OptiRoute - A Route Optimisation Web Application

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Abstract— Manual route planning is often inconsistent, time-consuming and resource-intensive, and thus unsuitable for smooth operations . This paper proposes a Route optimisation web application to improve and automate the route selection process. Through best routing APIs , this application leverages techniquesto generate most optimised path and provide it to the drivers , while maintaining accuracy and consistency. This web application is implemented using a React. js frontend, a Node. js and Express. js backend, and a MongoDB database, with seamless API integration for real-time route generation and handling multiple drivers and routes through single application .

Comparative analysis of the performance of the various approaches shows that algorithm based route optmisation can outperform human based plannings by 30% and it also leads to mileage cut by upto 20% leading to the lesser wastage of fuel . Apart from this most important thing that it improves is the accuracy of the drivers and better time management and planning of the organisations specially dealing with completely unknown areas of metropolitan cities . Also it is quite good dealing with routes with more stops and alternate paths .

These results offer exciting glimpse at the scope of this web application for transforming traditional evaluation methods into a reliable, efficient and efficient alternative for selection of efficient routes for small businesses .

Keywords— Route Optimisation, Path Evaluation, Route Algorithms, Web Technology, System Architecture.

I. INTRODUCTION

In today’s high paced enviornment , manually planning everything and then executing it is quite challenging specially when you are a small business owner and deciding your current day's workflow like number of vehicles , thier capacities and the locations where deliveries need to be made . In such a scenario our application can be proved quite beneficial because it provides you solution to all the problems mentioned just above . This application is able to handle all of these issuses affectively where routes for different capacity vehicles and their completion is marked accordingly with no worries and extra plannings .

The application system is built on a front-end driven by React. js, a Node. js/Express. js backend, and MongoDB for scale-out and live real time assessments. Unlike manual routing whichis likely tobe subjective[3], This application is more refined and accurate when dealing with unknown paths where driver's decision sometimes can be prone to human errors because of lot of hustle and tusle around the day managing different tasks [4].

Although there are many other options are available out there but those can be costly for small businesses and complex to operate also where drivers might not be habitual with dealing such softwares leading to wastage of time .

This is evident not only from this application , but also from other examples: the use of Automated algorithm based routing can help transform route selection and management problems : by combining automation with accountability, businesses will receive better equity and precision in their working, which are part of the paradigm shift toward data-driven working models [10].

II. RELATED WORK

Vehicle Routing Problem

This problems first appeared as the truck dispatching problem , in a paper by George Dantzig and John Ramser related to petrol deliveries.It generalises the travelling salesman problem , equivalent to requiring a single route to visit all locations. It has many direct applications claiming cost savings of 5% - 30% . Few of its objectives includes minimize the global transportation cost based on global distance travelled , minimize number of vehicles needed to serve all customers , least variation in travel time load , minimize penalties for low quality service and maximize a collected profit or score .

Capacitated Vehicle Routing Problem

Both manual and automated route planning come with their own pros and cons , and it's important to review all of them before you invest in a new system.One thing that is beneficial without a doubt is knowing your options. By default automated is better than manual routing because humans are prone to error and managing all things by yourself is not fruitful in long run and in scalable systems . Hence there will always be need of some reliable automated system to ease these complications at work for smoother conduct .

AI-Driven and Heuristic Optimization Approaches

This combines rules based methods and machine learning to analyze vast datasets for optimal routes . It works by processing large volumes of data including real time traffic , weather and delivery constraints to make intellgent decisions.The major advantages of it includes - routes can be adjusted in real-time dealing with unexpected events , other types of predictions can also be made , goals like cost,time and customer satisfaction are better managed and also it can handles a high number of routes and complex constraints .

Future Directions

Emerging trends in route optimization involves various things like machine learning , advance driver navigation tools , real time tracking mechanism and all of these will make routing platforms more advance and scalable presenting opportunities for enhancing capabilities of proposed system in future .

III. System Architecture and Methodology

MODULAR Architecture

This application is a collection of multiple modular components that together with each other act as platform for both the Student as well as the Teacher. At a high level the architecture consists of:

1. Authentication Module

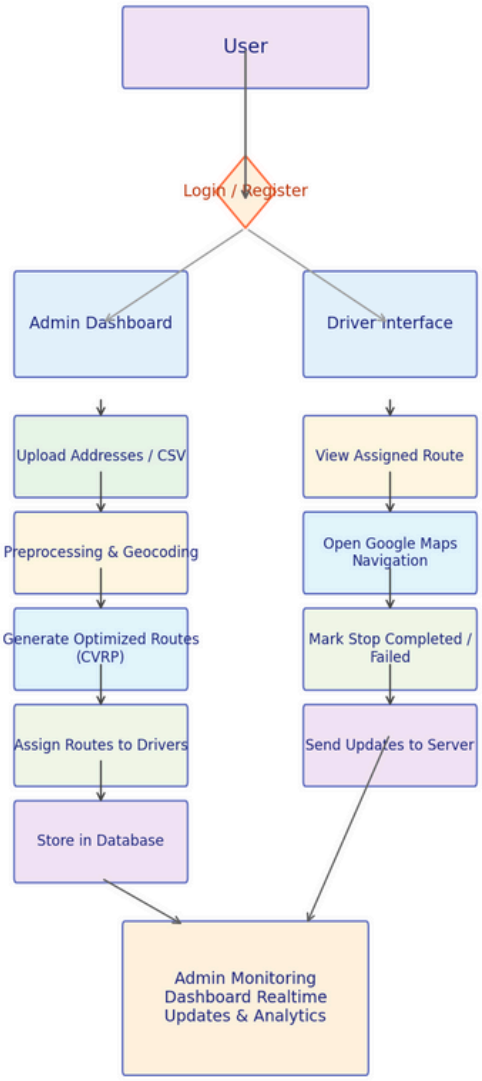
- *Pages:* Login and Register
- *Roles:* Admin and Drivers
- *Flow:*
  - On *Register*, users choose "Admin" or "Driver," supply basic info, and receive a JWT.
  - On *Login*, credentials are verified, and role-based access tokens are issued.

2. Admin Dashboard

Once authenticated, a Admin sees:

- Upload CSV/JSON
- Assign routes to the drivers

Figure 1. System UI Overview Diagram



3. Driver / Web Client

- Recieve assigned routes
- work with navigation links

4. Optimise Route Generation

- Core: CVRP problem formulation (nodes = customers with demands; vehicles = capacity-limited).
- Map solver routes to drivers/vehicles (respecting capacity, availability, and proximity)

5. Assignment and Dispatch Module

- Map solver routes to drivers/vehicles (respecting capacity, availability, and proximity)
- Admin may override automatic assignment. Send push notifications / SMS.

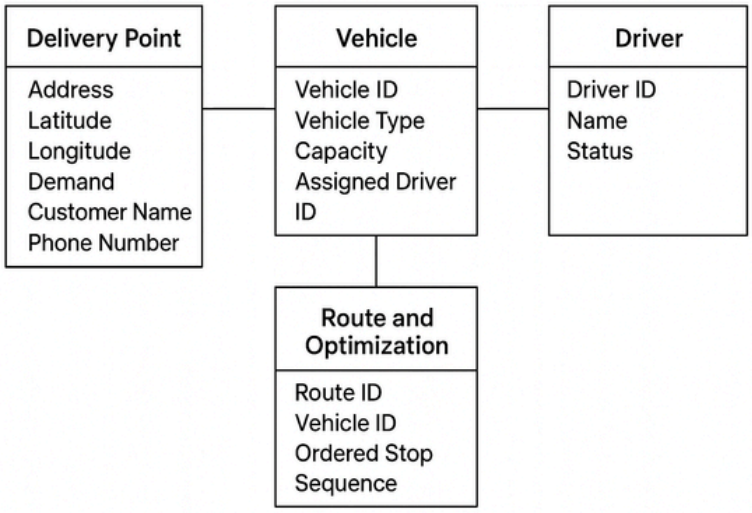
6. Data Storage (MongoDB)

Core Storage components

- User & Access Storage
- Vehicle & Fleet Information
- Delivery Point Storage
- Route & Optimization Storage

7. Dataset and Attributes

- Delivery Point Dataset
- Vehicle Dataset
- Route and Optimisation Dataset
- Driver Dataset



Data Flow Summary

1. Admin → Upload CSV/JSON with addresses & demands → Ingestion Service validates and returns errors/warnings.
2. Valid batch → Geocoding Service (batch) → Results cached in GeocodeCache.
3.Coordinates → Distance Matrix Service → Pairwise distances/times.
4. Optimization Orchestrator → Solve CVRP for each partition → Produce ordered routes (respecting vehicle capacities/time-windows).
5. Assignment → Dispatch to drivers (automatic/manual) → Notifications sent.
6. Driver executes route → Sends completion events & location pings → Realtime Engine streams to Admin Dashboard.
7. Completed routes → Persisted for analytics & exported reports.

IV. WORKFLOW

1. Role Initialisation and Authentication

User first sees the login/register interface and then authentication is done using JWT for the credentials . Upon successfully doing that you can choose the role .

2. Uploading Data and Preprocessing

The user upload the location informations using CSV/pdf files and then preprocessing is done like removing the duplicate coordinates and other important internal workings like reporting invalid entries .

3. Caching and Geocoding

Locations undergo geocoding using ORS apis and google maps and the outputs are then stored in cache for saving time and for fast usage .

4. Link Creation and Route Selection

\The optimized stop sequence is transformed into Google maps navigation links and stored in database with metadata like total distance/time and delivery assigned etc.

5. Driver Assignment

Drivers are assigned based on vehicle capacity , Driver availability and proximity and workload but admins may override these manually based on their usecase and after this drivers can see these assignments on thier interface.

6. Task Execution and Updates

Once seeing the tasks on thier dashboard , the drivers can hit the navigation link and follow the routes and can show completed , failed or delayed as per the scenario of the task going on . After the successful completion of the routes , we can store these records in routes logs also for the future usage and references.

V. Route Optimization Algorithms and APIs

The integration of algorithms and apis is very much important , crucial and also pivotal for this application as the main work that is the optimisation is done through this process and thing . This deals with architectural foundations and technological principles focusing on ORS - OpenRouteService and VROOM as central tools . By using advanced algorithmic approaches , these platforms contribute significantly to optimize delivery routes , improving utilization of resources , and ensuring timely deliveries in logistics operations .

The proposed algorithm to is based on CVRP and followed a structured multi-stage optimisation pipeline .First it dones input acquistion and raw addresses are normalised and converted into pecise geographic coordinates , then there is generation of distance-time matrix which is used as optimisation backbone , it basically constructs a cost matrix . After this , constraint formulation is done with the goal Minimize $\sum C(i,j)$ subject to capacity constraints , vehicle route continuity and other constraints. After this Optimisation using heuristic solver comes into picture which internally performs multi-steps to deliver a fully optimis

In conclusion , both of the ORS and VROOM both are very good specially when their comparative strengths and regional adoption trends of both further underscore their relevance in modern ecosystems particularly in high demand markets such Asia-Pacific.

Comparison of ORS and VROOM Efficiency and Features

Feature	OpenRouteService (ORS)	VROOM
Algorithm Type	Graph-based routing	Metaheuristic optimization
Primary Use Case	General route planning and navigation	Delivery and logistics optimization
API Accessibility	Open and widely documented	Specialized, requires integration
Efficiency in Large-Scale Delivery Routes	Moderate	High
Popularity in Asia-Pacific (2020-2023)	Growing	Significant

Data Source: Google Search

VI. IMPLEMENTATION

1. Backend Implementation

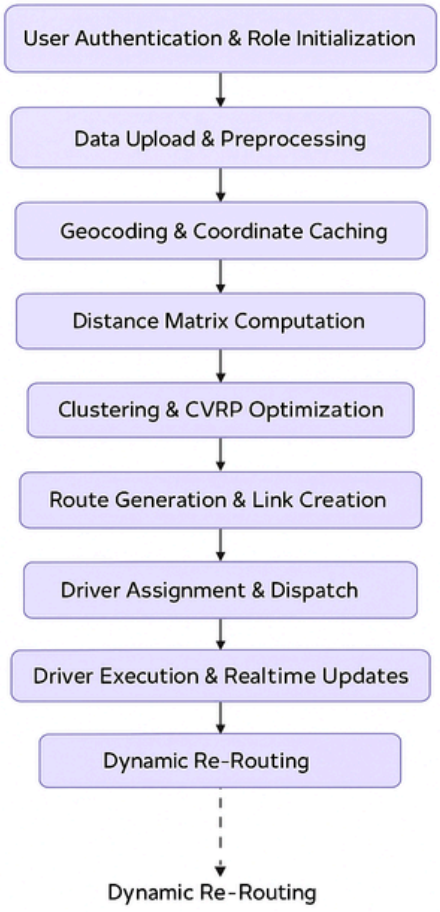
The backend is implemented using Node.js and Express.js , which manages core of the operations and well structured RESTful APIs. Major Backend parts includes JWT based authentication , upload and validaton of delivery points using csv files , geocoding and caching , route optimization using CVRP and driver assignment and dispact and updates and event loggings .

2. Frontend Implementation

The frontend is implemented using React.js enabling modular and responsive interface built using reusable components . It is quite fast and reliable .

3. Database Management

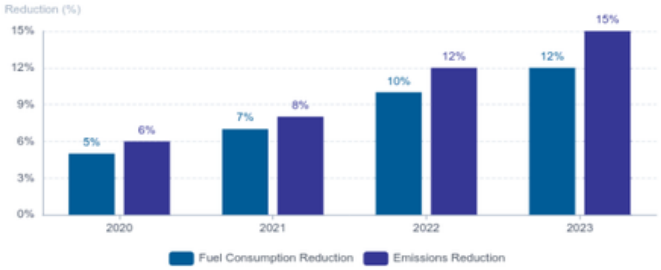
All of our data is stored in MongoDB , which is very good dealing with flexible schema design and high query performance . Data is organized into collections including User data , vehicles , drivers and operational things , Delivery points , Generated routes , Real time events , cached geocoding entries etc.

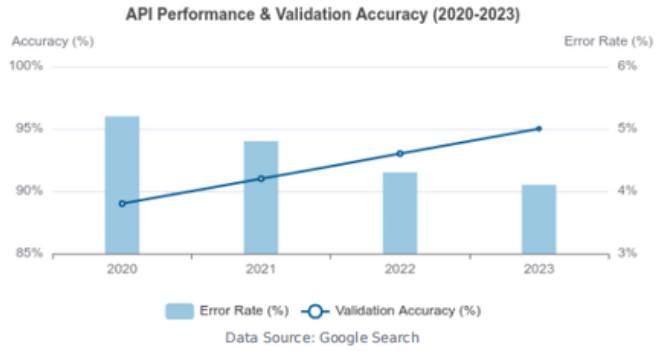


VII. RESULTS & DISCUSSION

Efficiency Analysis

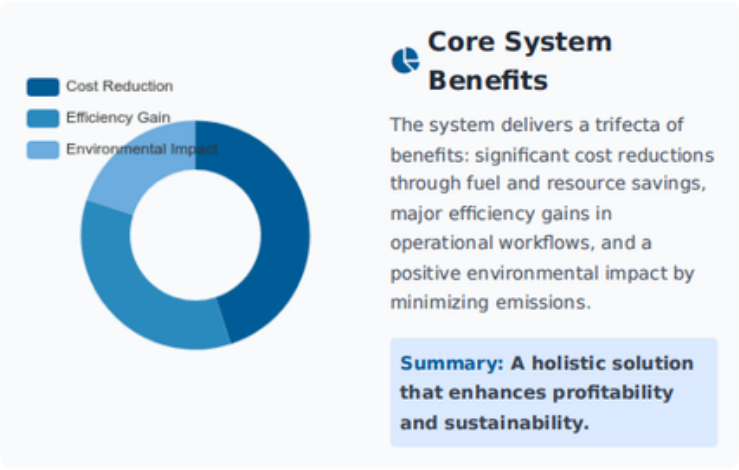
There are great results when it comes to efficience analysis of this application . The range in which there is reduction of fuel and distance is typically in the range of 10-25% , reduction in time is in the range of 10-15% and as expected there is reduction in cost which is what small businesses are concerned with eventually .

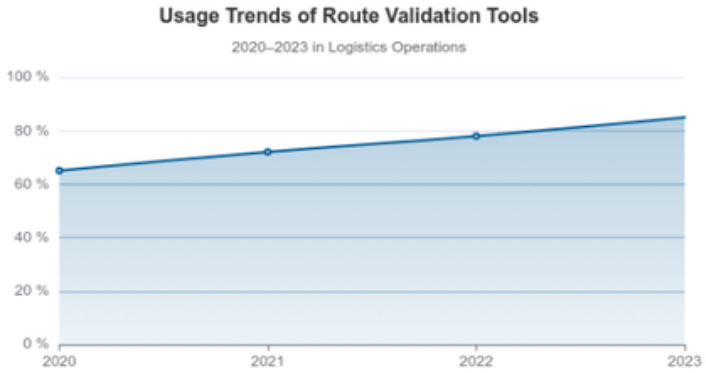




Discussion of Implications and Limitations

This application shows strong potential to improve operational efficiency , especially for small businesses that deals with delivery of things like we can see around us a very popular start up Delhivery or other such businesses . By automating route sequencing , managing vehicle capacities and enabling updates into a single easy to use application we can tremendously improve time and resource management and have cost reductions . The limitations are also there to be pointed out like giving invalid inputs like incorrect location coordinates or missing traffic information or other such small issues like incorrect addresses can degrade the performance of the optimization quality. Also depending on external geocoding or mapping services may affect cost , performance or data privacy which is the most important thing in today's world where data security is the biggest concern.





VIII. CONCLUSION

This research presented the design and implementation of a route optimisation system that integrates algorithms and APIs to generate a optimised routes for the drivers and small business solving a capacitated vehicle routing problem . This system automates the traditional way of delivery of the vehicles where everything is done manually form planning to execution which is very time consuming and highly prone to human errors which are bound to happen when dealing with complex tasks and routes simultaneously .

The developed application demonstrates that modern routing algorithms with great interface and data flow happening in real time can do wonders enhancing logistics without requiring complex infrastructure or specialized expertise on the user's part .

Overall , the work validates the importance and usefulness of merging CVRP based optimisation into everyday workflow of delivery based small businesses. Future developments may extend the system with dynamic re-routing , predictive traffic modelling , machine learning and large data to also take into account the terrain and weather conditions , mountain mapping roads where small things can lead to many consequences and operational intelligence in real world logistics envriornments.

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