

Problem 5.16 : LAW ENFORCEMENT. The police department of the city of Flint, Michigan, has divided the city into 15 patrol sectors, such that the response time of a patrol unit (squad car) will be less than three minutes between any two points within sector.

Until recently, 15 units, one located in each sector, patrolled the streets of Flint from 7:00 pm to 3:00 am. However severe budget cuts have forced by at least one unit located either within that sector or in an adjacent sector.

The accompanying figure depicts the 15 patrol sectors of Flint, Michigan. Formulate and solve a BILP that will determine the minimum number of units required to implement the chief's policy.

Solution:

a. Variables:

- X_1 : Sector 1 Selection (binary),
- X_2 : Sector 2 Selection (binary),
- X_3 : Sector 3 Selection (binary),
- X_4 : Sector 4 Selection (binary),
- X_5 : Sector 5 Selection (binary),
- X_6 : Sector 6 Selection (binary),
- X_7 : Sector 7 Selection (binary),
- X_8 : Sector 8 Selection (binary),
- X_9 : Sector 9 Selection (binary),
- X_{10} : Sector 10 Selection (binary),
- X_{11} : Sector 11 Selection (binary),
- X_{12} : Sector 12 Selection (binary),
- X_{13} : Sector 13 Selection (binary),
- X_{14} : Sector 14 Selection (binary),
- X_{15} : Sector 15 Selection (binary),

Note : If X_i is equal to 1 it means i. Sector was selected.

b. Model:

$$\text{MIN: } X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8 + X_9 + X_{10} + X_{11} + X_{12} + X_{13} + X_{14} + X_{15}$$

$$X_1 + X_2 + X_9 + X_{10} + X_{11} \geq 1 \quad (\text{Adjacent sectors of Sector 1})$$

$$X_1 + X_2 + X_3 + X_9 \geq 1 \quad (\text{Adjacent sectors of Sector 2})$$

$$X_2 + X_3 + X_4 + X_8 + X_9 \geq 1 \quad (\text{Adjacent sectors of Sector 3})$$

$$X_3 + X_4 + X_5 + X_6 + X_8 \geq 1 \quad (\text{Adjacent sectors of Sector 4})$$

$$X_4 + X_5 + X_6 + X_7 \geq 1 \quad (\text{Adjacent sectors of Sector 5})$$

$$X_4 + X_5 + X_6 + X_7 + X_8 \geq 1 \quad (\text{Adjacent sectors of Sector 6})$$

$$X_5 + X_6 + X_7 + X_8 + X_{13} + X_{14} + X_{15} \geq 1 \quad (\text{Adjacent sectors of Sector 7})$$

$$X_3 + X_4 + X_6 + X_7 + X_8 + X_9 + X_{13} \geq 1 \quad (\text{Adjacent sectors of Sector 8})$$

$$X_1 + X_2 + X_3 + X_8 + X_9 + X_{10} + X_{13} \geq 1 \quad (\text{Adjacent sectors of Sector 9})$$

$$X_1 + X_9 + X_{10} + X_{11} + X_{12} + X_{13} \geq 1 \quad (\text{Adjacent sectors of Sector 10})$$

$$X_1 + X_{10} + X_{11} + X_{12} \geq 1 \quad (\text{Adjacent sectors of Sector 11})$$

$$X_{10} + X_{11} + X_{12} + X_{13} + X_{14} \geq 1 \quad (\text{Adjacent sectors of Sector 12})$$

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$$X_7 + X_8 + X_9 + X_{10} + X_{12} + X_{13} + X_{14} \geq 1 \quad (\text{Adjacent sectors of Sector 13})$$

$$X_7 + X_{12} + X_{13} + X_{14} + X_{15} \geq 1 \quad (\text{Adjacent sectors of Sector 14})$$

$$X_7 + X_{14} + X_{15} \geq 1 \quad (\text{Adjacent sectors of Sector 15})$$

$$X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}, X_{13}, X_{14}, X_{15} = \text{binary}$$

Note: You can see the solution of the problem in [g6-s5-p16.xls](#) excel document by using the solver.