

Model of Demand Robust Counterpart Open Capacitated Vehicle Routing Problem (DRC-OCVRP) Simplification by Applying Preprocessing Techniques in Rubbish Controlling in Sematang Borang District, Palembang

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Abstract. The activity of rubbish controlling in Palembang is one of the applications of Demand Robust Capacitated Vehicle Routing Problem (DRC-OCVRP). In transporting rubbish in Sematang Borang district by preprocessing and probing technique are needed to obtain the simplest DRC-OCVRP model. The result shows that the optimal routes in those districts after applying the techniques are the same routes. In addition, the reduction of constraints, variables and the reduction of iteration numbers are also obtained. For Sematang Borang district, the reducing is mostly done on the working area 2 (WK 2) that is reducing as much 9 variables and 8 constraints of the initial number of variables as much as 36 and 66 constraints that has been previously obtained in the past research.

1 Introduction

The problem of waste is one of the things that must be handled in Palembang city; this is because the amount of waste produced every day has increased. Therefore, it is necessary to apply the appropriate method of transporting waste that can make waste management efficient. The official of the Sanitation and Hygiene Agency (DKK) of Palembang city transports trash located at the waste disposal site (TPS) by using the garbage-trucking vehicle to the final disposal site (TPA) conducted according to the sub-district by working area (WK). TPS consists of various types, generally in the form of containers, bins made of fiber, iron plate or garbage bin of concrete. The garbage is transported by means of garbage vehicle in the form of arm-roll and dump truck.

Mixed Integer Linear Program (MILP) solution was conducted to survey the solutions using probing techniques and preprocessing techniques that resulted in the reduction of

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border size (both lower and upper limit) as well as reduction of coefficient size in constrain matrix[1].

Robust Counterpart Vehicle Routing Problem (R-CVRP) method is a problem in VRP that is used to handle data uncertainty constraints such as travel time, cost of travel and demand[2, 3]. While in garbage transportation in Palembang, there is the uncertainty of data in the form of garbage volume at each polling station in each different working area and in controlling the garbage, some research already attempted to obtain the optimal routes in these problem[4, 5]. The problem is classified in Demand Robust Counterpart Open Vehicle Routing Problem (DRC-OVRP) problem, which can be solved by MILP where DRC-OCVRP model previously using the balancing technique included in the preprocessing step of OCVRP[6, 7]. So, the contribution of this current research is to simplify the models previously discussed [4, 5, 8], with the use of preprocessing techniques primarily related to the technique of identifying non-fiscal constraints and redundant constraints, increasing limits and coefficients as well as setting variable values [9].

This study discusses the simplification of the DRC-OCVRP model in the issue of garbage transportation of one of the sixteen sub-districts in Palembang city and then the model that has been formed will be tested its validity. The simplification of the DRC-OCVRP model aims to see a comparison of previous DRC-OCVRP models [3-4] with simplified models, or with the aim of forming models that are more efficient.

2 Materials and Methods

To simplify the model of the transportation system, three stages are conducted as follows.

1. Form the DRC-OCVRP model

The model is formed according to rubbish transportation data in Sematang Borang District containing the distance from the route of each WK, vehicle's capacity, and rubbish volume. Data were obtained by conducting surveys and interviews to the DKK in Palembang City for Sematang Borang District.

2. Simplify the DRC-OCVRP

To simplify the model, some steps were taken such as strengthening the bounds of constraint variables, eliminating the redundant constraint and fixing variables.

3. Solve the DRC-OCVRP model

The solution is the objective function and some decision variables that will display the optimal distance from the route. Then the solution compares before and after the application of the technique

3 Results and Discussions

In this part, the descriptions of the steps of simplifying DRC-OCVRP model using preprocessing techniques were explained. For briefly explanation, the MILP model is only displayed for WK1 and the rest of the WK's will be shown the final optimal routes. The distance data are obtained in previous research [6-7].]

For Working Area 1 Sematang Borang

DRC-OCVRP model after setting up the probing technique is

$$\begin{aligned} \text{Minimize } Z = & 16.1y_{01} + 16.7y_{02} + 16.6y_{03} + 15.7y_{04} + 16.1y_{10} + 2.4x_{12} \\ & + 2.0x_{13} + 1.57x_{14} + 16.7y_{20} + 2.4x_{21} + 0.95x_{23} + 3.26x_{24} \\ & + 16.6y_{30} + 2.0x_{31} + 0.95x_{32} + 3.91x_{34} + 15.7y_{40} + 1.57x_{41} \\ & + 3.26x_{42} + 3.91x_{43} \end{aligned}$$

Subject to

$$\begin{aligned}
 & x_{12} = 1 \\
 & y_{02} + y_{20} = 1 \\
 & y_{03} = 1 \\
 & x_{34} = 1 \\
 & y_{04} + y_{40} = 1 \\
 & y_{01} + y_{02} + y_{03} + y_{04} + y_{10} + y_{20} + y_{30} + y_{40} + x_{12} + x_{13} + x_{14} + x_{21} \\
 & \quad + x_{23} + x_{24} + x_{31} + x_{32} + x_{34} + x_{41} + x_{42} + x_{43} \geq 4 \\
 & y_{10} + y_{20} + y_{30} + y_{40} - y_{01} - y_{02} - y_{03} - y_{04} + x_{12} + x_{13} + x_{14} + x_{21} \\
 & \quad + x_{23} + x_{24} + x_{31} + x_{32} + x_{34} + x_{41} + x_{42} + x_{43} \geq 0 \\
 & y_{01} + y_{02} + y_{03} + y_{04} = 1 \\
 & 2000 \leq l_1 < 4000 \\
 & 2000 \leq l_2 < 4000 \\
 & 1000 \leq l_3 < 4000 \\
 & 3000 \leq l_4 < 4000 \\
 & l_1 - l_2 + 4000x_{12} \leq 2000 \\
 & l_1 - l_3 + 4000x_{13} \leq 3000 \\
 & l_1 - l_4 + 4000x_{14} \leq 1000 \\
 & l_2 - l_1 + 4000x_{21} \leq 2000 \\
 & l_2 - l_3 + 4000x_{23} \leq 3000 \\
 & l_2 - l_4 + 4000x_{24} \leq 1000 \\
 & l_3 - l_1 + 4000x_{31} \leq 2000 \\
 & l_3 - l_2 + 4000x_{32} \leq 2000 \\
 & l_3 - l_4 + 4000x_{34} \leq 1000 \\
 & l_4 - l_1 + 4000x_{41} \leq 2000 \\
 & l_4 - l_2 + 4000x_{42} \leq 2000 \\
 & l_4 - l_3 + 4000x_{43} \leq 3000 \\
 & y_{01}, y_{02}, y_{03}, y_{04}, y_{10}, y_{20}, y_{30}, y_{40}, x_{12}, x_{13}, x_{14}, x_{21}, x_{23}, x_{31}, x_{32}, x_{34}, x_{41}, x_{42}, \\
 & x_{43}, l_1, l_2, l_3, l_4 \geq 0
 \end{aligned}$$

The DRC-OCVRP model is simplified by applying Preprocessing techniques consisting of three stages, namely, strengthen the bounds of constraint variables, eliminate excessing constrains, and fix the variable.

3.1 Preprocessing Technique

3.1.1 Strengthen the Bounds of Constraint Variables

At the boundary strengthening stage, the amplified limit is the limit on the constraint variable. In general, this process considers each of the constraints and investigates whether the constraints are in accordance with the limitations of the variables or whether the variables can be strengthened in each of the boundaries.

Since $y_{01}, y_{02}, y_{03}, y_{04}, y_{10}, y_{20}, y_{30}, y_{40}, x_{12}, x_{13}, x_{14}, x_{21}, x_{23}, x_{24}, x_{31}, x_{32}, x_{34}, x_{41}, x_{42}, x_{43} \in \{0,1,2\}$ and then if each variable has a non-negative restriction and based on the previous calculation the obtained variables are $y_{01}=0; y_{02}=0; y_{03}=1; y_{04}=0; y_{10}=1; y_{20}=1; y_{30}=0; y_{40}=1; x_{12}=1; x_{13}=0; x_{14}=0; x_{21}=1; x_{23}=0; x_{24}=0; x_{31}=0; x_{32}=0; x_{34}=1; x_{41}=0; x_{42}=0; x_{43}=0$

Strengthen the bound for variable x_{12} in (a)

Strengthen the bound for variable y_{02} in (b)

- Strengthen the bound for variable y_{03} in (c)
- Strengthen the bound for variable x_{34} in (d)
- Strengthen the bound for variable y_{04}, y_{40} in (e)
- Some variables in (f) cannot be strengthened
- Some variables in (g) cannot be strengthened
- Strengthen the bound for variable $y_{01}, y_{03}, y_{30}, y_{04}$ in (h)

3.1.2 Eliminate Excessive Constraint

Basically preprocessing is a process that changes a formulation in such a way as to eliminate some constraints on a formulation that is considered excessive. An obstacle is said to be excessive if the removal or removal of the constraint does not change the feasible area. Constraints (g) and (h) satisfy the lower limit of non-negative constraints. Since constraints meet the upper and lower limits of the non-negative constraint variable, the Constraints (g) and (h) are said to be redundant and can be eliminated.

3.1.2 Fix the Variable

In Constraints (a) to Constraints (e), all forms of inequality are marked “=”, it is defined that the right side value is 1 and the largest coefficient value is 1 then the sum of the largest variable coefficients is 1. At the sum does not exceed RHS, so the variable with the largest coefficients need not be fixed to 0.

The new DRC-OCVRP model are obtained as follows that has been transformed to initial form:

$$\text{Minimize } Z = 16,6y_{03} + 2,4x_{12} + 16,7y_{20} + 3,91x_{34} + 15,7y_{40}$$

Subject to

$$x_{12} = 1$$

$$y_{20} = 1$$

$$y_{03} = 1$$

$$x_{34} = 1$$

$$y_{40} = 1$$

$$2000 \leq l_1 < 4000$$

$$2000 \leq l_2 < 4000$$

$$1000 \leq l_3 < 4000$$

$$3000 \leq l_4 < 4000$$

$$l_1 - l_2 + 4000x_{12} \leq 2000$$

$$l_1 - l_3 + 4000x_{13} \leq 3000$$

$$l_1 - l_4 + 4000x_{14} \leq 1000$$

$$l_2 - l_1 + 4000x_{21} \leq 2000$$

$$l_2 - l_3 + 4000x_{23} \leq 3000$$

$$l_2 - l_4 + 4000x_{24} \leq 1000$$

$$l_3 - l_1 + 4000x_{31} \leq 2000$$

$$l_3 - l_2 + 4000x_{32} \leq 2000$$

$$l_3 - l_4 + 4000x_{34} \leq 1000$$

$$l_4 - l_1 + 4000x_{41} \leq 2000$$

$$l_4 - l_2 + 4000x_{42} \leq 2000$$

$$l_4 - l_3 + 4000x_{43} \leq 3000$$

$$y_{01}, y_{02}, y_{03}, y_{04}, y_{10}, y_{20}, y_{30}, y_{40}, x_{12}, x_{13}, x_{14}, x_{21}, x_{23}, x_{31}, x_{32}, x_{34}, x_{41}, x_{42}, x_{43}$$

For the rest of Working Area, the same steps as above are conducted, and it is summarized into Table 1.

Table 1. Before and After Applying Preprocessing Technique

Working Area	Before Applying Preprocessing Technique[7]		After Applying Preprocessing Technique		Optimal Solution (km)
	Variable	Constraint	Variable	Constraint	
1	25	46	18	39	55,31
2	36	66	27	58	53,717

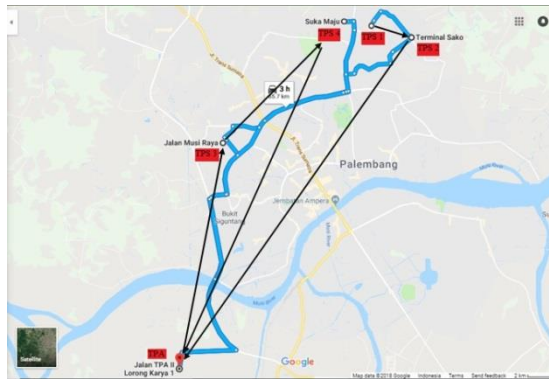
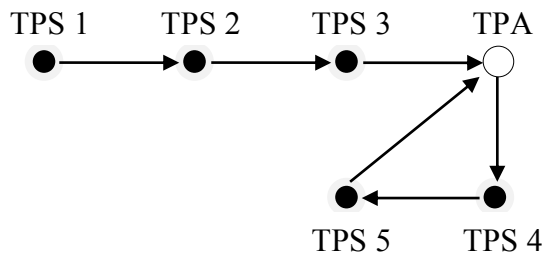


Fig. 1. Shows an image of the route with the optimal distance of Working Area 1 and Working Area 2 with optimal distance details on Table 1.

(a)



(b)

Fig. 2. Route of Working Area 1 (a) and Working Area 2 (b)

According to Figure.1(a), the optimal route of WK 1 of Sematang Borang District, will be TPS Simpang Dogan – TPS Terminal Sako – TPA Karya Jaya – TPS Sepanjang Jl. Musi Raya – TPS Sukamaju – TPA Karya Jaya. For WK 2, the optimal routes will be TPS Kecamatan Sematang Borang – TPS Terminal – TPS Perumnas Lama – TPA Karya Jaya – TPS Pasar Multi Wahana – TPS Giant Mall – TPA Karya Jaya. By applying the method, the route of transporting the waste remains the same, but a simpler formulation is

generated. If it is dealing with computational results, it means saving more time to solve the calculations.

4 Conclusions

It can be concluded that after the use of preprocessing techniques can results in a simpler and faster DRC-OCVRP model in the model completion process compared to the DRC-OCVRP model before using preprocessing techniques. The variable number and constraints of 2 WK before the preprocessing technique is 61 variables and 112 constraints. After the preprocessing technique, has the variable number and constraints is reduced to 45 variables and 97 constraints. It can be seen that the DRC-OCVRP model using preprocessing technique has the variable number and fewer number of constraints that can be seen in Table 1.

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