

# Developing capacitated p-median

*location-allocation model in the spopt library to allow UCL student teacher placements using public transport*

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# The problem

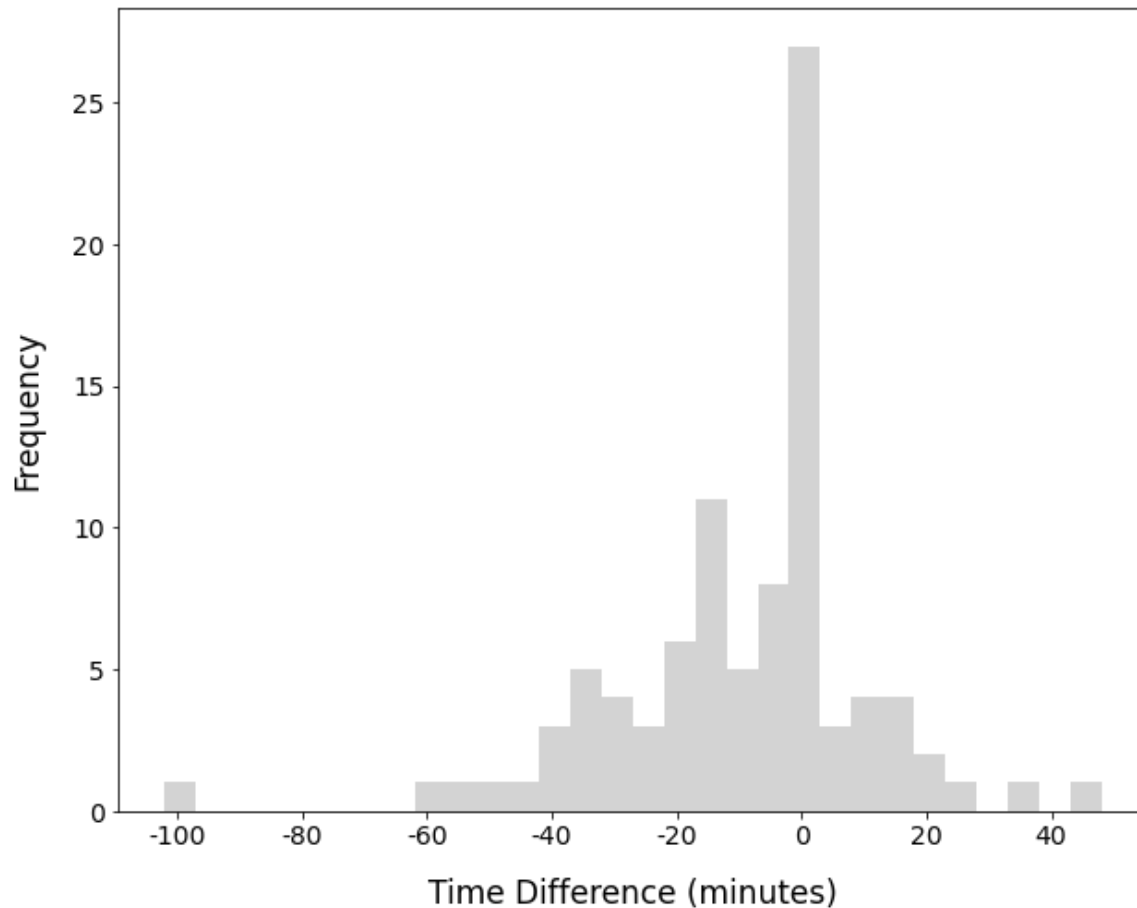
- UCL IOE (Institute of Education) run a teacher placement programme.
- These students are learning how to become high school teachers.
- They have about 800 students who need to be placed across about 500 schools.
- Currently they use a combination of Google Maps (locations and public transport routing) and Excel spreadsheets to do this process manually.

# We know there is a better way

- Location-Allocation could be a solution to this problem.
- Most tools: drive-time distances, few: public transport
- About 70% of UCL students use public transport.
- Range of additional criteria for schools and students.
  - Subject, caring, disability, school priority, ...
- Tool created needed to be easy to use by IOE Placement Team.

# Initial Results

- Applied a capacitated p-median location-allocation model
- Reduced travel time by **9.58** min per student



- Negative values = decrease in travel time
- Positive values = increase in travel time
- (*compared with the IOE allocation*)





# How did we do this?

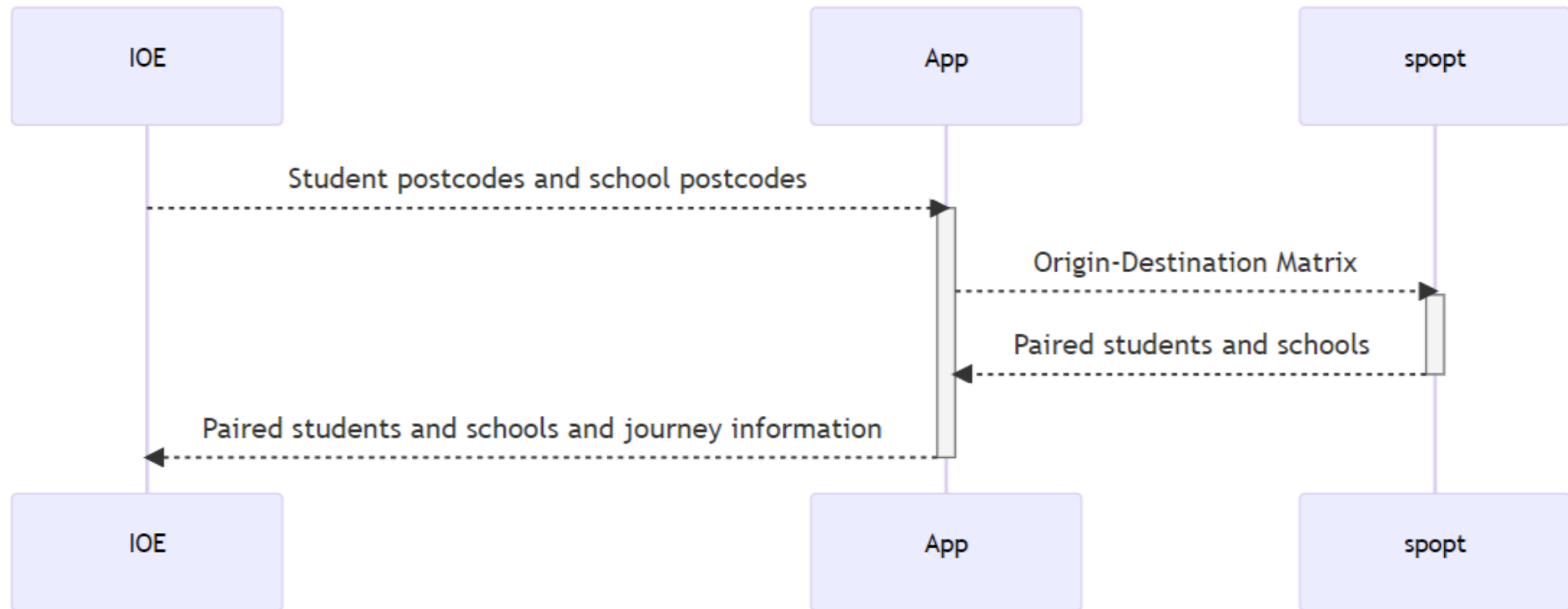
- Many ways of doing location-allocation
- Need to intergrate public transport data
  - *can create an OD matrix from TFL API*
- Need to work with a large number of students (~800) and schools (~500)
- Considered ArcGIS Pro, FLP Spreadsheet Solver, PySpatialOpt, Allagash
- Reached out via Twitter

# How did we do this?

- Qunshan Zhao suggested spopt
- spopt couldn't do what I wanted, but happy to develop
- Applied for AGILE funding to do this, successful (+ Glasgow)
- Rongbo Xu added capacitated p-median location-allocation model to spopt
- Also Patrick Roddy created code to calculate routes for student (postcode) to school (postcode) using TfL API



# Data Flow



# Model Formulation

$$\text{Minimise } \sum_{i=1}^n \sum_{j=1}^m c_{ij} X_{ij} \quad (1)$$

Subject to:

$$\sum_{j=1}^m X_{ij} = 1, \quad \forall i \in I \quad (2)$$

$$\sum_{i=1}^n X_{ij} \leq b_j, \quad \forall j \in J \quad (3)$$

$$\sum_{i=1}^n X_{ij} = b_j, \quad \text{when } p_j = 1 \quad (4)$$

$$X_{ij} \leq Y_j, \quad \forall j \in J \quad (5)$$

Where:

$$X_{ij} = \begin{cases} 1, & \text{if student } i \text{ is assigned to} \\ & \text{school } j; \\ 0, & \text{otherwise.} \end{cases}$$

$$Y_j = \begin{cases} 1, & \text{if school } j \text{ is selected;} \\ 0, & \text{otherwise.} \end{cases}$$

- i - student, I - all students.
  - j - schools (facilities), J - all schools
2. ensures that each student is assigned to one slot
  3. ensures that number of students assigned to each school for each subject does not exceed the available slots.
  4. ensures that the slots of priority 1 schools are fulfilled.
  5. ensures the number of students X is smaller than or equal to the number of slots/schools Y

Sample data: 19 students, 38 schools 0.2 seconds | 20 students, 70 schools 0.7 seconds

# Next steps

## Initial Feedback from UCL IOE

- Potential to be very useful
- Need to look at those with a large journey time increase
- and different transport mode mixes (train/tube vs bus)

## Developments

- Visualisation of the outputs beyond a static map, e.g. dashboard
- Create a tool to allow IOE to run and customise allocation
- Also to 'lock' specific placements and re-run allocation

# Links & Thanks

- spopt: Spatial Optimization <https://pysal.org/spopt/>
- GitHub site for code, including Jupyter Notebook with reproducible example and sample student data - <https://github.com/UCL/ioe-student-school-allocation>
- Thanks to AGILE for funding
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