Optimal Location of STATCOM in Nigerian 330kv Network using Ant Colony Optimization Meta-Heuristic

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Abstract

This paper introduces the ant colony meta-heuristic technique to optimally locate STATCOM in 330kV Nigerian Network. The Ant Colony Optimization (ACO) algorithms used the STATCOM parameters and probabilistic model to generate solutions to the problem of siting STATCOM in Nigerian network. The optimal location of STATCOM in Nigerian network is evidenced in bus voltage profile enhancement and minimization of transmission losses. The probabilistic model is called pheromone model which consists of a set of model parameters, often referred to as pheromone values. At runtime, the ACO algorithms try to update the pheromone values from previously generated solutions in such a way that the probability to generate high quality solutions increases over time. Finally, the graph of pheromone trail and path treaded by the ants along the various nodes are captured whose codes are validated using the Matrix Laboratory Software (MATLAB) environment.

Index terms— STATCOM, 330kv nigerian network, ant colony optimization (ACO),

1 Introduction

enerally, in Engineering the concept of exactness and specific location for device placements is of paramount importance. As a result, certain measures/algorithms are being developed to achieve such goal.

In recent years, many research works have been devoted to the use of optimization technique, particularly as regards power system applications. Owing to the cost effectiveness of the FACTS devices generally, the installation of STATCOM in power system network should be done in such a way as to select the optimal locations to enhance system parameters and maintain proper control of them once installed beside the capital cost [3]. These reasons have made many researchers to propose various techniques of Heuristics methods for siting the FACTS device. Among these techniques of Heuristics methods are the Genetic Algorithm and Ant-Colony [3].

Many researchers have shown that colonies behaviour can be seen as natural model of collective problem solving. The analogy between the way ants look for food and combinatorial paradigm, which is called ant colony meta-heuristic elucidates the appropriateness of this technique in siting FACTS devices [1].

Nwohu, [7] explored a sensitivity based FACTS device placement for improving static and transient stability, whereas in obtaining the finest location of installation, the research used a sensitivity index for selecting the suitable buses.

The ant colony approach optimization to shunt capacitor placement on distribution systems under capacitor switching constraints, indicates that the optimum capacitor allocation solution is possible for the system of feeders fed through their transformer and not for any individual feeder [9].

The Ant Colony Optimization (ACO) technique for Optimal Reactive Power Dispatch (ORPD) has also been made to improve voltage stability condition along with transmission loss and voltage profile monitoring. They pointed that there is a set of cooperating agents called "ant" to find the optimal point of reactive power dispatch [5].

However, in this paper it is aimed to come up with an algorithm that will be suitable in placing the STATCOM on the Nigerian 330kV transmission grid system. The Ant Colony Optimization Technique is found to be appropriate in the optimal placement of STATCOM on the Nigerian grid system.

2 II.

3 The Nigerian Grid System

The Nigerian Grid System constitutes the principal core study system in this research work. Herein, the grid system is conveniently zoned into four geographical areas in conformity with operational structure of the electric utility [6,8]. The three hydro power stations are situated in Area 1 while Area 2 has thermal power station located in it and areas 3 and 4 have gas power stations located in them. The Nigerian National Grid is characterized by poor voltage profile in most parts of the network (especially in the Northern region), inadequate dispatch and control infrastructure, radial and fragile grid network, frequent system collapse, and exceedingly high transmission losses.

The current social impacts of the 330kV Nigerian Transmission Grid system and the growth in environmental requirements have not only called for the Almost all electricity consumers in Nigeria have expressed concern over the deterioration of quality of electrical power supply in Nigeria. Power utilities are required to provide electrical energy to consumers as economically and reliably as possible with high efficiency and according to load schedules. However, frequent interruption of electrical power supply in Nigeria has become a regular feature that constitutes problem of loss of goods and services for consumers and the power utilities. Undoubtedly, this situation has led to the rapid growth of standby electric power supply in large consumer premises and domestic dwellings. Even when power is available from the distribution network, problems of low voltage have damaged a lot of voltagesensitive industrial plants and instruments as well as domestic appliances. Therefore, in order to ameliorate the situation of instability of the Nigerian power network, an appropriate FACTS device is introduced to the system, hence, STATCOM. This, of course, will make the system stable and reliable [10,4].

4 III.

5 Ant-Colony Heuristic Approach

Research has proven that insect colonies behaviour can be seen as natural model of collective problem solving. The analogy between the way ants look for food and combinatorial paradigm is called ant colony meta-heuristic.

This meta-heuristic uses the ant colony optimization (ACO) method. The ant colony can be seen as a simulation of a set of agents that cooperate to find a solution of an optimization problem by means of uncomplicated communications.

The inspiration was taken from the observation of real ants. Ants are social insects living in colonies. It was observed that a moving ant deposits some pheromone (in variable quantities) on the ground; hence making the path it follows [1].

Next ant moving towards the feeding area can identify the pheromone left by the previous ant, decide with high probability to follow it, and reinforce the selected trail with its pheromone. This form of indirect Ants make use of pheromone in order to find a shortest path between two points connected with two branches. If there is no pheromone, ants decide randomly which path to choose. Therefore, more pheromone deposited on the lower path determines the number of new ants that will choose this path willingly [1]. However, the ants in the ant system are different from natural ants. They have memory, they are not completely blind, and they live in an environment where time is discrete or discontinuous.

Characters of the ACO algorithms use the device parameters and probabilistic model to generate solutions to the problem under consideration. The probabilistic model is called pheromone model. The pheromone model consists of a set of model parameters, which are called pheromone values.

At run-time, the ACO algorithms try to update the pheromone values in such a way that the probability to generate high quality solutions increases over time. The pheromone values are updated using previously generated solutions [1].

6 a) Ant Colony Algorithm

The key idea is that, when a given ant has to choose between two or more paths, the path that was more frequently chosen by other ants in the past will have a greater probability of being chosen by the ant. Therefore, trails with greater amount of pheromone are synonyms of shorter paths.

Figure 1.1a, 1.1b, 1.1c and 1.1d demonstrate how real ants find a shortest path.

In Figure 1.1a, the ants are moving from food source L to the nest R on a straight line and arrive at a decision point.

Once an obstacle appears as shown in Figure 1.1b, some ants choose the upper path and some the lower path. The choice is random. Figure 1.1c depicts the fact that since ants move at approximately a constant speed, the ants which choose the lower, shorter, path reach the opposite decision point faster than those which choose the upper, longer, path. That is, will collect larger amount of pheromone than the longer. In Figure 1.1d, as Pheromone accumulates at a higher rate on the shorter path, the number of dashed lines is approximately proportional to the amount of pheromone deposited by ants.

Therefore, more ants will be increasingly guided to move on the shorter path. Due to this autocatalytic process, very soon all ants will choose the shorter path. This behavior forms the fundamental paradigm of the ? Tour calculation: The distance between parameters is calculated by generating the first Node (bus) randomly. The first node selected further generates random numbers according to a uniform distribution ranging from 1 to n; n>0. ? Model estimation (Transition Rule): In this stage, the ant located at the current node will choose the next node and if the system is not satisfactory, the ant will move to the next location based on the probabilistic transition function and pheromone is converged.

? Local Updating Rule: The optimal location of FACTS Device is achieved as ants visit edges and change their pheromone level.

? Fitness Evaluation: This is performed when all ants have completed their tours.

? Global Updating Rule: This figure out the best ant tour which gives the best fitness among all the ants.

? Repeating Criterion: The algorithm stop the iteration when a maximum number of iteration have been performed, otherwise, the tour calculation process is repeated.

IV.

7 Analysis of the Case Study by Load Flow under Fault Condition

In order to demonstrate the effect of the STATCOM on the network under consideration, certain scenarios are considered and analyzed in PSCAD environment as follows. a) Without STATCOM A single line-to-earth fault was initiated at 0.2sec and cleared at 0.75sec; the system experiences a sharp swing which gradually leads to a total collapse of the entire network. During the fault on the system, the fault current increases leading to a decrease on the power flow along the transmission line and hence, a decrease in bus voltage profile (See Figure 1.6a).

8 b) With STATCOM

During fault condition and with STATCOM installed on the network, the fault current though experiences a swing but in this case, the compensation effect of the STATCOM enhances the power flow on the network as well as the bus voltage profile by damping the swing. This is shown in Figure 1.6b. V.

9 Simulation and Results

The ant colony code developed was incorporated and performed on the MATLAB environment; the following results were obtained for various cases.

Also, the algorithm when simulated for the minimum number of iterations required for convergence, finally presents the best results of the optimal bus located by the ant tour and pheromone trail demonstrated graphically in Figures 1. 4 Considering IEEE 14-Bus system, the algorithm is performed with number of bus (Nbus = 13) and converges at the 50 th iteration with the optimal bus located at Bus 6. The result of the ant tour and the pheromone trail is demonstrated in Figure 1.4a an Figure 1.4b. ACO Algorithm MATLAB Display for a 14 Bus System with Optimal Bus as Bus 6.

10 Conclusion

In conclusion, this paper has given us a pragmatic approach to STATCOM placement in Nigerian Grid system by Ant colony optimization technique. This can also be used in application to other systems networks outside the scope of this study.

Also, with the optimal placement of STATCOM in a transmission line, most of the bus voltage profiles increase considerably. The optimal placement of the STATCOM is also valid under contingency conditions in both system under study and the IEEE 14-bus systems. [1] [2] [3]

[1] expansion of the existing grid but demanded more for the optimization of the grid[2].? ?

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[3]Optimal Location of STATCOM in Nigerian 330kv Network using ant Colony Optimization Meta-Heuristic

Figure 1: G

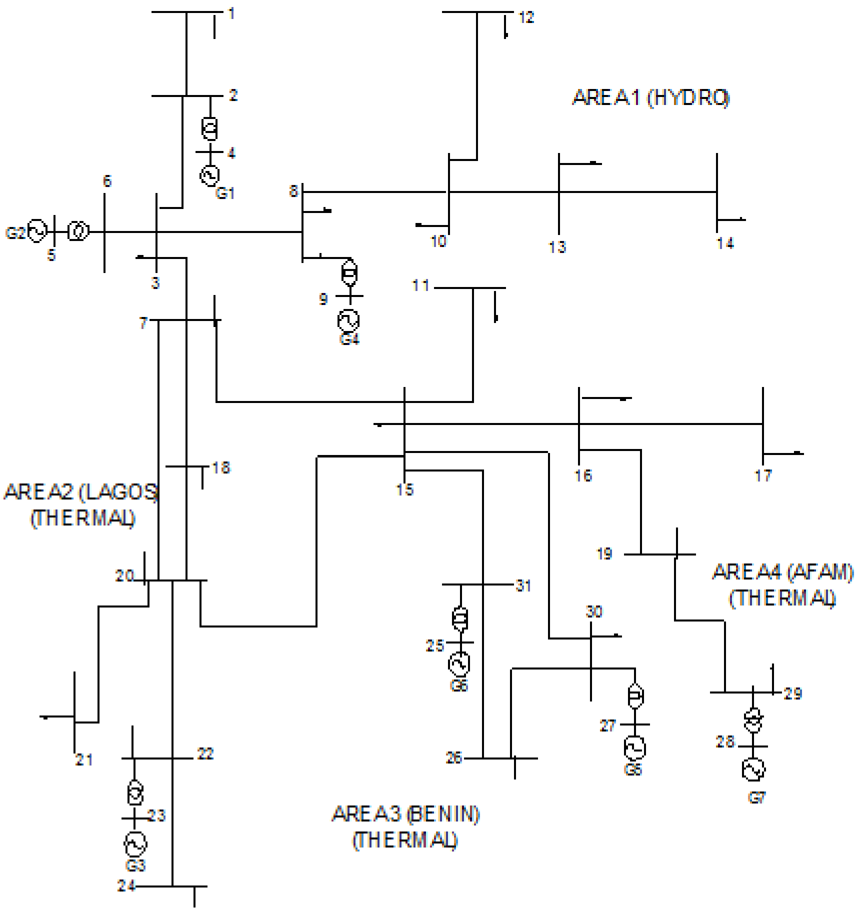

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Figure 2: Figure 1 . 0 :

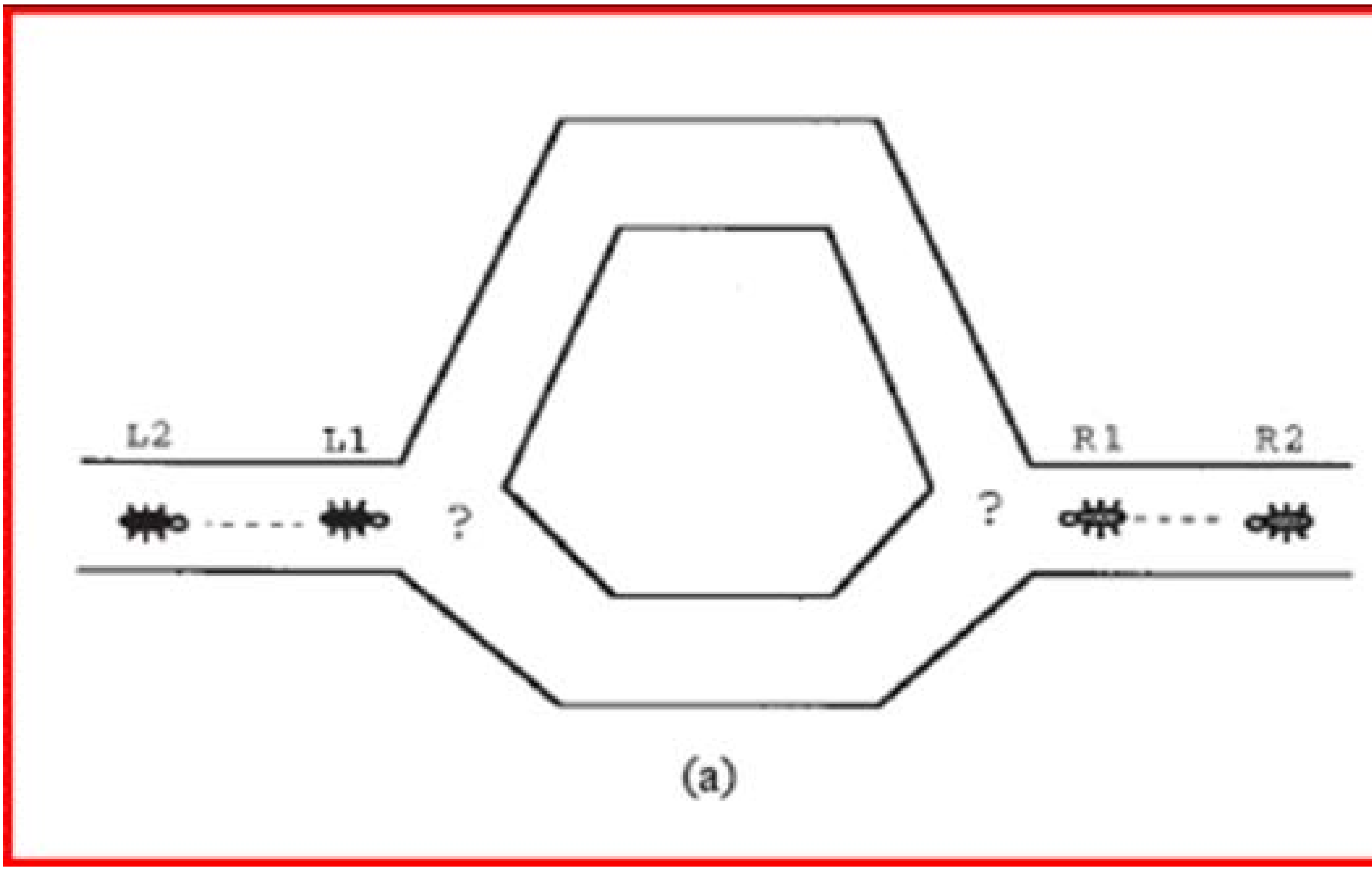


Figure 3: Global

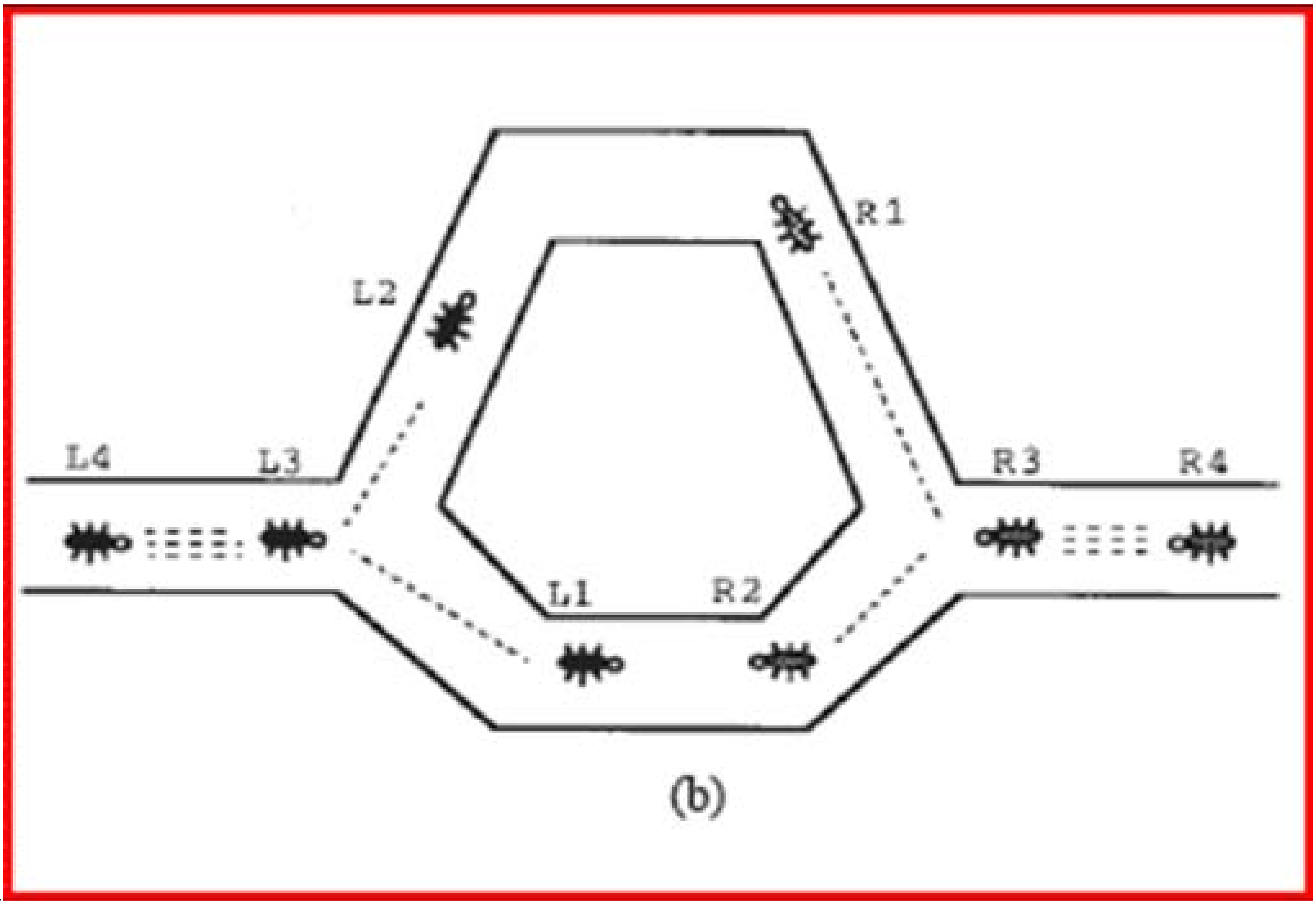
1 

Figure 4: Figure 1 .

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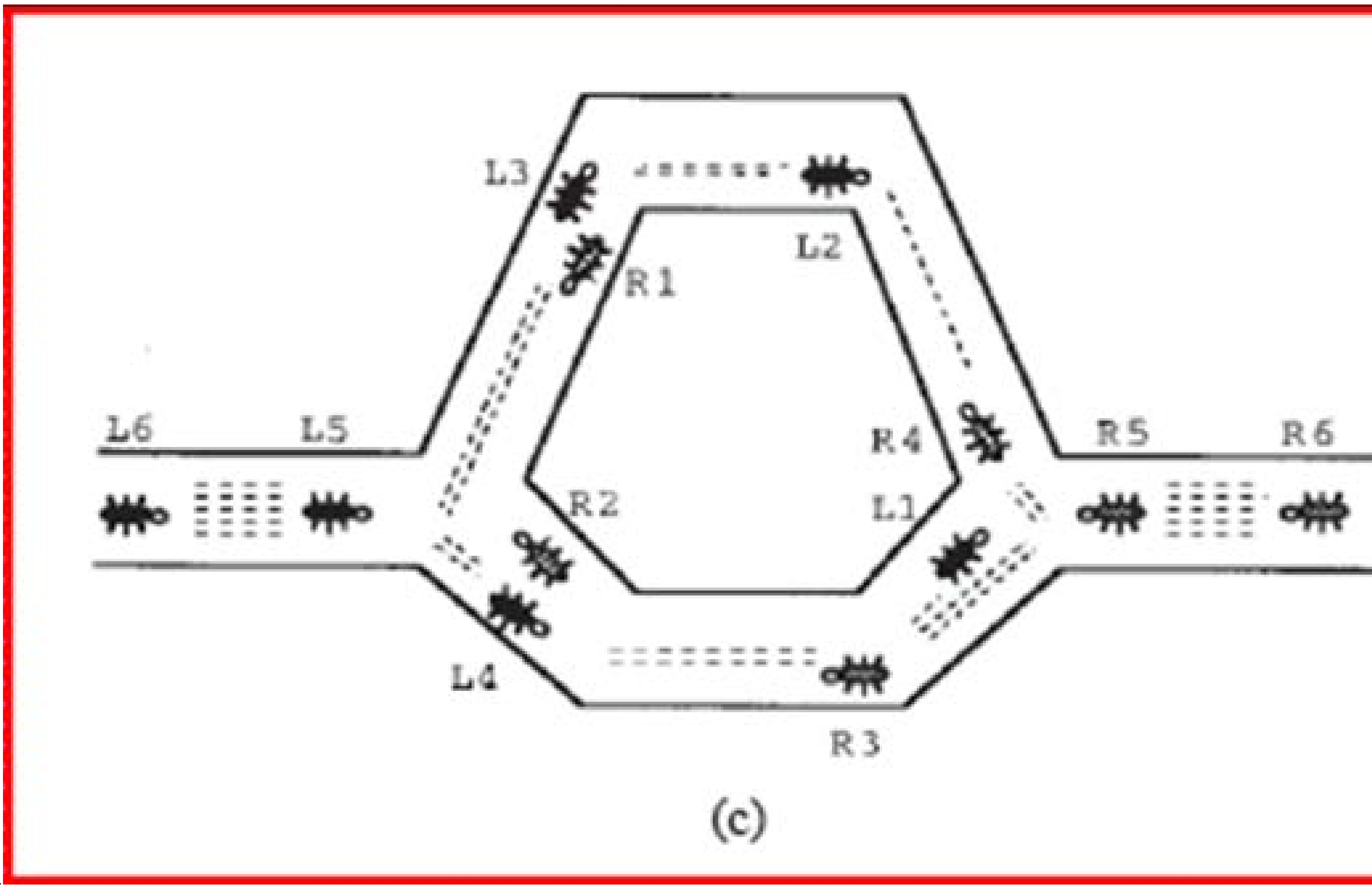

Figure 5: Figure 1 .

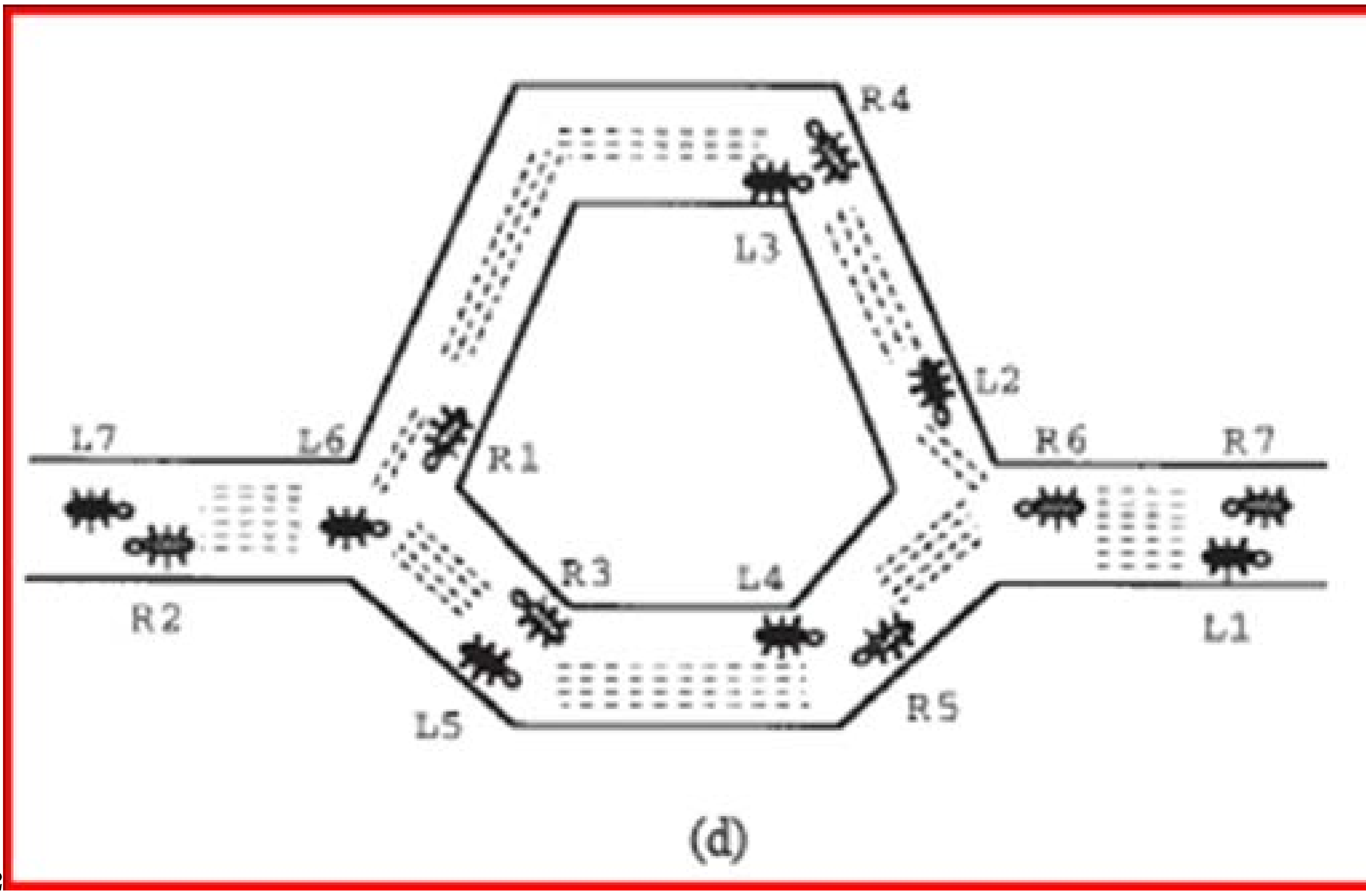

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Figure 6: Figure 1 . 2 :

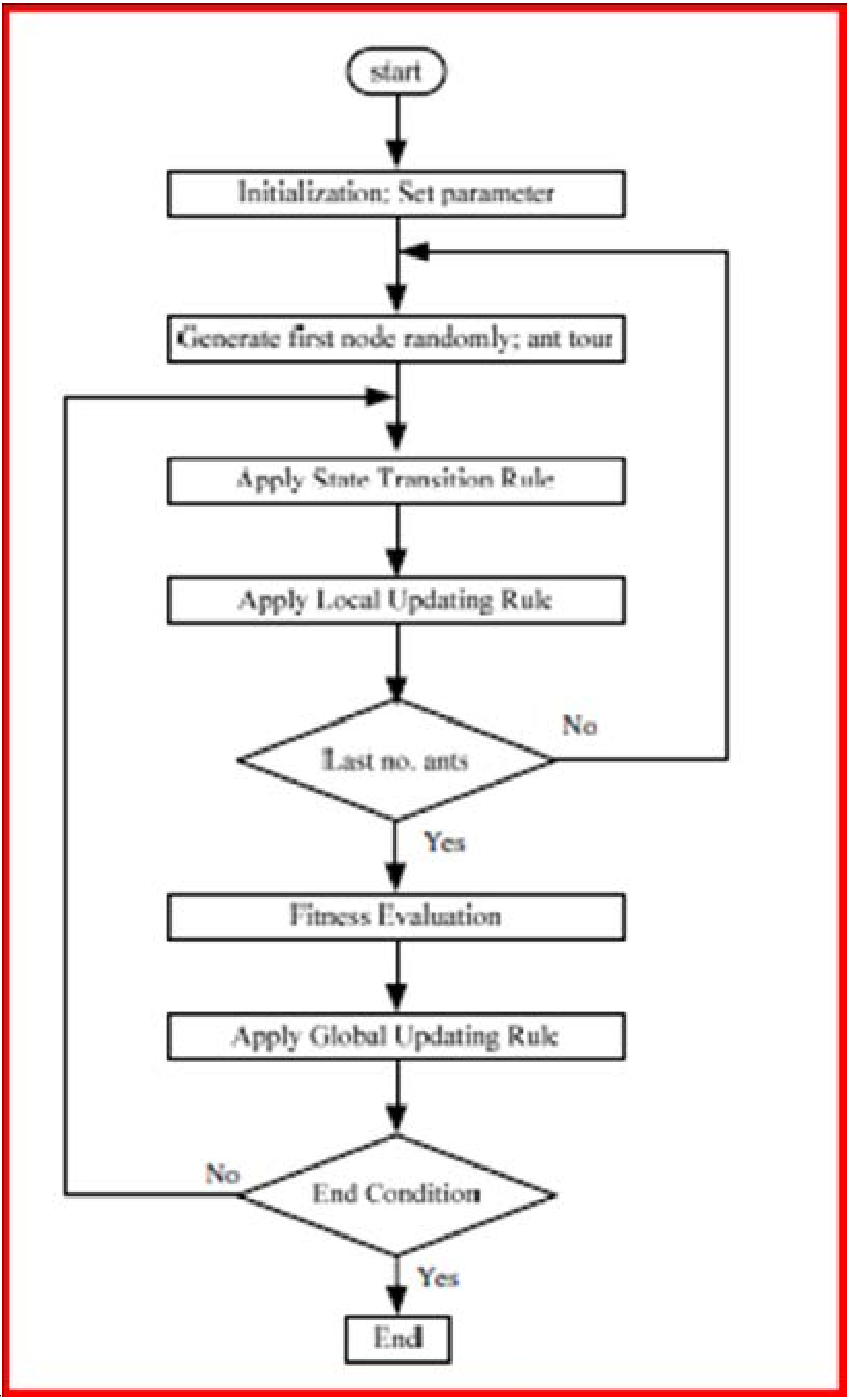

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Figure 7: Figure 1 .Figure 1 . 6 Figure 1 .

.1 Appendix

.2 Summary of problem parameters

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