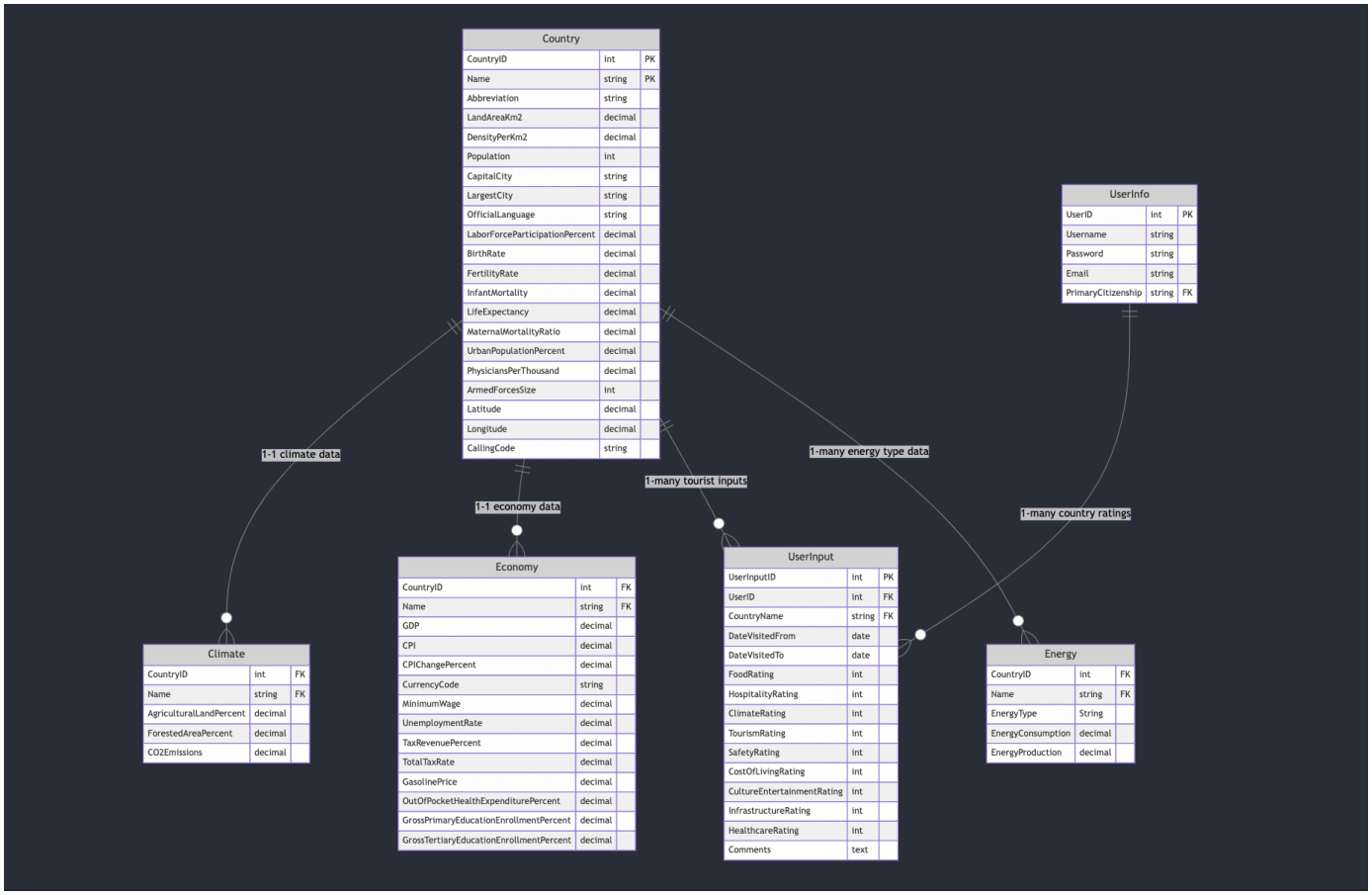
Country Pollution App Conceptual and Logical Database Design

Entity-Relationship Diagram (ERD)



ER Diagram Description

The Entity-Relationship Diagram (ERD) for the Country Pollution App consists of six entities:

1. **Country**
2. **Climate**
3. **Economy**
4. **Energy**
5. **UserInfo**
6. **UserInput**

There are 5 total relationships between these entities (between 2 types):

- **Country** has a **1-to-1** relationship with **Climate**.
- **Country** has a **1-to-1** relationship with **Economy**.
- **Country** has a **1-to-many** relationship with **Energy**.
- **UserInfo** has a **1-to-many** relationship with **UserInput**.
- **Country** has a **1-to-many** relationship with **UserInput**.

Assumptions and Explanations

1. Country

- **Assumptions:**
  - Each country is uniquely identified by a CountryID.
  - A country's Name is also unique and can serve as another primary key.
  - Attributes like Population, CapitalCity, and OfficialLanguage are properties that describe the demographics and geographic information about the country.
- **Explanation:**
  - The Country entity is central to the application as it represents the primary subject of analysis.
  - We modeled Country as an entity to encapsulate all country-specific data in one place.
  - Attributes were chosen for users to learn facts about the country they're analyzing

2. Climate

- **Assumptions:**
  - Each country has one set of climate data.
  - Climate data includes metrics like AgriculturalLandPercent, ForestedAreaPercent, and CO2Emissions.
- **Explanation:**
  - Climate is modeled as a separate entity to manage the most up-to-date climate-related attributes, which are substantial and may change over time.
  - The 1-to-1 relationship with Country reflects that each country has a unique climate profile.

3. Economy

- **Assumptions:**
  - Each country has one set of economic data.
  - Economic data includes indicators like GDP, CPI, and UnemploymentRate.
- **Explanation:**
  - Similar to Climate, Economy is a separate entity to handle economic attributes efficiently.
  - The 1-to-1 relationship ensures that each country's economic data is directly linked to it.

4. Energy

- **Assumptions:**
    - A country can have multiple energy sources (natural gas, coal, solar, hydro, etc.).
    - Each energy source has specific data like EnergyType, EnergyConsumption, and EnergyProduction.
- **Explanation:**
    - Energy is modeled as an entity to accommodate multiple energy records per country.
    - This design avoids data redundancy and allows for detailed energy data management.
    - The 1-to-many relationship with Country shows that a country can have multiple energy sources.

5. UserInfo

- **Assumptions:**
    - Each user is uniquely identified by a UserID.
    - Users have attributes like Username, Email, and PrimaryCitizenship.
- **Explanation:**
    - UserInfo is the sole entity representing user accounts, adhering to the project requirement of having at most one user entity.
    - It stores essential user information for authentication and personalization.

6. UserInput

- **Assumptions:**
    - Users can provide multiple inputs or ratings for different countries.
    - Each input includes ratings on various aspects like FoodRating, SafetyRating, and Comments.
- **Explanation:**
    - UserInput captures user-generated content, crucial for the application's interactive features.
    - The 1-to-many relationship with UserInfo allows users to submit multiple inputs.
    - The 1-to-many relationship with Country enables aggregation of inputs for each country.

Relationships and Cardinality

Country to Climate (1-to-1)

- **Assumptions:**
    - Each country has one unique set of climate data.
- **Explanation:**
    - This relationship ensures that climate data is directly associated with its respective country without duplication.

Country to Economy (1-to-1)

- **Assumptions:**

    - Each country has one unique set of economic data.
- **Explanation:**
    - Economic data is specific to a country and doesn't vary per user, justifying the 1-to-1 relationship.

Country to Energy (1-to-many)

- **Assumptions:**
    - A country can have multiple energy sources.
- **Explanation:**
    - The 1-to-many relationship allows for multiple energy records (different energy sources) linked to a single country.

UserInfo to UserInput (1-to-many)

- **Assumptions:**
    - A user can submit multiple inputs for the same or different countries.
- **Explanation:**
    - This relationship enables users to provide numerous ratings and feedback entries over time.

Country to UserInput (1-to-many)

- **Assumptions:**
    - A country can have multiple inputs from different users.
- **Explanation:**
    - Aggregates user inputs for a country, facilitating collective analysis and integration of user feedback.

Normalization

To ensure data integrity and eliminate redundancy, our database schema has been normalized. More specifically, we prove below that our normalization adheres to Boyce-Codd Normal Form (BCNF. To begin with, the Third Normal Form (3NF) is defined to have every non-prime attribute be fully functionally dependent on the primary key, with no transitive dependencies. BCNF reinforces this a step further by requiring that for every non-trivial functional dependency, the determinant must be a superkey.

First Normal Form (1NF)

- **Definition:** A table is in 1NF if all its attributes are atomic;, meaning each attribute contains only indivisible values, and there are no repeating groups or arrays.
- **Application to Our Schema:**
    - **All attributes are atomic:** Each attribute in every table holds a single value.
    - **No repeating groups:** There are no arrays or lists within any attribute.
- All entities in our schema meet 1NF.

Second Normal Form (2NF)

- **Definition:** A table is in 2NF if it is in 1NF and all non-key attributes are fully functionally dependent on the primary key.
- **Application to Our Schema:**
  - **Country:** Non-key attributes depend solely on CountryID.
  - **Climate:** Attributes depend on CountryID.
  - **Economy:** Attributes depend on CountryID.
  - **Energy:** Attributes depend on the composite key (CountryID, EnergyType).
  - **UserInfo:** Attributes depend on UserID.
  - **UserInput:** Attributes depend on UserInputID.
- All entities meet 2NF as there are no partial dependencies; non-key attributes depend on the entire primary key.

Third Normal Form (3NF)

- **Definition:** A table is in 3NF if it is in 2NF and all the attributes are dependent only on the primary key, not on any other non-key attributes (no transitive dependencies).
- **Application to Our Schema:**
  - **No transitive dependencies exist:**
    - **Country:** Attributes like CapitalCity and OfficialLanguage depend only on CountryID, not on other non-key attributes.
    - **Climate, Economy, Energy, UserInfo, UserInput:** All attributes are directly dependent on their respective primary keys.
- All tables are in 3NF as every non-key attribute is directly dependent only on the primary key.

Boyce-Codd Normal Form (BCNF)

- **Definition:** A table is in BCNF if it is in 3NF and, for every non-trivial functional dependency $X \rightarrow Y$ is a superkey, meaning X is either a candidate key or a superset of a candidate key.
- **Application to Our Schema:**
  - **Country:**
    - **Determinants:** CountryID, Abbreviation, Name (assuming Abbreviation and Name are unique).
    - **Functional Dependencies:** All non-key attributes are functionally dependent on superkeys.
  - **Climate:**
    - **Determinant:** CountryID (primary key).
  - **Economy:**
    - **Determinant:** CountryID (primary key).
  - **Energy:**
    - **Determinant:** Composite key (CountryID, EnergyType).
  - **UserInfo:**
    - **Determinants:** UserID, Username, Email (assuming Username and Email are unique).

        - **UserInput:**
            - **Determinant:** UserInputID (primary key).
- Every determinant in the functional dependencies is a candidate key or a superkey. Thus, the schema adheres to BCNF.

Relational Schema

Country

```
Country(
   CountryID: INT [PK],
   Name: VARCHAR(100),
   Abbreviation: VARCHAR(10),
   LandAreaKm2: DECIMAL,
   DensityPerKm2: DECIMAL,
   Population: INT,
   CapitalCity: VARCHAR(100),
   LargestCity: VARCHAR(100),
   OfficialLanguage: VARCHAR(100),
   LaborForceParticipationPercent: DECIMAL,
   BirthRate: DECIMAL,
   FertilityRate: DECIMAL,
   InfantMortality: DECIMAL,
   LifeExpectancy: DECIMAL,
   MaternalMortalityRatio: DECIMAL,
   UrbanPopulationPercent: DECIMAL,
   PhysiciansPerThousand: DECIMAL,
   ArmedForcesSize: INT,
   Latitude: DECIMAL,
   Longitude: DECIMAL,
   CallingCode: VARCHAR(10)
)
```

Climate

```
Climate(
   CountryID: INT [PK, FK to Country.CountryID],
   AgriculturalLandPercent: DECIMAL,
   ForestedAreaPercent: DECIMAL,
   CO2Emissions: DECIMAL
)
```

Economy

Economy(
  CountryID: INT [PK, FK to Country.CountryID],
  GDP: DECIMAL,
  CPI: DECIMAL,
  CPIChangePercent: DECIMAL,
  CurrencyCode: VARCHAR(10),
  MinimumWage: DECIMAL,
  UnemploymentRate: DECIMAL,
  TaxRevenuePercent: DECIMAL,
  TotalTaxRate: DECIMAL,
  GasolinePrice: DECIMAL,
  OutOfPocketHealthExpenditurePercent: DECIMAL,
  GrossPrimaryEducationEnrollmentPercent: DECIMAL,
  GrossTertiaryEducationEnrollmentPercent: DECIMAL
)

Energy

Energy(
  CountryID: INT [FK to Country.CountryID],
  EnergyType: VARCHAR(50),
  EnergyConsumption: DECIMAL,
  EnergyProduction: DECIMAL,
  [PK: CountryID, EnergyType]
)

UserInfo

UserInfo(
  UserID: INT [PK],
  Username: VARCHAR(50),
  Password: VARCHAR(50),
  Email: VARCHAR(100),
  PrimaryCitizenshipID: INT [FK to Country.CountryID]
)

UserInput

UserInput(
  UserInputID: INT [PK],
  UserID: INT [FK to UserInfo.UserID],

```
    CountryID: INT [FK to Country.CountryID],
    DateVisitedFrom: DATE,
    DateVisitedTo: DATE,
    FoodRating: INT,
    HospitalityRating: INT,
    ClimateRating: INT,
    TourismRating: INT,
    SafetyRating: INT,
    CostOfLivingRating: INT,
    CultureEntertainmentRating: INT,
    InfrastructureRating: INT,
    HealthcareRating: INT,
    Comments: TEXT
)
```

Summary

- **Entities:** The database includes six entities—Country, Climate, Economy, Energy, UserInfo, and UserInput—each serving a specific purpose in the application.
- **Relationships:** The schema includes various relationships with cardinalities such as 1-to-1 and 1-to-many, satisfying the requirement of having at least two types of relationships.
- **Normalization:** The database schema is normalized to BCNF, ensuring minimal redundancy and optimal data integrity.
- **Relational Schema:** The logical design translates the conceptual ERD into a relational schema, formatted as per the specified guidelines.