***Smart Waste Management System***

**Introduction**

Waste management is a critical challenge in growing urban areas. Traditional collection methods rely on static schedules, often resulting in inefficiencies such as unnecessary collection of empty bins and delayed collection of overflowing ones. To address this, the proposed Smart Waste Management System (SWMS) leverages a database-driven approach to optimize waste collection. The system integrates relational and NoSQL databases to manage both structured data (such as trucks, bins, routes, and schedules) and unstructured data (including real-time bin fill levels). By applying DBMS concepts such as indexing, query optimization, transactions, concurrency control, and recovery, the system ensures efficient and reliable waste collection. A web-based dashboard enables administrators to monitor bins, assign trucks, and track landfill capacity in real time, improving operational efficiency and sustainability.

**Objectives**

* Design a robust database system to store information about trucks, bins, routes, and schedules.
* Quickly identify bins that need urgent collection by using indexing and query optimization.
* Implement transaction management to ensure reliable updates during waste collection (assigning trucks, emptying bins, updating landfill data).
* Apply concurrency control to prevent multiple trucks from servicing the same bin simultaneously.
* Use NoSQL integration for handling real-time, unstructured sensor-like data (bin fill levels).
* Build a frontend dashboard for city administrators to monitor bin status, truck schedules, and landfill usage.
* Provide a backend API to process requests, manage data consistency, and handle recovery from system crashes.

**System Features**

1. **Bin Management** – Track bins, fill levels, and collection history.
2. **Truck Scheduling** – Assign trucks to optimized routes for full bins.
3. **Route Optimization** – Generate the shortest/most efficient collection path.
4. **Landfill Management** – Track landfill capacity and usage.
5. **Real-Time Monitoring** – Dashboard showing bins nearing overflow.
6. **Transaction Safety** – Ensure atomic updates during collection.
7. **NoSQL Integration** – Store frequent updates of bin fill data.

**Technology Stack**

* **Frontend:** React.js + Tailwind CSS .
* **Backend:** Node.js(Express)
* **Database (SQL):** PostgreSQL
* **Database (NoSQL):** MongoDB
* **Optional:** Leaflet.js

**DBMS Concepts Implemented**

* **ER Modeling & Normalization → Structured schema design for trucks, bins, routes.**
* **Indexing & Query Optimization → Geo-index for bin location, B+ tree for fill-level queries.**
* **Transaction Management → Atomic process for truck assignment & bin collection.**
* **Concurrency Control → Locking to prevent multiple trucks from servicing the same bin.**
* **Recovery Management → Log-based recovery for crash safety.**
* **NoSQL Integration → MongoDB for real-time unstructured bin fill data.**

**Team Division**

1. **DBMS Engineer** – ER model, schema, SQL + NoSQL integration.
2. **Backend Developer** – API endpoints, transaction logic, concurrency control.
3. **Frontend Developer** – Admin dashboard, bin/truck/route visualization.
4. **Optimization Specialist** – Query optimization, route planning algorithm, recovery handling.

**Expected Outcomes**

* A working web application with database-driven waste management.
* Optimized waste collection efficiency using query optimization and route planning.
* A resume-ready project that highlights core DBMS principles and full-stack development.

**Future Scope**

* **AI-based Predictions:** To further optimize truck deployment and forecast bin fill times, machine learning methods can be incorporated.
* **Citizen Mobile App:** Residents can report overflowing bins directly, improving responsiveness.
* **Smart Contracts:** Blockchain-based verification for waste collection logs, ensuring transparency.
* **Integration with Government Systems:** For centralized monitoring, city authorities can be given access to real-time dashboards.
* **Sustainability Insights:** By revealing waste patterns, data analytics can help improve recycling and environmentally friendly regulations.