Facility Location Problem with Python Implementation

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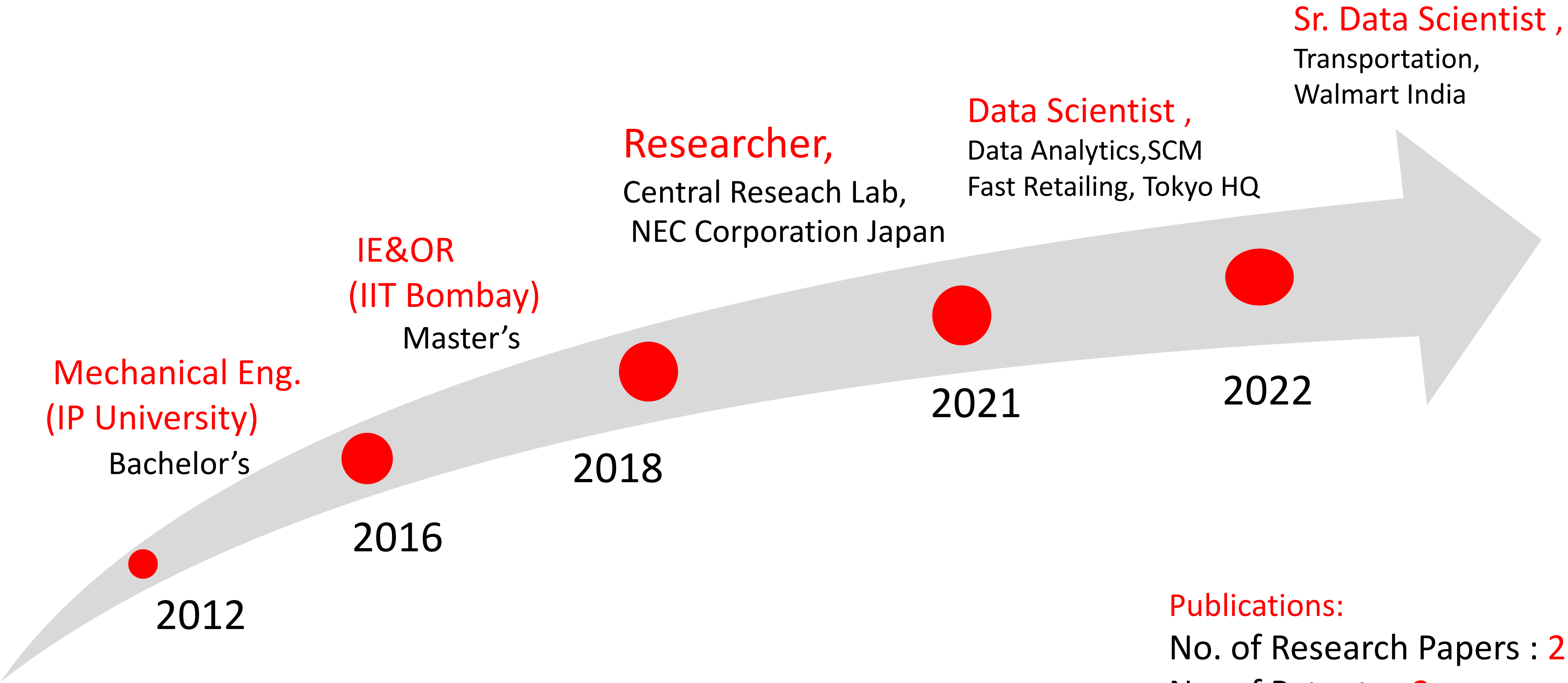
Career Overview



Publications:

No. of Research Papers : 2

No. of Patents : 2

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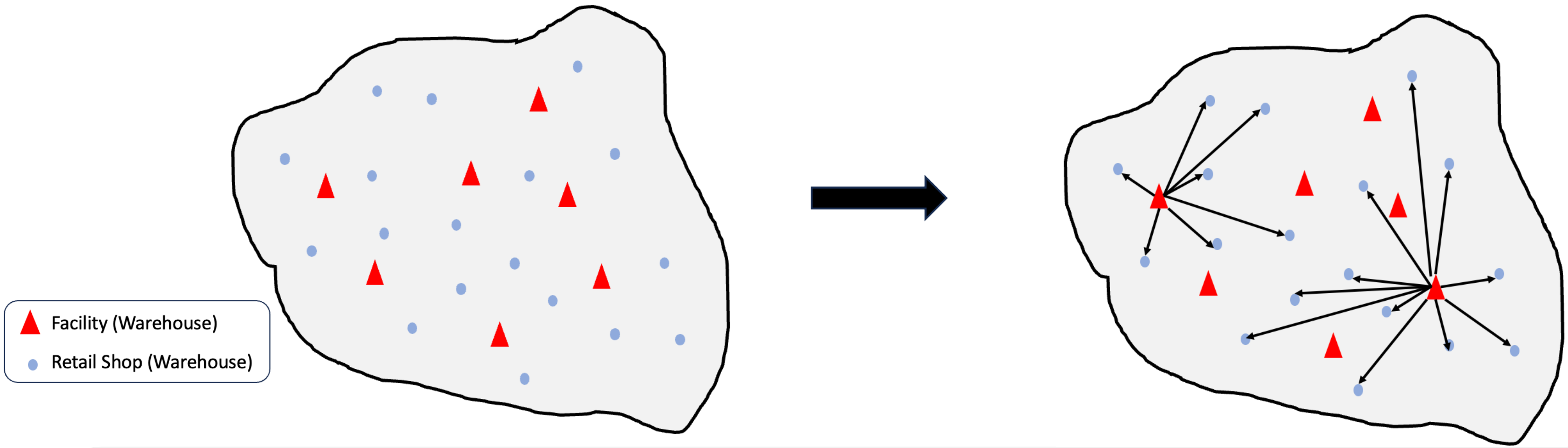
Introduction – Facility Location Problem (FLP)



Given

- ➢ Set of Retail Shops (with estimated Demands)
- ➢ Candidate Warehouse Locations with their capacity
- ➢ Transportation cost and Warehouse setup Cost

Objective

Choose the best among candidate Warehouses such that all

- ➢ Demand at each Retail shop is fulfilled
- ➢ Total cost is minimized

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How FLP is Optimization Problem?

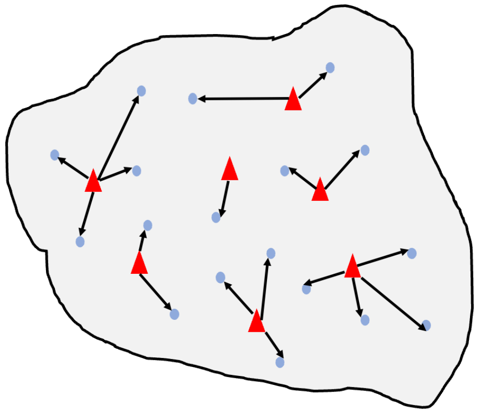
Objective?

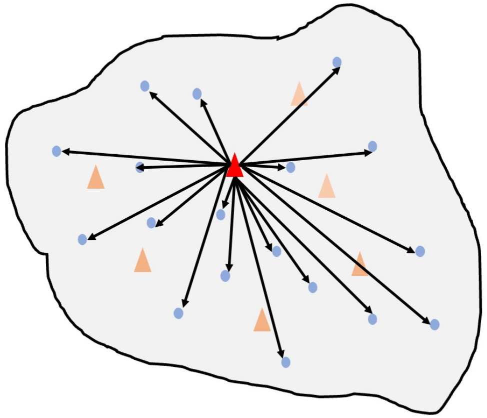
Minimize Cost

What is cost in FLP?

Transportation cost
(Warehouse to Retail Shop)

Warehouse setup cost





Is this the best Solution? **or** is this the best Solution?

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Mathematical Formulation

Data

- let I be the set of facilities and J be set of stores.
- $C_{i,j}$ is the transportation cost per unit from Facility i ϵ I to Store j ϵ J.
- F_i is the fixed cost for setting up facility i ϵ I.
- D_j be the demand at store j ϵ J.
- A_i be the capacity of facility i ϵ I.

Decision variable

- x_i is binary variable which is 1 if facility i is open, otherwise 0.
- $y_{i,j}$ is binary variable which is 1 if jth store demand is fulfilled by facilty i, otherwise 0.

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Mathematical Formulation

$$Minimize(\underbrace{\sum_{i \epsilon I} F_i.x_i}_{\text{Warehouse Setup Cost}} + \sum_{i \epsilon I, j \epsilon J} \underbrace{C_{i,j}.D_j.y_{i,j}}_{\text{Transportation Cost}})$$

$$\sum_i y_{i,j} = 1 \quad \forall j \epsilon J$$ → Demand constraints

$$\sum_j D_j.y_{i,j} \leq A_i \quad \forall i \epsilon I$$ → Capacity Constraints

$$y_{i,j} \leq x_i \quad \forall i \epsilon I$$ → Decision variable activation constraints

$$\sum_j y_{i,j} \leq M.x_i \quad \forall i \epsilon I$$ → Decision variable activation constraints

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Python Implementation

Problem 1

Stores j	1	2	3		
Demand D_j	270	250	160		
Facility i		$C_{i,j}$		F_i	A_i
1	4	5	6	1200	1000
2	6	4	3	800	1000

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Mathematical Modeling in Python

What do we need Model implementation?

1. A package to write LP Model (PuLP, Pyomo, docplex ..)

2. A Solver for LP Model (CPLEX, CBC, SCIP. ..)

Flow of Implementation

1. Define Data
2. Define Decision Variable
3. Write Constraints
4. Write objective function
5. Solve Model using solver
6. Display results

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Python Implementation

Problem 2 : E-commerce Inventory Placement

Data

# of WH = 10
# of Regions = 100

WH10_Region100_data

	Unnamed: 0	WH ID	Region ID	Cost	Demand	WH Cap	WH Setup Cost
0	0	502	5098	7.0760000000000000	1	935	1000
1	1	502	5126	7.0760000000000000	9	935	1000
2	2	502	5133	7.0760000000000000	1	935	1000
3	3	502	5135	7.0760000000000000	3	935	1000
4	4	502	5138	4.385	2	935	1000
5	5	502	5166	3.603741935483870	31	935	1000
6	6	502	5244	6.30333	2	935	1000
7	7	502	5246	6.30333	1	935	1000
8	8	502	5255	6.30333	4	935	1000
9	9	502	5269	4.347856666666670	66	935	1000
10	10	502	5272	4.790521785714290	28	935	1000
11	11	502	5280	6.89933	7	935	1000
12	12	502	5299	3.998665	4	935	1000

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Challenges in Real World Problem

1. Problem Size

   - Divide the problem into subproblems
   - Use Heuristics to solve some part of the problem

2. Cost function (unknown/non-linear)

   - Simplify non-linear cost function to linear function.

3. Additional Business constraints (shipping Capacities/ service Levels)

   - Understand additional constraints and either solve them in preprocessing / postprocessing or modify formulation

Thank you