Shelter location Problem Considering People's Trial-and-Error Behavior

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Problem Statement

The problem is formulated as the **P-Median model**, which makes the location and allocation decisions to minimize the total system cost, which is both the total travel time of evacuees finding and not finding shelters.
Evacuees follow a **trial-and-error** process to find the nearest shelter. They go from affected zones to the nearest shelters. People stay at the shelter if it can accommodate them unless they go to the nearest shelter from their current position. They follow this behavior until they can find a shelter with capacity.

Problem Statement - Assumptions

1. Nodes within a predefined vicinity of zones hit by hurricane are considered as a ‘affected zones’, which are unsafe for opening shelters.
2. Each shelter has a predefined capacity for the total number of people accommodated in them.
3. It may not be possible to accommodate all the people in a given scenario.
4. P shelters can be opened in any given scenario.
5. People who cannot find shelter are assumed to receive service from

Formulation - Base Model

Notations

$j \epsilon J$: Index of candidate nodes for opening shelters

$i \epsilon I$: Index of network zones

Parameters

1. P: Numbers of shelters to be opened or located
2. c_j: Capacity of each shelter
3. h_i: Number of evacuees from node i seeking shelters
4. n_j: Binary parameters that show if shelter at site j is safe to be opened
5. t_{ij}: Travel time between node i and node j
6. γ: Assumed travel time for the people not accommodate in shelters

Decision Variables

1. X_j a binary decsion variable to be one if a shelter is located at site j and zero otherwise.
2. $Y_{i,j}$ a non-negative decision variable to indicate the number of evacuees from origin i that use a shelter at site j
3. Z_i a non-negative decision variable to indicate the number of evacuees from origin i who seek shelters but cannot be accommodated.

Formulation - Trial-and-Error Model

Notations and Sets

1. $j \in J$: Index of candidate node for shelters
2. $i \in I$: Index of demand node
3. $N_i \subset J$: Sorted list of each node neighboring candidate based on people's trial-and-error behavior

Parameters

1. P Numbers of shelters can be located
2. c_j capacity of shelters (thousand people)
3. h_i number of evacuees from node i seeking shelters
4. n_j binary parameters that shows if shelter at site j is safe to be opened
5. $\tilde{t_{i,j}}$ travel time between demand nodes and candiadate location based on the people's trial-and-error behavior
6. γ assumed travel time for the people not accommodated in shelters.

Formulation

Base Model

$$\min \quad \gamma \sum_i Z_i + \sum_i \sum_j t_{i,j} Y_{i,j}$$

$$\text{s.t.} \quad \sum_j X_j = P$$

$$X_j \leq n_j \qquad \forall j \in J$$

$$\sum_i Y_{i,j} \leq c_j X_j \qquad \forall j \in J$$

$$\sum_j Y_{i,j} + Z_i = h_i \qquad \forall j \in J$$

Trial-and-Error Model

$$\min \quad \gamma \sum_i Z_i + \sum_i \sum_j \tilde{t_{i,j}} Y_{i,j}$$

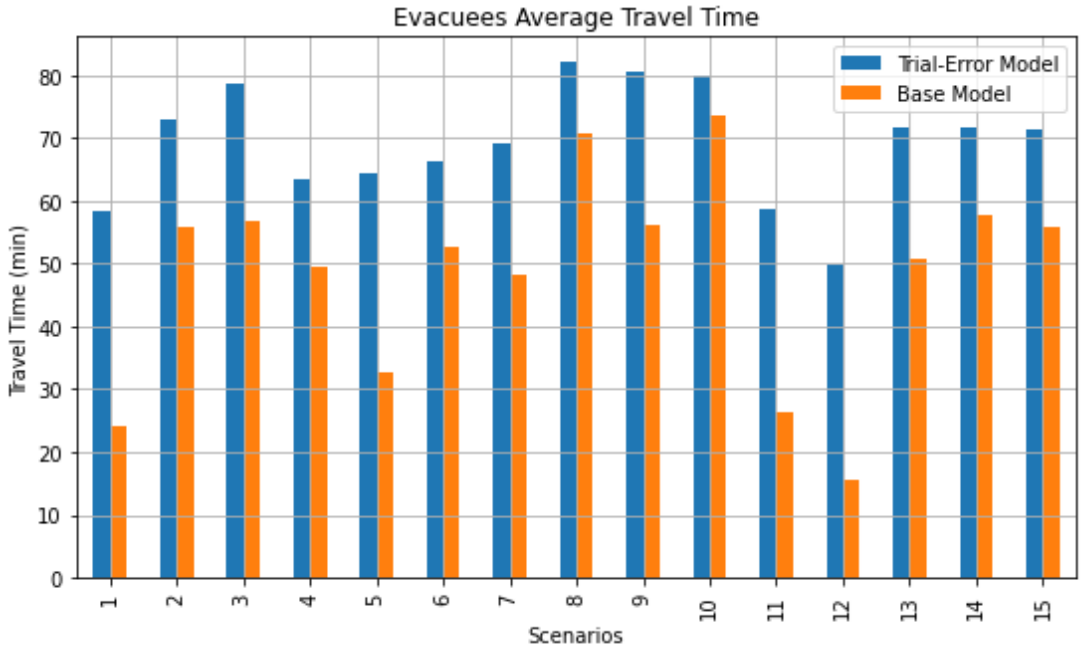
$$\text{s.t.} \quad \sum_j X_j = P$$

$$X_j \leq n_j \qquad \forall j \in J$$

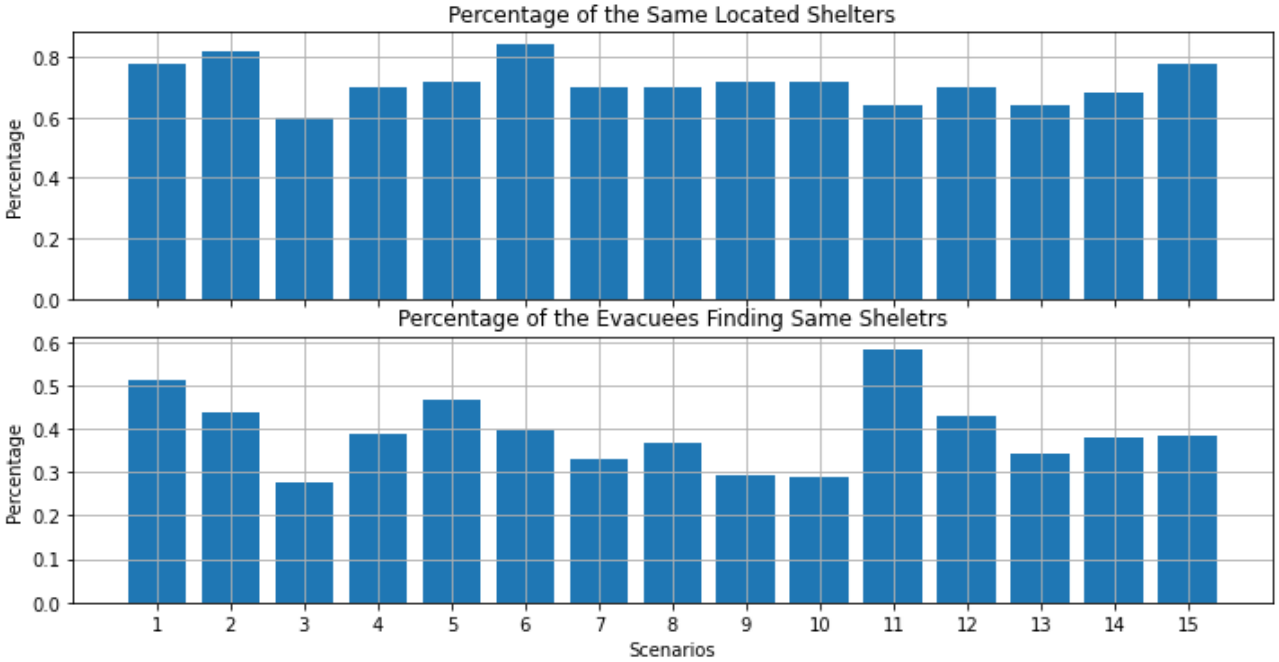
$$\sum_i Y_{i,j} \leq c_j X_j \qquad \forall j \in J$$

$$\sum_j Y_{i,j} + Z_i = h_i \qquad \forall j \in N_i$$

Results


Evacuees Average Travel Time
Trial-Error Model
Base Model
Travel Time (min)
0
10
20
30
40
50
60
70
80
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Scenarios

Results


Percentage of the Same Located Shelters
Percentage
0.0
0.2
0.4
0.6
0.8
Percentage of the Evacuees Finding Same Sheletrs
Percentage
0.0
0.1
0.2
0.3
0.4
0.5
0.6
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Scenarios