Development of an Emergency Response Dashboard and Associated Infrastructure - Final Report (Group 2)

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December 2025

Contents

1 Objectives

1.1 Rationale behind the analysis

Effective emergency response is paramount to public safety, yet emergency services are often collected and monitored by disparate systems. Understanding trends and patterns across different jurisdictions and agencies can help decision-makers and public administrators make better decision about resource allocation. The challenge that this project is addressing is converting a high volume of raw, unstructured call data, such as that depicted in [4], into meaningful, operational intelligence.

In this project, we will discuss different approaches for data aggregation and storage and will outline some examples of ways these data can be shared with stakeholders and administrators, alike.

1.2 Structured Data in a SQL Database

Storing the emergency response data in a relational database offers several critical advantages for building an effective and reliable dashboard. The primary rationale is centered on data integrity, efficient analysis, and compatibility with standard business intelligence tools, specifically, web and mobile applications that stakeholders will want to use to view and interact with the data.

There are several key reasons why a SQL database is an appropriate choice for this project. First, most call data will have a predicable and well-structured format, e.g., incident type, timestamp, location (zip code, township), latitude and longitude. Data without these basic attributes are going to be less useful to stakeholders. Next, data organized into a relational database can be stored much more effectively than a two-dimensional dataframe (assuming a well-designed schema and sufficient normalization). A relational database management system (RDBMS) will also give administrators the ability to implement constraints in order to maximize data integrity. This includes adding lookup tables (i.e, foreign key constraints) and enforcing uniqueness, either within a column (e.g., should only have a single entry for a zipcode in a ZipCode table) or even between columns (e.g., combinations of ćity, śtateánd ćountryśhould be unique in an AdministrativeArea table).

Finally, a SQL database is highly compatible with REST APIs, and the two technologies are commonly used together in modern application architecture. A REST API would allow us to implement reactive tools for viewing and interacting with the data across a variety of platforms, for example, browsers, alert-systems or mobile applications.

1.3 Unstructured Data in a NoSQL Database

NEED SOME HELP HERE!

2 Data Preparation

2.1 Emergency - 911 Calls from Kaggle

The principle dataset used for the project was sourced from Montgomery County, Pennsylvania and is accessible from kaggle [4]. This structured, tabular dataset is provided as a flat CSV file and consists of over 600,000 records of emergency calls from December 2015 to April 2020.

After an initial inspection of the data using exploratory tools from Pandas [7], a SQL schema of five tables was devised. The five tables and their descriptions are as follows:

- Category - categorical descriptions of the types of calls received (e.g., car accident)

- Township - township name and state (e.g., Kings Township, PA)

- ResponseUnit - complete list of units responding to emergency calls (e.g., Station 123, EMS)

- ResponseType - the response unit type (e.g., EMS, Traffic, or Fire)

- EmergencyCall - this is the primary data table and used to store information about emergency calls received. It has several links to the above tables.

In addition to the foreign key constraints between tables, indexes were added to each table to improve performance. Unique constraints were placed on fields in tables were duplication of data entry was not wanted. For example, we only wanted there to be a single entry for ̈back pain ̈in the Category table and only a single entry for ̈EMS ̈in the ResponseType table. The Township and ResponseUnit tables both had unique together constraints across two columns. In the case of the former, only a single entry for a combination of township name and state was desired and for the latter, only a single combination of response unit and station name was desired. Finally, Figure 1 presents a visual portrayal of the five above table and the relationships between them.

2.2 A Dashboard Application and Database

In order to better demonstrate and a feasible use-case for this dashboard, our group created a mock-up of an application. The framework selected for this project was Django [5]. This python framework is a Object-Relational

Mapping (ORM) tool and supports fast-paced development. Furthermore, we were able to take advantage of the Django API to migrate changes to an actual database. For demonstration purposes, our group decided to use a simple sqlite database however the django framework and the work we did was database agnostic. Django also has some great packages for developing a REST API, specifically, we leveraged classes from the Django REST Framework [6] package.

In addition to HTML Django templates, the reactive front-end of the application was developed using Vue.js [3], Leaflet [2] and Charts.js [1].
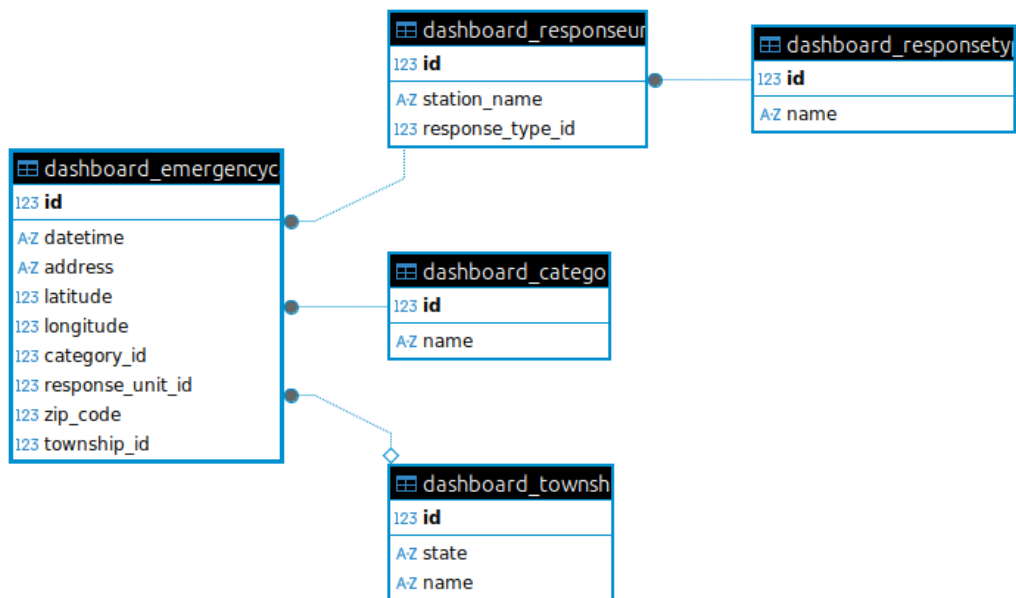
PythonAnywhere

Figure 1: A visual depiction of the five tables in our SQL database design.

3 Analysis

3.1 Methodology

4 Conclusions

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5 Appendix 1: SQL Schema of Emergency Response Database

```
CREATE TABLE IF NOT EXISTS "EmergencyCall" (
    "id" integer NOT NULL PRIMARY KEY AUTOINCREMENT,
    "datetime" datetime NOT NULL,
    "address" text NULL,
    "latitude" real NOT NULL,
    "longitude" real NOT NULL,
    "category_id" bigint NOT NULL
        REFERENCES "Category" ("id"),
    "response_unit_id" bigint NOT NULL
        REFERENCES "ResponseUnit" ("id"),
    "zip_code" smallint NULL, "township_id" bigint NULL
        REFERENCES "Township" ("id")
);

CREATE INDEX "emergencycall_category_id_28afcc20"
    ON "EmergencyCall" ("category_id");

CREATE INDEX "emergencycall_response_unit_id_f0a9566e"
    ON "EmergencyCall" ("response_unit_id");

CREATE INDEX "emergencycall_township_id_c7779d84"
    ON "EmergencyCall" ("township_id");

CREATE TABLE IF NOT EXISTS "Township" (
    "id" integer NOT NULL PRIMARY KEY AUTOINCREMENT,
    "state" varchar(10) NOT NULL,
    "name" varchar(255) NOT NULL
);

CREATE UNIQUE INDEX "township_state_name_a30a5e69_uniq"
    ON "Township" ("state", "name");
```

```
CREATE TABLE IF NOT EXISTS "ResponseUnit" (
    "id" integer NOT NULL PRIMARY KEY AUTOINCREMENT,
    "station_name" varchar(255) NOT NULL,
    "response_type_id" bigint NOT NULL
        REFERENCES "ResponseType" ("id")
);

CREATE UNIQUE INDEX "responseunit_response_type_id_station_name_25efee89_uniq"
    ON "ResponseUnit" ("response_type_id", "station_name");

CREATE INDEX "responseunit_response_type_id_21e2bd85"
    ON "ResponseUnit" ("response_type_id");

CREATE TABLE IF NOT EXISTS "Category" (
    "id" integer NOT NULL PRIMARY KEY AUTOINCREMENT,
    "name" varchar(255) NOT NULL UNIQUE
);

CREATE TABLE IF NOT EXISTS "ResponseType" (
    "id" integer NOT NULL PRIMARY KEY AUTOINCREMENT,
    "name" varchar(255) NOT NULL UNIQUE
);
```

References

[1] Chart.js — Simple yet flexible JavaScript charting library for the modern web. .

[2] Leaflet—A JavaScript Library for Interactive Maps.

[3] Vue.JS - The Progressive JavaScript Framework.

[4] Mike Chirico. Emergency - 911 calls, 2020.

[5] Django Software Foundation. Django.

[6] Encode (main developer Tom Christie) and contributors. Django REST framework.

[7] NumFOCUS. pandas. `https://pandas.pydata.org/pandas-docs/stable/index.html`, 2023. Accessed on 2023-12-11.