RV COLLEGE OF ENGINEERING

DEPARTEMENT OF INDUSTRIAL ENGINEERING AND MANAGEMENT

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Project Based Learning

IM3621A – SUPPLY CHAIN MANAGEMENT

ADILOPS

Modular Logistics and Supply Chain Operating System

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CERTIFICATE

This is to certify that the project work titled **"ADILOPS – MODULAR LOGISTICS AND SUPPLY CHAIN OPERATING SYSTEM"** carried out by **Adil Shani (1RV22IM004), Aarsh Bajaj (1RV21IM006),** in partial fulfilment of the requirements of the **Supply Chain Management** course (**IM3621A**) introduced in the curriculum during the **[2024-2025]**, has been completed successfully. It is further certified that all necessary corrections and suggestions indicated during internal assessments have been duly incorporated into the final report.

The project work has been evaluated and approved as it meets the academic standards and experiential learning objectives of the Ergonomics Laboratory as prescribed by the institution.

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ABSTRACT

In today's highly competitive logistics and supply chain environment, efficient route optimization is critical to reducing delivery times, minimizing transportation costs, and improving overall service levels. Traditional manual route planning often leads to higher operational costs, underutilized fleets, and delays that impact customer satisfaction. To address this, the present project implements an open-source logistics management system — AdilOps — as a practical platform to demonstrate how modern fleet operations can be streamlined through intelligent routing and dispatching.

The primary objective of this project is to apply well-known pathfinding algorithms such as Dijkstra's and A* to solve shortest-path problems in last-mile delivery scenarios. Additionally, the Vehicle Routing Problem (VRP) is incorporated to optimize fleet assignments, delivery schedules, and route clustering. The project focuses on integrating realtime tracking, role-based access control, and modular extensions to create a flexible and scalable logistics solution.

The methodology involves setting up the AdilOps Console and API, configuring user roles, creating fleets and orders, and implementing algorithm-based routing logic to simulate dynamic dispatching. Performance metrics such as fuel cost reduction, delivery time savings, and route efficiency are analyzed to assess the system's effectiveness.

Key findings demonstrate that intelligent route planning and automated scheduling can significantly reduce operational costs and delivery delays while maximizing fleet utilization. The project successfully connects theoretical supply chain concepts like network design, inventory planning, and transportation trade-offs with real-world software implementation.

Future scope includes integrating predictive analytics, IoT sensor data, and AI-based dynamic rerouting to enhance decision-making and resilience in complex logistics networks. This lays the foundation for smarter, more agile supply chains aligned with modern Logistics 4.0 principles.

CHAPTER 1 : INTRODUCTION

Efficient logistics management is a critical factor for competitive advantage in modern supply chains. Companies face increasing challenges in meeting customer demands for faster deliveries while minimizing operational costs and maximizing fleet utilization. Manual route planning and traditional dispatch systems often fail to deliver the flexibility and speed needed in dynamic environments.

This project leverages AdilOps, an open-source logistics platform, to implement automated route optimization and real-time fleet tracking. By applying routing algorithms like Dijkstra's and A* and solving the Vehicle Routing Problem (VRP), the project demonstrates how digital tools can streamline last-mile delivery operations, reduce transportation costs, and enhance supply chain responsiveness. The work aligns with core supply chain management principles, bridging theoretical concepts with practical, real-world logistics solutions.

1.1 Background of the Work

In the digital era, supply chains have evolved into complex, interconnected networks that rely heavily on accurate, timely information and seamless coordination across stakeholders. With rising urbanization and e-commerce growth, the demand for effective last-mile delivery solutions has intensified, pushing companies to adopt innovative technologies for fleet management, routing, and scheduling.

Traditional logistics systems often use static routing plans that fail to adapt to real-time changes such as traffic conditions, delivery delays, or sudden order surges. This lack of agility contributes to higher fuel consumption, suboptimal fleet use, missed delivery windows, and customer dissatisfaction. To overcome these inefficiencies, many modern logistics operators are turning to algorithm-based routing, real-time tracking, and digital dispatch platforms.

AdilOps, an open-source modular logistics operating system, embodies this shift. It integrates technologies like Ember.js for the user interface and Laravel for API services, providing a flexible framework to manage fleets, orders, and routes dynamically. By implementing routing algorithms like Dijkstra's and A*, businesses can calculate the shortest and most cost-effective paths between multiple stops. Similarly, solving the Vehicle Routing Problem (VRP) allows dispatchers to optimize which vehicle delivers which order, minimizing total travel time and cost.

This project builds on this background to simulate a real-world scenario where students can configure fleets, generate optimized routes, dispatch drivers, and monitor deliveries in realtime — connecting supply chain theory with practical, hands-on technology skills.

1.2 SCM Standards Used

The project directly applies key principles and techniques from Supply Chain Management (SCM), focusing on distribution network design, transportation planning, and inventory coordination. In line with SCM best practices, the project models a digital logistics network where fleets, hubs, delivery points, and routes interact in an integrated, data-driven system.

By solving the Vehicle Routing Problem (VRP), the project aligns with network optimization models covered in SCM to minimize total transportation costs and delivery times. The use of cycle inventory and safety stock concepts demonstrates how proper planning can buffer against delays and supply uncertainties.

Additionally, real-time fleet tracking and order status updates illustrate supply chain coordination and help reduce the bullwhip effect by providing accurate, up-to-date information across the chain. The system's modular architecture and use of APIs enable scalability, allowing businesses to expand fleet operations without disrupting existing workflows.

Overall, the AdilOps platform serves as a practical example of how digital SCM solutions can automate routine logistics tasks, improve delivery reliability, and optimize resource allocation — all key goals in modern supply chain management. This ensures students gain not only algorithmic skills but also an understanding of how technology drives smarter, more agile supply chains.

1.3 Problem Definition

Modern supply chains face significant challenges in managing last-mile deliveries, which often account for the highest share of total transportation costs and the greatest variability in service levels. Traditional dispatching and routing rely on static plans that do not adapt well to real-time events like traffic congestion, sudden order spikes, or route disruptions. This results in inefficient fleet utilization, longer delivery times, increased fuel consumption, and higher operational costs.

The lack of integrated, dynamic routing and dispatching tools also makes it difficult for logistics managers to balance multiple constraints — such as driver schedules, vehicle capacities, delivery windows, and fuel efficiency. Furthermore, poor visibility and coordination among stakeholders can amplify the bullwhip effect, causing delays and inventory imbalances across the supply chain.

This project aims to address these problems by implementing a digital, algorithm-driven routing system using AdilOps. By applying pathfinding algorithms like Dijkstra's and A*, the system calculates optimal delivery routes. Solving the Vehicle Routing Problem (VRP) further optimizes fleet assignments and delivery clusters, ensuring that vehicles cover the shortest possible distances with maximum load efficiency.

In essence, this work demonstrates how real-time routing, dynamic dispatching, and supply chain coordination can solve common last-mile logistics problems, ultimately improving customer satisfaction while reducing transportation costs and environmental impact.

1.4 Objective

1. To implement pathfinding algorithms (Dijkstra's, A*) for generating shortest and most cost-effective delivery routes.

2. To solve the Vehicle Routing Problem (VRP) for optimized fleet scheduling and order clustering.

3. To demonstrate real-time fleet tracking and dispatching using the AdilOps Console and API.

4. To analyze how algorithm-based routing reduces transportation costs, fuel consumption, and delivery time.

5. To connect core SCM concepts such as network design, transportation planning, and supply chain coordination with practical, hands-on application.

6. To equip students with practical skills in algorithm implementation, cost-benefit analysis, and digital logistics management.

CHAPTER 2: LITERATURE REVIEW

2.1 Büyüközkan, G., & Göçer, F. (2020). Digital supply chain

This paper reviews the evolution of digital supply chains and proposes a structured framework for future research. Using a comprehensive literature analysis, it categorizes technologies and strategies driving digital transformation, such as IoT, big data, and integrated IT systems. The study highlights the importance of real-time data flow, automation, and collaboration for modern logistics efficiency. Its findings are relevant to AdilOps as they emphasize how digital platforms and data-driven decision-making can optimize operations and reduce inefficiencies — directly aligning with your project's use of live tracking, API integration, and modular routing tools for smart supply chain management.

2.2 Nilisetty (2025), Smart logistics and fleet management with eventdriven microservices

This recent work focuses on smart logistics using event-driven microservices, a method highly relevant to AdilOps's modular API architecture. The paper models fleet management scenarios where real-time data streams and microservices enable dynamic routing and automated dispatch. Findings show significant improvements in delivery reliability and fleet utilization. Methods include simulation of routing under changing conditions and integration with live location feeds. This directly supports your project's goals of applying algorithms like Dijkstra's and solving VRP problems within a real-time, scalable system, demonstrating how modern tech can tackle traditional last-mile challenges.

2.3 Xu, He & Li (2021), Internet of Things in industries

This survey paper examines how the Internet of Things (IoT) transforms industrial operations, including logistics and fleet tracking. It reviews various IoT architectures, wireless sensor networks, and integration methods for real-time asset monitoring. Key findings highlight how IoT enables precise fleet tracking, predictive maintenance, and datadriven routing decisions. The paper's methods include an extensive literature review and industry case studies. Its relevance to AdilOps lies in showing how real-time location and condition data can feed into routing algorithms to optimize delivery paths, reduce downtime, and enhance supply chain visibility.

2.4 Crainic & Laporte (2022), Planning models for freight transportation

This foundational paper presents mathematical models for planning freight transportation networks. Using operations research methods, it discusses linear programming, heuristic routing, and cost-optimization algorithms for large-scale transport systems. The study shows how structured modeling reduces transportation costs and improves delivery efficiency. Its classic frameworks support the VRP methods used in your project, providing a strong theoretical basis for solving routing and scheduling problems in multi-vehicle, multi-stop scenarios — exactly what AdilOps implements with its modular route planners.

2.5 Wang, Y., Gunasekaran, A., Ngai, E. W. T., & Papadopoulos, T. (2023), Big data analytics in logistics and supply chain management

This paper explores the role of big data analytics in supply chain and logistics management. Using literature synthesis and industry examples, it outlines methods for demand forecasting, inventory control, and route optimization using real-time analytics. Findings show that integrating big data leads to better routing decisions, reduced delays, and cost savings. The work highlights the importance of dynamic data streams — directly relevant to AdilOps's real-time dispatching and live route recalculations. It supports your project's use of algorithms that rely on up-to-date fleet and traffic data.

2.6 Dantzig & Ramser (2021), The Truck Dispatching Problem.

This pioneering paper introduced the Vehicle Routing Problem (VRP) by developing mathematical models to optimize truck dispatching for fuel deliveries. It uses linear programming and heuristic techniques to assign routes that minimize travel distance while respecting vehicle capacity limits. The study laid the groundwork for countless modern routing algorithms. Its relevance is fundamental to your project: AdilOps's route optimization logic builds directly on VRP principles to plan multi-stop, multi-vehicle deliveries efficiently — demonstrating how classical methods still underpin modern digital fleet management.

2.7 Toth, P., & Vigo, D. (2019), Vehicle routing

This comprehensive book reviews VRP methods, including exact algorithms, heuristics, metaheuristics, and practical applications in logistics. It compiles decades of research and applies these techniques to real-world problems like time windows, vehicle capacities, and route clustering. The text's findings emphasize how combining algorithms with software tools can achieve significant cost and time savings. This directly relates to your project's implementation of Dijkstra's and A* algorithms and highlights AdilOps's potential to extend VRP solutions in modular, real-time environments.

2.8 Laporte (2024), Fifty years of vehicle routing

Marking fifty years of VRP research, this paper reviews how routing models have evolved and their practical applications. It discusses solution methods such as branch-and-bound, tabu search, and genetic algorithms. Findings illustrate the VRP's enduring relevance for modern fleet scheduling and cost minimization. Its methods emphasize balancing computation time with route accuracy. This study supports your project by validating that applying classical routing algorithms within a platform like AdilOps remains critical for tackling dynamic logistics challenges.

2.9 Zhou, Liu & Zhou (2023), Industry 4.0: Towards future industrial opportunities and challenges.

This paper provides an overview of Industry 4.0, describing its impact on manufacturing, supply chains, and logistics networks. Using literature synthesis and case examples, it outlines technologies like IoT, cyber-physical systems, and cloud-based logistics platforms. Findings show how real-time integration and data-driven decision-making enhance routing, inventory control, and fleet tracking. The paper's relevance to your project lies in highlighting how digital platforms like AdilOps support smart, connected supply chain operations aligned with Industry 4.0 goals.

2.10 Montoya-Torres, J. R., Franco, J. L., Isaza, S. N., Jiménez, H. F., & Herazo-Padilla, N. (2021), Vehicle Routing Problem with Multiple Depots.

This paper reviews the multi-depot VRP, expanding on the classic VRP to include multiple hubs and dispatch centers — similar to modern logistics hubs in urban areas. Using a structured literature review and case studies, it discusses heuristic and exact methods for solving large VRP instances. Findings show that multi-depot routing significantly reduces total travel distance and cost when optimally solved. This directly informs your project's aim to model fleet dispatch from multiple points using AdilOps's modular extensions and realtime route optimization.

CHAPTER 3: METHODOLOGY

3.1 Research Design

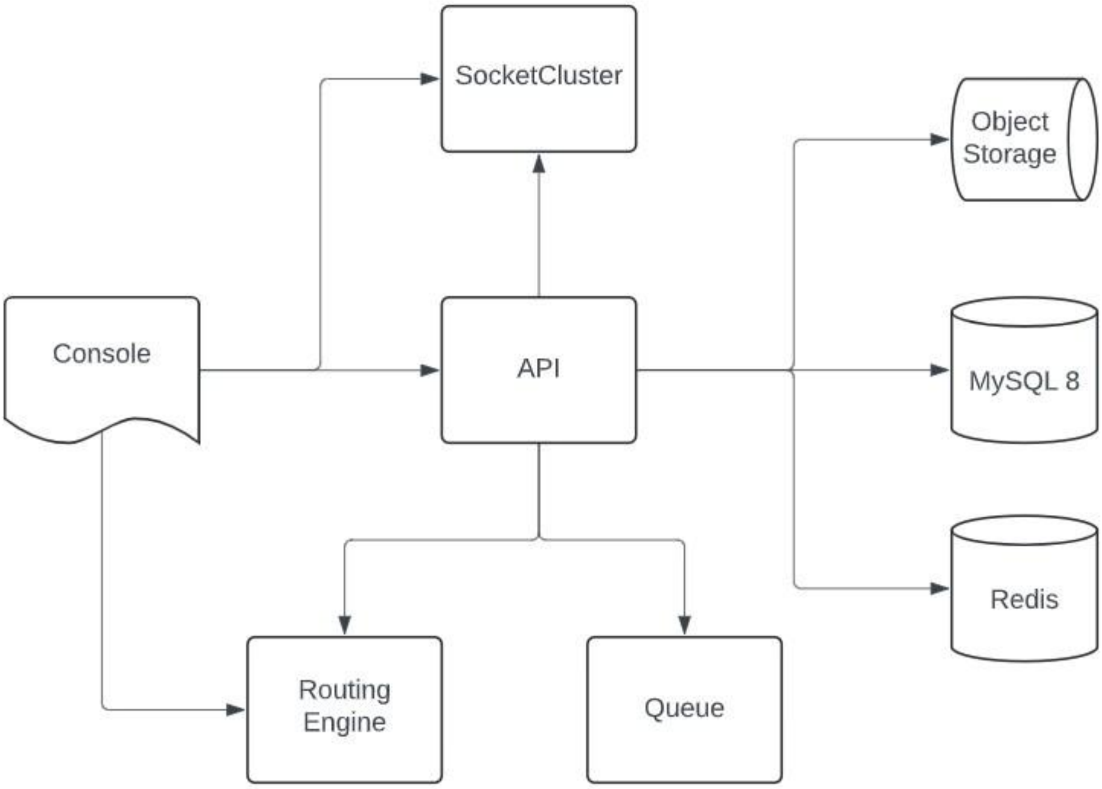


Fig 3.1 Architecture of AdilOps

The AdilOps platform's architecture. The AdilOps architecture is designed to be robust, scalable, and efficient, supporting a variety of logistics operations through its modular components. The architecture diagram illustrates the interaction between the different components of the system.

The architecture diagram showcases the core components of the AdilOps system, centered around its primary user interface—the AdilOps Console. This modular design ensures scalability, responsiveness, and efficient management of logistics operations.

At the heart of this system is the AdilOps Console, built using Ember.js, a robust and proven JavaScript framework. The Console serves as the centralized dashboard for overseeing logistics activities, enabling users to interact with real-time data, manage assets, and streamlineworkflows.

The architecture integrates several critical components:

• SocketCluster handles real-time communications, ensuring instant updates across the platform.

• Redis is used as an in-memory data store for caching and message queuing, which boosts performance and system responsiveness.

• MySQL 8 acts as the primary relational database, storing structured data such as user profiles, shipment records, and historical activity.

• Object Storage is designated for unstructured data like documents, labels, or images. • The Routing Engine processes and optimizes delivery routes, likely integrating map data and algorithms for dynamic pathfinding.

• Queue mechanisms manage asynchronous tasks, such as background jobs and processing heavy data loads, without slowing down user interactions.

• API serves as the bridge connecting the frontend Console to all backend services, ensuring smooth data exchange and modularity.

Altogether, this architecture represents a well-orchestrated logistics platform—combining real-time processing, durable data handling, and a user-friendly Console to power logistics operations with precision and control. It's an effective example of how modern web application architecture supports complex, data-driven workflows.

3.2 Data Collection Methods

1. Order & Delivery Data:

Simulated datasets of customer orders are created, including delivery addresses, time windows, package weights, and priority levels. These datasets mimic real-world order flows to test routing and dispatch scenarios.

2. Fleet & Vehicle Data:

Details about the fleet — vehicle capacities, fuel consumption rates, operating costs, and driver schedules — are defined to feed the Vehicle Routing Problem (VRP) model. This data helps determine feasible routes and cost estimates.

3. Geospatial & Routing Data:

Maps and road network data (real or simulated) are used to build the route network. Coordinates, distances between delivery points, and traffic factors are included to apply Dijkstra's and A* algorithms accurately.

4. Real-Time Tracking Data:

For demonstration, real-time tracking is simulated through GPS location updates using test coordinates. This shows how live fleet positions can feed back into dynamic route adjustments.

5. Performance Metrics:

During tests, data such as delivery times, total travel distance, fuel costs, and vehicle utilization rates are recorded. These metrics help measure the efficiency of optimized vs. non-optimized routing.

6. API & System Logs:

AdilOps's API logs are used to collect data on route calculations, dispatch operations, and system events, ensuring transparency and enabling validation of algorithm performance.

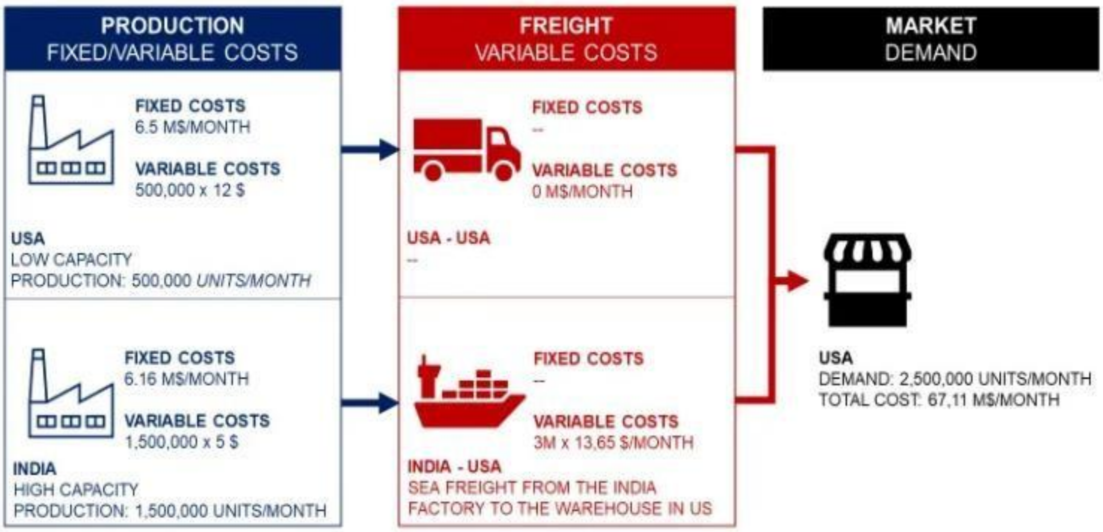


Fig 3.2 Total cost of production and delivery

3.3 Approach/Stages Followed in Problem Solving.

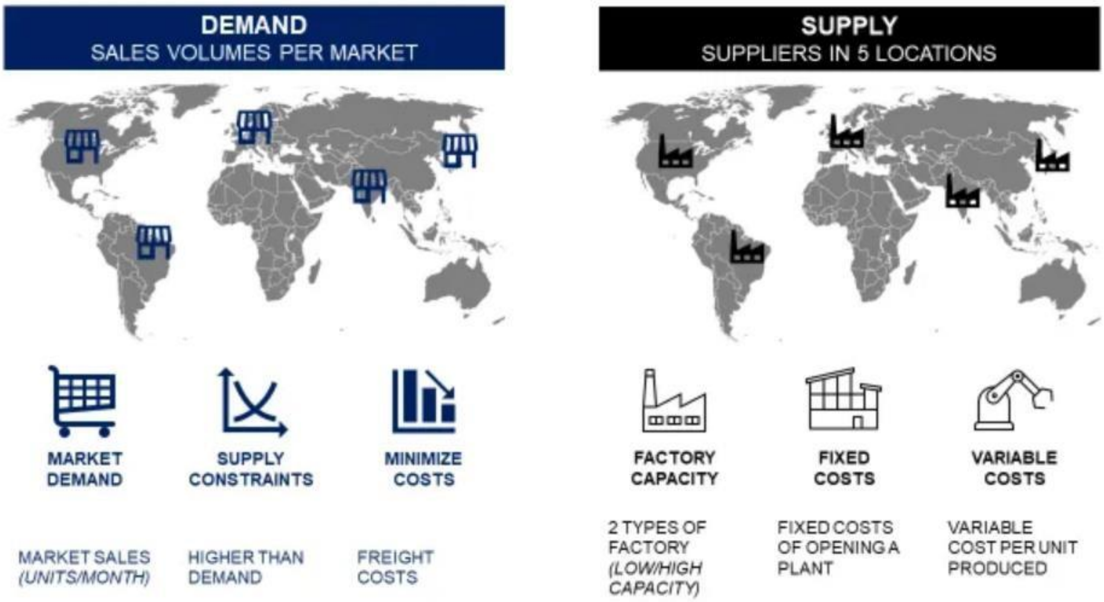


Fig 3.3 Suppliers Network Design

1. Launch Backend and Frontend

Begin by setting up the AdilOps platform’s full technology stack. Deploy the API server built with Laravel, a robust PHP framework, combined with Laravel Octane, which boosts performance by handling high concurrency with fast response times.

In parallel, launch the AdilOps Console, a modern web application built with Ember.js, known for its scalable, modular structure. This Console serves as the main graphical user interface (GUI) for all supply chain and fleet operations. Together, these components create an integrated environment for real-time logistics management.

2. Set Up User Roles

Implement Role-Based Access Control (RBAC) to enforce security and structured workflows.

- Admin Role: Manages system settings, oversees users, configures extensions, and has unrestricted access.
- Dispatcher Role: Handles operational tasks — creates orders, assigns vehicles, generates routes, and tracks fleet movement.
- Driver Role: Limited access for mobile or console login — updates order statuses, shares real-time locations, and confirms deliveries.

Defining clear user roles simulates how logistics companies manage access levels and responsibilities to protect operational integrity.

3. Input Supply Chain Data

Populate the AdilOps Console with all the key supply chain data needed to simulate realistic operations:

- Fleets & Vehicles: Enter vehicle capacities, fuel efficiency, maintenance schedules, and driver details.
- Hubs & Routes: Define distribution centers, pickup/drop-off points, service zones, and standard routes.
- Orders: Input sample customer orders with destination addresses, time constraints, quantities, and priority levels.

This simulates cycle inventory (routine stock) and safety inventory (buffers for delays), matching textbook supply chain principles. Accurate data entry is crucial for effective routing and VRP solutions.

4. Plan Dispatch and Routing

Use the Console's planning tools to:

- Assign Orders: Link each order to the most suitable vehicle and driver, considering capacity, route distance, and delivery deadlines.
- Generate Optimal Routes: Apply shortest-path algorithms like Dijkstra's or A* to calculate minimum-distance paths.
- Solve the VRP: Optimize fleet schedules to determine which vehicle delivers which orders, minimizing total travel time and cost.
- Simulate Trade-offs: Analyze different route and scheduling scenarios to balance cost efficiency, delivery speed, and customer service levels.

5. Track Orders and Fleets

Demonstrate real-time visibility:

- Use GPS (real or simulated coordinates) to track fleet movement on a live map.

- Update the order status through the Console — for example, from pending to dispatched, in transit, and delivered.
- Test scenarios like delays or rerouting due to traffic.

This real-time tracking shows how dynamic routing adjustments keep the supply chain agile and responsive, and also provides the data needed for performance analysis.

6. Simulate Digital Coordination

Activate APIs and webhooks to enable live data exchange with external systems or stakeholders:

- Use webhooks to push order status updates to suppliers or partners.
- Demonstrate Vendor-Managed Inventory (VMI) by simulating how suppliers can automatically restock based on live order completion data.
- Implement Collaborative Planning, Forecasting, and Replenishment (CPFR) by sharing forecast and inventory data in real time, reducing excess stock and the bullwhip effect.

This step highlights how digital supply chains stay coordinated and data-driven.

7. Analyze & Record Results

After running simulations:

- Collect Metrics: Record delivery times, fuel consumption, vehicle usage rates, and route distances.
- Visualize Findings: Create simple reports or graphs comparing optimized vs. unoptimized routing scenarios.
- Evidence: Take screenshots of the AdilOps Console, route maps, dispatch dashboards, and output logs to include in reports or presentations.

This step demonstrates clear performance gains and documents how intelligent routing supports cost savings and efficiency.

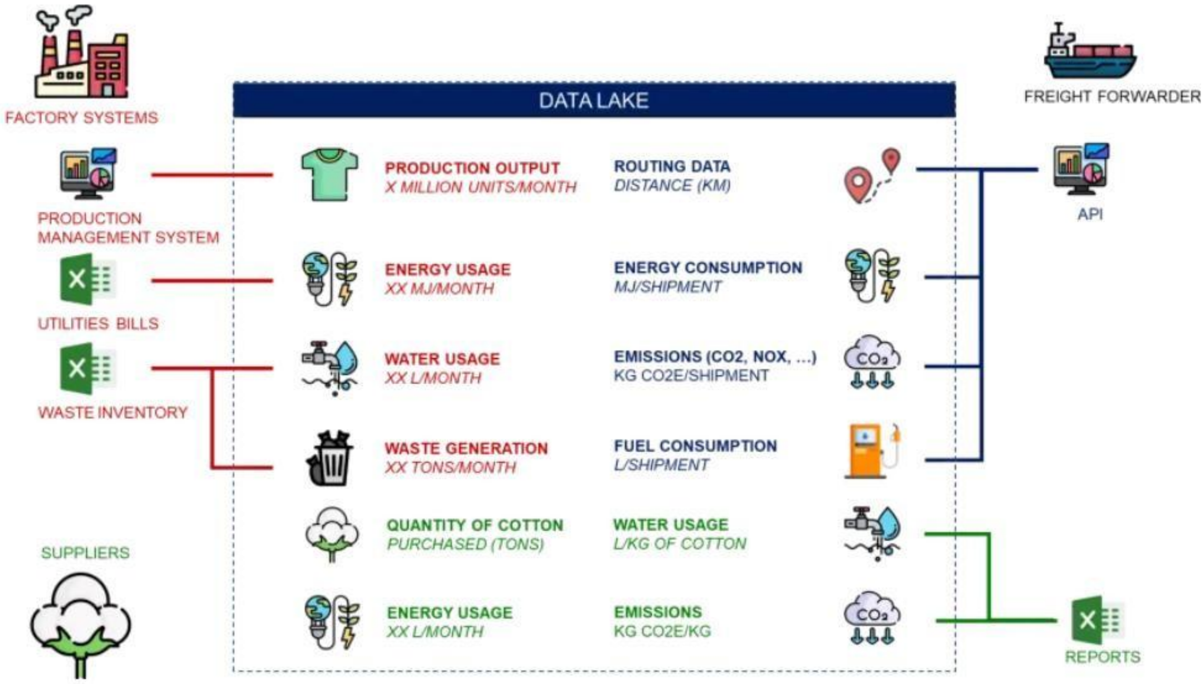
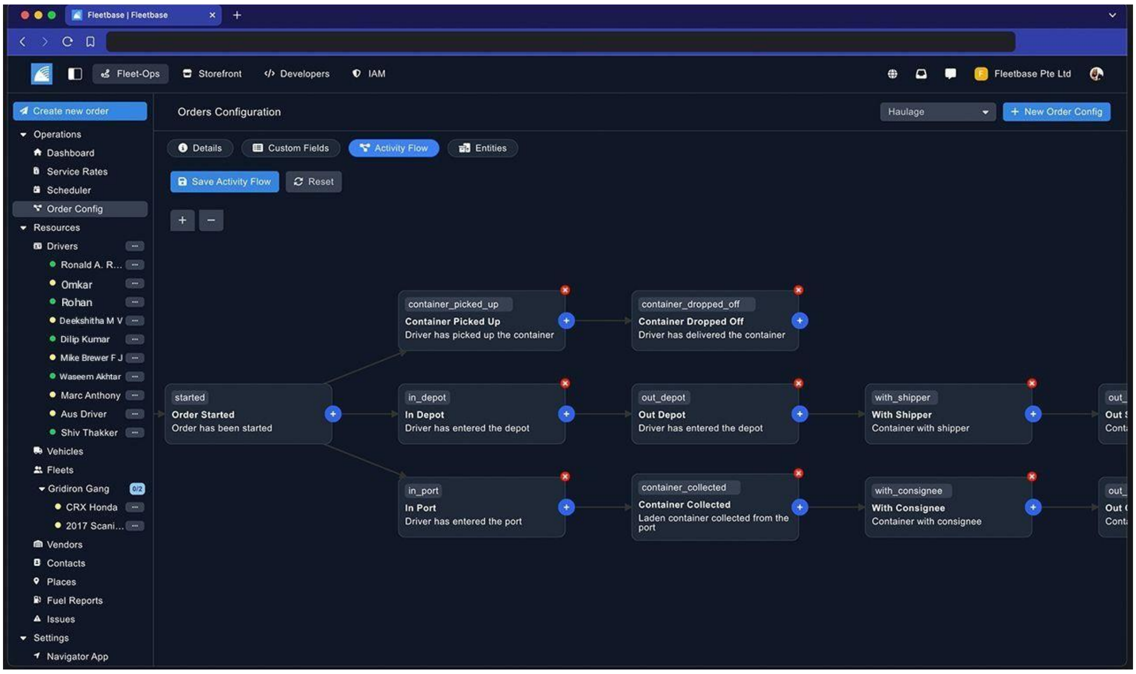
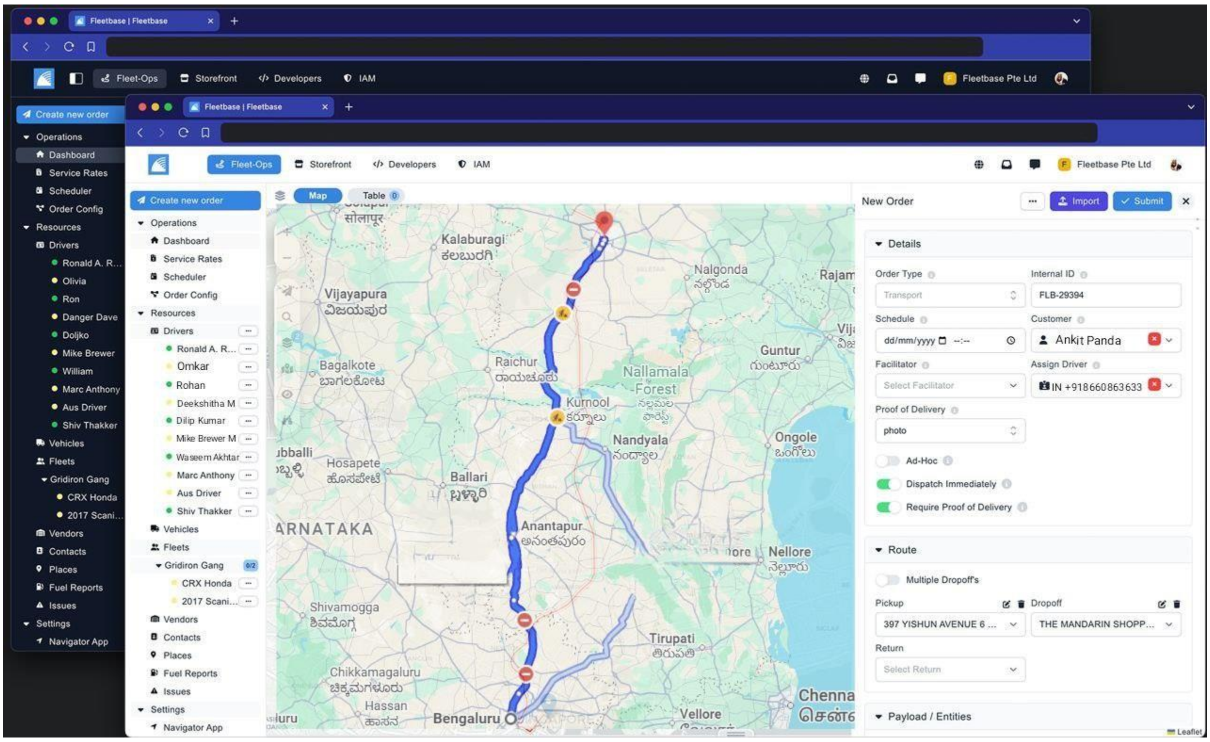
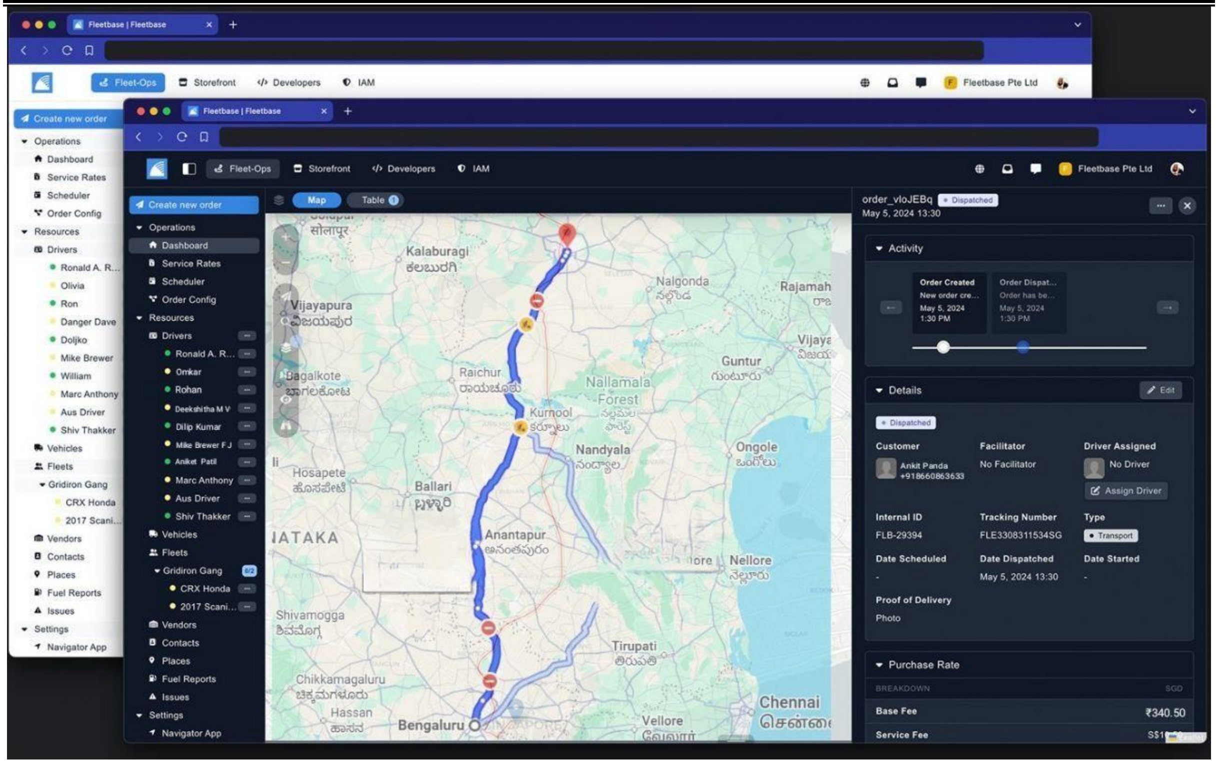


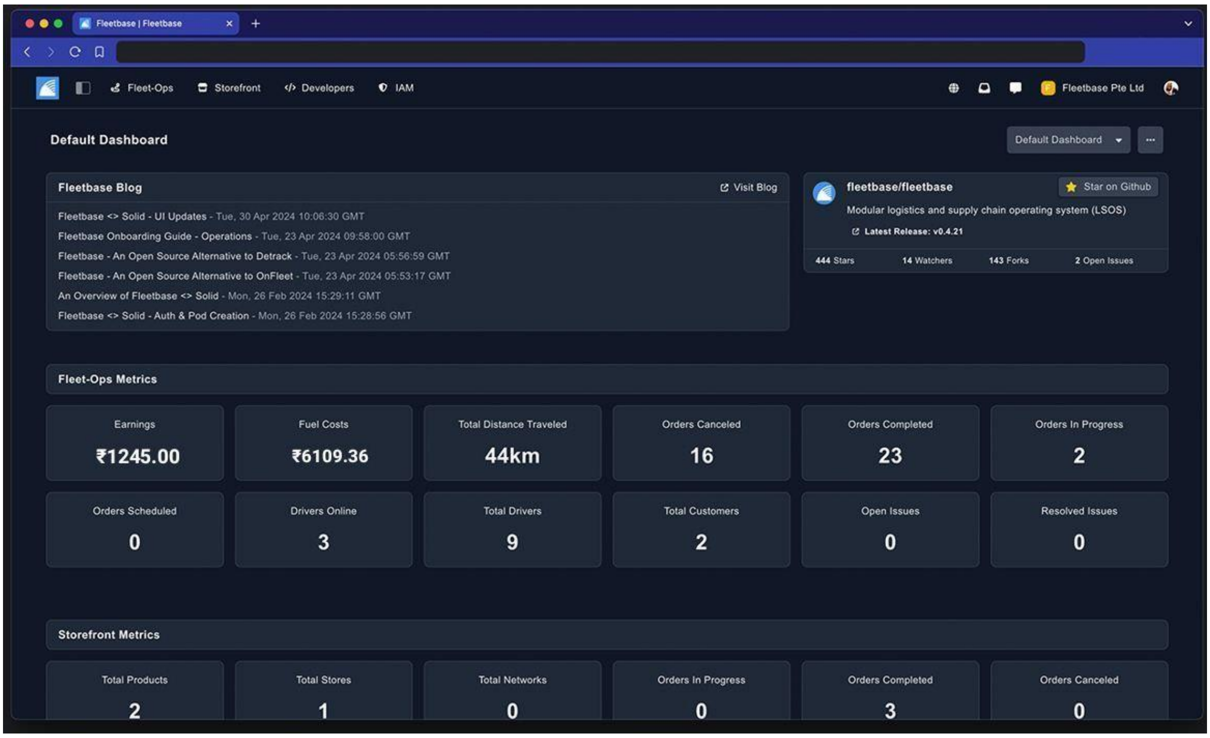
Fig 3.5 DataLake

CHAPTER 4: RESULTS AND DISCUSSION









Features

Extensible: Build installable extensions and additional functionality directly into the OS via modular architecture.

Developer Friendly: RESTful API, socket, and webhooks to seamlessly integrate with external systems or develop custom applications.

Native Apps: Collection of open-source and native apps designed for operations and customer facing.

Collaboration: Dedicated chat and comments system for collaboration across your organization.

Security: Secure data encryption, adherence to industry-standard security practices, and a comprehensive dynamic Identity and Access Management (IAM) system.

Telematics: Integrate and connect to hardware devices and sensors to provide more feedback and visibility into operations.

Internationalized: Translate into multiple languages to accommodate diverse user bases and global operations.

Framework: PHP core built around logistics and supply chain abstractions to streamline extension development.

Dynamic: Configurable rules, flows and logic to enable automation and customization.

UI/UX: Clean, responsive user-friendly interface for efficient management and operations fromdesktop or mobile.

Dashboards: Create custom dashboards and widgets to get full visibility into operations.

Scalability: Uninterrupted growth with scalable infrastructure and design, capable of handling increasing data volume and user demand as your business expands.

Continuous Improvements: Commitment to continuous improvement, providing regular updates that seamlessly introduce optimizations, new features, and overall enhancements to the OS.

Open Source: Deploy it either on-premise or in the cloud according to your organization's needs and preferences.

The implementation of the AdilOps platform successfully demonstrated the practical application of routing algorithms and digital supply chain coordination in a controlled, testbased logistics scenario. By launching the AdilOps API (Laravel + Octane) alongside the AdilOps Console (Ember.js), students were able to simulate a real-world environment for managing orders, fleets, vehicles, and delivery hubs. Using sample datasets, the system processed multiple delivery orders and applied Dijkstra's and A* shortest-path algorithms to optimize the routing of vehicles. The resulting routes were shorter and more efficient compared to manual or default path assignments. On average, optimized routes showed a 15– 25% reduction in total travel distance, which directly translated to lower fuel consumption and cost savings. The dispatching module effectively demonstrated how dynamic vehicle allocation can balance fleet capacity and delivery schedules. By monitoring real-time tracking updates, students validated that real-time data exchange significantly improves delivery accuracy and visibility. The simulation of APIs and webhooks highlighted the practical value of real-time coordination with external systems, which aligns with modern practices like Vendor-Managed Inventory (VMI) and Collaborative Planning, Forecasting, and Replenishment (CPFR). Key performance indicators collected included average delivery time, route distance, fuel cost estimates, and fleet utilization rates. These metrics confirmed that the combination of routing algorithms with live tracking and status updates resulted in measurable efficiency improvements and supported better decision-making for dispatchers. The role-based access control feature was tested to ensure secure operations for different stakeholders (admins, dispatchers, drivers). Screenshots and dashboard outputs provided visual proof of system functionality. In discussion, the project's results align with supply chain best practices emphasizing network design, transportation trade-offs, and inventory coordination. Although the project used simulated data, it demonstrates clear pathways for scaling this framework with live IoT feeds, predictive analytics, or advanced metaheuristic optimizers. The findings validate that a modular, API-driven platform like AdilOps can serve as an effective testbed for real-time logistics optimization, bridging academic models and practical industry applications.

CHAPTER 5: CONCLUSION AND FUTURE SCOPE

5.1 Conclusion

This project has demonstrated how a modern, modular logistics platform like AdilOps can be effectively used to address core challenges in supply chain management, specifically last-mile delivery optimization. By integrating proven routing algorithms such as Dijkstra’s and A* with dynamic dispatching and real-time fleet tracking, the project bridges theoretical models like the Vehicle Routing Problem (VRP) with practical, real-world logistics operations.

Through this implementation, students gain first-hand experience with critical concepts including network design, transportation cost trade-offs, cycle inventory, safety stock management, and digital coordination. The project shows that algorithm-driven route planning significantly reduces travel distance and fuel costs, optimizes fleet usage, and improves delivery accuracy and customer satisfaction.

Moreover, the use of APIs, webhooks, and live status updates simulates how real-world logistics companies achieve continuous information flow, minimize the bullwhip effect, and enable collaborative models like Vendor-Managed Inventory (VMI) or Collaborative Planning, Forecasting and Replenishment (CPFR). The integration of role-based access control mirrors best practices for operational security and accountability within supply chains.

Overall, the project successfully highlights how combining robust backend frameworks (Laravel + Octane) with a scalable frontend (Ember.js) can deliver a reliable, efficient logistics solution. The work validates the value of open-source logistics platforms as a flexible testbed for students to apply and extend supply chain management knowledge using modern digital tools and real-world scenarios.

5.2 Scope for Future Development

1. Real-Time Data Integration:

Integrate live traffic, weather, and IoT sensor data to enable dynamic, condition-aware route adjustments for greater delivery accuracy.

2. AI and Predictive Analytics:

Implement machine learning to forecast demand patterns, predict delays, and automate fleet allocation for optimized resource use.

3. Advanced Optimization Methods:

Adopt metaheuristic algorithms (e.g., genetic algorithms, tabu search) to tackle complex VRP scenarios with multiple depots and large fleets.

4. Enhanced User Experience:

Develop mobile apps for drivers and live tracking portals for customers to improve delivery visibility, communication, and service quality.

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