Scheduling NYPD Officers

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Background

There are approximately 285,000 calls to 911 in NYC every day! Of those, only **150** actual crimes (those reports that qualify as a violation, misdemeanor, or felony) are reported to the NYPD within Manhattan.

Police officers are assigned to one of 22 precincts in Manhattan from which they will be based (this is where they will spend time when not out responding to a report).

When we entered into this project, our hope was to optimize the scheduling of these NYPD officers so that they would be able to respond to the reports in the most efficient manner possible.

Problem Scope

We obtained the NYPD Complaint Data Historic from NYC Open Data.

The Complaint Data included the time of the report, the type of report (i.e. violation, misdemeanor, or felony), along with completion time of report, and latitude/longitude.

We focused on Manhattan-based crimes to narrow down the scope of the data used.

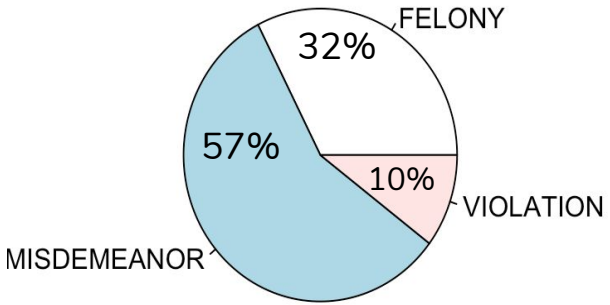
Process

1. Created **composite dataset** consisting of data from both sources
2. Constructed **LP model for scheduling police allocation across precincts**
    - Defined variables, main objective, and constraints given the features available in the dataset
3. Solved LP using Gurobi to determine **optimized performance**
4. Ran simulation to determine **baseline performance**
    - Compared baseline with optimized performance
5. Drew from data and results recommendations to improve police scheduling policies

Dataset

- **Data Sources**
  - NYPD Complaint Data Historic
  - NYPD Police Precincts
- **Construction of the Composite Dataset**
  - Converted relevant features in Complaint data to rj, dj, and Cj, from which pj was derived
  - Corresponding precinct number from Police Precinct data was assigned to each crime
  - Assigned weight to each crime based on its severity

```
       X                rj                Cj             lat             long
 Min.   :    0   12:00:00: 33457           :299484   Min.   :-76.82   Min.   :40.51
 1st Qu.:12500   15:00:00: 27089   12:00:00: 16178   1st Qu.:-73.99   1st Qu.:40.74
 Median :25000   18:00:00: 24882   15:00:00: 14279   Median :-73.98   Median :40.76
 Mean   :25000   16:00:00: 24229   17:00:00: 13252   Mean   :-73.97   Mean   :40.77
 3rd Qu.:37499   17:00:00: 24123   16:00:00: 13184   3rd Qu.:-73.95   3rd Qu.:40.80
 Max.   :49999   14:00:00: 22554   18:00:00: 12463   Max.   :-73.73   Max.   :59.66
                 (Other) :993666   (Other) :781160   NA's   :3316     NA's   :3316
   ofns_desc            law_cat_cd
 55     :273602   FELONY     :374198
 26     :175776   MISDEMEANOR:657207
 28     :116363   VIOLATION  :118595
 8      : 90075
 12     : 88035
 14     : 61808
 (Other):344341
```



LP - Variables and Objectives

Minimize $\sum_r U_r$

t is in minutes

- P_{ikt} :=1{police officer i is allocated to precinct k at time t}
- PR_{irkt} := 1{police officer i is allocated to report r within precinct k at time t}
- $\sum_{it} P_{ikt}$ $t \in [a,b]$ is the number of police officers allocated to precinct k during time period [a,b]
- P_t is the total number of available police officers during time t
- U_r:= Officers assigned to report r at release time = $1 - \sum_{irk} PR_{irkt}$ for $t = r_r \in \{0,1\}$

LP - Constraints

Objective: $\min \sum_r U_r$

S.t. $PR_{irkt} \leq P_{ikt} \ \forall r$ //Police officers can only be allocated to report r if their precincts match

$(PR_{irkt} - PR_{irk(t-1)}) * p_r \leq \sum_t^{t+pr} PR_{irkt} \ \forall i,r$ //If police officer i is assigned to report r at time t, they must be busy for the next p_r time units where p_r is the processing time of report r

$PR_{irkt} = 0 \ \forall \ t < r_r$ //Officers cannot be assigned to report until they are released

$\sum_{ikt} PR_{irkt} \leq 1 \ \forall \ r$ //Officers can only be allocated to at most 1 report at any time

$\sum_{rkt} PR_{irkt} \leq 4 \ \forall \ i$ //Any report assigned at most 4 officer at any time.

$\sum_{ik} P_{ikt} \leq P_t \ \forall \ t$ //Total allocated officers at any time is less than cap P_t

$\sum_{ikt} PR_{irkt} = 4p_r \ \forall \ r$ //Allocation time to report r must be equal to its processing time

Simulation of Performance

- **Assumptions:**
  - Number of active police officers follows the. ICMA deployment policy, a “Rule of 60,” which maintains that approx. 60% of all officers should be on patrol at any time. The mean is ⅔ of officers across various departments.
  - Shifts are non-overlapping 8-hour shifts
  - (1) 4 police officers are dispatched for each crime report or (2) 2, 4, 6 officers are dispatched for violations, misdemeanors and felonies respectively
  - There are 5230 patrolling officers available for allocations
  - Reports arrive exponentially with lambda = 1/150
  - Reports are tended to using FIFO
  - Processing Times for Violations: 45min, Misdemeanors: 1hr 18min, Felonies: 1hr 53min
- **Baseline Performance**
  - Police force is equally distributed across shifts and precincts (91 each)
- **Optimal Performance**
  - All shifts have the same allocations across shifts

Results

Baseline (250 iterations, 180 days)

[4, 4, 4]	Best	Average	Worst
avgMaxWorkload	89.58%	91.28%	92.45%
maxQueue	216	237	263
$\mathbf{U_j}$ (% of reports)	47.59%	51.50%	55.49%

[2, 4, 6]	Best	Average	Worst
avgMaxWorkload	93.83%	95.90%	97.07%
maxQueue	137	168	194
$\mathbf{U_j}$ (% of reports)	34.12%	39.83%	43.97%

Optimal (50 iterations, 180 days)

[4, 4, 4]	Best	Average	Worst
avgMaxWorkload	93.19%	94.62%	95.57%
maxQueue	148	169	193
$\mathbf{U_j}$ (% of reports)	37.35%	40.41%	44.04%

[2, 4, 6]	Best	Average	Worst
avgMaxWorkload	93.24%	94.62%	95.70%
maxQueue	145	167	185
$\mathbf{U_j}$ (% of reports)	36.63%	39.82%	42.94%

Recommendations

Our optimal allocation (after 100 iterations of descent) was:

Precinct	1	5	6	7	9	10	13	17	19	20	23	24	25	26	28	30	32	33	34
Officer	89	92	87	89	91	97	87	98	91	86	92	91	86	91	90	90	88	93	100

- Far better results given [4, 4, 4] situation
- Better worst case results

Thank you!
Any questions?