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and Anastasia L. Maukar

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**CLARK WRIGHT SAVING ALGORITHM MODEL DEVELOPMENT  
FOR VEHICLE ROUTING PROBLEM WITH TIME WINDOWS**



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In this paper we proposed a developed Clarke Wright saving Algorithm for asymmetric capacitated with different capacity vehicle within the time window to overcome the lack of Clarke Wright saving algorithm with the subject of minimization travel distance.

## THEORY

The objective of the savings method is to minimize the total distance traveled by all vehicles and to minimize indirectly the number of vehicle needed to serve all stops. The logic of the method is to begin with a dummy vehicle serving each stop and returning to the depot.

The Clarke Wright Savings algorithm as follows"

1. Label the customers as cities  $1, 2, \dots, n$  and let the warehouse be city 0.
2. Determine the cost  $c_{ij}$  to travel between all pair of cities and the warehouse  $i=0, 2, \dots, n; j=0, \dots, n$ .
3. Select the warehouse as the central city
4. Calculate the saving  $S_{ij} = c_{i0} + c_{0j} - c_{ij}$  for all pairs of cities (customer)  $i, j$  ( $i=1, 2, \dots, n; j=1, 2, \dots, n; i \neq j$ )
5. Order the savings,  $S_{ij}$ , from the largest to smallest
6. Starting with the largest savings, do the following:
  - a. If the linking cities  $i$  and  $j$  results in a feasible route, then add this link to the route; if not, reject the link
  - b. Try the next savings in the list and repeat (a). Do not break any links formed earlier, start new routes when necessary, and stop when all cities are on a route.

## CLARKE WRIGHT ALGORITHM DEVELOPMENT

The proposed algorithm that has been developed as follows:

1. Input customer, customer demand, distance between customers, distance between depot and customer, the number of vehicles, vehicle's capacity, average velocity, time window, and loading-unloading time.
2. Calculate the *saving*  $S_{ij} = c_{ik} + c_{kj} - c_{ij}$  for  $i = 1, 2, 3, \dots, n, j = 1, 2, 3, \dots, n, i \neq k, j \neq k, i \neq j$ .
3. Delete negative *Saving*
4. Sort vehicle capacity in decreasing order
5. For each vehicle:
  - a. Delete path which accumulated customer demand in all nodes in the path exceeds vehicle capacity and total time spending for delivery bigger than time window.
  - b. For each customer:
    1. Find the list of customer on the list of path.
    2. If there is customer in the list of customer then proceed to step 5.b.3. if not, go to step 5.b.4.
    3. Proceed with the next customer.
    4. Sequence the customer into the route then proceed 5.f
  - c. Sort saving in decreasing order
  - d. Schedule the path with the largest saving as a vehicle basic route.
  - e. For each path:
    1. If there is a possibility for combine path with basic route, then proceed to step 5.e.2. If it is not, then proceed to step 5.e.3.
    2. Combine with basic route, reduce the vehicle capacity with the allocated customer demand for all nodes in the path.
    3. Proceed to the next path.
  - f. Check vehicle capacity and total duration of vehicle trips
  - g. Delete all paths from the first route
  - h. Repeat step (a) to (g) for the next route
6. Calculate distance for all routes.

The above model will prioritize the largest vehicle's capacity to be firstly assigned. This is consistent to the greedy algorithm concept that tries to maximize profit (represented by 'saving') due to joining locations result. By assigning the largest vehicle's capacity first, more chance to join as many locations as possible to maximize saving.

## NUMERICAL EXAMPLE

### 1 Input data

Input data for the this problem are distances between depot and customer and distance between customers, and customer demand shown as table 1 and table 2 below.

**TABLE 1**  
**DISTANCES BETWEEN CUSTOMERS AND**  
**BETWEEN DEPOT (0) AND CUSTOMERS (IN KM)**

	0	1	2	3	4	5	6	7	8	9
0	0	15	20	19	9	16	12	8	16	19
1	16	0	12	30	28	20	7	14	11	13
2	25	10	0	17	11	15	15	14	32	16
3	13	31	11	0	7	18	3	25	25	25
4	14	21	9	11	0	8	4	11	24	13
5	13	18	13	15	5	0	9	20	19	14
6	11	6	12	5	3	7	0	21	17	13
7	10	12	15	22	13	22	18	0	11	11
8	14	12	30	29	25	21	15	13	0	28
9	20	10	15	20	19	9	16	12	31	0

**TABLE 2**  
**CUSTOMER DEMAND**

<i>Customer</i>	1	2	3	4	5	6	7	8	9
<i>Demand</i>	30	18	27	25	21	19	10	20	17

It is assumed that:

- a. Number of vehicles = 2
- b. Capacity of vehicle 1 = 120 units
- c. Capacity of vehicle 2 = 80 units
- d. Average velocity = 40 kms/hour
- e. Loading/unloading time = 2 minutes/unit.
- f. Time window = 10.00 am-16.00 pm (6 hours = 360 minutes)

### 2 Calculate savings.

The calculation is used the formula:

$$S_{ij} = c_{ik} + c_{kj} - c_{ij}, \quad \text{for } i = 1, 2, 3, \dots, n, j = 1, 2, 3, \dots, n, i \neq k, j \neq k, i \neq j.$$

$S_{12} = 16 + 20 - 12 = 24$	$S_{29} = 28$	$S_{47} = 11$	$S_{65} = 20$	$S_{83} = 4$
$S_{13} = 16 + 19 - 30 = 5$	$S_{31} = -3$	$S_{48} = 6$	$S_{67} = -2$	$S_{84} = -2$
$S_{14} = -3$	$S_{32} = 22$	$S_{49} = 20$	$S_{68} = 10$	$S_{85} = 9$
$S_{15} = 12$	$S_{34} = 15$	$S_{51} = 10$	$S_{69} = 17$	$S_{86} = 11$
$S_{16} = 21$	$S_{35} = 11$	$S_{52} = 20$	$S_{71} = 13$	$S_{87} = 9$
$S_{17} = 10$	$S_{36} = 22$	$S_{53} = 17$	$S_{72} = 15$	$S_{89} = 5$
$S_{18} = 21$	$S_{37} = -4$	$S_{54} = 17$	$S_{73} = 7$	$S_{91} = 25$
$S_{19} = 22$	$S_{38} = 4$	$S_{56} = 16$	$S_{74} = 6$	$S_{92} = 25$
$S_{21} = 30$	$S_{39} = 7$	$S_{57} = 1$	$S_{75} = 4$	$S_{93} = 19$
$S_{23} = 27$	$S_{41} = 8$	$S_{58} = 10$	$S_{76} = 4$	$S_{94} = 10$
$S_{24} = 23$	$S_{42} = 25$	$S_{59} = 18$	$S_{78} = 15$	$S_{95} = 27$
$S_{25} = 4$	$S_{43} = 22$	$S_{61} = 20$	$S_{79} = 18$	$S_{96} = 16$
$S_{26} = 22$	$S_{45} = 22$	$S_{62} = 19$	$S_{81} = 17$	$S_{97} = 16$
$S_{27} = 19$	$S_{46} = 22$	$S_{63} = 25$	$S_{82} = 4$	$S_{98} = 5$
$S_{28} = 9$		$S_{64} = 17$		



### 3 Delete negative saving.

$S_{14}, S_{31}, S_{37}, S_{67}$ , and  $S_{84}$  are deleted, because they have negative value.

### 4 Sort vehicle capacity in decreasing order.

Vehicle 1 has the largest vehicle capacity.

### 5 For each vehicle (vehicle 1)

- a. Delete path with accumulated customer demand in all nodes in the path exceeds vehicle capacity and total duration exceed time window.

#### Customer demand

Node	Demand (unit)	Node	Demand (unit)	Node	Demand (unit)	Node	Demand (unit)
1- 2	48	2- 4	43	3 -7	37	5 - 7	31
1- 3	57	2 - 5	39	3 - 8	47	5 - 8	41
1- 4	55	2 - 6	37	<b>3 - 9</b>	<b>44</b>	5 - 9	38
1- 5	51	2 - 7	28	4 - 5	46	6 - 7	29
1- 6	49	2 - 8	38	4 - 6	44	6 - 8	39
1- 7	40	2 - 9	35	4 - 7	35	6 - 9	36
1 - 8	50	3 - 4	52	4 - 8	45	7 - 8	30
1- 9	47	3 - 5	48	4 - 9	42	7 - 9	27
2- 3	45	3 - 6	46	5 - 6	30	8 - 9	37

The accumulated customer demand in all nodes in the path is smaller than vehicle 1 capacity.

#### Delivery Time

Delivery time is calculated:

Time for  $S_{ij} = (c_{ki} + c_{ij} + c_{jk}) \times 1.5 \text{ min/km} + (\text{demand customer } i + \text{demand customer } j) \times 2 \text{ min/unit}$

For node 1-2 ( $S_{12} = ((15+12+25) \times 1.5) + (48 \times 2) = 174 \text{ min}$ )

Saving	Time (min)	Saving	Time (min)	Saving	Time (min)	Saving	Time (min)
$S_{12}$	174	$S_{34}$	164	$S_{56}$	134	$S_{78}$	109.5
$S_{13}$	201	$S_{35}$	171	$S_{57}$	131	$S_{79}$	112.5
$S_{14}$	195.5	$S_{36}$	141.5	$S_{58}$	155.5	$S_{81}$	166
$S_{15}$	174	$S_{37}$	155	$S_{59}$	151	$S_{82}$	182.5
$S_{16}$	147.5	$S_{38}$	181	$S_{61}$	149	$S_{83}$	181
$S_{17}$	138.5	$S_{39}$	184	$S_{62}$	147.5	$S_{84}$	176.5
$S_{18}$	160	$S_{41}$	179	$S_{63}$	137	$S_{85}$	157
$S_{19}$	166	$S_{42}$	150.5	$S_{64}$	131.5	$S_{86}$	141
$S_{21}$	165	$S_{43}$	153.5	$S_{65}$	128	$S_{87}$	118.5
$S_{23}$	165	$S_{45}$	137	$S_{67}$	122.5	$S_{89}$	170
$S_{24}$	165	$S_{46}$	124	$S_{68}$	142.5	$S_{91}$	161.5
$S_{25}$	153.5	$S_{47}$	115	$S_{69}$	139.5	$S_{92}$	158.5
$S_{26}$	150	$S_{48}$	160.5	$S_{71}$	134	$S_{93}$	161.5
$S_{27}$	143	$S_{49}$	147	$S_{72}$	128	$S_{94}$	162
$S_{28}$	122	$S_{51}$	177	$S_{73}$	138.5	$S_{95}$	137.5
$S_{29}$	175	$S_{52}$	157	$S_{74}$	122.5	$S_{96}$	141
$S_{31}$	154	$S_{53}$	162	$S_{75}$	126.5	$S_{97}$	115.5
$S_{32}$	172.5	$S_{54}$	144.5	$S_{76}$	113.5	$S_{98}$	170

- Duration of each saving does not exceed time window (360 minutes).
- b. Find the customer is the remaining paths.  
All customers (customer 1 to customer 9) are in the set of paths.
- c. Sort savings in decreasing order  
 $S_{21}, S_{29}, S_{23}, S_{95}, S_{42}, S_{63}, S_{91}, S_{92}, S_{12}, S_{24}, S_{19}, S_{26}, S_{32}, S_{36}, S_{43}, S_{45}, S_{46}, S_{16}, S_{49}, S_{52}, S_{61}, S_{65}, S_{27}, S_{93}, S_{79}, S_{53}, S_{54}, S_{64}, S_{69}, S_{81}, S_{56}, S_{96}, S_{97}, S_{34}, S_{72}, S_{78}, S_{71}, S_{35}, S_{47}, S_{86}, S_{17}, S_{51}, S_{58}, S_{68}, S_{94}, S_{28}, S_{85}, S_{87}, S_{41}, S_{39}, S_{73}, S_{13}, S_{89}, S_{98}, S_{25}, S_{38}, S_{75}, S_{76}, S_{82}, S_{83}, S_{57}$
- d. Schedule the path with the largest saving as vehicle basic route  
 $S_{21}: 0-2-1-0$  (used capacity = 48 unit, delivery time = 165 minutes)
- e. Combine paths  
 $S_{21}: 0-2-1-0$  (used capacity = 48 unit, delivery time = 165 minutes)  
 $S_{29}: X$   
 $S_{23}: X$   
 $S_{95}: X$   
 $S_{42}: 0-4-2-1-0$  (used capacity = 73 unit, delivery time = 212 minutes)  
 $S_{63}: X$   
 $S_{91}: X$   
 $S_{92}: X$   
 $S_{12}: X$   
 $S_{24}: X$   
 $S_{19}: 0-4-2-1-9-0$  (used capacity = 90 units, delivery time = 241 minutes)  
 $S_{26}: X$   
 $S_{32}: X$   
 $S_{36}: X$   
 $S_{43}: X$   
 $S_{45}: X$   
 $S_{46}: X$   
 $S_{16}: X$   
 $S_{49}: X$   
 $S_{52}: X$   
 $S_{61}: X$   
 $S_{65}: X$   
 $S_{27}: X$   
 $S_{93}: 0-4-2-1-9-3-0$  (used capacity = 117 units, delivery time = 345 minutes, total distance = 74 kms)

Vehicle 1 route is 0-4-2-1-9-3-0 with total used capacity 117 units, total delivery time 345 minutes, and total distance 74 kms. As remaining capacity of vehicle 1 (3 units) is smaller than the smallest demand customer (10 units), vehicle 2 will be used to cover the next route.

Then delete each path which has been scheduled in vehicle 1. The list of unscheduled route as follows:

$$\begin{array}{ll}
 S_{56} = 13 + 12 - 9 = 16 & S_{76} = 10 + 12 - 18 = 4 \\
 S_{57} = 13 + 8 - 20 = 1 & S_{78} = 10 + 16 - 11 = 15 \\
 S_{58} = 13 + 16 - 19 = 10 & S_{85} = 14 + 16 - 21 = 9 \\
 S_{65} = 11 + 16 - 7 = 20 & S_{86} = 14 + 12 - 15 = 11 \\
 S_{68} = 11 + 16 - 17 = 10 & S_{87} = 14 + 8 - 13 = 9 \\
 S_{75} = 10 + 16 - 22 = 4 &
 \end{array}$$

## 6 For each vehicle (vehicle 2)

- a. Delete path for customer with demand bigger than vehicle capacity and total delivery time bigger than time window.

### Customer demand

$$\begin{array}{ll}
 S_{56} = S_{65} = 40 \text{ unit} & S_{67} = S_{76} = 29 \text{ unit} \\
 S_{78} = S_{87} = 30 \text{ unit} & S_{68} = S_{86} = 39 \text{ unit} \\
 S_{58} = S_{85} = 41 \text{ unit} & S_{57} = S_{75} = 31 \text{ unit}
 \end{array}$$

The vehicle 2 capacity is larger than all customer demand of each saving.

Delivery time

Saving	Time (min)	Saving	Time (min)	Saving	Time (min)
S <sub>56</sub>	134	S <sub>67</sub>	122.5	S <sub>78</sub>	109.5
S <sub>57</sub>	131	S <sub>68</sub>	142.5	S <sub>85</sub>	157
S <sub>58</sub>	155.5	S <sub>75</sub>	126.5	S <sub>86</sub>	141
S <sub>65</sub>	128	S <sub>76</sub>	113.5	S <sub>87</sub>	118.5

b. Find the customers in remaining set of paths. Cari customer di kumpulan path yang tersisa.  
All remain customers (customer 5,6,7, and 8) are in the set of path.

c. Sort saving in the decreasing order.

S<sub>65</sub>, S<sub>56</sub>, S<sub>78</sub>, S<sub>86</sub>, S<sub>58</sub>, S<sub>68</sub>, S<sub>85</sub>, S<sub>87</sub>, S<sub>75</sub>, S<sub>76</sub>, S<sub>57</sub>.

d. Schedule the path with the largest saving as vehicle basic route

S<sub>65</sub> : 0-6-5-0 (used capacity = 40 units, delivery time = 128 minutes)

e. Combine path

S<sub>65</sub> : 0-6-5-0 (used capacity = 40 units, delivery time = 128 minutes)

S<sub>56</sub> : x

S<sub>78</sub> : x

S<sub>86</sub> : 0-8-6-5-0(used capacity = 60 units, delivery time = 196.5 minutes)

S<sub>58</sub> : x

S<sub>68</sub> : x

S<sub>85</sub> : x

S<sub>87</sub> : x

S<sub>75</sub> : x

S<sub>76</sub> : x

S<sub>57</sub> : 0-8-6-5-7-0 (used capacity = 70 unit, delivery time interval =242 minutes, total distance= 68 km)

Total distance

Total distance of vehicle 1 is 74 km and total distance of vehicle 2 is 168 km. Total distance for both vehicles is 142 km.

**EXPERIMENTAL RESULT**

The inputs for experiment are as follows:

Number of customers: 5-10

1. Demand quantity : 25-75 units

2. Distance between Customer: 5-50 kms

Vehicle capacity: 250,125,and 70 units

Time Window : 6 hours

Average Velocity: 40 kms/hours

Loading/Unloading time: 1 minutes

The optimal solution using full enumeration is generated for comparing the development of algorithm's result and validating the developed algorithm. The result can be seen as table 3. It is shown that performance of algorithm that has been developed is 9.4%, on average, below the optimal solution



**TABLE 3  
EXPERIMENTAL RESULT**

Replication	Customer	Vehicle	With Algorithm		Optimal		% below optimal
			Computational Time	Distance	Computational Time	Distance	
1	6	3	0.71"	109	2.57"	104	4.81%
2	6	3	0.61"	135	2.49"	131	3.05%
3	5	3	0.53"	153	0.86"	140	9.29%
4	9	4	0.64"	134	719':2"	105	27.62%
5	10	4	0.67"	218	1440':5"	209	4.31%
6	7	3	0.59"	187	15.74"	154	21.43%
7	8	3	0.58"	135	2':26.54"	131	3.05%
8	7	4	0.57"	99	1':12.26"	92	7.61%
9	6	3	0.54"	88	2.53"	86	2.33%
10	7	3	0.69"	143	16.64"	135	5.93%
11	7	3	0.62"	141	16.01"	120	17.50%
12	5	3	0.52"	108	0.90"	102	5.88%
Average performance							9.40%

### CONCLUSION

The performance of Clarke Wright Saving modification algorithm was 9.4%, on average, below optimal solution.

In this research, we provide infinite number of vehicles with different capacity, thus all customer could be served in the same day. For further research, the finite number of vehicle and the vehicle capacity constraints should be considered in the model.

### REFERENCES

- Ballou, Ronald H. (1998), *Business Logistic Management*, 4<sup>th</sup> Ed. Prentice Hall International Inc.
- Bodin et al, (1985), *Routing and Scheduling of Vehicles and Crews*, Pergamon Press Ltd., Great Britain.
- Boudali, Imen, et. al, (2005), "An Interactive Distributed Approach for the VRP with Time Windows", *International Journal of Simulation*, Vol. 6 No 10-11. pp. 48-59.
- Endah, Dini et all, (2003), "Design and Application of Technology, Widya Mandala University Surabaya" Vol. 1 pp.10-17