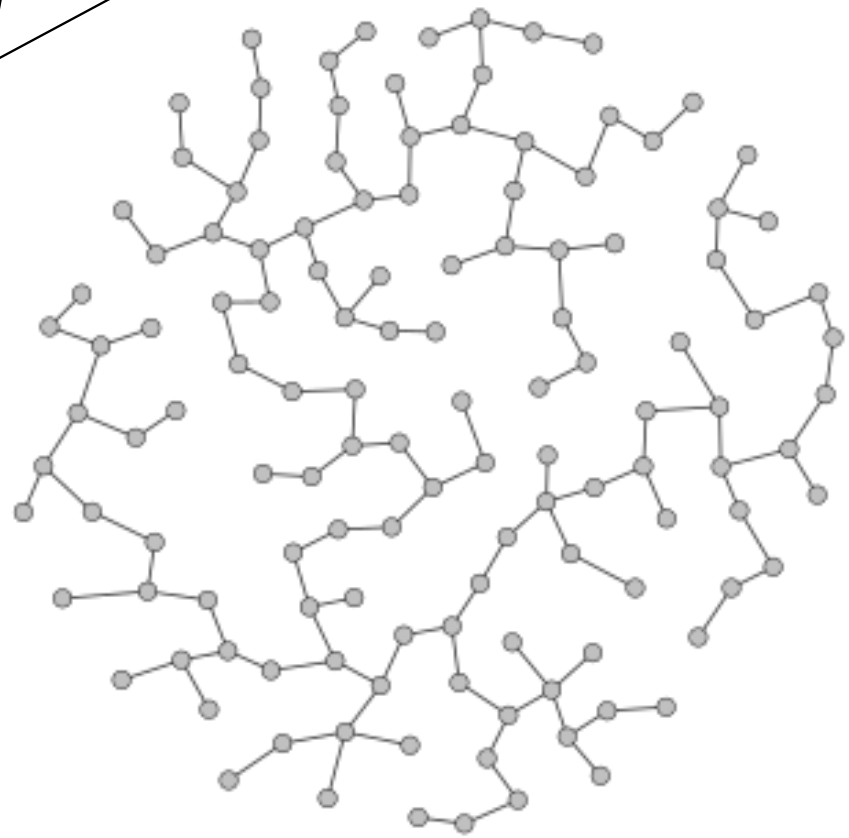

OPEN-SOURCE OPTIMIZATION TOOLS

Alireza Soroudi,

Alireza.Soroudi@gmail.com

H

U

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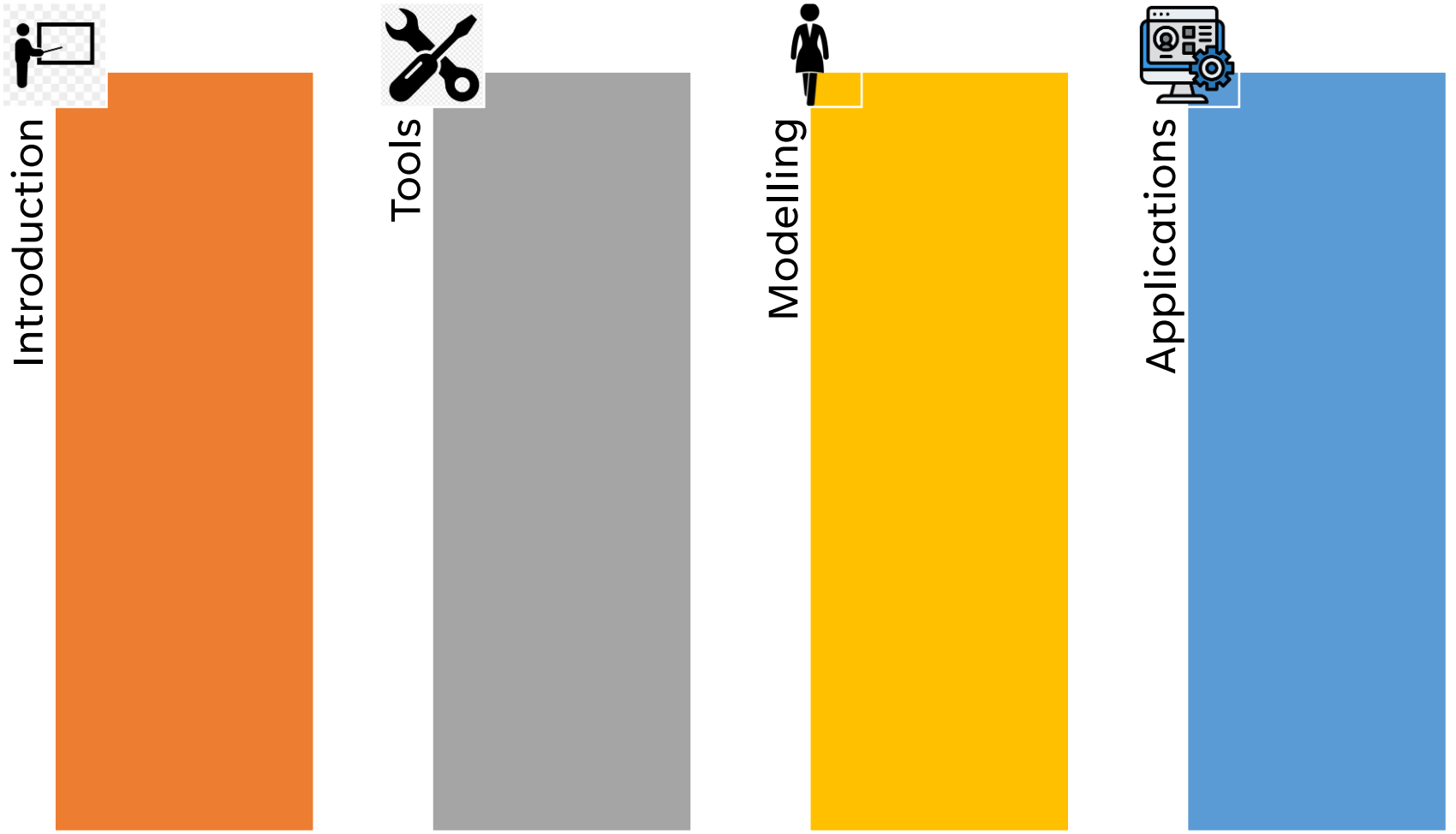
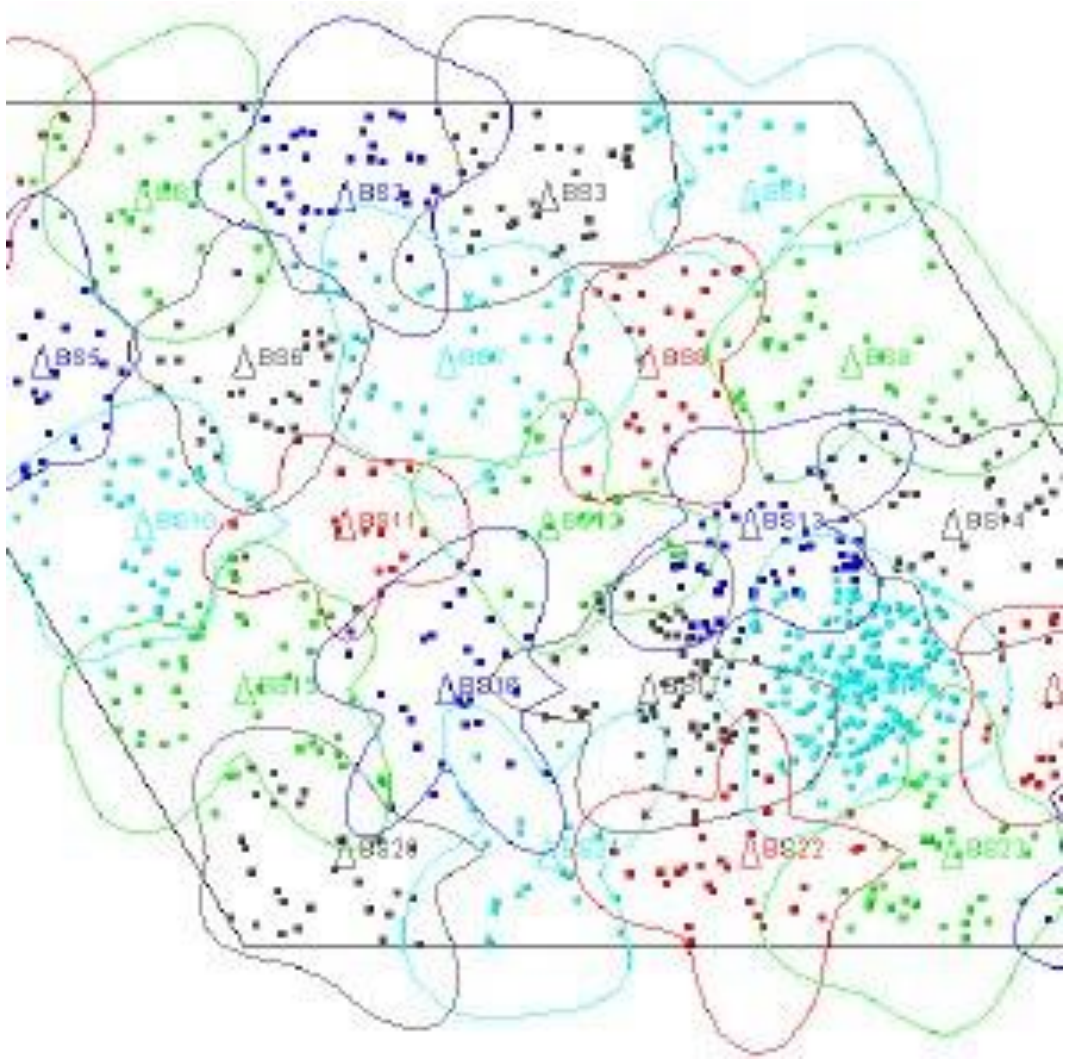

Introduction
Tools
Modelling
Applications

SOME EXAMPLES

- Antenna Allocation
- Power flow studies
- Path planning
- Resource Scheduling
- Min Spanning Tree
- Shortest Path



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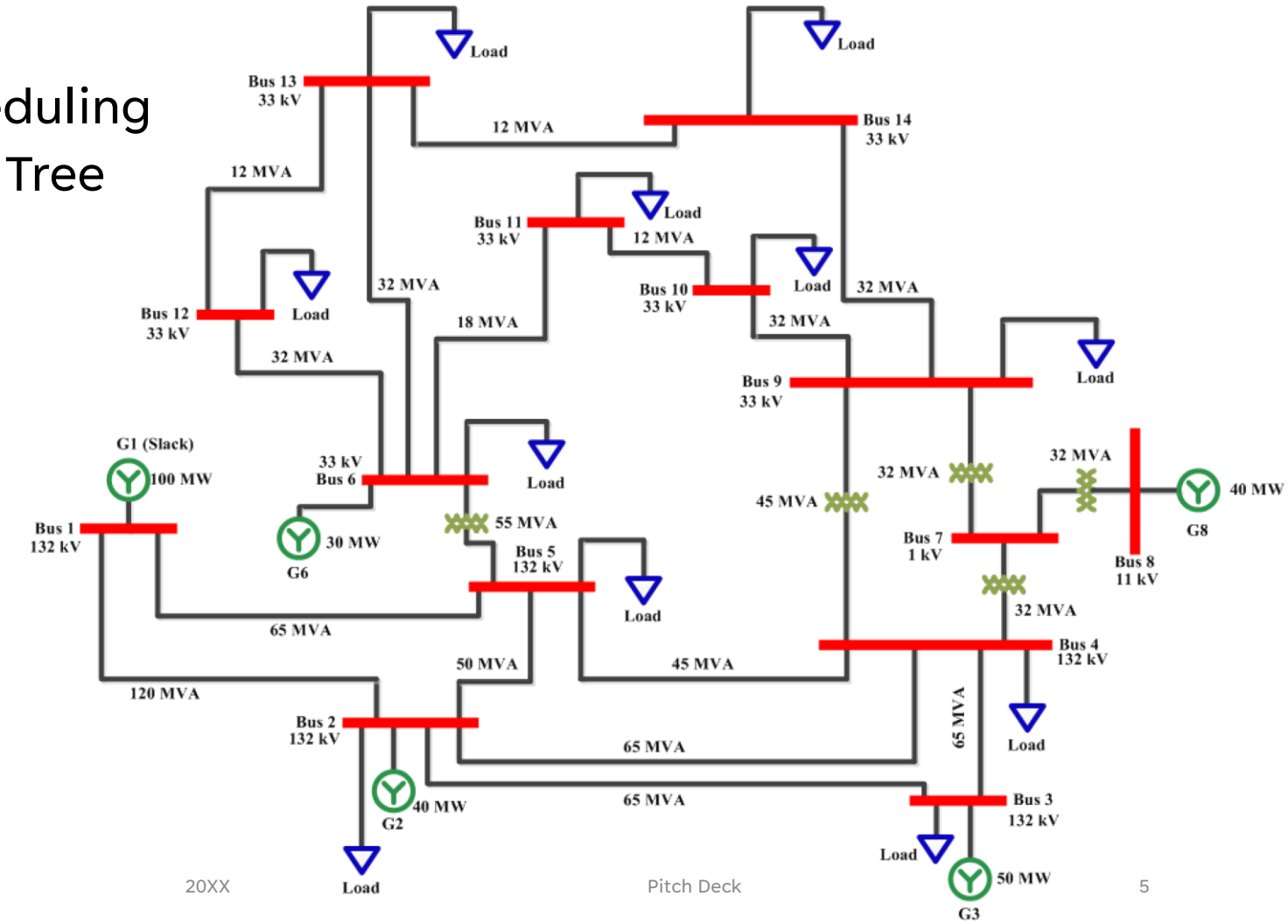

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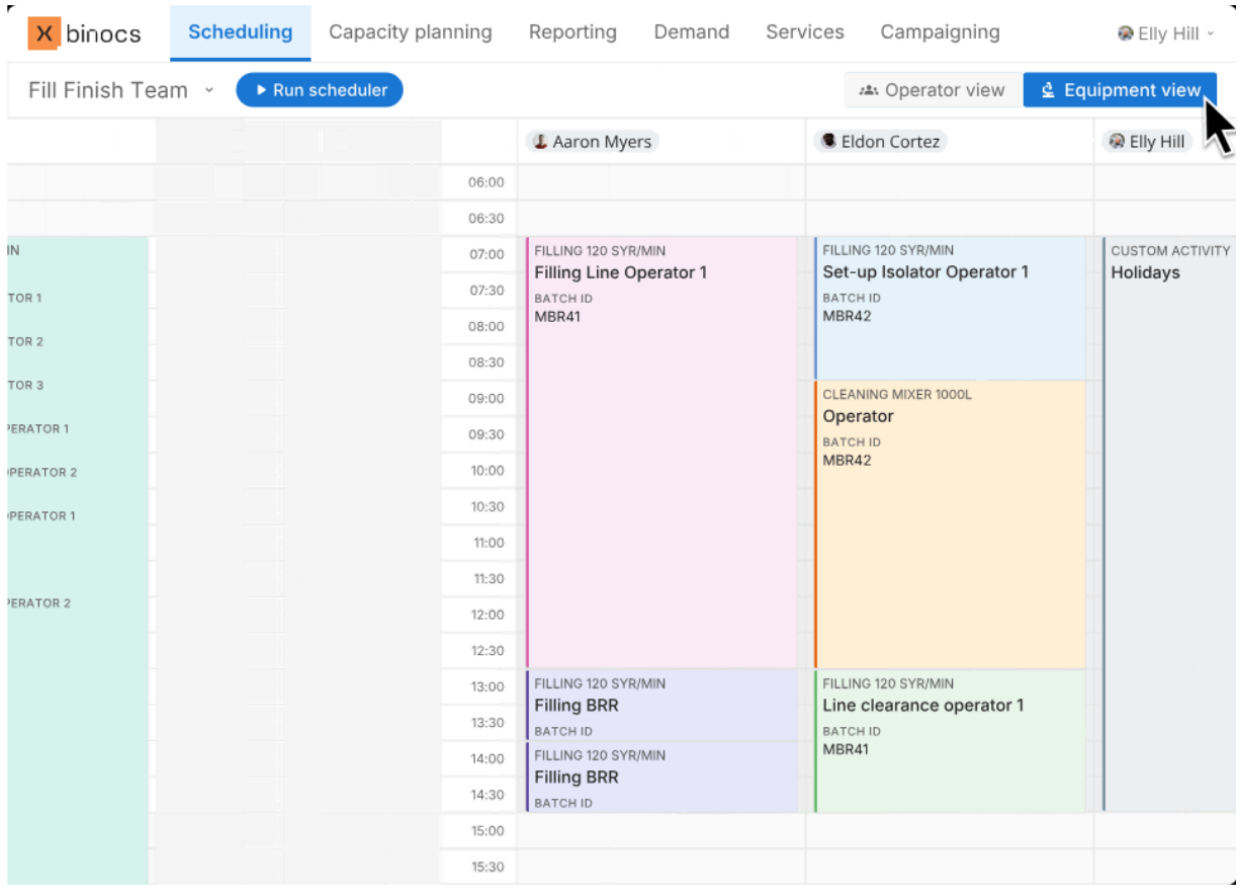

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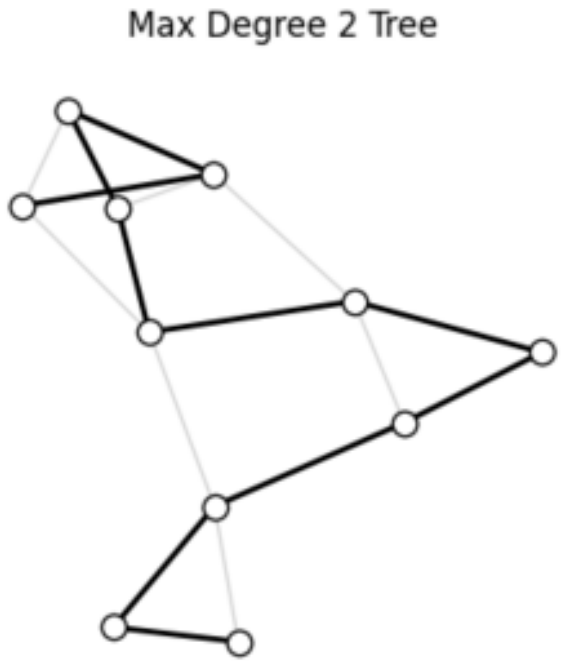

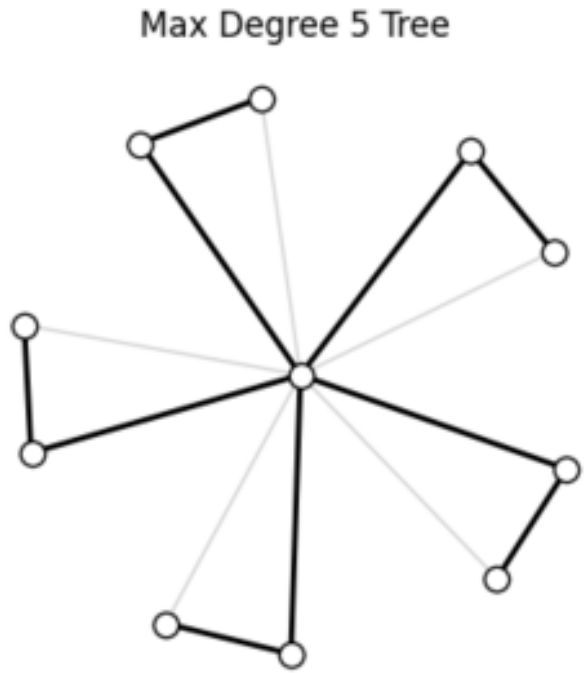

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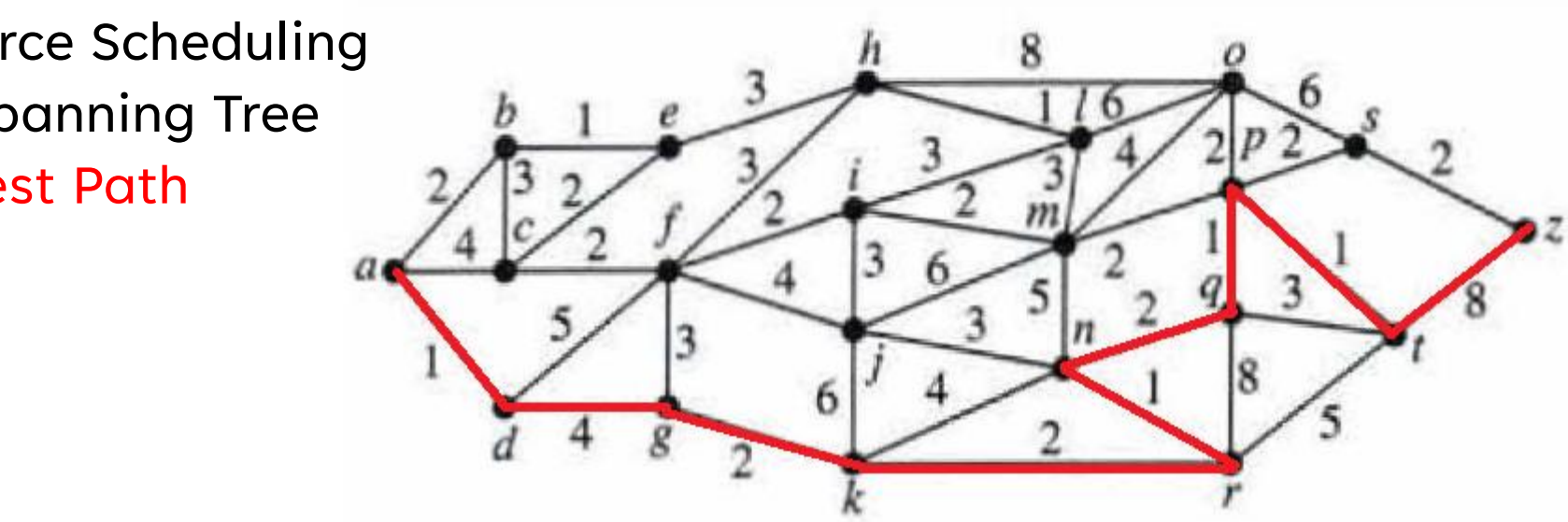


GUROBI
OPTIMIZATION

PYOMO

IBM
CPLEX

Google OR-Tools

Nonlinearly Constrained Optimization

- ANTIGONE [GAMS]
- CONOPT [AMPL] [GAMS]
- FICO-Xpress [MOSEL]
- filter [AMPL]
- Ipopt [AMPL] [GAMS] [NL]
- Knitro [AMPL] [GAMS] [NL]
- LANCELOT [AMPL]
- LINDO [GAMS]
- LOQO [AMPL]
- MINOS [AMPL] [GAMS]
- PATHNLP [GAMS]
- SNOPT [AMPL] [GAMS] [NL]

Mixed Integer Linear Programming

- Cbc [AMPL] [GAMS] [MPS]
- COPT [AMPL] [GAMS] [LP] [MPS] [NL]
- CPLEX [AMPL] [GAMS] [LP] [MPS] [NL]
- FICO-Xpress [AMPL] [GAMS] [MOSEL] [MPS] [NL]
- Gurobi [AMPL] [GAMS] [LP] [MPS] [NL]
- HiGHS [AMPL] [GAMS] [LP] [MPS]
- MINTO [AMPL]
- MOSEK [AMPL] [GAMS] [LP] [MPS] [NL]
- ODHCPLEX [GAMS]
- RAPOSa [AMPL]
- scip [AMPL] [GAMS] [LP] [MPS] [NL]
- SYMPHONY [MPS]

Mixed Integer Nonlinearly Constrained Optimization

- AlphaECP [GAMS]
- ANTIGONE [GAMS]
- BARON [AMPL] [GAMS] [NL]
- Bonmin [AMPL] [GAMS]
- Couenne [AMPL] [GAMS]
- DICOPT [GAMS]
- FilMINT [AMPL]
- Knitro [AMPL] [GAMS]
- LINDO [GAMS]
- LINDOGlobal [AMPL] [GAMS]
- MINLP [AMPL]
- SBB [GAMS]
- scip [AMPL] [GAMS] [LP] [MPS] [NL]
- SHOT [GAMS]

MODELLING

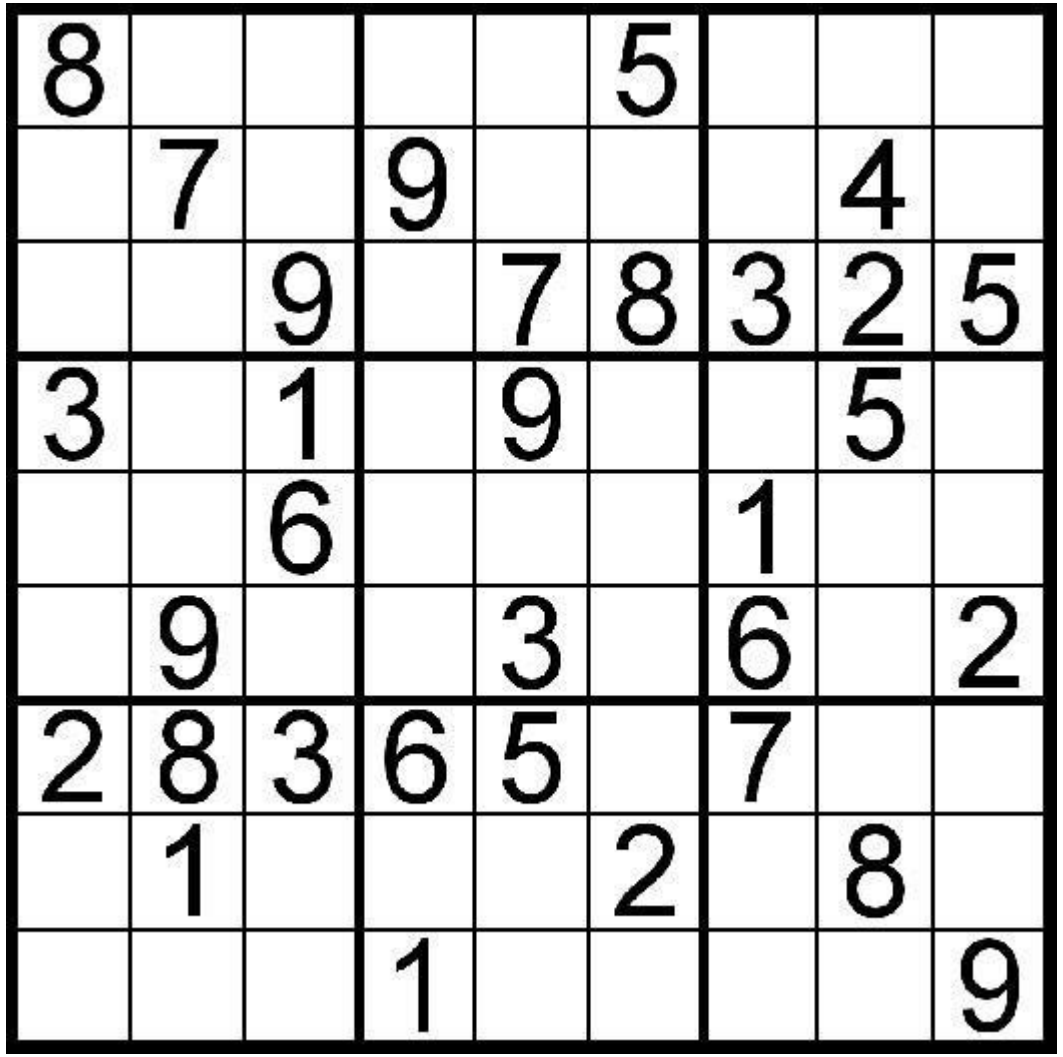
Maximize: $5.00x_1 + 7.50x_2$

Subject to:

$$
\begin{aligned}
x_1 &\leq 200 \\
x_2 &\leq 300 \\
1.0x_1 + 1.5x_2 &\leq 650 \\
x_1, x_2 &\geq 0
\end{aligned}
$$

MODELLING

PUZZLE



GENERAL ALGEBRAIC MODELLING

Maximize $z = 2x_1 + 3x_2 + 4x_3$

subject to the constraints

$$3x_1 + 2x_2 - 3x_3 \leq 4$$

$$2x_1 + 3x_2 + 2x_3 \leq 6$$

$$3x_1 - x_2 + 2x_3 \geq -8$$

$$x_1 \geq 0, \quad x_2 \geq 0, \quad x_3 \geq 0.$$

Resource Scheduling

```
PEOPLE =['Alice', 'Bob', 'Carol', 'Dave', 'Eve']
GIFTS= ['Book', 'Toy', 'Chocolate', 'Wine', 'Flowers']
GIFTCOSTS=[ 10, 20, 5, 15, 7]
HAPPINESS={
'Book': [3, 2, 5, 1, 4],
'Toy': [5, 2, 4, 3, 1],
'Chocolate': [1, 3, 4, 5, 2],
'Water': [2, 5, 3, 4, 1],
'Flowers': [4, 3, 1, 2, 5]}
BUDGET= 50
```

Transportation Problem

From	To				Supply
	D_1	D_2	D_3	D_4	
O_1	6	4	1	5	140
O_2	8	9	2	7	160
O_3	4	3	6	2	50
Demand	60	70	100	40	

- Power flow studies

G	Pmin	Pmax	a	c
1				
2				
3				

- **Min Spanning Tree**

```
import matplotlib.pyplot as plt
import networkx as nx

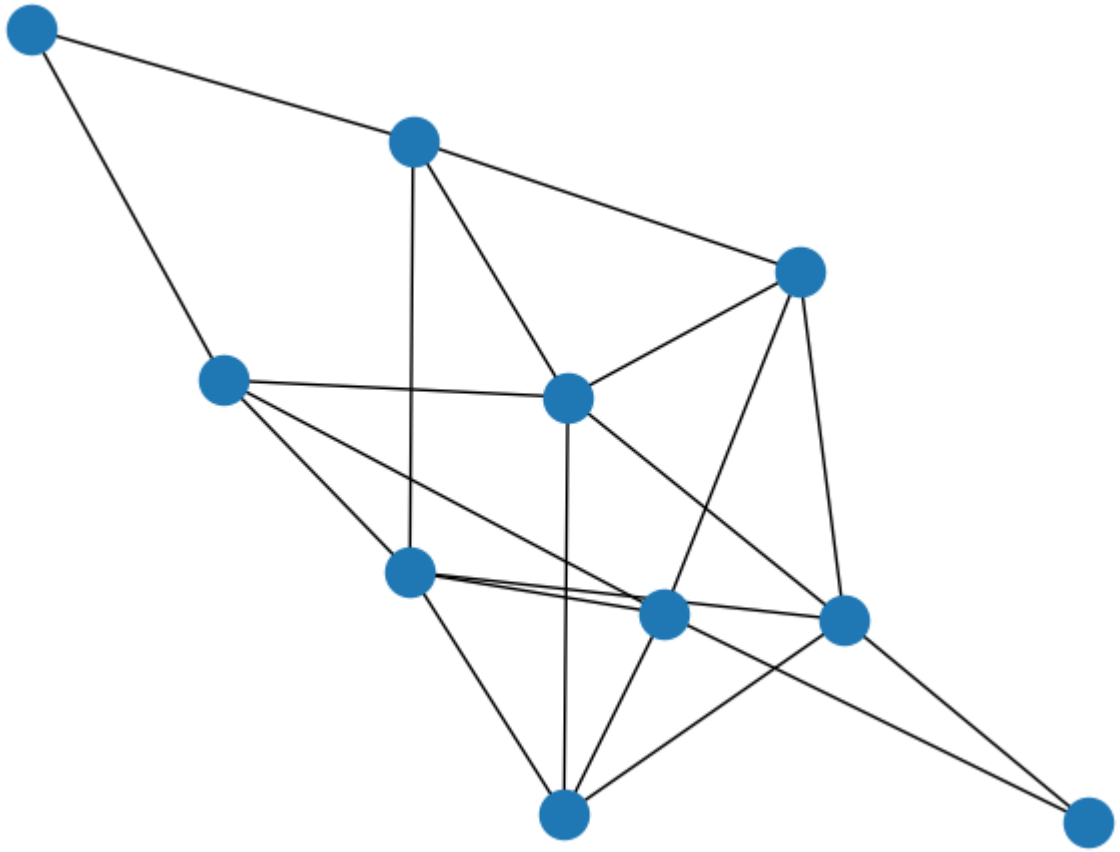
n = 10  # 10 nodes
m = 20  # 20 edges
seed = 20160  # seed random number generators for reproducibility

# Use seed for reproducibility
G = nx.gnm_random_graph(n, m, seed=seed)

# some properties
print("node degree clustering")
for v in nx.nodes(G):
    print(f"{v} {nx.degree(G, v)} {nx.clustering(G, v)}")

print()
print("the adjacency list")
for line in nx.generate_adjlist(G):
    print(line)

pos = nx.spring_layout(G, seed=seed)  # Seed for reproducible layout
nx.draw(G, pos=pos)
plt.show()
```



- **Shortest path**

```
import matplotlib.pyplot as plt
import networkx as nx

n = 10  # 10 nodes
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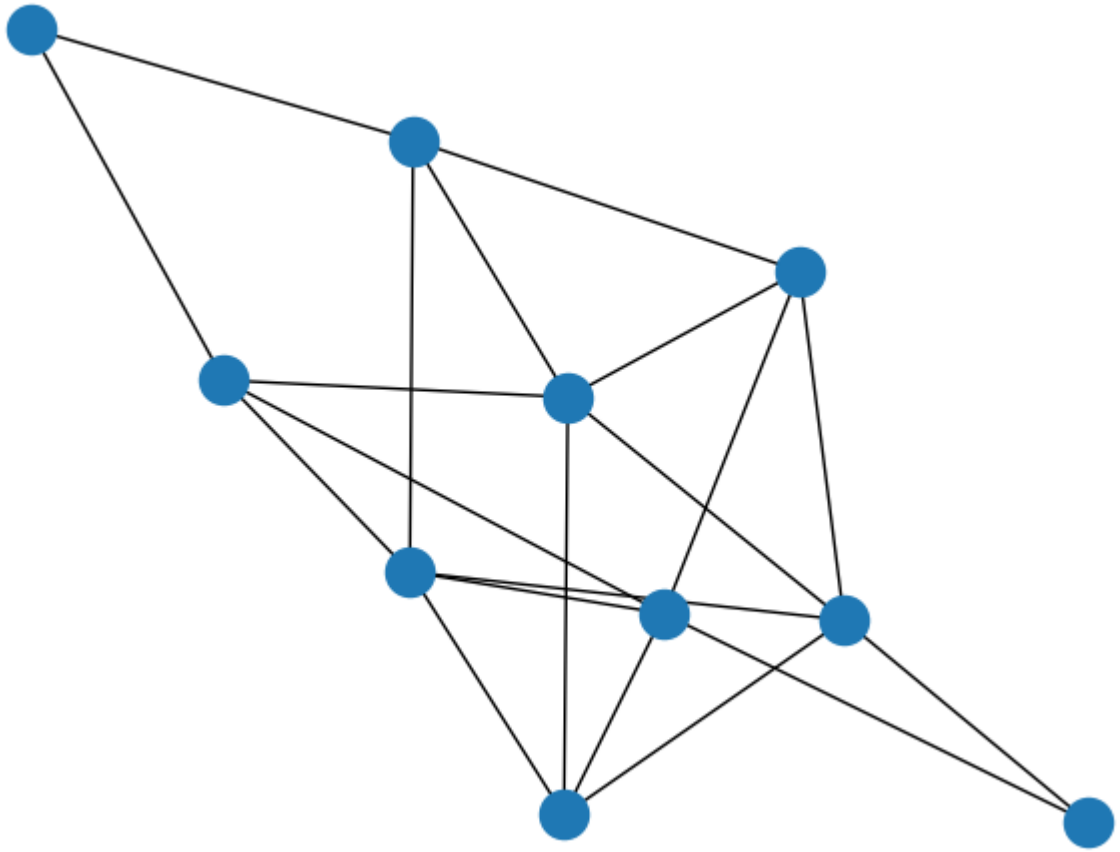
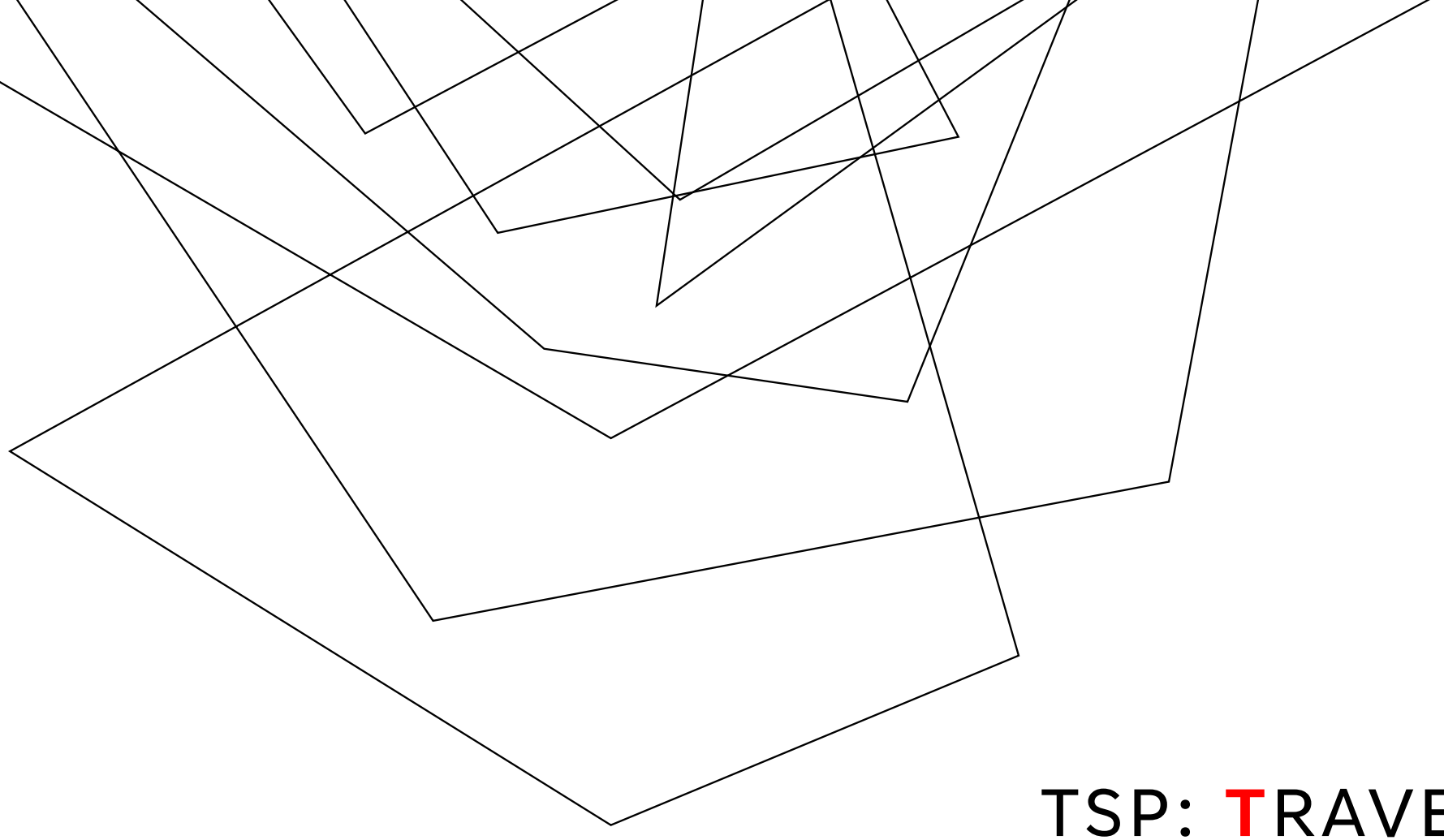
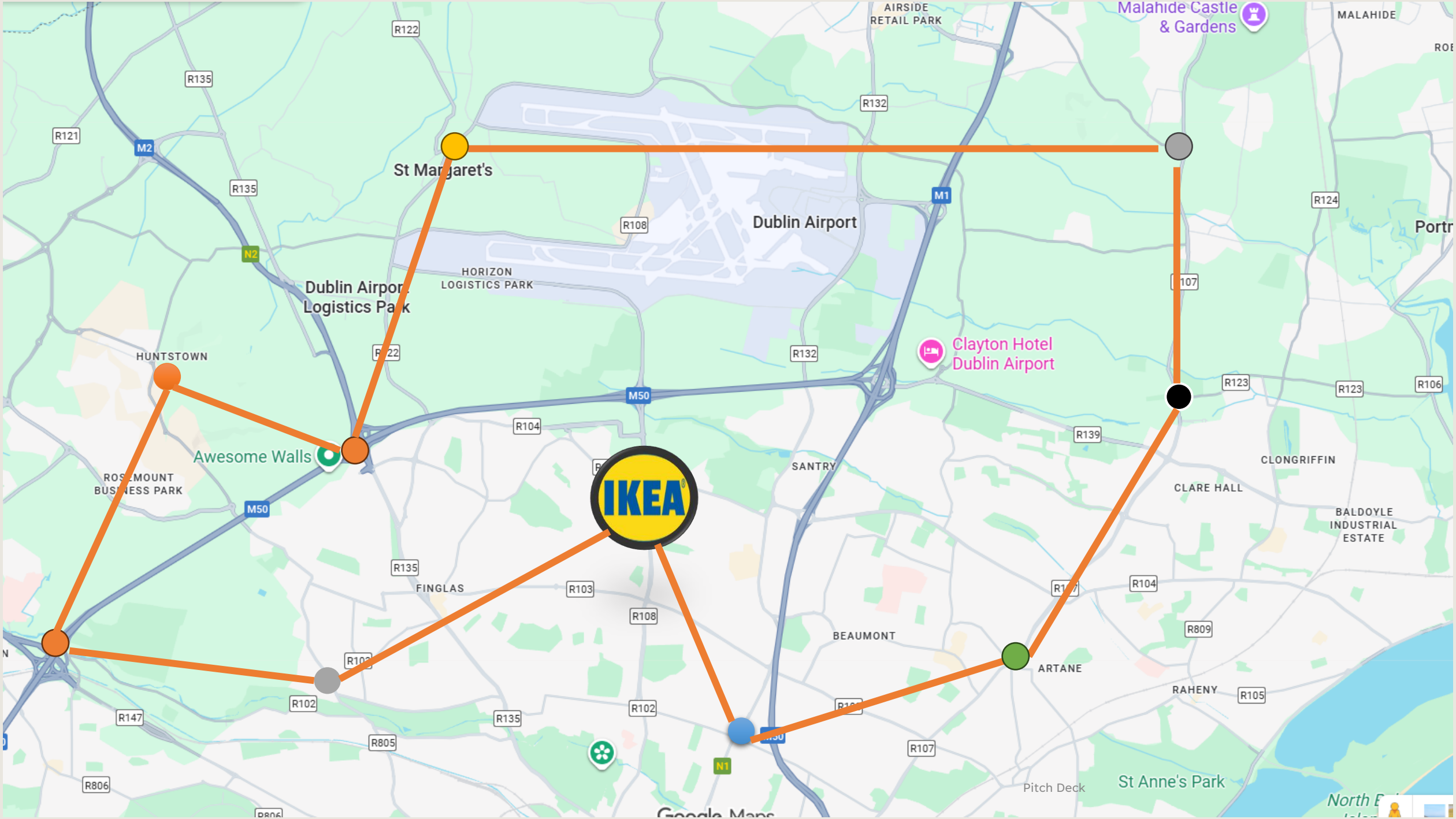




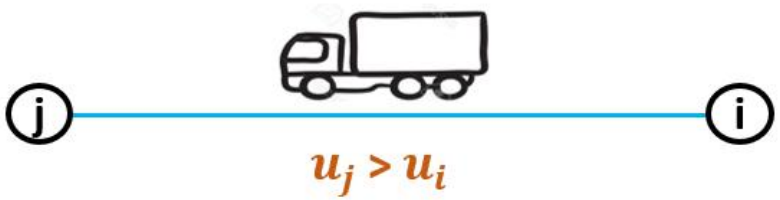
Path planning

TSP: **T**RAVELING
SALESMAN **P**ROBLEM

FINDING THE OPTIMAL VISIT ORDERS


St Margaret's
Dublin Airport
Dublin Airport Logistics Park
HORIZON LOGISTICS PARK
AIRSIDE RETAIL PARK
Malahide Castle & Gardens
MALAHIDE
Clayton Hotel Dublin Airport
HUNTSTOWN
Awesome Walls
ROSEMOUNT BUSINESS PARK
IKEA
SANTRY
CLONGRIFFIN
CLARE HALL
BALDOYLE INDUSTRIAL ESTATE
FINGLAS
BEAUMONT
ARTANE
RAHENY
St Anne's Park
Pitch Deck
Google Maps
R121
R122
R132
R135
R124
R107
R108
R123
R106
R139
R104
R103
R809
R102
R147
R805
R105
R806
M1
M2
M50
N1
N2

MATH MODEL



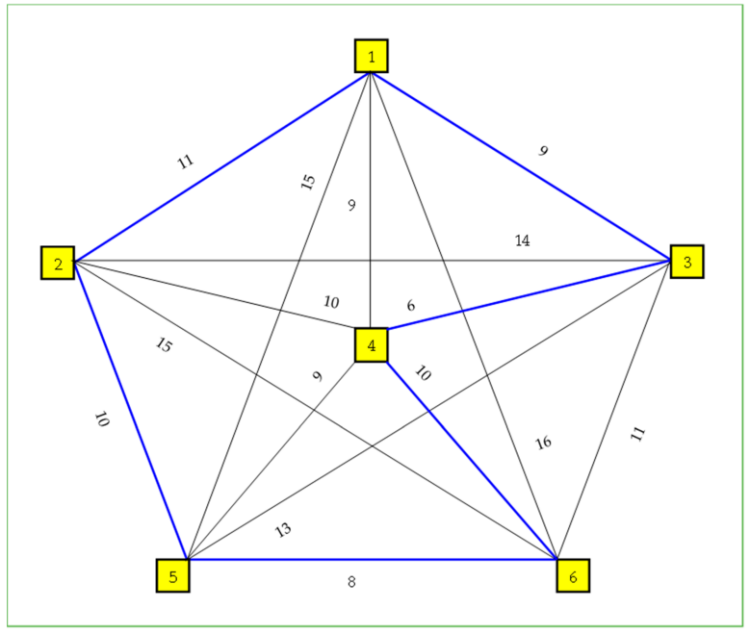
$$\min \sum_{i=0}^{n} \sum_{j \neq i, j=0} c_{ij} x_{ij}$$

x_{ij} Binary $\qquad i, j = 0, \ldots n$

$$\sum_{i=0, i \neq j}^{n} x_{ij} = 1 \qquad j = 0, \ldots, n$$

$$\sum_{j=0, j \neq i}^{n} x_{ij} = 1 \qquad i = 1, \ldots, n$$

$$u_i - u_j + n x_{ij} \leq n - 1 \qquad 1 \leq i \neq j \leq n.$$

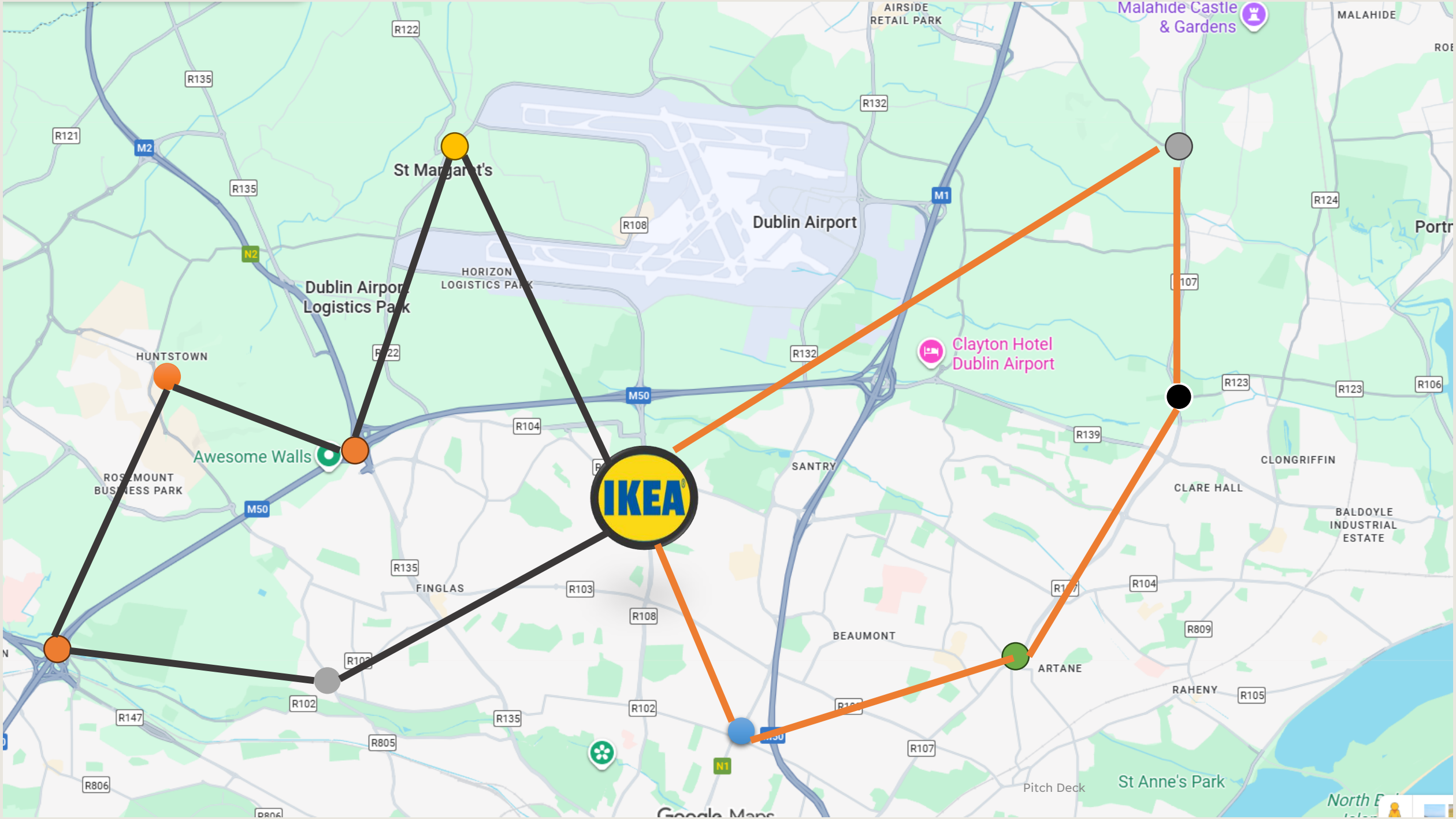


COMPUTATION DIFFICULTY

X_{ij}

N(n-1) binary

N!


AIRSIDE RETAIL PARK
Malahide Castle & Gardens
MALAHIDE
R122
R135
R121
M2
R135
St Margaret's
R132
M1
R124
Dublin Airport
R108
HORIZON LOGISTICS PARK
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M50
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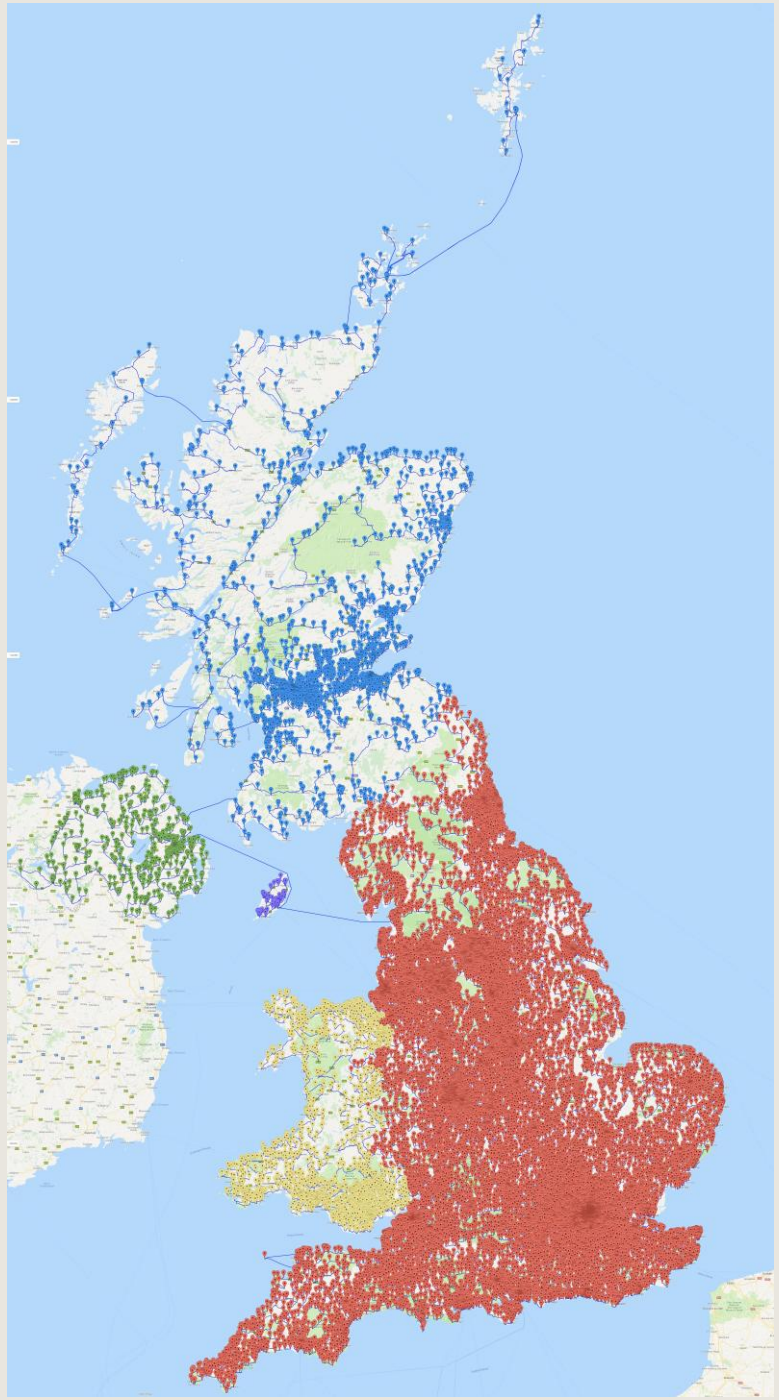
Pitch Deck
St Anne's Park
Google Maps




United States
MONTANA
NORTH DAKOTA
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SOUTH DAKOTA
WISCONSIN
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WYOMING
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NEVADA
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MISSOURI
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FLORIDA
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