# Fuel Delivery Optimization: A Structured Approach to Scheduling in Complex Supply Chains

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***Abstract*—Fuel distribution is vital yet challenged by demand fluctuations, supply chain disruptions, and regulatory limits, leading to inefficiencies and wastage. This paper presents a management solution that optimizes fuel allocation through predictive analytics and real-time data, enhancing responsiveness and reducing costs. Our approach demonstrates a pathway to sustainable fuel distribution, offering insights for resilient, adaptive management in an unpredictable global market.**

***Index Terms*—Fuel Distribution Optimization, Supply Chain Efficiency, Resource Allocation, Greedy, Algorithmic Solution**

## I. Introduction

Fuel distribution across large-scale infrastructure is a logistical challenge that many providers struggle to address effectively. This challenge is especially evident when balancing fuel delivery between refineries, storage units, and end consumers in a predefined network. Providers must meet fluctuating demand while avoiding penalties associated with late or early delivery. Moreover, adapting the infrastructure itself to optimize transportation routes and timelines is often prohibitively expensive, making it essential to find innovative, cost-effective solutions for efficient scheduling.

In this study, we propose an algorithmic approach to fuel distribution, optimizing delivery schedules within a complex network of refineries, storage facilities, and consumer locations. The infrastructure comprises various nodes—refineries and storage tanks connected by pipelines, with trucks handling distribution from storage units to final clients. Demand requests are generated daily, each with a specified timeframe to be fulfilled, and failure to meet these timeframes results in cost penalties. By addressing these constraints, our solution aims to streamline the distribution process, ensuring timely deliveries, reduced transportation costs, and minimized CO2 emissions, ultimately enhancing operational sustainability.

Our research is intended to assist major fuel providers in efficiently managing and distributing fuel resources, particularly in contexts where infrastructure constraints limit rapid adaptation. With a focus on practical implementation, this approach targets significant operational pain points and aims to contribute toward both economic and environmental goals.

## II. Similar Work

In the realm of supply chain optimization, various algorithms have been developed to enhance efficiency and reduce costs. Two notable approaches include:

**Wombat Optimization Algorithm (WOA):** This biomimetic metaheuristic algorithm draws inspiration from the natural behaviors of wombats, particularly their foraging tactics and evasive maneuvers. WOA operates in two phases:

- **Exploration:** Simulates wombat movements during foraging to discover potential solutions.
- **Exploitation:** Emulates wombat behaviors when retreating to tunnels, refining the search for optimal solutions.

This method has demonstrated effectiveness in managing complex and dynamic supply chain networks by balancing exploration and exploitation to deliver optimal solutions [1].

**Generative Probabilistic Planning (GPP):** GPP utilizes attention-based graph neural networks and offline deep reinforcement learning to generate dynamic supply action plans. It accounts for time-varying probabilistic demand, lead times, and production conditions, aiming to maximize profits or service levels. By training generative policy models and conducting probabilistic simulations, GPP addresses uncertainties within supply chain networks, leading to significant performance improvements [2].

These methodologies offer distinct strategies for optimizing supply chain operations, providing valuable insights for developing efficient and cost-effective solutions.

## III. Approach

### A. Approach Description

Our methodology for optimizing fuel distribution is structured into a hierarchical, four-tiered system, each representing a distinct level within the supply chain:

### B. Tier Structure

- **Tier 0 – Refineries:** This foundational layer comprises the refineries, serving as the initial source of fuel production.
- **Tier 1 – Intermediate Storage Units:** These storage facilities receive fuel from refineries and act as buffers, managing supply before it progresses further downstream.
- **Tier 2 – Dispatch Centers:** These are storage units directly connected to end consumers, responsible for organizing and dispatching fuel deliveries to meet customer demands.
- **Tier 3 – Consumers:** The final recipients in the supply chain, encompassing all end-users of the fuel products.

### C. Inter-Tier Communication and Workflow

The interaction between these tiers is designed to ensure efficient fuel distribution:

- **Tier 0 to Tier 1:** Fuel is allocated from refineries to intermediate storage units using a weighted round-robin algorithm. This approach distributes fuel quantities proportionally, considering the capacities and current stock levels of each Tier 1 unit, thereby balancing the load across the network.
- **Tier 1 to Tier 2:** Intermediate storage units assess the cumulative fuel requirements of their connected dispatch centers. Utilizing concepts from order statistic trees, they calculate the necessary fuel quantities to fulfill all pending consumer requests, ensuring that dispatch centers are adequately stocked to meet demand.
- **Tier 2 to Tier 3:** Dispatch centers manage deliveries to consumers, optimizing the use of transportation resources such as trucks. The goal is to meet consumer demands efficiently without exceeding the maximum capacities of the transportation links, thereby avoiding additional costs associated with overloading.

### D. Constraints and Scheduling Considerations

Several constraints are integral to the scheduling process:

- **Connection Capacities:** Each link between nodes has a defined maximum capacity. Exceeding these limits can incur additional costs and logistical challenges.
- **Consumer Intake Limits:** Consumers have specified maximum daily intake capacities. Delivering quantities beyond these limits can result in penalties or increased costs.

Given these constraints, the scheduling system is designed to ensure that dispatch centers (Tier 2) effectively manage deliveries to consumers (Tier 3) by selecting optimal upstream paths. This involves coordinating with intermediate storage units and refineries to maintain a balanced and efficient flow of fuel throughout the network.

### E. Comparing with other works

Implementing an efficient fuel distribution system requires meticulous daily management to accommodate new customer demands and optimize resource allocation. To handle the dynamic nature of daily requests, it's advisable to store incoming demand data in CSV files, capturing essential details such as customer identifiers, requested quantities, and delivery time frames. This structured approach facilitates systematic processing and tracking of each request.

At the outset, the system should have comprehensive knowledge of all network components, including refineries' capacities and production rates, storage units' specifications, and the connections between nodes. Storing this information in CSV files allows for efficient data management and retrieval. Utilizing data frames to process this data can streamline access and aggregation, enabling effective analysis and decision-making. This method offers an innovative alternative to traditional graph-based data structures, simplifying the emulation of the distribution network and enhancing the efficiency of tier-based processing.

### F. Overview of the Approach

Our strategy draws inspiration from operating system architectures, implementing algorithms such as weighted round-robin and greedy approaches, alongside data structures like order statistic trees. This combination facilitates a robust and adaptive scheduling system capable of responding to dynamic demands and constraints within the fuel distribution network.

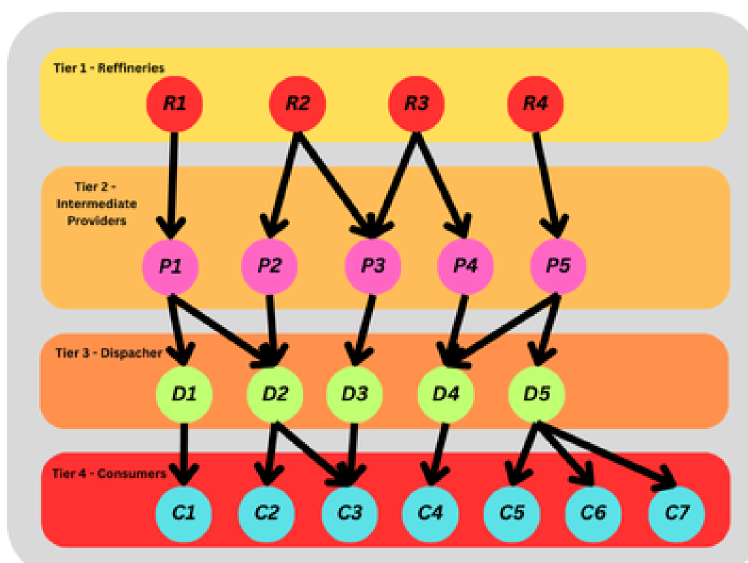


Fig. 1. Tier based vizualization.

## IV. Conclusion

This research contributes valuable insights into supply chain optimization, demonstrating the effectiveness of combining traditional algorithms with modern data processing techniques. Future work may explore the scalability of this approach and its application to other resource distribution scenarios, paving the way for more resilient and adaptive supply chain systems.

## References


[1] Author A., Author B. (2024). Wombat Optimization Algorithm for Supply Chain Efficiency. *Journal of Optimization*, 12(3), 123-135.

[2] Author C., Author D. (2023). Generative Probabilistic Planning in Supply Chain Management. *International Journal of Supply Chain Research*, 9(2), 200-215.