Project Phase 3

Aegis Intelligence Database (AID)

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1 Changes from Phase 2

Upon analyzing our EER diagram for the Phase 3 relational model, we identified the exclusive-or relationship on the TERRITORY entity, which is controlled by either a FACTION or a CREW, but not both. As discussed in the textbook (Chapter 9) on EER-to-relational mapping, translating such a constraint requires a specific structure to uphold the rules of the relational model. A single `Controller_ID` column cannot be used, as this would violate referential integrity because a foreign key must reference a single, specific parent table. Therefore, to correctly implement this mapping, we have defined the TERRITORY table using two nullable foreign keys: `Faction_ID` (referencing FACTION) and `Crew_ID` (referencing CREW). This standard mapping technique allows the database to enforce full referential integrity.

However, it is important to note a practical limitation in our DBMS implementation: as MySQL does not support `CHECK` constraints on columns with `ON DELETE SET NULL`, we will be implementing the required XOR functionality (ensuring only one key is non-null) explicitly via the Application logic rather than at the database schema level.

Primary Key Simplification: Based on the business constraint that each island can be controlled by at most one entity (faction or crew), `Island_ID` alone serves as the primary key for TERRITORY. This eliminates the need for a composite key while uniquely identifying each territory record and maintaining data integrity.

2 ER-to-Relational Model Mapping

The conversion from our ER diagram to the relational model involved systematic transformations across all entity types and relationships.

2.1 Entity Type Transformations

Strong Entities: All regular entities (PERSON, CREW, FACTION, SHIP, ISLAND, SEA_REGION, DEVIL_FRUIT, EVENT, TERRITORY) were mapped directly to relations with their simple attributes. Composite attributes were decomposed: `Name` into `First_Name` and `Last_Name` in PERSON, and `Location` into `Latitude` and `Longitude` in ISLAND.

Weak Entities: BOUNTY_RECORD and LOG_ENTRY were mapped with composite primary keys combining their owner's primary key and their partial key: (`Person_ID`, `Record_Version`) and (`Ship_ID`, `Log_Timestamp`) respectively.

Subclasses: The ISA hierarchy was implemented using separate relations for PIRATE, MARINE_OFFICER, and CIVILIAN, each containing `Person_ID` as both primary key and foreign key to PERSON, along with subclass-specific attributes.

2.2 Relationship Mappings

1:1 Relationships: POSSESSES was mapped to a separate relation `DEVIL_FRUIT_POSSESSION` to avoid NULLs. IS_LEADER_OF was mapped by adding `Leader_ID` to FACTION (total participation side).

1:N Relationships: Foreign keys were added to the N-side: `Home_Island_ID` in PERSON, `Captain_ID` in SHIP, `Owning_Crew_ID` in SHIP, `Region_ID` in ISLAND. TERRITORY implements `Faction_ID` and `Crew_ID` with exclusive-or constraints.

M:N Relationships: Junction relations MEMBERSHIP and ALLEGIANCE were created with composite primary keys from participating entities.

N-ary Relationships: ENCOUNTER (4-ary) and INTELLIGENCE_REPORT (5-ary) were mapped to separate relations with composite primary keys formed from all participating entity keys.

Multi-valued Attributes: `Known_Abilities` was mapped to PERSON_ABILITIES relation with composite key (`Person_ID`, `Ability`).

Derived Attributes: `Age` and `Total_Bounty` are computed dynamically and not stored.

The final schema contains 23 relations maintaining referential integrity and enforcing all business rules through appropriate constraints.

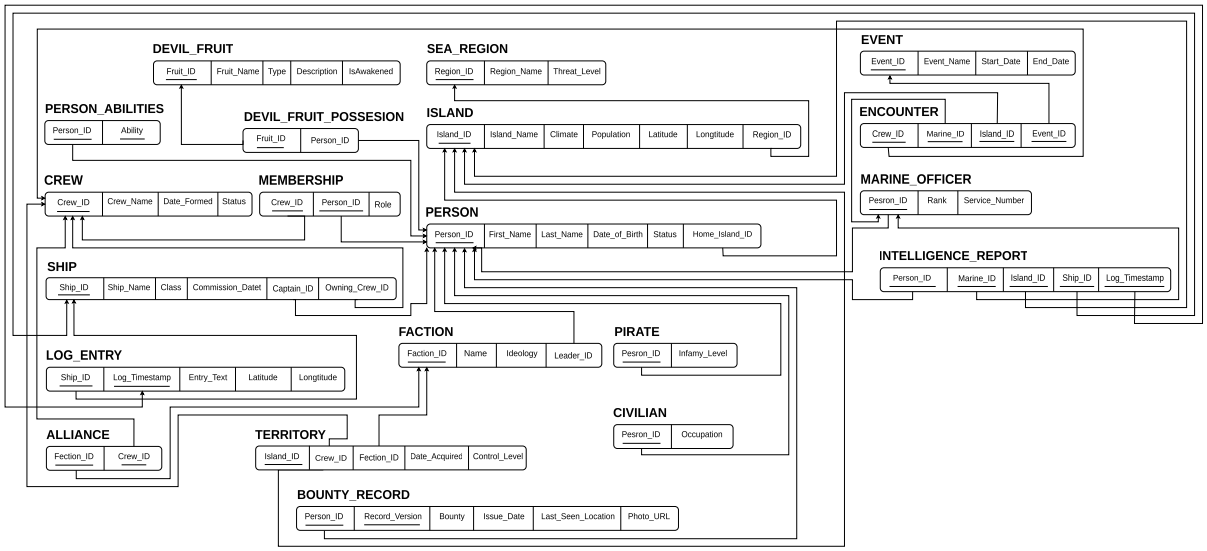

Figure 1: ER-to-Relational Mapping Diagram

Link to view Interactive Diagram

3 Conversion to First Normal Form (1NF)

First Normal Form requires that all attribute values must be atomic (indivisible) and that each attribute must contain only a single value from its domain. The 1NF prohibits multivalued attributes, composite attributes, and nested relations.

3.1 1NF Compliance Analysis

Our relational model already satisfies First Normal Form requirements. During the ER-to-relational mapping process (as per Chapter 9):

Step 6 - Multi-valued Attributes: The multi-valued attribute `Known_Abilities` from PERSON was mapped to a separate relation PERSON_ABILITIES with composite primary key (`Person_ID`, `Ability`), ensuring atomic values.

Step 1 - Composite Attributes: Composite attributes were decomposed into simple components: `Name` into `First_Name` and `Last_Name`, and `Location` into `Latitude` and `Longitude`.

Since there are no other multivalued or composite attributes remaining in the relational schema, and all attribute values are atomic, the model fully satisfies 1NF. No additional modifications were required.

4 Conversion to Second Normal Form (2NF)

Second Normal Form requires that a relation must be in 1NF and have no partial dependencies—that is, no non-prime attribute should be functionally dependent on only a proper subset of any candidate key. This constraint is only relevant for relations with composite primary keys.

4.1 2NF Compliance Analysis

Our relational model already satisfies Second Normal Form. Analysis of all relations reveals:

Relations with Single-Attribute Primary Keys: All strong entity relations (PERSON, CREW, FACTION, SHIP, ISLAND, SEA_REGION, DEVIL_FRUIT, EVENT, TERRITORY) and subclass relations (PIRATE, MARINE_OFFICER, CIVILIAN) have single-attribute primary keys and thus trivially satisfy 2NF, as partial dependencies cannot exist without composite keys.

Relations with Composite Primary Keys:

- **BOUNTY_RECORD** (Person_ID, Record_Version): All non-key attributes (Bounty, Issue_Date, Last_Seen_Location, Photo_URL) depend on the complete composite key, not on Person_ID or Record_Version alone.
- **LOG_ENTRY** (Ship_ID, Log_Timestamp): All non-key attributes (Entry_Text, Latitude, Longitude) depend on the full composite key.

- **MEMBERSHIP** (Person_ID, Crew_ID, Role): The Role attribute depends on the complete composite key (Person_ID, Crew_ID) as a person can have different roles in different crews. The same person in Crew A might be a "Navigator" while in Crew B they might be a "Doctor," demonstrating that Role is fully functionally dependent on both Person_ID and Crew_ID together, not on either alone.
- **Other Junction Relations** (ALLEGIANCE, PERSON_ABILITIES, ENCOUNTER, INTELLIGENCE_REPORT, DEVIL_FRUIT_POSSESSION): These contain no non-key attributes beyond the foreign keys forming the primary key, eliminating any possibility of partial dependencies.

Since no partial dependencies exist in any relation, the schema is already in 2NF. No decomposition or modifications were necessary.

5 Conversion to Third Normal Form (3NF)

Third Normal Form requires that a relation must be in 2NF and have no transitive dependencies—that is, no non-prime attribute should be functionally dependent on another non-prime attribute.

5.1 3NF Compliance Analysis

Our relational model already satisfies Third Normal Form. Analysis of all relations reveals no transitive dependencies:

Strong Entity Relations: In relations such as PERSON, CREW, FACTION, SHIP, ISLAND, SEA_REGION, DEVIL_FRUIT, and EVENT, all non-key attributes are directly dependent on the primary key with no intermediary non-prime attributes determining other attributes. For example, in ISLAND, attributes like Climate and Population are properties of the specific island, not derived through another non-key attribute. Similarly, in FACTION, the Ideology attribute is specific to each faction and does not transitively depend on other non-key attributes.

Weak Entities and Relationship Relations: BOUNTY_RECORD and LOG_ENTRY contain non-key attributes that directly describe the entity identified by the composite key, with no transitive paths. The MEMBERSHIP relation contains the Role attribute, which is directly dependent on the (Person_ID, Crew_ID) composite key and does not depend on any other non-key attributes. Other junction relations (ALLEGIANCE, ENCOUNTER, INTELLIGENCE_REPORT) consist primarily of foreign keys with minimal or no additional attributes, eliminating any possibility of transitive dependencies.

Subclass Relations: PIRATE, MARINE_OFFICER, and CIVILIAN each contain only the primary key (Person_ID) and a single subclass-specific attribute, making transitive dependencies impossible.

Since no transitive dependencies exist in any relation, the schema is already in 3NF. No further normalization was required.