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Optimization Technique in Scheduling Duck Tours

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***Abstract*—**Tourism industries are rapidly increased for the last few years especially in Malaysia. In order to attract more tourists, Malaysian Governance encourages any effort to increase Malaysian tourism industry. One of the efforts in attracting more tourists in Malacca, Malaysia is a duck tour. Duck tour is an amphibious sightseeing tour that works in two types of engines, hence, it required a huge cost to operate and maintain the vehicle. To other country, it is not so new but in Malaysia, it is just introduced, thus it does not have any systematic routing yet. Therefore, this paper proposed an optimization technique to formulate and schedule this tour to minimize the operating costs by considering it into Travelling Salesman Problem (TSP). The problem is then can be solved by one of the optimization technique especially meta-heuristics approach such as Tabu Search (TS) and Reactive Tabu Search (RTS).

***Keywords*—**Optimization, Reactive Tabu Search, Tabu Search, Travelling Salesman Problem

I. Introduction

TRANSPORTATION and logistics hold a central place in modern economies. Several studies have established that the transportation costs account for a proportion of 11% to 13% of the total cost of goods. It is estimated that in Canada and the United Kingdom, transportation expenses represent 15% of the total national expenses [2]. This percentage excluding the expenditure of operations in the public sector such as bus routing and mail delivery. These operations surely will generate huge costs of traversal. Thus, in order to cut off some unprofitable costs, a systematic schedule is one of the best ways to prefer.

Simulation and scheduling are well-establish techniques in operations research and industrial engineering [3]. A lot of researcher simulated a routing problem into scheduling techniques and used optimization techniques to optimize the operations. For example, Maria Candida Mourao and Ligia Amado present a new heuristics method to generate feasible solution to an extended Capacitated Arc Routing Problem (CARP) on mixed graphs, inspired by the household refuse collection problem in Lisbon [12]. Junhyuk Park and Byung-In Kim simulated a bus routing problem into Vehicle Routing Problem (VRP) and proposed to solve this problem by several techniques in optimization [14]. Zuhaimy Ismail and Norhazwani Md Yunos present a new approach for solving CARP using the Reactive Tabu Search (RTS) approach, modeled for solid waste collection problems in the Municipal of Johor Bahru [17].

Basically the Travelling Salesman Problem (TSP) is a problem formulated especially to find the shortest path through a several set of nodes, visiting the nodes for at least once and returning back to the origins nodes at the end. Such like a salesman, which want to sales their product to each house in one area. They move from one house to another until the last house and then return back to where they start. The purpose of this tour is to minimize the distance or trip, in some way it can minimize the cost of traversal. TSP actually is not a new model. It is one of the most widely studied combinatorial optimization problems [11]. By now TSP already has its own practical applications in various field of research such as drilling of printed circuit boards, overhauling gas turbine engines, the order-picking problem in warehouses, computer wiring, scheduling with sequence dependent process times, vehicle routing, controlling robot motions, etc [9].

In this paper, we proposed a new approach for solving TSP using one of meta-heuristics methods which is Tabu Search (TS), modeled for scheduling duck tour problem in Malacca. TS is a meta-heuristics search technique that guides a local heuristic search procedure to explore the solution space beyond local optimality and has been proven to be effective in many optimization problems [17].

The presentation of this paper begins with a briefly describes the problem of scheduling duck tour and present the problem as a TSP. It is a problem of serving the demand to each node in such a way that the cost function is minimized. It is then followed with the solving method and finally a proposed model to schedule a duck tour.

II. Problem Description

Through recent acknowledgment as world heritage site by UNESCO not too long ago, Malacca is now attracting more local and foreign tourists than before. Malacca governance estimated about 6.5 million tourists annually visiting Malacca and in 2010, it was increase to 8 million tourists. There are a lot of tourist attraction that offers something different and from different perspective apart from the usual heritages, cultures, architectures and sightseeing which are Eye on Melaka, Melaka River Cruise, Menara Taming Sari (Taming Sari Tower) and Eye on Malaysia. Melaka Duck Tour has the same objective as well, to allow tourists to experience and view what Malacca has to offer on land and sea by touring the city with the amphibious vehicle.

The main purpose of duck tour is to offer sightseeing service journey to tourist to experience and view what Malacca has. Currently practice, the duck tour will traverse

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from one interesting places or monument to another over the selected region, on the land and in the sea which is shown in Fig. 1. This practice is not yet systematic. There is no systematic routing have been applied until now where it might cause an unprofitable. In order to gain high income for this business, the traversal of the duck tour should be well schedule so that all things that does not cause profit can be avoid. This is because, a complete journey of duck tour need rather a large amount of operating costs and also maintaining costs as it is work in two type of engine.

Fig. 1 Currently Practice by Malacca Duck Tour

Since the common practice by the management of a duck tour is to visit each interesting places or monument in selected region, based on some literatures, we can simulate this problem into TSP. The objective function in TSP cases is to minimize the total cost of traversal through each vertex or node while the variable involve in the data collection and data generations is the calculated cost for each arc. The calculated costs involved in the computation are labor cost, fuel cost and operating cost. The TSP works by determining a minimum distance circuit or cycle passing through each node once and only once.

For this TSP, the mathematical structure is a graph where each interesting places or monument is denoted by a point (node) and lines (streets) are drawn connecting two nodes called arcs or edges. Associated with every line connecting two nodes is calculated cost, c_{ij}. When the vehicle can service all the interesting places (nodes) and finally back to where it starts regardless if there is untour edges, then the graph is said to be complete. A network model can be represented as shown in Fig. 2.

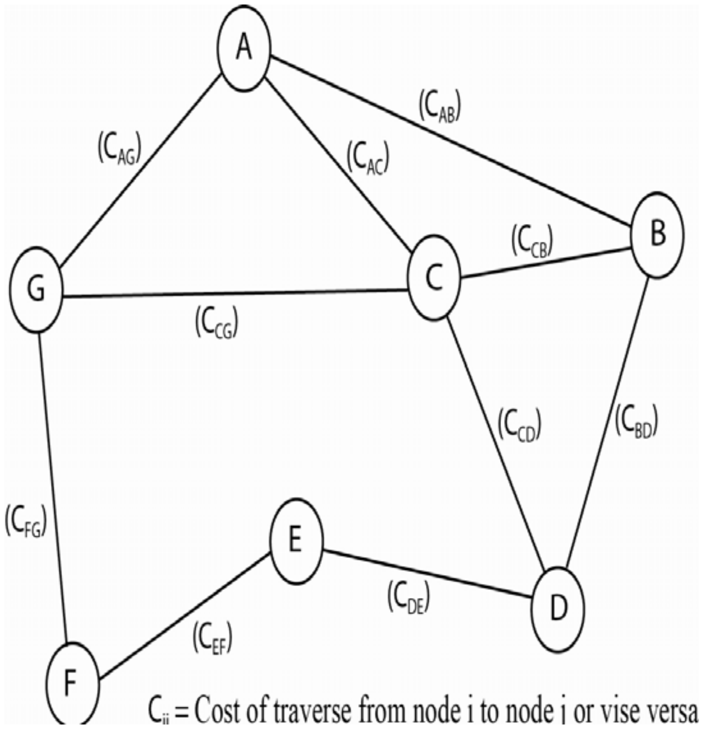

Fig. 2 Network Representation

III. Proposed Model

A meta-heuristics is a general solution method that provides both a general structure and strategy guidelines for developing a specific heuristic method to fit a particular kind of problem [8]. In this problem, we proposed to use TS with dynamic tabu list size which is known as RTS as our solution method. TS were introduced as a memory structure to support and encourage its non-monotonic search [5], [6], [7]. Thus, tabu search meta-strategy has been showed to be an effective and efficient scheme for combinatorial optimization that combines a hill-climbing search strategy based on a set of elementary moves and a heuristics to avoid the stops at suboptimal points and the occurrence of cycles [1].

The facts that we already know in TS implementation is that cycles are avoided if the repetition of previous visited configuration is prohibited. The larger tabu list size, the stronger the memory. But it is actually not sufficient for an effective and efficient search technique because it may cause low efficiency when the size of the tabu list is too large. However, when the size of tabu list is too small, the searching trajectory may form a limit cycle. Thus, the chaotic like attractor should be discouraged [1]. Because of that, RTS is applying to discover of a new high quality solution.The reactive tabu scheme is actually maintains the basic concept and also the terminologies of TS. RTS was proposed in this problem due to energetically of tabu list to change the size during the search process. This is because, the success of TS algorithm is highly depends on the settings of its components specially the tabu list size [15]. Therefore, we try to adapt the tabu list size to the problem to the current evolution of the search, also escape strategy for diversifying the search process.

A. Initial Solution Generation

When a complete graph of the problem has been constructed, then TS approach can be applied into the problem. The computational of TS algorithm starts with an initial solution to assign the value to the decision variables and to assess the fitness function. This initial solution can be feasible or otherwise. It can be generated randomly or via a suitable heuristic by an optimal method [13]. A good-quality of the initial configuration is used as a starting solution to obtain a good algorithm performance [17]. Usually there are advantages to start from high quality of initial solution. However, if the initial solution is already very good, it could make out TS quite restrictive [16].

B. Neighbourhood Search Procedure

The search space of TS heuristic is simply the space of all possible solutions that can be considered (visited) during the search process [4]. The move can be described as a modification done to the current solutions in each iteration to produce a set of neighbourhood. This neighbourhood is constructed in order to identify the adjacent solutions that can be reached from any current solution. The size for the search neighbourhood is not limited but it must have significant influence on the result. The larger the search size, the better the quality of the solution but it requires more execution time [10].

C. Tabu List Size (Reactive Tabu Search Implementation)

Based on literature, TS is a memory search method in which tabus are used to prevent cycling when moving away from local optima through non-improving moves. The key realization here is that when this situation occurs, something needs to be done to prevent the search from tracking back its steps to where it came from. This is achieved by declaring tabu moves that reverse the effect of recent moves [4]. Therefore, tabu list size is the important component in TS procedure and it is hard to set. The size of the tabu list represents its memory ability. If tabu list size is set to a small value, it may be too flexible and the probability of cycling may be high. But if tabu list size is set to a large value, it may be too strict and a good solution may be missed due to the move leading to them remained tabu for a long time. This can be avoided by using dynamic tabu list size and it is the reactive part in this proposed TS scheme.

Dynamic tabu list size can be periodically changes over times or also can be continuously change. If the tabu list size change periodically over times, this mean that the tabu list size will kept fixed for certain number of iteration and the process is repeated for *k* times. If the tabu list size is continuously changes over times, the changes of tabu list size will depend on certain function or formulated function for the selected moves or in other word it will change when it is needed [13]. This implementation seems to perform very well since the trajectory search is not bound with the limited tabu list size. The basic RTS algorithm is shown in Fig. 3.

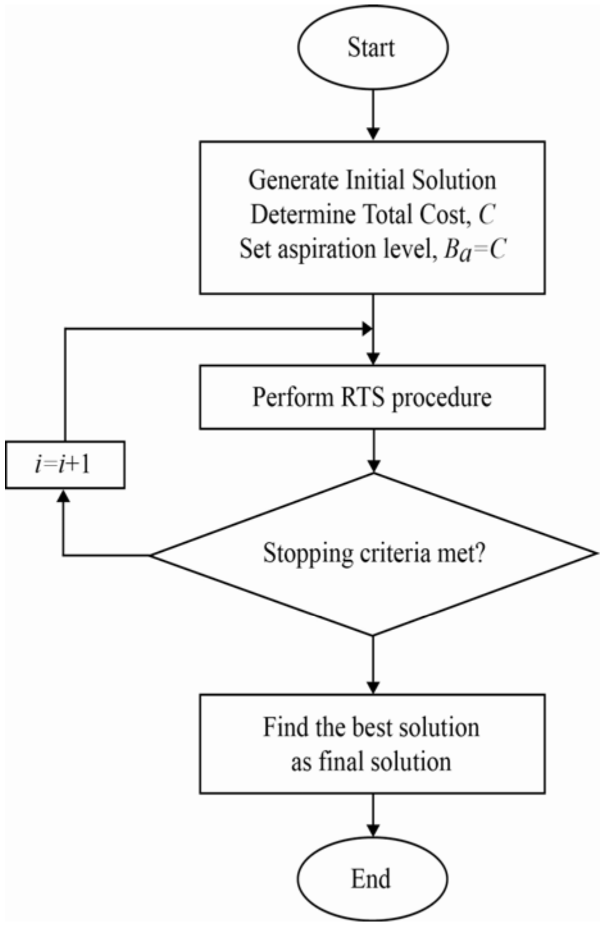

Fig. 3 Basic RTS Algorithm

D. Aspiration Criteria

In TS implementation, tabus are sometimes too powerful. They may prohibit attractive moves even when there is no danger of cycling or they may lead to an overall stagnation of the searching process. It is thus necessary to use algorithmic devices that will allow one to cancel tabus. These are called aspiration criteria [4]. In simple words, aspiration criterion is the rule that overrides tabu restriction. Aspiration criterion can make a certain forbidden moves become allowable when it is satisfy the rule. It works by deleting the tabu restrictions of the solutions to reconsider in further steps of the search. The goal of the aspiration function is to avoid cycling in order to provide the ability to find an improved solution and it is organized to be compatible.

There are three types of aspiration criteria which are aspiration by objective, aspiration by default and soft aspiration criteria. The simplest and most commonly used aspiration criterion is aspiration by default. It will allow a move (in case if all moves are tabu), if the solution of the objective value better than the current best-known solution. However, aspiration by objective is still good to be considered. It is because this criterion will freed the tabu moves if it leads to a solution that is better than any solution found so far. In other words, this type of aspiration criterion will lead to jump away from current neighbourhood search space to new portions of search space and thus perform more extensive exploration. The illustration of this implementation is shown in Fig. 4.

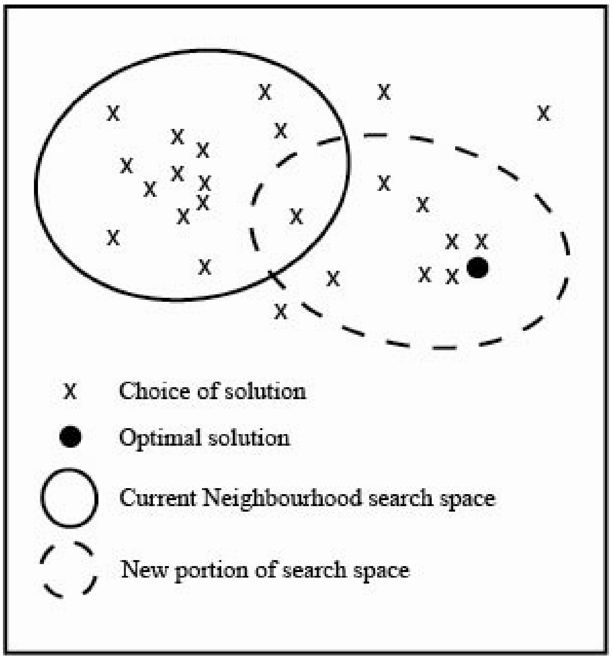

Fig. 4 Illustration of Aspiration by Objective

E. Stopping Criteria

Since the algorithm is open-ended, so the stopping criterion is always needed. In theory, the search could go on forever, unless the optimal value of the problem is known beforehand. The simplest form of stopping criterion is a fixed number of iterations, such as after 1000 iterations or by using computational time, such as after 10 minutes computations. It always a trade-off to consider because maybe the computational need just two to three minutes computation, but we set it to stop after 10 minutes computation, so there is no sense of running the programme after that amount of time.

Nonetheless, if the algorithm stops too early, the optimum solution may not be found yet and conversely the computation time can be wasted if the algorithm stops too late. Thus the dynamic stopping criterion that is taking advantage of the solution changes is more suitable in most cases. For example, the stopping criterion can be considered if there is no improvement on the last improved solution after a prescribed number of successive iterations.

IV. Conclusion

After TS algorithm completely been developed, then we can proceed to the computational part. We can use a variety of programming languages such as C, C++, C#, Java, Delphi etc to develop the algorithm. It is worth to let the computer do the computational compare if we manually calculate which is highly impractical.

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