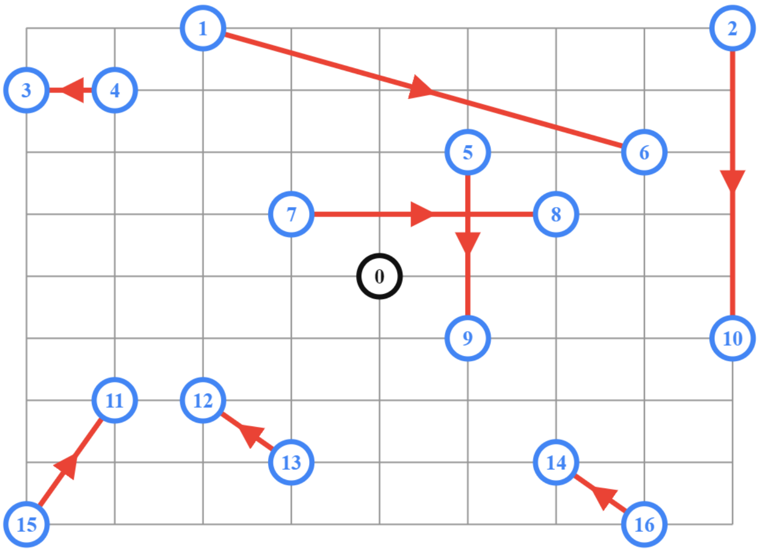
Pick-up-Delivery Problem

Here, each vehicle picks up items at various locations and drops them off at others. The problem is to assign routes for the vehicles to pick up and deliver all the items, while minimizing the length of the longest route.



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


def create_data_model():
    data = {}
    data['distance_matrix'] = [
        [
            0, 548, 776, 696, 582, 274, 502, 194, 308, 194, 536, 502, 388,
354,
            468, 776, 662
        ],
        [
            548, 0, 684, 308, 194, 502, 730, 354, 696, 742, 1084, 594, 480,
674,
            1016, 868, 1210
        ],
        [
            776, 684, 0, 992, 878, 502, 274, 810, 468, 742, 400, 1278,
1164,
            1130, 788, 1552, 754
        ],
        [
            696, 308, 992, 0, 114, 650, 878, 502, 844, 890, 1232, 514, 628,
822,
            1164, 560, 1358
        ],
        [
            582, 194, 878, 114, 0, 536, 764, 388, 730, 776, 1118, 400, 514,
708,
            1050, 674, 1244
        ],
        [
            274, 502, 502, 650, 536, 0, 228, 308, 194, 240, 582, 776, 662,
628,
            514, 1050, 708
        ],
        [
            502, 730, 274, 878, 764, 228, 0, 536, 194, 468, 354, 1004, 890,
856,
            514, 1278, 480
        ],
        [
            194, 354, 810, 502, 388, 308, 536, 0, 342, 388, 730, 468, 354,
320,
            662, 742, 856
        ],
        [
            308, 696, 468, 844, 730, 194, 194, 342, 0, 274, 388, 810, 696,
662,
            320, 1084, 514
        ],
        [
            194, 742, 742, 890, 776, 240, 468, 388, 274, 0, 342, 536, 422,
388,
            274, 810, 468
        ],
        [
            536, 1084, 400, 1232, 1118, 582, 354, 730, 388, 342, 0, 878,
764,
            730, 388, 1152, 354
        ],
        [
            502, 594, 1278, 514, 400, 776, 1004, 468, 810, 536, 878, 0,
114,
            308, 650, 274, 844
        ],
        [
            388, 480, 1164, 628, 514, 662, 890, 354, 696, 422, 764, 114, 0,
194,
            536, 388, 730
        ],
        [
            354, 674, 1130, 822, 708, 628, 856, 320, 662, 388, 730, 308,
194, 0,
            342, 422, 536
        ],
        [
            468, 1016, 788, 1164, 1050, 514, 514, 662, 320, 274, 388, 650,
536,
            342, 0, 764, 194
        ],
        [
            776, 868, 1552, 560, 674, 1050, 1278, 742, 1084, 810, 1152,
274,
            388, 422, 764, 0, 798
        ],
        [
            662, 1210, 754, 1358, 1244, 708, 480, 856, 514, 468, 354, 844,
730,
            536, 194, 798, 0
        ],
    ]
```

We also need to know from where to where the pickup and delivery must take place.

```
    data['pickups_deliveries'] = [
        [1, 6],
        [2, 10],
        [4, 3],
        [5, 9],
        [7, 8],
        [15, 11],
        [13, 12],
        [16, 14],
    ]
    data['num_vehicles'] = 4
    data['depot'] = 0
    return data


def print_solution(data, manager, routing, solution):
       total_distance = 0
    for vehicle_id in range(data['num_vehicles']):
        index = routing.Start(vehicle_id)
        plan_output = 'Route for vehicle {}:\n'.format(vehicle_id)
        route_distance = 0
        while not routing.IsEnd(index):
            plan_output += ' {} -> '.format(manager.IndexToNode(index))
            previous_index = index
            index = solution.Value(routing.NextVar(index))
            route_distance += routing.GetArcCostForVehicle(
                previous_index, index, vehicle_id)
        plan_output += '{}\n'.format(manager.IndexToNode(index))
        plan_output += 'Distance of the route:
{}m\n'.format(route_distance)
        print(plan_output)
        total_distance += route_distance
    print('Total Distance of all routes: {}m'.format(total_distance))


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

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

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


    # Define cost of each arc.
    def distance_callback(from_index, to_index):
        # 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)
    routing.SetArcCostEvaluatorOfAllVehicles(transit_callback_index)

    # Add Distance constraint.
    dimension_name = 'Distance'
    routing.AddDimension(
        transit_callback_index,
        0,  # no slack
        3000,  # vehicle maximum travel distance
        True,  # start cumul to zero
        dimension_name)
    distance_dimension = routing.GetDimensionOrDie(dimension_name)
    distance_dimension.SetGlobalSpanCostCoefficient(100)
```

We need to next define the pickup and delivery requests.

```
    # Define Transportation Requests.
    for request in data['pickups_deliveries']:
        pickup_index = manager.NodeToIndex(request[0])
        delivery_index = manager.NodeToIndex(request[1])
        routing.AddPickupAndDelivery(pickup_index, delivery_index)
        routing.solver().Add(
            routing.VehicleVar(pickup_index) == routing.VehicleVar(
                delivery_index))
        routing.solver().Add(
            distance_dimension.CumulVar(pickup_index) <=
            distance_dimension.CumulVar(delivery_index))

    # Setting first solution heuristic.
    search_parameters = pywrapcp.DefaultRoutingSearchParameters()
    search_parameters.first_solution_strategy = (
        routing_enums_pb2.FirstSolutionStrategy.PARALLEL_CHEAPEST_INSERTION
)

    # Solve the problem.
    solution = routing.SolveWithParameters(search_parameters)

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


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