the intermediate node k to decide on the next node to be connected. The function of the decision is to consider the size of the queue and the pheromone deposit level (see equation (2) for details). To further evaluate the response of the algorithms, to the congestion level of some nodes, we include heuristic information associated with the bandwidth that is available between the links that is to be chosen (Tavares and Pereira, 2006). In this way, we were able to create a new method which we call the Ant Network Bandwidth sensing (AntNet) and the Depth Search Ant Explore Network Bandwidth (DS-ANTENetBW) sensing which now stand as an improvement to the AntNet and DS-ANTENet procedure.

Furthermore, in this our newly developed algorithms, the forward ants of the DS-ANTENet ($F^{DS\text{-}ANTE}_{k\rightarrow d}$) and the forward ant of the AntNet ($F^{Ant}_{s\rightarrow d}$) are forwarded according to the probabilistic action rule given below:

EXPERIMENTAL RESULTS

In order for us to be able to compare the efficiency of the algorithm developed with the existing ones, the implementation of the AntNet algorithm is done with the same data used on the DS-ANTENet algorithm.The same implementation frame is used on the AntNetBW andDS-ANTENet algorithms comparatively. Also, AntNet method was adapted by implementing the depth searching mechanism of the DS-ANTE algorithm which then resulted to the DS-ANTENet. Again, the routing mechanism with bandwidth sensing is implemented by the introduction of equation (4) into the AntNet and the DS-ANTENet code (replacing equation (2) in the algorithm) which now resulted to the development of the ANTENeBWt and the DS-ANTENetBW that have been described in section (III).

After developing the algorithm, we tested the performance of the algorithm so proposed using different instances and its performance proved to be a clear improvement of the algorithms discussed in the literature in terms of packet loss, and speed in the process of routing through a given network link.

Figure 1: Application Home Screen

The java based screen shot package as shown in figure 1 has two menus. The File menu and the ACO menu where the actual configuration of the optimization process is to be entered.

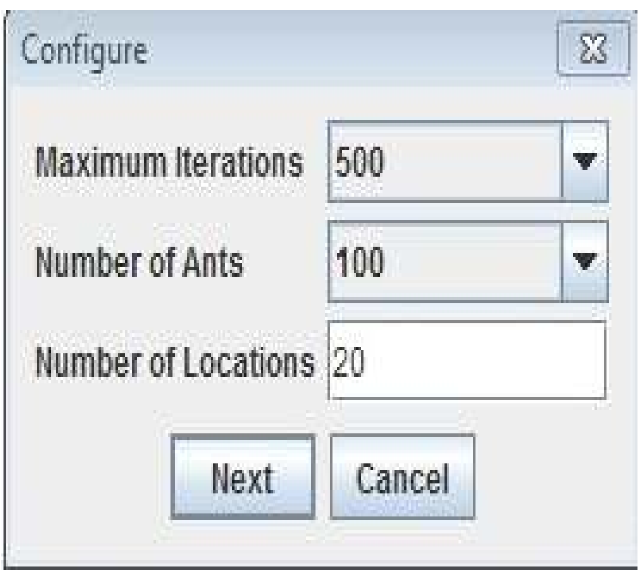

Figure2: Configuration Screen

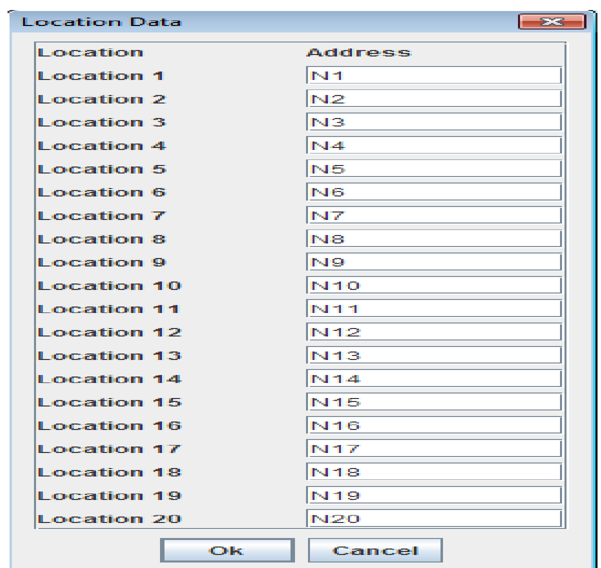

Figure 3: Data Input Screen

The configure dialog box where the maximum iterations, the number of ants and the number of sites or locations to route.

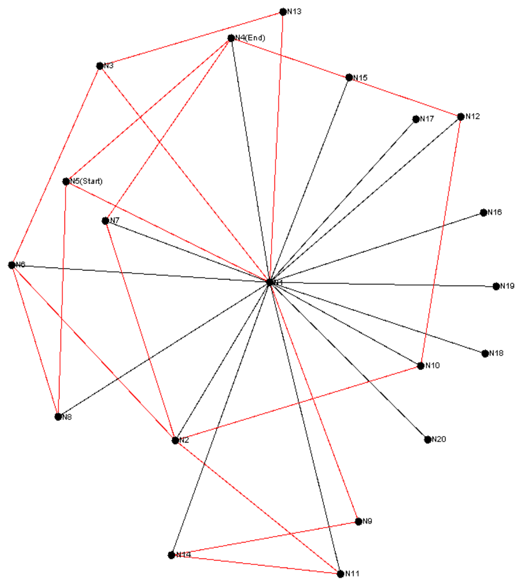

Fig. 4: Graphical route flow output

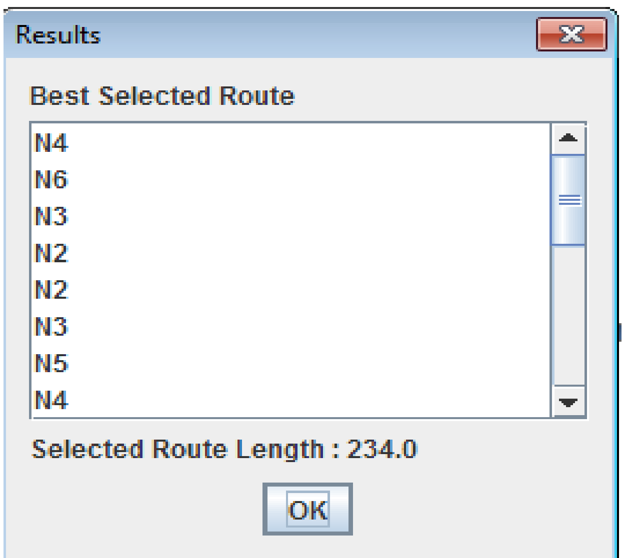

Figure 5: Result Output Screen
Fig. 5: Best selected route result with the total route length.

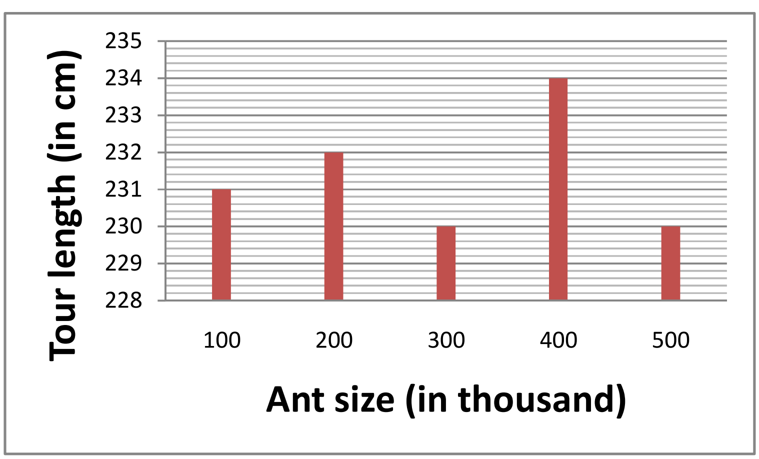

Figure 6: percentage means comparing five different algorithms with 500 instances.

DISCUSSION

Figures 1,2,3,4 explains the performance of the proposed algorithm. We then made comparison with the algorithms discussed in the literature. The protocols were sorted out in terms of average number of lost packets ranging from the higher priority queue to the lower priority queue which then resulted to the following observations:

1st AntNetBW (loss ratios reduction of 9.6% andwhen compared to the AntNet and the Link-State algorithm respectively.

2nd DS-ANTENetBW (loss ratios reduction of 8.3% and 36.7% when compared to the AntNet and the Link-State algorithm respectively

3rd DS-ANTENet (loss ratios reduction 0.7% and 33.2% when compared to the AntNet and the Link-State algorithm respectively

After making comparison of the algorithm, we found out that the performance of the algorithm proved to be better in terms of packet losses. With this result obtained, we can conclude that the use of available bandwidth parameters has imposed a better tuning to the distribution of packets in network traffic in different links in a network resulting to lower level of packet loss.

CONCLUSION/ FUTURE WORK

In this paper, we proposed new Ant Colony Optimization routing algorithm that include the available bandwidth parameters between different links in the forwarding of network packets in a network route. These newly proposed parameters, has reduced the number of packet losses in a network route. From the presented work, some future developments can also be proposed as to perform a better tuning of the proposed methods, to study the behavior of the algorithms on different network topologies and traffic patterns. And to adapt the method such that they can distinguish between different types of traffic priorities (a multiple objective model).

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