# LAMPIRAN

Lampiran 1. Iterasi pada pemilihan rute berdasarkan *Nearest*

| NO | Rute | Iterasi 1 | | Iterasi 3 | | Iterasi 3 | | Iterasi 4 | | Rute Hasil *Nearest Neighbor* |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | A00-A01-A02-A00 | **Tujuan** | **A00** | **Tujuan** | **A02** | **Tujuan** | **A01** | **Tujuan** | - | A00-A02-A01-A00 |
| | | A01 | 16,2 | A01 | 3,9 | A00 | 13,3 | - | - | |
| | | A02 | 13,3 | A02 | 0 | | | | | |
| 2 | A00-A03-A04-A00 | **Tujuan** | **A00** | **Tujuan** | **A04** | **Tujuan** | **A03** | **Tujuan** | - | A00-A04-A03-A00 |
| | | A03 | 41,6 | A03 | 62,2 | A00 | 41,6 | - | - | |
| | | A04 | 14,1 | A04 | 0 | | | | | |
| 3 | A00-A05-A06-A00 | **Tujuan** | **A00** | **Tujuan** | **A06** | **Tujuan** | **A05** | **Tujuan** | - | A00-A06-A05-A00 |
| | | A05 | 31,4 | A05 | 8,1 | A00 | 31,4 | - | - | |
| | | A06 | 18,9 | A06 | 0 | | | | | |
| 4 | A00-A07-A08-A00 | **Tujuan** | **A00** | **Tujuan** | **A08** | **Tujuan** | **A07** | **Tujuan** | - | A00-A08-A07-A00 |
| | | A07 | 15,8 | A07 | 13,3 | A00 | 15,8 | - | - | |
| | | A08 | 14,1 | A08 | 0 | | | | | |
| 5 | A00-A09-A10-A11-A00 | **Tujuan** | **A00** | **Tujuan** | **A11** | **Tujuan** | **A09** | **Tujuan** | **A10** | A00-A11-A09-A10-A00 |
| | | A09 | 31,8 | A09 | 15,4 | A09 | 0 | A00 | 33,6 | |
| | | A10 | 33,6 | A10 | 45 | A10 | 4,8 | | | |
| | | A11 | 9,9 | A11 | 0 | A11 | - | | | |
| 6 | A00-A14-A12-A13-A00 | **Tujuan** | **A00** | **Tujuan** | **A12** | **Tujuan** | **A14** | **Tujuan** | **A13** | A00-A12-A14-A13-A00 |
| | | A12 | 14,3 | A12 | 0 | A12 | - | A00 | 33,6 | |
| | | A13 | 33,6 | A13 | 32,5 | A13 | 2,1 | | | |
| | | A14 | 25,8 | A14 | 30,3 | A14 | 0 | | | |
| 7 | A00-A15-A16-A00 | **Tujuan** | **A00** | **Tujuan** | **A16** | **Tujuan** | **A15** | **Tujuan** | - | A00-A16-A15-A00 |
| | | A15 | 14,5 | A15 | 22,2 | A00 | 14,5 | - | - | |
| | | A16 | 11 | A16 | 0 | | | | | |

Lampiran 2.. Total waktu seluruh rute distribusi awal

| NO | Tujuan | | Jarak | Permintaan (karung) | Jumlah Karung | Waktu (menit) | | Waktu Perjalanan (menit) | Waktu Total (menit) |
|---|---|---|---|---|---|---|---|---|---|
| | Dari | Ke | | | | *Loading* | *Unloading* | | |
| 1 | - | - | 0 | 0 | 31 | 15.5 | 0 | 0 | 15.50 |
| | A00 | A01 | 16.2 | 6 | 25 | 0 | 4.02 | 24.3 | 28.32 |
| | A01 | A02 | 3.9 | 25 | 0 | 0 | 16.75 | 5.85 | 22.60 |
| | A02 | A00 | 13.3 | 0 | 0 | 0 | 0 | 19.95 | 19.95 |
| 2 | - | - | 0 | 0 | 35 | 17.5 | 0 | 0 | 17.50 |
| | A00 | A03 | 41.6 | 25 | 10 | 0 | 16.75 | 62.4 | 79.15 |
| | A03 | A04 | 62.2 | 10 | 0 | 0 | 6.7 | 93.3 | 100.00 |
| | A04 | A00 | 14.1 | 0 | 0 | 0 | 0 | 21.15 | 21.15 |
| 3 | - | - | 0 | 0 | 20 | 10 | 0 | 0 | 10.00 |
| | A00 | A05 | 31.4 | 10 | 10 | 0 | 6.7 | 47.1 | 53.80 |
| | A05 | A06 | 8.1 | 10 | 0 | 0 | 6.7 | 12.15 | 18.85 |
| | A06 | A00 | 18.9 | 0 | 0 | 0 | 0 | 28.35 | 28.35 |
| 4 | - | - | 0 | 0 | 45 | 22.5 | 0 | 0 | 22.50 |
| | A00 | A07 | 15.8 | 37 | 8 | 0 | 24.79 | 23.7 | 48.49 |
| | A07 | A08 | 13.3 | 8 | 0 | 0 | 5.36 | 19.95 | 25.31 |
| | A08 | A00 | 14.1 | 0 | 0 | 0 | 0 | 21.15 | 21.15 |
| 5 | - | - | 0 | 0 | 35 | 17.5 | 0 | 0 | 17.50 |
| | A00 | A09 | 31.8 | 6 | 29 | 0 | 4.02 | 47.7 | 51.72 |
| | A09 | A10 | 4.8 | 4 | 25 | 0 | 2.68 | 7.2 | 9.88 |
| | A10 | A11 | 45 | 25 | 0 | 0 | 16.75 | 67.5 | 84.25 |
| | A11 | A00 | 9.9 | 0 | 0 | 0 | 0 | 14.85 | 14.85 |
| 6 | - | - | 0 | 0 | 31 | 15.5 | 0 | 0 | 15.50 |
| | A00 | A14 | 14.3 | 11 | 20 | 0 | 7.37 | 21.45 | 28.82 |
| | A14 | A12 | 30.3 | 15 | 5 | 0 | 10.05 | 48.75 | 58.80 |
| | A12 | A13 | 2.1 | 5 | 0 | 0 | 3.35 | 3.15 | 6.50 |
| | A13 | A00 | 33.6 | 0 | 0 | 0 | 0 | 38.7 | 38.70 |
| 7 | - | - | 0 | 0 | 38 | 19 | 0 | 0 | 19.00 |
| | A00 | A15 | 14.5 | 16 | 22 | 0 | 10.72 | 21.75 | 32.47 |
| | A15 | A16 | 22.2 | 22 | 0 | 0 | 14.74 | 33.3 | 48.04 |
| | A16 | A00 | 11 | 0 | 0 | 0 | 0 | 16.5 | 16.50 |
| **TOTAL** | | | **472.4** | **235** | **389** | **117.5** | **157.45** | **700.2** | **975.15** |

Lampiran 3. Total waktu seluruh rute distribusi dengan *Nearest Neighbor*

| NO | Tujuan | | Jarak | Permintaan (karung) | Jumlah Karung | Waktu (menit) | | Waktu Perjalanan (menit) | Waktu Total (menit) |
|---|---|---|---|---|---|---|---|---|---|
| | Dari | Ke | | | | *Loading* | *Unloading* | | |
| 1 | - | - | 0 | 0 | 31 | 15.5 | 0 | 0 | 15.50 |
| | A00 | A02 | 13.3 | 25 | 6 | 0 | 16.75 | 19.95 | 36.70 |
| | A02 | A01 | 3.9 | 6 | 0 | 0 | 4.02 | 5.85 | 9.87 |
| | A01 | A00 | 16.2 | 0 | 0 | 0 | 0 | 24.3 | 24.30 |
| 2 | - | - | 0 | 0 | 35 | 17.5 | 0 | 0 | 17.50 |
| | A00 | A04 | 14.1 | 10 | 25 | 0 | 6.7 | 21.15 | 27.85 |
| | A04 | A03 | 62.2 | 25 | 0 | 0 | 16.75 | 93.3 | 110.05 |
| | A03 | A00 | 41.6 | 0 | 0 | 0 | 0 | 62.4 | 62.40 |
| 3 | - | - | 0 | 0 | 20 | 10 | 0 | 0 | 10.00 |
| | A00 | A06 | 18.9 | 10 | 10 | 0 | 6.7 | 28.35 | 35.05 |
| | A06 | A05 | 8.1 | 10 | 10 | 0 | 6.7 | 12.15 | 18.85 |
| | A05 | A00 | 31.4 | 0 | 0 | 0 | 0 | 47.1 | 47.10 |
| 4 | - | - | 0 | 0 | 45 | 22.5 | 0 | 0 | 22.50 |
| | A00 | A08 | 14.1 | 8 | 37 | 0 | 5.36 | 21.15 | 26.51 |
| | A08 | A07 | 13.3 | 37 | 0 | 0 | 24.79 | 19.95 | 44.74 |
| | A07 | A00 | 15.8 | 0 | 0 | 0 | 0 | 23.7 | 23.70 |
| 5 | - | - | 0 | 0 | 35 | 17.5 | 0 | 0 | 17.50 |
| | A00 | A11 | 9.9 | 25 | 10 | 0 | 16.75 | 14.85 | 31.60 |
| | A11 | A09 | 41.3 | 6 | 4 | 0 | 4.02 | 61.95 | 65.97 |
| | A09 | A10 | 4.8 | 4 | 0 | 0 | 2.68 | 7.2 | 9.88 |
| | A10 | A00 | 33.6 | 0 | 0 | 0 | 0 | 50.4 | 50.40 |
| 6 | - | - | 0 | 0 | 31 | 15.5 | 0 | 0 | 15.50 |
| | A00 | A12 | 14.3 | 11 | 20 | 0 | 7.37 | 21.45 | 28.82 |
| | A12 | A13 | 32.5 | 15 | 5 | 0 | 10.05 | 48.75 | 58.80 |
| | A13 | A14 | 2.1 | 5 | 0 | 0 | 3.35 | 3.15 | 6.50 |
| | A14 | A00 | 25.8 | 0 | 0 | 0 | 0 | 38.7 | 38.70 |
| 7 | - | - | 0 | 0 | 38 | 19 | 0 | 0 | 19.00 |
| | A00 | A16 | 11 | 16 | 22 | 0 | 10.72 | 16.5 | 27.22 |
| | A16 | A15 | 22.2 | 22 | 0 | 0 | 14.74 | 33.3 | 48.04 |
| | A15 | A00 | 14.5 | 0 | 0 | 0 | 0 | 21.75 | 21.75 |
| **TOTAL** | | | **464.9** | **235** | **384** | **117.5** | **157.45** | **697.35** | **972.3** |

Lampiran 4. Total waktu seluruh rute distribusi dengan *Simulated Annealing*

| NO | Tujuan | | Jarak | Permintaan (karung) | Jumlah Karung | Waktu (menit) | | Waktu Perjalanan (menit) | Waktu Total (menit) |
|---|---|---|---|---|---|---|---|---|---|
| | Dari | Ke | | | | Loading | Unloading | | |
| 1 | - | - | 0 | 0 | 37 | 18.5 | 0 | 0 | 18.5 |
| | A00 | A07 | 15.8 | 37 | 6 | 3 | 24.79 | 23.7 | 51.49 |
| | A07 | A00 | 15.8 | 0 | 0 | 0 | 0 | 23.7 | 23.7 |
| 2 | - | - | 0 | 0 | 41 | 20.5 | 0 | 0 | 20.5 |
| | A00 | A01 | 16.2 | 6 | 35 | 0 | 3 | 24.3 | 27.3 |
| | A01 | A09 | 21.6 | 6 | 29 | 0 | 3 | 32.4 | 35.4 |
| | A09 | A10 | 4.8 | 4 | 25 | 0 | 2 | 7.2 | 9.2 |
| | A10 | A03 | 11.5 | 25 | 0 | 0 | 12.5 | 17.25 | 29.75 |
| | A03 | A00 | 41.6 | 0 | 0 | 0 | 0 | 62.4 | 62.4 |
| 3 | - | - | 0 | 0 | 40 | 20 | 0 | 0 | 20 |
| | A00 | A14 | 25.8 | 5 | 35 | 0 | 2.5 | 38.7 | 41.2 |
| | A14 | A13 | 2.1 | 15 | 20 | 0 | 7.5 | 3.15 | 10.65 |
| | A13 | A05 | 23 | 10 | 10 | 0 | 5 | 34.5 | 39.5 |
| | A05 | A06 | 8.1 | 10 | 0 | 0 | 5 | 12.15 | 17.15 |
| | A06 | A00 | 18.9 | 0 | 0 | 0 | 0 | 28.35 | 28.35 |
| 4 | - | - | - | - | - | - | - | - | - |
| 5 | - | - | 0 | 0 | 41 | 20.5 | 0 | 0 | 20.5 |
| | A00 | A02 | 13.3 | 25 | 16 | 0 | 12.5 | 19.95 | 32.45 |
| | A02 | A15 | 2.8 | 16 | 0 | 0 | 8 | 4.2 | 12.2 |
| | A15 | A00 | 14.5 | 0 | 0 | 0 | 0 | 21.75 | 21.75 |
| 6 | - | - | 0 | 0 | 33 | 16.5 | 0 | 0 | 16.5 |
| | A00 | A16 | 11 | 22 | 11 | 0 | 11 | 16.5 | 27.5 |
| | A16 | A12 | 16 | 11 | 0 | 0 | 5.5 | 24 | 29.5 |
| | A12 | A00 | 14.3 | 0 | 0 | 0 | 0 | 21.45 | 21.45 |
| 7 | - | - | 0 | 0 | 43 | 21.5 | 0 | 0 | 21.5 |
| | A00 | A11 | 9.9 | 25 | 18 | 0 | 12.5 | 14.85 | 27.35 |
| | A11 | A08 | 8.4 | 8 | 10 | 0 | 4 | 12.6 | 16.6 |
| | A08 | A04 | 1.3 | 10 | 0 | 0 | 5 | 1.95 | 6.95 |
| | A04 | A00 | 14.1 | 0 | 0 | 0 | 0 | 21.15 | 21.15 |
| **TOTAL** | | | **310.8** | **235** | **413** | **102** | **123.79** | **466.2** | **691.99** |

Lampiran 5. *Neighbor* Tabel biaya distribusi dan biaya pengiriman

| No. | Kode Konsumen | Alamat | Biaya Distribusi | Biaya Jasa Pengiriman |
|---|---|---|---|---|
| 1 | A01 | Laladon | 150.000 | 75.000 |
| 2 | A02 | Rph-Bubulak | 100.000 | 50.000 |
| 3 | A03 | Cisarua | 200.000 | 75.000 |
| 4 | A04 | Sawangan | 150.000 | 75.000 |
| 5 | A05 | Citeurep | 200.000 | 75.000 |
| 6 | A06 | Cibinong | 150.000 | 75.000 |
| 7 | A07 | Gunung Sindur | 150.000 | 75.000 |
| 8 | A08 | Sawangan | 150.000 | 75.000 |
| 9 | A09 | Ciawi | 150.000 | 75.000 |
| 10 | A10 | Gadog-Ciawi | 150.000 | 75.000 |
| 11 | A11 | Tajur Halang | 200.000 | 75.000 |
| 12 | A12 | Ciampea | 150.000 | 75.000 |
| 13 | A13 | Balitnak | 150.000 | 75.000 |
| 14 | A14 | Ciawi | 150.000 | 75.000 |
| 15 | A15 | Bubulak | 100.000 | 50.000 |
| 16 | A16 | Ciseeng | 150.000 | 75.000 |

Lampiran 5. Algoritma *Simulated Annealing*

```
"""Capacited Vehicles Routing Problem (CVRP)."""

from __future__ import print_function
from ortools.constraint_solver import routing_enums_pb2
from ortools.constraint_solver import pywrapcp


def create_data_model():
    """Stores the data for the problem."""
    data = {}
    data['distance_matrix'] = [
        [0, 162, 133, 416, 141, 314, 189, 158, 141, 318, 336, 99, 143, 336, 258, 145, 110],
        [162, 0, 39, 315, 278, 261, 242, 291, 278, 216, 235, 231, 92, 231, 225, 51, 242],
        [133, 39, 0, 330, 240, 228, 209, 258, 240, 232, 251, 198, 94, 246, 122, 28, 209],
        [416, 315, 330, 0, 622, 341, 340, 563, 615, 187, 115, 484, 404, 117, 427, 341, 495],
        [141, 278, 240, 622, 0, 304, 188, 140, 13, 434, 453, 84, 283, 448, 209, 257, 124],
        [314, 261, 228, 341, 304, 0, 81, 597, 304, 216, 234, 215, 288, 230, 211, 222, 376],
        [189, 242, 209, 340, 188, 81, 0, 272, 171, 218, 237, 156, 246, 236, 460, 180, 335],
        [158, 291, 258, 563, 140, 597, 272, 0, 133, 466, 485, 154, 252, 481, 427, 290, 92],
        [141, 278, 240, 615, 13, 304, 171, 133, 0, 434, 453, 84, 283, 449, 54, 258, 124],
        [318, 216, 232, 187, 434, 216, 218, 466, 434, 0, 48, 413, 335, 27, 60, 329, 424],
        [336, 235, 251, 115, 453, 234, 237, 485, 453, 48, 0, 450, 328, 37, 360, 261, 416],
        [99, 231, 198, 484, 84, 215, 156, 154, 84, 413, 450, 0, 221, 362, 304, 172, 130],
        [143, 92, 94, 404, 283, 288, 246, 252, 283, 335, 328, 221, 0, 325, 303, 91, 160],
        [336, 231, 246, 117, 448, 230, 236, 481, 449, 27, 37, 362, 325, 0, 21, 258, 413],
        [258, 225, 122, 427, 209, 211, 460, 427, 54, 60, 360, 304, 303, 21, 0, 254, 408],
        [145, 51, 28, 341, 257, 222, 180, 290, 258, 329, 261, 172, 91, 258, 254, 0, 222],
        [110, 242, 209, 495, 124, 376, 335, 92, 124, 424, 416, 130, 160, 413, 408, 222, 0]
    ]
    data['demands'] = [0, 6, 25, 25, 10, 10, 10, 37, 8, 6, 4, 25, 11, 15, 5,16,22] #permintaan
    data['delivery_capacity'] = [45, 45, 45, 45,45,45,45] # kapasitas setiap pengiriman
    data['num_delivery'] = 7 #jumlah pengiriman
    data['depot'] = 0
    return data
```

```
def print_solution(data, manager, routing, solution):
    """Prints solution on console."""
    total_distance = 0
    total_load = 0
    for vehicle_id in range(data['num_delivery']):
        index = routing.Start(vehicle_id)
        plan_output = 'Rute untuk pengiriman ke {}:\n'.format(vehicle_id+1)
        route_distance = 0
        route_load = 0
        while not routing.IsEnd(index):
            node_index = manager.IndexToNode(index)
            route_load += data['demands'][node_index]
            plan_output += ' A{0} Beban({1}) -> '.format(node_index, route_load)
            previous_index = index
            index = solution.Value(routing.NextVar(index))
            route_distance += routing.GetArcCostForVehicle(
                previous_index, index, vehicle_id)
        plan_output += ' {0} Beban({1})\n'.format(manager.IndexToNode(index),
                                                  route_load)
        plan_output += 'Jarak yang ditempuh: {}km\n'.format(route_distance/10)
        plan_output += 'Beban pengiriman: {}\n'.format(route_load)
        print(plan_output)
        total_distance += route_distance
        total_load += route_load
    print('Jarak tempuh semua pengiriman: {}km'.format(total_distance/10))
    print('Jumlah beban semua pengiriman: {}'.format(total_load))


def main():
    """Solve the CVRP problem."""
    # Instantiate the data problem.
    data = create_data_model()

  # Create the routing index manager.
  manager = pywrapcp.RoutingIndexManager(len(data['distance_matrix']),
                                         data['num_delivery'], data['depot'])

  # Create Routing Model.
  routing = pywrapcp.RoutingModel(manager)


  # Create and register a transit callback.
  def distance_callback(from_index, to_index):
      """Returns the distance between the two nodes."""
      # Convert from routing variable Index to distance matrix NodeIndex.
      from_node = manager.IndexToNode(from_index)
      to_node = manager.IndexToNode(to_index)
      return data['distance_matrix'][from_node][to_node]

  transit_callback_index = routing.RegisterTransitCallback(distance_callback)

  # Define cost of each arc.
  routing.SetArcCostEvaluatorOfAllVehicles(transit_callback_index)


  # Add Capacity constraint.
  def demand_callback(from_index):
      """Returns the demand of the node."""
      # Convert from routing variable Index to demands NodeIndex.
      from_node = manager.IndexToNode(from_index)
      return data['demands'][from_node]
```

```
    demand_callback_index = routing.RegisterUnaryTransitCallback(
        demand_callback)
    routing.AddDimensionWithVehicleCapacity(
        demand_callback_index,
        0,  # null capacity slack
        data['delivery_capacity'],  # vehicle maximum capacities
        True,  # start cumul to zero
        'Capacity')

    # Setting first solution heuristic.
    search_parameters = pywrapcp.DefaultRoutingSearchParameters()
    search_parameters.first_solution_strategy = (
        routing_enums_pb2.FirstSolutionStrategy.PATH_CHEAPEST_ARC)
    search_parameters.local_search_metaheuristic = (
    routing_enums_pb2.LocalSearchMetaheuristic.SIMULATED_ANNEALING)
    search_parameters.time_limit.seconds = 30
    # Solve the problem.
    solution = routing.SolveWithParameters(search_parameters)

    # Print solution on console.
    if solution:
        print_solution(data, manager, routing, solution)


if __name__ == '__main__':
    main()
```