**Lahore Transport Management System**

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**Project Overview**

The **Lahore Transport Management System (LTMS)** is a comprehensive database solution for managing public transport networks, including metro and bus services. The system is designed to handle various aspects such as passenger information, route mapping, driver assignments, ticketing, and real-time updates on transport operations. This ensures a seamless and efficient experience for passengers while enabling administrators to manage resources effectively.

The database architecture of the TMS is built using **Structured Query Language (SQL)** and adheres to **3rd Normal Form (3NF)** principles. This ensures minimal redundancy, maintains data consistency, and optimizes performance. The system includes **static tables** for core, unchanging data and **dynamic tables** for real-time and frequently updated data, making it both scalable and robust.

**Key Objectives of the System**

1. **Passenger Management**  
   Maintain accurate records of passenger details, including personal information, contact numbers, and account balances for ticket purchases or other services.
2. **Route Optimization**  
   Store and manage data about metro and bus routes, including their origins, destinations, number of stops, and vehicle assignments.
3. **Driver and Staff Management**  
   Manage driver and employee schedules, ensuring proper assignments to routes and shifts.
4. **Ticketing and Transactions**  
   Record all ticket purchases, including route information and passenger details, ensuring secure and efficient payment processing.
5. **Real-Time Updates**  
   Track operational data like current passenger counts, route traffic, and service statuses.
6. **Maintenance and Feedback**  
   Log maintenance activities and collect feedback to improve service quality and operational efficiency.

**Tables Overview**

The TMS database comprises **15 key tables**, categorized into static and dynamic tables.

**Static Tables**

Static tables contain foundational data that remains consistent over time and provides the structural backbone for the system:

1. **Passenger**  
   Stores details about passengers, such as:
   * **CNIC** (unique identifier, primary key)
   * First and last names
   * Contact and emergency contact numbers
   * Account balance for managing top-ups or ticket purchases
2. **Metro\_Routes**  
   Information about metro routes, including:
   * Route ID (primary key)
   * Origin and destination stations
   * Number of stops and trains on the route
3. **Bus\_Routes**  
   Details of bus routes, such as:
   * Route ID (primary key)
   * Origin and destination
   * Number of stops, buses assigned, and route length
4. **Bus\_Stop**  
   Data about individual bus stops:
   * Stop ID (primary key)
   * Stop name
   * Associated route ID
   * Current passenger capacity
5. **Metro\_Stops**  
   Similar to bus stops, but specific to metro operations. It includes:
   * Stop ID and name
   * Associated route ID
   * Passenger capacity, status (operational/non-operational), and type of stop
6. **Buses**  
   Stores details about buses operating on various routes:
   * Bus ID (primary key)
   * Assigned route ID
   * Schedule and current passenger count
7. **Trains**  
   Similar to buses but specific to metro operations. Fields include:
   * Train ID (primary key)
   * Route ID
   * Schedules and passenger capacity
8. **Bus\_Driver**  
   Information about bus drivers:
   * Driver ID (primary key)
   * Name, contact number, and assigned route
   * Shift schedule
9. **Metro\_Driver**  
   Similar to bus drivers but specific to metro services.

**Dynamic Tables**

Dynamic tables track real-time data, enabling continuous updates and operational monitoring:

1. **Tickets**  
   Records ticket purchase details, including:
   * Passenger CNIC (foreign key)
   * Bus and metro route IDs
   * Purchase date
2. **Employee Shifts**  
   Tracks the schedules of drivers and employees:
   * Employee ID
   * Assigned route
   * Shift start and end times
3. **Passenger Transactions**  
   Logs passenger account activities, including:
   * Top-ups
   * Ticket purchases
   * Transaction timestamps
4. **Route Traffic Logs**  
   Monitors traffic data on various routes, including:
   * Route ID
   * Timestamp of traffic log
   * Passenger counts and flow data
5. **Maintenance Logs**  
   Tracks maintenance activities for buses, trains, and stops:
   * Maintenance ID
   * Vehicle or stop ID
   * Maintenance date and description
6. **Service Feedback**  
   Gathers passenger feedback to evaluate and improve services:
   * Feedback ID
   * Passenger details
   * Ratings and comments

**Detailed Explanation of Static vs. Dynamic Tables**

* **Static Tables** are foundational, with data that changes infrequently. These tables provide structure and define entities like routes, vehicles, and employees. For example:
  + **Passenger**: Defines passengers in the system.
  + **Metro\_Routes** and **Bus\_Routes**: Describe predefined transit paths.
  + **Buses** and **Trains**: Store static information about the fleet.
* **Dynamic Tables** store data that is updated in real time or changes frequently during operations. For example:
  + **Tickets**: Updated every time a ticket is purchased.
  + **Maintenance Logs**: Reflect ongoing maintenance activities.
  + **Route Traffic Logs**: Capture live data for traffic management and analytics.

This categorization helps maintain a clear separation between static and operational data, improving system organization and performance.

**Key Features and Benefits**

1. **Efficiency in Resource Allocation**  
   By tracking passenger counts, driver schedules, and vehicle statuses, administrators can optimize resource usage and reduce operational costs.
2. **Real-Time Monitoring**  
   The system captures and updates traffic data, maintenance logs, and passenger transactions in real time, enabling swift decision-making.
3. **Scalability**  
   With its normalized structure, the database can handle increasing data volumes as the transport network grows.
4. **Enhanced Passenger Experience**  
   A seamless ticketing system, coupled with feedback collection and route optimization, ensures improved service quality for passengers.

**Conclusion**

The Lahore Transport Management System (LTMS) is a powerful solution for modernizing public transport networks. By integrating static tables for unchanging data and dynamic tables for real-time operations, the system ensures both efficiency and scalability. Its adherence to database normalization principles guarantees data integrity and minimizes redundancy.

From passenger management to route optimization, the TMS covers all aspects of public transport operations, making it an essential tool for enhancing service quality and operational efficiency. This project provides a strong foundation for future expansions, such as integrating advanced analytics or AI-driven optimizations.