

Meta-heuristic Optimization Algorithms for Network Routing: A Survey

AKANDE Hakeem Babalola¹, ABIKOYE Oluwakemi Christiana¹, JAURO Usman Abubakar², SALIHU Shakirat Aderonke¹

¹ University of Ilorin, Ilorin, Nigeria.

Department of Computer Science, Faculty of Communication and Information Sciences,
E-Mail:hakeemobabs@gmail.com, kemi_adeoye@yahoo.com, Salihu.sa@unilorin.edu.ng

² Federal University Kashere, Gombe, Nigeria,

Department of Computer Science,
E-Mail:ausamin63@gmail.com

Abstract – *In the society today, communication network systems are virtually used everywhere. The growth in the users and services raise many problems of the network performance. The recent developments in the communication network give significant prospects to people and establishments in a globally connected world, but there still exist a large number of difficult problems in which network users encounter. The routing problem in the network remains the one of significant challenges. Researchers have employed different meta-heuristics algorithms to solve the problem of routing process in a network system. This paper presents a review on the application of several nature-inspired optimization algorithms in solving routing problems.*

Keywords: *meta-heuristic; network routing; optimization algorithm; communication network.*

I. INTRODUCTION

In communication network system, routing remains a significant process. The process involves the selection of a route for traffic across many networks. The process of routing can be in different networks including circuit-switched networks such as the general switched telephone network, computer networks like the internet and public / private transportation. Routing is an advanced level decision making that directs network packets from the source toward their destination through intermediate network nodes by definite packet forwarding tools.

Routing protocol performs an important part in computing, selecting and choosing of most appropriate route for transmitting data from the starting point to the destination efficiently [1].

Several routing algorithms have been employed to locate the fastest route and also to upturn the network throughput. The major purpose of routing in a network is to regulate the traffic from source to the destination by

optimizing network performance [2]. The categorization of communication networks can be grouped into circuit-switched and packet-switched.

In a packet-switched network, data packets can arrive out of order with different routes passing through diverse nodes in order to get to the target point. A number of techniques can be applied to make the flow of traffic effective in a network, such as regulation of congestion flow, where nodes action packet are acknowledged from destination nodes to optimize the speed of packet transmission.

Meta-heuristics forms an efficient general technique that includes broad application areas such as finance, engineering and networking. Meta-heuristic algorithms have been increasingly used to solve hard combinatorial problems that cannot be solved by any deterministic approach within a reasonable time. Most of these algorithms are nature-inspired like whale optimization algorithm (WOA) and simulated annealing (SA), genetic algorithms (GA), ant colony optimization (ACO).

In ant colony optimization, free movement of ants provide the ability of solving various routing and congestion problems in computer network. This is achieved by continuous modification of routing tables in response to congestion. In a network problem solving standard, collection of ants (individual giving some information) cooperate to handle a huge challenge.

Recently, algorithms based on ants have been used to produce solution to typical problems such as salesman travel problem, routing of vehicle, connectionless routing, sequential ordering and graph coloring [3]. The inspiration of metaheuristics are not the same and as a result techniques cannot be of the similar types.

On the other hand, all these algorithms make use of some certain structures for computing the major formulae updating. For instance, the genetic algorithms were motivated by evolution characteristics of Darwinian (biological systems), such as cross over and mutation and selection of the fittest are used. Solutions in genetic algorithms are to be represented as chromosomes or binary/real strings.

II. METAHEURISTIC OPTIMIZATION ALGORITHMS

Optimization through meta-heuristic is an approach employs heuristic techniques to solve a broad of different problems [4]. Meta-heuristics are standard algorithms that manage heuristics and rules to provide solutions that are near optimal to hard combinatorial problems. There are several nature-inspired meta-heuristic algorithms:

(a) *Ant Colony Optimization (ACO)*

It is a technique that is probabilistic in nature used for resolving computational problems. This approach can also be concentrated to location of better paths through graphs [5]. ACO is a system based on activities of natural ants such as cooperation and adaptation mechanism that exist in their colony [6]. The technique has been effectively employed to handle numerous hard combinatorial optimization problems in various domains in order to provide solutions in a reasonable time [7]. The algorithm was built based on the social behaviour of natural ants, ants have no vision and are capable of locating the food source by deposition of chemical substance (pheromone) which is used as a form of indirect communication method to mark the route [8].

(b) *Genetic Algorithm*

It is a random search algorithm that uses the reference of natural selection and genetics theory in biosphere [9]. The algorithm uses the approach of natural selection act on a population of individuals that go through selection in the operators availability such as mutation and crossover [10]. The individuals and reproductive success diverge with fitness is calculated using fitness function. A population of solution is changed from one generation to the next generation in every iteration. Solutions with better results are combined again with each other to produce solutions of new results.

(c) *Bee Colony Optimization (BCO)*

There are many agents in BCO, which work in a group to proffer a solution optimization problems [11]. This technique is a abit different from the normal bee colony. Initially before BCO there were two algorithms: ecological algorithm and bee system algorithm [12]. The BCO can also be called as the population algorithm because it finds the optimal solution. It is meta-heuristic and it is driven by the foraging behaviour of bees. The algorithm is used widely to solve real life problems.

(d) *Bat Optimization Algorithm (BOA)*

The global optimization approach of bats is totally founded on the noise activities of bats with different rates of pulse release and volume [13]. The making of noise (echolocation) is termed as the natural means used by some animals for movement and locating of foods in their environments. The animals performing echolocation produce signals to the surroundings and

pay attention to the echoes of those signals that return from different objects close them. The echoes are used to find and detect the objects.

III. RELATED WORK

[14] came up with an improved algorithm using computational intelligence. A particle swarm optimization (PSO) and a Tabu search meta-heuristics algorithm were applied for efficient network route optimization. The hybrid search process combined particle swarm optimization for changing the computation for population of better solutions and tabu search for varying the local search technique to get solution to this challenge. A priority based on not direct coding and non coding method applying heuristics used for showing the shortest path problem factors as a particle in PSO. Simulation results with many networks of unsystematic topologies were used to demonstrate the robustness of the proposed hybrid algorithm for calculation of the optimal route.

[15] conducted a survey of new studies proposing different meta-heuristic methods to handle different challenges in communication network. Three telecommunication areas were focused in the study: design of networks, routing, and distribution. The fields discovered numerous small problems, simply because the telecommunication systems design consist of many separate phases: topologies, resources location in links and nodes, unicast versus multicast routing, dependability and accessibility of networks. It was concluded that the population-based meta-heuristics such as genetic algorithm, ant colony optimization, and particle swarm optimization are most commonly used algorithms than single-solution ones like tabu Search and simulated annealing.

[16] proposed a novel MSN routing algorithm COMSN. The study employed ant colony optimization for routing in mobile social network. The system used the processing approach for information of node on the path transmission to get information list between the node pairs in order to obtain the correct relay node to produce active information while sending data to other nodes. Also, the ACOMSN designed procedures for pheromone updating and data forwarding. The experiments on real data sets showed that comparing typical MSN routing algorithms, ACOMSN can effectively improve the critical performance of data transmission with considerable overhead in MSN.

[17] solved the problem of data in MANET or wireless network by application of BAT algorithm which provided a solution with its working scenario and extra computation. The study applied a diversity function and further introduced with computation of BAT algorithm execution to opt out efficient energy module throughout the section scenario of routing. A setup using NS2 was performed with traditional BAT and also proposed BAT algorithm. Experimental result obtained with parameters such as PDR, End to end delay, showed that the enhancement of BAT provide better result as compared to traditional mechanism.

[18] presented a routing system to solve static Network Routing Problems using the Artificial Intelligence Technique. ACO was introduced. The system was developed using Visual Basic.Net 2012 (VB 11.0). The result showed that the proposed system permitted the network to start fresh path, when service time out, congestion or bottleneck in the existing route. Several test analyses were conducted to ensure the efficiency of the algorithm.

[1] applied three Ant Colony Optimization Algorithm variations, ACO1, ACO2 and ACO3. Diverse standard network systems were employed and the results also analyzed and conclusion was made. A Tabu list maintained for a network with large number of nodes and results were collected to find the optimum size of the Tabu list in one of the algorithms proposed. Several experiments were conducted by changing the network load. The throughput and the network reliability were considered as the performance factor of the network.

[5] introduced an approach using heuristic method to minimize in take of energy in wireless sensor network (WSNs) routing process using ACO. The study used three Ant Colony optimization algorithms, the Ant System, Ant Colony System and improved AS and the application in WSN routing process. The simulation results showed that ACO is an effective way to reduce energy consumption and maximize WSN lifetime.

[19] developed a routing algorithm to determine the shortest path (minimize the cost of path) using Particle Swarm Optimization. Multicast routing problem was solved which gave optimal path from graph. Discrete mathematics was used to encode particles or increase number of PSO iterations, which divided search space in small search space and solved the discrete optimization. Zhao et al. (2010) presented an enhanced ant colony optimization, the study developed a new method to keep the pheromone increase called ant-weight strategy and a operation of mutation to provide solution to the CNRP. The results of simulation were reported and a comparison was conducted with the results of simple ant colony optimization.

IV. SUMMARY AND DISCUSSION

The performance measurement of a communication network such as the bits delivered per unit time (throughputs) and successful number of packets getting to the destination need to be considered during routing. In spite of all the contributions of optimization algorithms based on nature-inspired methods such as bat optimization algorithm, artificial bee colony, ACO and so on in solving network routing problem whenever the number of packets increases. Some of these algorithms cannot be used in controlling the network congestion. Each of these algorithms has different advantages, therefore effort needs to be made to design hybrid system that will complement advantages with disadvantages in order to develop an improved routing system.

ACO as a widely used meta-heuristics algorithm for routing is not fit to handle congestion in network optimally, as the node chosen to be the next is selected unsystematically and dynamically with the possibility of obtaining the shortest path. Many packets possibly go with other paths which increase the network throughput when the number of packets in the network increases. The application of ACO for routing has its demerits of prolong time taken and loss of packets before reaching destination [1]. It is therefore necessary to improve upon the routing system using meta-heuristics by introducing sequential hybridization technique of meta-heuristic algorithms.

V. CONCLUSIONS

One of the important criteria for performance of communication network is the routing effectiveness. Finding a robust technique in solving routing is identified to be a major task in traditional communication networks. Several meta-heuristic optimization algorithms like ; ant colony optimization, bat colony optimization, artificial bee Colony optimization and Particle Swarm based optimization techniques have been developed to solve complex routing problems in communication networks. This paper focused on the review of existing works applied using meta-heuristic optimization algorithms in handling routing problem. An enhanced meta-heuristics optimization routing system was discussed and also recommended for future work.

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