CS4.301: Data and Applications

Project Phase 3

Relational Model and Normalization

The Olympian Codex

Team 42: RNA

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Explanation: ER-to-Relational Model Mapping

The conceptual Entity-Relationship (ER) model from Phase 2 was converted to a logical Relational Model by applying the standard 7-step mapping algorithm. This process resulted in the creation of 19 distinct relations (tables) to logically represent the data and its relationships.

The key transformations were as follows:

- **Strong Entities:** All strong entities (`God`, `Demigod`, `Monster`, `Prophecy`, `Quest`, `Divine_Artifact`) were mapped directly to their own tables, with their primary keys and simple attributes becoming columns.
- **Composite Attributes:** The composite `Name` attribute in the `Demigod` entity was split into two atomic columns: `First_Name` and `Last_Name`.
- **Multi-valued Attributes:** All multi-valued attributes (`Known_Abilities`, `Known_Weaknesses`, `Common_Habitats`, `Magical_Properties`) were removed from their parent tables and mapped to new, separate relations to satisfy 1NF.
- **Weak Entities:** The weak entities `Quest_Log` and `Sighting_Log` were mapped to their own tables. Their primary keys are composite keys formed from the foreign key(s) of their owner(s) and their own partial key (discriminator).
- **M:N Relationships:** All many-to-many relationships (`Encounters`, `Combat_Encounter`, `Rescue_Mission`) were mapped to new junction tables. Their primary keys are composite keys formed from the foreign keys of the participating entities.
- **Subclass Hierarchies:** The `God` and `Monster` subclass hierarchies were mapped using the *specialization* approach, creating separate tables for each subclass (`Olympian`, `Titan`, etc.) where the primary key is also a foreign key referencing the superclass table. Redundant `Type` columns were also included in the superclass tables at this stage.

The resulting relational model snapshot is presented below.

Snapshot: Initial Relational Model

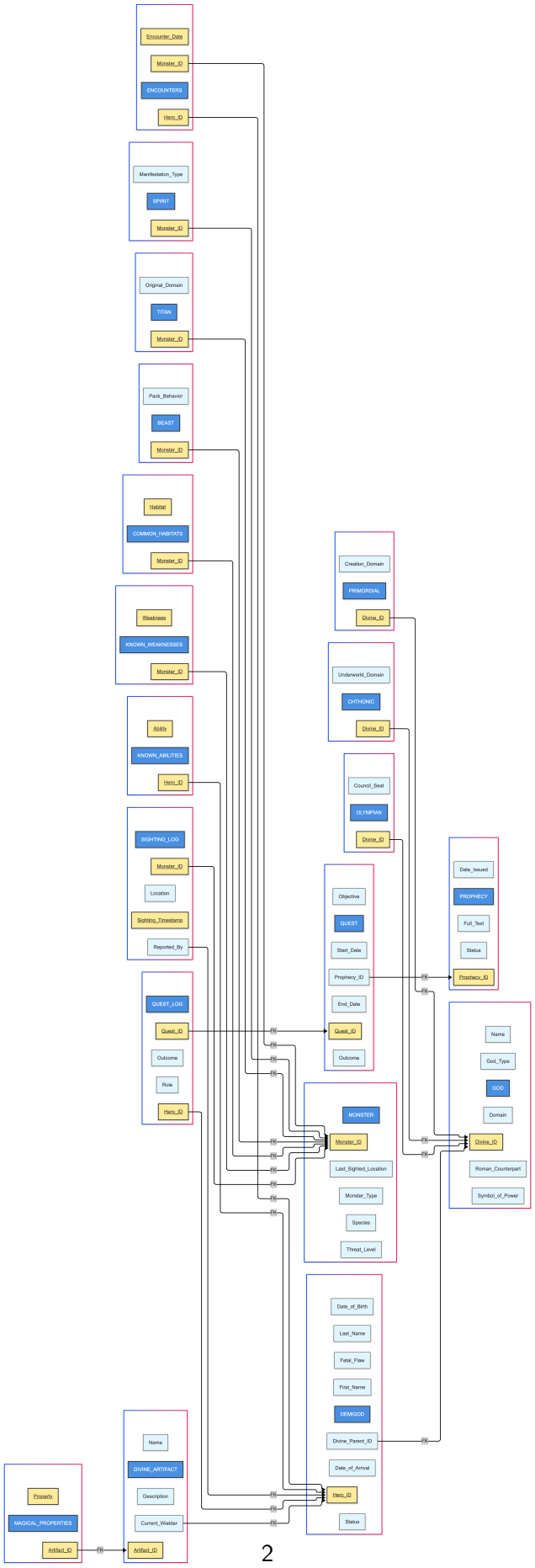

Figure 1: The initial relational model after mapping from the ER diagram.

View-Only Link:
https://www.mermaidchart.com/d/5f857519-fdb6-4ea4-9684-bc3b72e7e6c7

Explanation: Conversion to First Normal Form (1NF)

No changes were required to convert the initial relational model to the First Normal Form (1NF).

The standard ER-to-Relational mapping algorithm, when correctly applied, inherently produces a model that is already in 1NF.

- All attributes in the model are atomic.
- The composite attribute `Name` was preemptively split into `First_Name` and `Last_Name`.
- All multi-valued attributes (e.g., `Known_Abilities`, `Known_Weaknesses`, `Common_Habitats`, `Magical_Propert` were removed from their parent entities and placed in separate relations.

As a result, every column in every table contains only a single, atomic value, which satisfies the definition of 1NF. Therefore, the snapshot for 1NF is identical to the initial relational model snapshot.

Explanation: Conversion to Second Normal Form (2NF)

No changes were required to convert the 1NF model to the Second Normal Form (2NF).

The model is already in 2NF. The 2NF rule requires that all non-key attributes must be fully functionally dependent on the *entire* composite primary key. This rule is only applicable to relations with a composite primary key.

An analysis of the relations in our model confirms this:

- In the `Quest_Log` relation, the primary key is (`Hero_ID`, `Quest_ID`). The non-key attributes `Role` and `Outcome` are dependent on the entire key (a hero's role is specific to a particular quest), not on just a part of it.
- In the `Sighting_Log` relation, the primary key is (`Monster_ID`, `Sighting_Timestamp`). The non-key attributes `Location` and `Reported_By` are dependent on the entire key (a specific location for a specific monster at a specific time).
- All other relations with composite primary keys (e.g., `Known_Abilities`, `Encounters`, `Combat_Encounter`) have no non-key attributes and therefore trivially satisfy 2NF.

Since no partial dependencies exist in the model, it is already in 2NF.

Explanation: Conversion to Third Normal Form (3NF)

Changes were required to convert the 2NF model to the Third Normal Form (3NF).

The 3NF rule requires that the model must not contain any transitive dependencies (where a non-key attribute is dependent on another non-key attribute). The normalization process at this stage also provides an opportunity to resolve data anomalies identified in Phase 2 of the project.

The following changes were made:

- **Transitive Dependency Removed:** The attribute `Last_Sighted_Location` was removed from the `Monster` relation. This attribute was transitively dependent on the `Sighting_Timestamp` in the `Sighting_Log` relation, not on the `Monster`'s primary key (`Monster_ID`). This dependency was the source of the update anomaly identified in Phase 2. The information can be derived at query-time from the `Sighting_Log`.

- **Redundant Data Removed:** The attributes `God_Type` and `Monster_Type` were removed from the `God` and `Monster` relations, respectively. This information was redundant, as it is implicitly represented by the existence of a corresponding record in one of the subclass tables (e.g., `Olympian`, `Titan`).
- **Anomalies Resolved:** To resolve the insertion and deletion anomalies identified in Phase 2, the `Divine_Parent_ID` foreign key in the `Demigod` table was altered to be `NULLABLE`. This change allows for new, unclaimed demigods to be inserted into the database (resolving the insertion anomaly) and permits the referential integrity constraint `ON DELETE SET NULL` to be applied, which preserves demigod records if their parent `God` record is deleted (resolving the deletion anomaly).

The snapshot of the final 3NF model is presented below.

Snapshot: Third Normal Form (3NF) Relational Model

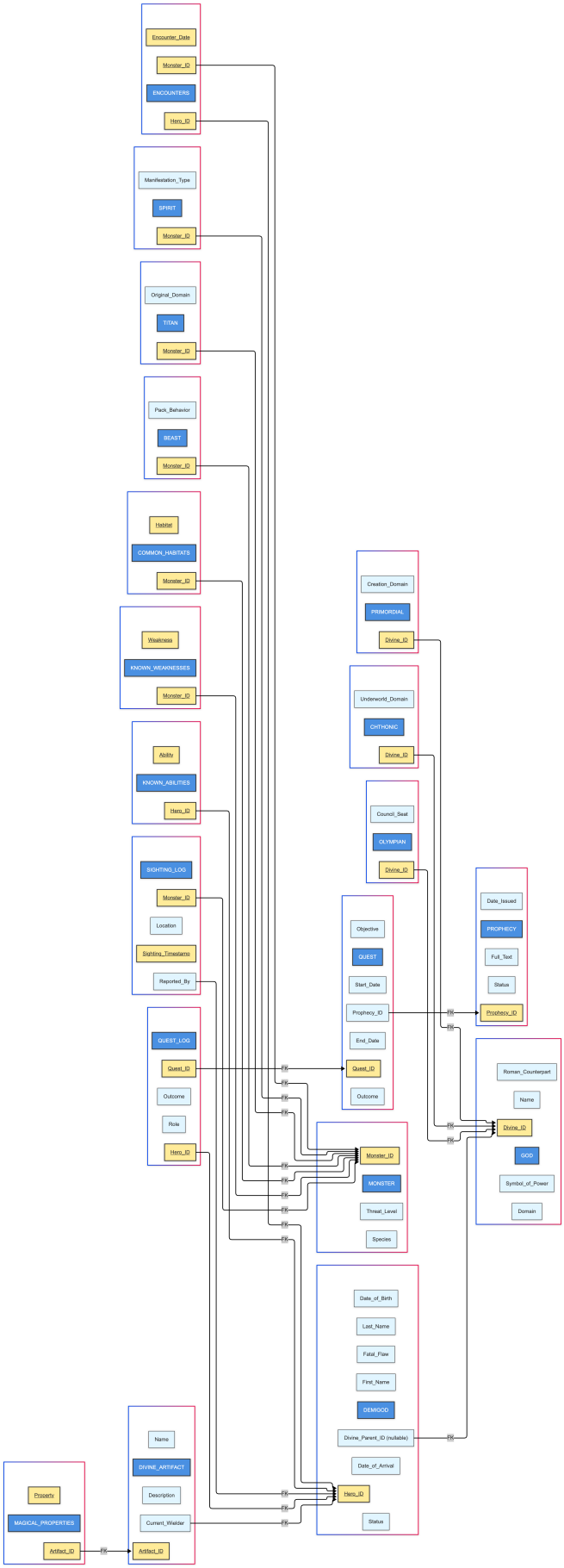

Figure 2: The final relational model after conversion to 3NF.

View-Only Link:
https://www.mermaidchart.com/d/40156222-f9b7-4489-8094-138c5951d12c