OPTIMIZATION PROJECT

Presented by:

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Selected Research Paper:

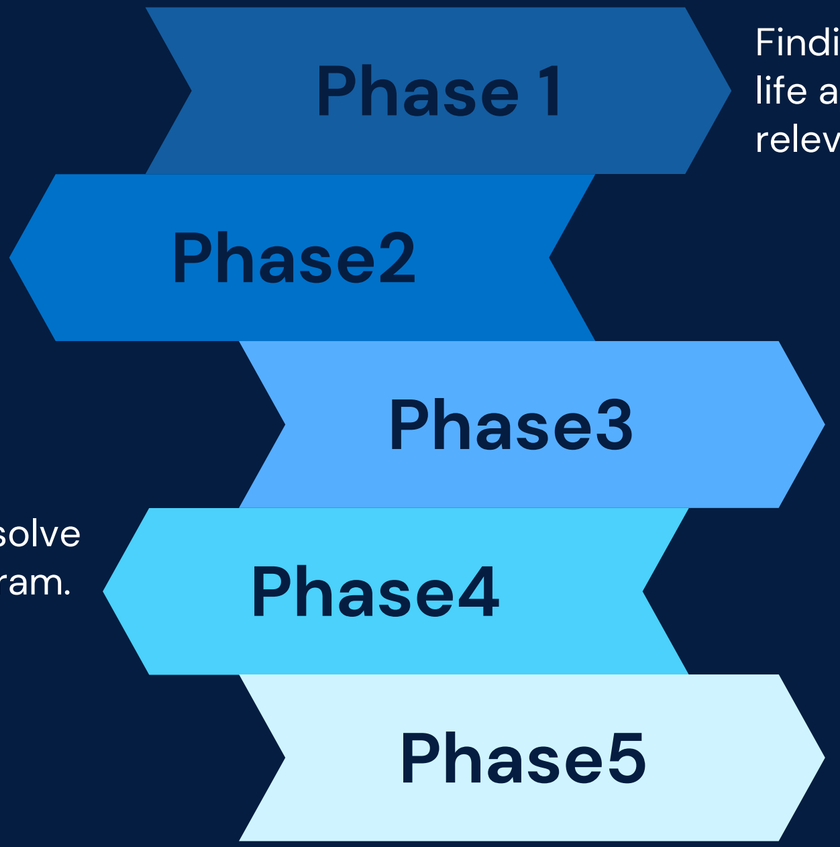
A Lagrangian Relaxation Method for an Online Decentralized Assignment of Electric Vehicles to Charging Stations

Journal: IEEE TRANSACTIONS ON SYSTEMS MAN, AND CYBERNETICS

Publish month: September 2023

Link to paper

Workflow



Finding research papers having real life application and simultaneously relevant to the course

Understanding the problem formulation, optimisation technique and algorithm in detail

Implementing the algorithm given in paper while solving the various ambiguities, and getting better results by putting some improvements into the algorithm

Using open source library to solve the linear program.

Comparing and visualising the results of both the algorithms on similar dataframes

PROBLEM

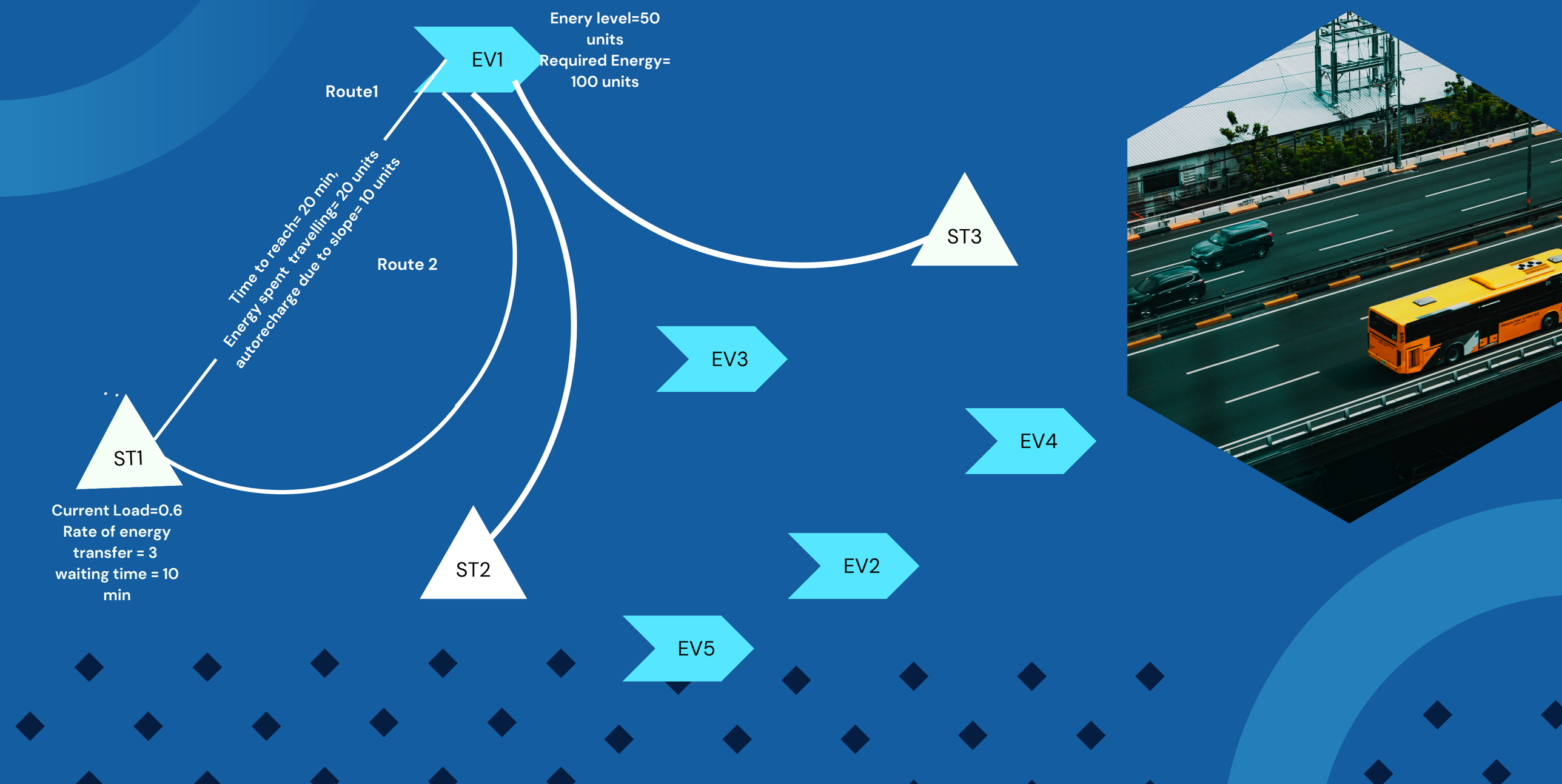
This project focuses on the critical problem of efficiently assigning electric vehicles to charging stations while minimizing their maximum completion time and achieving load balancing among stations.

01 The assignment problem is formulated as a linear integer programming problem.

02 The approach envisions a collaborative and decentralized interaction between electric vehicles and the charging infrastructure to effectively match supply and demand.

03 A Lagrangian relaxation heuristic is introduced to solve this problem, enabling each electric vehicle to select an optimal charging station

EV-STATION-ROUTE DIAGRAM



LANGRANGIAN RELAXATION HEURISTIC

Lagrangian relaxation heuristic refers to a more practical, approximate, or heuristic application of Lagrangian relaxation. Lagrangian relaxation is applied in a way that involves simplifications, approximations, or shortcuts to make the optimization process more computationally feasible

01 Primal problem- Minimize Cmax subject to constraints for finding optimal values of decision variables (assignment)

02 Applied Langrangian relaxation on few constraints and introduced Langrange multipliers (load)

03 Problem is divided into subproblems and each is solved independently by an EV, multipliers are updated

04 Iteratively these subproblems produce an assignment slowly converging to the optimal solution

ALGORITHM IMPLEMENTATION

PROBLEMS WE FACED

- The updation of waiting time and load (langrange multiplier) were ambiguous from the paper.
- Constant Cmax values at each iteration
- Completion time calculated being lower bound

SOLUTION AND IMPROVEMENT INTRODUCED

- As soon as an EV chooses a station, the load at the station is increased by a factor proportional to the completion time of the EV .
- `new_load = prev_load + prev_load* (CT_ev)/(CT_st)`
- Every assignment considers the updated load values, hence gives better assignment.

CODE

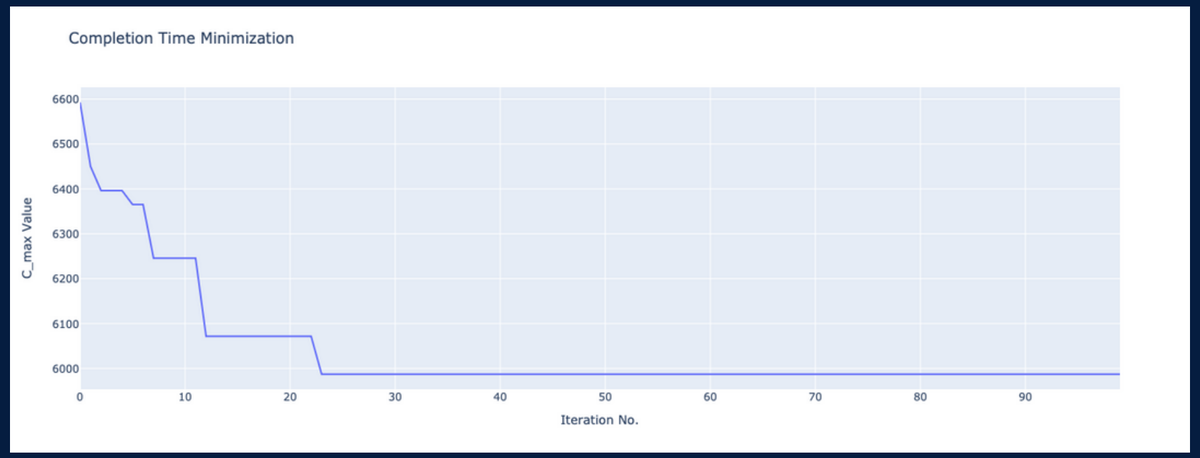
Details

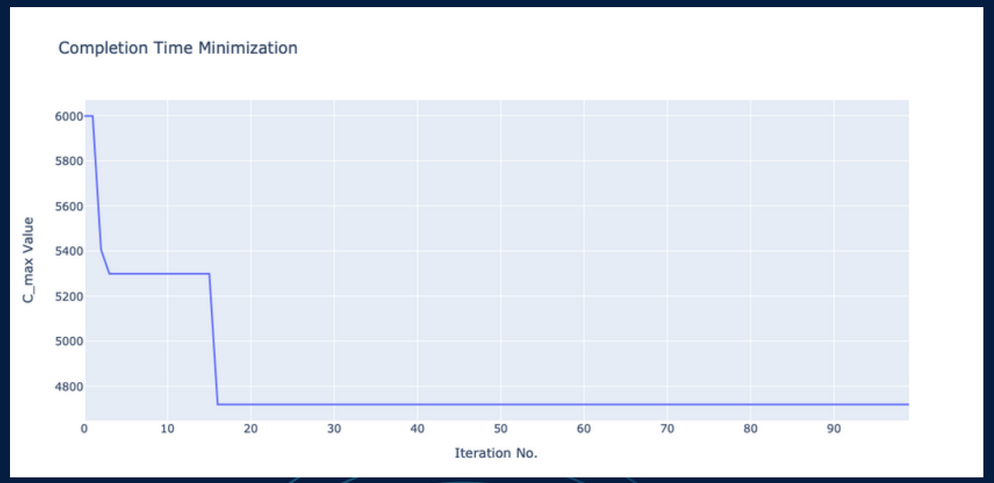
- Synthetic data creation
- Subproblem function
- Main algorithm
- Evaluation and Visualisation

Colab link

Results

CMAX VALUE VS ITERATIONS





EVALUATION METRICS

MAX_CT	5987.08
MIN_CT	1399.48
AVG_CT	2864.7
MAX_LOAD	1.0
MIN_LOAD	0.24
AVG_LOAD	0.48
CT_highestload-CT_lowestload	4587.59

LP SOLVER AND SIMPLEX

01

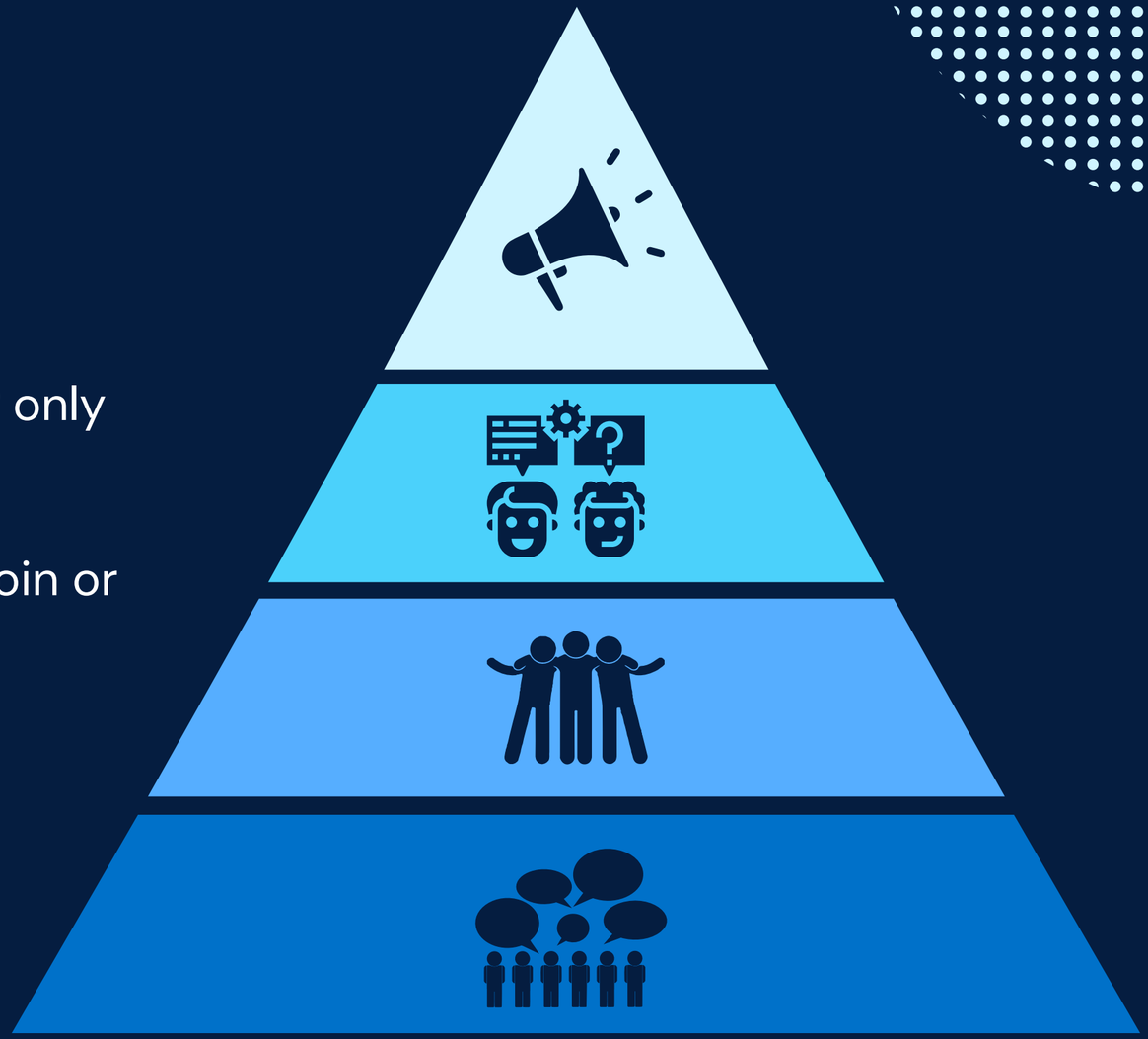
Formulated the research Problem as an LP.

02

Orignal Research Problem Focuses on both Assignment and Routing, but we applied LP only on the assignment Problem.

03

Made use of PulP library which calls CBC(Coin or Branch Cut). Makes use of Simplex for Minimization.



CODE

Details

- Synthetic data creation using assumptions for assignment problem.
- Subproblem function
- Usage of LP Solver
- Simulating Research paper Algorithm as Assignment Problem and Comparing Results.

Colab link

COMPARISON OF METRICS FOR ASSIGNMENT PROBLEM

SIMPLEX LP SOLVER

Minimum Maximum Com**pletion Time:** 183.40425

LAGRANGIAN HEURISTIC METHOD

Minimum Maximum Completion Time: 285.467189

POSSIBLE REASONS?

THANK YOU