CAPSTONE PROJECT 1

SAFETY AT SEKYERE

OPTIMIZATION REPORT

INTRODUCTION

Project Description:

This project is basically about a District Chief Executive (DCE) of a community called Sekyere East who wishes to promote Safety in his community by installing Emergency Telephones at selected locations. The DCE wishes to maximize the effectiveness of the Telephones by placing them at the intersections of the streets. There are a total of Eleven (11) main streets in all labelled as street A to street J and Eight (8) intersections of the streets numbered 1 to 8 as shown below:

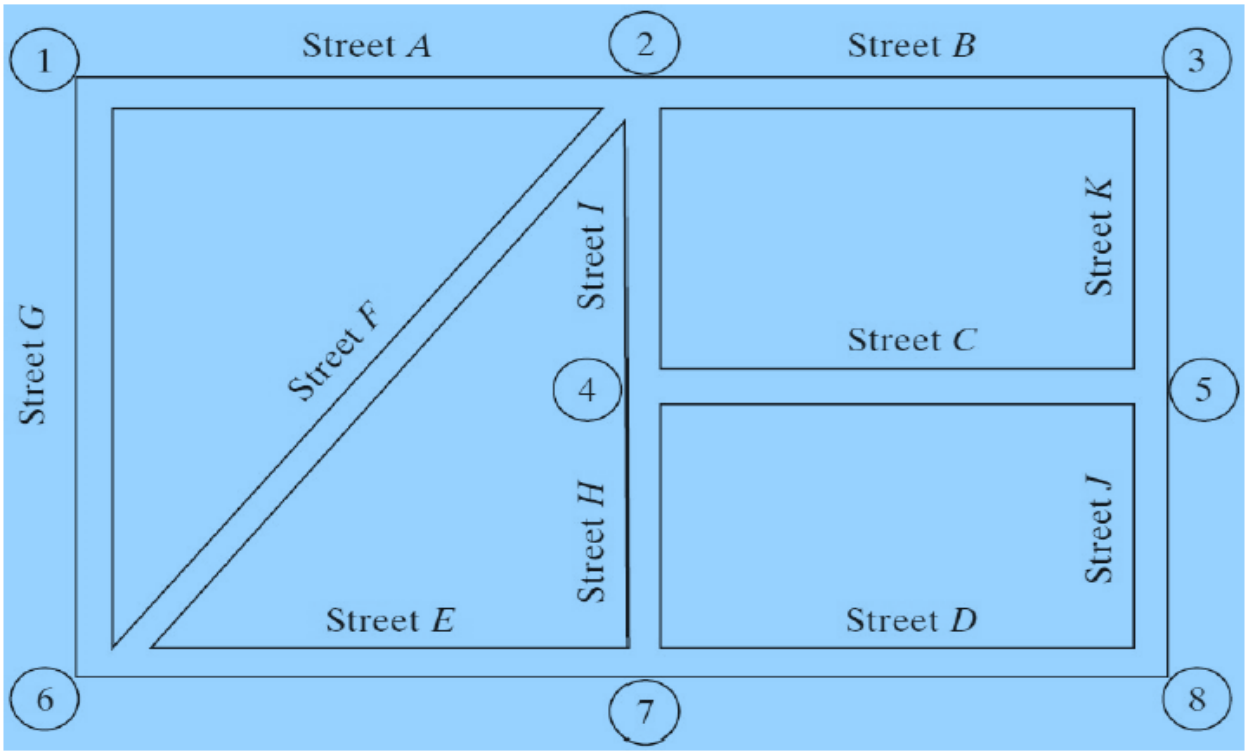

Figure 1: Street map Sekyere East.

PROBLEM STATEMENT

The problem to be solved in this project is to find the optimal solution required to meet the DCE's ambition of promoting safety in the community, whiles cutting down cost but ensuring that a single telephone when installed at a location is able to serve at least two (2) streets.

GOAL OF PROJECT

The goal is to find the Minimum number of Telephones that can be installed to serve the main streets in the community.

ASSUMPTIONS

1. The cost involved in the installation of a telephone irrespective of the selected location is the same.
2. The distance between the intersections of the main streets are all equal.
3. No priority is given to any particular street or intersection.

SOLUTION APPROACH

Since this is a Linear programming problem of optimization, I utilized the Linear Production Model in Python known as ***Pyomo.***

Pyomo is a state-of-the-art language for solving optimization problems embedded within Python. Using Pyomo, a user can describe optimization model by specifying decision **variables**, **constraints**, and an optimization **objective**. Pyomo includes a rich set of features to enable modeling of complex systems, specifying a solver, and displaying the solution.

MATHEMATICAL FORMULATION OF PROBLEM

Based on the optimization problem presented, I define two functions:

- Objective Function
- Inequality Constraints

Objective Function:

Our goal per the problem is to Minimize the number of Telephone to be installed at eight intersections of the streets:

Define

$$x_j \begin{cases} 1, & a\ telephone\ is\ installed\ in\ location\ j \\ 0, & otherwise \end{cases}$$

Let $\boldsymbol{Z}$ be the Objective function to minimize and $\boldsymbol{X_i's}$ be the telephones to be installed at the selected location (at the intersections of the streets).

$$Z_{minimize} = X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8$$

Inequality Constraints:

The constraints of the problem require installing at least one telephone on each of the 11 streets (A to K). Thus, the inequality constraints are subject to:

$$x_1 + x_2 \geq 1 \ldots\ldots\ldots\ldots street\ A$$
$$x_2 + x_3 \geq 1 \ldots\ldots\ldots\ldots street\ B$$
$$x_4 + x_5 \geq 1 \ldots\ldots\ldots\ldots street\ C$$
$$x_7 + x_8 \geq 1 \ldots\ldots\ldots\ldots street\ D$$
$$x_6 + x_7 \geq 1 \ldots\ldots\ldots\ldots street\ E$$
$$x_2 + x_6 \geq 1 \ldots\ldots\ldots\ldots street\ F$$
$$x_1 + x_6 \geq 1 \ldots\ldots\ldots\ldots street\ G$$
$$x_4 + x_7 \geq 1 \ldots\ldots\ldots\ldots street\ H$$
$$x_2 + x_4 \geq 1 \ldots\ldots\ldots\ldots street\ I$$
$$x_5 + x_8 \geq 1 \ldots\ldots\ldots\ldots street\ J$$
$$x_3 + x_5 \geq 1 \ldots\ldots\ldots\ldots street\ K$$
$$x_j = (0,1), j = 1, 2, \ldots 8$$

SOLUTION OF PROBLEM

The optimization problem is then solved using *glpk solver* in **Pyomo (**a python library) as discussed above. Details of the solution, solution steps and outputs can be found in the attached Jupiter notebook file.

```
Number of Telephone to Install =  4.0

Decision Variables :

For Telephone to be installed the decision variable should have a value of Xi = 1, otherwise do not Install
x1 =  0
x2 =  1
x3 =  0
x4 =  0
x5 =  1
x6 =  1
x7 =  1
x8 =  0

END OF SOLUTION
```

RECOMMENDATION/CONCLUSION

From the above solution output of the optimization problem, the **minimum** number of telephones to be installed on the streets of Sekyere is **four (4).** This optimal number meets the DCE's ambition of promoting safety in the community and maximizing the effectiveness of the telephones by placing them at the intersection of the streets as desired.

Hence, based on the solution, I recommend that the DCE installs one telephone each at intersection 2, intersection 5, intersection 6 and intersection 7. These selected locations serve at least two (2) of the main streets effectively as desired by the DCE.

REFERENCES

1. https://jckantor.github.io/CBE30338/06.04-Linear-Production-Model-in-Pyomo.html#6.4.4-Example:-Linear-Production-Model-with-Constraints
2. https://pyomo.readthedocs.io/en/stable/solving_pyomo_models.html#supported-solvers