

IMPROVING WATER METER READING OPERATIONS USING  
OPTIMIZATION TECHNIQUES FOR SYARIKAT AIR JOHOR

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A project report submitted in partial fulfilment of the  
requirements for the award of the degree of  
Master of Engineering (Industrial Engineering)

Faculty of Mechanical Engineering  
Universiti Teknologi Malaysia

JUNE 2015

This study is humbly dedicated to  
Allah, the Almighty,  
for granting me the opportunity to serve  
the believers, those who seek the Truth.

## ACKNOWLEDGEMENTS

In the name of Allah, Most Gracious, Most Merciful, I thank Allah for granting me perseverance and strength I needed to complete this study.

Appreciation and gratitude to Prof. Madya Dr. Adnan Bin Hassan for his advice, encouragement, criticism, guidance and friendship while completing this study. Without continued support and interest, this study would not have been the same as presented here. I appreciate the patience of Prof. Madya Dr. Adnan Bin Hassan who is willing to share information and expertise, accessibility and spend his time every week to supervise me. The spirit of patience, careful reading, interest in this study and feedback is very helpful to enhance the study.

I am also very much indebted to En.Nasarudin Bin Selamat for giving me permission to conduct my research in Syarikat Air Johor Kota Tinggi. In addition, many thanks to Mr. Mohamad Yusuf B Panji for guidance and explaining in detail about the meter-reading operations. I would like to convey my appreciation here to En. Azfar Bin Hussin for he set aside time to explain how meter reader implement their task from the first reading process until the end.

I am grateful to all my family members, especially my parents Mohamad Ali Bin Mahidin and Marsilah Binti Chik for their prayers and moral support during my study. In addition, I would like to thank Omar Fariz, for showing patience and giving moral support and last not least I would like to say thanks to those involved directly or indirectly in completing this study.

## ABSTRACT

Water meter distribution network is a challenge for decision makers to choose the best route during water bill distribution to ensure all places are visited without skipping any consumer's house. In particular, rural areas are more challenging as compared to urban areas because there are a lot of barriers or challenges faced by meter reader during water bill reading process. Based on observation and interview session there are four factors causing the problem during meter reading process which are geographic factor, human factor, machine factor and external factor. Furthermore, meter reading department needs to complete their task within a specific time frame which is in between 29 to 30 days for all consumers (58587 registered accounts). If billing days are less than 29 days the effect is profit to Syarikat Air Johor (SAJ), if more than 30 days SAJ will lose the profit. Win-win situation for SAJ and customers will happen if the billing days are exactly 30 days. Currently SAJ Kota Tinggi is unable to comply with this requirement. Overdue cycle is a financial lost to the company and early reading is a financial lost to the customers. The purpose of this study is to propose an optimum assignment and route for meter readers. Technique based on travelling salesman problem and assignment problem were used in this study. Evaluations were made using travelling salesman problem method and minimum spanning tree as a comparison for total time, sequence path and estimation time analysis. The findings suggest that the travelling salesman problem provided a minimum total time compared with minimum spanning tree and the current practice for both rural and urban areas covered in this study. In terms of estimated reading time, the result suggests 99% probability that meter reading task can be completed in 205 minutes for 175 rural areas consumers and 126 minutes for 167 urban areas consumers.

## ABSTRAK

Rangkaian pengedaran bil air adalah satu cabaran kepada pembuat keputusan untuk memilih laluan yang terbaik semasa proses pengagihan bil air untuk memastikan semua tempat dikunjungi tanpa meninggalkan mana-mana rumah pengguna. Kawasan luar bandar khususnya, lebih mencabar berbanding dengan kawasan bandar kerana banyak halangan atau cabaran yang dihadapi oleh pembaca meter. Berdasarkan sesi pemerhatian dan temu duga terdapat empat faktor yang menyebabkan masalah semasa proses bacaan meter iaitu faktor geografi, faktor manusia, mesin dan faktor luaran. Tambahan pula, jabatan bacaan meter perlu menyelesaikan tugas mereka dalam tempoh masa tertentu iaitu di antara 29 sehingga 30 hari untuk semua pengguna (58587 akaun berdaftar). Jika tarikh bil kurang dari 29 hari kesannya adalah memberi keuntungan kepada Syarikat Air Johor (SAJ), jika lebih daripada 30 hari SAJ akan mengalami kerugian. Situasi yang memihak kepada SAJ dan pelanggan akan berlaku jika tarikh bil adalah tepat pada 30 hari. Pada masa ini SAJ Kota Tinggi tidak dapat memenuhi sepenuh keperluan tersebut. Kitaran bacaan air tertunggak memberi menyebabkan kerugian kepada syarikat, dan bacaan awal akan merugikan pelanggan. Tujuan kajian ini adalah untuk mencadangkan rangkaian dan laluan pengedaran optimum untuk pembaca meter air. Teknik “Travelling Salesman Problem” dan “Assignment Problem” telah digunakan dalam kajian ini. Penilaian telah dilakukan menggunakan “Travelling Salesman Problem” dan “Minimum Spanning Tree” dari segi jumlah masa, laluan urutan dan analisis masa anggaran. Hasil kajian menunjukkan bahawa “Travelling Salesman Problem” menyediakan jumlah masa minimum berbanding dengan “Minimum Spanning Tree” dan amalan semasa bagi kedua-dua kawasan bandar dan luar bandar dalam kajian ini. Berbeza dari segi anggaran masa, hasil kajian menunjukkan, 99% kebarangkalian tugas bacaan meter tamat ialah 205 minit bagi 175 pengguna di kawasan luar bandar dan 126 minit bagi 167 pengguna di kawasan bandar.

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## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Background of the Study**

Network design refers to a repeated process, overall topological design, network syntheses and network realization to ensure that a new telecommunication network or service fulfill customers' and operators' needs. The implementation process is used to arrange new network or services. Classical network planning methodology contributes to five different fields which are business planning, long term and network planning, short term planning, IT asset sourcing, and operation and maintenance.

This network process involves external information on forecasting of a new network or services as well as the economic condition that focus on the cost and technical details of network capabilities in terms of geography or structure. The network planning contributes to three main steps which are topology design, network syntheses and network realization as the following descriptions:

- a) Topology design: Identify the best place of the component and how to connect each of these components. A mathematical method called Graph Theory can be utilized during these steps where it focus on cost of transmission and optimum connection between two paths or more.

- b) Network synthesis: This step contributes to the size of component and involves the topology to calculate a routing plan or size
- c) Network realization: These step define how to meet capacity requirement which is similar to the concept of customer and demand, beside to ensure the reliability within the network

In reality, there are many examples of distribution networks such as newspaper delivery problems. These problems include route optimization where the focus is to minimize total cost of routes. Newspapers are based on current situation. This is why it cannot be printed early. In this situation, distribution centres play a critical role to ensure that customers receive newspaper before 6.00 am. The distribution process starts at midnight which is based on 6 hours time frames. The process will start from the printing facility, the distribution centre which will send them to the home delivery carrier routes which will be following with drop off point. Then, the newspaper will be sent to the customers' home (Hurter and Buer, 1996).

Second related problem is the school bus services. The bus needs to pick up children at their houses. Thus, the problems of this situation occurs as the total of the routes and distances which is based on children's houses is less than the total distances from a single house to school (Bock et al, 2013). The variables in this research are distance travelled, number of routes or number of bus used and coverage house used based on the optimized routes. In this problem, the bus needs to pick up children from house to school and make sure that the travel time is less than the time taken for parents to send their children by car.

A waste collection or garbage collection system, which relates to public health and environment quality is similar. Vehicles routing and scheduling program in garbage collection requires a lot of evaluation to ensure the vehicles and labor are fully utilized and optimal. If the company fails to use minimum routes, the company will be facing a high cost of operation. Garbage collector will pick up garbage from one house to another without skipping. This require network design for garbage collection using minimum routes and specific time to complete their task (Chang et al, 2012). The main objective of these researches is to minimize total operating cost based on management resources and operational requirement.

Travelling postmen method is one of the related network problems in terms of distribution of mails to customers. Basically, the objective for this study is to maximize number of services and minimize the travelling cost. Postmen need to sort all mails based on the address and routes used. Basically, rural areas were challenging compared to urban area because of the geographic nature, structure of roads and distances of houses. At times, they might need to walk instead of using a vehicle which requires postmen to park their vehicle at a strategic place (Matis, 2010). This application is also the same as the meter reading task where meter readers need to park their vehicles and start reading water meter from one house to another (walking distances).

Water Meter reading is another daily occurring activity and representative of route optimization problem. Meter reading has a specific time to ensure the distribution of water bill ranges from 29 days to 30 days for each of the customers. Meter reader need to walk house to house during reading process and distribute water bill to customer on the spot. The total time to read all meter is expected to be reduced as the meter reader has an efficient route along the household. There are two types of location that will be visited by meter readers, rural and urban areas. Rural areas are considered more challenging because of the structure of the roads and the location of meter are not standardized as in urban area.

Water Meter reading at Syarikat Air Johor (SAJ) Kota Tinggi has a standard procedure, which will be discussed in Chapter Four. A meter reader travels by using a motorcycle from SAJ Kota Tinggi agency to the designated location based on specified schedule. The meter reader will observe the area and park the motorcycle at a strategic place before reading the first house. In rural areas, the challenging part is usually the location of meter or the far distance between houses which requires a longer time to be completed compared to urban areas. Besides, a repeated step to park a motorcycle when moving to a new block of houses is also time consuming. In lean manufacturing, repeated process is considered as a waste and needs to be reduced or eliminated. In addition, it is a challenge to find a save and strategic place for motorcycle parking which needs to corroborate end of the routes to complete the reading process. This challenge needs to be studied to overcome the problem and to help meter reader identify the shorter routes and shorter time to complete their task.

## 1.2 Problem Statement

Syarikat Air Johor (SAJ) Kota Tinggi Johor needs to complete reading water meters for its customers within a specific time frame which is in between 29 to 30 days for all consumers (58587 register account). If the billing days are less than 29 days, the effect is profit to SAJ but if it is more than 30 days, SAJ will lose the profit. A win-win situation between SAJ and customers will happen if the billing days is exactly within 30 days. Currently, SAJ Kota Tinggi is unable to fully comply with this requirement. Overdue cycle is a financial lost to the company, and early reading is a financial lost to the customers.

## 1.3 Objectives

There are two objectives to achieve during this project, which are as follows:

- a) To propose an optimum route for water meter reading operation to minimize the monthly total completion reading time
- b) To propose an assignment plan for water meter readers to different localities to achieve minimum total cost.

## 1.4 Research Questions

There are several questions need to be considered during this project as the following:

- a) Which path should be made priority for meter reading?
- b) What is the shortest path routes to distribute water bill?
- c) How to reduce meter reading time?
- d) Where should be the last routes?
- e) How to minimize over time claimed by meter readers?

## **1.5 Scopes**

Scopes are an important part that needs to be highlighted during this project process to ensure that we have guidelines to start the project. The scope for this project is as follows:

- a) Study the current practice of water meter reading network distribution at SAJ Kota Tinggi.
- b) Mode of transportation used in this case study is motorcycles and walking.
- c) The location of this study focus on Taman Kota Jaya 2 (urban areas) and Sedili Besar (rural areas).
- d) The measurement of routes distance will be conducted in minutes
- e) Using mathematical modelling techniques, travelling salesmen problem (TSP) and assignment problem method to analyze the data
- f) Validate the result based on QM software, LINDO, TORA and a comparison with the current practice at SAJ.
- g) Propose the best solution and analyze the effective techniques to solve problems and a comparison with previous works.

## **1.6 Important of the Study**

This study is important to reduce total billing days that exceeds 30 days and reduce the total time by using an optimum network distribution to help SAJ improve on efficiency of services. Additional importance for this study is as follows:

- a) Minimize operating cost
- b) Minimize total time
- c) Minimize total distances
- d) Fulfill customer demand
- e) Use reliable routes
- f) Distribute water bills without hiring new meter readers as the preparation for the next population growth.

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