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Abstract — The development of telecommunication network has opened the possibility to the birth of new applications that make human life becomes more productive. This application is packaged into an Internet of Things (IoT) concept that requires wireless sensors for its implementation. The more wireless sensors needed would necessitate the need for a mature planning concept. One of the models used to design is TSP. TSP still has some obstacles and is open for development, especially the scenario of finding the lowest cost. In this study, heuristic methods are proposed as one solution with a given algorithm. Based on the test results, this algorithm can be little bit better compared to Ant Colony Optimization for bigger number of nodes as well for the number of small nodes, it matches the brute forces mechanism.

Index Terms— TSP, WSN, Ant Colony, Heuristic

I. INTRODUCTION

Wireless technology is growing rapidly in telecommunication network today. It can be explained by the development of wireless technology generation that is always supported by continuous research. The movement of wireless technology is now getting closer to 5G, some countries / companies / consortium racing to be the first in implementing 5G. 5G infrastructure offers many advantages and new service possibilities which supports the involved connections with smart cities such as: Internet of Things, Clouds of Things, and Advanced Artificial Intelligence [1]. Wireless Sensor Networks (WSNs) is an emerging technology which apply Internet of Things (IoT) technology to the smart city concept, IoT has so many useful functions to solve a city problem such as: traffic monitoring system, earthquake detection, and environmental condition monitoring system. A wireless sensor networks is a set of individual nodes which organized each other into a cooperative network [2]. WSN is kind of research topic which make many researchers interested, one of key challenges in WSN is related with unit power consumption.

In wireless sensor networks there is a need for topologies with low power consumption because a sensor may have limited battery life [3]. Zhi et al [4] proposed algorithm considers energy efficient based on ring topology with multi-hop clustering routing. This algorithm performs better in reducing the energy consumption of nodes and increasing the lifetime of WSNs pretends remaining energy when choosing cluster heads and uses multi-round clustering instead of clustering in every round. Younis et al [9] also proposed an algorithm for energy-efficient, using clustering nodes in ad-hoc sensor networks, the algorithm periodically selects cluster heads according to a hybrid of their residual energy and a secondary parameter, such as node proximity to its neighbors or node degree. Heinzelman et al [10] proposed an architecture called low-energy adaptive clustering hierarchy (LEACH) for microsensor networks that combines the ideas of energy-efficient cluster-based routing media access together

Communication between sensor using ring topology is not only because it has low power consumption, but also from their characterized which every sensor unit connect with two neighbors for communication which direction either clockwise or counter-clockwise. Suppose the sensor communication can prevent from disconnection of single node failure, because when one side is failure, the data could be sent again using opposite direction.

Designing a ring topology can be approached using a Traveling Salesman Problem (TSP) model. In TSP model, the salesman must search the shortest route to visit all the encouraged cities (nodes), whereas it can only be visited by once, and the travelling of the salesman must be ended in his starting city. So from this description of travelling the salesman, the journey path will be modeled as a ring topology with has a minimum distance cost.

Therefore, in these paper, we proposed a method which is approach to find a smallest cost in TSP modeling route, also with their implementation to create a ring topology for Wireless Sensor Network’s (WSN).

The rest of this paper is organized in sections as follows. In Section II will be described about literature surveys which is explain the state of the art of studies on ring topologies in new directions. Section III presents proposed algorithm for solving TSP model with their performance and also its comparison with other method.
such as: Brute force and Ant Colony. Lastly, in the Section IV presents analysis result and conclusion.

II. RELATED WORKS

The traveling salesman problem (TSP) is kind of widely studied of NP-hard combinatorial optimization. Its problem is quite simple, but challenging many researchers to find the best heuristic method to solve TSP.

The most trusted method is called Brute Force Algorithm, which is try all the combinatorial of each node, then select a path with the minimum cost. Today, this algorithm is the only method that can achieve an absolute minimum value to TSP model. Brute force algorithm has a formula \((n-1)!/2\) which is “\(n\)” symbolized from the node/city. For the example to find the shortest route of 100 nodes, there will be \(4.67\times10^{155}\) ring topology combinatorial. This complexity cannot be solved manually even the most powerful computation machine today, still cannot solved it in the tolerant times.

Therefore, the wise solution is using a heuristic method. Many researchers develop this method to solve TSP. Pasquier J. L. et al [5] explain about the comparative three metaheuristics: Genetic Algorithm (GA), Ant Colony Optimization (ACO) and Simulated Annealing (SA). Ant Colony Optimization can reach an optimum value, but it takes longer time in computational time than does a Genetic Algorithm.

Junedul Haque [6] proposed the Solution of Traveling Salesman Problem (TSP) Using Genetic, Memetic Algorithm and Edge assembly Crossover. The result on different parameter like group size and mutation percentage, when mutation percentage is increased the distance value will be decreased.

Khan et al [7] using Multilevel Graph Partitioning Scheme to reduce the complexity of the TSP traveling salesman problem through k-mean partitioning algorithm which divides the main problem into multiple partitions graph in a very less time.

There is also [8] which has contributed to define its heuristic mechanism to get the lower cost of forming the ring topology as well as compared to ant colony. Nevertheless, it still has issue on time consumption for computing.

Shortly a new heuristic method is still needed to find optimum value, as close as the value which Brute force algorithm made, with shorter in computational time.

III. PROPOSED ALGORITHM

From the section II, it can be concluded that TSP has not been solved enough yet. Many researchers proposed their algorithm in the hope of producing a path to the ring topology with values as close as possible to the brute force method. The idea is also proposing the algorithm by having the same expectations with many other researchers.

The main idea of our algorithm is connecting nodes which has low cost to build a big ring. In Fig. 1, it is presented a flowchart which can help to understand the workflow of the algorithm clearly. By connecting the only low cost links it hopes that the total cost will be the lowest as well. Assuming that we have a matrix which represent the distance cost of the nodes. To make a shortest path/link on given node by connecting a node which has minimum cost.

To get a group of minimum cost, we have to sort a given value on the matrix with ascending scheme. Sorting all given cost will be the essential step to start this algorithm so it will be the foundation of the calculation. Cost in this step represents value of each link provided. This method used as the guidance to the way of creating the shortest link.

![Fig. 1. A proposed algorithm flowchart](image)

Ascending sort means the link is listed by the minimum to the maximum number. The next lowest cost of the link will be utilized to define the connection either it is connected to previous nodes or performs new separated links. This step is continued to the last possibility of connecting links until the final ring formed.

Some notes to this algorithm are: If the next node read has an associated with other previous nodes, so it has to be determined whether the node will create a close circuit (loop) or not. If the next node is independent from any associated nodes, so it can be kept as the link of nodes.
This algorithm can guarantee that all nodes are visited by once, because if it is found a link that associated to previous link, so it will be discarded. The workflow of this proposed algorithm can be easily figured out by the example matrix as well the solution for Travelling Salesman Problem to get an optimum ring topology.

Matrix on Table I describes a cost distance node to node, for example from node A to B the cost is 25 and from node D to F the cost is 15. Based on the matrix above, then it should be created a shortest path to form a ring topology. For the first step, all the data matrix will be sorted as ascending method which is shown on Table II.

From the Table II, it is known that the most minimum cost is 2 which is for the link node A-C. The next step will be B-F, then B-D, after that A-F. When it is checked for D-F, node F has been related to node B and Node A. If the decision is to connect node D and F, it forms circle without connecting all nodes. That is why link from node D to F should be rejected. This step will be repeated until the ring topology is formed. The above steps give the path to form ring topology illustrated in Fig. 2 with a minimum value of 62.

To get a fair comparison, the matrix of cost need to be defined which describes the cost of links from one node to others. Fig. 3 shows the data matrix used in simulation. The similar matrix is used to test each algorithm used in this study. This matrix is formed for 25 nodes which has random cost that varies from the lowest to the highest value while for brute force, it is only used for 14 nodes. While it finishes with the 25 nodes of implementation, then it is expanded until the number nodes of 50.

Interesting condition need to be considered for the next seven nodes, where both algorithms have different value. The proposed algorithm is still less effective to form ring topology of seventeen nodes. However, the more interesting condition is performed for the next several number of nodes until the end of the test. The proposed algorithm has a better value for the number of nodes upper than seventeen. Fig. 4 shows that this condition can be continued for several nodes ahead.
Performance of the algorithm still can be evaluated by considering the time execution. It is figured out at the Fig. 5 where the time execution of the proposed algorithm leading among others. The proposed algorithm only takes for about 0.029 second to form ring topology of 50 nodes while [8] need to compute for about 2500 second. Ant Colony has a better time computation compared to [8] but still it under the proposed algorithm for the task of computing time.

Algorithm shown in [8] is leading to find the minimum value to perform ring topology but it has drawback on time execution. However, the proposed algorithm still less effective to perform ring topology regarding to [8] but it has pretty good efficiencies on time execution. The test is not finished by comparing ant colony algorithm and the proposed one. It still need to compare the proposed algorithm with the brute force which is known as mechanism to find the absolute minimum value to form the ring topology. This test also utilizes the same matrix used for the test of ant colony and the proposed algorithm.

V. CONCLUSIONS

The idea behind the proposed algorithm to collect all the minimum values to form a ring topology from given number of nodes has a quite good result. It can lead ant colony algorithm and still can be enhanced to get lower value close to the brute forces.

By evaluating the data above then it can be simply looked that the proposed algorithm has the pros for its time computing. Then it also tried to verify its pros for executing by handle similar task using another bigger data matrix. For this task, then it generates statistically random 100 x 100 matrix so it can be utilized to form as many as 100 nodes.

For the difference data matrix from the previous test, the proposed algorithm takes 0.049 second to form 60 nodes and it increases become 0.13 second to form 100 nodes.

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