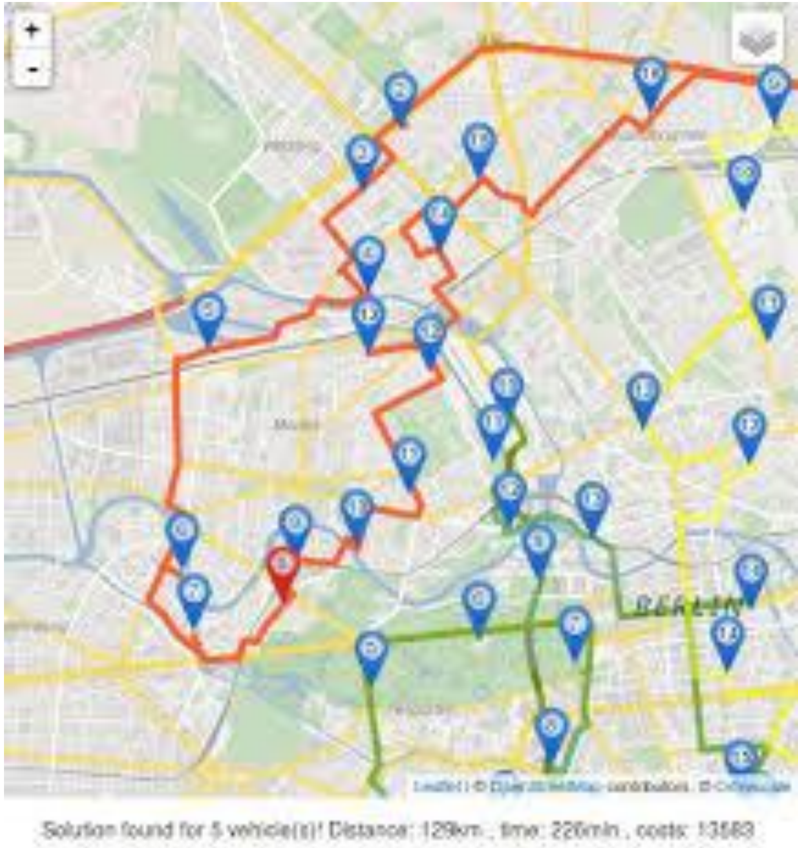
KnIT Anaemia
Survey Route Optimization

Muhammed Abdul Majeed Ameen

Introduction.

A tool that can be used by survey supervisors to optimize the surveying strategy in terms of scheduling village visits and choosing sites for base of operations.

The tool will aid in choosing an optimal survey schedule for the next day, and can be rerun at the end of each day to update the schedule with latest data.



Solution found for 5 vehicle(s)! Distance: 129km , time: 226min , costs: 13583

How?

Operations Research problem.

Mixed - linear programming - under the routing spectrum.

Library used - Google OR tools.

1.Objective Function ?

2.Constraints?

3.Solution?

Objective Function

The objective is to minimize the total cost incurred.

directly proportional to the total time spent for the survey

objective of this optimization will be to minimize the time taken to complete the survey

Time is chiefly spent on answering the questionnaire and the inter village travel times for the interviewers

Time can be divided into 2 categories:

1.Time spend in a village

2.Time spend in travelling from one village to another

Consider , there are n villages to be covered , say with village 0 as starting village.
There will be (n-1)! Possible routes.

Let us consider one particular route in that :
X_{rij} - the binary decision variable that indicates if the vehicle, r, traverses between villages i and j in an optimal solution

T_{ij} - Denotes the time taken to travel from i to j

p - the total no of vehicles.
n - the total no of villages.

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$$\sum_{r=1}^{p}\sum_{i=1}^{n}\sum_{j=0|j!=i}^{n} X_{rij} * T_{ij}$$

Constraints.

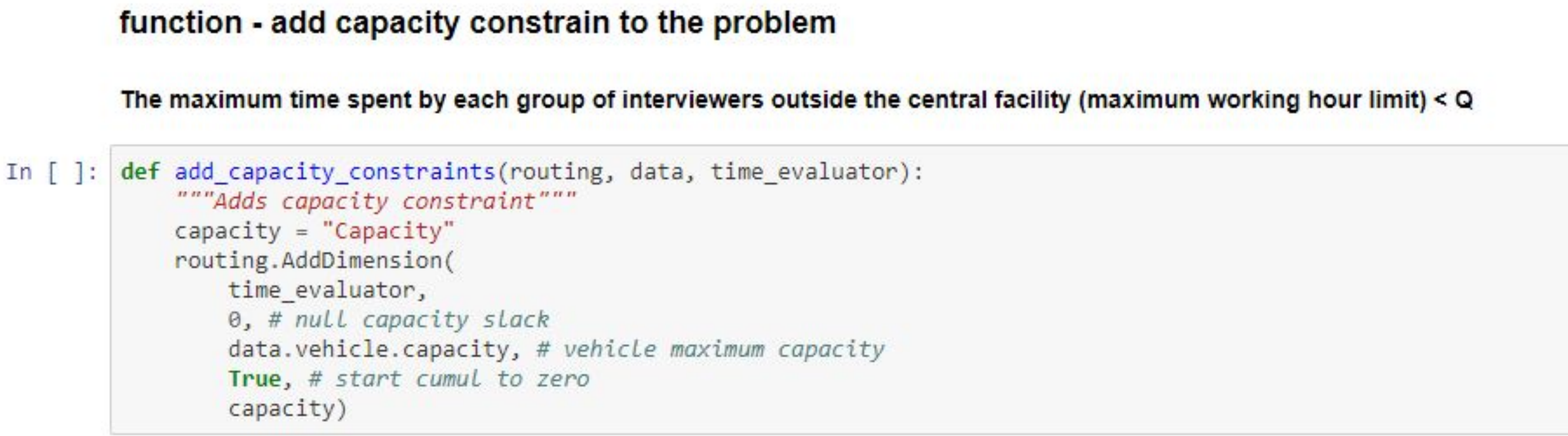
1.Every village is visited

$$\sum_{r=1}^{p}\sum_{i=1}^{n} X_{rij} = 1 \ \forall \ r \, \epsilon \, (1, 2, ...p)$$

2.The maximum time spent by each group of interviewers outside the central facility (maximum working hour limit).

$$\sum_{i=1}^{n} \sum_{j=0|j!=i}^{n} X_{rij}(T_{ij} + D_j) \leq Q \, \forall \, r \, \epsilon \, (1, 2, ...p)$$

Where p is the total no of vehicles, n is the total no of villages and Q is the maximum working time for an interviewer, D_j denotes the time requirement of a particular village.



function - add capacity constrain to the problem

The maximum time spent by each group of interviewers outside the central facility (maximum working hour limit) < Q

In [ ]:

```
def add_capacity_constraints(routing, data, time_evaluator):
    """Adds capacity constraint"""
    capacity = "Capacity"
    routing.AddDimension(
        time_evaluator,
        0, # null capacity slack
        data.vehicle.capacity, # vehicle maximum capacity
        True, # start cumul to zero
        capacity)
```

Implementation.

1. Initial data taken from survey supervisor includes:

   · the average time required for the interview
   · no of households in all villages
   · buffer time for intra household travel - for each village
   · time matrix of time between villages

Implementation.

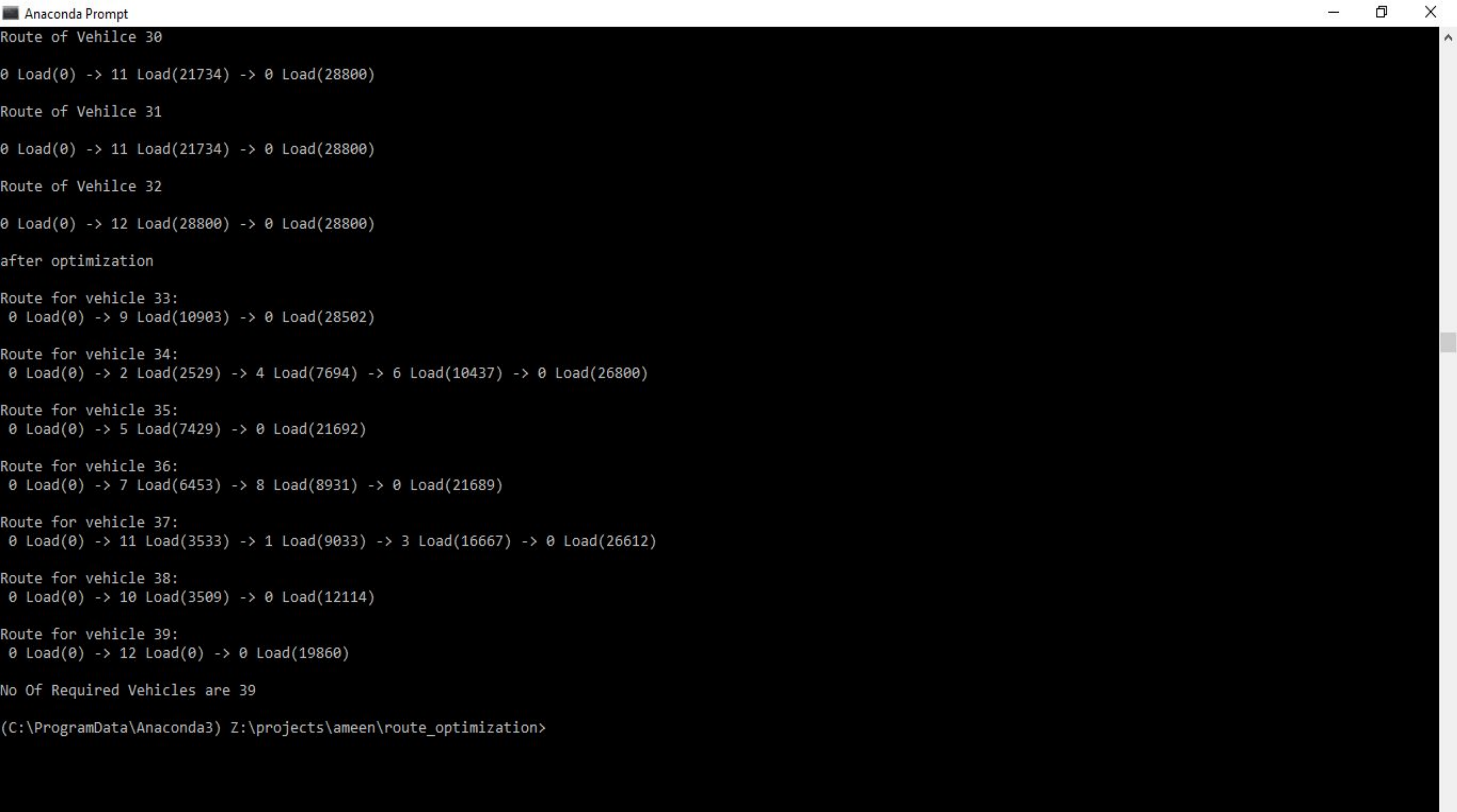
2. Formulation:

- total time = no of households * (time per households + buffer for intra traversal).
- run the algorithm and display the initial set of routes to be followed - only for day 1.

Implementation.

3. Iterative approach:

- collect the feedback at the end of the day
- modify the demand vector and add time add time constraints to villages if any
- run the algorithm again on the modified data to get the new set of routes
- iterate till all the demands are met



```
Route of Vehilce 30

0 Load(0) -> 11 Load(21734) -> 0 Load(28800)

Route of Vehilce 31

0 Load(0) -> 11 Load(21734) -> 0 Load(28800)

Route of Vehilce 32

0 Load(0) -> 12 Load(28800) -> 0 Load(28800)

after optimization

Route for vehicle 33:
 0 Load(0) -> 9 Load(10903) -> 0 Load(28502)

Route for vehicle 34:
 0 Load(0) -> 2 Load(2529) -> 4 Load(7694) -> 6 Load(10437) -> 0 Load(26800)

Route for vehicle 35:
 0 Load(0) -> 5 Load(7429) -> 0 Load(21692)

Route for vehicle 36:
 0 Load(0) -> 7 Load(6453) -> 8 Load(8931) -> 0 Load(21689)

Route for vehicle 37:
 0 Load(0) -> 11 Load(3533) -> 1 Load(9033) -> 3 Load(16667) -> 0 Load(26612)

Route for vehicle 38:
 0 Load(0) -> 10 Load(3509) -> 0 Load(12114)

Route for vehicle 39:
 0 Load(0) -> 12 Load(0) -> 0 Load(19860)

No Of Required Vehicles are 39

(C:\ProgramData\Anaconda3) Z:\projects\ameen\route_optimization>
```

Additional Constraints Involved.

Villages may have Time constraints

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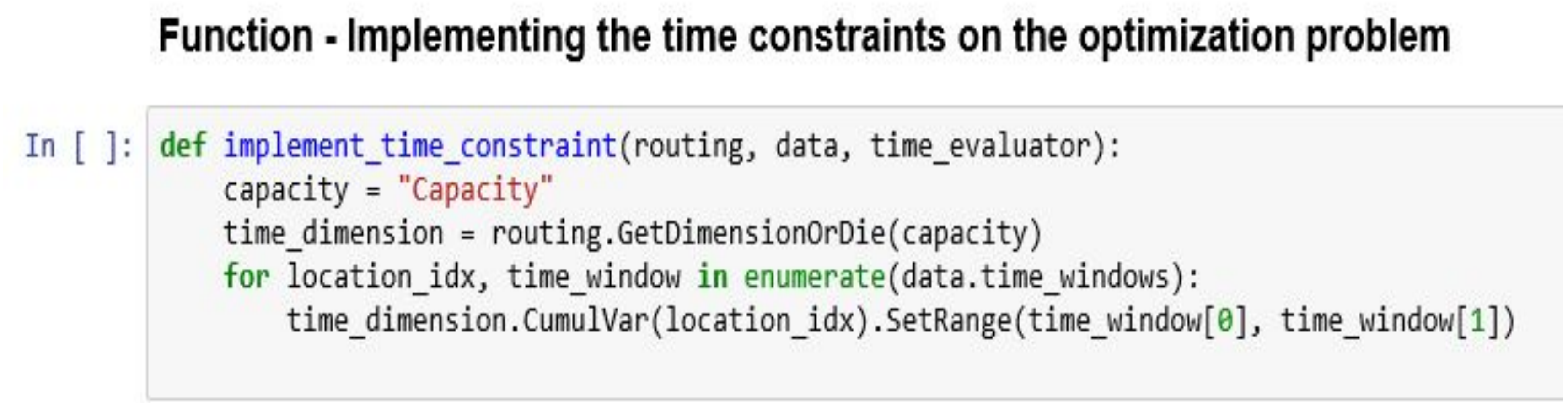

Function - Implementing the time constraints on the optimization problem

```
In [ ]: def implement_time_constraint(routing, data, time_evaluator):
            capacity = "Capacity"
            time_dimension = routing.GetDimensionOrDie(capacity)
            for location_idx, time_window in enumerate(data.time_windows):
                time_dimension.CumulVar(location_idx).SetRange(time_window[0], time_window[1])
```

Additional Constraints Involved.

All the vehicles need not exactly start and end at the same central facility.

A vehicle can start at some village and end at totally different village.

Assumptions Involved.

The interviewers leave the central facility in groups of same size and the time demand of each village is expressed in terms of the time required by this group.

The central facility has a time_demand of 0. The demand of central facility is met outside the optimization by vehicles that return early or on the last day.

Intra household traversal time is a constant for a given village, given by the supervisor at the beginning of the survey

Known Issues that may impede a possible optimum solution

1. Inherent variability in time taken per interviewer

2. Accuracy of distance and time estimates provided by google

3. Variability induced in distance and time estimates due to natural phenomena.
* This may cause a permanent change in schedules, rendering the solution implemented as non-optimal.

4. Accuracy of GPS coordinates used in geocoding the villages