Inter IIT tech meet 13.0

FedEx ULD Optimization

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Problem Overview

- **Objective**: Optimize packing for ULDs to reduce operational costs and improve efficiency.

- **Constraints**:
- Weight and volume limits for ULDs
- Prioritize shipping all high-value priority packages
- Minimize ULD count carrying priority packages

- **Output**: Optimal package-ULD assignments with minimized costs.

- **Important Metrics**:
- Total cost incurred
- Number of priority packages shipped successfully
- Efficiency in ULD space utilization

Approach Overview

- **Step 1**: Use Linear Programming (LP) to find a basic feasible solution respecting ULD constraints.

- **Step 2**: Apply Mixed-Integer Linear Programming (MILP) for precision, particularly for binary decisions (e.g., package-ULD assignments).

- **Step 3**: Enhance solution with Greedy Heuristic and Genetic Algorithm (GA) to improve packing and cost efficiency.

Objective in Linear Programming

- Cost of Spreading Priority Packages
- Cost of Packages Left Behind (Delay Cost)

$$\text{Minimize} \sum_{i \in P} c_i \cdot (1 - x_{i,u}) + K \cdot \sum_{u \in U} y_u$$

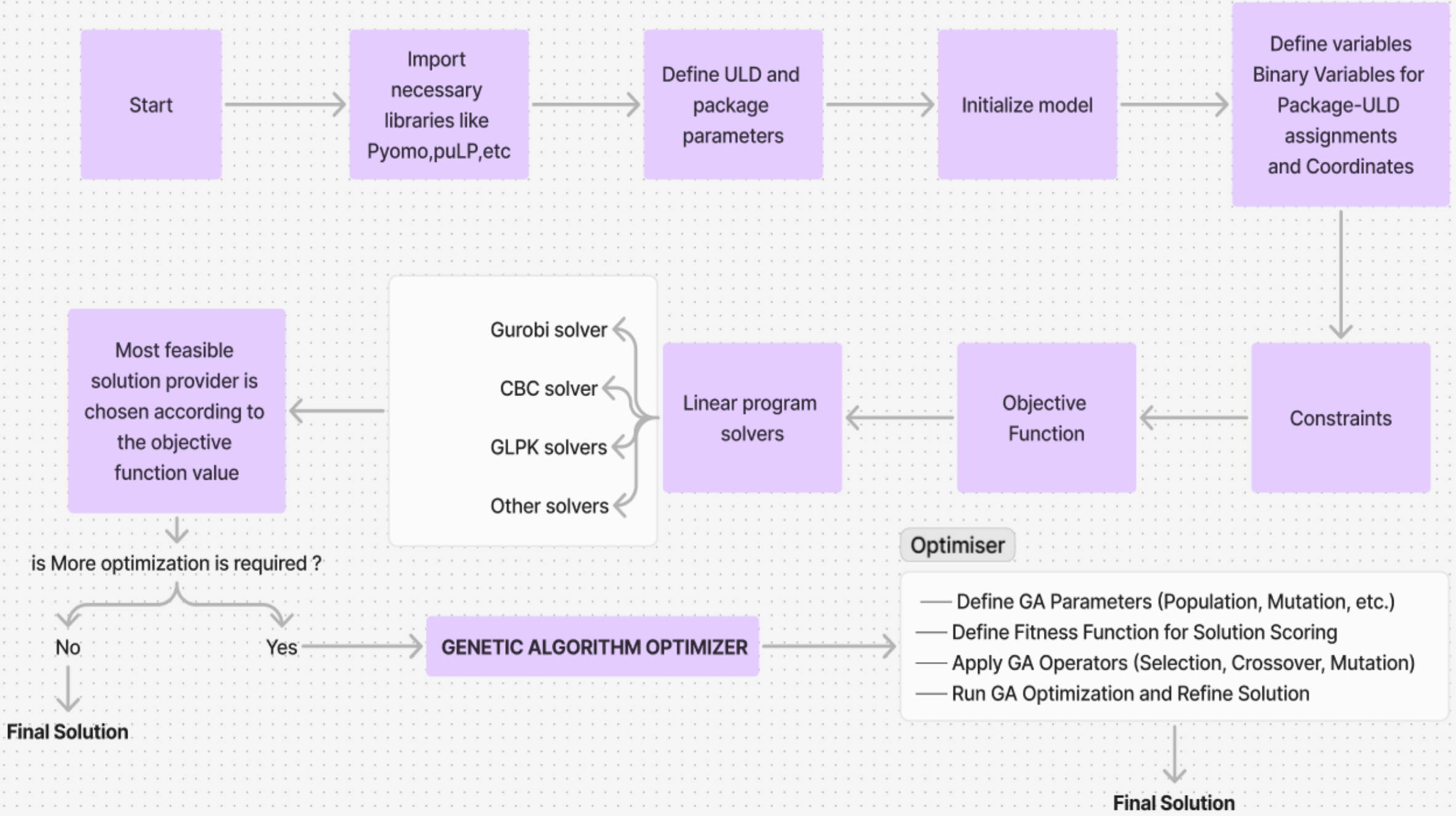
- xi, u is a binary variable that is 1 if package i is assigned to ULD u, and 0 otherwise.
- y_uis a binary variable that is 1 if ULD u contains any priority packages, and 0 otherwise.

Constraints

- Weight Constraint :

$$\sum_{i \in P} w_i \cdot x_{i,u} \leq W_u, \quad \forall u \in U$$

- Volume Constraint(according to coordinates)
  - →Varies when each package is put in the ULD
  - →(continuous updating of new available dimensions is necessary)
- Priority Constraint
- ULD priority order


Start
Import necessary libraries like Pyomo,puLP,etc
Define ULD and package parameters
Initialize model
Define variables Binary Variables for Package-ULD assignments and Coordinates
Constraints
Objective Function
Linear program solvers
Gurobi solver
CBC solver
GLPK solvers
Other solvers
Most feasible solution provider is chosen according to the objective function value
is More optimization is required ?
No
Final Solution
Yes
GENETIC ALGORITHM OPTIMIZER
Optimiser
Define GA Parameters (Population, Mutation, etc.)
Define Fitness Function for Solution Scoring
Apply GA Operators (Selection, Crossover, Mutation)
Run GA Optimization and Refine Solution
Final Solution

Enhance the Linear Programming Model

- Relax Constraints
- Tighter Bounds on Variables
- Use Column Generation

- **Hybrid Approach: Combine LP and GA**

  →Optimize GA Parameters
- Heuristic Initialization, Iterative Relaxation

Genetic Algorithm Enhancement

- **Purpose**: Refine the LP/MILP solution by exploring alternative package placements.

- **Steps**:
  - **Chromosome Representation**: Encode package-ULD assignments.
  - **Fitness Function**: Based on minimized cost and efficient ULD use.

- **Operations**: Selection, Crossover, and Mutation to optimize solutions iteratively.

Thank You

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