P4 Database Schema Implementation

Topic: EV Charging Station Management System

Team Project Submission
Course: Data mgt and Database Design
Northeastern University

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We follow the Professor's feedback and update our P3 and P4 parts.

OUR GitHub URL is below (public repo):
https://github.com/starsbro/DAMG6210_Group02

Below is the link of P4 ERD (Normalization)
https://drive.google.com/file/d/10AXvbb2af887WFozj-uPeNUp0paKF7M4/view?usp=sharing

The Script upload in GitHub.

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1. Scope

The scope of this phase (P4) is to transition the Logical ERD from Project P3 into its Physical implementation in Microsoft SQL Server. This includes defining all DDL statements for tables, constraints, relationships, and enforcing data integrity rules, along with a comprehensive INSERT script providing at least ten records per table.

2. Professor's Comments from P3

The following feedback was provided by the professor based on the P3 Logical ERD submission: No data types had been included in the P3 logical model. The model could be further normalized to Third Normal Form (3NF). Attributes such as user name, operator name, and technician name could be generalized into a single entity. For the charging session, it was suggested to include information about the vehicle that was charged. These comments guided the refinement and improvement of the physical model in P4.

3. Key Changes from P3

In response to the professor's feedback, the following major enhancements were made in P4: All entities were implemented in SQL Server with appropriate and consistent data types. The model was normalized to 3NF by introducing a generalized **Person** entity, from which **User**, **Operator**, and **Technician** are derived as subtypes. The **Charging_Session** table now includes a foreign key to **Vehicle** to capture the specific vehicle used during charging. Three **ON DELETE CASCADE** constraints were added in meaningful locations to ensure referential integrity upon deletion. CHECK constraints were applied to enforce valid domain values (e.g., station hours, connector type, payment method type). A unique constraint enforces a 1:1 relationship between **Invoice** and **Charging_Session**. All tables include IDENTITY-based primary keys for automatic record generation. INSERT scripts now populate each table with ten realistic rows for testing.

4. Entities and Foreign Key Relationships

The physical model contains 21 entities organized into core, subtype, and associative tables. All relationships are enforced with foreign keys, and cascading actions were applied only where logical in real-world scenarios. The major relationships include:

Child Table	Parent Table	Foreign Key	Action
Charge_Point	Station	station_id	Standard FK
Payment	Invoice	invoice_id	Standard FK
Technician_Skill	Technician	technician_id	Standard FK
Invoice	Address	billing_address_id	Standard FK
Vehicle	User	user_id	Standard FK
Operator	Station	station_id	Standard FK
User_Subscription	Subscription_Plan	plan_id	Standard FK
Charging_Session	Vehicle	vehicle_id	Standard FK
Maintenance_Record	Charge_Point	charge_point_id	Standard FK
Notification	Payment	payment_id	Standard FK

5. Relationship Confirmation

Referential integrity has been validated for all foreign keys. Cascading deletions ensure dependent records are automatically removed where appropriate, while optional relationships (such as the invoice billing address) use ON DELETE SET NULL to preserve flexibility.

6. Integrity and Normalization

The final schema adheres to Third Normal Form (3NF), ensuring no repeating groups, partial dependencies, or transitive dependencies. Surrogate primary keys (IDENTITY) maintain uniqueness and stability. CHECK constraints were strategically implemented to enforce logical and domain rules across tables.

7. Assumptions

Each person may have multiple addresses (Home, Work, Billing). Each station has one unique address. Deleting a station deletes all charge points under it. Deleting a technician deletes related skill mappings. Each invoice corresponds to exactly one charging session. Billing address in an invoice is optional and set to NULL if removed.

8. Conclusion

The P4 physical model fully addresses the feedback from P3 by incorporating data types, normalizing the schema to 3NF, and establishing a unified person structure. It enforces robust referential integrity and provides realistic test data for all entities, making the database implementation ready for production use and application integration.