2025

Column Generation Algorithm: Optimizing Large-Scale LP & IP Problems

A Project Proposal for Crew Scheduling & Vehicle Routing

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Motivation: The need for Advanced optimization

Challenges:

- Growing Complexity
- Inefficiency Cost
- Traditional Methods Limitations
- Demand for Agility

Solution:

- Bridging the Gap
- Unlocking Efficiency
- Driving Innovation
- Real World Impact

Technologies Used & Project Summary

Languages or Tools to be used:

- Simplex Method
- Dual Problem
- Branch-and-Bound

Programming Language: C/C/++/JAVA
Libraries: IBM CPLEX Optimization Studio
Tools: Git, VS Code / Neovim
Platform: maCOS

Project Summary:

- Combines algorithmic research with practical optimization applications.
- Focus on operations research and logistics.

Project Overview: Column Generation Algorithm Large-Scale for & IP Problems

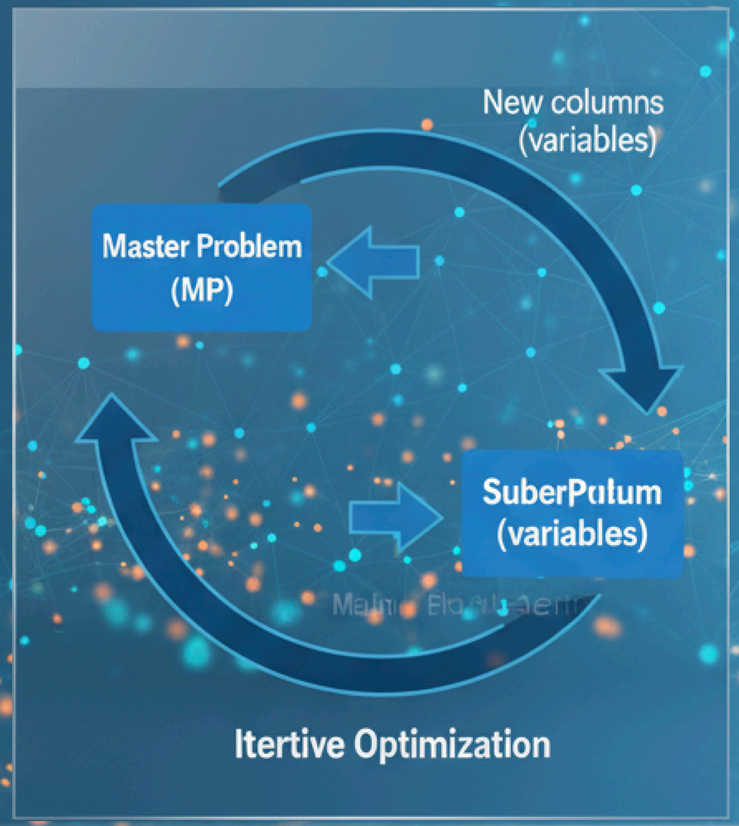
2025

Key Points:

- **Focus**: Implementing a Column Column Algorithm (CGA).
- **Application**: Solving large-scale (LP and Integer
- **Specific Problem Domains**: Crew Scheduling Problems (CSP) & Vehicle Routing Problems (VRP).

CGA Decomposition:

- **Master Problem** (**MP**): Formulated with a subset of variables.
- **Subproblem** (**SP**): Generates new variables (columns) with negative reduced cost to improve the MP solution.



Implementation Approach & Real-World Applications

Content:

- Simplex Method
- Dual Problem
- Branch-and-Bound (for integer constraints)

Real-World Modeling

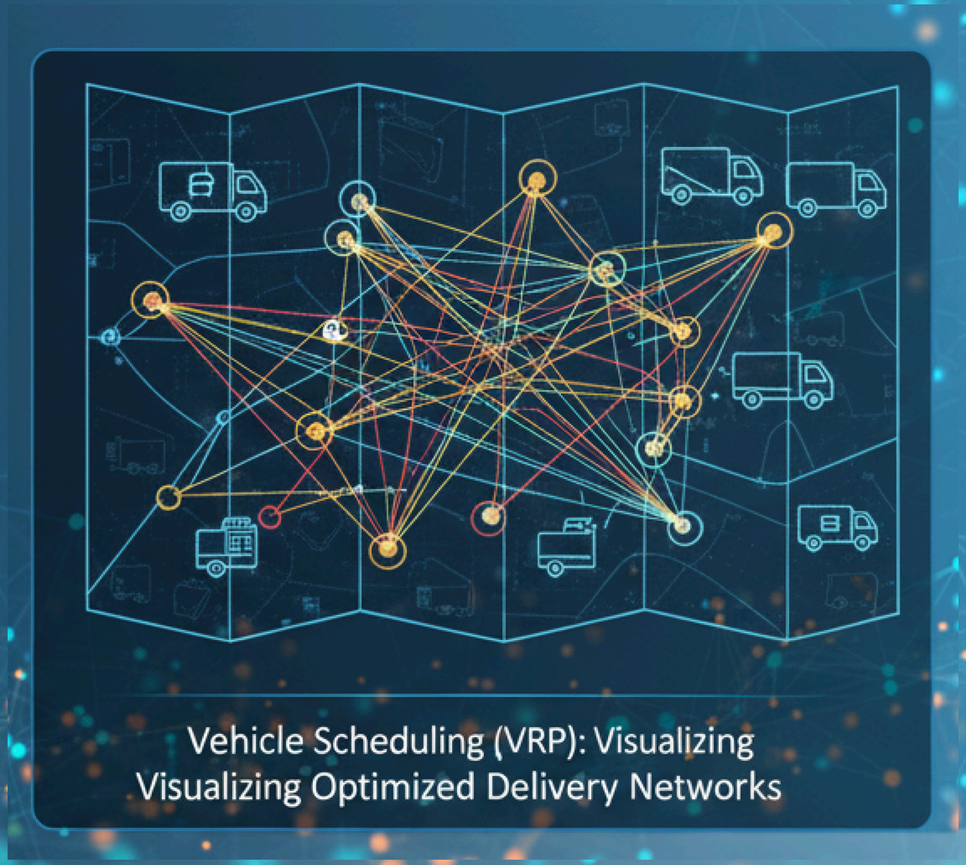
- Crew Scheduling Problem (CSP:Minimizing crew cost while ensuring trip coverage.
- Optimizing delivery routes to minimize total distance/cost.

Crew Scheduling Problem (CSP)

- **Definition**: Assigning crews (eg), airline, flight attendants to set scheduled tasks or trips.
- **Objective**: Minimize operational costs (salaries, overtime, layovers) while adhering complex regulations and labor rules.
- **Key Constraints**: Legal work-hour limits, rest periods, qualifications, base locations, and ensuring coverage's for all scheduled duties.
- **Challenges**: Large number of potential crew assignments leads to a massive search space.
- **Project Relevance**: Our Column Generation Algorithm is highly effective in solving large-scale CSPs, leading a significant cost savings and improved operational efficiency.

Vehicle Routing Problem (VRP)

- **Definition**: Optimizing delivery or service routes for a fleet of vehicles.
- **Objective**: Minimize total distance traveled, cost, or time.
- **Key Constraints**: Vehicle capacities, time windows, customer locations, and delivery priorities.
- **Relevance to Project**: Our Column Generation approach provide efficient method an efficient method for solving complex VRP instances, ensuring optmal logistics and resource allocation.



Vehicle Scheduling (VRP): Visualizing
Visualizing Optimized Delivery Networks

Thank you