❐   31

Preprocessing Techniques in SCVRP Model: Case of Rubbish Transportation Problem in Kecamatan Ilir Barat II Palembang South Sumatera Indonesia

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Article Info	ABSTRACT
	Rubbish transportation activities in Palembang can be considered as one of the application of Vehicle Routing Problem (VRP). We call it Symmetric Capacitated Vehicle Routing Problem (SCVRP) since we allow two way direction routes. We focus on rubbish transportation of Kecamatan Ilir Barat II Palembang, one of the biggest districts in Palembang to be simplified using preprocessing techniques to achieve simpler SVCRP model. This technique can simplify the model through some stages such as strengthening the bounds of constraint, eliminating redundant variables or fixing the variables [1]. The results show that preprocessing techniques can create simpler SCVRP formulation and easily solve the problem with aid of optimization tool.

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1. INTRODUCTION

Transportation system in Palembang basically is conducted in steps. Rubbish was taken from homes and collected at nearest Temporary Rubbish Disposal (TRD). The rubbish was collected by workers of Rubbish Disposal Agency of Palembang using dump trucks to Final Rubbish Disposal (FRD) or depot. The transportation system of rubbish is conducted into working areas. There exist some disposal forms such as fiber boxes, or concrete material. Also, TRDs have some or only one disposal spot.

Model of Symmetric Capacitated Vehicle Routing Problem (SCVRP) is one model that can be used to describe the situation of rubbish transportation system in Palembang. Routes of rubbish vehicles the distances between TRD and FRD or between one TRD and other TRDs are fixed. We also know the vehicle's capacity and rubbish volume for each TDP.

One way to solve SCVRP is by using preprocessing techniques. This technique can simplify the model through some stages such as strengthening the bounds of constraint, eliminating redundant variables or fixing the variables [1]. Therefore, based on the ability of that technique, we attempt to simplify the model of transportation system in Kecamatan Ilir Barat II.

2. RESEARCH METHOD

To simplify the model of that transportation system, we conduct three stages as follows.
1. Form the SVCRP model

The model is formed according to rubbish transportation data in Kecamatan Ilir Barat II Palembang such as routes, distance between FRD and TRDs, vehicle's capacity, number of vehicles used and rubbish volume. We obtain the data through surveying and interviewing in details' to staff of rubbish management in FRD of Sukabangun area and several drivers of rubbish trucks.

2. Simplify the SCVRP model
   To simplify the model, we conduct steps such as strengthening the bounds of constraint variables, eliminating redundant constraints and fixing variables.

3. Solve the SCVRP model
   The solution is to obtain optimal objective function and each decision variables of the model. The solution is based on non-simplified model and simplified model and we seek to compare that simplified model yield efficient result.

3.   RESULTS AND ANALYSIS
In this part, we describe the steps of simplifying SCVRP model using preprocessing techniques.

3.1. Data Description
In Kecamatan Ilir Barat II there exist 19 TRD consisting of 5 working area as Table 1 depicted.

Table 1.Rubblish Volume in each TRD and Distance from FRD-TRD (in km)

Wilayah Kerja	Lokasi TPS	Kapasitas TPS (Ton)	TPA	T1	T2	T3	T4	T5
WK-1	TPA Sukawinatan (TPA)		0	14,5	11,9			
	TPS Jl. Sekanak (T1)	4,0	14,5	0	5,9			
	TPS Depo 23 Ilir (T2)	5,0	11,9	5,9	0			
WK-2	TPA Sukawinatan (TPA)		0	14	13	11,7		
	TPS Jl. Tlg. Kerangga (T1)	3,8	14	0	1,3	2,3		
	TPS Masjid Taqwa (T2)	4,0	13	1,3	0	3,9		
	TPS 32 Ilir (T3)	4,0	11,7	2,3	3,9	0		
WK-3	TPA Sukawinatan (TPA)		0	11,7	12,6	18	13,2	
	TPS Jl. Hang Tuah (T1)	5,0	11,7	0	6,8	9,8	4,8	
	TPS 30 Ilir (T2)	4,0	12,6	6,8	0	13	7,2	
	TPS Pasar Induk Jakabaring (T3)	5,0	18	9,8	13	0	11,5	
	TPS Gajah Mada (T4)	4,0	13,2	4,8	7,2	11,5	0	
WK-4	TPA Sukawinatan (TPA)		0	12	11,6	10,5	18	11,2
	TPS 29 Ilir (T1)	3,8	12	0	6,8	6,8	9,7	8,6
	TPS Taman Situs Purbakala (T2)	4,0	11,6	6,8	0	14,2	8,7	10,3
	TPS PT. Gajah Ruku (T3)	5,0	10,5	6,8	14,2	0	6,9	11,2
	TPS Perum. Griya Asri Gandus (T4)	4,0	18	9,7	8,7	6,9	0	13
	TPS PT. Panca (T5)	5,0	11,2	8,6	10,3	11,2	13	0
WK-5	TPA Sukawinatan (TPA)		0	12	6,5	5,3	6,9	12,6
	TPS SMPN 1 (T1)		12	0	2,3	2,3	3,3	4,3
	TPS Jl. Diponegoro (T2)		6,5	2,3	0	2,5	3,8	5,2
	TPS Jl. Tlg Kerangga (T3)		5,3	2,3	2,5	0	2,8	3,8
	TPS Jl. Makrayu (T4)		6,9	3,3	3,8	2,8	0	6,3
	TPS Pasar Tangga Buntung (T5)		12,6	4,3	5,2	3,8	6,3	0

3.2. Model Simplification using Preprocessing Technique
To compare the efficiency between model before simplification and after simplification, we attempt to solve both models using Branch and Bound solver [2, 3, 4, 5, 6] with aid of LINDO. We can see how many iterations needed to get the optimal solution.

3.3. Arrangement of Initial SCVRP Model

We assume that each vehicle begins to collect the rubbish from FRD to each TRD by crossing its usual route and go back to FRD. Each TRD was visited once route with total average volume for each TRD does not exceed the capacity C.

Given number of vehicles K, vehicle capacity C, a symmetrical distance matrix and average volume for each TRD is d_i, with $i=1, 2, \ldots, n$, the SCVRP model can be formulated mathematically as follows (see [7]).

Minimize
$$Z = \sum_{0 \leq i \leq j \leq n} c_{ij} x_{ij}$$

Subject to
$$\sum_{i \leq j \leq n} x_{0k} = 2K$$

The collection starts from depot to TRD and go straight to depot. K is number of vehicles collecting rubbish. In this case, $K = 1$ for each working area so $\sum_{e \in \delta(i)} x_e = 2$.

Since the travel is symmetric, so the travel from i to j will equal to j to i. If we say the travel from i to j is 1, then the travel from i to j and the travel from j to i are 2 then
$$\sum_{0 \leq j \leq n} x_{ij} = 2 , 1 \leq i \leq n .$$

The travel does not begin from depot $\sum_{j \in S} x_{oj} + \sum_{(i,j) \in S} x_{ij} = 2 \leq 2b(S)$ for $\forall S \subset V \backslash \{0\}$; $|S| \geq 2$.

We have parameter as follows.

$b(S)$ = lower bound of vehicle needed to visit customer S that is obtained from $b(S) = \dfrac{\sum_{i \in S} d(i)}{C}$

$d(i)$ = number of TRD volume
C = vehicle capacity (truck)
S = collection of identical TRD visited

$x_{ij} \in \{0,1,2\}$ for all $e \in \delta(0)$ which is value of travel routes or nonnegativity binary constraint.

For some working areas, if we cannot obtain minimum route and there exist more than or equal to one TRD unvisited, and then the equation $\sum_{0 \leq j \leq n} x_{ij} = 2$ can be split into some permutations of subset S as follows. $\sum_{j \in S} x_{1j} = 2$

$$\sum_{j \in S} x_{2j} = 2$$
$$\vdots$$
$$\sum_{j \in S} x_{nj} = 2$$

with n is the number of TRD in working area.

3.4. Transformation of SCVRP Model

Preprocessing technique can be applied to SCVRP model with constraint having sign of "$<$","$>$","$\leq$", or "$\geq$". Meanwhile, our initial SCVRP model would be "$=$". This occurs since the model should be transformed into formed that is recognized by the preprocessing technique without changing the meaning of the model.

From initial SCVRP model, we have to transform the constraint into

$$\sum_{i \leq j \leq n} x_{0k} \leq 2K \quad \text{and}$$

$$\sum_{0 \leq j \leq n} x_{ij} \leq 2 .$$

We change the sign "=" into "$\leq$" since the objective of the model is to minimize the objective function. We create that in order to give meaning that each route (TDR-TDR ot TRD-FRD) should be crossed at maximum twice.

3.5. Preprocessing Technique for Rubbish Transportation in Kecamatan Ilir Barat II
Following is the steps to simplify working area I of Rubbish Transportation in Kecamatan Ilir Barat II Palembang.

Simplification of SCVRP Model in Working Area I
Step 1: Form of Initial SCVRP model
From data, we obtain

$$b(S) = \frac{\sum_{i \in S} d(i)}{C} = \frac{4+5}{8} = 1,125 \quad \text{then } 2b(S) = 2\,(1,125) = 2.25.$$

Initial SCVRP model is

$$\text{Min } z = 14,5x_{01} + 11,9x_{02} + 14,5x_{10} + 5,9x_{12} + 11,9x_{20} + 5,9x_{21} \tag{3.1}$$

Subject to

$$x_{01} + x_{02} = 2 \tag{3.2}$$
$$x_{10} + x_{12} + x_{20} + x_{21} = 2 \tag{3.3}$$
$$x_{01} + x_{02} + x_{12} + x_{21} \leq 2,25 \tag{3.4}$$

and

$$x_{01} \geq 0 ; \ x_{02} \geq 0 ; \ x_{10} \geq 0 \ x_{12} \geq 0 ; \ x_{20} \geq 0 ; \ x_{21} \geq 0$$
$$x_{01}, x_{02}, x_{10}, x_{12}, x_{20}, x_{21} \in \{0,1,2\}$$

Step 2 : Transform the initial SCVRP model
We transform (3.2) and (3.3) into

$$x_{01} + x_{02} \leq 2 \tag{3.2*}$$
$$x_{10} + x_{12} + x_{20} + x_{21} \leq 2 \tag{3.3*}$$

Step 3: Preprocessing Technique
1. Strengthen the bounds of constraint variables
Since $x_{01}, x_{02}, x_{10}, x_{12}, x_{20}, x_{21} \in \{0,1,2\}$ and assume that $x_{01} = 0$; $x_{02} = 2$; $x_{10} = 2$; $x_{12} = 0$; $x_{20} = 0$; $x_{21} = 0$ then

a) Strengthen the bounds of constraint variables (3.2*)
i. For variable x_{01}, substitute the value of $x_{02} = 2$ into (3.2*) so we have $x_{01} \leq 0$. We can strengthen the x_{01} since it has initial bound $x_{01} \geq 0$. We can strengthen this variable to be $x_{01} \leq 0$.

ii. For variable x_{02}, substitute the value of $x_{01} = 0$ into (3.2*) so we have $x_{02} \leq 2$. Since $x_{02} \leq 2$ is in initial bound $x_{02} \geq 0$, so we create new bound for x_{02} that is $0 \leq x_{02} \leq 2$

b) Strengthen the bounds of constraint variables (3.3*)
i. For variable x_{10}, substitute the value of $x_{12} = 0$, $x_{20} = 0$, and $x_{21} = 0$ into (3.3*) so we have $x_{10} \leq 2$. Since $x_{10} \leq 2$ is in initial bound $x_{10} \geq 0$ so we create new bound for $0 \leq x_{10} \leq 2$

ii. For variable x_{12} substitute the value of $x_{10} = 2$, $x_{20} = 0$, and $x_{21} = 0$ into (3.3*) and we have new strengthened bound of $x_{12} \leq 0$.

iii. For variable x_{20} substitute the value of $x_{10} = 2$, $x_{12} = 0$, and $x_{21} = 0$ into (3.3*) and we have new strengthened bound of $x_{20} \leq 0$.

iv. For variable x_{21} substitute the value of $x_{10} = 2$, $x_{12} = 0$, and $x_{20} = 0$ into (3.3*) and we have new strengthened bound of $x_{21} \leq 0$.

c) Strengthen the bounds of constraint variables (3.4)

i. For variable x_{01} substitute the value of $x_{02} = 2$, $x_{12} = 0$ and $x_{21} = 0$ into (3.4). Since x_{01} has been strengthened into $x_{01} = 0$ so x_{01} cannot be strengthened into $x_{01} \leq 0.25$ since it does not satisfy the previous bound of x_{01}.

ii. For variable x_{02} substitute the value of $x_{01} = 0$, $x_{12} = 0$ and $x_{21} = 0$ into (3.4). x_{02} cannot be strengthened since it does not satisfy the previous bound of x_{02}.

iii. For variable x_{12} substitute the value of $x_{01} = 0$, $x_{02} = 2$ and $x_{21} = 0$ into (3.4). x_{12} cannot be strengthened into $x_{12} \leq 0.25$ since it does not satisfy the previous bound of x_{12}.

iv. For variable x_{21} substitute the value of $x_{01} = 0$, $x_{02} = 2$, and $x_{12} = 0$ into (3.4) x_{21} cannot be strengthened $x_{21} \leq 0.25$ since it does not satisfy the previous bound of x_{21}

2. Eliminate Redundant variables

Next, we will investigate whether the constraints satisfy the upper bound and lower bound of nonnegative constraints.

a) By using upper bound

Using upper bound of nonnegativity constrains resulted in strengthening bounds, we have $x_{01} = 0$, $x_{02} = 2$, $x_{12} = 0$, and $x_{21} = 0$, substitute to (3.4), we have $2 \leq 2.25$. So (3.4) satisfies the upper bound of nonnegativity constraint.

b) By using lower bound

Using upper bound of nonnegativity constrains resulted in strengthening bounds, we have $x_{01} = 0$, $x_{02} = 0$, $x_{12} = 0$, and $x_{21} = 0$, substitute to (3.4), we have $0 \leq 2.25$ So (3.4) satisfy the upper bound of nonnegativity constraint and it is said to be redundant and can be eliminated.

3. Fix variable

Assume that we will fix variables x_{12} and x_{12}. We got the variable values from (3.3*)

a) Evaluation for variable x_{12}.

In constraint (3.3*), we have "$\leq$" inequality, by definition it said that value of right hand side is 2 and the biggest coefficient value is 1, then total of biggest variable coefficient is 4. Since that total exceed RHS then variable with biggest coefficient can be fixed into 0 or $x_{12} = 0$. Since in constraint (3.3*) total of biggest coefficient exceed RHS then we eliminate (3.3*).

b) Evaluation for variable x_{21}

In constraint (3.3*) have "$\leq$" inequality, by definition it said that value of right hand side is 2 and the biggest coefficient value is 1, then total of biggest variable coefficient is 4. Since that total exceed RHS then variable with biggest coefficient can be fixed into 0 or $x_{21} = 0$. Since in (3.3*) total of biggest coefficient exceed RHS then (3.3*) cannot be eliminated.

Variable values of $x_{12} = 0$ and $x_{21} = 0$ can be substitute to model and we have new model as follows.

Objective function :
Min $z = 14{,}5x_{01} + 11{,}9x_{02} + 14{,}5x_{10} + 11{,}9x_{20}$ (3.1*)
Subject to
$x_{01} + x_{02} \leq 2$ (3.2**)

$$x_{10} + x_{20} \le 2 \tag{3.3**}$$

and

$$x_{01} = 0 \; ; \; 0 \le x_{02} \le 2 \; ; \; 0 \le x_{10} \le 2 \; ; \; x_{02} = 0$$

Step 4: Transform to Initial Form

After obtaining new simpler SCVRP, we transform the model back to original model as follows. Transform constraint (3.2**) into $x_{01} + x_{02} = 2$ and constraint (3.3**) into $x_{10} + x_{20} = 2$ then, we obtain new SCVRP model :

New model for Working Area I

Min $z = 14,5x_{01} + 11,9x_{02} + 14,5x_{10} + 11,9x_{20}$

Subject to

$$x_{01} + x_{02} \le 2$$

$$x_{10} + x_{20} \le 2$$

and

$$x_{01} = 0 \; ; \; 0 \le x_{02} \le 2 \; ; \; 0 \le x_{10} \le 2 \; ; \; x_{02} = 0$$

Using above procedure, we also obtain simpler formula of SCVRP as follows.

New model for Working Area II

Min $z = 14x_{01} + 13x_{02} + 11,7x_{03} + 14x_{10} + 1,3x_{12} + 13x_{20} + 3,9x_{23} + 11,7x_{30} + 2,3x_{31}$

Subject to

$$x_{01} + x_{02} + x_{03} = 2$$

$$x_{10} + x_{12} = 2$$

$$x_{20} + x_{23} = 2$$

$$x_{30} + x_{31} = 2$$

$$x_{01} + x_{02} + x_{03} + x_{12} + x_{23} + x_{31} \le 2.95$$

and

$x_{01} = 0 \; ; \; x_{02} = 0 \; ; \; 0 \le x_{03} \le 2 \; ; \; 0 \le x_{10} \le 2 \; ; \; 0 \le x_{12} \le 1 \; ; \; 0 \le x_{20} \le 2 \; ; \; 0 \le x_{23} \le 1 \; ;$

$0 \le x_{30} \le 2 \; ; \; 0 \le x_{31} \le 2$.

$x_{01}, x_{02}, x_{03}, x_{10}, x_{12}, x_{20}, x_{23}, x_{30}, x_{31} \in \{0,1,2\}$

New model for Working Area III

$\min z = 11,7x_{01} + 12,6x_{02} + 18x_{03} + 13,2x_{04} + 11,7x_{10} + 6,8x_{12} +$
$\quad 9,8x_{13} + 4,8x_{14} + 12,6x_{20} + 6,8x_{21} 13x_{23} + 7,2x_{24} + 18x_{30} +$
$\quad 13x_{32} + 11,5x_{34} + 13,2x_{40} + 4,8x_{41} + 11,5x_{43}$

Subject to

$$x_{01} + x_{02} + x_{03} + x_{04} = 2$$

$$x_{10} + x_{12} + x_{13} + x_{14} = 2$$

$$x_{20} + x_{21} + x_{23} + x_{24} = 2$$

$$x_{30} + x_{32} + x_{34} = 2$$

$$x_{40} + x_{41} + x_{43} = 2$$

$$x_{01} + x_{02} + x_{03} + x_{04} + x_{12} + x_{13} + x_{14} + x_{21} + x_{23} + x_{24} + x_{31} + x_{32} + x_{34} + x_{41} + x_{42} + x_{43} \le 4,5$$

and

$x_{01} \ge 0 \; ; x_{02} \ge 0 \; ; \; x_{03} \ge 0 \; ; \; x_{04} \ge 0 \; ; \; 0 \le x_{10} \le 1 \; ; \; x_{12} = 0 \; ; \; 0 \le x_{13} \le 1 \; ; \; x_{14} = 0 \; ; \; 0 \le x_{20} \le 2 \; ; \; 0 \le x_{21} \le 2 \; ;$

$0 \le x_{23} \le 2 \; ; \; 0 \le x_{24} \le 2 \; ; \; 0 \le x_{30} \le 2 \; ; \; 0 \le x_{32} \le 1 \; ; \; 0 \le x_{34} \le 1 \; ; \; 0 \le x_{40} \le 2 \; ; \; 0 \le x_{41} \le 2 \; ; \; 0 \le x_{43} \le 2$.

$x_{01}, x_{02}, x_{03}, x_{04}, x_{10}, x_{12}, x_{13}, x_{14}, x_{20}, x_{21}, x_{23}, x_{24}, x_{30}, x_{31}, x_{32}, x_{34}, x_{40}, x_{41}, x_{42}, x_{43} \in \{0,1,2\}$

New model for Working Area IV

$\text{Min } z = 12x_{01} + 11{,}6x_{02} + 10{,}5x_{03} + 18x_{04} + 12x_{10} + 6{,}8x_{13} + 9{,}7x_{14} + 8{,}6x_{15}$

$\qquad + 11{,}6x_{20} + 6{,}8x_{21} + 8{,}7x_{24} + 10{,}3x_{25} + 10{,}5x_{30} + 6{,}8x_{31} + 14{,}2x_{32} + 6{,}9x_{34}$

$\qquad + 11{,}2x_{35} + 18x_{40} + 9{,}7x_{41} + 8{,}7x_{42} + 6{,}9x_{43} + 13x_{45} + 11{,}2x_{50} + 8{,}6x_{51}$

$\qquad + 10{,}3x_{52} + 11{,}2x_{53} + 13x_{54}$

Subject to

$x_{01} + x_{02} + x_{03} + x_{04} = 2$

$x_{10} + x_{13} + x_{14} + x_{15} = 2$

$x_{20} + x_{21} + x_{24} + x_{25} = 2$

$x_{30} + x_{31} + x_{32} + x_{34} + x_{35} = 2$

$x_{40} + x_{41} + x_{42} + x_{43} + x_{45} = 2$

$x_{50} + x_{51} + x_{52} + x_{53} + x_{54} = 2$

and

$x_{01} = 0$; $x_{02} = 0$; $0 \le x_{03} \le 2$; $x_{04} = 0$; $x_{10} \ge 0$; $x_{13} \ge 0$; $x_{14} \ge 0$; $x_{15} \ge 0$;

$0 \le x_{20} \le 2$; $0 \le x_{21} \le 1$; $0 \le x_{23} \le 1$; $0 \le x_{24} \le 1$; $0 \le x_{25} \le 1$; $0 \le x_{30} \le 2$;

$0 \le x_{31} \le 1$; $0 \le x_{32} \le 1$; $0 \le x_{32} \le 1$; $0 \le x_{34} \le 1$; $0 \le x_{35} \le 1$; $0 \le x_{40} \le 2$; $x_{41} = 0$; $x_{42} = 0$; $x_{43} = 0$;

$x_{45} = 0$; $x_{50} = 0$; $0 \le x_{51} \le 2$; $x_{52} = 0$; $x_{54} = 0$; $x_{53} = 0$.

$x_{01}, x_{02}, x_{03}, x_{04}, x_{10}, x_{13}, x_{14}, x_{15}, x_{20}, x_{21}, x_{24}, x_{25}, x_{30}, x_{31}, x_{32}, x_{34}, x_{35}, x_{40}, x_{41}, x_{42},$

$x_{43}, x_{45}, x_{50}, x_{51}, x_{52}, x_{53}, x_{54} \in \{0,1,2\}$

New model for Working Area V

$\text{Min } z = 12x_{01} + 5{,}3x_{03} + 6{,}9x_{04} + 12{,}6x_{05} + 12x_{10} + 2{,}3x_{12} + 3{,}3x_{14} + 4{,}3x_{15}$

$\qquad + 6{,}5x_{20} + 2{,}5x_{23} + 3{,}8x_{24} + 5{,}2x_{25} + 5{,}3x_{30} + 2{,}3x_{31} + 2{,}5x_{32} + 3{,}8x_{35} + 6{,}9x_{40}$

$\qquad + 3{,}3x_{41} + 2{,}8x_{43} + 6{,}3x_{45} + 12{,}6x_{50} + 4{,}3x_{51} + 5{,}2x_{52} + 6{,}3x_{54}$

Subject to

$x_{01} + x_{03} + x_{04} + x_{05} = 2$

$x_{10} + x_{12} + x_{14} + x_{15} = 2$

$x_{20} + x_{23} + x_{24} + x_{25} = 2$

$x_{30} + x_{31} + x_{32} + x_{35} = 2$

$x_{40} + x_{41} + x_{43} + x_{45} = 2$

$x_{50} + x_{51} + x_{52} + x_{54} = 2$

and

$x_{12} = 0$; $x_{13} = 0$; $x_{14} = 0$; $x_{15} = 0$; $0 \le x_{20} \le 2$; $x_{21} = 0$; $x_{23} = 0$; $x_{24} = 0$; $x_{25} = 0$; $x_{30} \le 2$; $x_{31} = 0$;

$x_{32} = 0$; $x_{34} = 0$; $x_{35} = 0$; $0 \le x_{40} \le 1$; $x_{41} = 0$; $x_{42} = 0$; $x_{43} = 0$; $0 \le x_{45} \le 1$; $0 \le x_{50} \le 2$; $x_{51} = 0$; $x_{52} = 0$

; $x_{53} = 0$; $x_{54} = 0$.

$x_{01}, x_{03}, x_{04}, x_{10}, x_{12}, x_{14}, x_{15}, x_{20}, x_{23}, x_{24}, x_{25}, x_{30}, x_{31}, x_{32}, x_{35}, x_{40}, x_{41}, x_{43}, x_{45},$

$x_{50}, x_{51}, x_{52}, x_{54} \in \{0,1,2\}$

4. CONCLUSION

We can conclude from above results that by using preprocessing technique, we can obtain simpler SCVRP model and also we can solve the model faster by applying optimization tool. But due to limitations, we only conduct preprocessing technique to simplify the model. For further research, it is better to also include other technique to simplify the model such as using probing technique.

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