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DATABASE DESIGN AND IMPLEMENTATION

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2024/2025 Academic Year

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1. Data Elements

The CarCare app stores various data elements essential for enabling car diagnostics, mechanic discovery, and service tracking. These data elements are organized into entities, each representing a core component of the system.

- **User**
  - user_id – Unique identifier
  - password
  - phone_number
  - location
  - role – Either car_owner or mechanic

- **Vehicle**
  - vehicle_id
  - user_id – Linked to User
  - model

- **DashboardImage**
  - image_id
  - user_id
  - image_url
  - fault_detected
  - upload_date

- **EngineSoundFile**
  - audio_id
  - user_id
  - audio_url
  - diagnosis_result
  - recorded_at

- **Diagnostic**
  - diagnostic_id
  - user_id
  - vehicle_id
  - image_id
  - audio_id
  - summary
  - fault_code
  - recommendation
  - created_at

- **TutorialVideo**
  - video_id
  - title
  - url
  - fault_related
  - duration
  - source

2. Conceptual Design

This section outlines the high-level structure of the CarCare app's database using MongoDB. The system follows a flexible NoSQL schema optimized for scalability and fast querying.

2.1 Key Concepts:

- **User-centric design** with car owners and mechanics stored in the same collection but differentiated by role.
- **Media integration** through image and sound file storage for diagnostics.
- **Support for car tracking** via vehicle registration and service logs.
- **Mechanic rating system** using review and feedback collections.
- **Scalable content** through tutorial videos linked to fault types.

2.2 Main Relationships:

- One User owns multiple Vehicles, Diagnostics, DashboardImages, EngineSoundFiles, and can give Feedback or write Reviews.
- A MechanicProfile is a one-to-one extension of User.
- Each Diagnostic is linked to an optional Vehicle, an uploaded DashboardImage, and an EngineSoundFile.
- A TutorialVideo can be linked to fault codes in diagnostics but is generally standalone content.

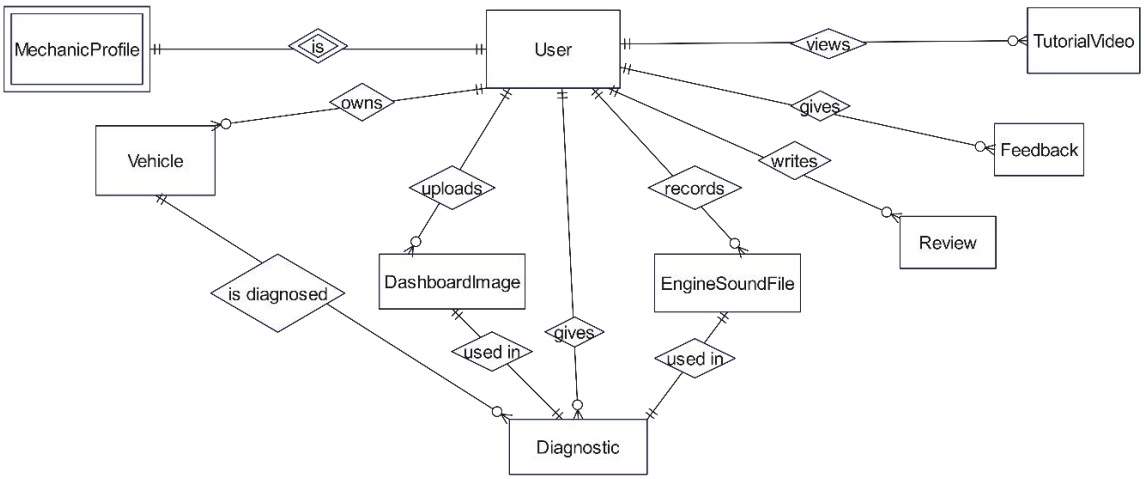
3. Entity-Relationship (ER) Diagram Summary

3.1 Strong Entities:

- User
- Vehicle
- DashboardImage
- EngineSoundFile
- Diagnostic
- TutorialVideo

3.2 Weak Entity:

- MechanicProfile – relies on User (uses user_id as both PK and FK)



4. Database Implementation (Prisma + MongoDB)

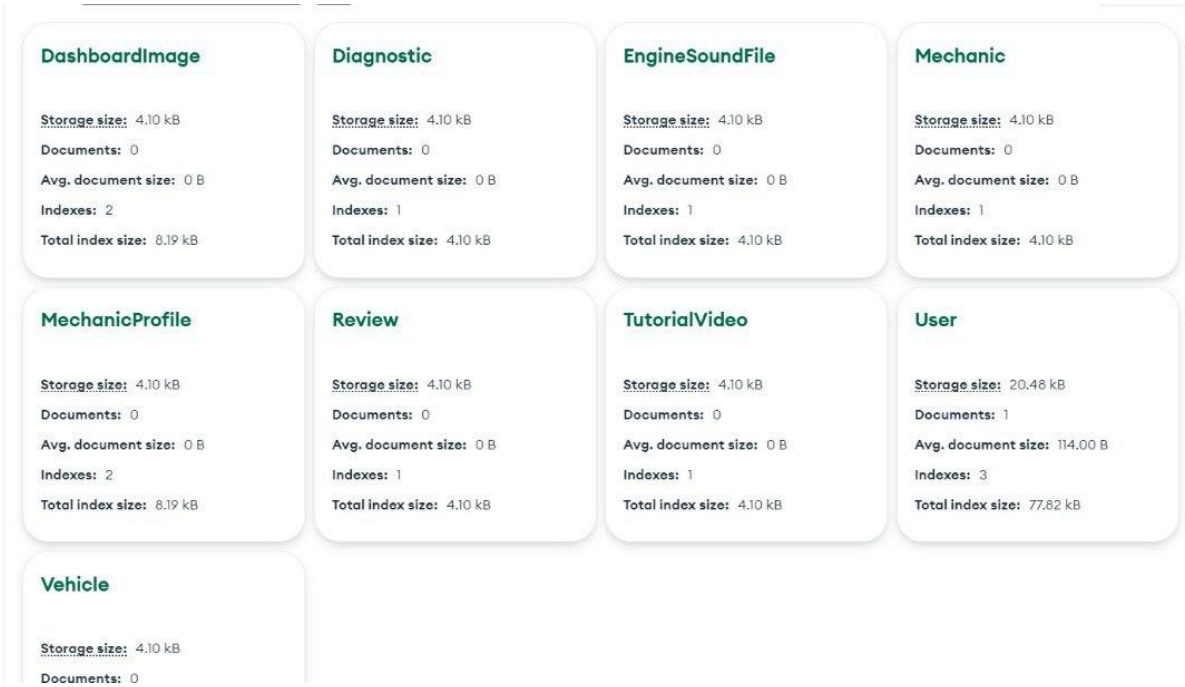
This project uses Prisma ORM with MongoDB as the database. The schema is defined in a schema prisma and models the relationships between users, users' vehicles, diagnostics, media files, reviews, and tutorial videos.

4.1 Key Concepts

- **User Roles:** There are two main user roles: `car_owner` and `mechanic`
- **User:** Stores user details, authentication info, and relations to vehicles, uploaded media, reviews, and mechanic profile.
- **MechanicProfile:** Contains additional info for users who are mechanics (experience, specialization, etc.).
- **Vehicle:** Represents a car owned by a user, with a relation to diagnostics performed on it.
- **DashboardImage & EngineSoundFile:** Media files uploaded by users for diagnostic purposes, each linked to the uploading user and related diagnostics.
- **Review:** Users can write reviews for diagnostics, with each review linked to a user and a diagnostic.
- **TutorialVideo:** Stores YouTube video url or other tutorial videos related to specific diagnostics and faults.
- **Diagnostic:** Central model representing a diagnostic event, linking to a vehicle, optional dashboard image and engine sound, reviews, and tutorial videos.

4.2 Relationships

- **User ↔ Vehicle:** One-to-many (a user can own multiple vehicles).
- **User ↔ DashboardImage/EngineSoundFile:** One-to-many (a user can upload multiple images/sounds).
- **User ↔ Review:** One-to-many (a user can write multiple reviews).
- **User ↔ MechanicProfile:** One-to-one (if the user is a mechanic).
- **Vehicle ↔ Diagnostic:** One-to-many (a vehicle can have multiple diagnostics).
- **DashboardImage/EngineSoundFile ↔ Diagnostic:** One-to-many (a media file can be used in multiple diagnostics).
- **Diagnostic ↔ Review/TutorialVideo:** One-to-many (a diagnostic can have multiple reviews and tutorial videos).



4.3 Implementation Notes

- All models use MongoDB's ObjectId as the primary key.
- Relations are explicitly defined using Prisma's `@relation` attribute.
- The schema supports advanced queries and population of related data via Prisma Client.
- The design supports extensibility for new media types, diagnostic methods, or user roles.

4.4 File Reference

- **Prisma schema:** `prisma/schema.prisma`
- **Generated Prisma Client:** Used in `src/routes.ts` and controllers for all DB operations.

4.5 Example Entity Flow

1. A user (car owner) uploads a dashboard image or engine sound.
2. The system creates a `DashboardImage` or `EngineSoundFile` record linked to the user.
3. A `Diagnostic` is created, referencing the vehicle, uploaded media, and storing the diagnosis result.
4. The user (or mechanic) can add a `Review` for the diagnostic.
5. The system can link relevant `TutorialVideo` records to the diagnostic for user guidance.

5. Backend Implementation

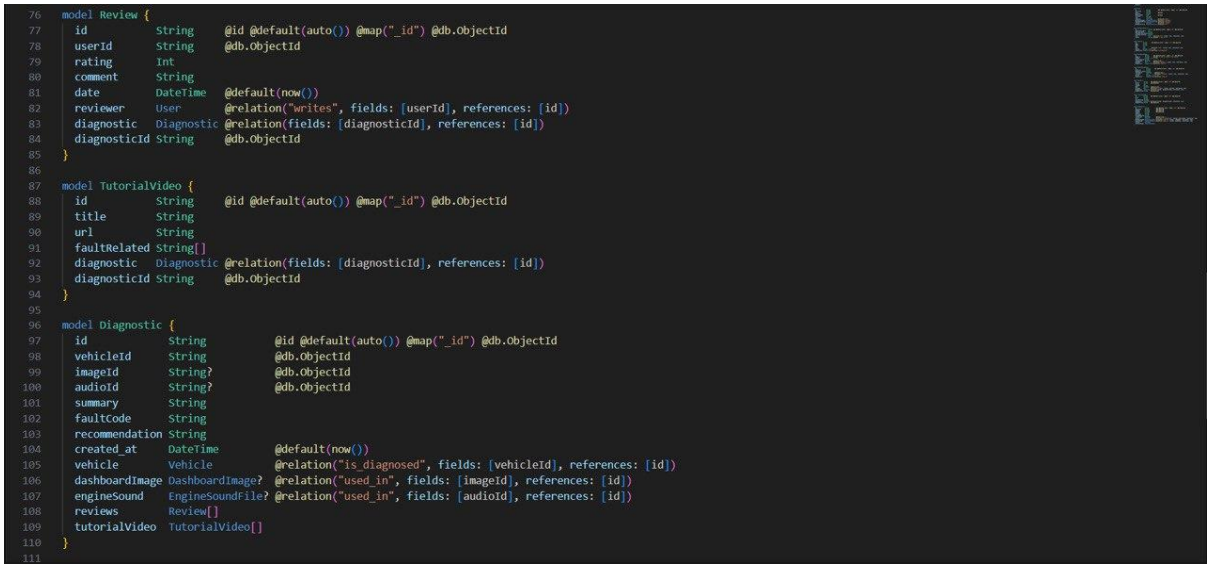
This backend is built with Node.js, Express, TypeScript, and uses Prisma ORM to interact with a MongoDB database. It powers the CarCare car fault diagnosis system, providing RESTful API endpoints for user management, vehicle and diagnostic data, media uploads, reviews, and AI-powered car fault diagnosis.

5.1 Key Technologies

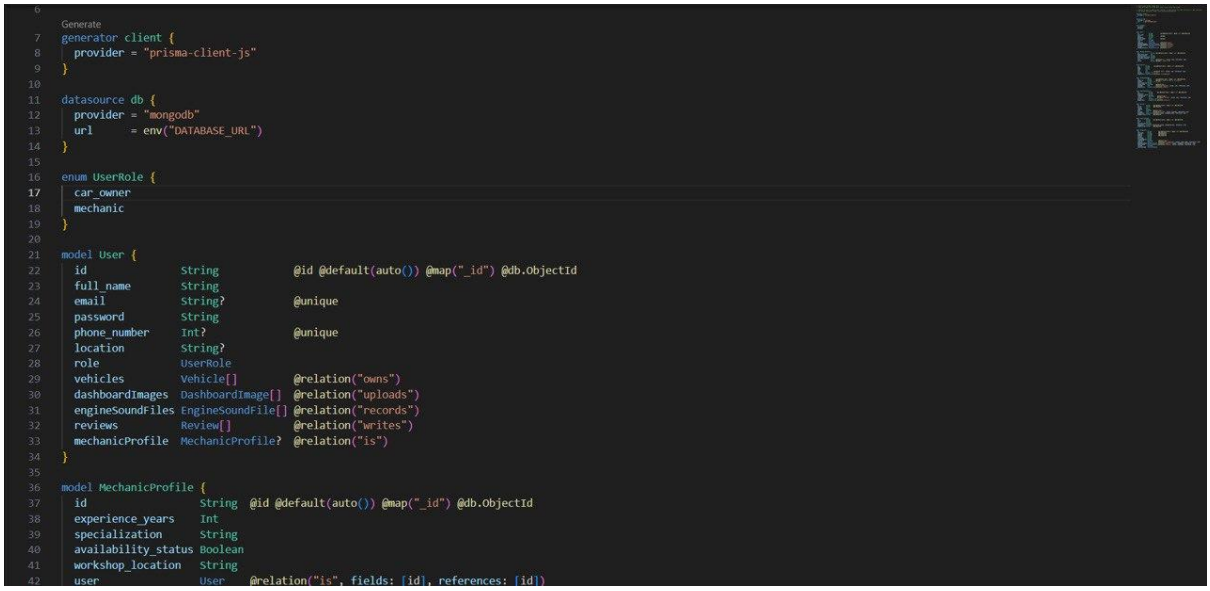
- **Node.js & Express:** For building scalable REST APIs.
- **TypeScript:** For type safety and maintainability.
- **Prisma ORM:** For database modeling and queries (MongoDB as the database).

- **Mongoose (optional):** Alternative routes provided for direct MongoDB access.
- **Swagger:** For API documentation and testing.
- **Multer:** For handling file uploads (dashboard images, engine sounds).
- **JWT & bcryptjs:** For authentication and password security.
- **Axios:** For calling external APIs (AI diagnosis, YouTube search).

```
model Vehicle {
  id          String       @id @default(auto()) @map("_id") @db.ObjectId
  make        String
  model       String
  year        Int
  user        User         @relation("owns", fields: [id], references: [id])
  userId      String // FK to User
  diagnostics Diagnostic[] @relation("is_diagnosed")
}

model DashboardImage {
  id             String       @id @default(auto()) @map("_id") @db.ObjectId
  image_id       String       @unique // UUID as shown in ER diagram
  userId         String // FK to User
  fault_detected String
  upload_date    DateTime     @default(now())
  uploader       User         @relation("uploads", fields: [id], references: [id])
  diagnostics    Diagnostic[] @relation("used_in")
}

model EngineSoundFile {
  id              String       @id @default(auto()) @map("_id") @db.ObjectId
  audio_url       String
  diagnosis_result String
  recorded_at     DateTime     @default(now())
  recorder        User         @relation("records", fields: [id], references: [id])
  userId          String // FK to User
  diagnostics     Diagnostic[] @relation("used_in")
}

model Review {
  id          String     @id @default(auto()) @map("_id") @db.ObjectId
  userId      String     @db.ObjectId
  rating      Int
  comment     String
```



```
model Review {
  id          String     @id @default(auto()) @map("_id") @db.ObjectId
  userId      String     @db.ObjectId
  rating      Int
  comment     String
  date        DateTime   @default(now())
  reviewer    User       @relation("writes", fields: [userId], references: [id])
  diagnostic  Diagnostic @relation(fields: [diagnosticId], references: [id])
  diagnosticId String    @db.ObjectId
}

model TutorialVideo {
  id          String     @id @default(auto()) @map("_id") @db.ObjectId
  title       String
  url         String
  faultRelated String[]
  diagnostic  Diagnostic @relation(fields: [diagnosticId], references: [id])
  diagnosticId String    @db.ObjectId
}

model Diagnostic {
  id             String           @id @default(auto()) @map("_id") @db.ObjectId
  vehicleId      String           @db.ObjectId
  imageId        String?          @db.ObjectId
  audioId        String?          @db.ObjectId
  summary        String
  faultCode      String
  recommendation String
  created_at     DateTime         @default(now())
  vehicle        Vehicle          @relation("is_diagnosed", fields: [vehicleId], references: [id])
  dashboardImage DashboardImage?  @relation("used_in", fields: [imageId], references: [id])
  engineSound    EngineSoundFile? @relation("used_in", fields: [audioId], references: [id])
  reviews        Review[]
  tutorialVideo  TutorialVideo[]
}
```



```
Generate
generator client {
  provider = "prisma-client-js"
}

datasource db {
  provider = "mongodb"
  url      = env("DATABASE_URL")
}

enum UserRole {
  car_owner
  mechanic
}

model User {
  id               String           @id @default(auto()) @map("_id") @db.ObjectId
  full_name        String
  email            String?          @unique
  password         String
  phone_number     Int?             @unique
  location         String?
  role             UserRole
  vehicles         Vehicle[]        @relation("owns")
  dashboardImages  DashboardImage[] @relation("uploads")
  engineSoundFiles EngineSoundFile[] @relation("records")
  reviews          Review[]         @relation("writes")
  mechanicProfile  MechanicProfile? @relation("is")
}

model MechanicProfile {
  id                String  @id @default(auto()) @map("_id") @db.ObjectId
  experience_years  Int
  specialization    String
  availability_status Boolean
  workshop_location String
  user              User    @relation("is", fields: [id], references: [id])
```

5.2 Project Structure

- `src/index.ts` — Main server entry point, Express app setup, Swagger docs, and DB connection.
- `src/routes.ts` — Main API routes using Prisma.
- `src/routes.mongoose.ts` — Alternative API routes using Mongoose.
- `src/swagger.ts` — Swagger documentation setup.
- `prisma/schema.prisma` — Prisma schema defining all models and relationships.
- `DATABASE.md` — Database design and relationship documentation.

6. Database Connection

6.1 Prisma:

- The connection string is set in `.env` as `DATABASE_URL` (must be a valid MongoDB URI).

- Prisma Client is initialized in `src/index.ts` and used in all controllers/routes for DB operations.

6.2 Main Features

- **User Authentication:** Signup/login with JWT, password hashing with bcryptjs.

- **Role-based Users:** Car owners and mechanics, with mechanic profiles.

- **Vehicle Management:** CRUD for vehicles owned by users.

- **Media Uploads:** Dashboard images and engine sound files, linked to users and diagnostics.

- **Diagnostics:** Central model linking vehicles, media, reviews, and tutorial videos.

- **AI Diagnosis:** `/diagnose` endpoint accepts image/sound, calls external AI APIs, and returns a diagnosis.

- **YouTube Integration:** After diagnosis, the system searches YouTube for a relevant tutorial and returns the video URL.

- **Reviews & Tutorials:** Users can review diagnostics and view related tutorial videos.

- **Swagger Docs:** All endpoints are documented and testable at `/api-docs`.
- All database models and relationships are defined in `prisma/schema.prisma`.
- The backend is modular and can be extended with new features or endpoints as needed.