

Coordinating Response to Fatal Accidents

Authors: Eric Culver and Christina Ebben

MATH 7594, Instructor: Dr. Steffen Borgwardt

Abstract

Denver Police and Fire Departments have separate dispatch systems that can only track their respective fleets. Because of this, dispatchers rarely have the opportunity to communicate to the other dispatch entity about their deployment decisions. Given that potentially fatal car accidents require a response from both police and fire units, we can better coordinate response to these incidents using a Many-to-One matching problem and the locations of previous fatal car accidents in Denver County. Our results offer a set of “suggested partnerships” of police and fire units given the location of a potentially fatal car crash. Deploying units with a set of “suggested partnerships” can improve the response to accidents; if the unit deployed from one entity is aware of the other’s activities, every responder will be better prepared to deal with life threatening emergencies.



Motivation

- As student participants in the Data to Policy Project we were motivated to utilize our skill sets to tackle a real world problem affecting our community
- After speaking with people on the front line of fatal accidents, we learned that coordinating police and fire department response is a genuine problem worthy of research
- Given the data sets available through the Denver Open Data Catalog, we chose to use a Many-to-One matching model to best handle a disproportionate number of Denver Police and Fire Stations

Objectives

- Facilitate cooperation between the different services by matching each fire station with a unique police station with which it can coordinate efficiently
- Interpret our results as policy recommendations that are practical and easy to implement
- Aid responders by ensuring that they are informed of estimated response times of the other entity
- Assist with Denver’s Vision Zero Program that seeks to eliminate traffic deaths



Model Description

We use Integer Programming to construct a Many-to-One matching between police stations and fire stations. We model this by assigning a binary variable to each pair that can be possibly matched. If a pair is matched, the variable has value 1. If the pair is not matched, the variable has value 0. We sum the variables of the pairs involving a certain fire station, and set that sum to 1, in order to ensure that every fire station is matched to exactly one police station. Similarly, we can set the sum of the variables of the pairs involving a certain police station to be at least 1 to ensure that every police station is matched to at least one fire station. We additionally apply a cost to each matching based on how synchronized those two stations would be responding to accidents based on past accident data. We then look for a matching satisfying these conditions which minimizes that cost.

Model

$$\text{Minimize } \sum_{i \in P, j \in F} c_{ij} x_{ij}$$

- Minimize the total “cost” of all partnerships

$$\text{Subject To } \sum_{i \in P} x_{ij} = 1 \quad \forall j \in F$$

- Match each fire station with a unique police station

$$\sum_{j \in F} x_{ij} \geq 1 \quad \forall i \in P$$

- Match each police station with at least one fire station

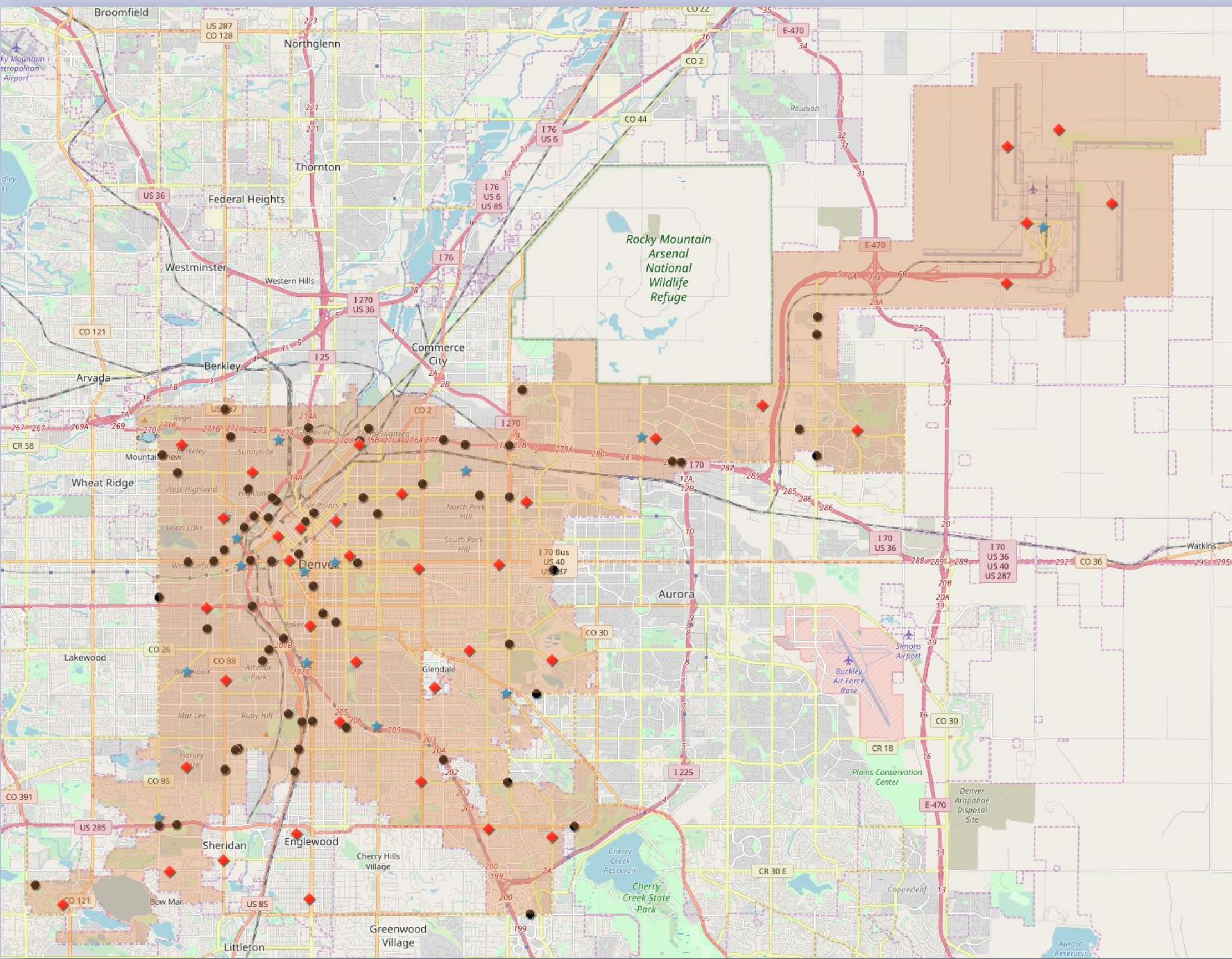
$$x_{ij} \in \{0,1\} \quad \forall i \in P, \forall j \in F$$

- The partnership is only considered if it is used

$$\text{Where } c_{ij} = \sum_{c \in C} |dist(c,i) - dist(c,j)|$$

- The cost of a matching is the difference of distances from a police unit and a fire unit to the same crash

Visual Representation of the Data

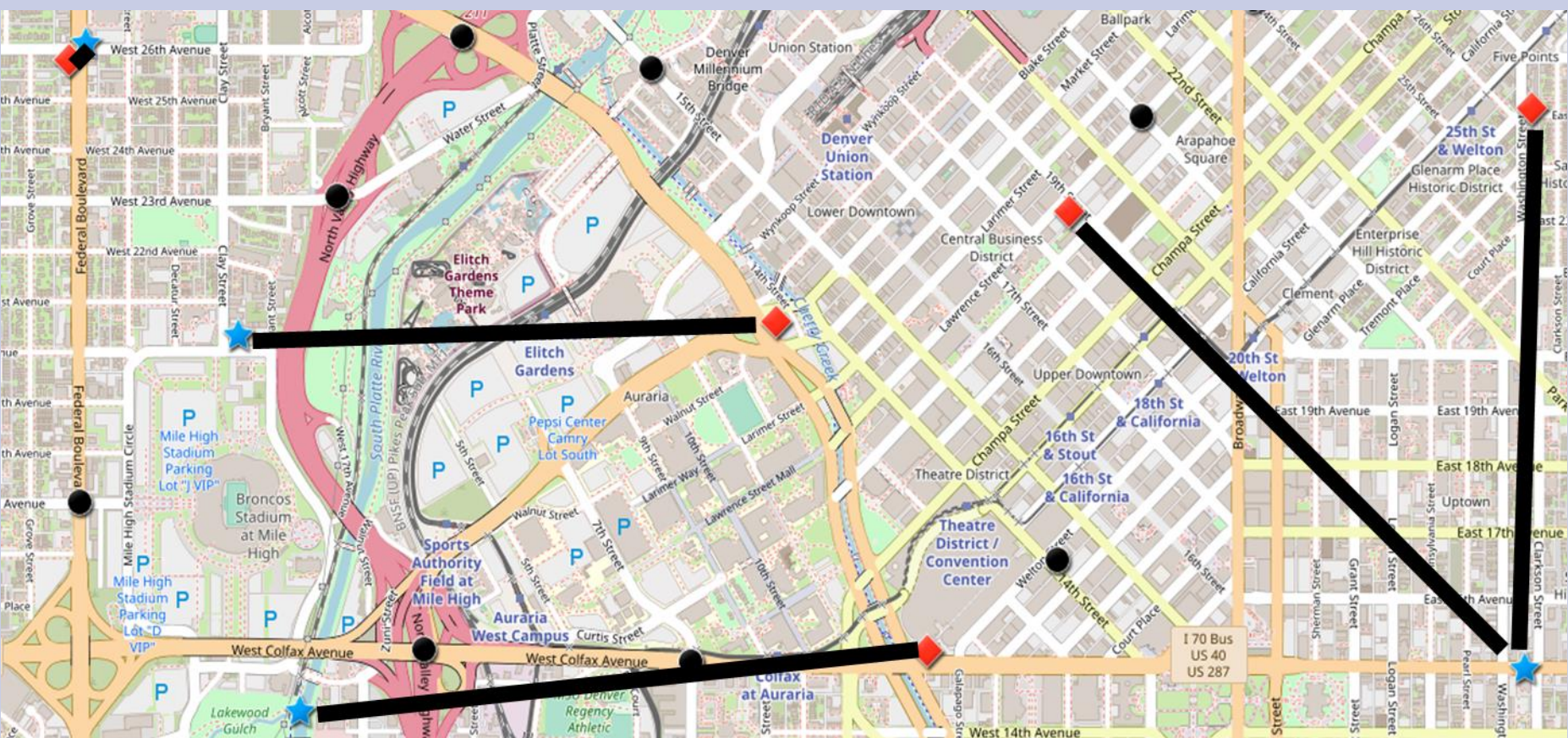


Legend

- Fire Stations in Denver County
 - 35 Data Points
- Police Stations, Substations and Cop Shops in Denver County
 - 14 Data Points
- Fatal Car Accidents (January 2018 – March 2019) in Denver County
 - 70 Data Points

Policy Recommendations

Here is an example of the “suggested partnerships” which would allow first responders to know who else is coming



References

- ArcGIS Desktop. Computer software. Redlands, CA: ESRI, 2010.
- City and County of Denver, Denver Police Department / Data Analysis Unit. *Denver Open Data Catalog: Police Stations*, (Data File). City and County of Denver, 2018.
- City and County of Denver, Denver Police Department / Data Analysis Unit. *Denver Open Data Catalog: Traffic Accidents*, (Data file). City and County of Denver, 2019.
- Denver Fire Department. *Denver Open Data Catalog: Fire Stations*, (Data File). City and County of Denver, 2018.
- “What Is Vision Zero?” City and County of Denver, 2019, www.denvergov.org/content/denvergov/en/vision-zero/what-is-vision-zero.html.