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SELF-DRIVE TOURISM ROUTE IN LANGKAWI: AN APPLICATION OF CAPACITATED MULTIPLE TRAVELING SALESMAN MODEL

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Abstract: *This paper deals with the determination of the best possible route for self-drive tourism in Langkawi Island, Kedah. Self-drive tourism represents a type of tourism where tourists driving their own or rented car as the primary mode of transport and only involves a tourist destination which can be linked with a roads network. This study was applied the capacitated multiple traveling salesman problem (CMTSP) model to find the best possible self-drive tourism route that minimizes the total travel distance. There are 19 most attractive tourist destinations around Langkawi were considered in this study. The model has been solved using LINGO12.0 software. The results showed that tourist need to spend four days to visit all 19 tourist destinations around Langkawi with the minimum travel distance of 219.75 km. When the travel distance minimum, it also minimizes the travel (petrol) cost.*

Keywords**:** *Self-Drive Tourism Route, Tourist Destination, Travel Distance, Capacitated Multiple Travelling Salesman Problem*

Introduction

This paper deals with the real-world self-drive tourism route application in Langkawi Island, Kedah. According to World Tourism Organization (WTO) (Wikipedia), the terms of tourism refers to, *"Activities of an individual travelling to a place outside their original environment and living there for not more than one consecutive year for leisure, business and other purposes."* Tourism is the study of human from its original habitat in which to respond to the industry and will also have an impact on the social, economic and physical environment (Mason 2003 in Jaffry & NorAzlina 2007). Meanwhile, Burkart (1981), defined the tourism as the temporary, short-term movement of people to destinations outside the places where they normally live and work, and their activities during the stay at these destinations. The main purpose of travel is to visit tourist attractions around the location.

Over the decades, tourism has experienced continued growth and deepening diversification to become one of the fastest growing economic sectors in the world. According Wearing et al. (2010), tourism is one of the fastest-growing sectors of the economy and major source of employment and investment. The contribution of tourism to economic well-being depends on the quality and the revenues of the tourism offer. To promote a culture of self-drive tourism in Malaysia, Ministry of Tourism Malaysia has organized the inaugural ASEAN Media Bloggers Tourism Hunt 2015 from 16 to 21 October to promote Malaysia to regional travellers and to encourage visitors to explore Malaysia through self-driving holidays. The theme of the Treasure Hunt is "Fun and Enjoyable Drive to Experience Malaysia". Due to the first event received encouraging response, then in 2017, Ministry of Tourism Malaysia has organized the second edition of the ASEAN Media Bloggers Tourism Hunt 2017, which commences from 11 until 14 July 2017. The ASEAN Media Bloggers Tourism Hunt is formatted as a treasure hunt, a race and social media contest that aims to introduce and promote Malaysia's unique culture, heritage, cuisine and other tourist offerings to the ASEAN market and publicize Malaysia by utilizing social media and digital media platforms such as Instagram and Facebook. This year's edition of the hunt is themed "Malaysia on Wheels" to highlight the concept of self-drive holidays in Malaysia utilizing Malaysia's network of highways and road systems, particularly the PLUS Highway which connects Malaysia from north to south. It can encourage the self-drive tourists to enjoy the interesting sight along the road of Malaysia.

There are a variety of tourist destinations to visit in Malaysia and one of them is Langkawi Island in Kedah. Langkawi Island has been selected to this study because it has more interesting places and had its own history. Langkawi Island is a popular tourist destination not only among international tourists but also locals. Dominating an archipelago of more than one hundred islands and islets, Langkawi Island is synonymous with sandy shores, jungle-cloaked valleys, bargain shopping, world-class infrastructure, mangroves rich in flora and fauna, and fascinating legends. Blonde beaches are the biggest draw, but this 478.5-square-km island has been duty free since 1987, making low-cost kitchenware a close second. Self-drive tourism is already beginning to be a choice for tourists who want to explore all places at this island. For improving the services for tourist, a shortest route model need to be create which it can help tourists to plan their trips of holiday wisely. The purpose of this study is to provide a better plan for tourist that based on shortest route by driving their own vehicles to interesting places that they want to go. Therefore, tourists can save their time and travel cost. By having this model, tourist can choose the best route that can connect from the destination to the next destination based on shortest route.

Since this study involved 19 tourist destinations in Langkawi, so it is suitable to choose self-drive tourism in order to explore all the places. In many tourism studies, the relationship between transport and tourism is defined in terms of accessibility; that is transport is seen as a link between tourist generating regions and tourism destination regions. Transport is seen as an enabler of tourism (Faulkner, 1989); a necessary precursor to tourism activity (Leiper, 1995); and as serving as part of the attractions mix in some scenarios (Hall, 1998). For travel to and within destinations, the choice of which mode of transport are used may depend on the tourists' evaluation of speed; carrying capacity; comfort; cost; and safety. From January to August 2017, Langkawi has received 2,326, 779 local and international tourists, which is increased by 1.1% compared to the same period in 2016 (lada.com.gov.my, 2017). An increasing number of tourists are not only capable encouraging domestic economy and attract investors even improve the living standard of population, especially those involved in the business. This is in line with the study by Bakri et al. (2014), which determine that tourism is seen as a sector that could

provide the most significant impact to local communities in terms of financial improvement aspect.

The aim of this paper is to determine the best route of a self-drive tour in Langkawi Island using a capacitated multiple traveling salesman problem (CMTSP) model. The tourists can visit the 19 tourist destinations around Langkawi Island with minimum travel distance and it will minimize the travel cost. Section 2 of this paper discusses about the literature review and section 3 discuss about the scope of the study. Meanwhile section 4 discuss about the mathematical formulation of CMTSP model and its application with the data involved in this study. Section 5 shows the results and discussion with section 6 giving the conclusion.

Literature review

Tourism is seen as an industry that contributes to the economic growth of government and the private sector, especially after the Second World War (1939-1945). The tourism industry is one of the major sources that contribute to national income. Tourism has been identified as an important factor in many contemporary island economies (Royle, 2008). Liew (2002) states that tourism development contributes towards the enhancement of local communities in the sense of providing greater economic benefits. The tourism sector has become increasingly important industry to many developing countries as a source of revenue as well as a source of employment. To encourage the development of tourism industry, the government provides appropriate policies and strategies to make tourism as a new source of economic growth. One of them is the self-drive tourism industry. Therefore, various studies using various mathematical programming models are carried out from time to time to enhance the effectiveness and improvement in the tourism industry.

Hardy (2006) define self-drive tourism as the tourism that is carried out by driving their own vehicle or hire a vehicle to the places of interest. Self-drive tourism is linked to the concept of special interest tourism, where the tourists have specific purposes (usually activity based) for visiting destinations (Carson et al., 2002). Self-drive tourism is usually a free travel, which is tourists can plan their own itinerary without being tied to a travel itinerary from a travel agency. This is one of the important features of self-drive tourism (Hsin, 2006). By using this mode of travel, tourists can determine or choose their own preferred route from a destination to the next destination in accordance with the provisions on travel costs and time required. According to Taplin and McGinley (2000), for most holiday makers traveling by car, the pursuit of satisfaction and enjoyment is limited by the length of time available and by travel distance. Meanwhile, Carson et al. (2002), determine that self-drive tourism has advantages to tourists in terms of: greater control over itinerary; often greater comfort and lower cost.

The multiple traveling salesman problem (MTSP) is a generalization of the well-known traveling salesman problem (TSP), where more than one salesman is allowed to be used in the solution. This occurs by dividing all the places to be visited to several groups and each group allocated to each salesman (Nallusamy et al. 2009). MTSP widely used in real scenarios such as in a variety of scheduling problems. For example, the problem of school bus travel (Angel et al. 1972), printing machine scheduling problem (Gorenstein, 1970), and Carter and Ragsdale, 2002), problem of scheduling interviews (Gilbert and Hofstra, 1992), crew scheduling (Svestka and Huckfeldt (1973), Lenstra and Rinnooy Kan (1975), Zhang et al. (1999), and Pang and Muyldemans, 2013) and so forth. Other problems are often formulated as an MTSP problem is vehicle routing problem (VRP). VRP means determining routes for several vehicles from a depot to a number of customers and then returning to the depot. VRP has a similar concept with

traveling salesman problem with multiple maximum capacities. The VRP is another name for CMTSP. Vehicle routing problem with capacity is described by a set of similar capacity vehicles stopped at the depot. Each vehicle needs to determine the route to meet the demand of customers in other cities. Capacitated vehicle routing problem (CVRP) is considered the most basic version or type of vehicle routing problem and has been used in the most common management problem in food, fuel and retail goods distributors. The objective function of those problems usually involves distance, cost, number of vehicles, or profits, among others. The purpose of solving the CVRP is to find the optimal solution that serves all the stations with the stated demand without exceeding the capacity of the vehicle used. In general, a CVRP considers equal capacities for all vehicles; although in real life vehicle fleet with different capacities can be used to solve the delivery problem (Vaira, 2014). The solution of vehicle routing problem with capacity was similar to capacitated multiple traveling salesman problem (CMTSP) (Schrage,2006). Akhand et al. (2016), in their study investigates a variant of Sweep algorithm for clustering nodes and different Swarm Intelligence based methods for route generation to get optimal CVRP solution.

A privilege of this method is to make sure every place visited only once and return back to where they started. We cannot apply the shortest-path problem in this study because the model only finds the shortest path with the minimum length from one destination to other destination without visiting all destinations in the network and not return back to where they started. Even though in the minimum spanning tree problem, all nodes in the network is connected such that the sum of length of the arcs is minimized, but we still cannot used this model in this study because a group of arcs should contain no loop and not return back to where they started (Winston, 2004).

Scope of the study

This paper presents a study on a real road network that connects tourist destinations around Langkawi Island. Although there are more than 30 tourist destinations in Langkawi (refer Figure 1), but this study only covers 19 of the most attractive tourist destinations around Langkawi. The tourist destinations were selected based on recommendations derived from the Ministry of Tourism Malaysia website. In addition, because the scope of our study only focused on self-drive tour, so the tourist destinations in the vicinity of the Langkawi archipelago is not included in this study. Table 1 shows the tourist destinations that have been selected as a tour destination in this study

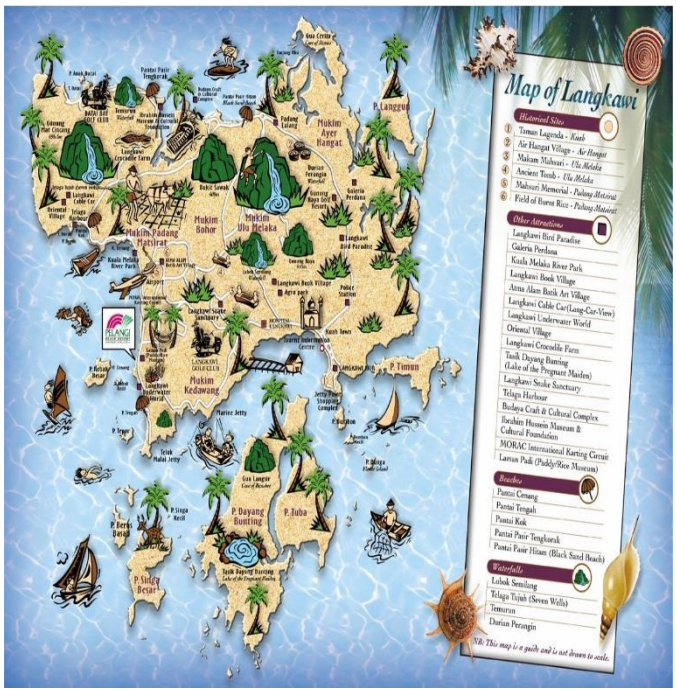

Figure 1: Map of Langkawi Island

Table 1: Tourist destinations

Destination	Abbreviation
Eagle Bay	DL
Taman Lagenda	TL
Langkawi Crystal	KL
Mahsuri Mausoleum	MM
Kampung Buku Malaysia, Langkawi	KBL
Underwater World	UW
Pantai Chenang	PC
Paddy Rice Museum	LP
Field of Burnt Rice	BT
Oriental Village (Langkawi Cable Car)	OV
Seven Walls Waterfalls	TT
Crocodile Farm	TB
Temurun Waterfall	ATT
Langkawi Craft Complex	KKL
Air Hangat Village	TAH
Tanjung Rhu	TR
Galeria Perdana	GP
Mount Raya (Gua Cherita)	GR
Langkawi Wildlife Park	ZM

The focus of this study is to develop the CMTSP for self-drive tourism in Langkawi Island. In developing the CMTSP model for this study, the total time for travel and day visit provided at least 10 hours. The reason for only 10 hours a day allocated to the holiday was because the operation started from 8.00 am until 6.00 pm in many of the tourist destinations in Langkawi. Estimated travel time to visit places of interest that exist between origin and destination is obtained from the estimated time given by the Google Maps application for each selected path. The distance from one destination to another are also found using the Google Maps application. Estimated trip time in minutes which provided to visits 19 tourist destinations is shown in Table 2.

Table 2: Estimated trip time (minutes) which provided to visit tourist destinations

Tourist Attraction	Estimated Trip Time (Minutes)
DL	30
TL	90
KL	60
MM	90
KBL	90
UW	120
PC	120
LP	90
BT	30
OV	150
TT	150
TB	120
ATT	150
KKL	90
TAH	120
TR	90
GP	90
GR	90
ZM	120

Mathematical formulation of CMTSP model

The CMTSP model was constructed to minimize the total travel distance. In this model, Hotel Grand Continental Langkawi (GC) has been selected as a depot because of its strategic location which is located right in the Kuah town. It also charges a lowest rate compared to the others accommodation around Kuah town with RM113.00 for one night. The CMTSP approach applies because we assume that all the visitors travel to Langkawi typically will stay at one accommodation only because the Langkawi area itself is not too wide and the distance to move from a tourist destination to other destination is not too far. Mathematical model to minimize the total travel distance is as follow.

Objective of this model is to minimize the total travel distance of the journey. The objective of this model is as follow:

$$Minimize \sum_{i=1}^{20} \sum_{j=1}^{20} d_{ij} x_{ij} \qquad [1]$$

$$\text{with } x_{ij} = \begin{cases} 1; \text{if there is a path from tourist destination } i \text{ to } j \\ 0; \text{otherwise} \end{cases}$$

d_{ij} = distance (in km) from tourist destination i to tourist destination j.

In order to develop the CMTSP model, we need to include all four constraints below.

$$\sum_{i=1}^{20} x_{ij} = 1; \quad j = 1, 2, ..., 20 \qquad [2]$$

The purpose of equation [2] is to make sure that tourists arrived in each tourist destination once.

$$\sum_{j=1}^{20} x_{ij} = 1; \quad i = 1, 2, ..., 20 \qquad [3]$$

Equation [3] means tourist leave each tourist destination once.

$$\sum_{i,j \in S} x_{ij} \leq |S| - 1 \qquad [4]$$

where $|S|$ = subset of tourist destination $S\{1, 2, \ldots, 20\}$.

Meanwhile equation [4] is to ensure sub-tour be unreasonable for each subset of S which is not include the depot station. In this model, Hotel Grand Continental Langkawi (GC) has been selected as a depot for its strategic location which is located right in the town of Kuah as well as impose a reasonable rental rate of RM113.00 for one night.

$$\sum_{i,j \in T} x_{ij} \leq |T| - k \qquad [5]$$

where: T = set of tourist destination.
k = the minimum number of destination should be deducted from set T to reduce it to one capacity.

Equation [5] was developed to ensure that all sets in excess of the visit will be limited to a reasonable day. For every T which includes the depot in which make up more than the capacity, let k be the minimum number of destinations should be deducted from set T to reduce it to one capacity

Result and discussion

To obtain results for the CMTSP model, LINGO software version 12.0 was used. LINGO is a comprehensive computer software and effective way to solve the problem of modeling linear and non-linear with the faster, easier and effectively (Schrage, 2006). In addition, LINGO is also a mathematical modeling language that allows us to express the optimization problem in a similar form to standard mathematical notation.

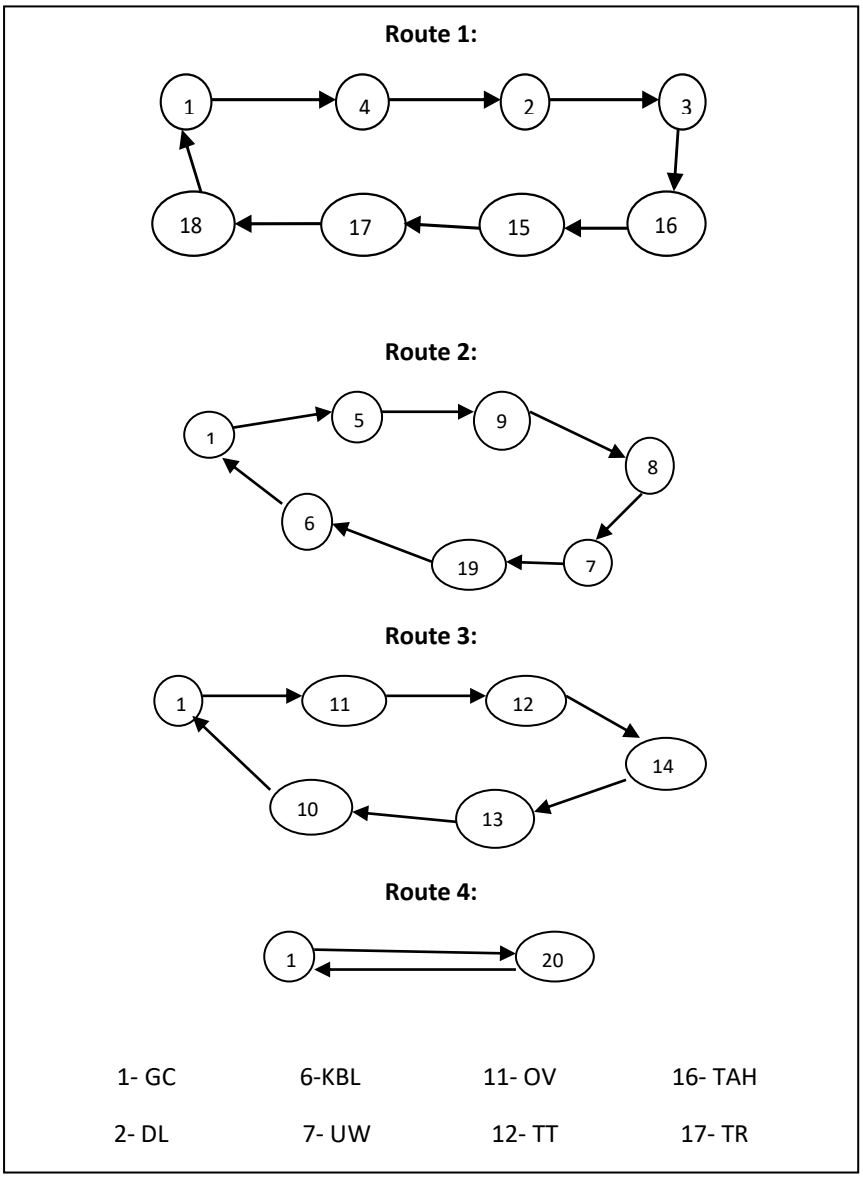

Figure 2: The network topology of CMTSP model

The result showed that the total number of days to visit all the 19 selected tourist destinations in this study is four days. Hotel Grand Continental Langkawi (GC) has been selected as a depot which is the starting and ending point for all four days travel. Figure 2 shows the route selected for all four days travel. Tourists can visit all the tourist destinations within four days and its depends on them to choose which route for the first day until day four. Its depends on their preferences and comfort. Based on result in Table 2, tourist needs to spend four days to visit all the 19 tourist destinations which is limited to traveling and visiting time of 10 hours (600 minutes) per day. After reach the time provided for each trip a day, tourist needs to return to Hotel Grand Continental Langkawi (GC) for that day. For this case, tourist will stay at this hotel for all the three days, and we assume that the last day visit, tourist will leave the Langkawi Island without stay at that night. The total travel distance for the whole journey is 219.75 km.

Table 3 shows the route network solutions that minimize the total travel distance for CMTSP model.

Table 3: Route network solutions that minimize total travel distance

Route	Destinations	Daily Total Travel Distance (KM)
1	GC→KL→DL→TL→TAH→KKL →TR→GP→GC	43.3
2	GC→MM→LP→PC→UW→GR→ KBL→GC	85.15
3	GC→OV→TT→ATT→TB→BT→ GC	86.1
4	GC→ZM→GC	5.2
	Total travel distance	**219.75**

Conclusion

Based on this study, the used of proposed model is proven to give an idea to the tourists in choosing a suitable route when they want to visit tourist destinations in Langkawi Island by drive their own vehicle without using the tourist guide. It shows that the proposed model was expected to help tourists make their travel plan guidance to choose the route that will minimize the travel distance. When the travel distance minimum, it also minimizes the travel (petrol) cost. Due to the current of petrol price constantly changing according to global market price of petrol, the price of petrol to be considered in this study is the actual price of petrol during the study. Indeed, the solution using a mathematical model such as this would facilitate the tourist in solving the problem more efficiently, rapidly and systematically. However, in practice, should be reminded that not all the planned would be implemented. Sometimes other factors such as traffic and the difficulty of the proposed route will also influence the choice of routes.

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