Project Proposal

Title: Middleware for Real-Time Data Management in Public Transport: Enhancing Operational Efficiency and Combating Fare Evasion

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Introduction

In most public transportation systems, such as RATP and SNCF, real-time information is critical for optimization, the apportioning of resources, and enhancing efficiency in service delivery. Our project concerns the design of a middleware solution that would be used to integrate IoT devices with a distributed database for data collection and analysis in real-time from the vehicles, such as passenger counts, ticket validations, vehicle location, and environmental conditions. This will equip RATP to draw valid inferences for the purpose of transportation planning optimization, operational smoothening, and fleet optimization in general.

Additionally, the system will help identify those vehicles in which high cases of fare evasion occur by comparing the number of passengers on board with the number of validated tickets. The functionality will support the elaboration of effective measures by RATP for fighting fare evasion through the timely delivery of real-time input to ticket controllers and administrators.

Objectives

- **Optimize Transportation Planning:** By leveraging real-time information on vehicle occupancy, location, and ambient environment, route optimization, scheduling, and resource deployment will ensure buses and trains are deployed where and when they are needed most.
- **Enhance Operational Efficiency:** Provide RATP with actionable insights on vehicle usage to further manage fleet resources better, cut inefficiencies, and improve overall service quality.
- **Real-Time Fare Evasion Detection:** Identify vehicles with discrepancies in passenger counts and ticket validations to help target non-paying travelers more effectively.
- **Middleware Integration:** Design a middleware that can connect IoT sensors with a distributed database to handle large-scale, real-time data collection and analysis.

Weekly Implementation Plan

- **Week 1:** Study IoT sensors (e.g., passenger counting, environmental monitoring) and select a distributed database platform (e.g., Cassandra, MongoDB, CockroachDB). Begin drafting the system architecture.

- **Week 2:** Design and implement the basic middleware structure for data ingestion from IoT devices and store it in the distributed database.
- **Week 3:** Establish communication between IoT devices (passenger counters, temperature sensors) and middleware. Implement data acquisition and ensure replication and consistency across distributed database nodes.
- **Week 4:** Develop the logic for real-time fare evasion detection by comparing ticket validation data with passenger counts. Start testing with sample data.
- **Week 5:** Optimize the middleware for real-time performance. Implement features that provide real-time insights for transportation planning, such as vehicle occupancy and route efficiency.
- **Week 6:** Test the entire system with simulated data, including vehicle movements and passenger counts. Begin preparing the demo and slides for the project presentation.
- **Week 7:** Finalize system deployment, conduct final tests, and prepare the project report and presentation.

System Architecture

- **IoT Devices:** Include passenger counting sensors, GPS for location tracking, and environmental sensors (e.g., temperature) installed on vehicles. These devices send real-time data to the middleware.
- **Middleware:** Manages data collection from IoT devices, processes the data in real-time, and interacts with the distributed database. The middleware also performs analytics on ticket validation data versus passenger counts for fraud detection.
- **Distributed Database:** A highly available, scalable database would store the data, such as passenger counts, ticket validations, vehicle locations, and environmental data, from thousands of vehicles. Each distributed node will have a consistent view of the data.
- **Data Analytics Dashboard:** Provides real-time visualizations of vehicle-centric data, allowing RATP to track fleet efficiency, passenger loads, and ticket fraud in real-time. Ticket controllers will be notified when vehicles with suspected fare evasion are detected.

Conclusion

The goal of this project is to improve public transport systems using IoT and distributed database technology for increased efficiency. Equipping RATP with real-time data on vehicle occupancy, route performance, and operational efficiency allows for optimal resource allocation and better overall service. Additionally, it helps identify fare evasion, enabling the transit authority to address this problem more effectively. Possible extensions include integrating machine learning to predict fare evasion trends or expanding the system to include additional data points such as traffic conditions or weather impacts on service.