LOCATING PARKS WITH A LEXICOGRAPHIC MULTIOBJECTIVE OPTIMIZATION METHOD

Under the tutelage of Shahriari

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Pomona College

BACKGROUND INFO

What does this mean?

BUILD MORE PARKS

- Parks have benefits!

BUILD MORE PARKS

- Parks have benefits!
- Bogotá's master plan

BUILD MORE PARKS

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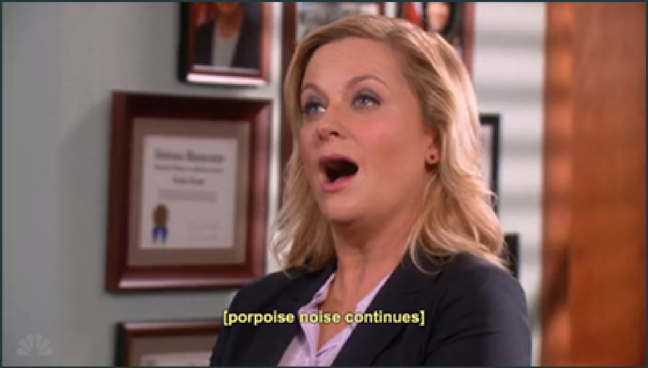
- Parks department

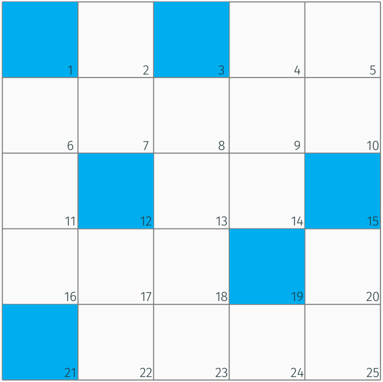
BUILD MORE PARKS

- Parks have benefits!
- Bogotá’s master plan
- Parks department
- Competing objectives

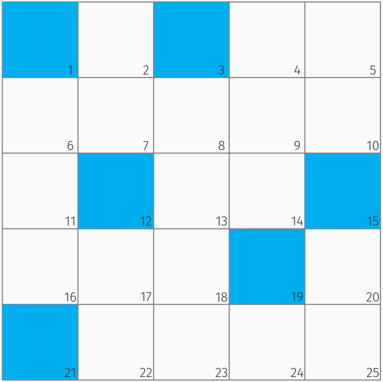
ESSENTIALLY



A BASIC EXAMPLE

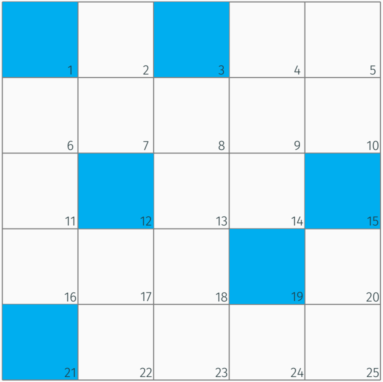


This is our 5×5 grid city



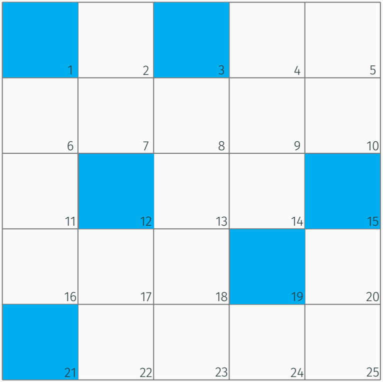
Maybe call it Pawnee.

EXAMPLE



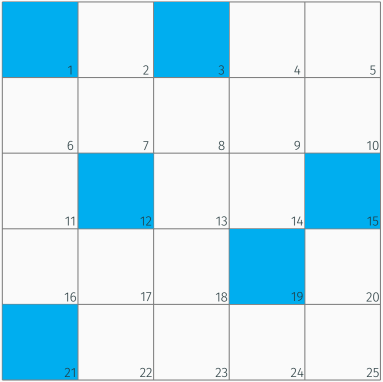
But definitely not.

EXAMPLE



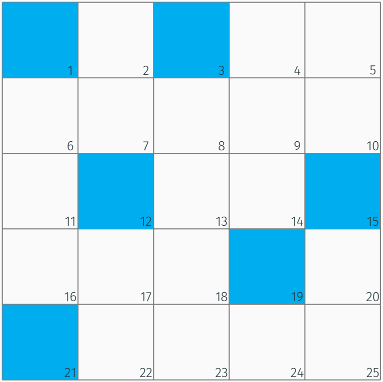
- Candidate parcels

EXAMPLE

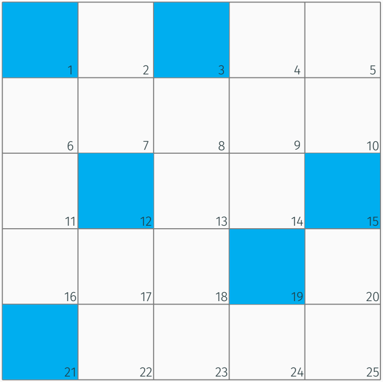


- Candidate parcels
- Every lot same size

EXAMPLE

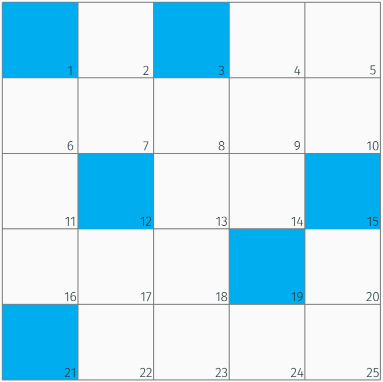


- Candidate parcels
- Every lot same size
- Service area



Which candidate parcel will maximize geographical coverage?

EXAMPLE



Which candidate parcel will maximize geographical coverage?

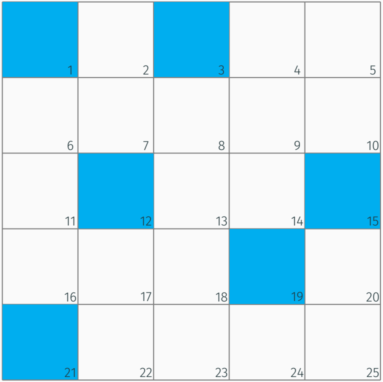
Candidate 12

$$
\begin{aligned}
\max \ f_1 = \sum_{j \in \mathcal{J}} z_j \\
\text{subject to } z_j \le \sum_{i \in \mathcal{W}_j} y_i, j \in \mathcal{J} \\
\left|\mathcal{W}_j\right| z_j \ge \sum_{i \in \mathcal{W}_j} y_i, j \in \mathcal{J} \\
z_j \in \{0, 1\}, j \in \mathcal{J} \\
y_i \in \{0, 1\}, i \in \mathcal{I}
\end{aligned}
$$

$$\max f_1 = \sum_{j \in \mathcal{J}} z_j$$

- $\mathcal{J}$ is the set of all blocks that could benefit from a new park

EXAMPLE

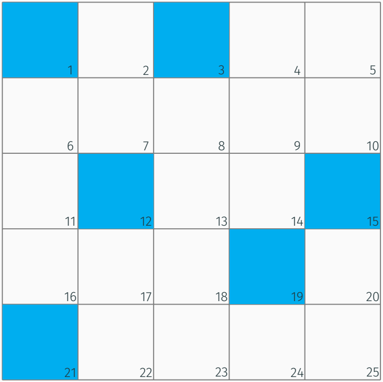


$$\mathcal{J} = \{2, 4, 6, 7, 8, \ldots, 22, 23, 24, 25\}$$

$$\max f_1 = \sum_{j \in \mathcal{J}} z_j$$
$$\text{subject to } z_j \in \{0, 1\}, j \in \mathcal{J}$$

- $\mathcal{J}$ is the set of all blocks that could benefit from a new park
- z_j is a binary decision variable, takes value of 1 if block $j \in \mathcal{J}$ is covered by at least one park, 0 otherwise

EXAMPLE



$\mathcal{J} = \{2, 4, 6, 7, 8, \ldots, 22, 23, 24, 25\}$

If we chose candidate 21, then $z_7 = 0$ and $z_{16} = z_{17} = z_{22} = 1$

$$
\begin{aligned}
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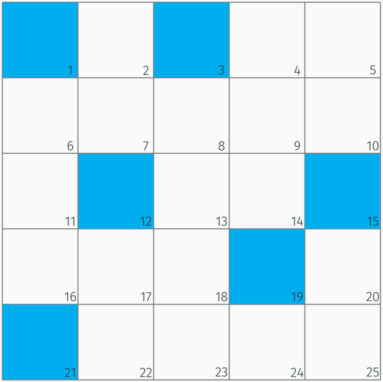
y_i &\in \{0, 1\}, i \in \mathcal{I}
\end{aligned}
$$

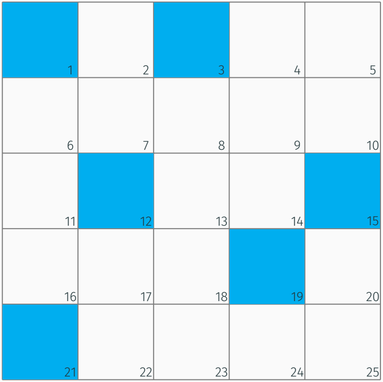
- $\mathcal{J}$ is the set of all blocks that could benefit from a new park
- z_j is a binary decision variable, takes value of 1 if block $j \in \mathcal{J}$ is covered by at least one park, 0 otherwise
- $\mathcal{I}$ is the set of candidate parcels
- candidate parcel i belongs to the set $\mathcal{W}_j$ if block j is serviced by parcel i
- y_i a binary decision variable, takes value 1 if candidate i is selected to become a park

EXAMPLE



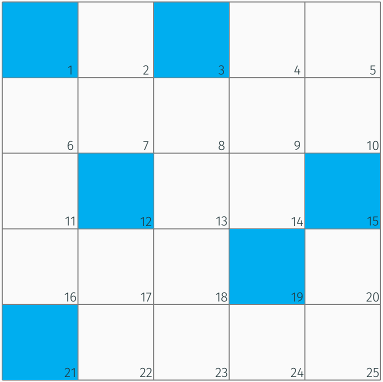
$\mathcal{J} = \{2, 4, 6, 7, 8, \ldots, 22, 23, 24, 25\}$
$\mathcal{I} = \{1, 3, 12, 15, 19, 21\}$

EXAMPLE



$\mathcal{J} = \{2, 4, 6, 7, 8, \ldots, 22, 23, 24, 25\}$
$\mathcal{I} = \{1, 3, 12, 15, 19, 21\}$
$\mathcal{W}_7 = \{1, 3, 12\}$

EXAMPLE



$\mathcal{J} = \{2, 4, 6, 7, 8, \ldots, 22, 23, 24, 25\}$
$\mathcal{I} = \{1, 3, 12, 15, 19, 21\}$
$\mathcal{W}_7 = \{1, 3, 12\}$
If we chose block 21, then $y_{21} = 1$

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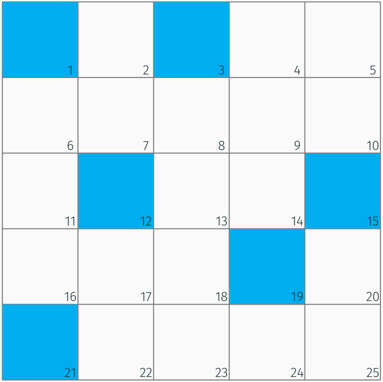
$$

- Guarantees that if block j is covered, then at least one candidate parcel covering it has been selected as a park
- If block j is not covered, then none of the candidate parcels serving it should be selected

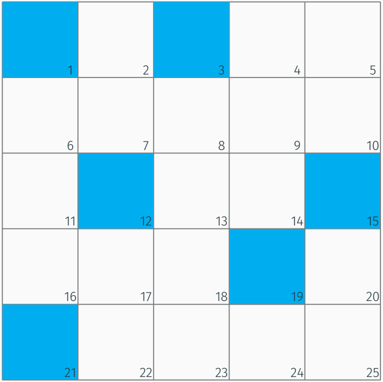
EXAMPLE



If we chose block 21, then the first constraint becomes

$$z_{16} \leq \sum_{i \in \mathcal{W}_{16}} y_i \Rightarrow z_{16} \leq y_{12} + y_{21} \Rightarrow 1 \leq 0 + 1$$

EXAMPLE



If we chose block 21, then the second constraint becomes

$$|\mathcal{W}_4|\, z_4 \geq \sum_{i \in \mathcal{W}_4} y_i \Rightarrow (1 \times 0) \geq y_3 \Rightarrow 0 \geq 0$$

COMPLICATIONS

- Maximize number of beneficiaries?

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- Maximize accessibility?

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- Place parks closer to positive facilities (like schools) and further from negative facilities (like waste treatment plants)?

MULTIOBJECTIVE

- Maximize number of beneficiaries?
- Maximize accessibility?
- Maximize connectivity to existing facilities?
- Place parks closer to positive facilities (like schools) and further from negative facilities (like waste treatment plants)?
- Minimize cost?

What if we want to do all these things?

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Need a way to maximize or minimize multiple objective functions at a time.

MORE ISSUES

- Now what if we had 100 blocks? 1000 blocks? More?

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- What if the parcels weren't all the same shape?

- Now what if we had 100 blocks? 1000 blocks? More?
- What if the parcels weren't all the same size?
- What if the parcels weren't all the same shape?
- How do you measure these things?

CONCLUSION

SUMMARY

Locating parks is a complicated problem.

Questions?