Flying Tourist Problem
An Integer Linear Programming Approach

MSc. in Aerospace Engineering
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27 November 2019

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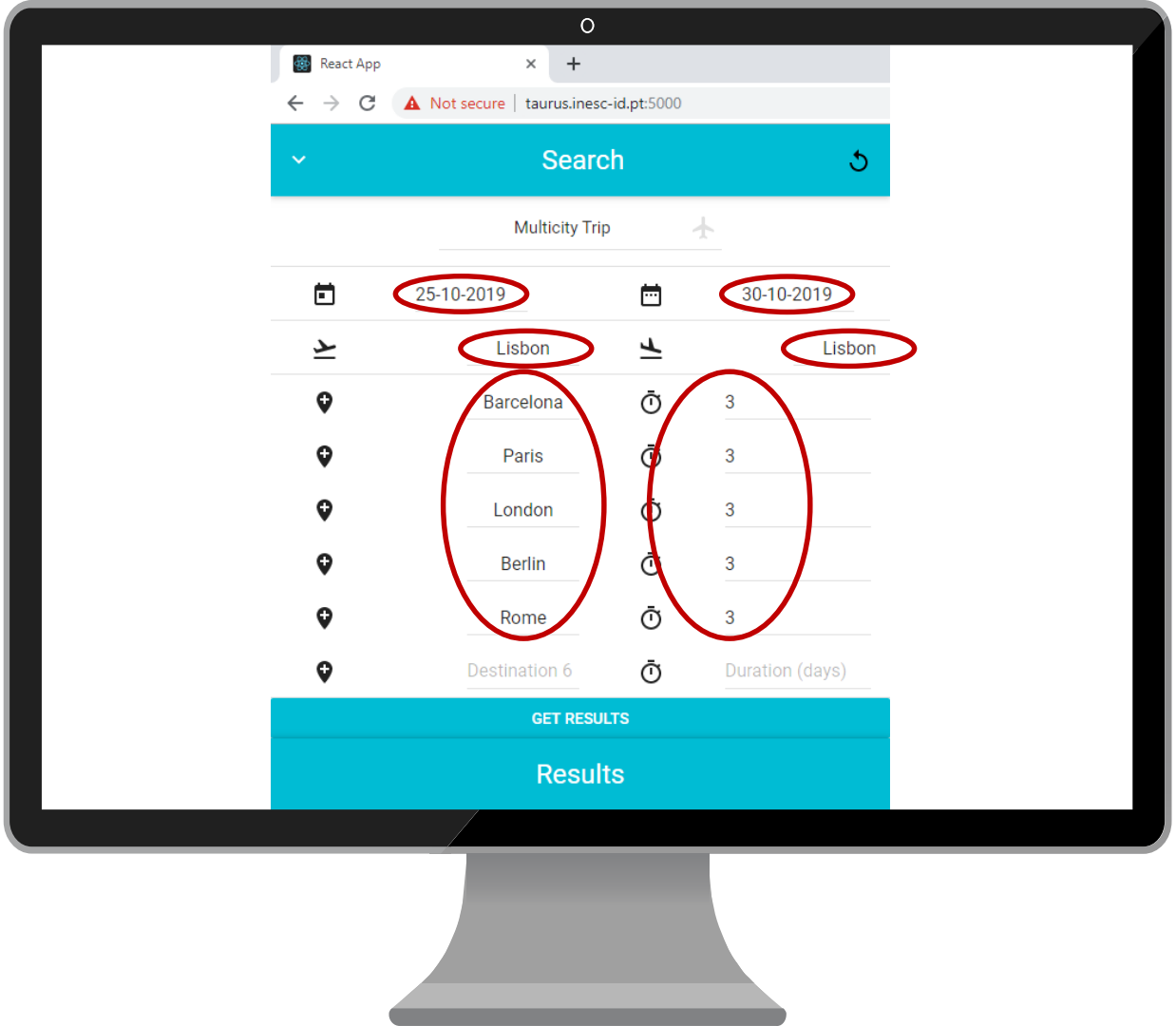
PROTOTYPE IMPLEMENTATION

Flying Tourist Problem
Client Side Application Demonstration



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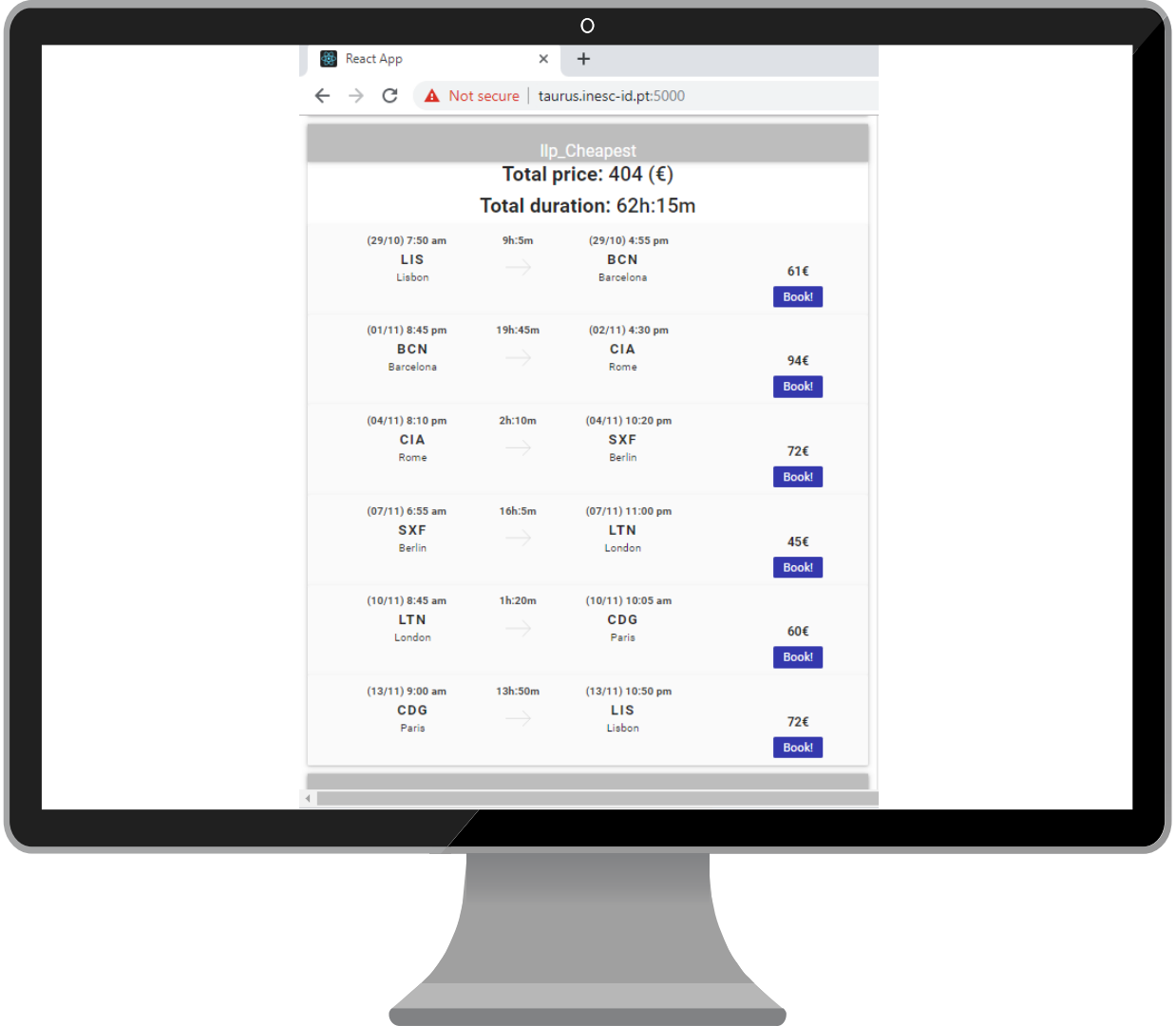

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CONTRIBUTIONS

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Development of an exact approach to the Flying Tourist Problem using Integer Linear Programming → Solve the problem to optimality

Formulate different models that fit different needs:

- Generalized problem
- Multi-objective variations

1 Literature Review

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2 Problem Formulation

3 Prototype Implementation

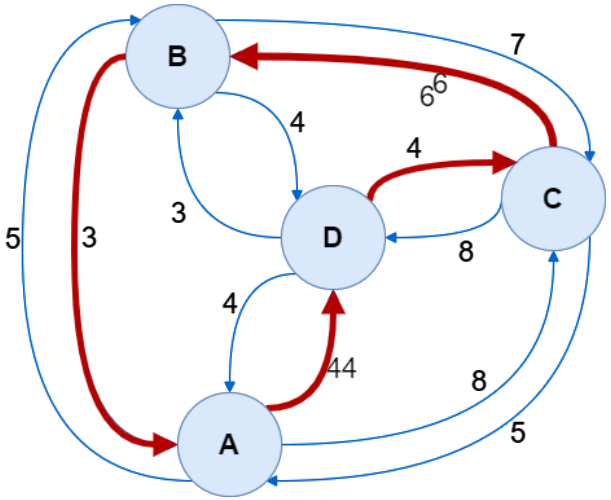
4 Experimental Results

5 Conclusion and Future Work

LITERATURE REVIEW

The Traveling Salesman Problem (TSP)

Given G = (N,A):



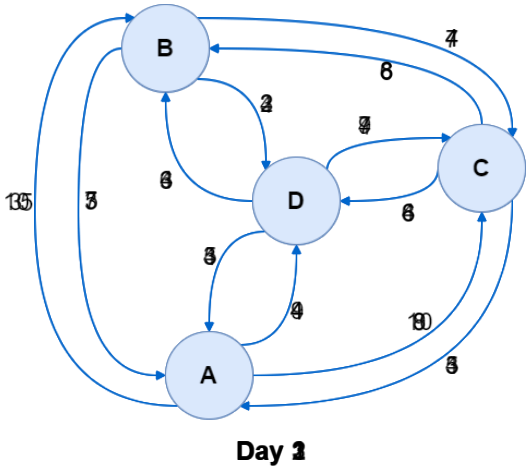
What is the minimum weight Hamiltonian cycle?

LITERATURE REVIEW

TSP Variations

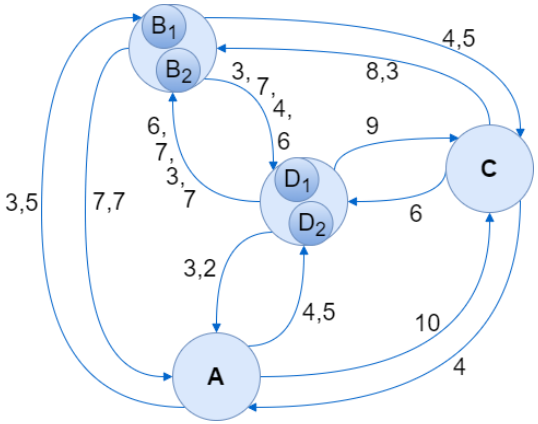
Time Dependent TSP (TDTSP)

- Weight is a function of time
- Each arc is associated with a traveling time



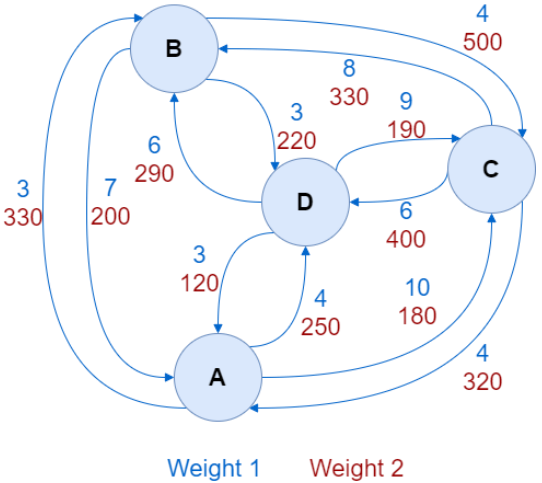
Generalized TSP (MO-TSP)

- Nodes are clusters
- One node per cluster visited



Multi-objective TSP (MO-TSP)

- Arcs have more than one weight associated



LITERATURE REVIEW

Optimization Techniques

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Incomplete Methods

- Usually stochastic
- Cannot guarantee the quality of the solution found

Heuristic

- Nearest Neighbour
- k-opt

Meta-Heuristic

- Simulated Annealing (SA)
- Ant Colony Optimization
- Genetic Algorithms

Complete Methods

- Exact
- Usually deterministic

Integer Linear Programming (ILP)

- Simplex
- Branch and Cut

PROBLEM FORMULATION

Flying Tourist Problem (FTP)

What is the best set of flights to visit each **city** exactly once in a specified **time-window**?

E.g: Starting date between 1st and 15th of October from Lisbon

{(London), (Barcelona), (Rome)}

{3,2,4} days

FTP →

Lisbon – Barcelona – London – Rome – Lisbon

7th – 9th – 12th – 16th

PROBLEM FORMULATION

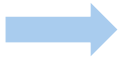
Generalized Flying Tourist Problem (GFTP)

What is the best set of flights to visit one city only of each **cluster** exactly once in a specified **time-window**?

E.g:

{(London), (Barcelona), (Rome)}

{(London, Liverpool), (Barcelona), (Rome, Florence, Venice)}



{(**London**, Liverpool), (**Barcelona**), (Rome, Florence, **Venice**)}

When compared to the FTP:

- Better or equally good solution
- Solution space as large or larger

PROBLEM FORMULATION

Multi-objective Variations

What if the tourist want to optimize **both** the cost and the flight duration of the trip?

Multi-Objective FTP (MO-FTP)

Traveling time and cost trade-off

When compared to the FTP:

- Traveling time **at most** as large
- Cost of the trip generally higher

Multi-Objective GFTP (MO-GFTP)

GFTP capacity to achieve better optimal values

Diminish the cost increase caused by the **MO-FTP**

PROTOTYPE IMPLEMENTATION

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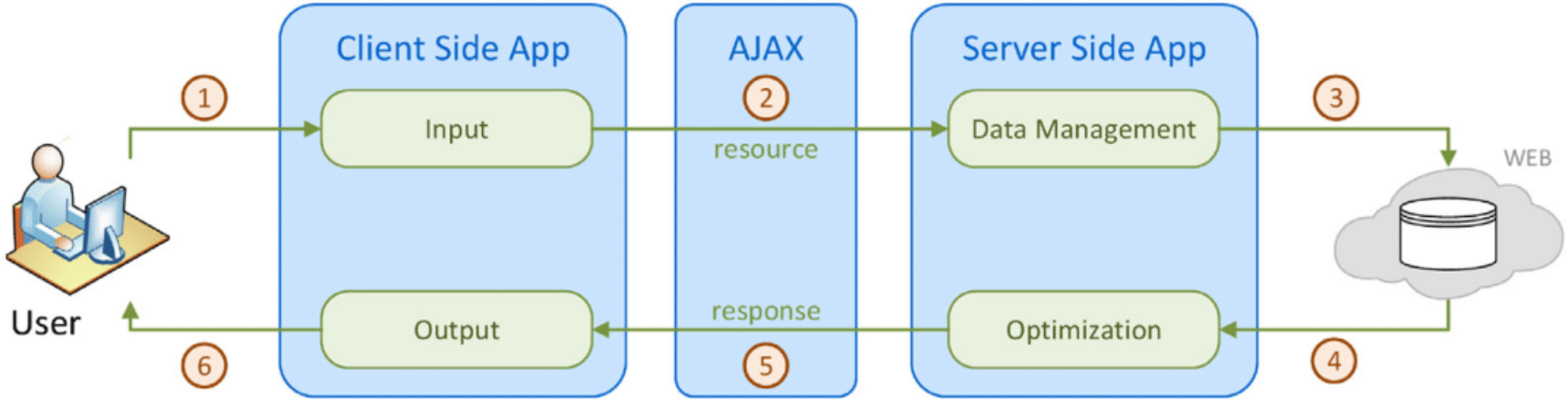
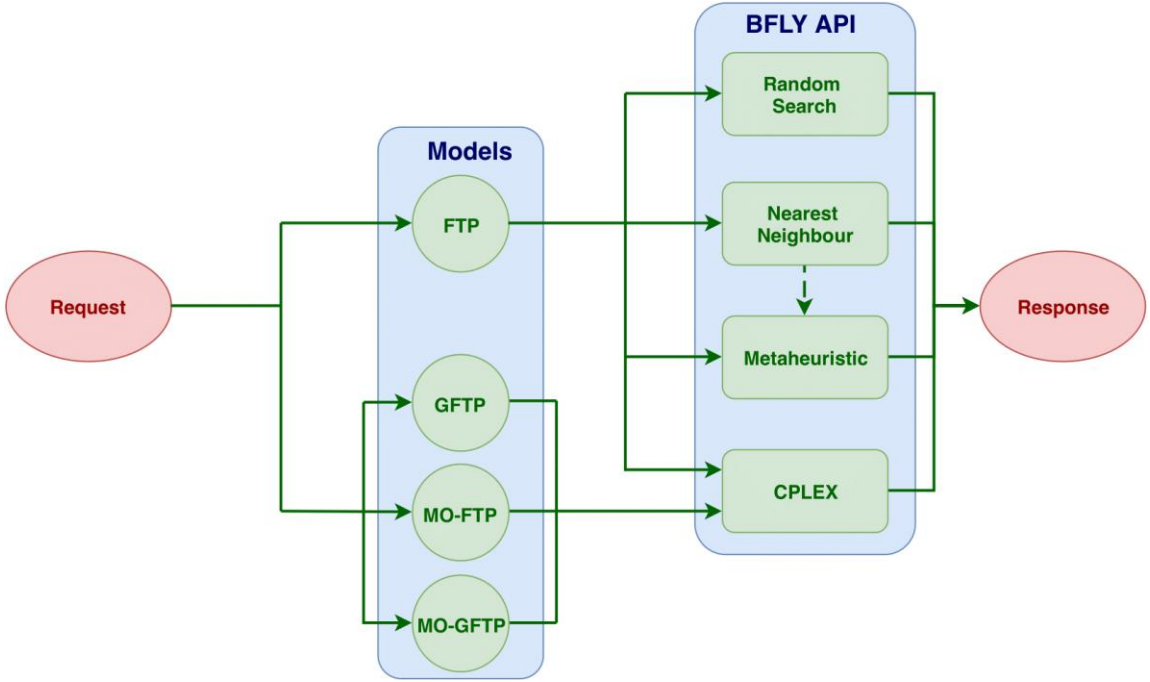
System Architecture



PROTOTYPE IMPLEMENTATION

Optimization Module



EXPERIMENTAL RESULTS

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Data Set construction:

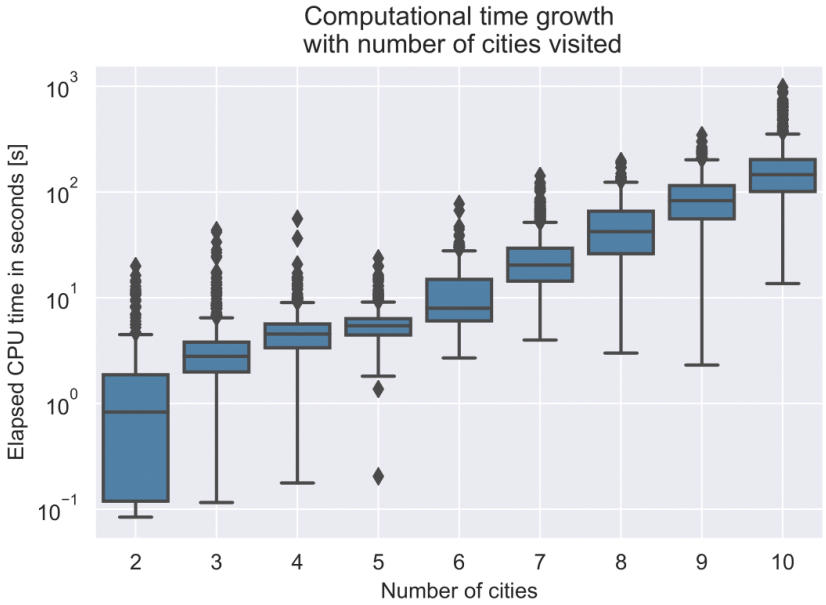
- Departure and Arrival city: Lisbon
- 50 possible intermediate cities
- 1st of October → 5th of December (65 days)

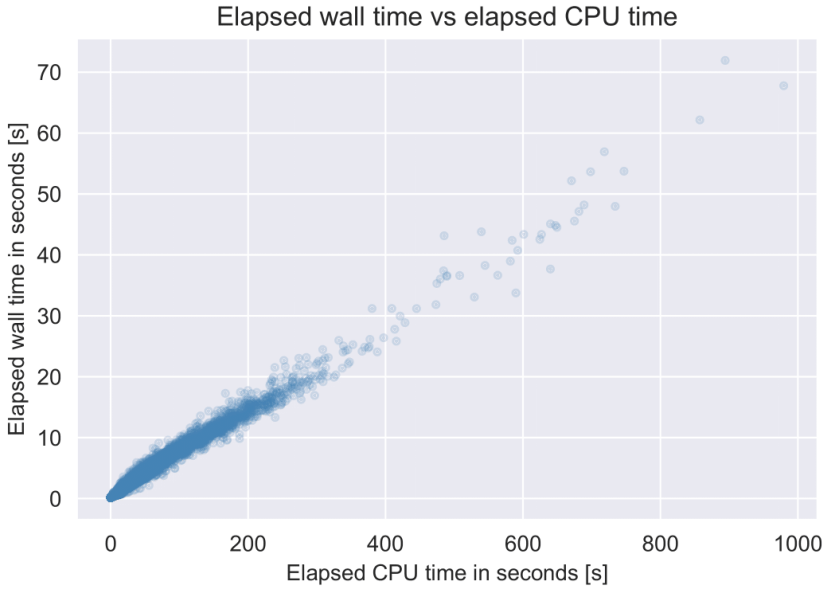
9000 different random requests for each problem with:

- Random number of cities/clusters (between 2 and 10)
- Random stop time at each city (between 2 and 5 days)
- Random starting window date between 1st and 15th of October

EXPERIMENTAL RESULTS

Flying Tourist Problem – Computational Analysis





EXPERIMENTAL RESULTS

Flying Tourist Problem - Comparison

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Comparing with the SA algorithm:

	Method	Entire Set
Cost per Flight in €	SA	62.37
	ILP	60.27 (-3.35%)
Elapsed Wall Time [s]	SA	2.46
	ILP	0.70 (-71.80%)

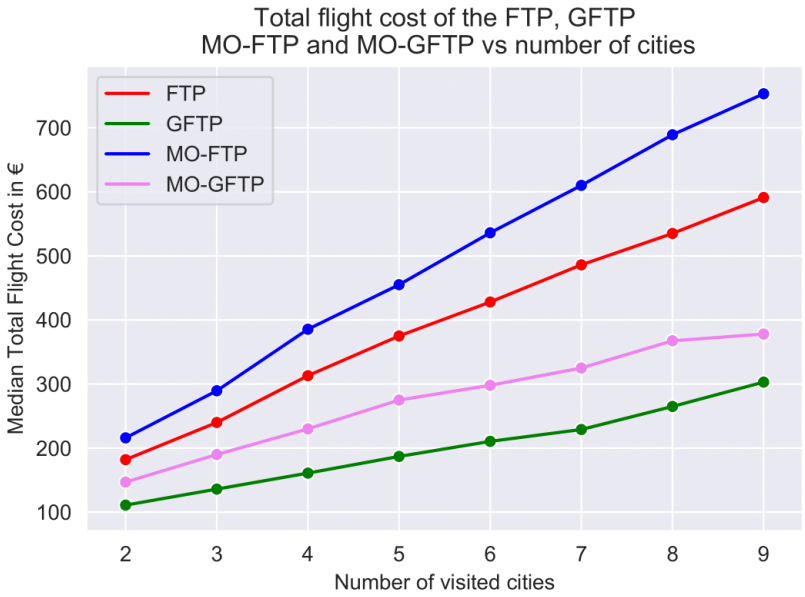
Up to 30%

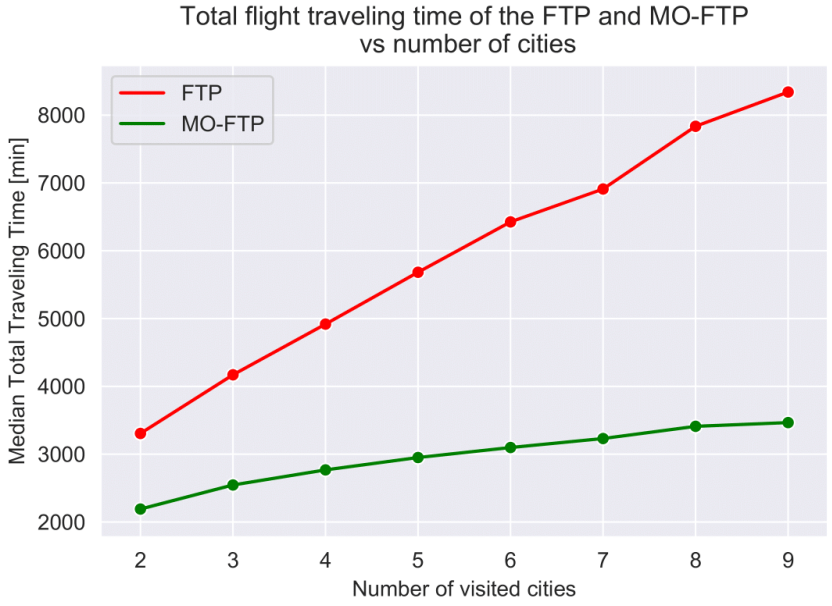
If the SA solution is used:

- CPU time decreased 70.80%

EXPERIMENTAL RESULTS

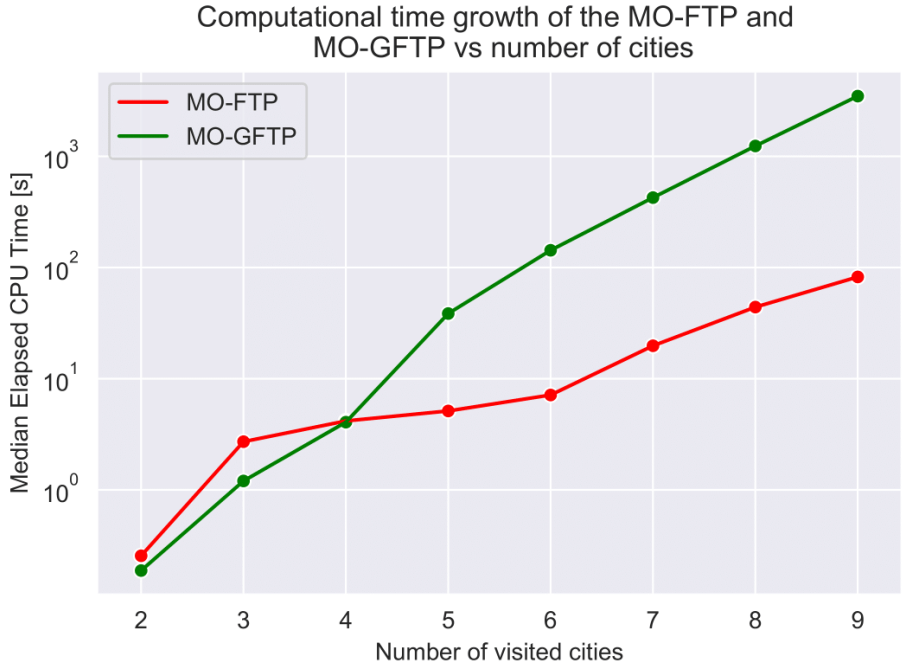
Flying Tourist Problem Variations





EXPERIMENTAL RESULTS

Flying Tourist Problem Variations



CONCLUSION

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- Proposed variations of the FTP that fit different needs
- Developed ILP models for the different problems
- Implemented a complete method to solve the 4 different models
- Implemented the work developed in an application prototype

FUTURE WORK

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- Integration of more means of transport
- Database integration
- Implement incomplete methods to solve the GFTP, MO-FTP and MO-GFTP
- Explore Multi-objective evolutionary algorithms

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