ArcGIS tool for creating equitable regions

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Background

Feature grouping/regionalization in a meaningful way is often required in the domain of optimization and spatial decision support.

Scenario 1: Assisted evacuation planning

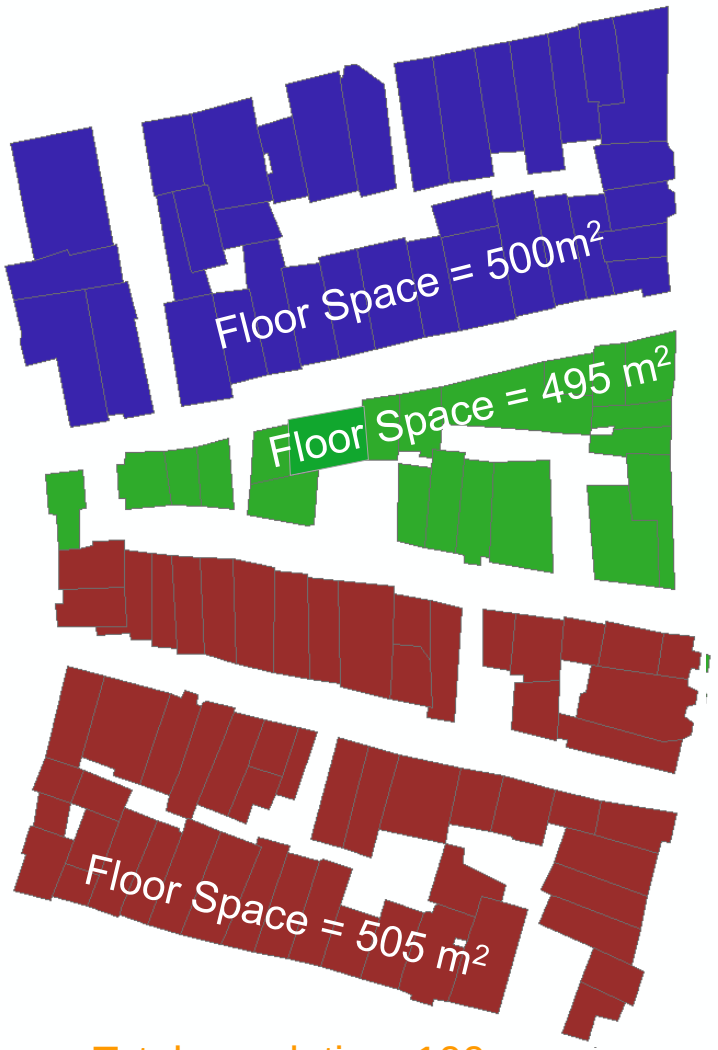
- The assisting providing authority has **2** evacuation units (vehicle) to cover the area

An area to be evacuated

Background

Scenario 2: Service coverage plan

- A service provider want to cover a certain area with their service
- Assume that they can provide only 3 service center of same capabilities
- Interested to divide the area into 3 equitable regions



Total population: 100
Total floor space: 1500 m²

Problem statement

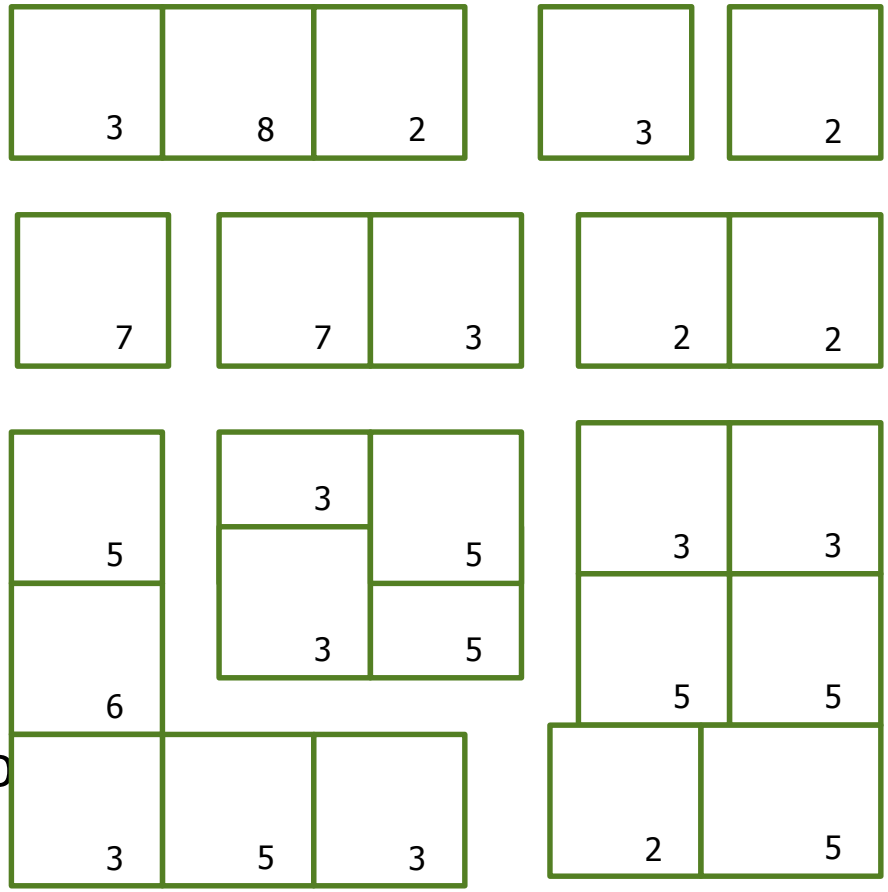
Task

→A geographic area ***G***

→Defined by a feature set consisting of ***n*** number of connected/non-connected features

→With a numeric attribute ***A***

→Has to be completely divided into ***N*** number of equitable regions



Geographic area ***G***, Where ***n*** = 25
Numeric attribute ***A*** = Population
Output equitable region ***N*** = 4

Problem statement

Criteria

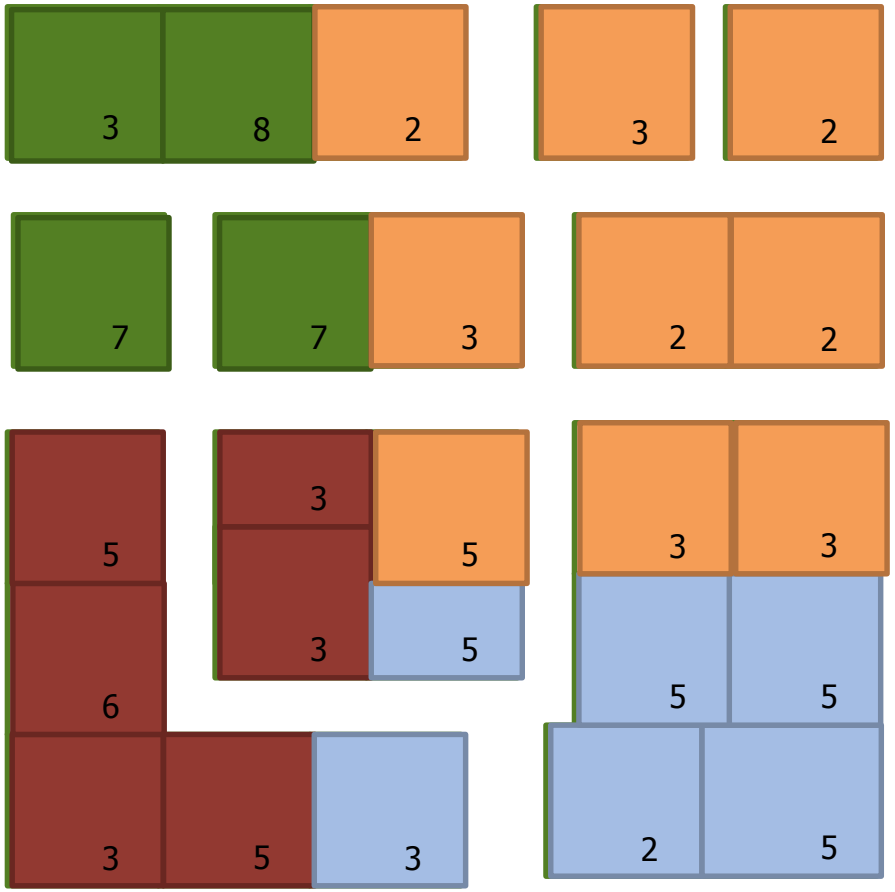
1. Feature splitting is not allowed

2. Sum of **|*A*|** of each output region should be equal to ***T*** ± ***d*** (Except one region)

$$T = \frac{\sum_{f=1}^{fn} |A|(G)}{N}$$

$d \in D = \{q \in \mathbb{Q} \mid 0 \leq q < MAX\ (|A|(G))\ \}$

3. The output regions should be disjoint, must not overlap

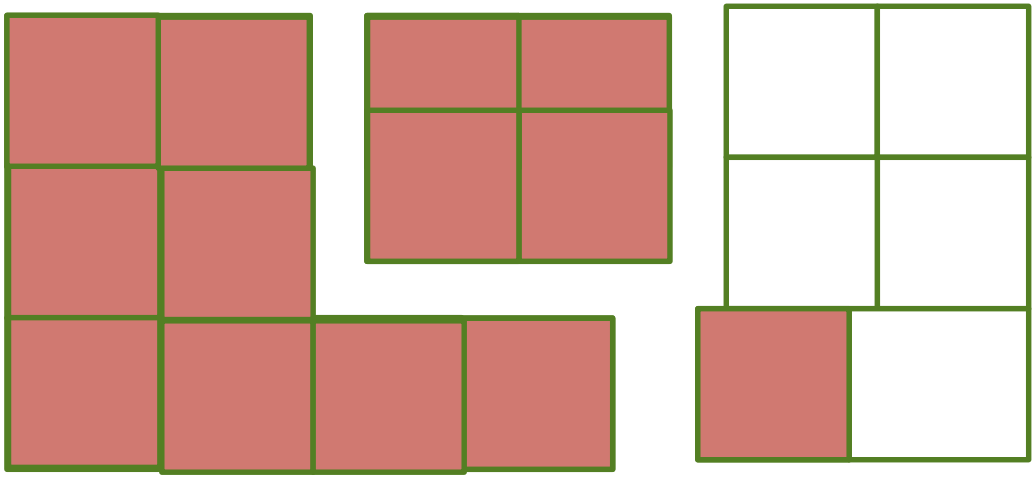


Geographic area ***G***, Where ***n*** = 25
Numeric attribute ***A*** = Population
Output equitable region ***N*** = 4

The algorithm

General overview

1. Region formation starts from a suitable corner of input dataset
2. It continues along the bounding line of the input dataset.
3. If all features along the bounding line are already classified into regions, region formation again starts from a suitable corner of unclassified features set
4. Continue the process



Would not work, violate criteria no 3 **N** = 2

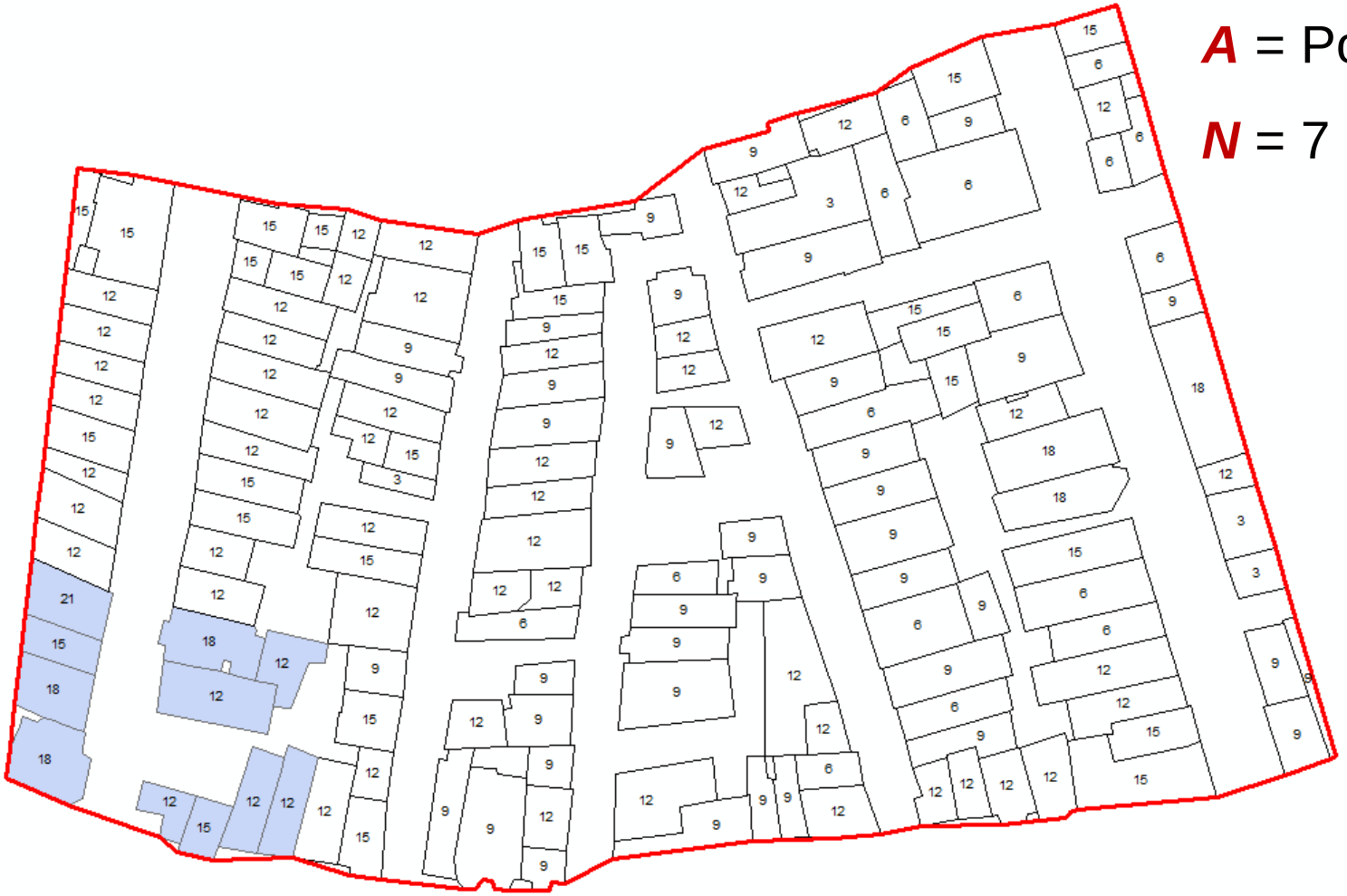
Step 1: Selecting the seed feature for first region

A = Population

N = 7

5. After the loop the feature with the next will be the staging feature

Step 2: Formation of the first region

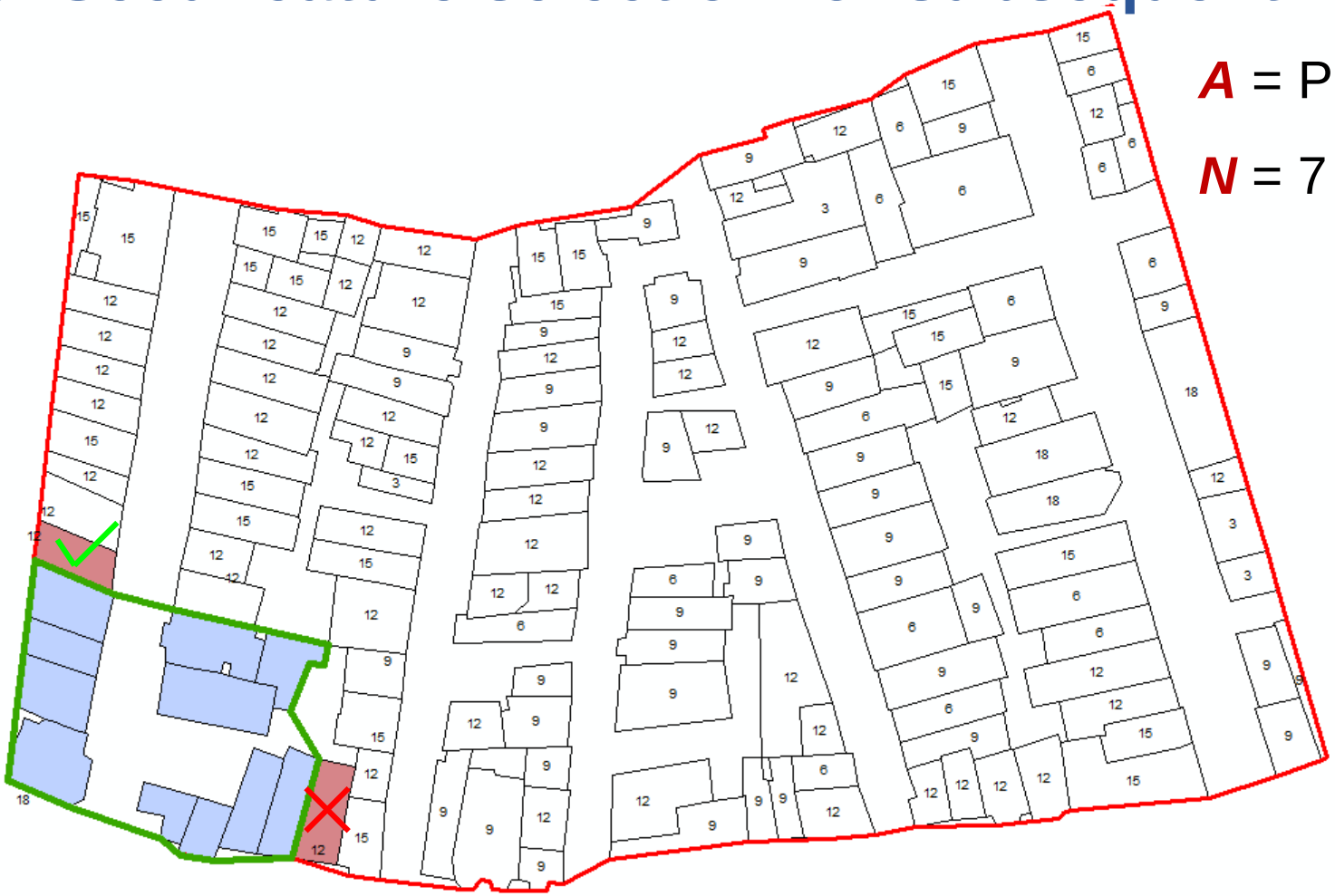


A = Population

N = 7

1. The process continues until the sum of ***A*** for the region becomes equal to ***T***
2. Neighboring features get grouped together with the starting feature on the basis of minimum distance

Step3: Seed feature selection for subsequent regions

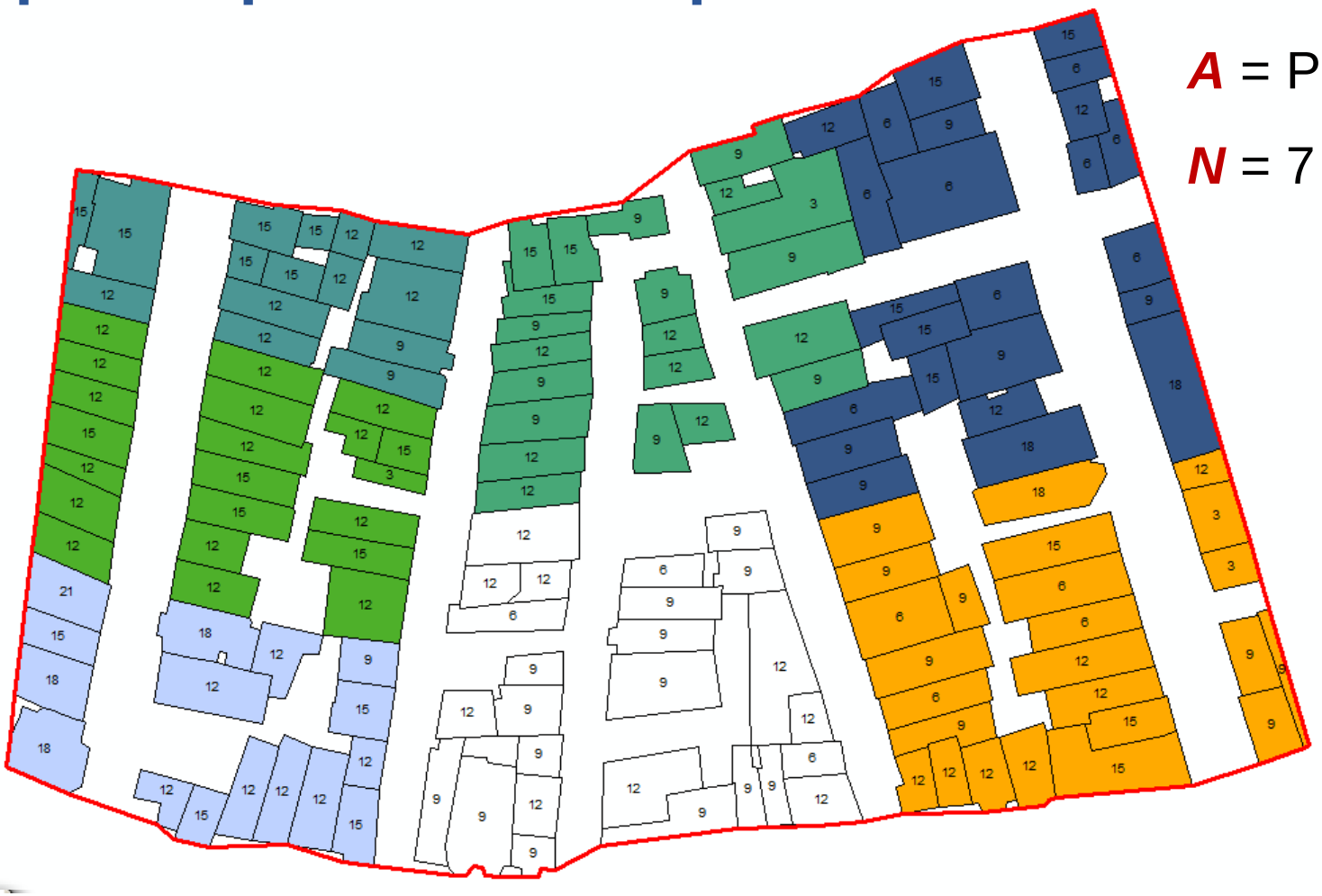


A = Population

N = 7

3. Select one of them

Step 4: Repetition of Step 2 and 3



A = Population

N = 7

2. Repeat step 2 and 3 until the ***N-1*** features are formed

The ***N***th region is formed with the remaining features after the formation of ***N-1***th region

Step 5 (if necessary): Recommence from step 1

A = Population

N = 13

2. Repeat steps 2 and 3 for the remaining features

Implementation and Result

A = Population, ***n*** = 341, ***N*** = 3
SUM (|*A*|) = 3654, ***T*** = 1218, ***d*** = 0-21

Region	Features	Sum_Population
0	107	1209
1	122	1224
2	112	1221

A = Population, ***n*** = 341, ***N*** = 7
SUM (|*A*|) = 3654, ***T*** = 522, ***d*** = 0-21

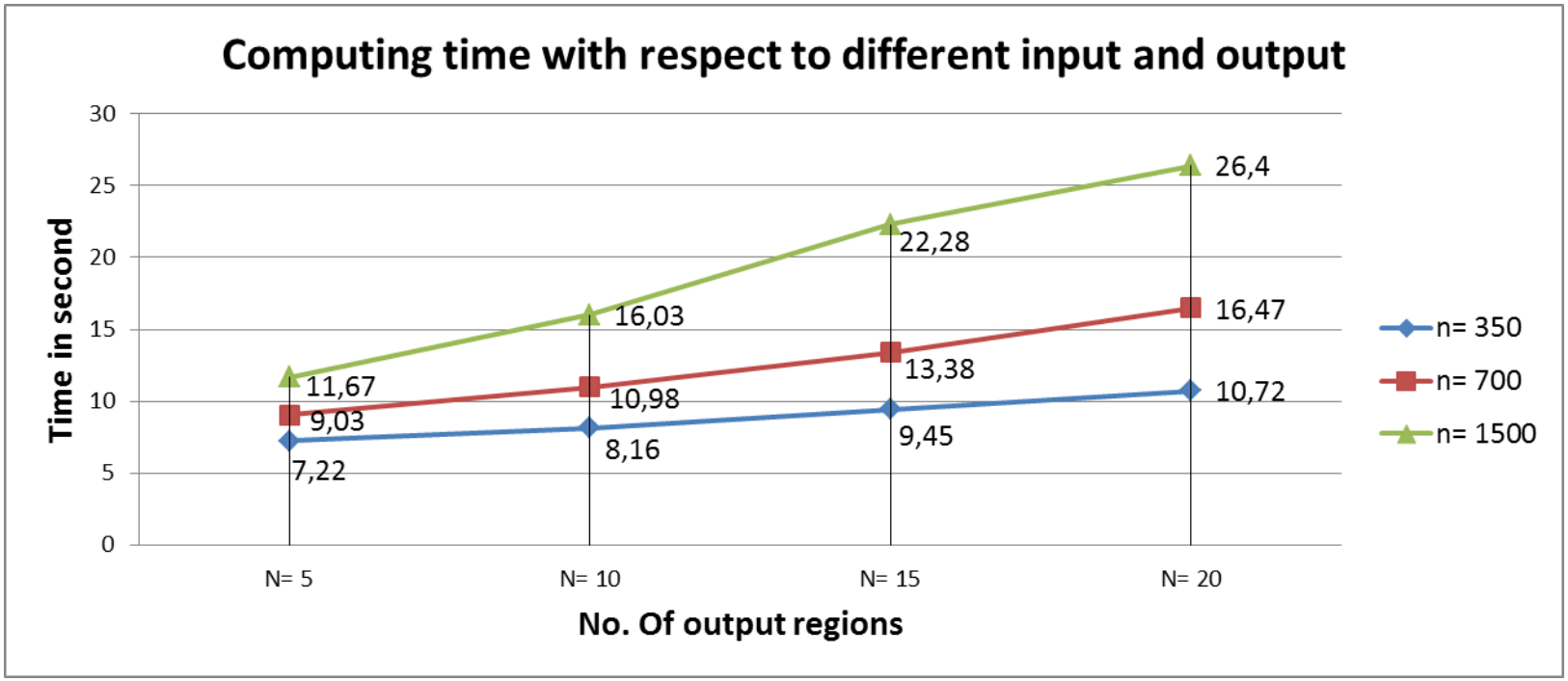
Region	Features	Sum_Population
0	50	504
1	56	522
2	52	522
3	45	525
4	41	528
5	46	528
6	51	525

Performance

Processor: Intel i5 @ 2.60 GHz

Memory (RAM): 8 GB

Operating system: Windows 7, 64 bit



Conclusion and future works

1. The algorithm is applicable for polygon and point features set.
2. Dealing with multiple attributes would be interesting future works
3. The algorithm could be further enriched by introducing constraints (e.g. major roads, other important structure etc.)
4. Moreover, computing time for lager input datasets could be improved with techniques like spatial indexing.

Thank you for your attention!!

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Related works

Automated Zone Design (AZD)

1. Automated Zonig Procedure (AZP) (Openshaw, 1977)
2. Modifiable Areal Unit Problem (MAUP) (Openshaw, 1984)
3. Automatic Zone Matching (AZM) (Martin, 2003)

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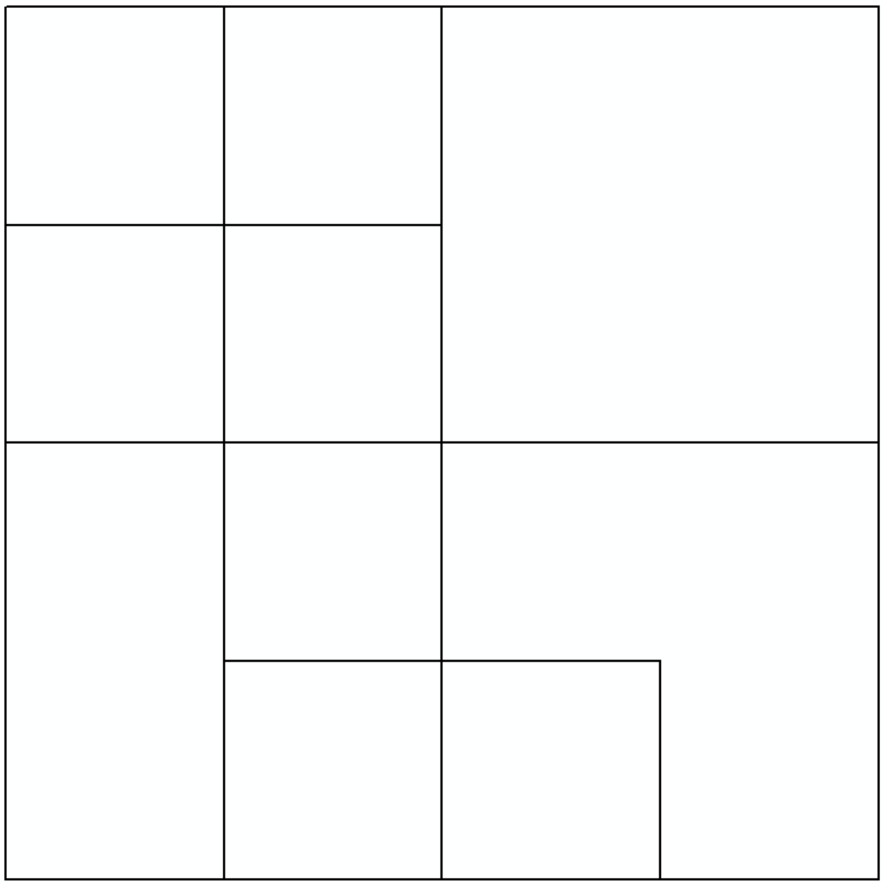
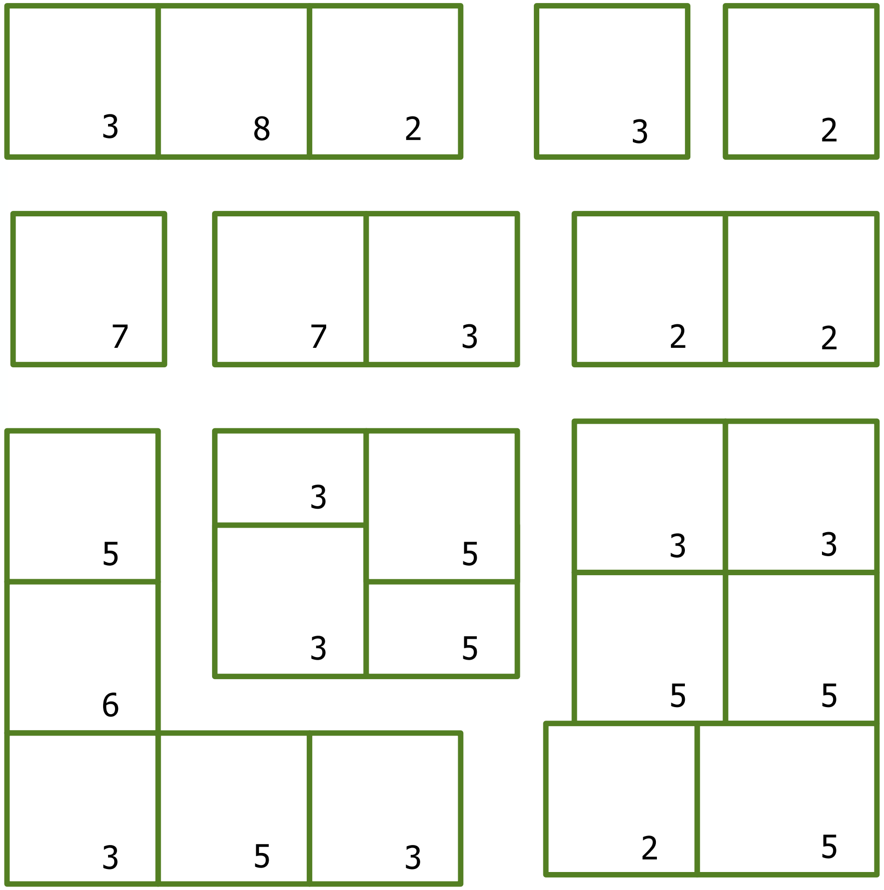
Main Task of the algorithms

- Aggregation of N zones into M regions (N>M)
- Based on an Objective Function
- Works by iteratively combining and recombining zones into regions

Related works

Problems of AZD we addressed in our algorithm





1. AZD works only with a **connected** feature set
2. Topological contiguity is therefore required

Content

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3. Related works
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5. Implementation
6. Concluding remarks

Implementation and Result

As an Add-In for ArcGIS 10.1

Application Programming Interface (API): ArcObjects

Programming Language: c#

Add-in Implemented in: ArcGIS 10.1