Vessel Route Planning Optimization Combined with Time Windows versus Worker Scheduling for Offshore Windmill Maintenance

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8. Overall Conclusions

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Problem Definition

- Planning optimization by solving Vehicle Routing Problem with Time Windows (VRPTW)

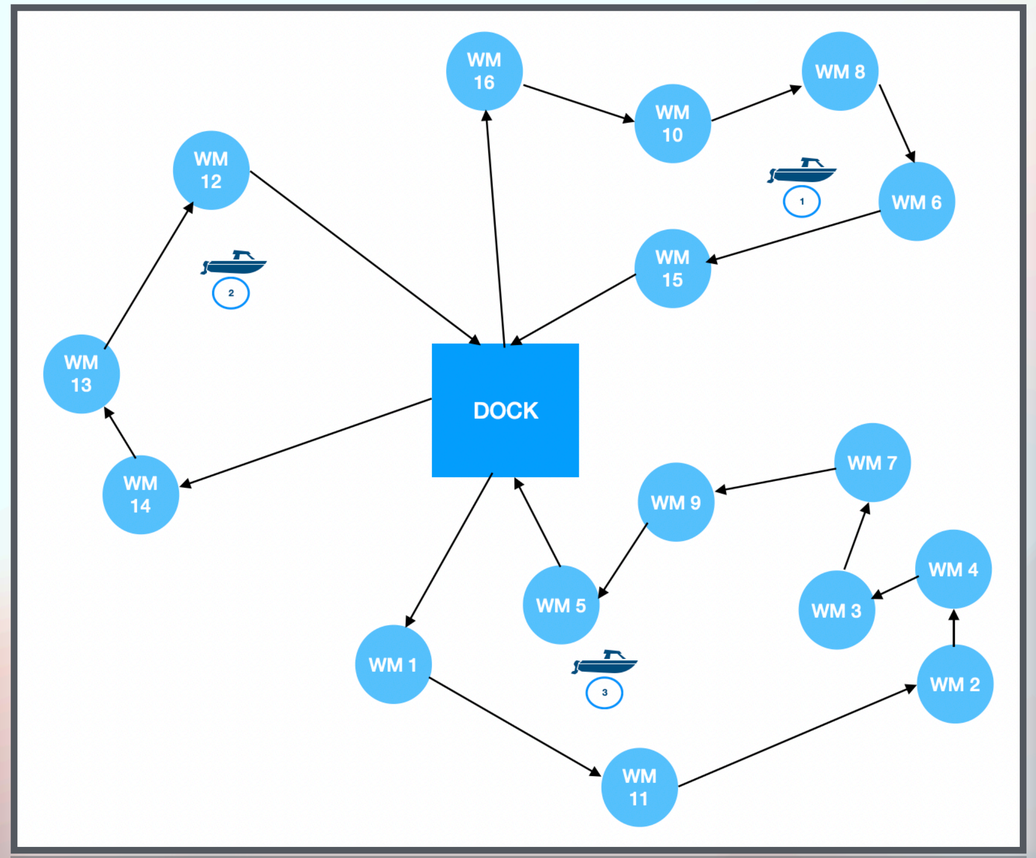
→ Minimize total travel time of all vessels or vans

- Planning optimization by solving Job Shop Scheduling Problem (JSSP)

→ Optimize workload and minimize downtime

- Planning optimization by combining VRPTW and JSSP

→ Minimize travel distance AND downtime



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Solution Methods

- Solution methods studied for VRPTW
  - VRPy
  - OR Tools
  - Ant Colony Optimisation
- Solution methods studied for JSSP
  - OR Tools

COMPARISON OF ALL METHODS USED TO SOLVE THE VRPTW

Method	Advantage	Disadvantage
VRPy	Easy Interface	Less Powerful
OR Tools	Fast and Accurate	No optimal result
ACO	Optimal results	No Easy Interface

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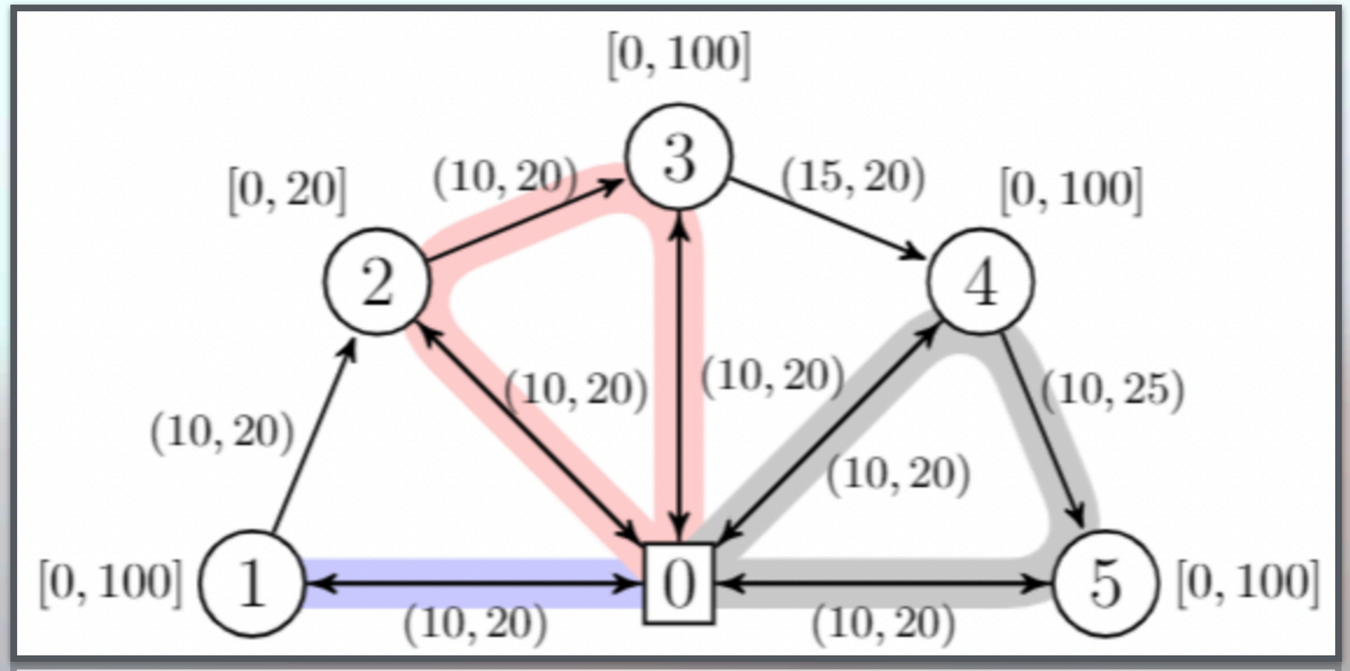
Solution Methods VRPTW - VRPy

VRPy solves vehicle routing problems with a column generation approach. The term *column generation* refers to the fact that iteratively, routes (or *columns*) are *generated* with a pricing problem, and fed to a master problem which selects the best routes among a pool such that each vertex is serviced exactly once.



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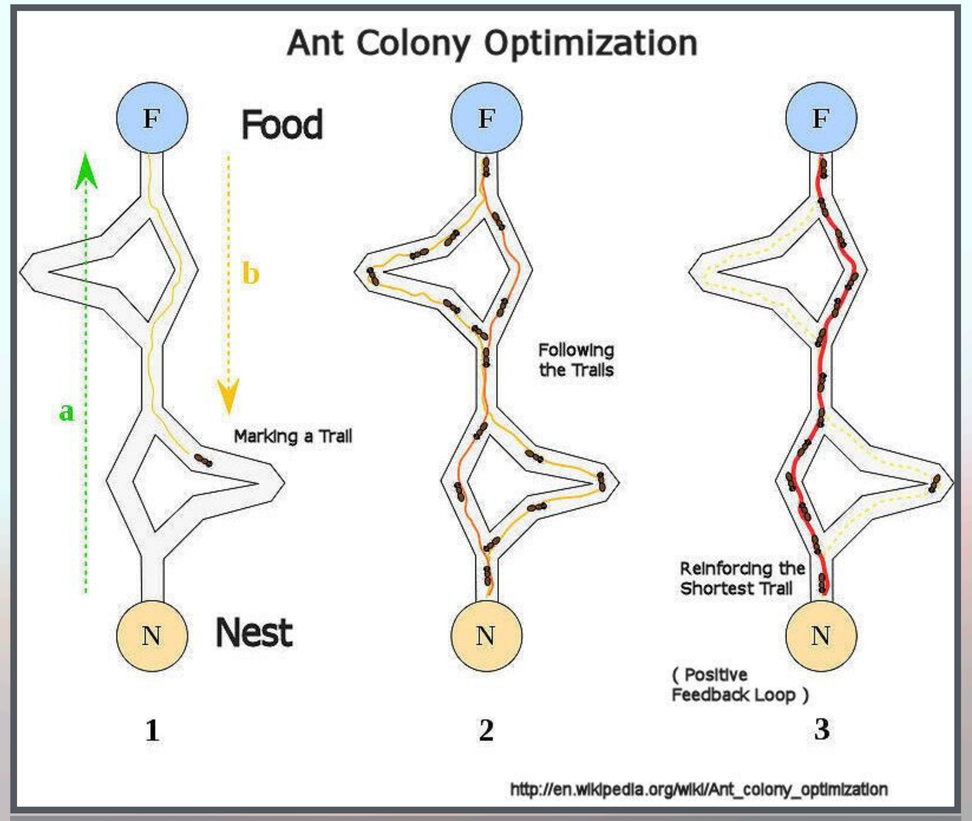
Solution Methods VRPTW - ACO

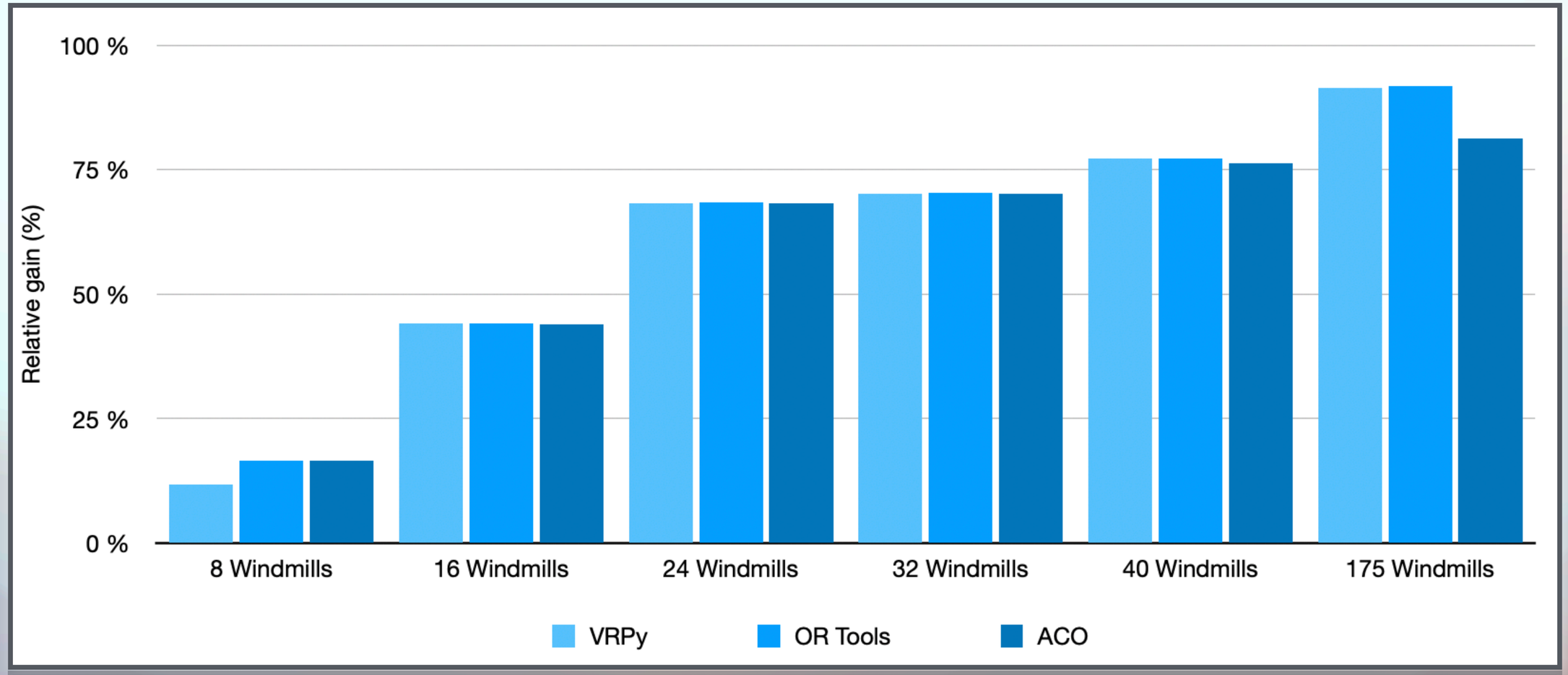
Ant Colony Optimization: probabilistic technique for solving computational problems that can be reduced to finding good paths through graphs.



Solution Methods VRPTW/JSSP - OR Tools

- *OR Tools*: OR-Tools is open source software for combinatorial optimization, which seeks to find the best solution to a problem out of a very large set of possible solutions.
- Some examples of problems that OR-Tools solves:
  - Vehicle routing: Find optimal routes for vehicle fleets.
  - Scheduling: Find the optimal schedule for a complex set of tasks.
  - Bin packing: Pack as many objects of various sizes as possible into a fixed number of bins with maximum capacities.

Results VRPTW - Windmills



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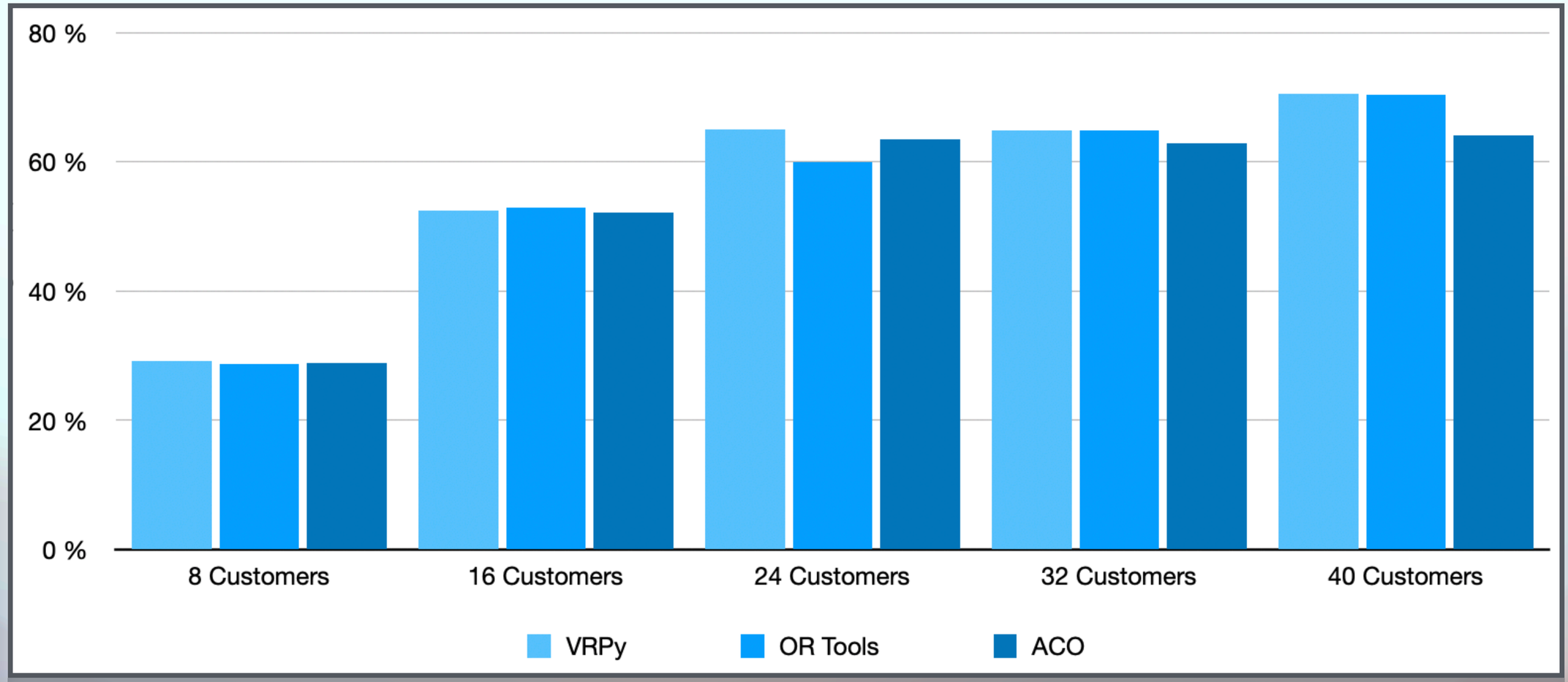
Results VRPTW - VAR Customers



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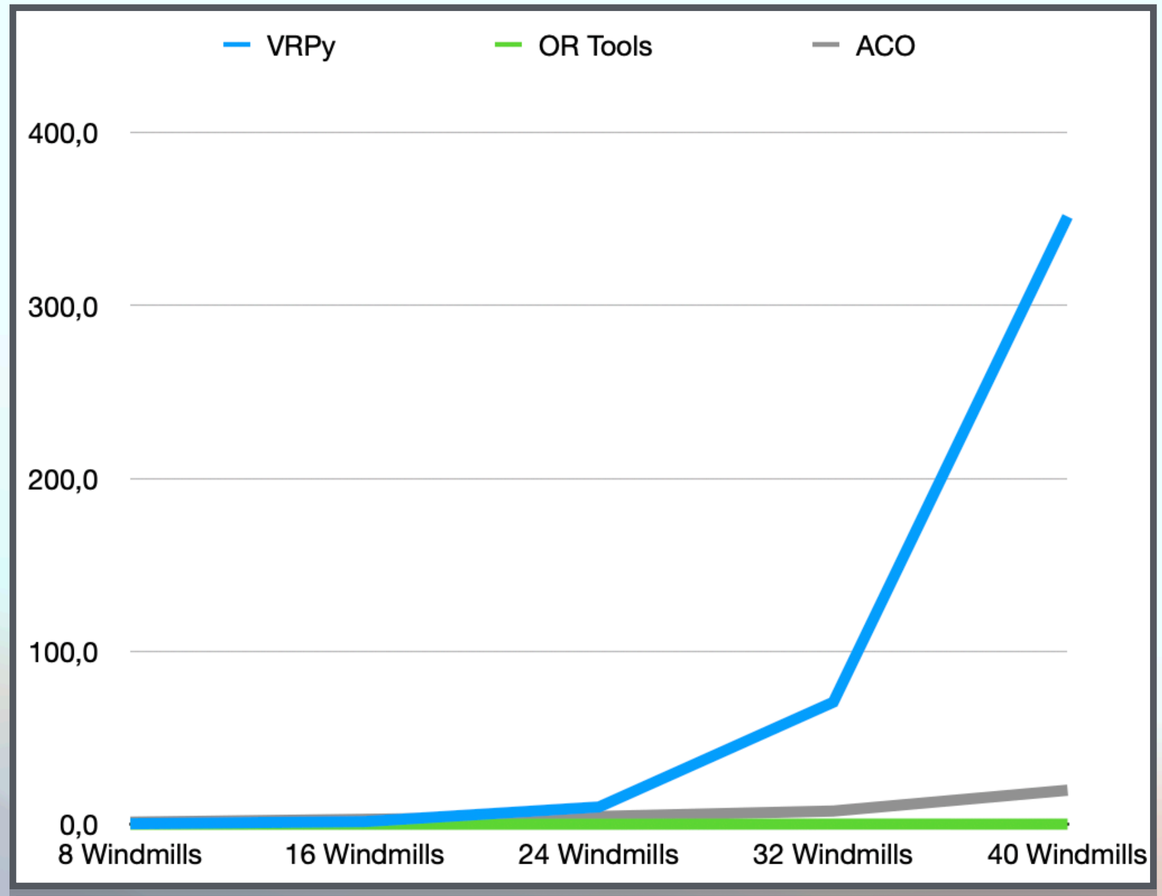
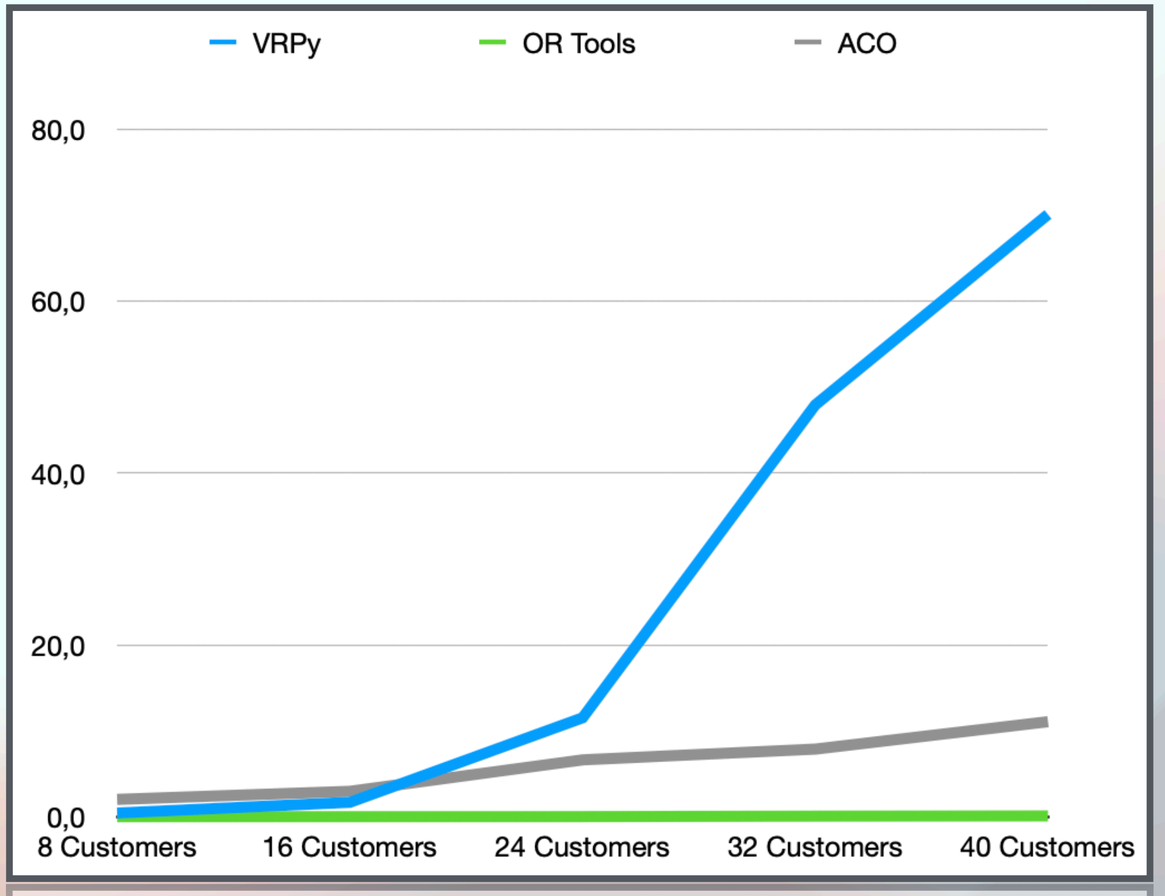
Calculation time VRPTW





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Conclusion VRPTW

1. VRPy, OR Tools, and ACO, lead to an almost equal relative gain compared to a random route time of all vessels/vans involved.

2. The number of vessels/van proposed by each method are (almost always) the same.

3. The only significant difference is the calculation time required to obtain an optimized solution.

    - All Instantaneous for small configurations.

    - ACO calculation time increases linear with larger configurations

    - VRPy calculation time increases exponentially with larger configurations

4. Similar results for Windmills and VAR Customers

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Results JSSP

Use Case	Relative gain
08 Windmills - 2 workers	38,9%
16 Windmills - 3 workers	48,7%
24 Windmills - 4 workers	53,8%
32 Windmills - 5 workers	59,6%
40 Windmills - 6 workers	62,5%

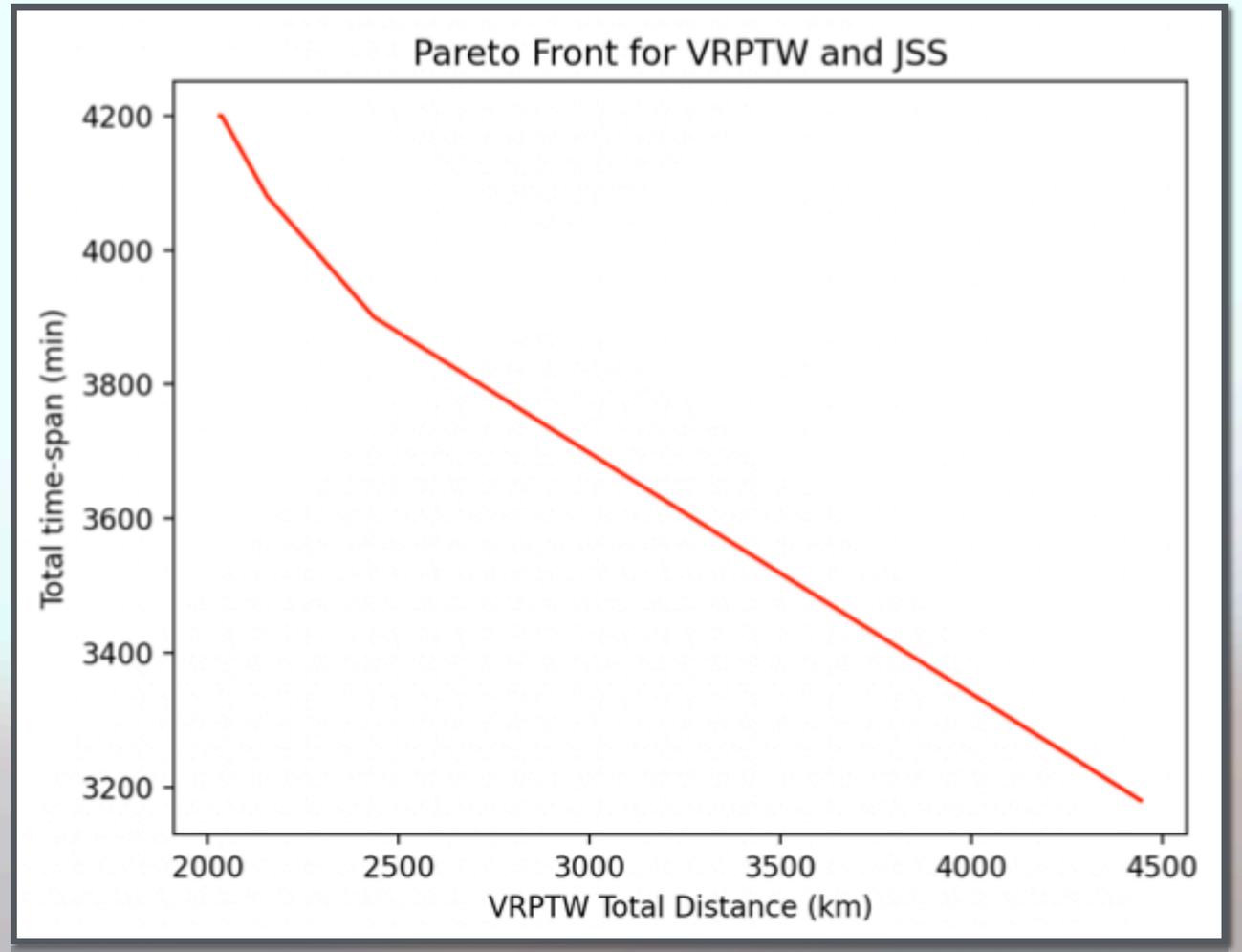
Conclusion JSSP

1. By employing more workers simultaneously, the total maintenance time lost is (more than) halved, and therefore downtime is reduced by (more than) 50%.

2. Although the total number of working hours is higher when using three workers instead of one, the amount of money gained by halving the downtime is significantly higher, hence the huge advantage of the JSSP solver.

3. From 4 workers onwards, the total maintenance time span does not lower very much when adding extra workers. The trade-off can thus be put at 4 workers or, when labor is expensive, at 3 workers.

Combined Results VRPTW - JSSP



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Overall Conclusion

1. Comparing the solutions for both objective functions, being distance minimization and maintenance time span optimization, led to sequences that are only optimal for one of the two objectives.

2. Pareto points are calculated to obtain solutions that are as optimal as possible for both objectives

3. The JSSP method thus leads to a much greater benefit than the distance reduction of the VRPTW solution.

Thanks for your attention!
Questions?

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