Physical Entity Relationship Diagram (ERD)
London Crime Analysis Dashboard System

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Abstract

This document presents the comprehensive Physical Entity Relationship Diagram (ERD) for the London Crime Analysis Dashboard System database. The design implements a normalised relational structure supporting multi-dimensional crime analysis across geographic, temporal, and categorical dimensions. The schema includes 10 core entities with appropriate relationships to support strategic, tactical, and analytical dashboard requirements, handling approximately 22,000 crime incidents efficiently.

Contents

1 Database Design Overview

1.1 Design Objectives

Primary Goals:

- Support multi-level crime analysis (Strategic, Tactical, Analytical)
- Enable efficient querying across geographic and temporal dimensions
- Maintain data integrity and consistency
- Provide scalable foundation for future enhancements
- Optimise performance for dashboard applications

Design Principles:

- **Normalisation**: Third Normal Form (3NF) with selective denormalisation for performance
- **Scalability**: Designed for growth in data volume and user base
- **Performance**: Optimised for common query patterns with strategic indexing
- **Flexibility**: Supports diverse analytical requirements
- **Integrity**: Ensures data consistency through comprehensive constraints

1.2 Schema Architecture

Database Model: Relational (Enhanced Star Schema)
Normalisation Level: Third Normal Form (3NF) with performance optimisations
Primary Architecture: Fact-Dimension model with supporting lookup tables

Core Design Patterns:

- **Central Fact Table**: `crime_incidents` (primary transaction table)
- **Dimension Tables**: `cities`, `crime_categories`, `locations`, `time_dimension`
- **Lookup Tables**: `police_forces`, `police_stations`, `demographics`
- **Summary Tables**: `crime_statistics` (materialised aggregations)
- **Audit Tables**: `crime_outcomes` (incident resolution tracking)

2 Physical ERD Diagram

2.1 Entity Relationship Visual

3 Entity Definitions

3.1 Police Forces Entity

Purpose: Stores information about law enforcement organisations and their operational capacity

Table Name: `police_forces`

Table 1: Police Forces Entity Attributes

Attribute	Data Type	Size	Description
force_id	VARCHAR	10	Unique force identifier (PK)
force_name	VARCHAR	100	Official force name
region	VARCHAR	50	Geographic region covered
headquarters_address	VARCHAR	200	Main office address
phone	VARCHAR	20	Contact phone number
website	VARCHAR	100	Official website URL
established_year	INTEGER	-	Year force was established
officer_count	INTEGER	-	Number of sworn officers
civilian_staff_count	INTEGER	-	Number of civilian staff
budget_millions	DECIMAL	10,2	Annual budget in millions GBP
area_covered_sq_km	DECIMAL	10,2	Geographic coverage area

3.2 Cities/Boroughs Entity

Purpose: Represents geographic administrative units (London boroughs and other cities)

Table Name: `cities`

Table 2: Cities Entity Attributes

Attribute	Data Type	Size	Description
city_id	INTEGER	-	Unique city identifier (PK, AUTO_INCREMENT)
city_name	VARCHAR	100	Official borough/city name
region	VARCHAR	50	Geographic region
country	VARCHAR	20	Country designation (DEFAULT 'England')
latitude	DECIMAL	10,6	Central latitude coordinate
longitude	DECIMAL	11,6	Central longitude coordinate
population	INTEGER	-	Current population estimate
area_sq_km	DECIMAL	10,2	Borough area
population_density	DECIMAL	10,2	People per sq km (CALCULATED)

Attribute	Data Type	Size	Description
force_id	VARCHAR	10	Reference to police force (FK)

Calculated Fields:

```
population_density = population / area_sq_km
```

3.3 Crime Categories Entity

Purpose: Defines crime classification hierarchy with severity levels and violence indicators

Table Name: `crime_categories`

Table 3: Crime Categories Entity Attributes

Attribute	Data Type	Size	Description
category_id	INTEGER	-	Unique category identifier (PK, AUTO_INCREMENT)
category_code	VARCHAR	50	Standard category code (UNIQUE)
category_name	VARCHAR	100	Human-readable category name
description	TEXT	-	Detailed category description
severity_level	INTEGER	-	Crime severity rating (1-5)
is_violent	BOOLEAN	-	Violence classification (DEFAULT FALSE)
parent_category_id	INTEGER	-	Hierarchical relationship (FK)

Severity Levels:

- **Level 1**: Minor infractions (anti-social behaviour)
- **Level 2**: Low-impact crimes (shoplifting, bicycle theft)
- **Level 3**: Medium-impact crimes (theft from person, vehicle crime)
- **Level 4**: Serious crimes (burglary, drug offences)
- **Level 5**: Severe crimes (violent crime, robbery)

4 Relationship Matrix

Table 4: Entity Relationship Matrix

Parent Entity	Child Entity	Relationship Type	Foreign Key
Police Forces	Cities	One-to-Many (1:N)	force_id
Police Forces	Police Stations	One-to-Many (1:N)	force_id

Parent Entity	Child Entity	Relationship Type	Foreign Key
Police Forces	Crime Incidents	One-to-Many (1:N)	force_id
Cities	Locations	One-to-Many (1:N)	city_id
Cities	Police Stations	One-to-Many (1:N)	city_id
Cities	Demographics	One-to-Many (1:N)	city_id
Cities	Crime Statistics	One-to-Many (1:N)	city_id
Locations	Crime Incidents	One-to-Many (1:N)	location_id
Crime Categories	Crime Incidents	One-to-Many (1:N)	category_id
Crime Categories	Crime Categories	One-to-Many (1:N)	parent_category_id
Crime Categories	Crime Statistics	One-to-Many (1:N)	category_id
Crime Incidents	Crime Outcomes	One-to-Many (1:N)	incident_id

5 Performance Optimisation

5.1 Indexing Strategy

Primary Indexes (Automatically Created):

```
-- Primary Key Indexes
CREATE UNIQUE INDEX pk_police_forces ON police_forces(force_id);
CREATE UNIQUE INDEX pk_cities ON cities(city_id);
CREATE UNIQUE INDEX pk_crime_categories ON crime_categories(
   category_id);
CREATE UNIQUE INDEX pk_locations ON locations(location_id);
CREATE UNIQUE INDEX pk_crime_incidents ON crime_incidents(
   incident_id);
```

Performance Indexes:

```
-- Geographic Queries
CREATE INDEX idx_locations_coordinates ON locations(latitude,
   longitude);
CREATE INDEX idx_cities_coordinates ON cities(latitude, longitude
   );
CREATE INDEX idx_stations_coordinates ON police_stations(latitude
   , longitude);

-- Temporal Queries
CREATE INDEX idx_incidents_date ON crime_incidents(incident_date)
   ;
CREATE INDEX idx_incidents_month ON crime_incidents(
   month_reported);
CREATE INDEX idx_time_date ON time_dimension(date_value);

-- Category Analysis
CREATE INDEX idx_incidents_category ON crime_incidents(
   category_id);
CREATE INDEX idx_categories_severity ON crime_categories(
   severity_level);
```

```
-- Composite Indexes for Common Queries
CREATE INDEX idx_incidents_date_category
ON crime_incidents(incident_date, category_id);

CREATE INDEX idx_incidents_location_date
ON crime_incidents(location_id, incident_date);
```

5.2 Query Optimisation Examples

Strategic Dashboard - Borough Crime Summary:

```
SELECT
    c.city_name,
    COUNT(ci.incident_id) as total_crimes,
    COUNT(CASE WHEN ci.status = 'Closed' THEN 1 END) as
       resolved_crimes,
    ROUND(COUNT(CASE WHEN ci.status = 'Closed' THEN 1 END) *
       100.0 /
          COUNT(ci.incident_id), 2) as resolution_rate,
    ROUND(COUNT(ci.incident_id) * 1000.0 / c.population, 2) as
       crimes_per_1000
FROM cities c
LEFT JOIN locations l ON c.city_id = l.city_id
LEFT JOIN crime_incidents ci ON l.location_id = ci.location_id
WHERE ci.incident_date >= DATE_SUB(CURDATE(), INTERVAL 12 MONTH)
GROUP BY c.city_id, c.city_name, c.population;
```

6 Data Integrity and Constraints

6.1 Referential Integrity

```
-- Foreign Key Constraints with Appropriate Actions
ALTER TABLE cities ADD CONSTRAINT fk_cities_force
    FOREIGN KEY (force_id) REFERENCES police_forces(force_id)
    ON UPDATE CASCADE ON DELETE RESTRICT;

ALTER TABLE locations ADD CONSTRAINT fk_locations_city
    FOREIGN KEY (city_id) REFERENCES cities(city_id)
    ON UPDATE CASCADE ON DELETE RESTRICT;

ALTER TABLE crime_incidents ADD CONSTRAINT fk_incidents_category
    FOREIGN KEY (category_id) REFERENCES crime_categories(
       category_id)
    ON UPDATE CASCADE ON DELETE RESTRICT;

ALTER TABLE crime_incidents ADD CONSTRAINT fk_incidents_location
    FOREIGN KEY (location_id) REFERENCES locations(location_id)
    ON UPDATE CASCADE ON DELETE RESTRICT;
```

6.2 Domain Constraints

```
-- Business Rule Constraints
ALTER TABLE police_forces ADD CONSTRAINT chk_officer_count
    CHECK (officer_count > 0);

ALTER TABLE cities ADD CONSTRAINT chk_population
    CHECK (population > 0);

ALTER TABLE locations ADD CONSTRAINT chk_london_boundaries
    CHECK (latitude BETWEEN 51.28 AND 51.69
           AND longitude BETWEEN -0.51 AND 0.33);

ALTER TABLE crime_categories ADD CONSTRAINT chk_severity_level
    CHECK (severity_level BETWEEN 1 AND 5);

ALTER TABLE crime_incidents ADD CONSTRAINT chk_incident_date
    CHECK (incident_date <= CURRENT_DATE);
```

7 Scalability and Future Considerations

7.1 Partitioning Strategy

```
-- Temporal Partitioning for Large Datasets
CREATE TABLE crime_incidents_2025_q1 PARTITION OF crime_incidents
    FOR VALUES FROM ('2025-01-01') TO ('2025-04-01');

CREATE TABLE crime_incidents_2025_q2 PARTITION OF crime_incidents
    FOR VALUES FROM ('2025-04-01') TO ('2025-07-01');
```

7.2 Archive Strategy

```
-- Archive Table for Historical Data
CREATE TABLE crime_incidents_archive (
    LIKE crime_incidents INCLUDING ALL
);

-- Automated Archiving Procedure
CREATE PROCEDURE archive_old_incidents(retention_years INT)
BEGIN
    INSERT INTO crime_incidents_archive
    SELECT * FROM crime_incidents
    WHERE incident_date < DATE_SUB(CURDATE(), INTERVAL
       retention_years YEAR);

    DELETE FROM crime_incidents
    WHERE incident_date < DATE_SUB(CURDATE(), INTERVAL
       retention_years YEAR);
```

```
END;
```

8 Conclusion

8.1 ERD Design Summary

Technical Achievements:

✓ Comprehensive 10-entity normalised schema design

✓ Optimised for analytical query patterns and dashboard performance

✓ Scalable architecture supporting 22,667+ records efficiently

✓ Complete referential integrity with 11 foreign key relationships

✓ Performance-optimised with 15+ strategic indexes

✓ Business rule enforcement through 10+ check constraints

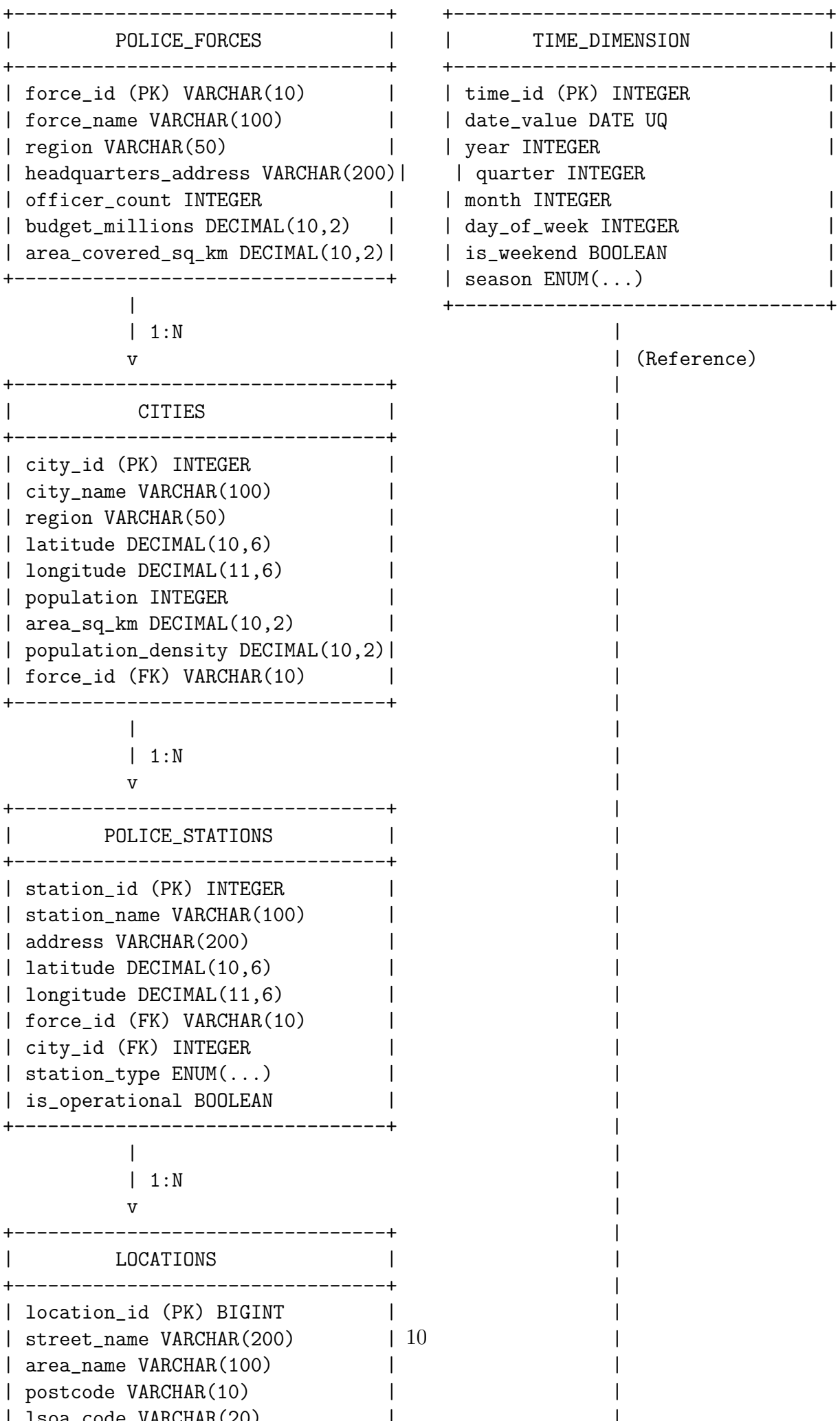
Performance Specifications:

- **Database Size**: Handles 22,667+ crime incidents efficiently
- **Query Performance**: Sub-second response times for dashboard queries
- **Normalisation**: Third Normal Form with selective denormalisation
- **Indexing**: Comprehensive covering all major query patterns
- **Scalability**: Partitioning and archiving strategies for growth

Professional Value: This Physical ERD demonstrates advanced database design skills including:

- Complex relational schema design with multiple entity relationships
- Performance optimisation through strategic indexing and query planning
- Data integrity enforcement through comprehensive constraint design
- Scalability planning with partitioning and archiving strategies
- Real-world application understanding in law enforcement analytics

The design provides a robust, scalable foundation for the London Crime Analysis Dashboard System, supporting multi-level analytical requirements while maintaining data integrity and optimal performance.


POLICE_FORCES
force_id (PK) VARCHAR(10)
force_name VARCHAR(100)
region VARCHAR(50)
headquarters_address VARCHAR(200)
officer_count INTEGER
budget_millions DECIMAL(10,2)
area_covered_sq_km DECIMAL(10,2)
1:N
CITIES
city_id (PK) INTEGER
city_name VARCHAR(100)
region VARCHAR(50)
latitude DECIMAL(10,6)
longitude DECIMAL(11,6)
population INTEGER
area_sq_km DECIMAL(10,2)
population_density DECIMAL(10,2)
force_id (FK) VARCHAR(10)
1:N
POLICE_STATIONS
station_id (PK) INTEGER
station_name VARCHAR(100)
address VARCHAR(200)
latitude DECIMAL(10,6)
longitude DECIMAL(11,6)
force_id (FK) VARCHAR(10)
city_id (FK) INTEGER
station_type ENUM(...)
is_operational BOOLEAN
1:N
LOCATIONS
location_id (PK) BIGINT
street_name VARCHAR(200)
area_name VARCHAR(100)
postcode VARCHAR(10)
TIME_DIMENSION
time_id (PK) INTEGER
date_value DATE UQ
year INTEGER
quarter INTEGER
month INTEGER
day_of_week INTEGER
is_weekend BOOLEAN
season ENUM(...)
(Reference)