Vroom

Vehicle Routing Open-source Optimization Machine

State of the Map 2018, Milan

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https://verso-optim.com/

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Contents

Vehicle routing problems

- - **TSP** *travelling salesman problem*
  - **CVRP** *capacitated vehicle routing problem* (1959)
  - **VRPTW** *vehicle routing problem with time-windows* (70-80)
  - ...
- NP-hard, combinatorial optimization
- Explosion of computing time when problem size increases

Real-life VRP solver requirements

- Real-life routing
- Get near-optimal solutions
- Low computing times
- Scale to huge problem instances

DATA

ROUTING

DATA

OSRM
OPEN SOURCE ROUTING MACHINE

Profiles

OPTIM

Vroom
Vehicle Routing Open-source Optimization Machine

Matrix

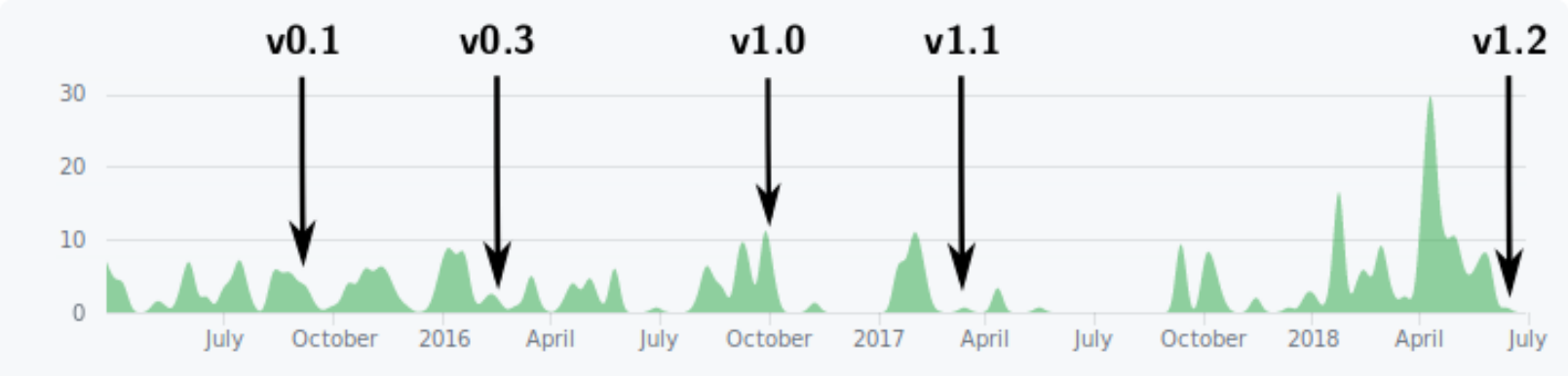
ROUTING

OSRM
OPEN SOURCE ROUTING MACHINE

Profiles

DATA

Timeline



Highlights:

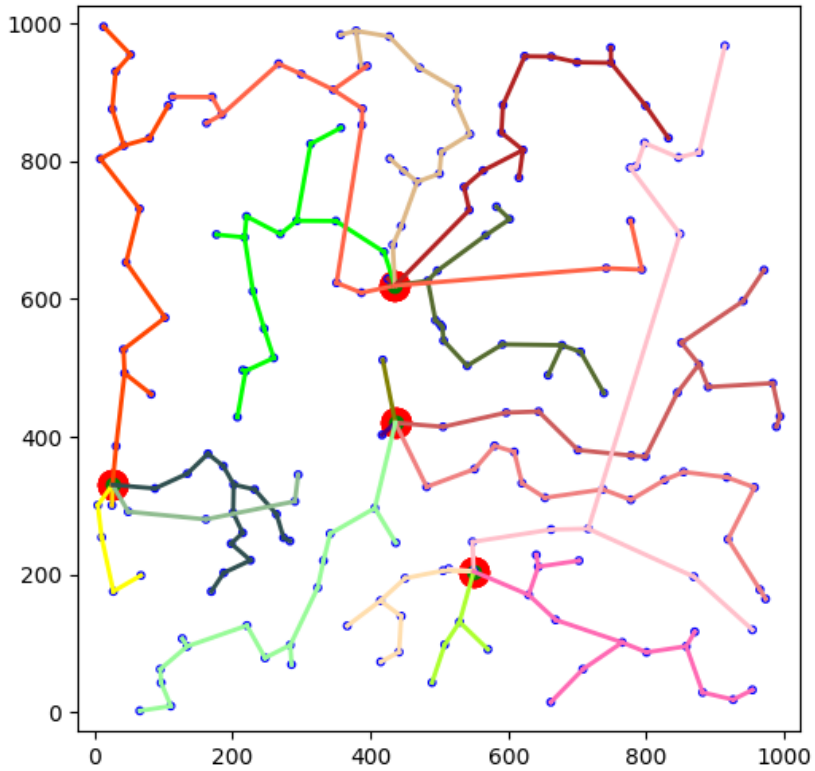
- **v0.1** Solve TSP with OSRM integration
- **v0.3** Handle "open" trips, improve results on asymmetric problems
- **v1.0** Stable API, multi-threading, switch to OSRM v5.*
- **v1.1** Support for `libosrm`
- **v1.2** Multiple vehicles, skills, multi-dimensional capacities, user-defined matrices, exploration level

TSP

Christofides heuristic (1976) on symmetrized problem

CVRP

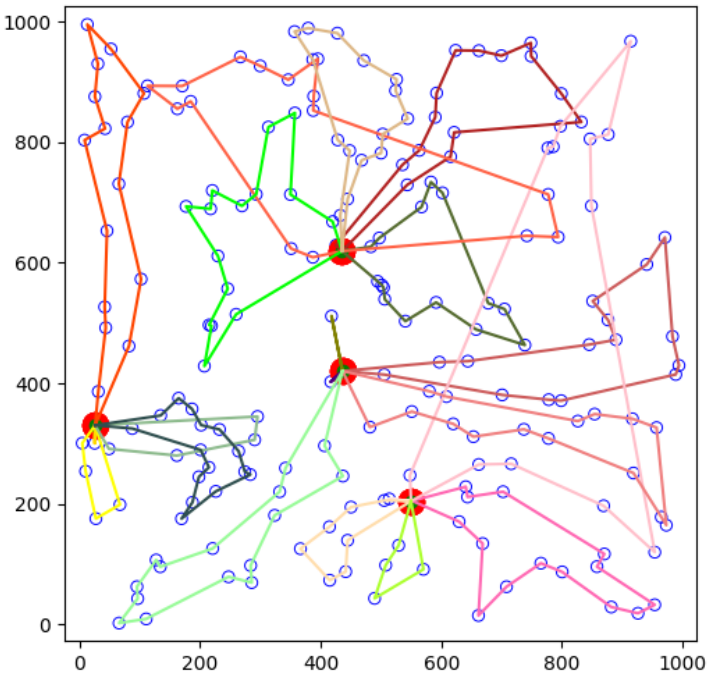
Dedicated clustering heuristic using spanning trees



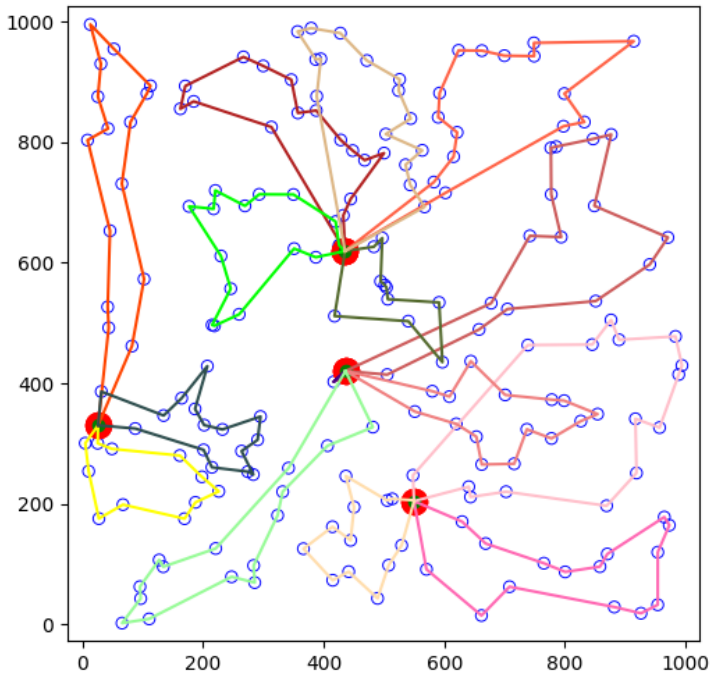
Local search

Apply modification operators to the heuristic solution

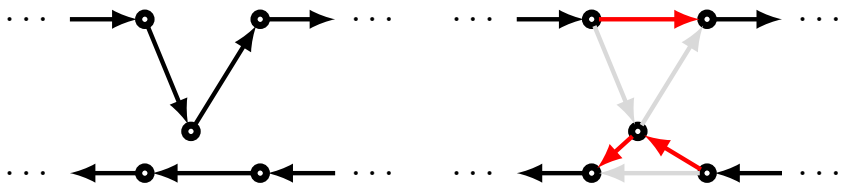
Before



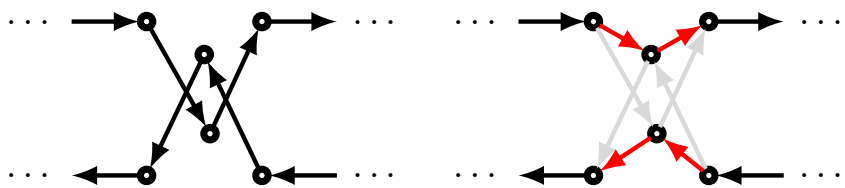
After



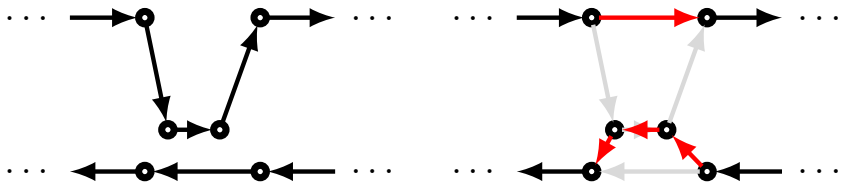
Relocate



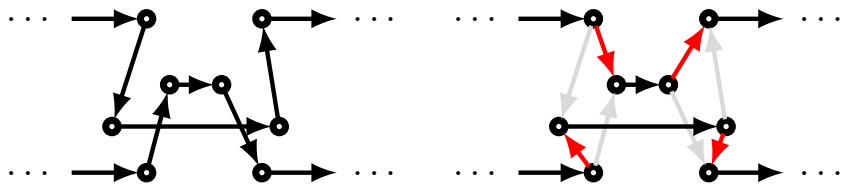
Exchange



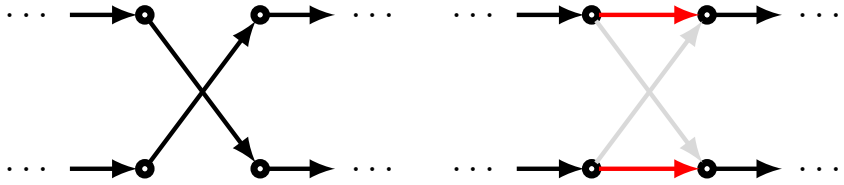
Or-Opt



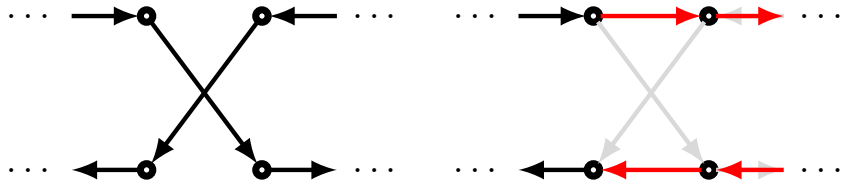
Cross-exchange



2-Opt



Reversed 2-Opt

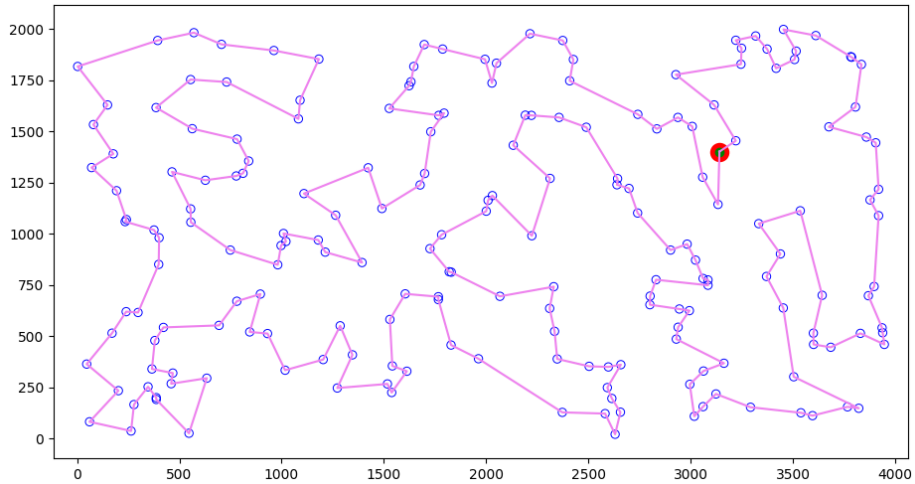


Local search implementation for CVRP

- Basic local search step
  1. Evaluate validity/gain for operators on all pair of routes
  2. Perform "best" move
  3. Re-evaluate only what's necessary until no more improvement is found
- Get out of local minimum or deadlock
  1. Remove the "worst" jobs for all routes
  2. Refill the routes and reapply a local search step
- Exploration level ranging from 0 to 5

TSPLIB benchmark description

- 78 TSP instances
- Sizes ranging from 50 to 18,511 points
- Average size $\simeq 1,170$ points



Hardware

CPU: Intel Xeon E5-1620 @ 3.50GHz, 4c/8t

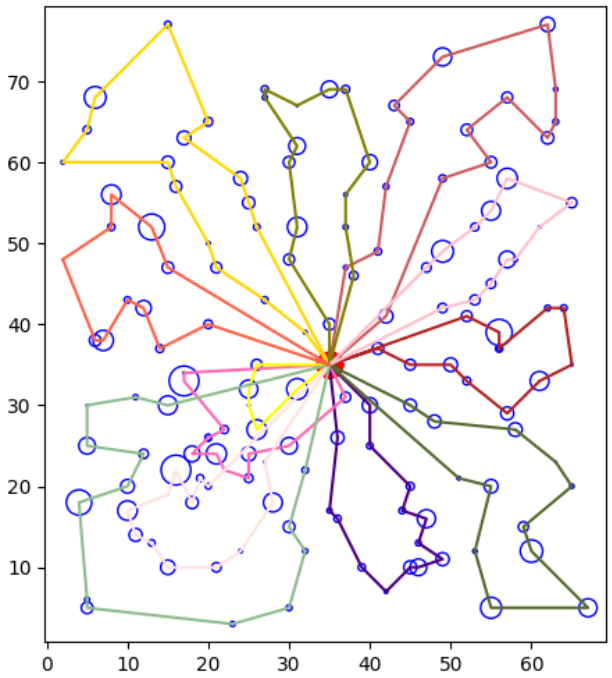
Results

- Median computing time: 28 ms
- Average gap to optimal solution: +3.0%
- Worst gap to optimal solution: +7.6%
- Examples

Instance	Size	Computing time	Gap
kroA100	100	5 ms	+0.0%
kroB200	200	9 ms	+1.7%
d493	493	48 ms	+3.8%
u1060	1,060	328 ms	+3.0%
u2152	2,152	1610 ms	+4.9%
rl5915	5,915	25.8 s	+2.4%
usa13509	13,509	$\simeq$14 m	+3.0%
d18512	18,512	$\simeq$35 m	+2.9%

CVRPLIB benchmark description

- 189 CVRP instances
- Sizes ranging from 15 to 1,000 jobs
- Average size $\simeq$ 240 jobs, number of vehicles ranging from 2 to 207
- Average capacity tightness $\left(\frac{\sum job\ \ amounts}{\sum vehicle\ \ capacity}\right)$: 0.95



Global indicators

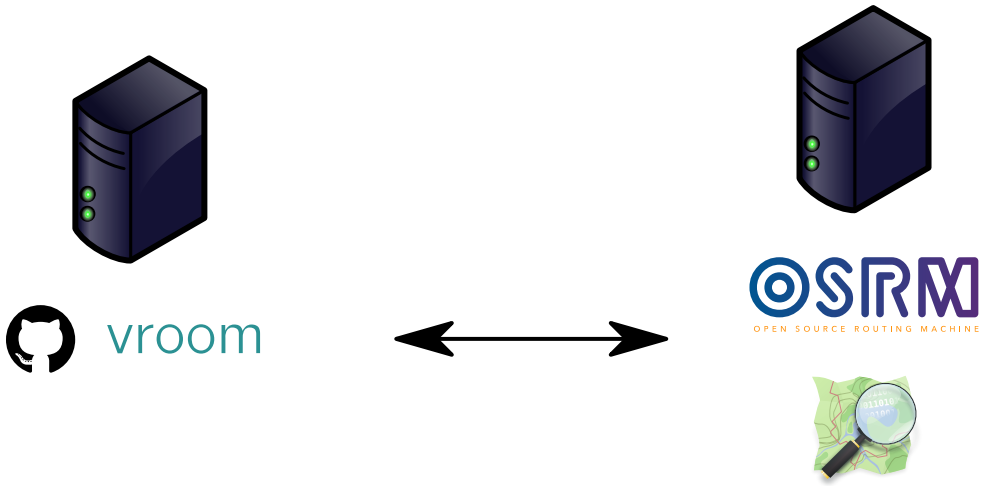
Exploration level	0 (fastest)	5 (best)
Median computing time	87ms	1019ms
Longest computing time	9.1s	254.3s
Jobs assigned	99.67%	99.88%
Solutions with all jobs	162 (85.7%)	171 (90.5%)
Best known solutions	8 (4.2%)	30 (15.9%)

Gaps to best known solutions

Only reported for instances with all jobs assigned.

Exploration level	0 (fastest)	5 (best)
Minimum gap	+0.00%	+0.00%
Median gap	+3.95%	+1.35%
Average gap	+4.81%	+2.23%
Worst gap	+21.45%	+12.95%

https://github.com/VROOM-Project



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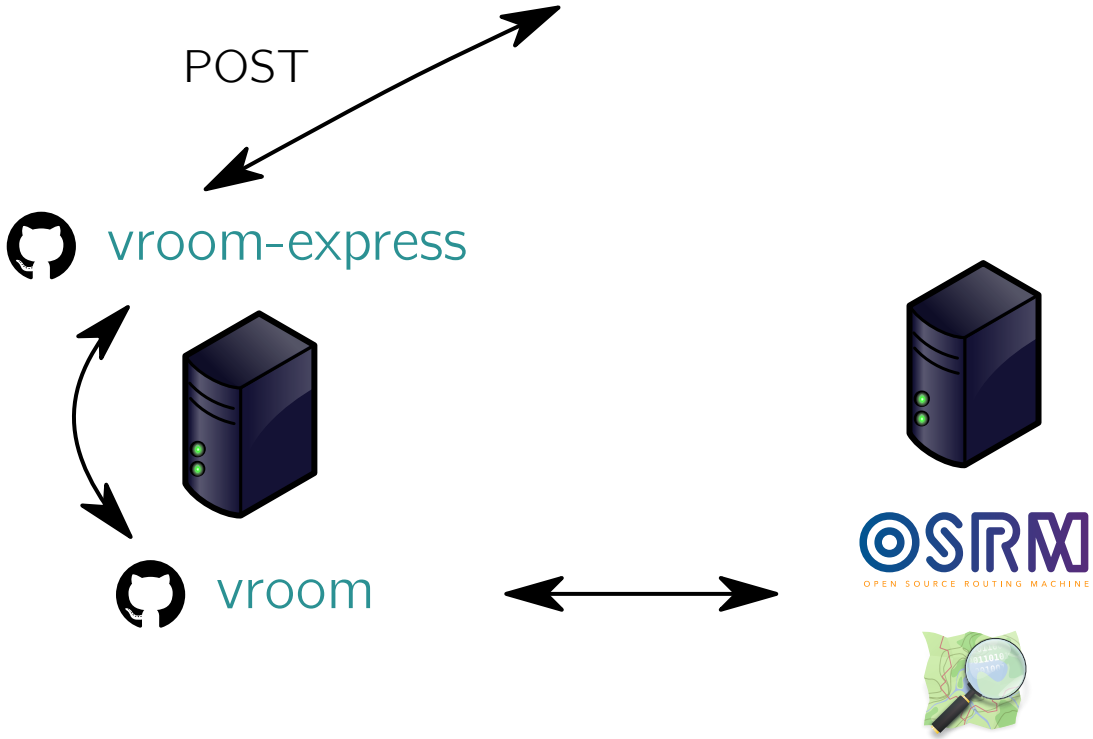

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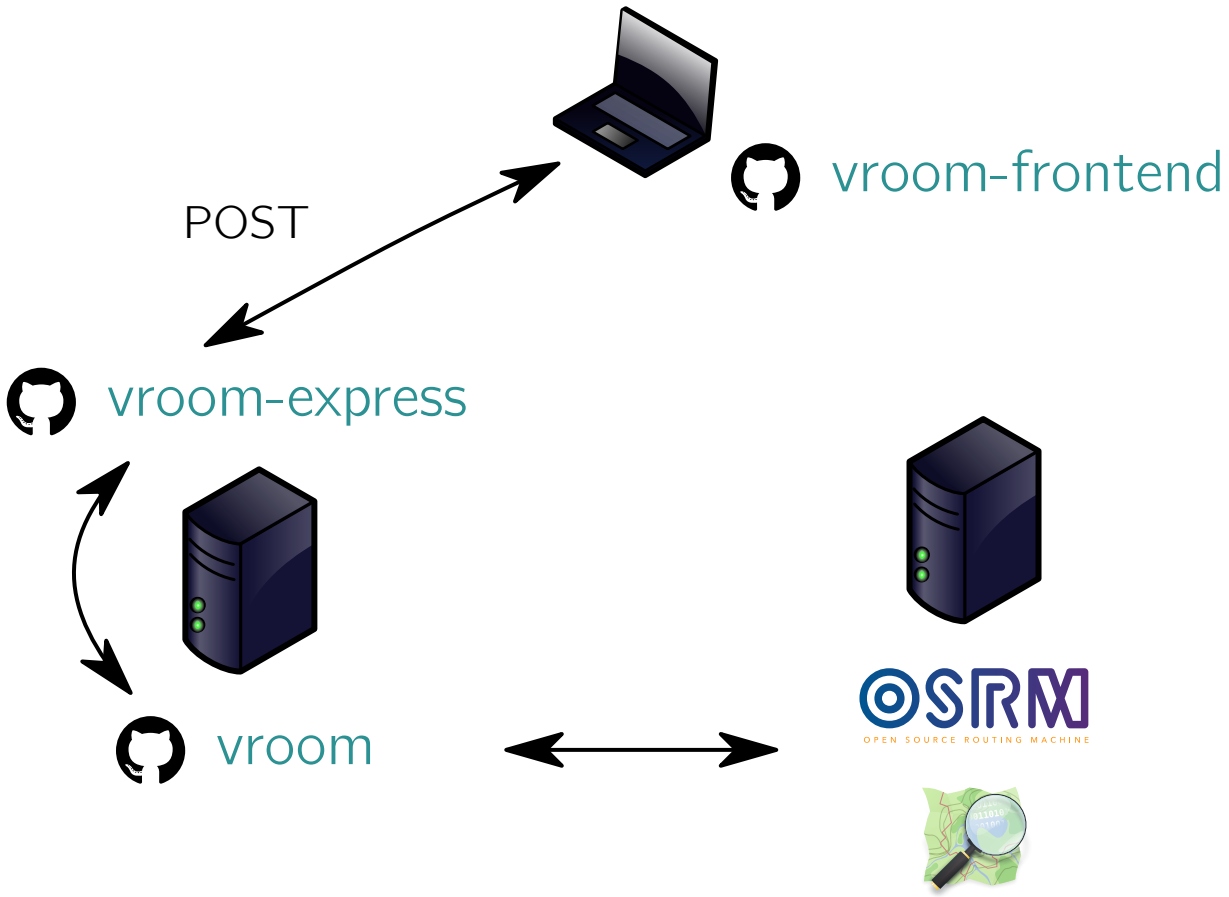

Command-line

```
$ vroom -i input.json -o output.json -t 4 -x 5
$ vroom -i input.json -g -a router.project-osrm.org -p 80
```

http request

```
$ curl --header "Content-Type:application/json"
       --data @input.json http://solver.vroom-project.org
```

Why use VROOM?

- Open
  - ✓ Based on OpenStreetMap data and tooling
  - ✓ BSD-licensed
- Efficient
  - ✓ Very good solutions
  - ✓ Very fast
  - ✓ Scale to huge problem sizes

Work in progress

Timing constraints are scheduled for v1.3.

http://map.vroom-project.org/

https://github.com/VROOM-Project/vroom/wiki

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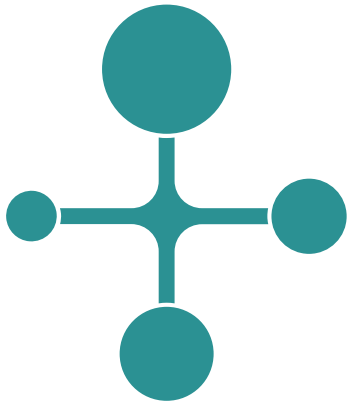

Thank you for your attention!