Project Report: Vehicle Parking System

Author

- **Name:** Kunal Sahu
- **Roll Number:** 23dp2000037
- **Email:** 23dp2000037@ds.study.iitm.ac.in
- **About:** I am a passionate developer with a keen interest in building full-stack web applications. I enjoy tackling challenges related to system architecture, database design, and creating seamless user experiences.

Description

This project requires building a comprehensive vehicle parking system with a clear separation between a Flask backend API and a Vue.js frontend. The system needs to support two distinct roles (Admin and User) with different functionalities, handle real-time parking spot management, and include asynchronous background jobs for reports and notifications. **Approximately 20%** of the code for both the backend and frontend was generated using an AI assistant for tasks like initial setup, database modelling, and component generation.

Technologies Used

- **Backend**:
    - **Flask**: A lightweight Python web framework used to build the core REST API.
    - **Flask-SQLAlchemy**: An ORM for interacting with the database using Python objects, simplifying database operations.
    - **Flask-JWT-Extended**: Implements JSON Web Token (JWT) authentication for securing API endpoints.
    - **Flask-Bcrypt**: Used for securely hashing user passwords.
    - **Celery**: A distributed task queue for running time-consuming background jobs asynchronously.
    - **Redis**: An in-memory data store used as the message broker for Celery.
- **Frontend**:
    - **Vue.js (v3)**: A progressive JavaScript framework for building a reactive Single Page Application (SPA).
    - **Vue Router**: The official router for Vue.js, used to handle client-side navigation.
    - **Pinia**: The official state management library for Vue, used to manage global application state.

- **Axios**: A promise-based HTTP client for making API requests from the frontend to the backend.
- **Bootstrap 5**: The exclusive CSS framework used for styling and creating a responsive user interface.

DB Schema Design

The database is designed with four interconnected tables to logically separate concerns and ensure data integrity.

- **User Table (users)**:
  - id (Integer, Primary Key): Unique identifier for each user.
  - username (String, Unique, Not Null): The user's chosen name.
  - email (String, Unique, Not Null): The user's email, used for login.
  - password_hash (String, Not Null): The securely hashed password.
  - role (String, Not Null, Default: 'user'): Defines user permissions ('user' or 'admin').
- **ParkingLot Table (parking_lots)**:
  - id (Integer, Primary Key): Unique identifier for each parking lot.
  - name (String, Unique, Not Null): The public name of the lot.
  - address (Text, Not Null): The physical address of the lot.
  - pin_code (String, Not Null): The postal code.
  - price_per_hour (Float, Not Null): The cost to park for one hour.
  - capacity (Integer, Not Null): The total number of spots in the lot.
- **Parking Spot Table (parking spots)**:
  - id (Integer, Primary Key): Unique identifier for each spot.
  - spot number (Integer, Not Null): The number of the spot within a lot.
  - status (String, Not Null, Default: 'Available'): The current status ('Available' or 'Occupied').
  - lot_id (Integer, Foreign Key to parking_lots.id): Links the spot to a specific parking lot.
- **Booking Table (bookings)**:
  - id (Integer, Primary Key): Unique identifier for each booking transaction.
  - user_id (Integer, Foreign Key to users.id): Links the booking to a user.
  - spot_id (Integer, Foreign Key to parking_spots.id): Links the booking to a specific spot.
  - park_in_time (Date Time, Not Null): Timestamp when the booking started.

- park_out_time (DateTime, Nullable): Timestamp when the booking ended.
- cost (Float, Nullable): The final calculated cost of the booking.

Design Rationale: This schema normalizes data to reduce redundancy. Separating

Bookings from ParkingSpots allows a spot to have a simple current status while the Booking table maintains a complete history of all transactions. Foreign key constraints are used to maintain referential integrity.

API Design

The API is designed as a RESTful service, organized by resources and roles using Flask Blueprints.

- **Authentication (/auth)**: This blueprint handles user registration (/register) and login (/login), and is responsible for validating credentials and issuing JWTs.
- **User (/api)**: This blueprint contains all endpoints for standard user actions, such as viewing lots, booking/releasing spots, and viewing booking history. All routes require a valid 'user' role JWT.
- **Admin (/admin)**: This blueprint provides endpoints for administrative control, including full CRUD operations for parking lots and system monitoring. All routes are protected by a custom decorator that requires a valid 'admin' role JWT.

Architecture and Features

- **Project Organization**:
    - The project is structured into

backend and frontend directories.

    - The backend follows a modular Flask application factory pattern, with logic separated into

routes/, models/, and tasks/ directories. Configuration is managed in

config.py.

    - The frontend is a standard Vue CLI project with source code organized into

views/, components/, router/, store/, and services/.

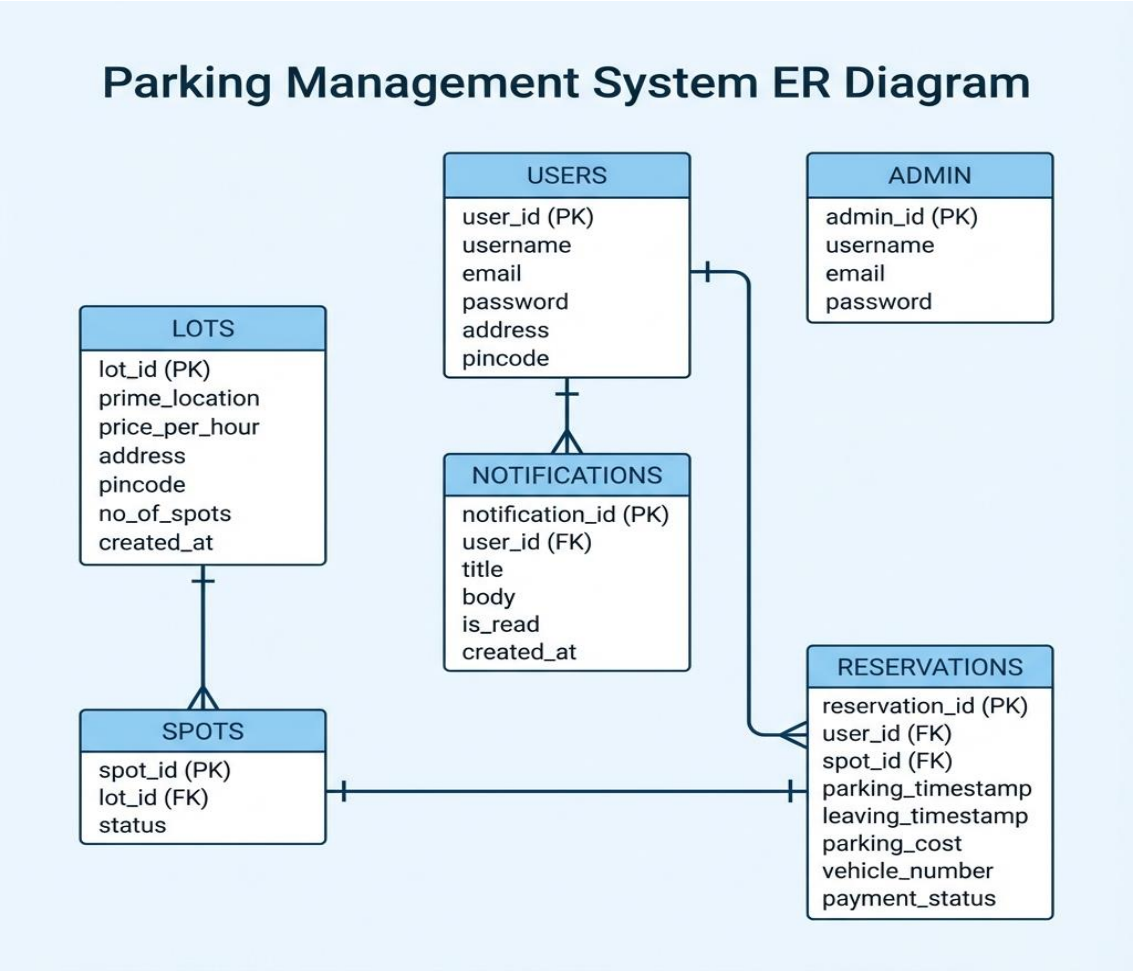
- **Features Implemented**:
    - **Role-Based Access Control**: Securely handles 'Admin' and 'User' roles using JWTs and a custom decorator (@admin_required) to protect administrative endpoints.
    - **Full Parking Lifecycle**: Users can view lots, book spots, view their active bookings, and release spots, with the cost calculated automatically.

- **Admin Management Dashboard**: A comprehensive dashboard for admins to create, edit, and delete parking lots, as well as monitor all users and the real-time status of every spot.
- **Asynchronous Background Jobs**:
  - A user can trigger a non-blocking CSV export of their booking history.
  - The system uses Celery Beat for scheduled tasks like daily reminders and monthly reports.
- **Booking History**: Both users and admins can view historical booking records.

API Resource

- **Authentication & Authorization Signup: /api/signup/**
- **Login: /api/login**
- **User Profile & Management**
- **User Info: /api/user**
- **User Detail: /api/user/**
- **Parking Lot Management Create/View/Update/Delete**
- **Lot: /api/lot Single Lot Operations: /api/lot/**
- **Parking Spot Management Spot Detail: /api/spot/**
- **Reservation Management Create Reservation: /api/reservation**
- **Reserve Spot by ID: /api/reservation/spot/**
- **View/Update/Delete Reservation: /api/reservation/**
- **Payments & Transactions Payment: /api/payment**
- **Analytics & Statistics Dashboard Stats: /api/stats**
- **Data Export Export Parking History: /api/export**

Database ER_DIAGRAM



Video:

https://drive.google.com/file/d/11_W5R2L6zmOzf_V60HKyEiWf3EA0wGap/view?usp=drive_link