CONTENTS

Implementation and visualization via code

(Capacitated) Vehicle Routing Problem:

Aim of the study –

Given a fleet of vehicles with uniform capacity, a common depot, and several customer demands, finds the set of routes with overall minimum route cost which service all the demands.

- Every demand point has to be serviced only once.
- The vehicles return to the depot.

VRP is NP-hard problem.

(Capacitated) Vehicle Routing Problem:

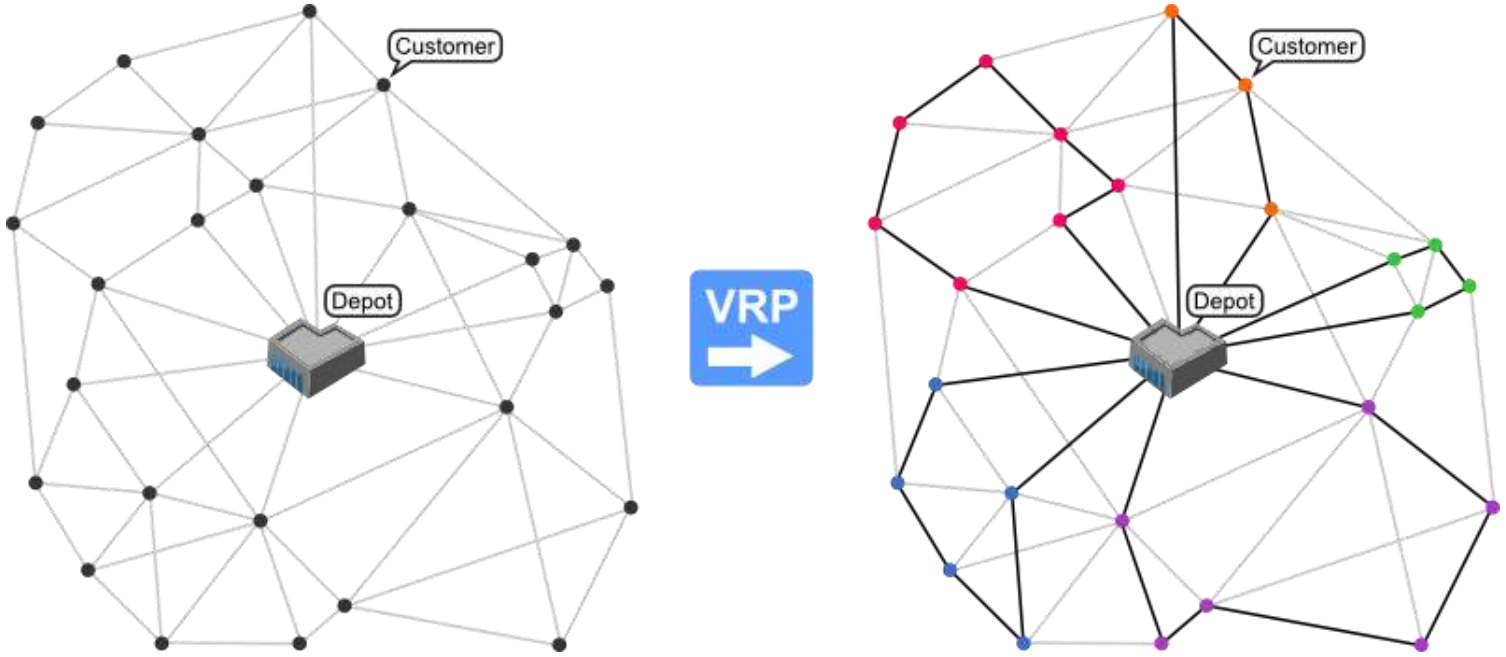
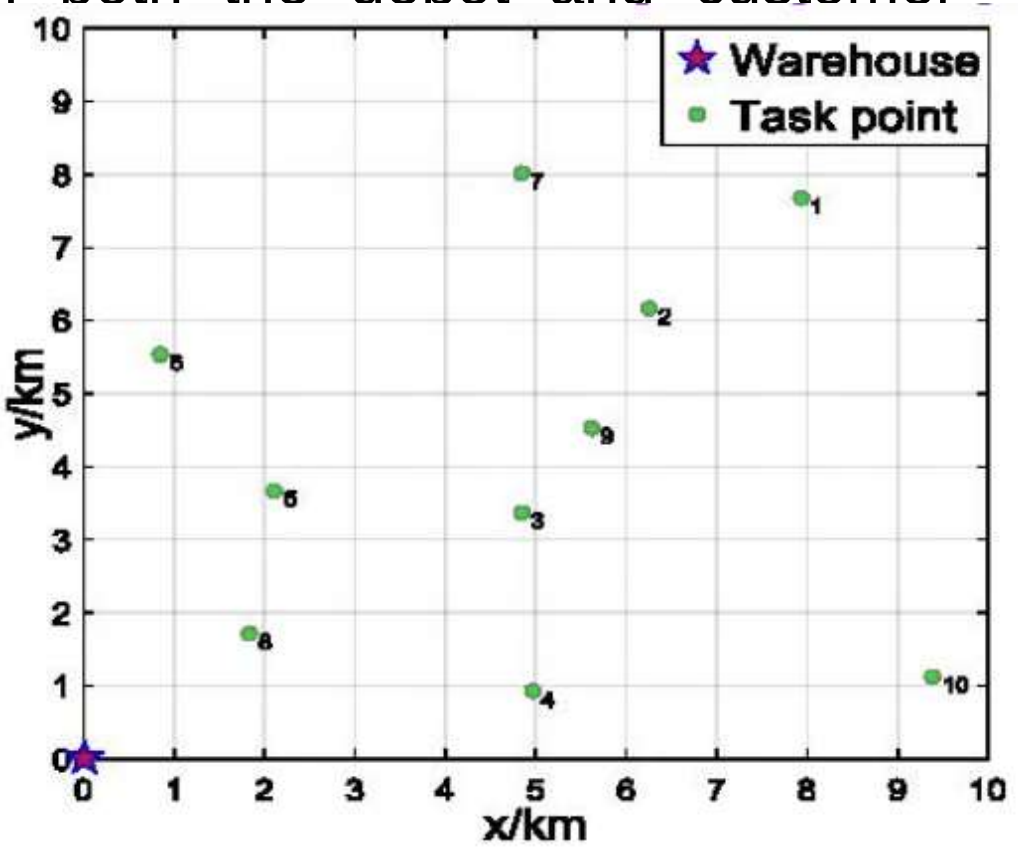


Image Source - http://neo.lcc.uma.es/vrp/vehicle-routing-problem/

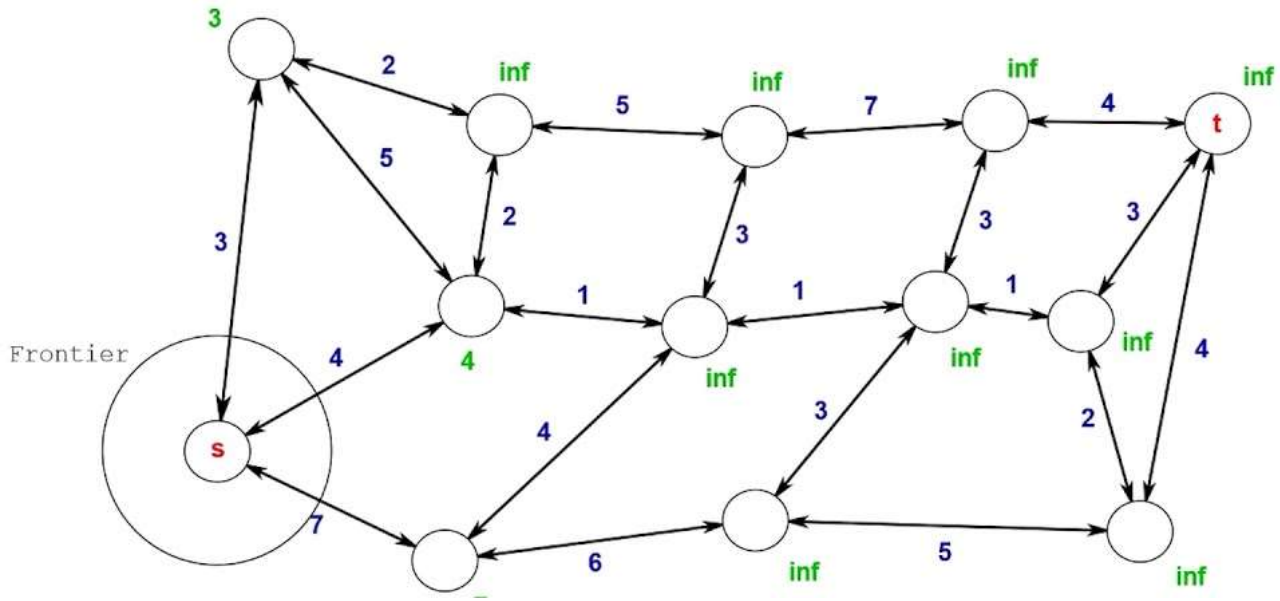
Data Collection:

- Data points include the location of both the depot and customer locations.
- A location contains:
  - X – coordinate
  - Y – coordinate
  - Demand
- Demand at depot is taken zero.



i. Graph theory:

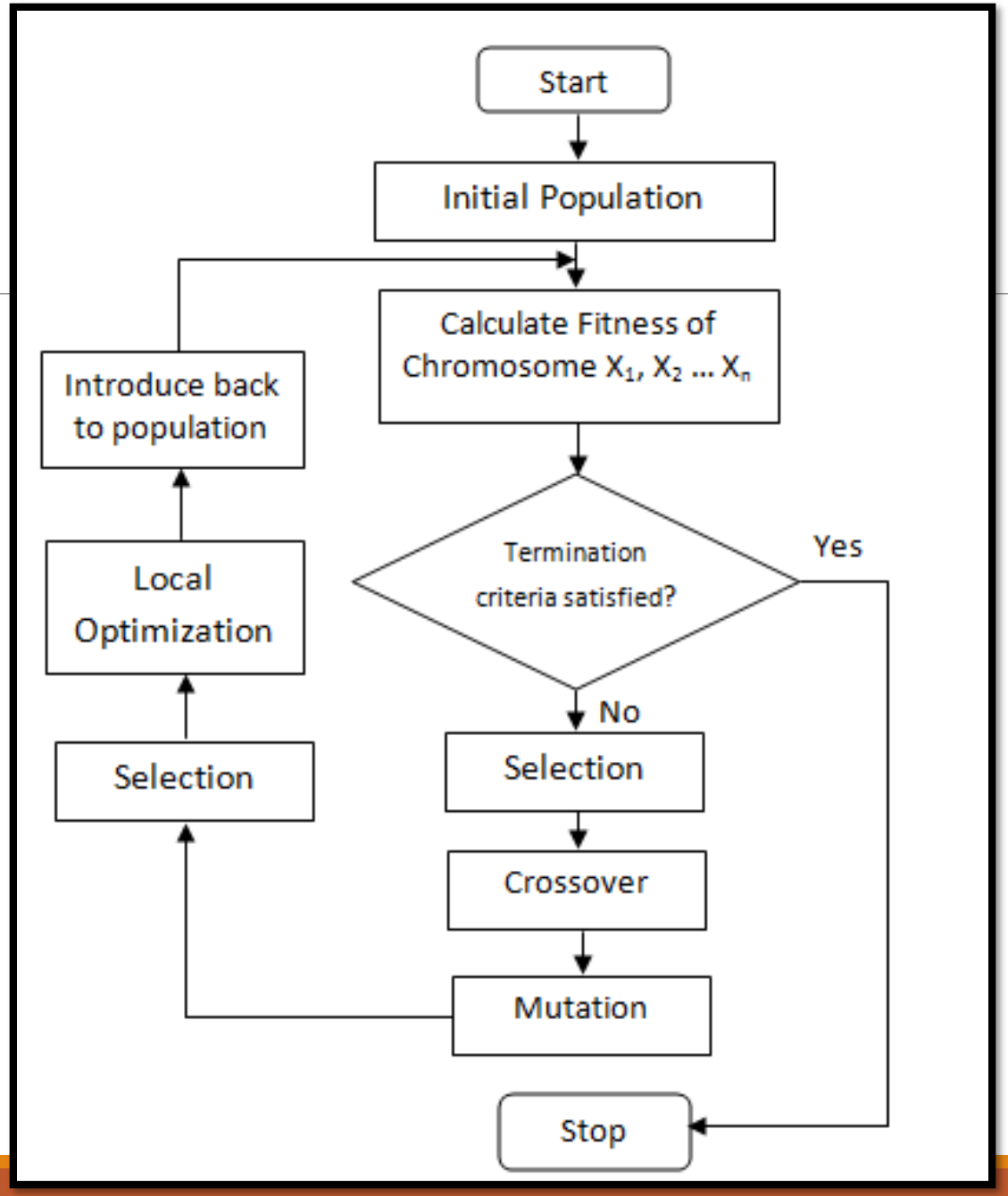
- Nodes → customer locations and numbers on arc → distance between connected nodes.
- Find shortest path to every node.
- Algorithms – Dijkstra's



- **Drawbacks:** Due to the nature of the problem it is not possible to use exact methods for large instances of the VRP as complexity of using graph theory is n! where n is number of nodes.

ii. Genetic Algorithm:

- Flow of process in algorithm →



ii. Genetic Algorithm:

- Generate Population (Random)
- Selection (Based on Fitness Function)
- Crossover
- Mutation

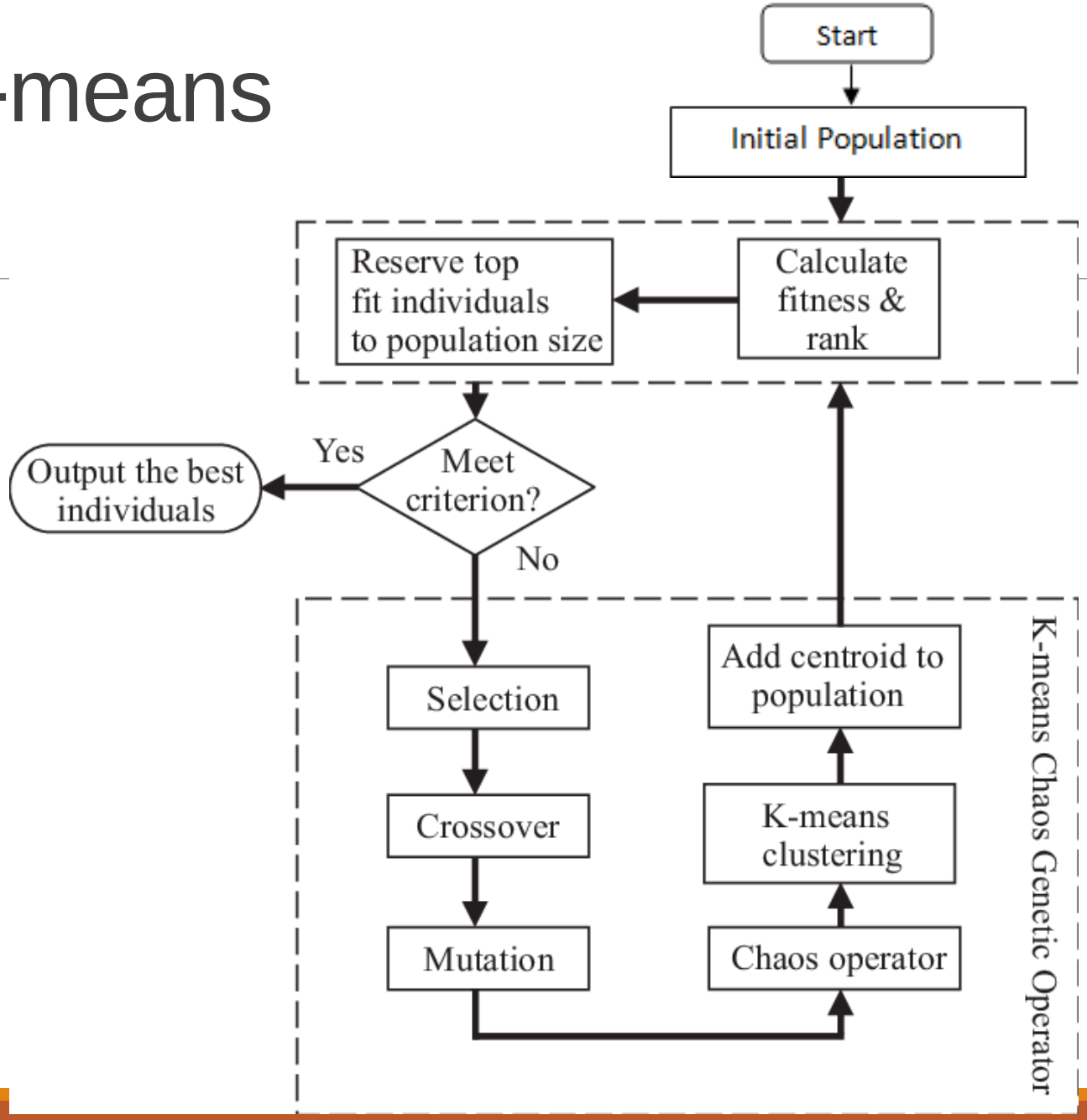
  Chromosome Structure

  { DEPOT – NODE1 – NODE2 – DEPOT – NODE3 – NODE4 – NODE5 - DEPOT}

- **Drawbacks:** Depends on selection of initial population, more time.

iii. Genetic k-means Algorithm:

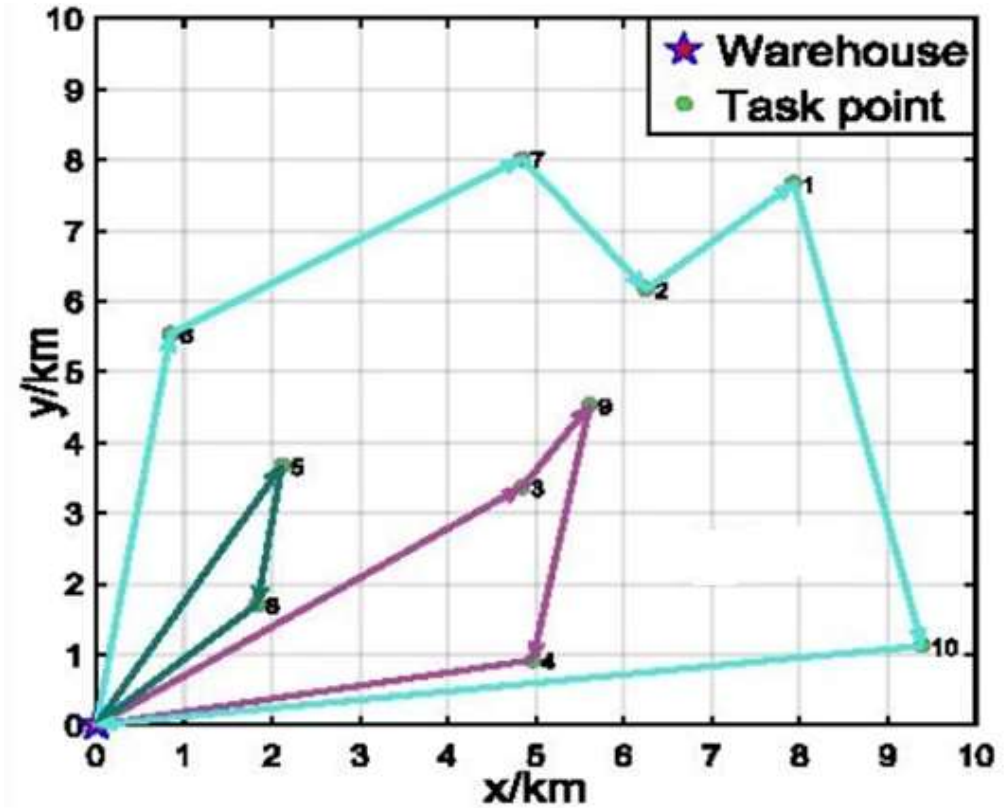
- Flow of process in algorithm →



iii. Genetic k-means Algorithm:

- Apply Sweep to order nodes radially.
- Each Vehicle traverses greedily to radially closest node and generates a route.
- Generate Population By Generating mutated versions of the found route.
- Select parents to cross based on fitness i.e. minimum route cost.
- Generate Children By Crossover and Mutation.
- Repeat Until all Nodes are covered.

iii. Genetic k-means Algorithm- Solution:



Distance covered – 956.27 units.

Comparison between GA1 and GA2:

Method	Genetic Algorithm	Genetic Algorithm with clustering
Implemented of code :	https://drive.google.com/file/d/1nGnYhkonRwJ9Z7DpRtzRo3fjnzwAHGNM/view?usp=sharing	https://drive.google.com/file/d/1_XswghcljgGF5JCMlNWm8NdWO54a5icP/view?usp=sharing
Optimal Number of vehicles :	3	5
Optimal distance travelled :	1702 units	956.27 units

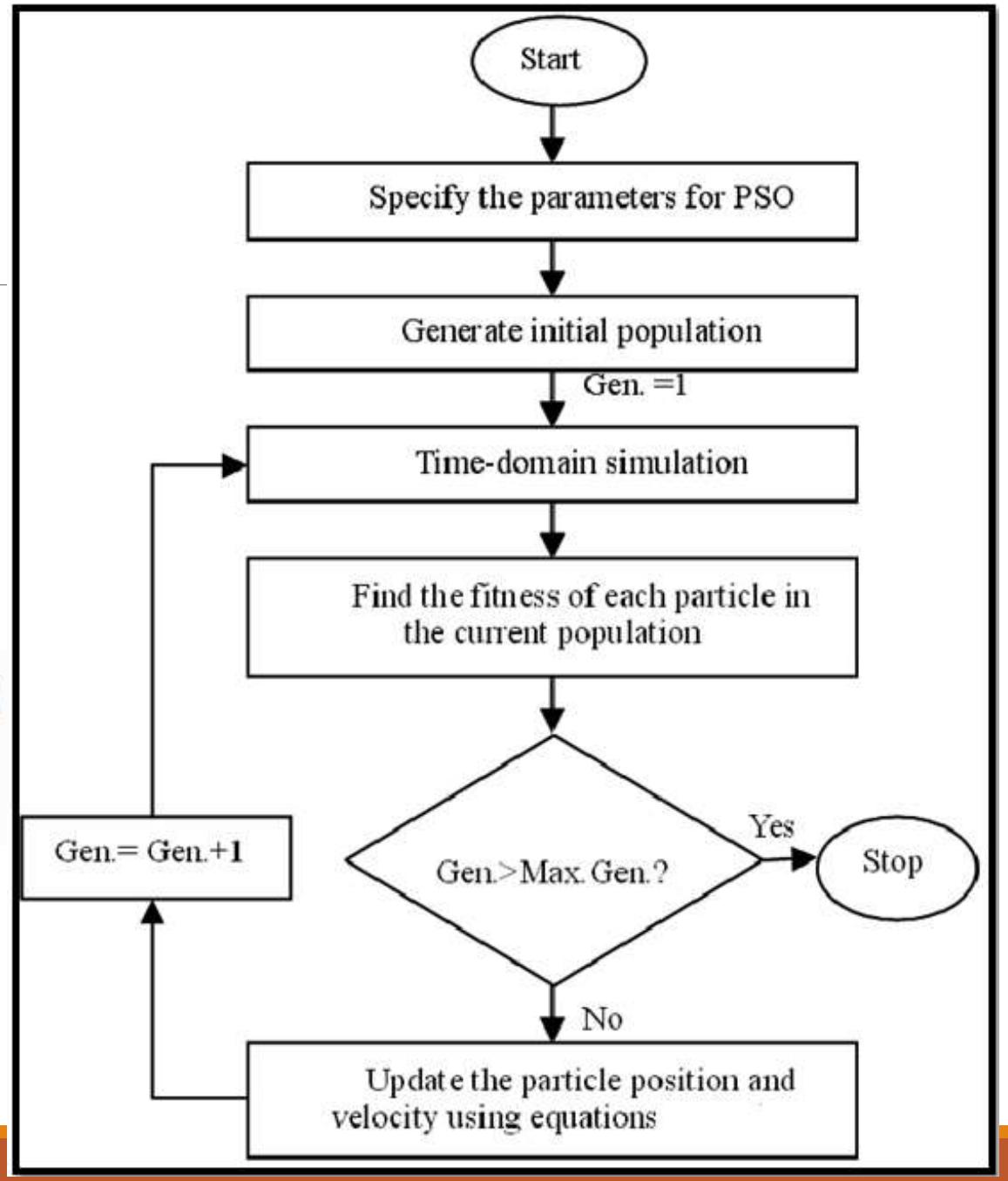
Data used: 36 nodes including depot -
https://drive.google.com/file/d/1mWdgVMsE04vh0MJN9mZeVbQFqhLuYkdm/view?usp=sharing

iv. Particle Swarm Optimization:

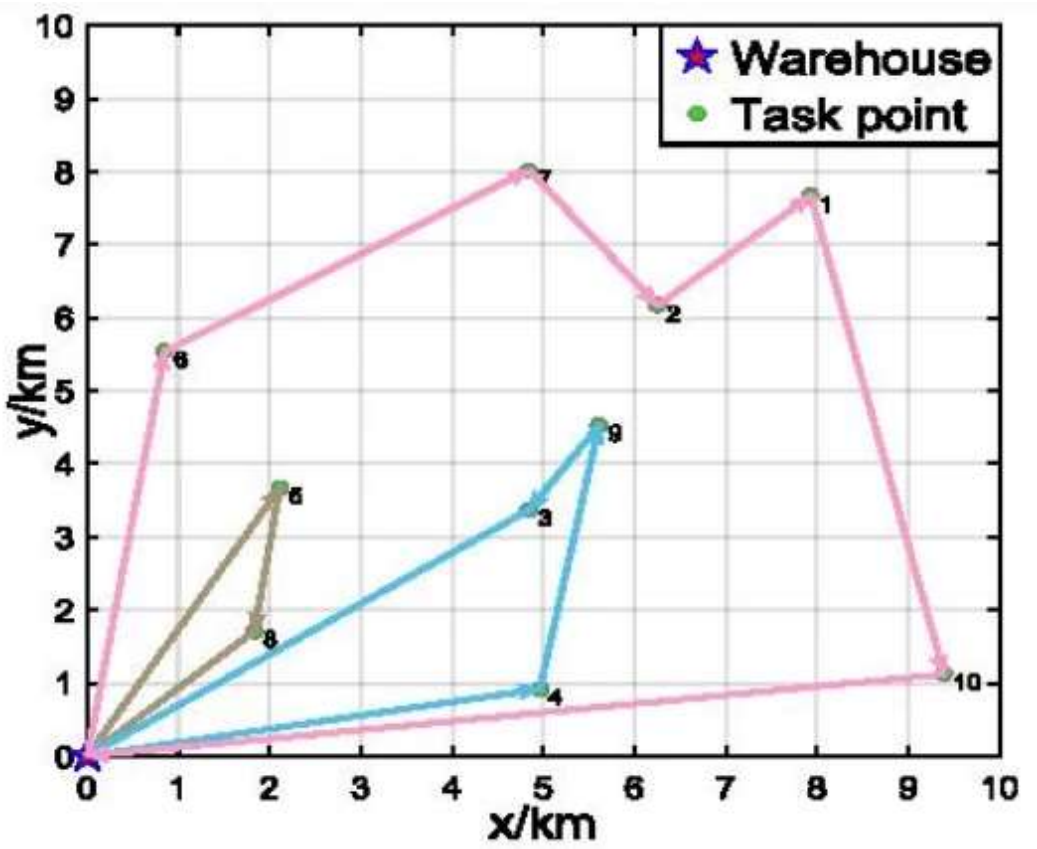
- Flow of process in algorithm →

$$v_i^k = \omega v_i^{k-1} + a_1 r_1 (Pbest_i - y_i^{k-1}) + a_2 r_2 (Gbest_i - y_i^{k-1})$$

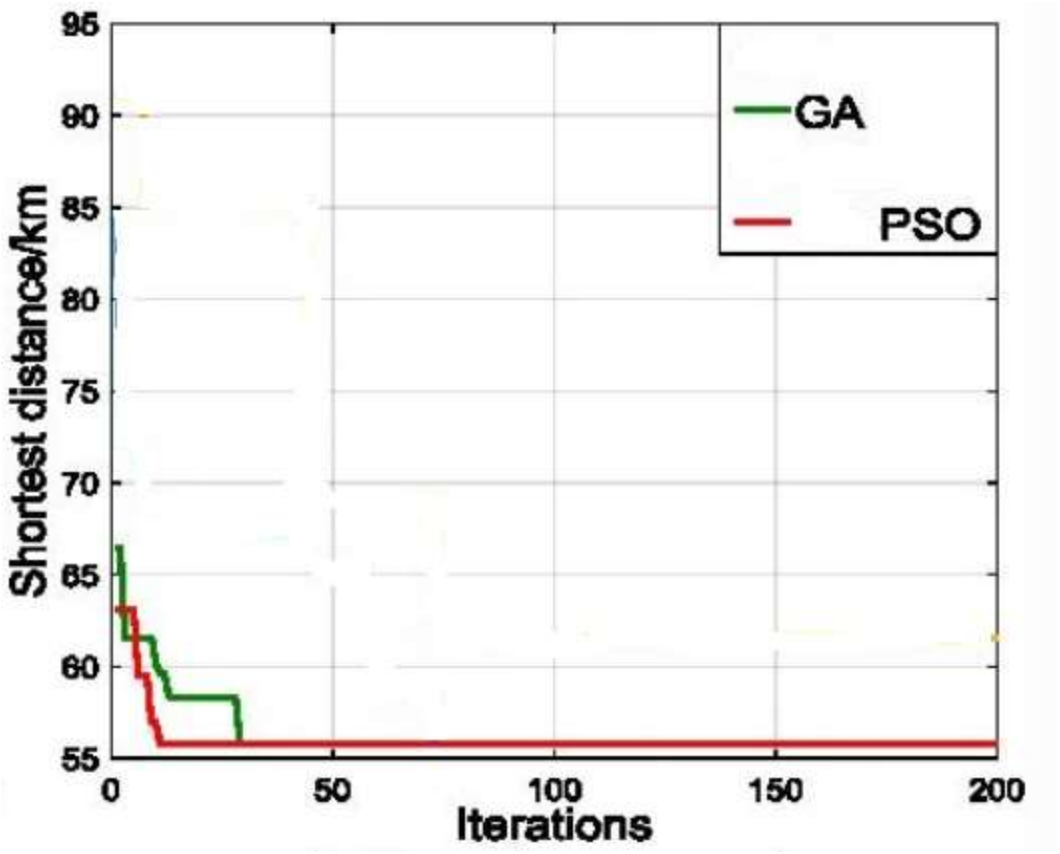
$$y_i^k = y_i^{k-1} + v_i^k$$



iii. Particle Swarm Optimization- Solution:



Comparison between GA and PSO:



Conclusion:

- Traditional approaches fail to scale efficiently for large datasets.
- Meta heurists like GA and PSO scale efficiently.
- When we want to dynamically update routes computational time matters.
- Search is needed almost everywhere at some stage.
- High exploration rate doesn't necessarily generate the best solution.
- GA when used with clustering give better optimal results.
- GA and PSO are widely used in real life applications for routing problems. Eg: Amazon delivery.

References:

- Ochelska-Mierzejewska, J.; Poniszewska-Mara ´nda, A.; Mara ´nda, W. Selected Genetic Algorithms for Vehicle Routing Problem Solving. Electronics 2021, 10, 3147. https://doi.org/10.3390/electronics10243147
- G. Clarke and J. Wright “Scheduling of vehicles from a central depot to a number of delivery points”, Operations Research, 12 #4, 568-581, 1964.
- M. L. Fisher and R. Jaikumar. “A Generalized Assignment Heuristic for Vehicle Routing”. Networks, 11:109-124, 1981.