# An Optimization Algorithm for the Tourist Trip Design Problem with Type-Covering Constraints

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LLEIDA TECH
ARTIFICIAL INTELLIGENCE & OPTIMIZATION CONGRESS

ICSO
INTELLIGENT COMPUTING
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# Part I:
# Introduction

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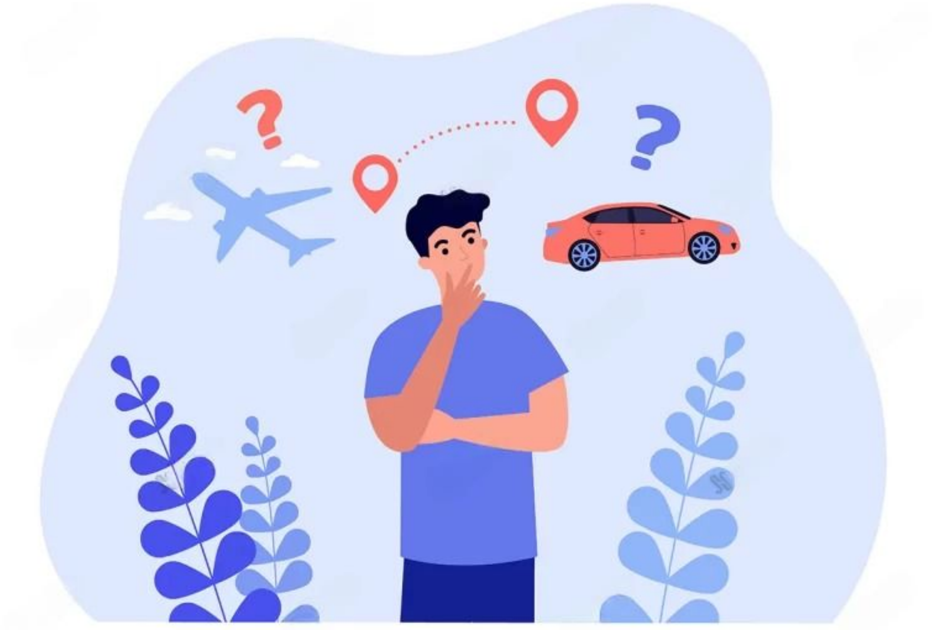

# Introduction

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- This is the core concept of the TTDP.

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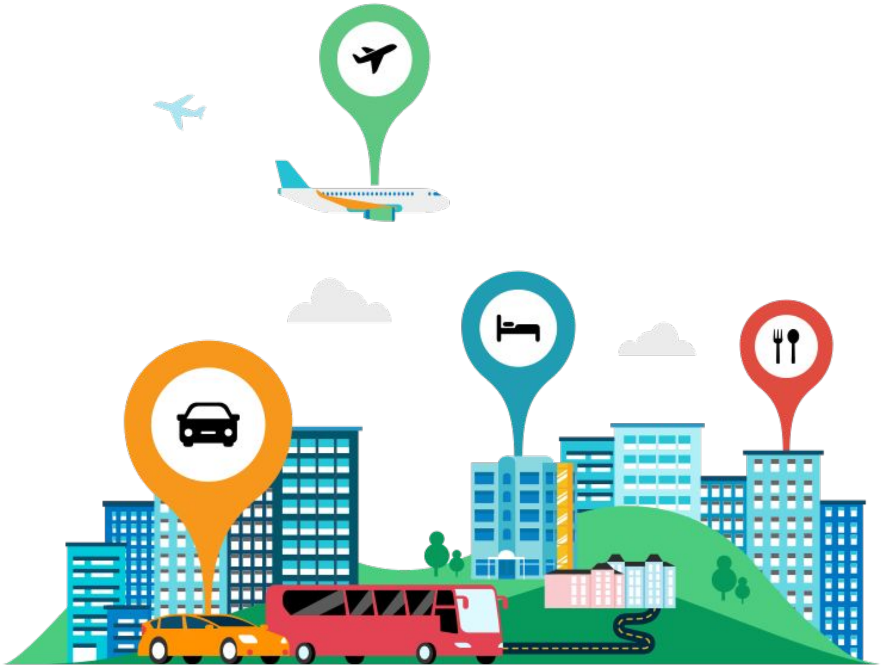
- Objective is maximize profit or preference value of visited POIs before maximum travel time.



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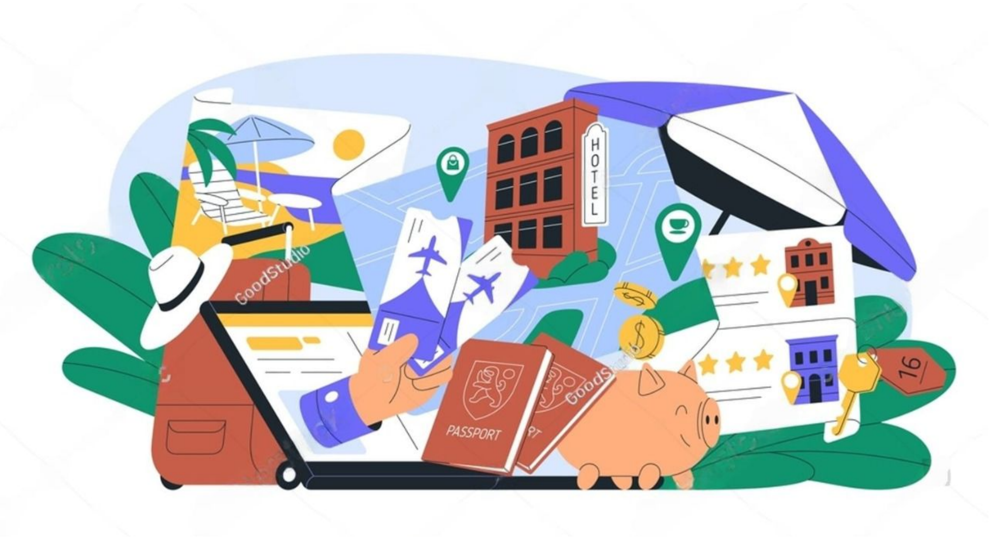

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- Provide tourists with more diverse experience with TC constraints.

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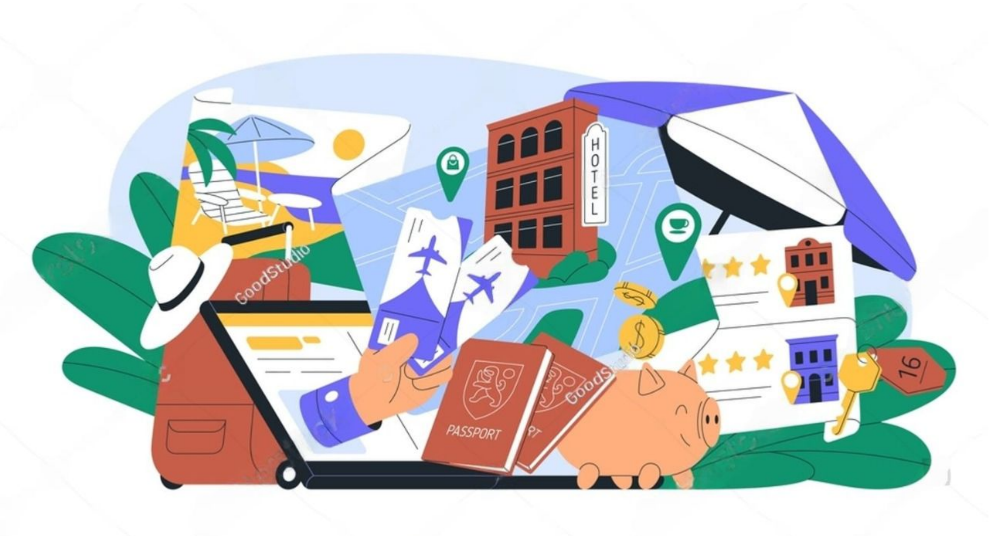
- Ensure each category or type of POI is visited throughout the trip.



# Part II:
# Problem Description

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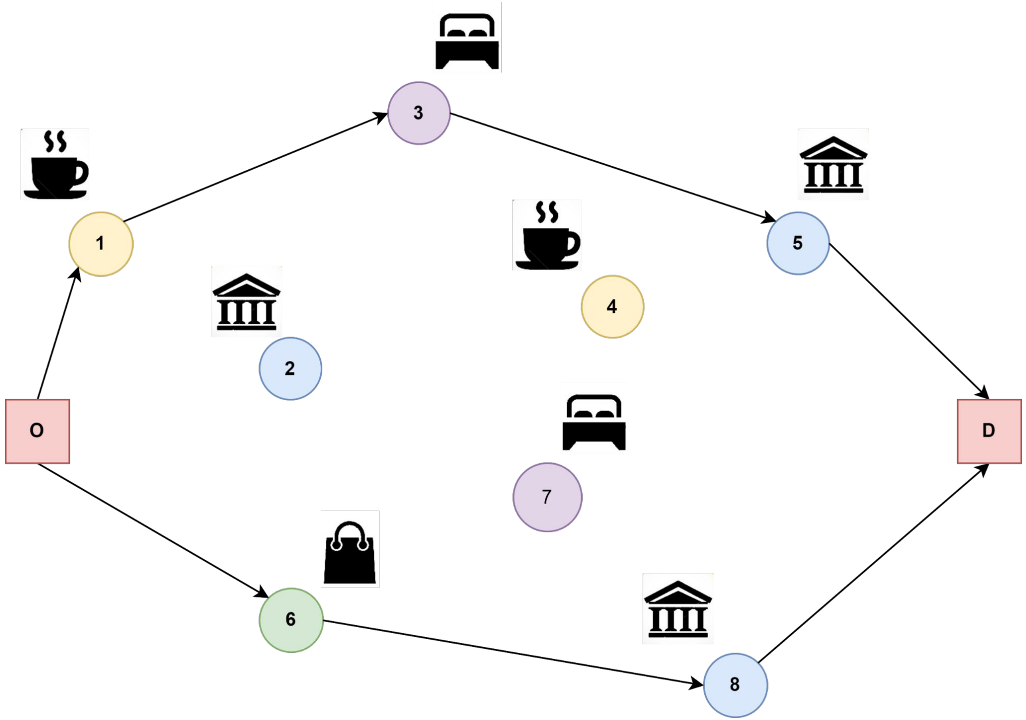

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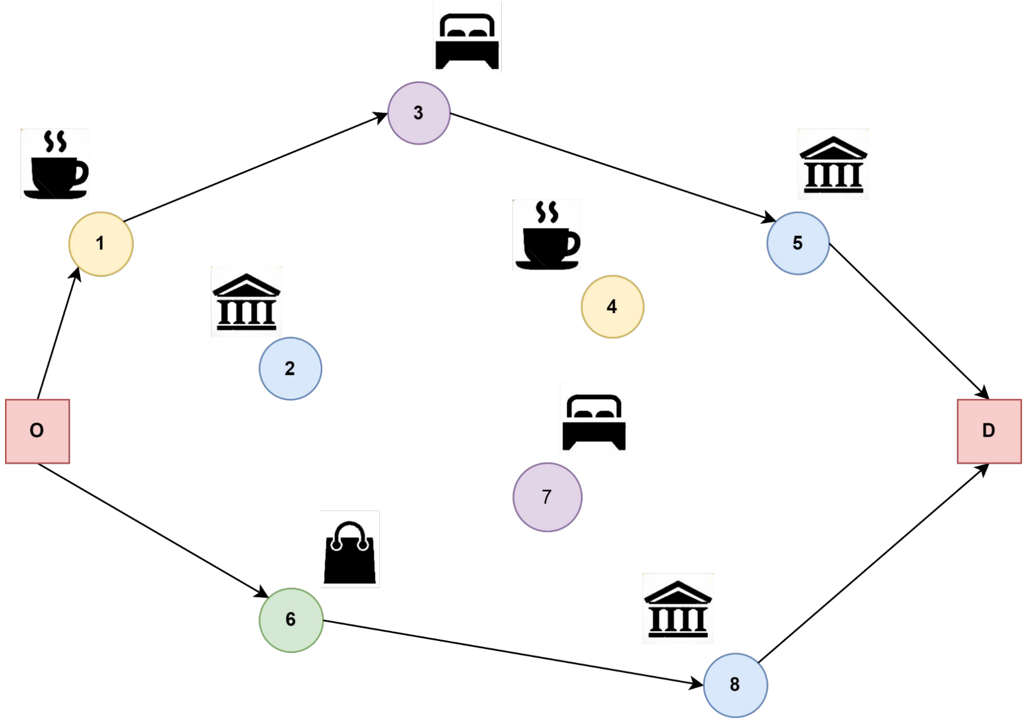
- The TTDP-TC is represented as a **directed graph**.



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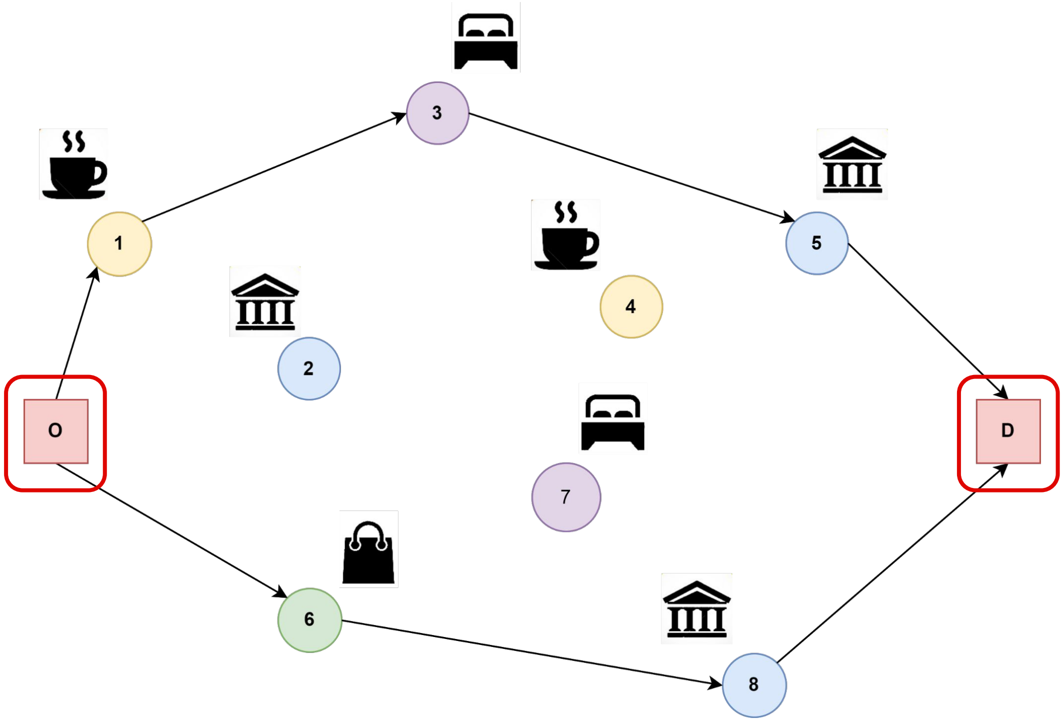

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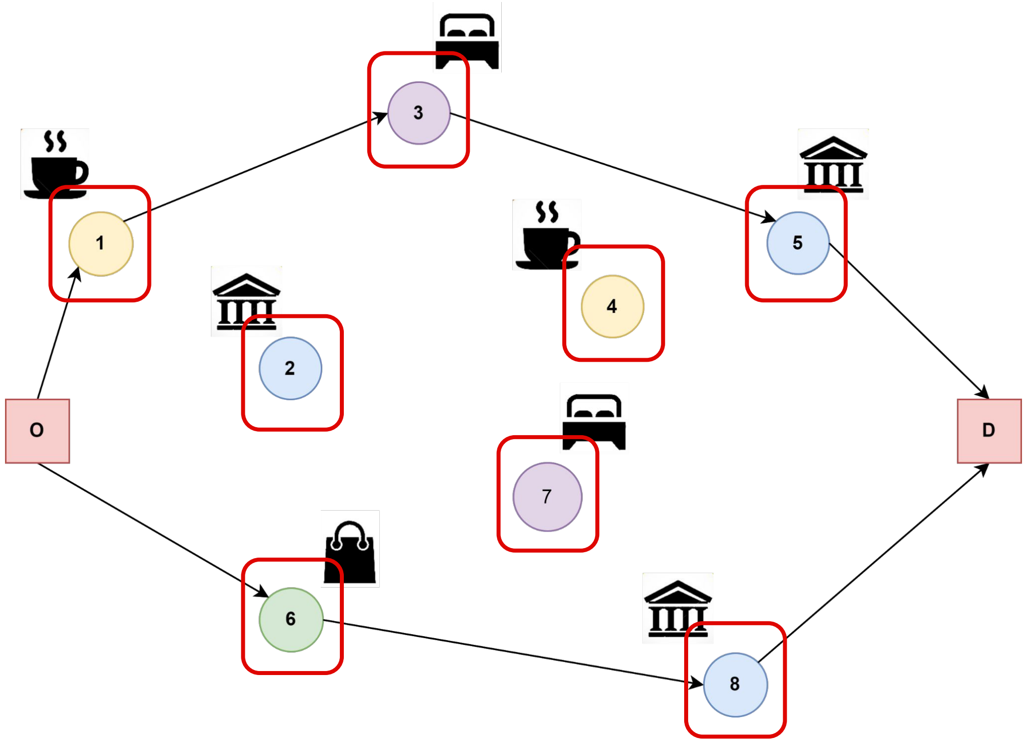

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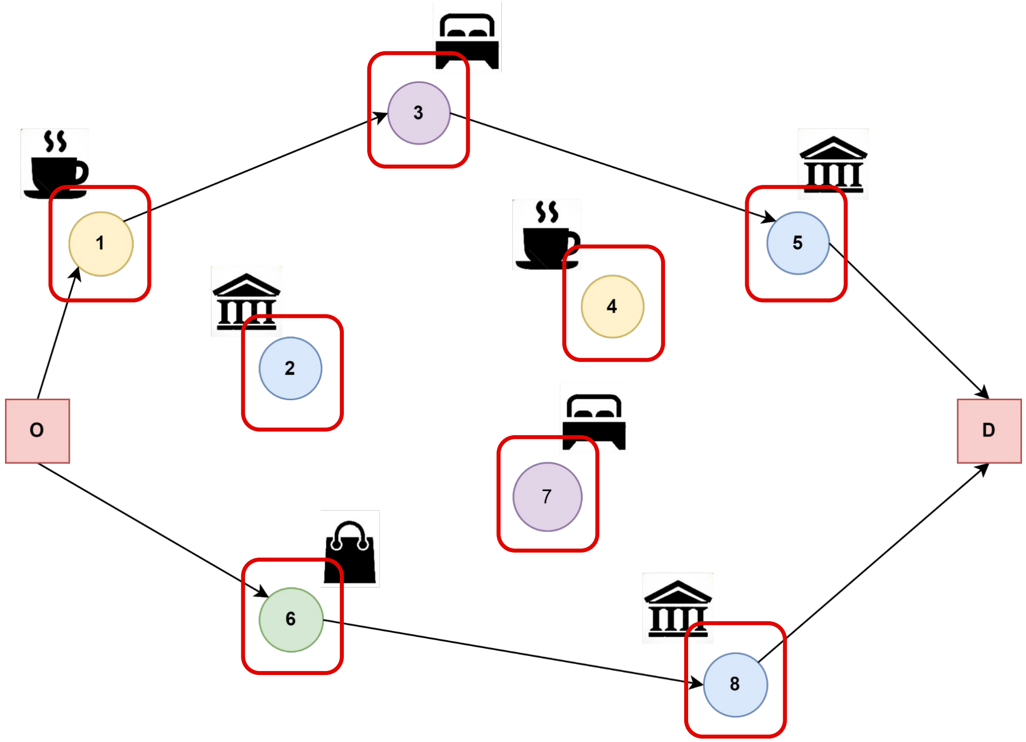
- Each POI has associated a **profit value**, indicating its preference.



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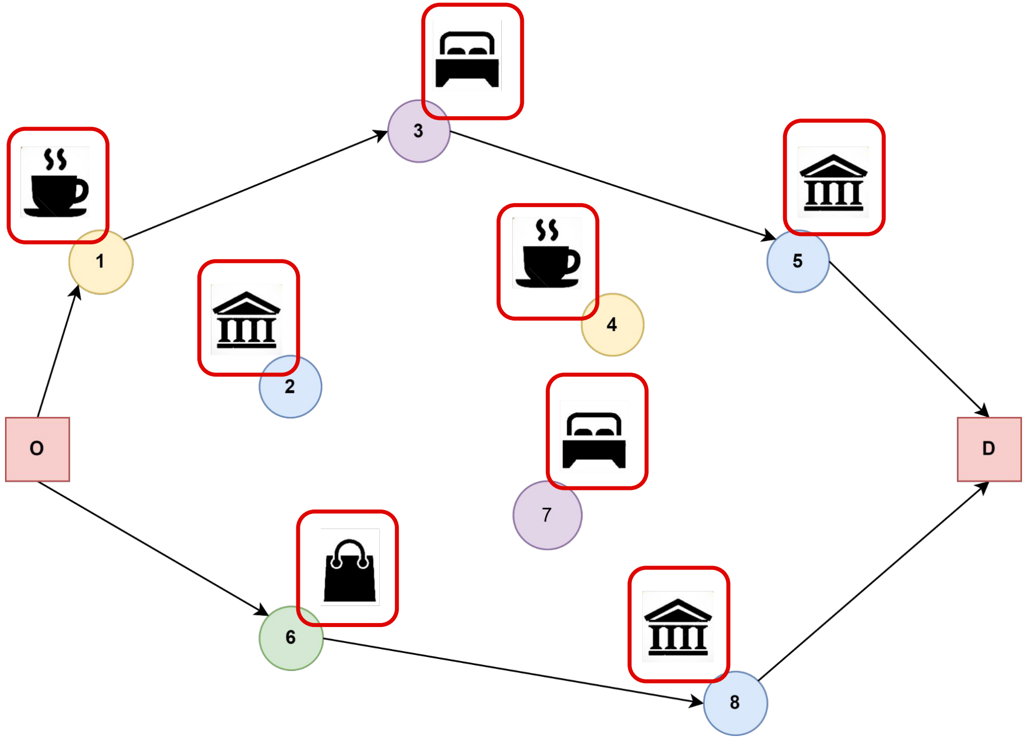

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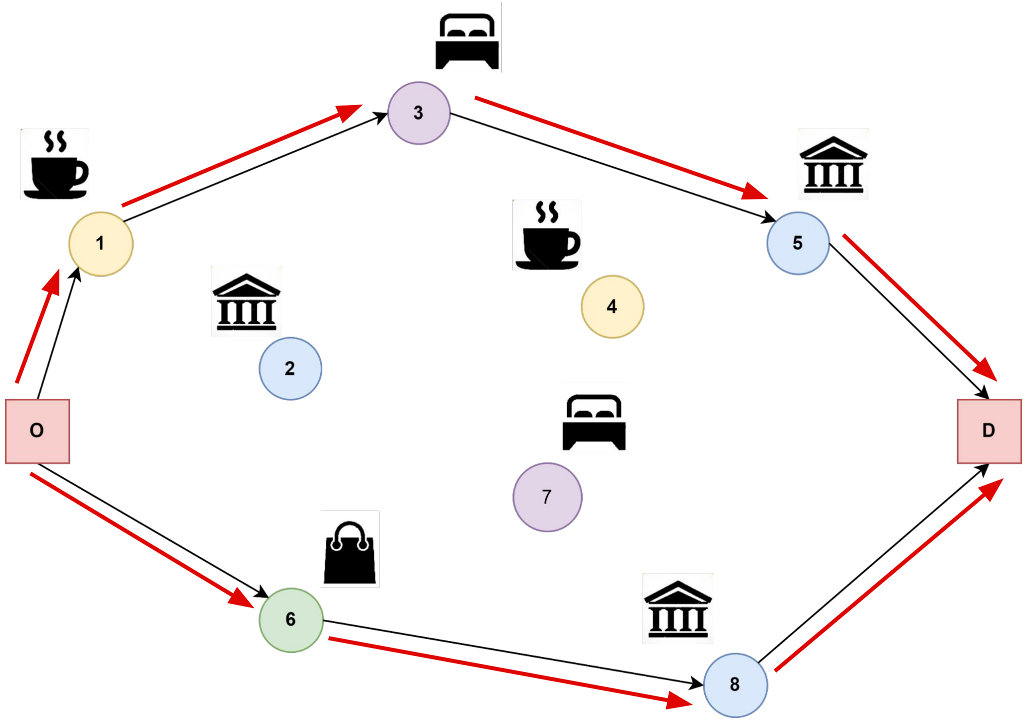

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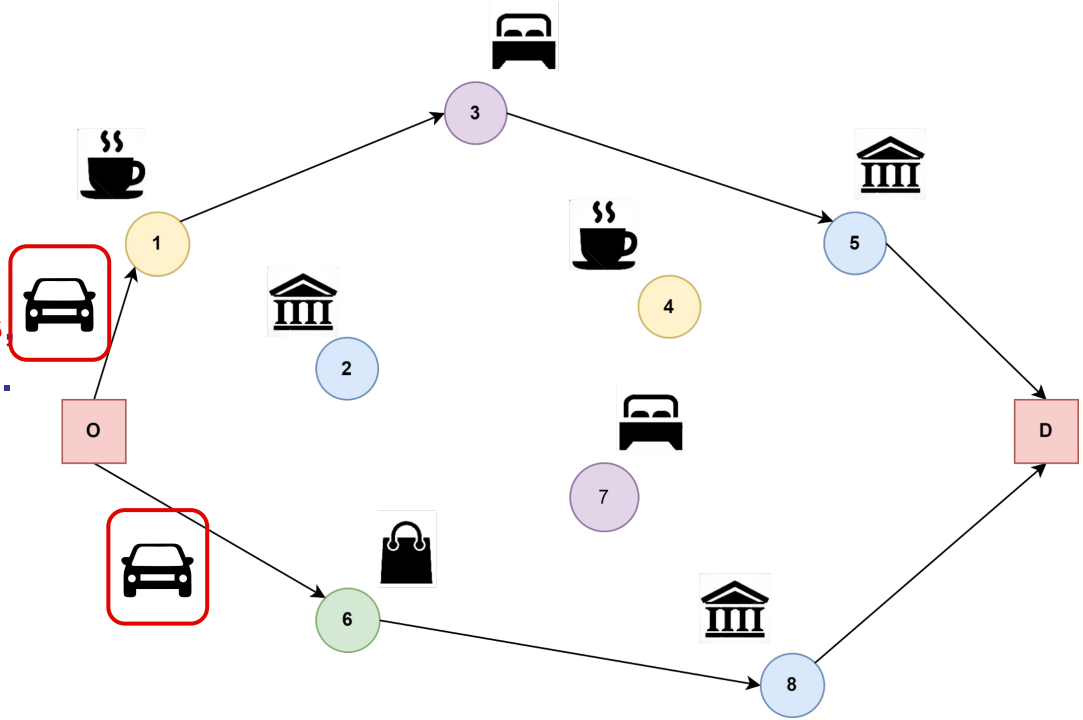
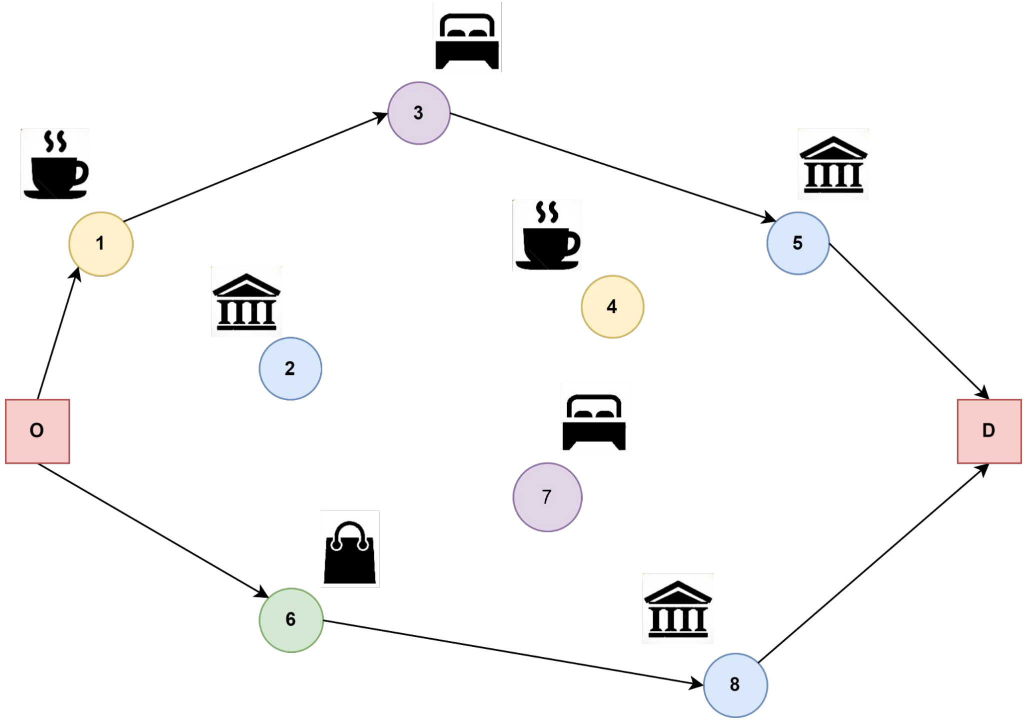
- Execute the *m*-days plan before **maximum travel time.**



# Problem Description

- To represent the problem, three variables are introduced.



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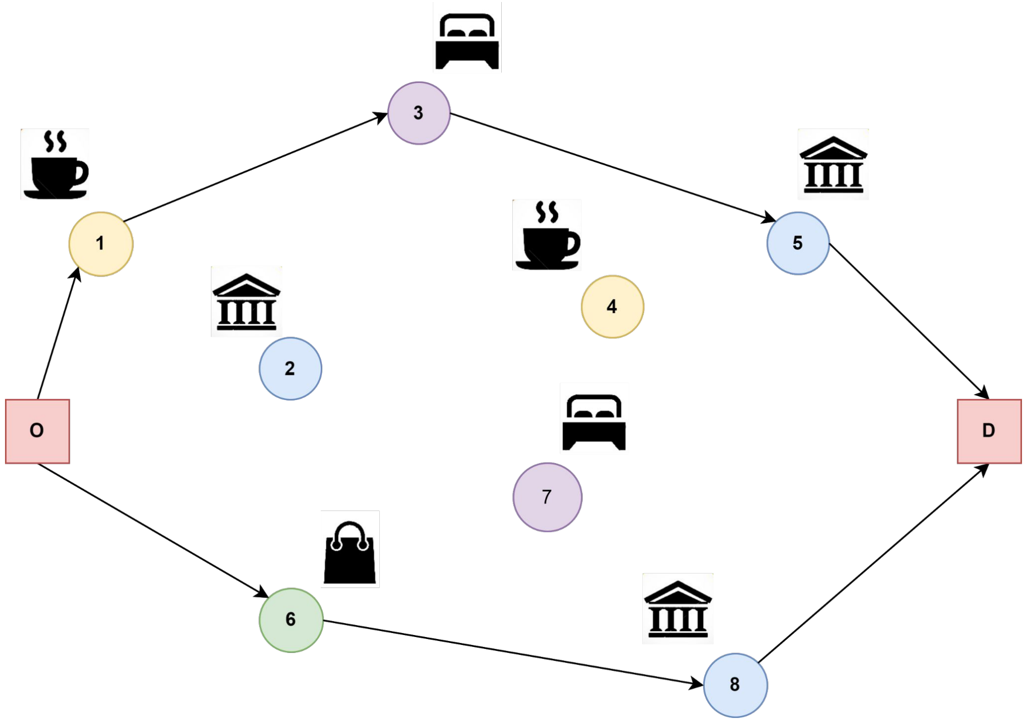
- $x_{i}$□ variable to indicate if a vehicle travels from i to j or not.



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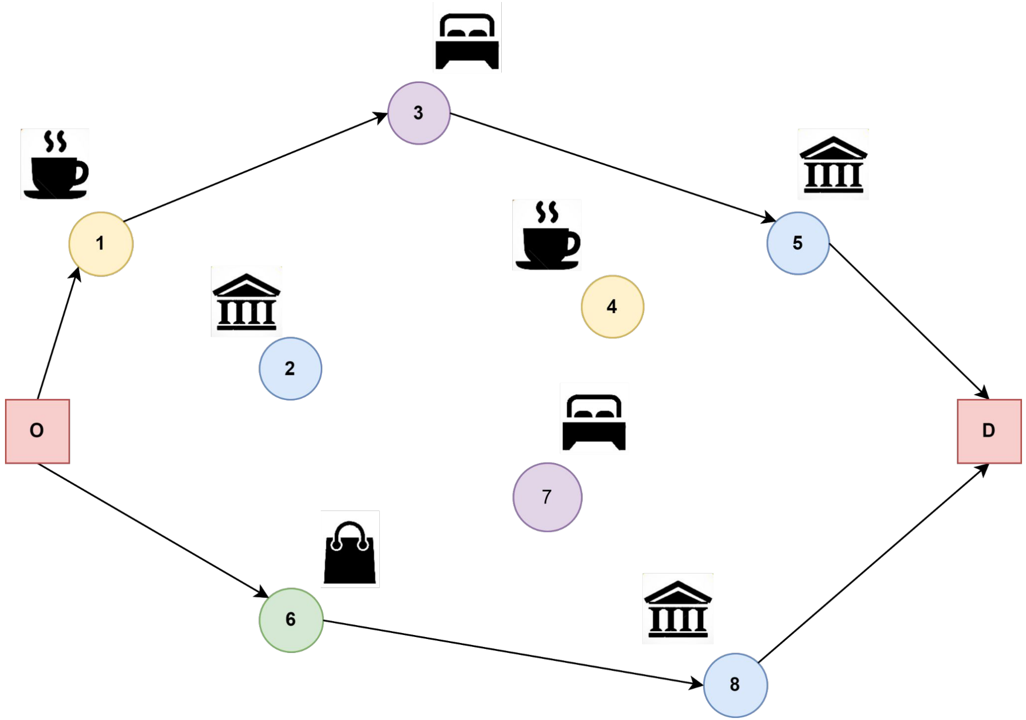
- $y_i$ variable to indicate if POI i has been visited or not.



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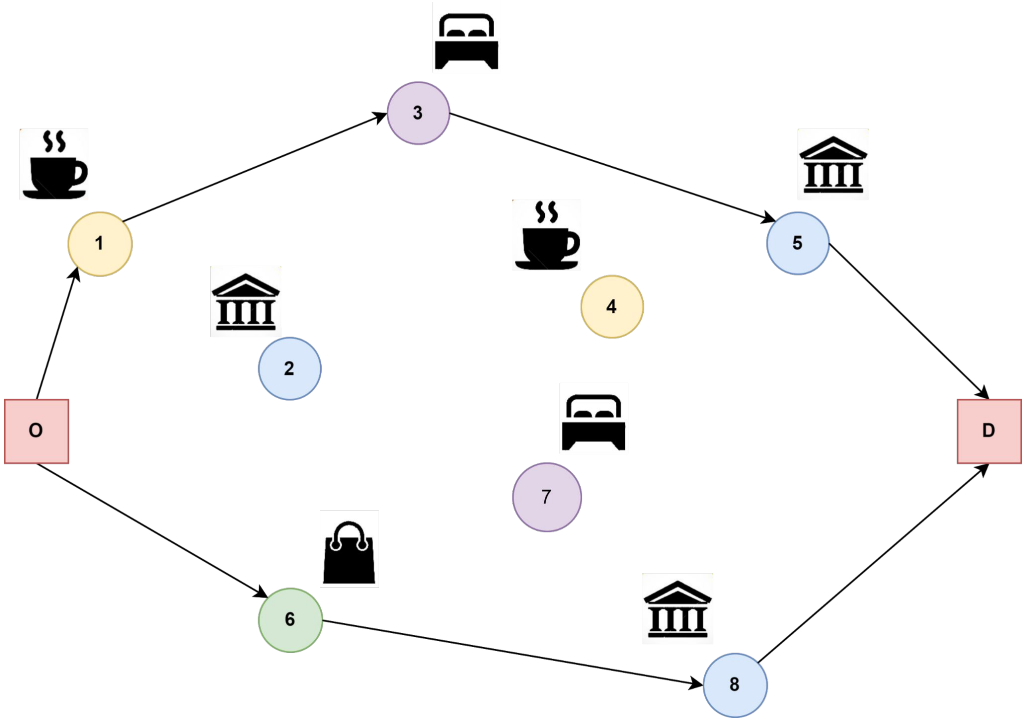
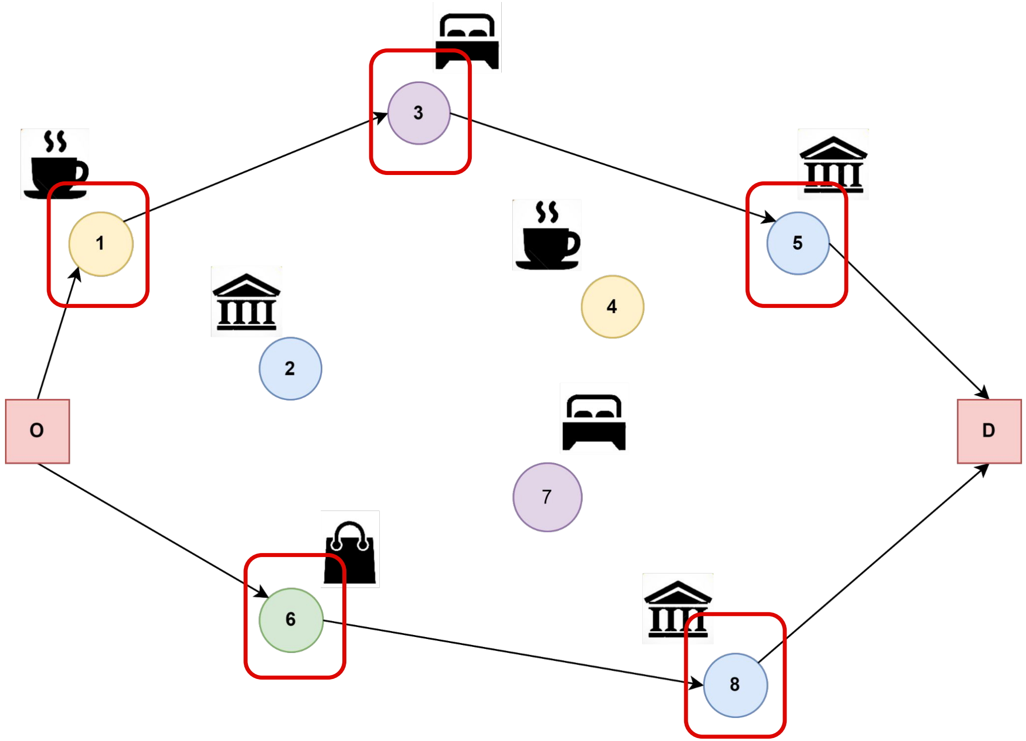
- To represent the problem, **three variables** are introduced.
- $x_i$□ variable to indicate if a vehicle travels from i to j or not.
- $y_i$ variable to indicate if POI i has been visited or not.
- $z_i$□ variable to represent the arrival time to j coming from i.



# Problem Description

- Objective function is to **maximize profit** collected by the visited POIs.

$$\max \sum_{i \in N} p_i y_i$$



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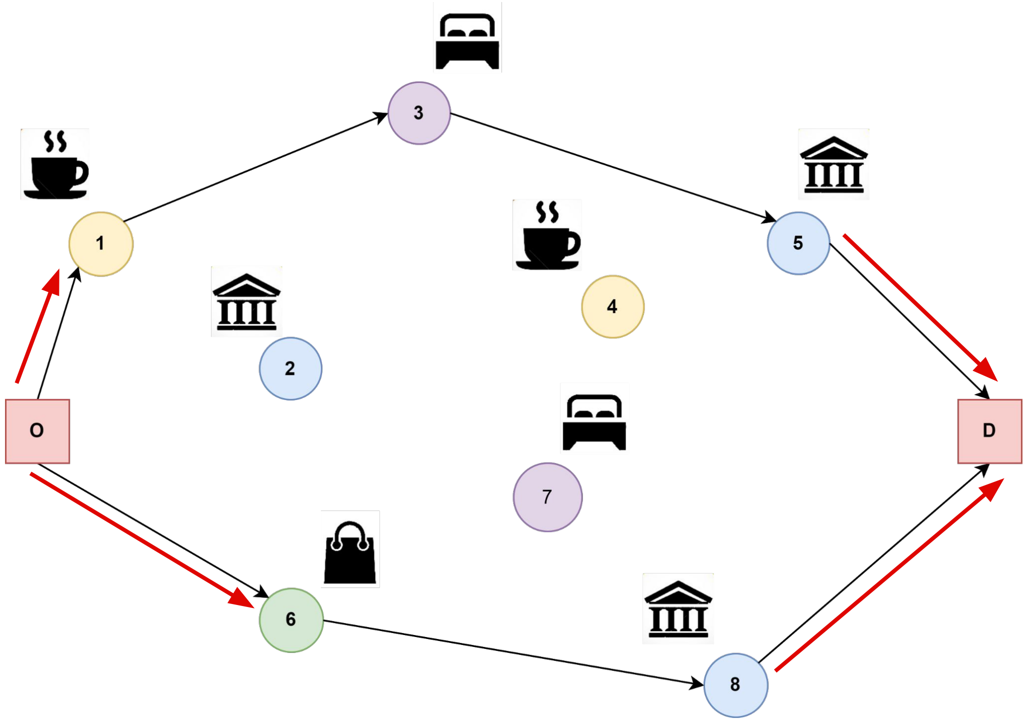
- **Impose vehicle leaves m times the origin and finish at destination.**

$$\sum_{j \in N} x_{0j} = \sum_{i \in N} x_{i,n+1} = m$$



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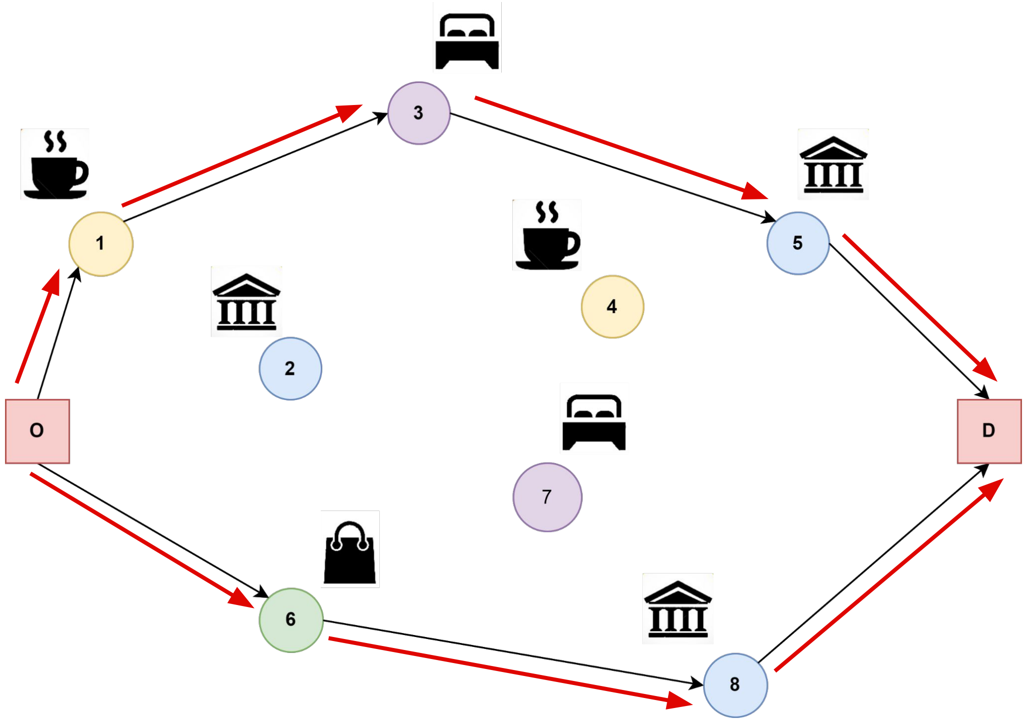
- Impose **vehicle leaves m times** the origin and finish at destination.

$$\sum_{j \in N} x_{0j} = \sum_{i \in N} x_{i,n+1} = m$$

- Impose a **POI** is entered and left **exactly once** if visited.

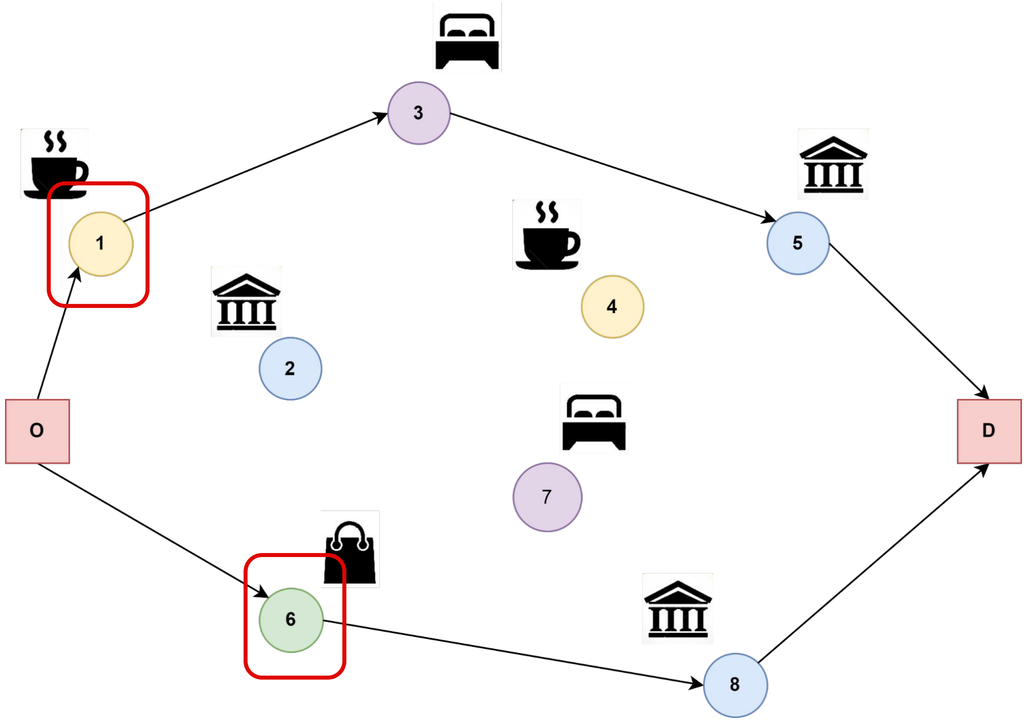
$$\sum_{(j,i) \in \delta^-(i)} x_{ji} = \sum_{(i,j) \in \delta^+(i)} x_{ij} = y_i$$



# Problem Description

- **Set arrival time starting from the origin depot.**

$$z_{0j} = t_{0j} x_{0j}$$



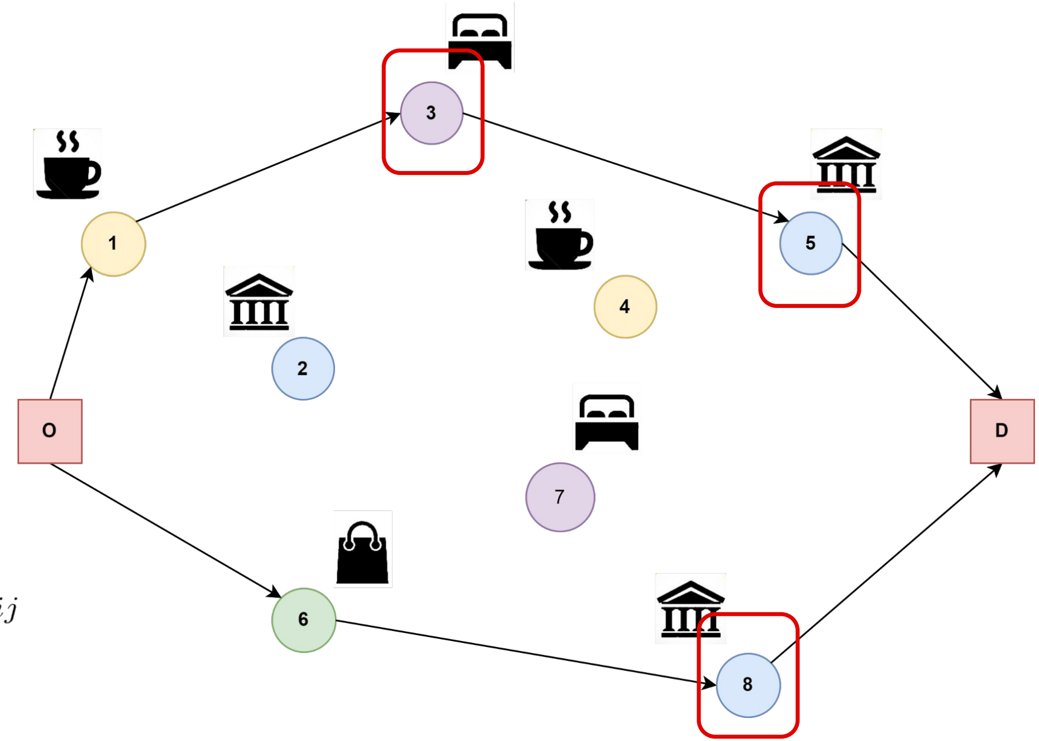
# Problem Description

- Set arrival time starting from the origin depot.

$$z_{0j} = t_{0j} x_{0j}$$

- Set arrival times coming out from each visited POI.

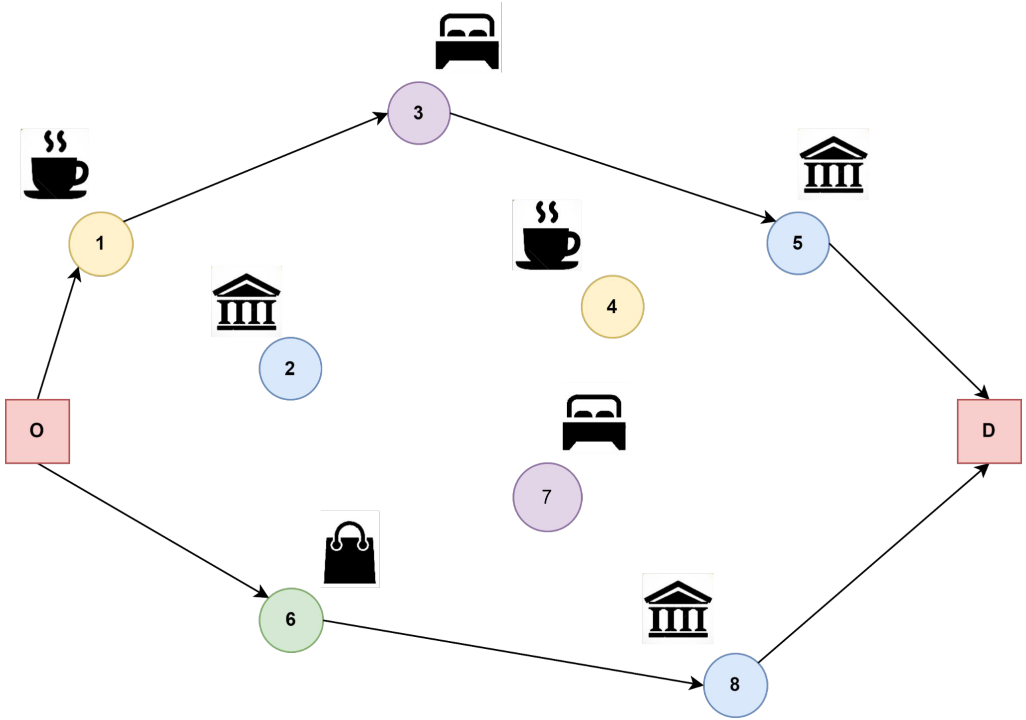
$$\sum_{(i,j)\in\delta^+(i)} z_{ij} - \sum_{(j,i)\in\delta^-(i)} z_{ji} = \sum_{(i,j)\in\delta^+(i)} t_{ij} x_{ij}$$



# Problem Description

- Set the lower bound limits on the arrival time of each route.

$$z_{ij} \geq (t_{0i} + t_{ij})x_{ij}$$



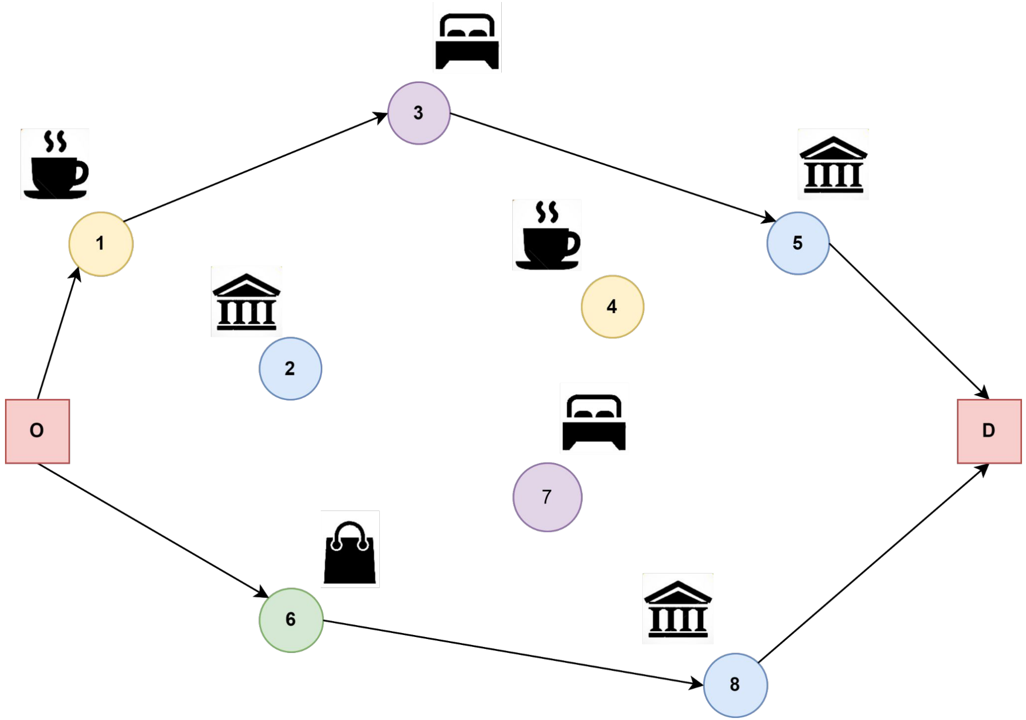
# Problem Description

- Set the **lower bound limits** on the arrival time of each route.

$$z_{ij} \geq (t_{0i} + t_{ij})x_{ij}$$

- Set the **upper bound limits** on the arrival time of each route.

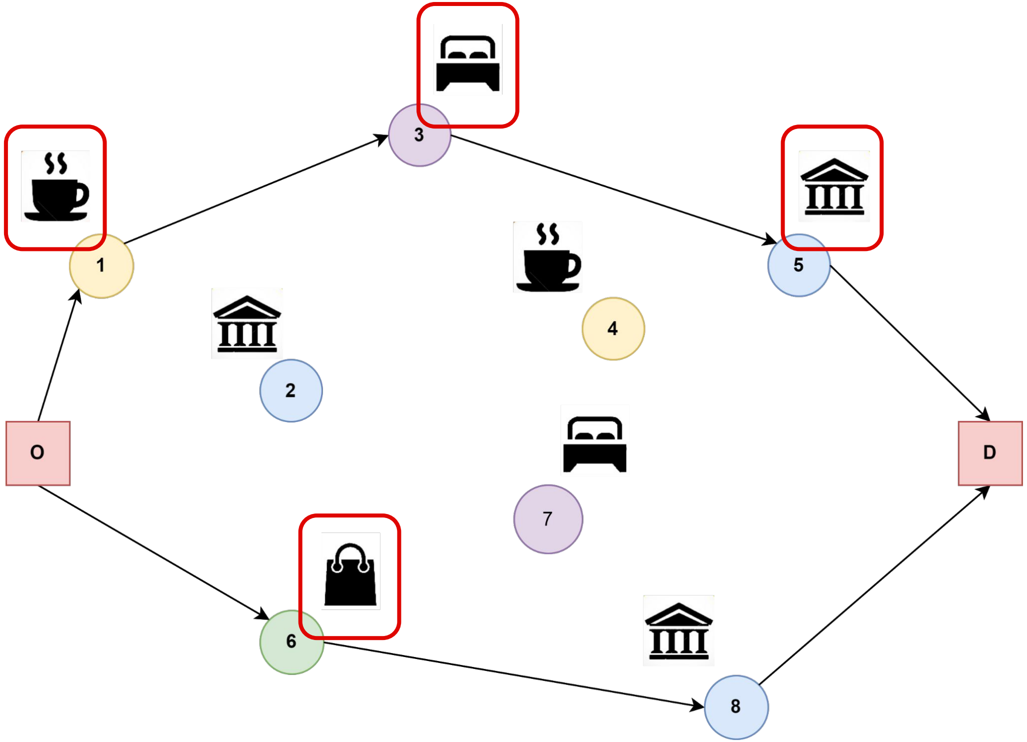
$$z_{ij} \leq (T_{\max} - t_{j,n+1})x_{ij}$$



# Problem Description

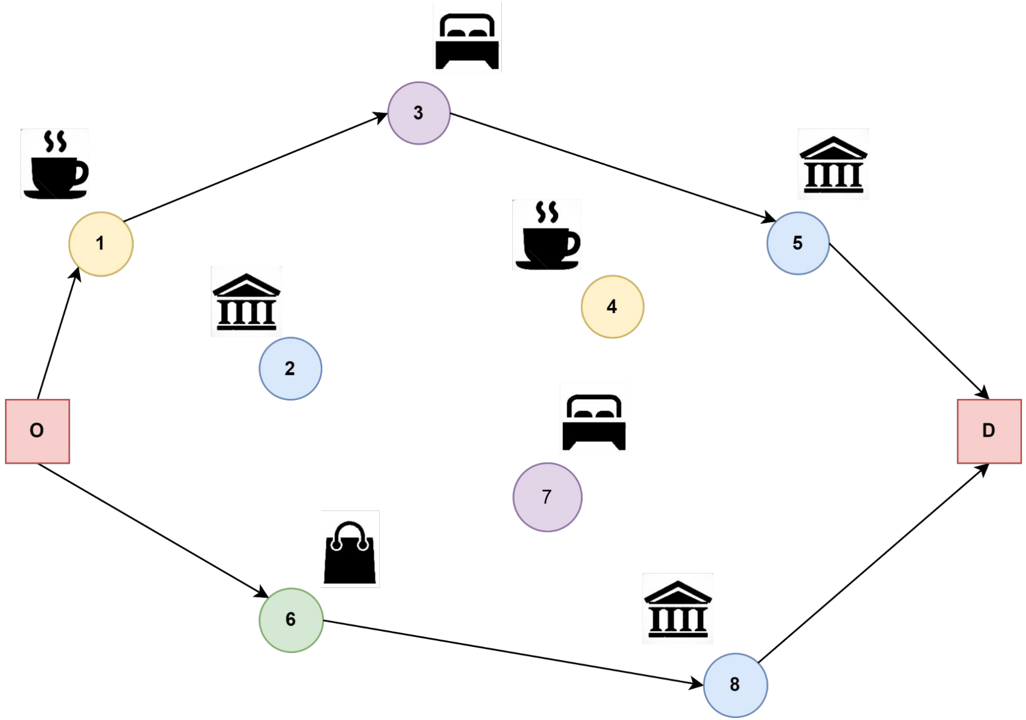
- **Ensure for each category, at least one POI is visited.**

$$\sum_{i \in C_i} y_i \geq 1$$



# Problem Description

- The formulation has polynomial number variables and constraints.



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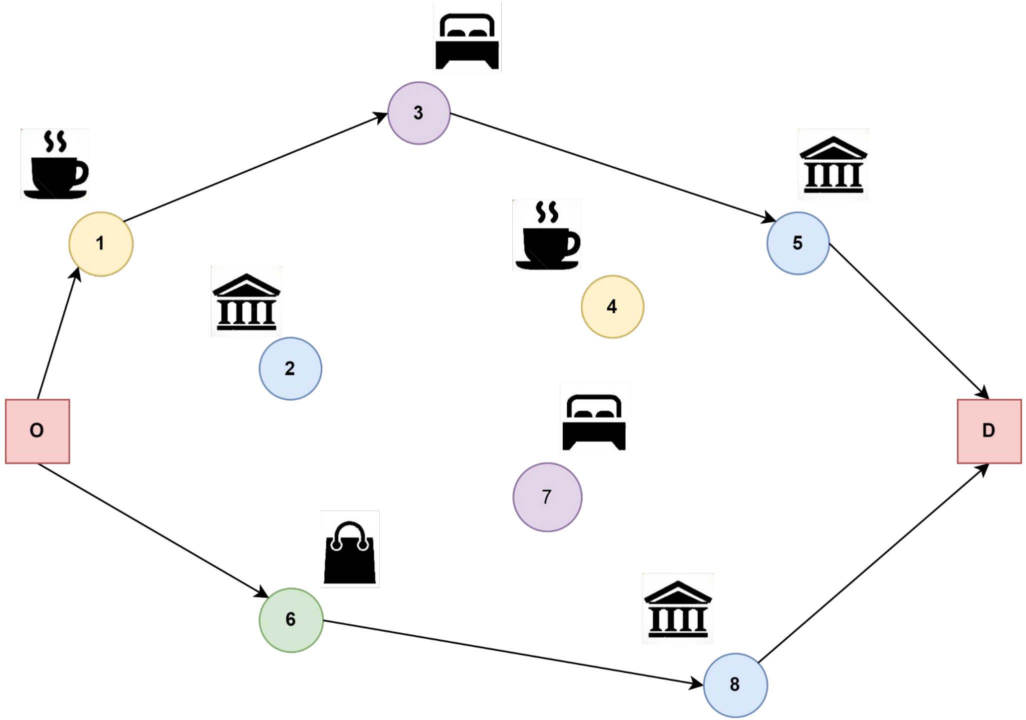
- The formulation has polynomial number variables and constraints.
- It can be used to solve instances of moderate size by optimizers.



# Part III:
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- Commercial solver Gurobi used to test benchmark instances.

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- Extended instances proposed for the TOP, adding category types.
- Commercial solver Gurobi used to test benchmark instances.
- A maximum time limit of 2 hours set to find optimal solutions.

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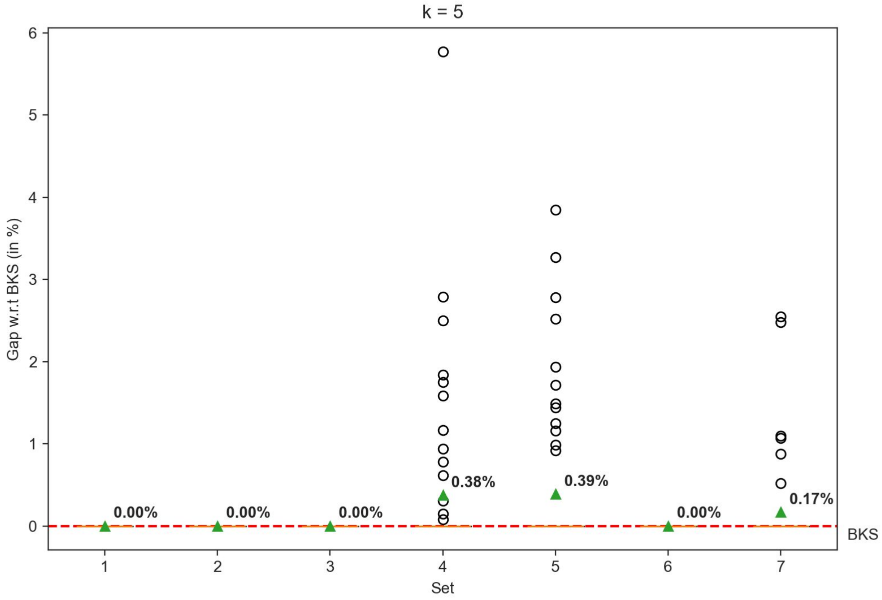

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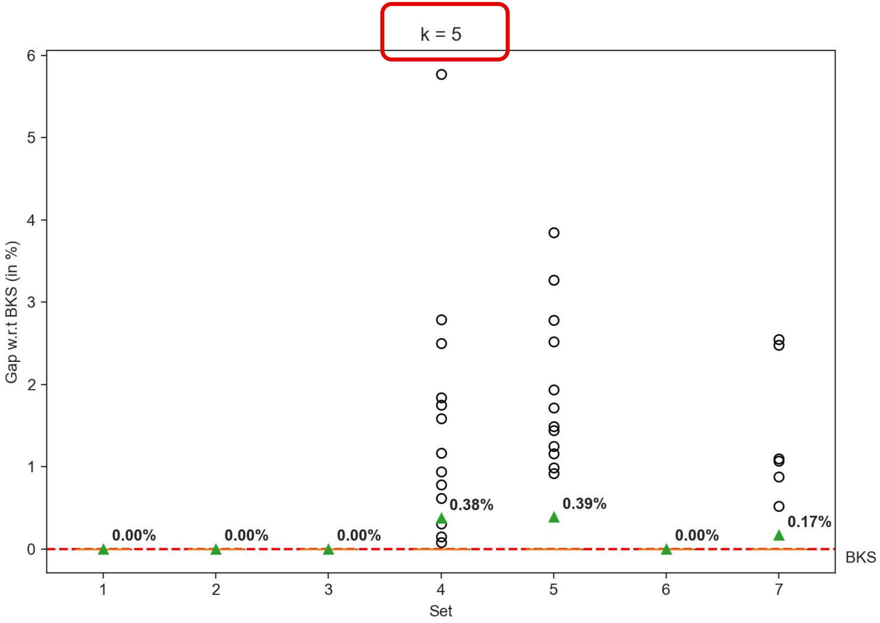
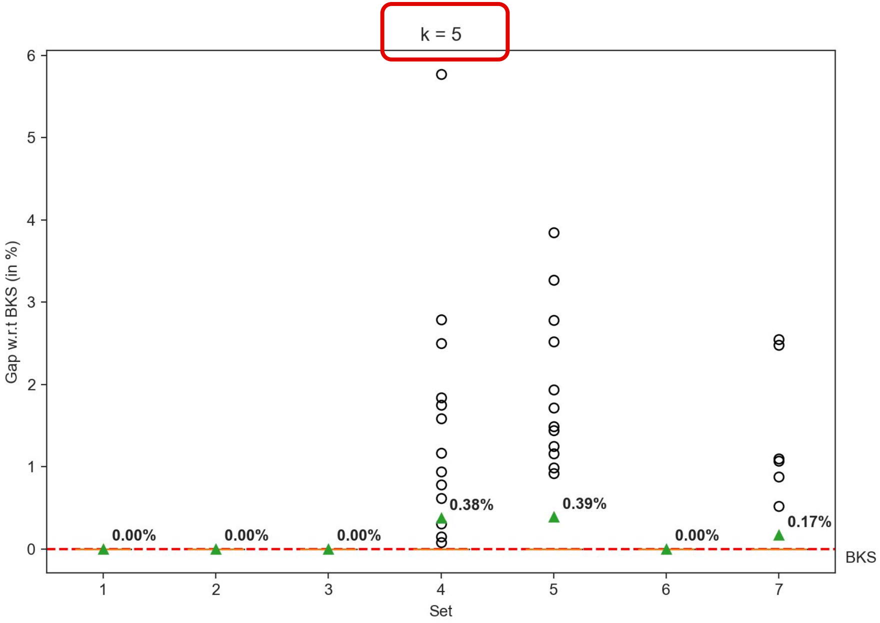


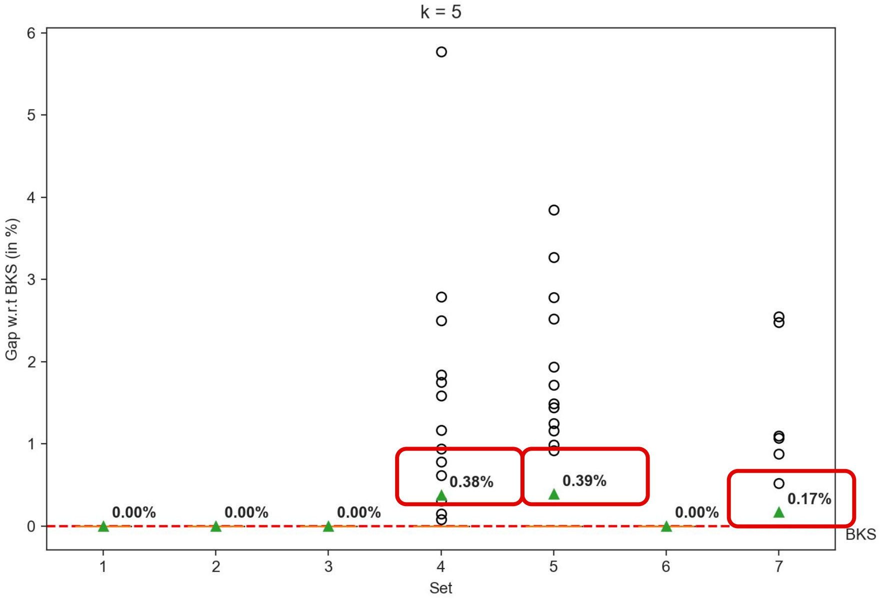
# Preliminary Results

- Obtained **optimal** or **near-optimal** solutions for benchmark instances.



# Preliminary Results

- **Obtained optimal or near-optimal solutions for benchmark instances.**
- **Benchmark sets 4, 5, and 7 are the most challenging to solve.**



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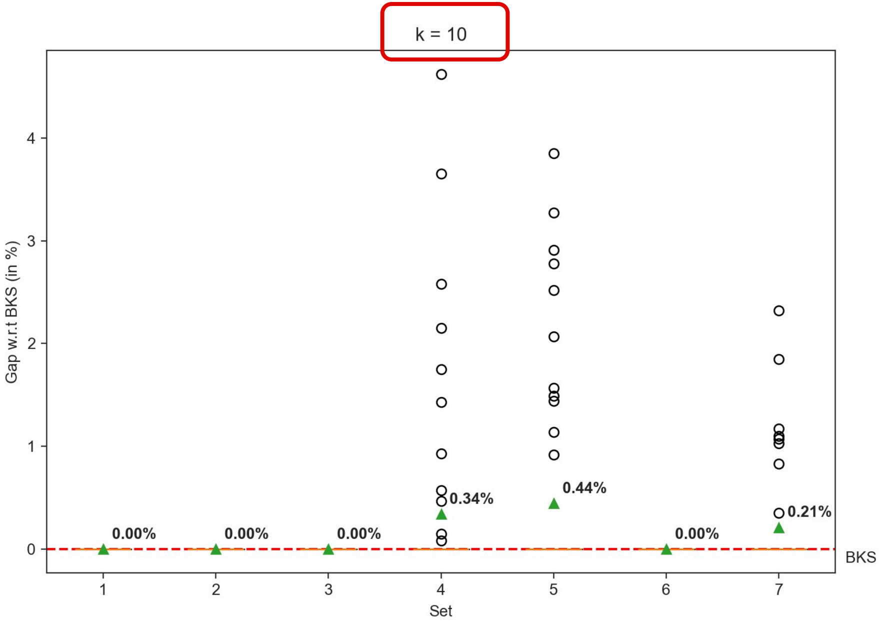
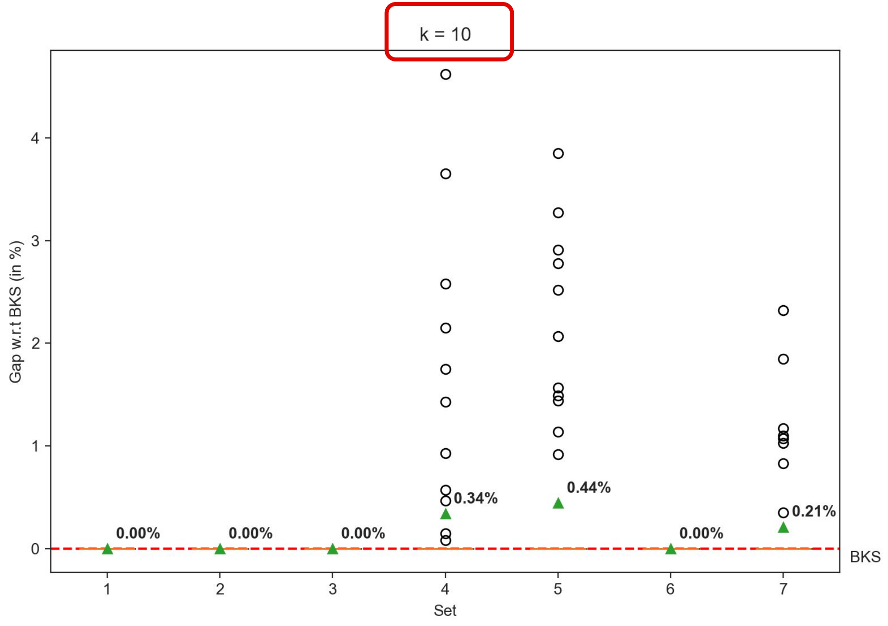


# Preliminary Results

- As number of categories increases, instances become more challenging.



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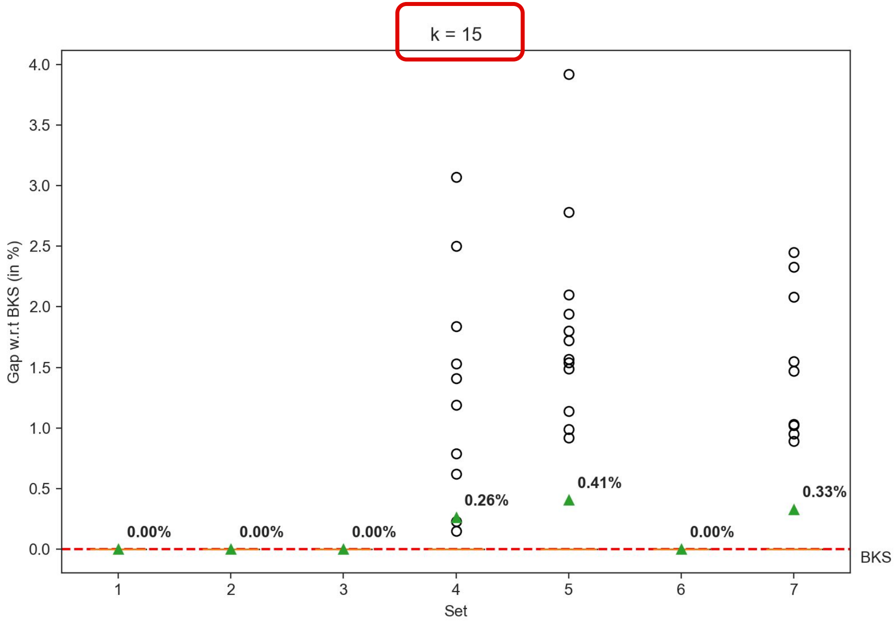

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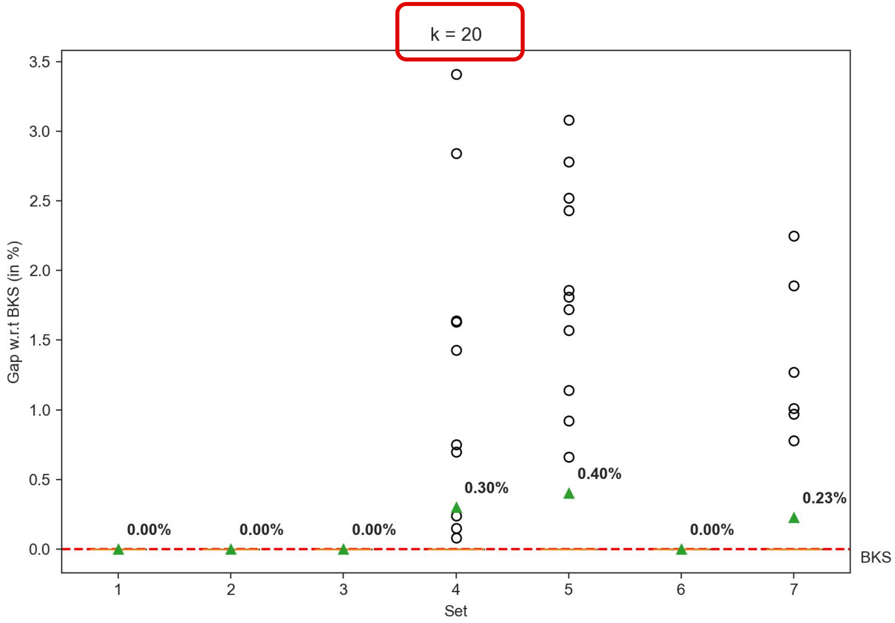
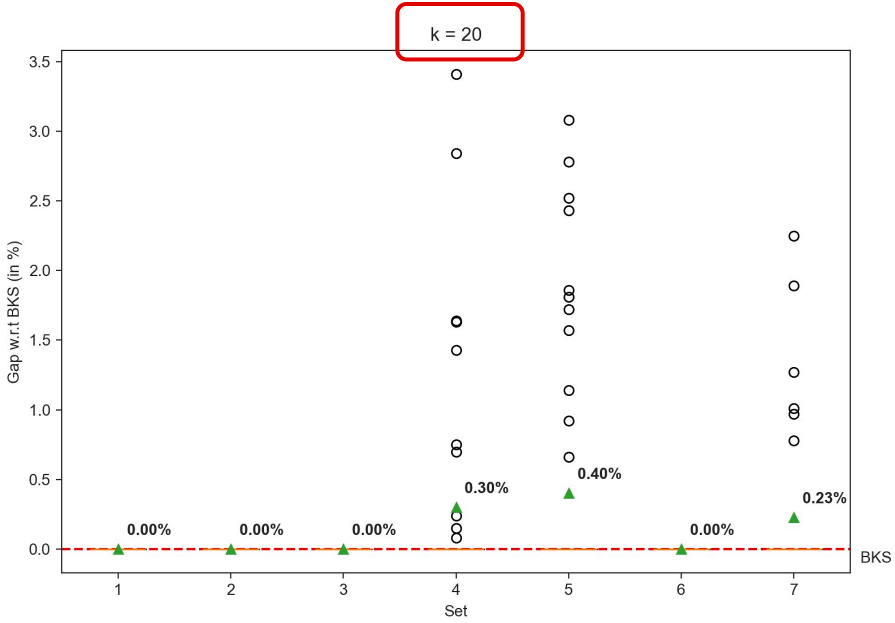


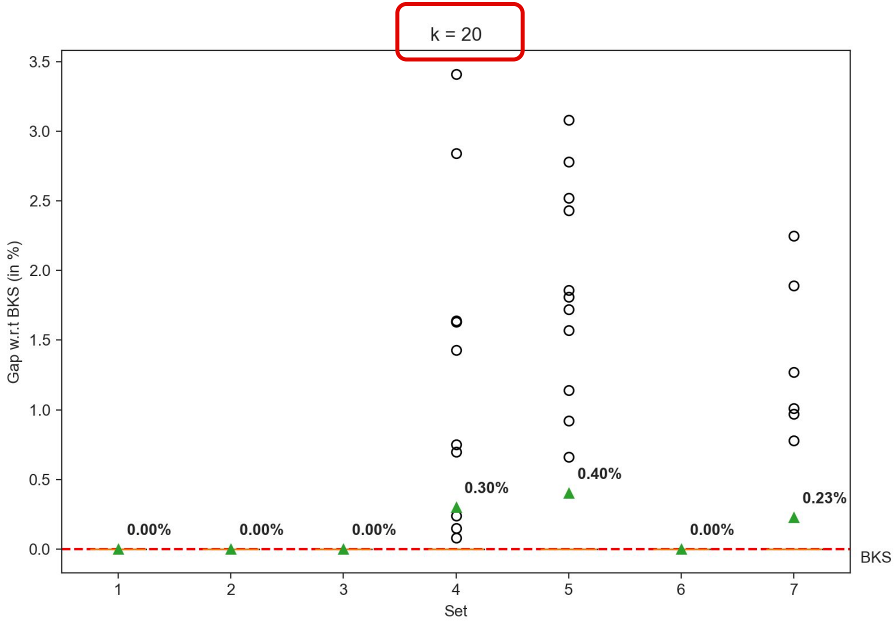
# Preliminary Results

- As number of categories increases, instances become **more challenging**.
- Collected profit decreases as solutions become **more diverse**.



# Preliminary Results

- As number of categories increases, instances become **more challenging**.
- Collected profit decreases as solutions become **more diverse**.
- Results are significant, with **optimal solutions** without complex methods.



# Part IV:
# Conclusions and Future Research

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- Considered TC constraints to provide more diverse routes.

# Conclusions

- Proposed a realistic and complex version of the TTDP.
- Considered TC constraints to provide more diverse routes.
- Solved TTDP-TC with an exact method to provide optimal solutions.

# Future Research Lines

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- Develop an agile optimization algorithm.

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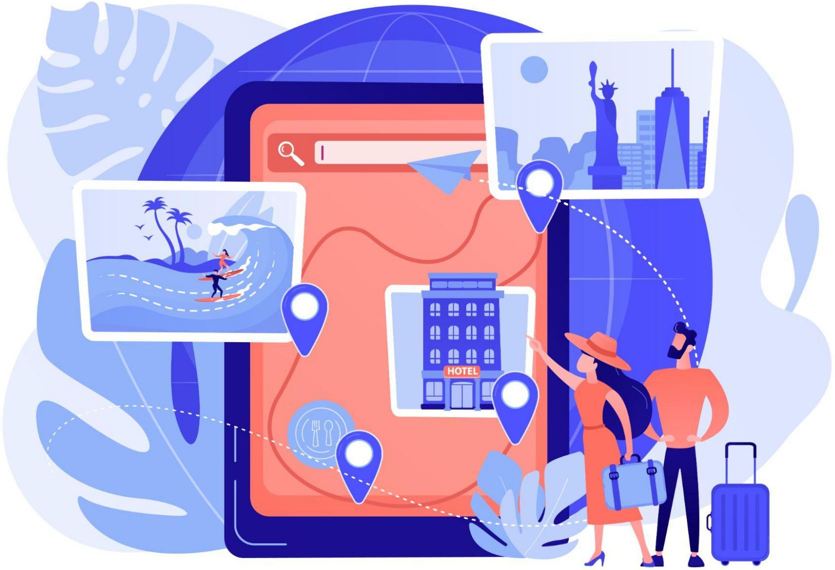
- Develop an **agile optimization algorithm.**
- Consider **time-dependent POI** availability.
- Incorporate **varying preference values** for POIs based on experience.



# Thank you for your attention!

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