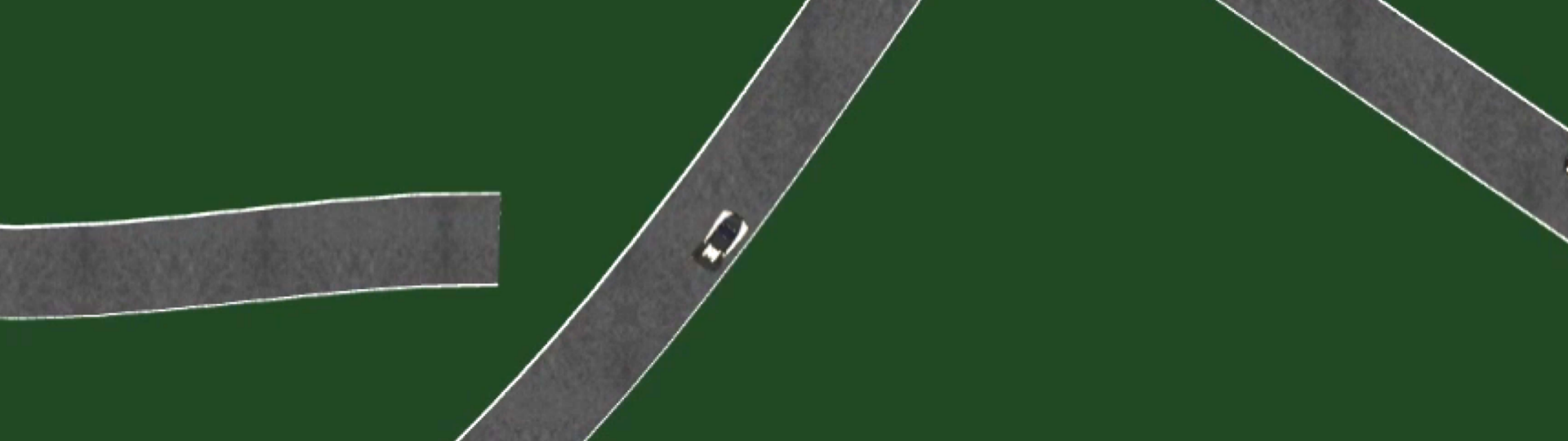




Simulation as a Service for Cooperative Vehicles

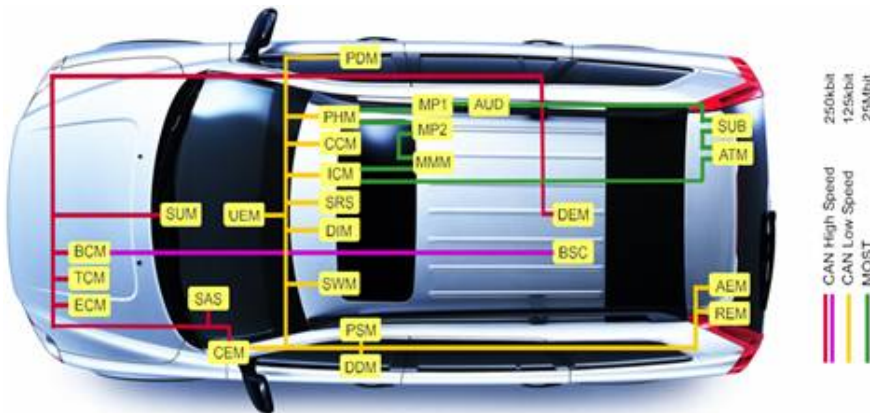
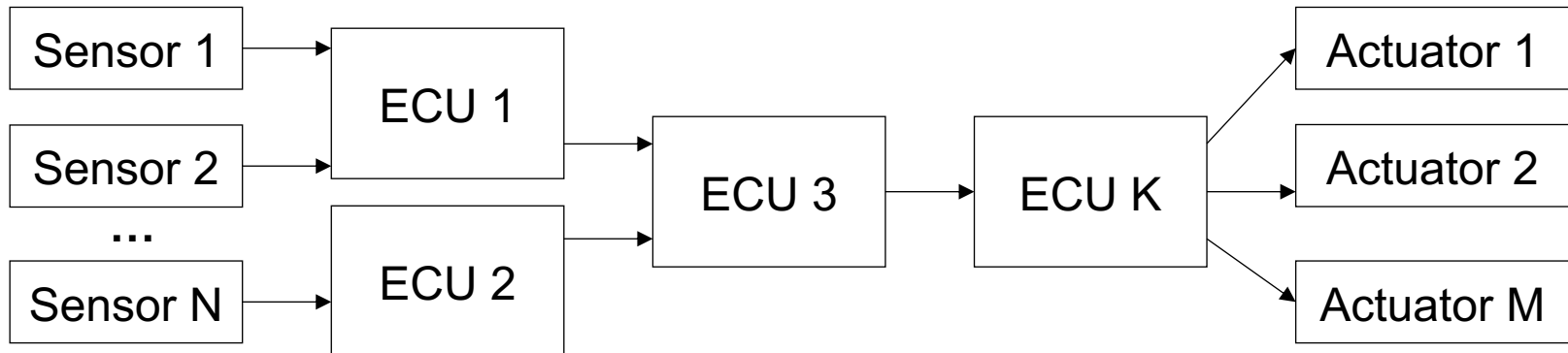
MASE 2019, Munich

Jörg Christian Kirchhof, Evgeny Kusmenko, Bernhard Rumpe and Hengwen Zhang
Software Engineering
RWTH Aachen University

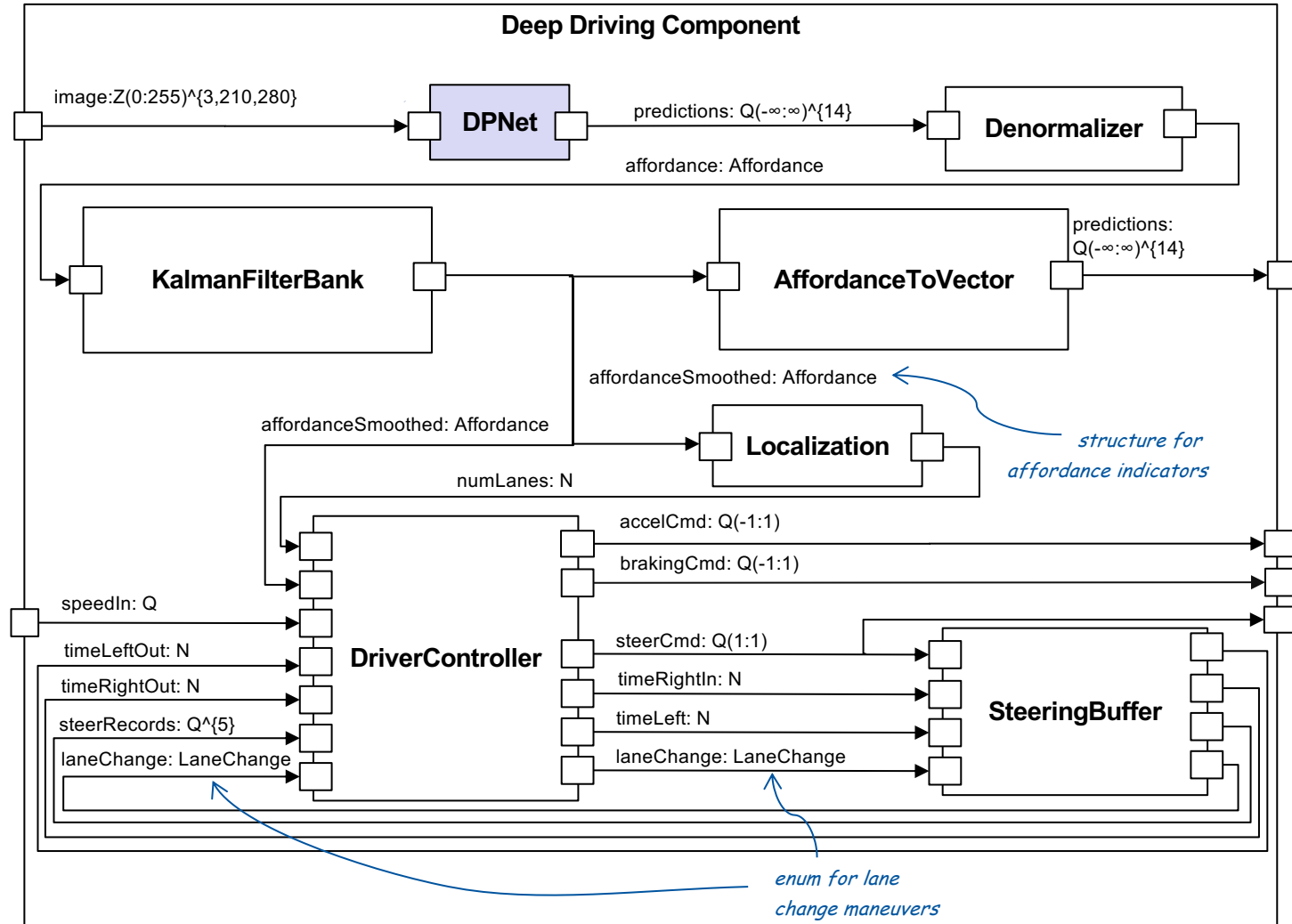
<http://www.se-rwth.de/>

Motivation

- **Our mission:** provide **MBSE methodologies** for the **automotive** domain
- **EmbeddedMontiArc:** Modeling language for automotive systems

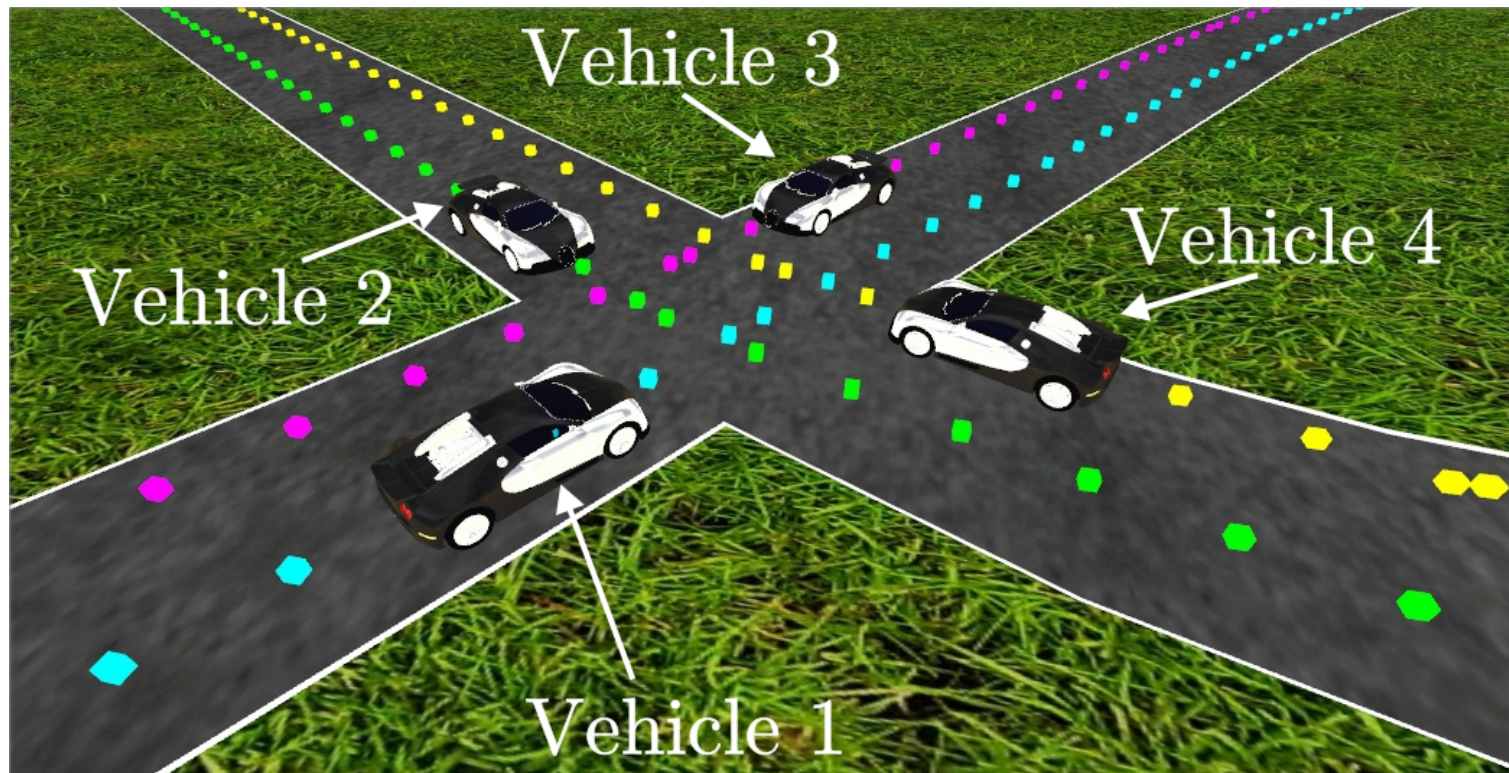


EmbeddedMontiArc

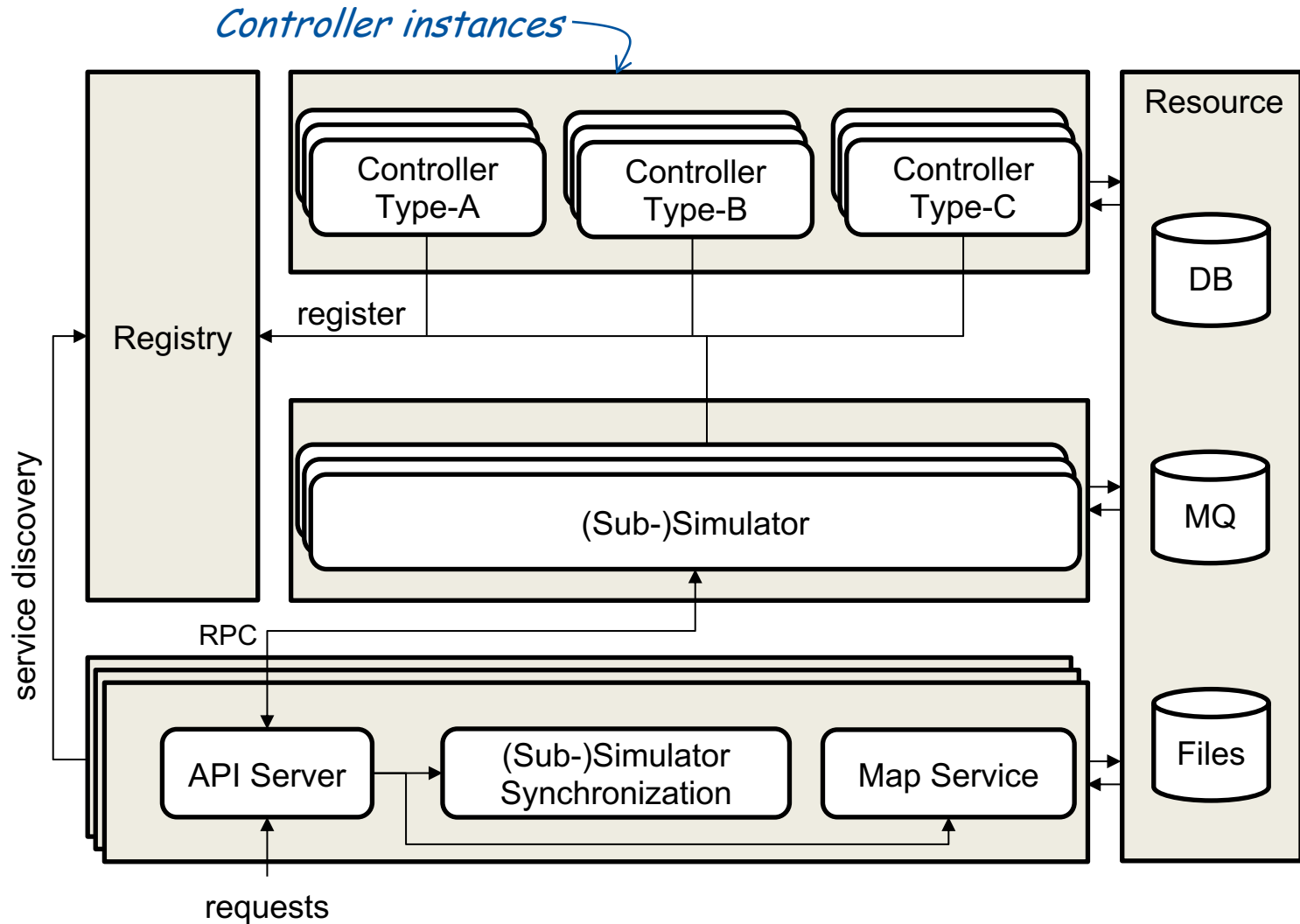


Requirements

- Cooperative Driving
 - Participant's decisions influence each other
 - Simulation of communication infrastructure
- Continuous Integration
 - Partition simulation to cloud computers
 - Frequently exchange parts of the code
 - Automatically evaluate simulation results



Architecture



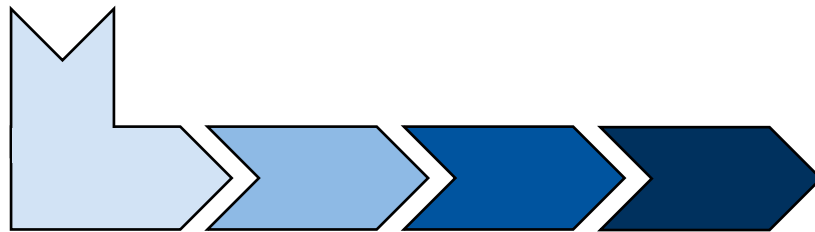
Simulation Model

```
1 simulation Example1 {
2   map = MunichCity.osm;
3   startTime = 22.06.2017 13:30;
4   deltaT = 1ms
5   wheather = noRain, noSnow;
6   duration = 30s;
7   cars {
8     AC-SE001: 50° 46'43.7"N 6° 03'38.6"E ->
9               50° 46'49.7"N 6° 04'32.5"E
10    M-SE003: ... -> ... } }
```

Sim

Start Position

Target Position

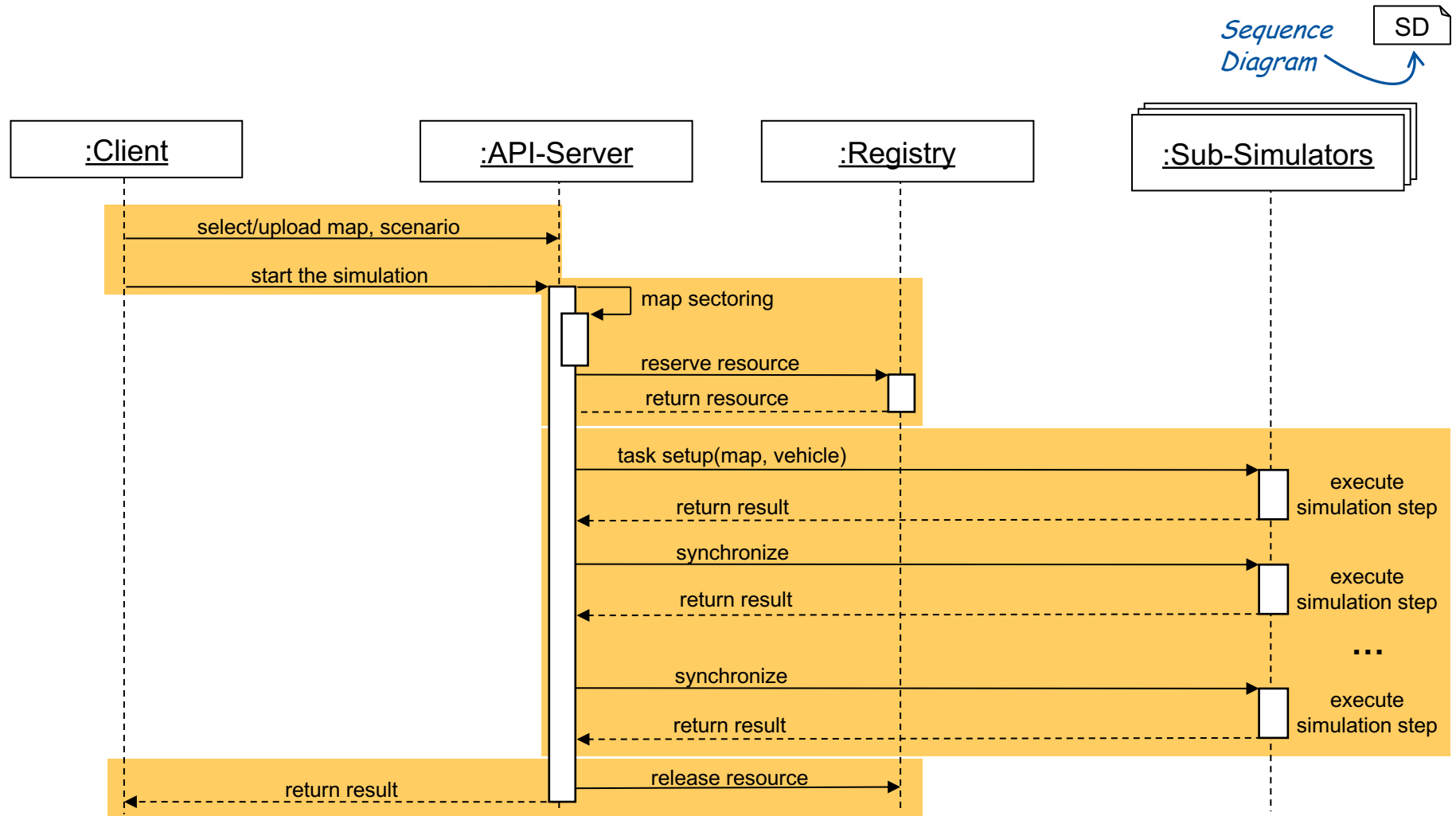


CI Pipeline

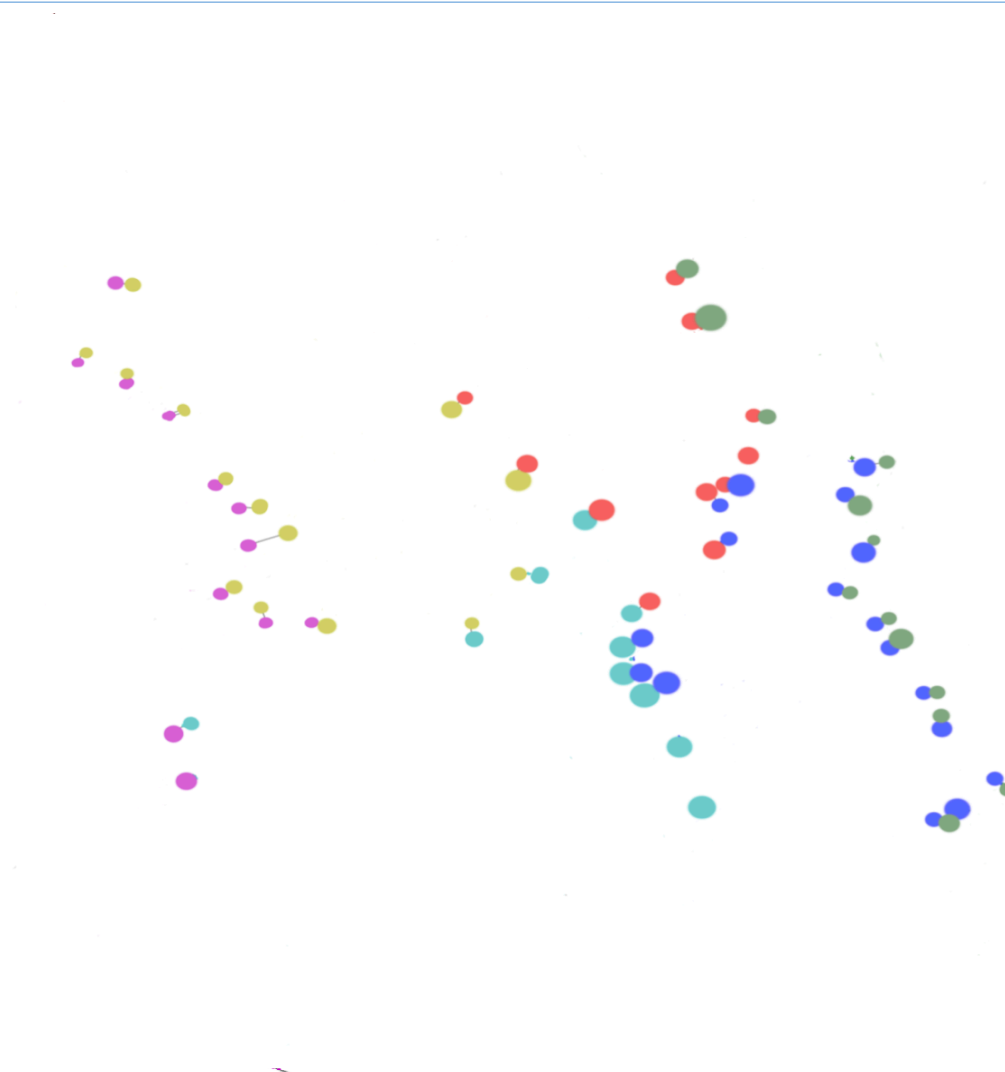
```
1 "frames": [
2   {
3     "deltaTime": 33,
4     "position": [
5       5.8806556,
6       50.83668824517681,
7       0.5429999999999999
8     ],
9     "steering": 0.0165,
10    "collision": false,
11    ...
12    "totalTime": 4059,
13    "vehicleID": "45124"
14  }, ...
15 ]
```

JSON

Sub-Simulator Synchronization

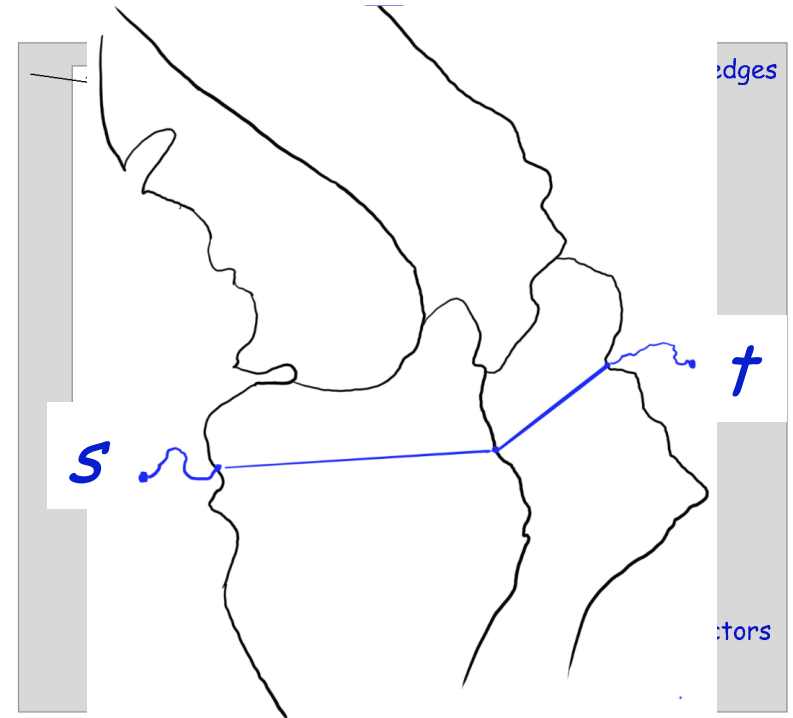


Map Sectorization

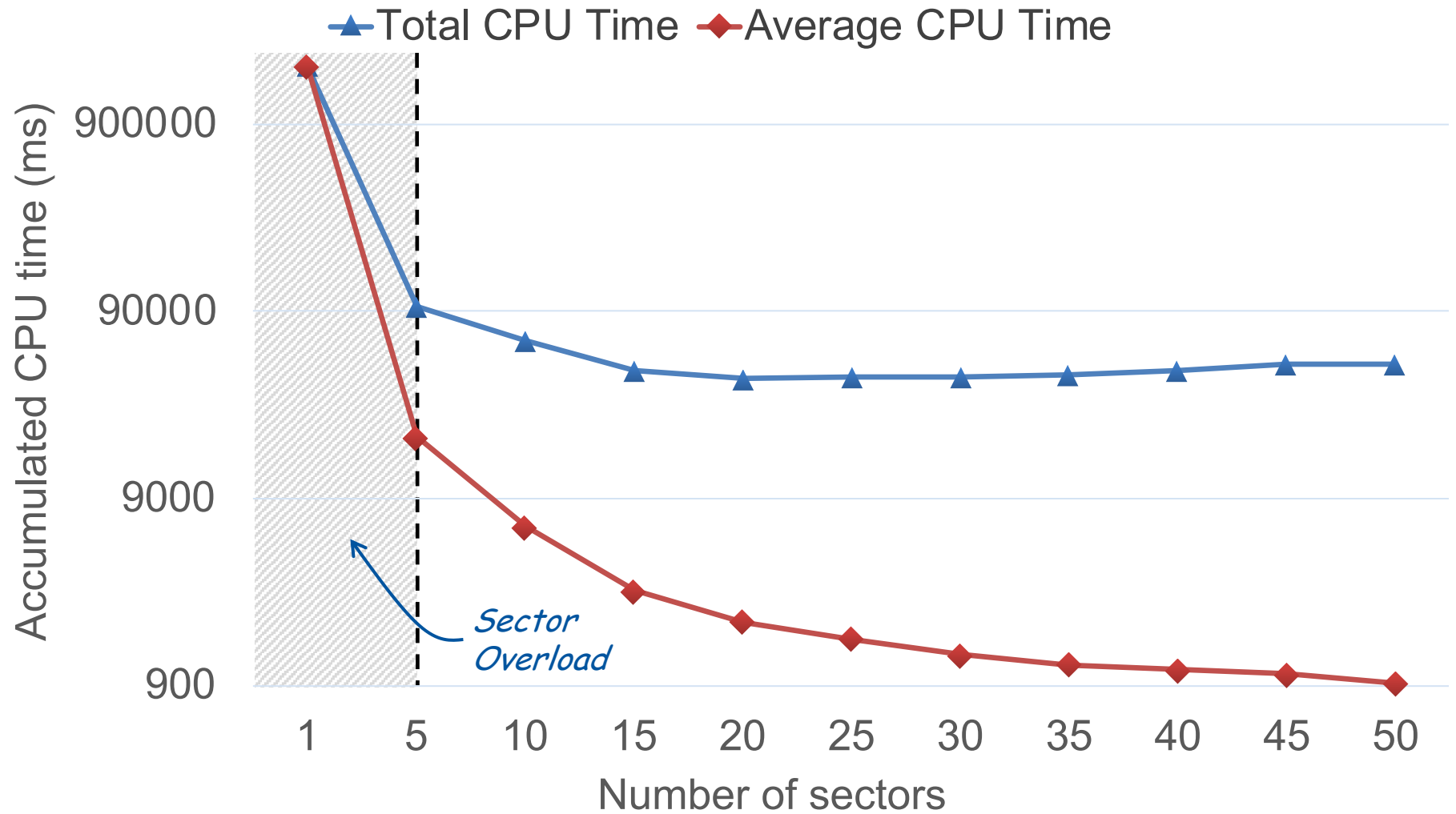


Route Planning

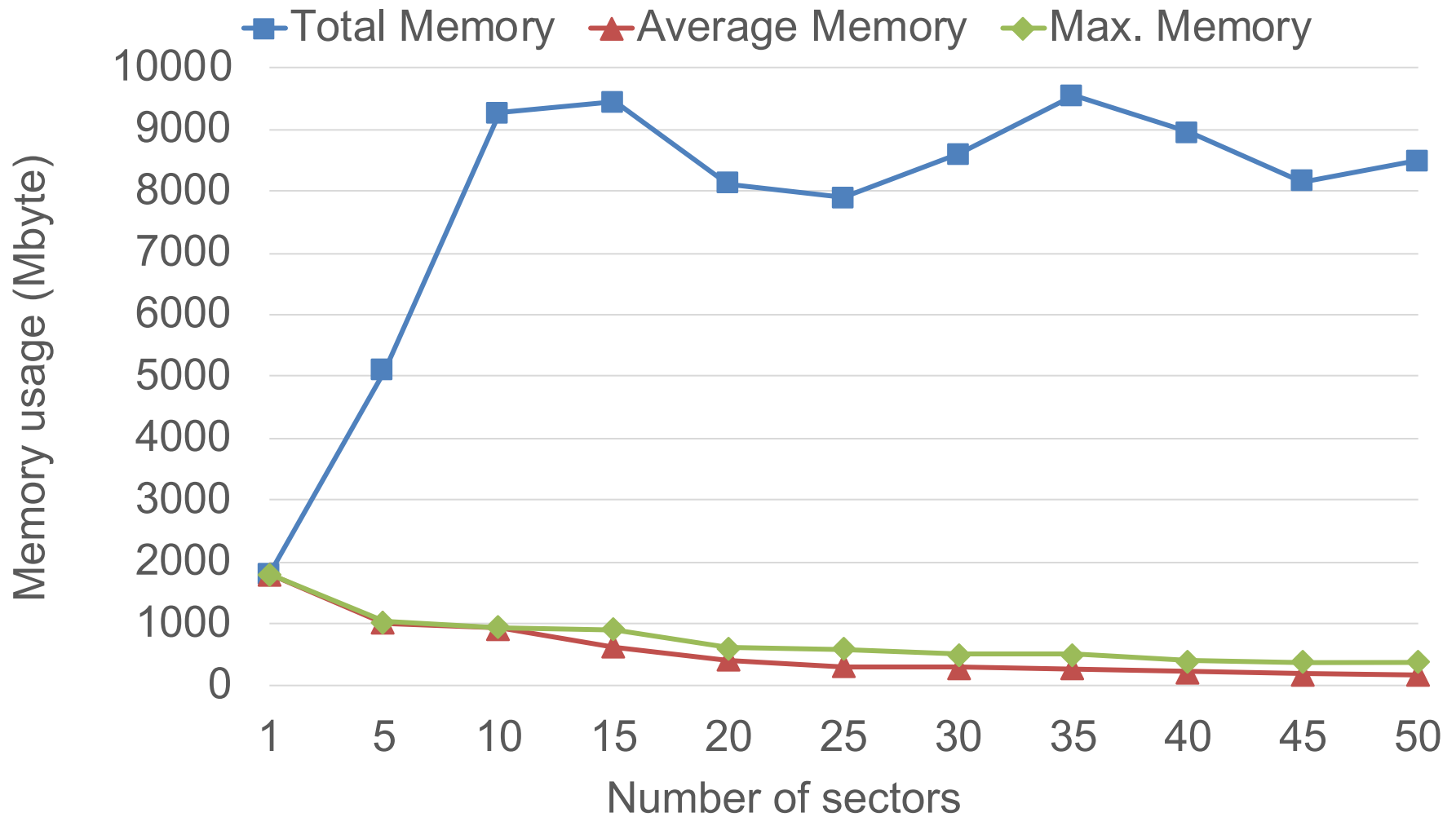
1. Sectorize map ← Previous slide
2. Find edges that go across sectors (*cut edges*)
3. In each sector find routes from one cut node to the others (*cut nodes*)
4. Find route between sectors



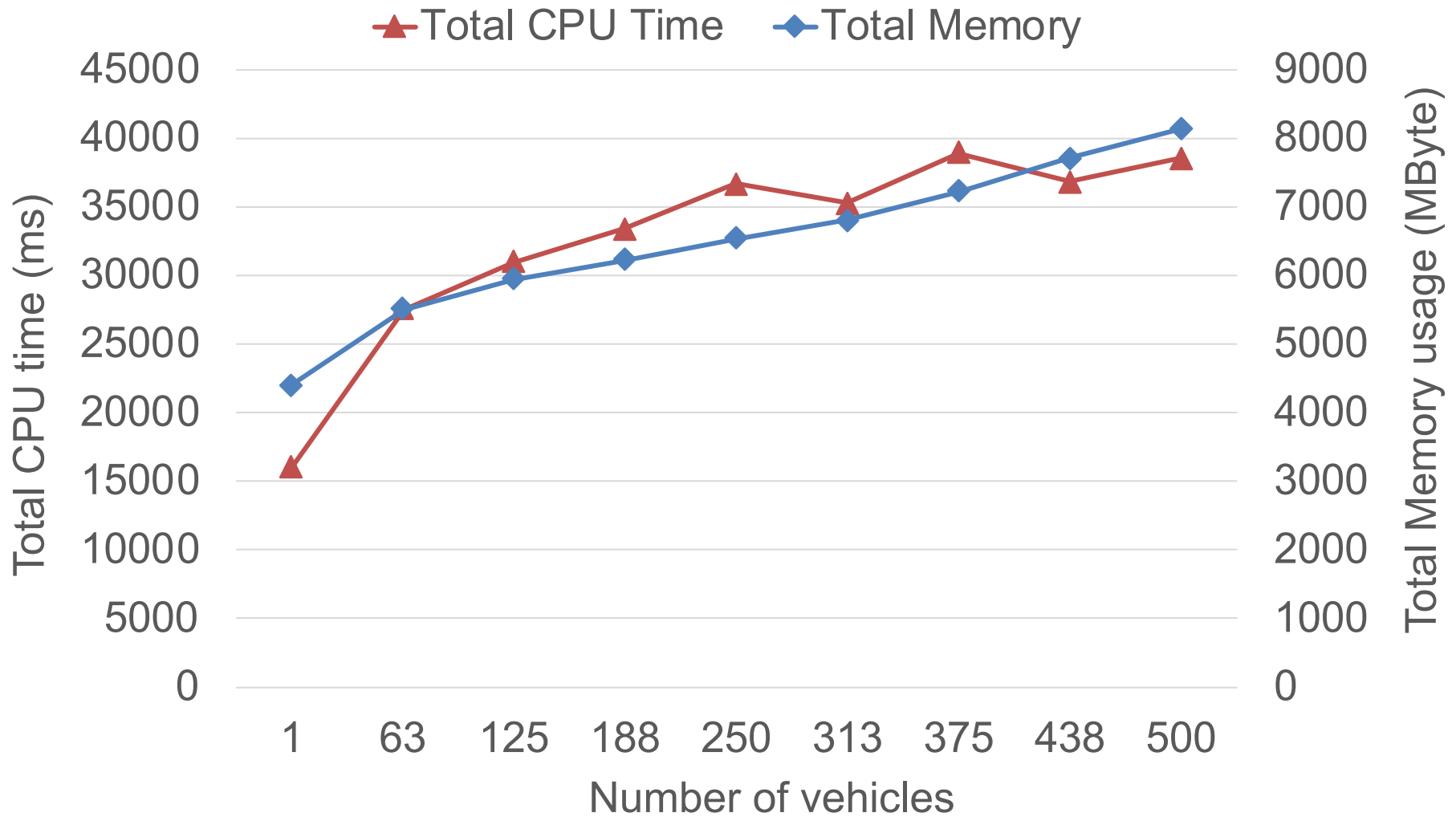
Evaluation: CPU Consumption



Evaluation: Memory Consumption

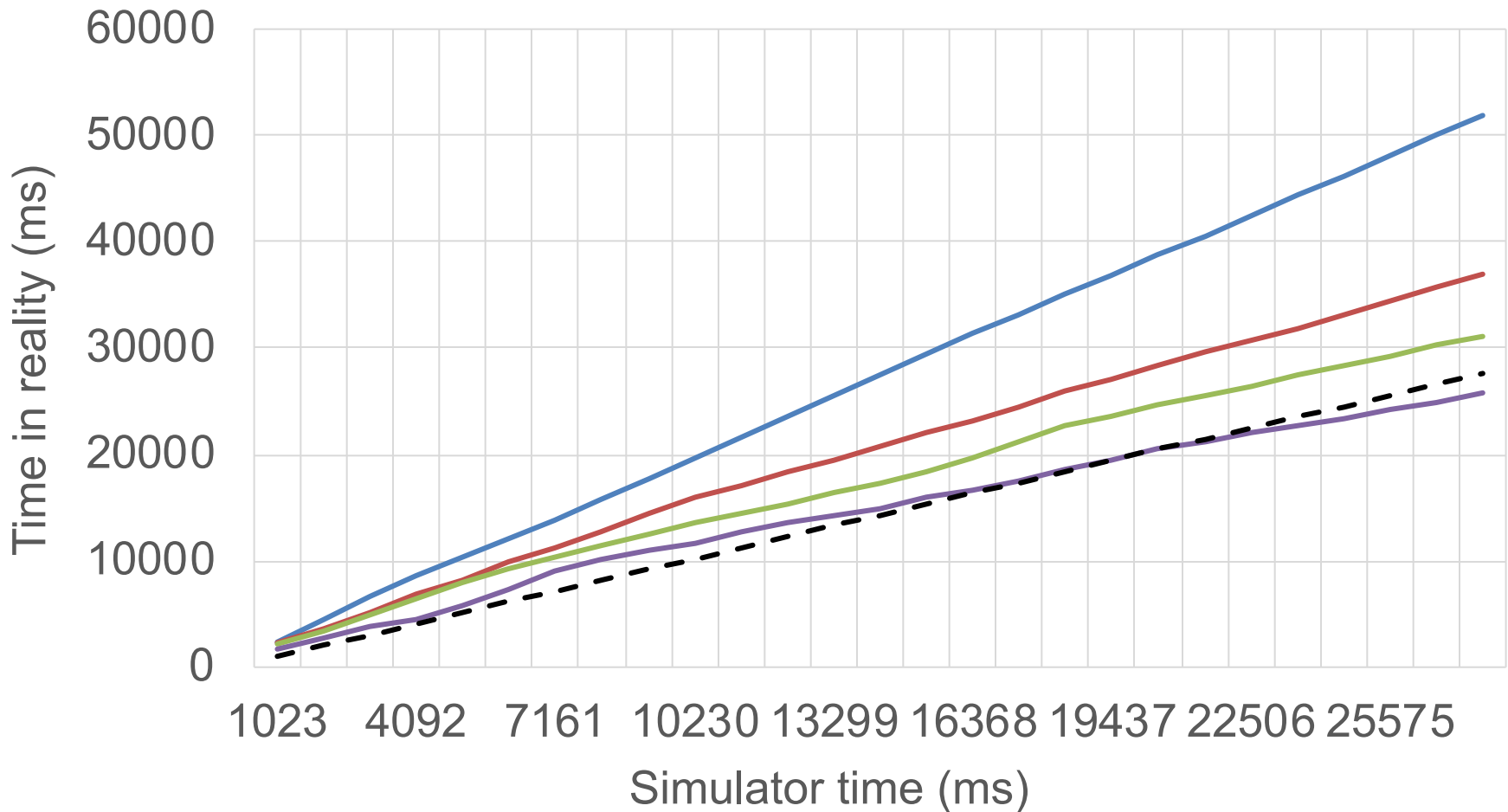


Evaluation: Scalability

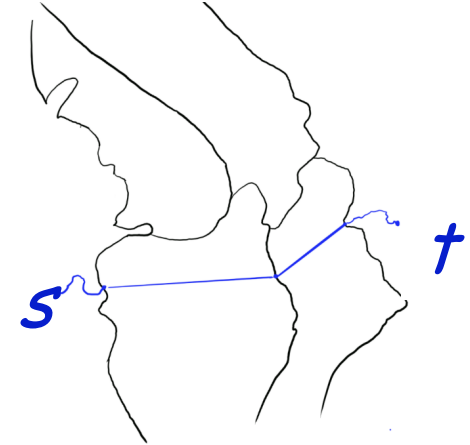
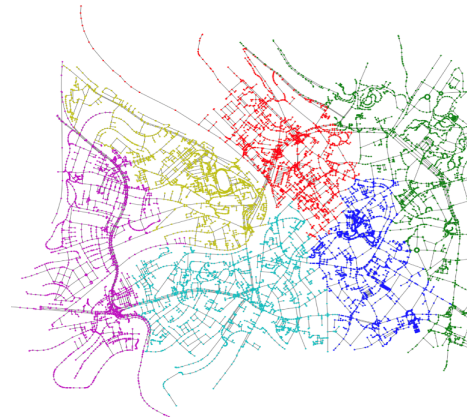
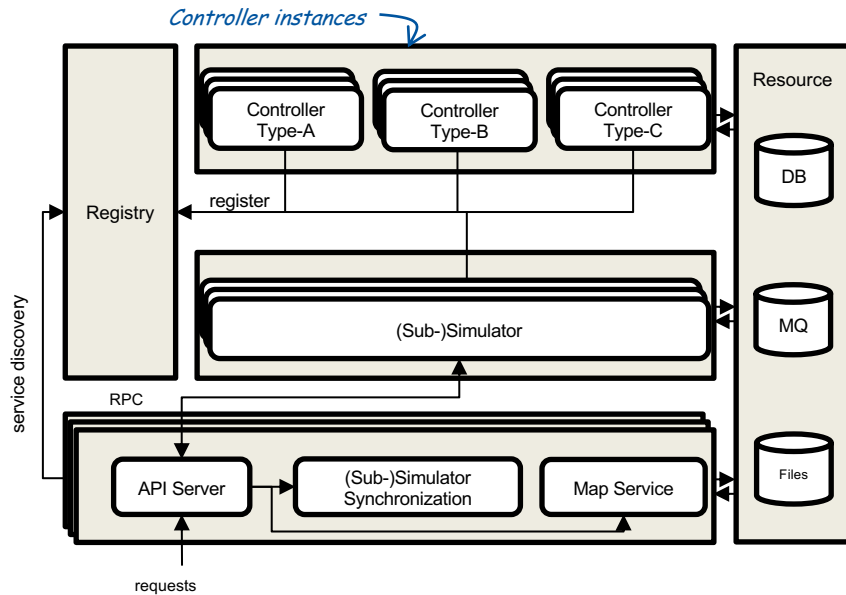


Evaluation: Simulation Speed

— 1 sector — 2 sectors — 3 sectors — 4 sectors - - Online Simulation



Conclusion



```

1 simulation Example1 {
2   map = MunichCity.osm;
3   startTime = 22.06.2017 13:30;
4   deltaT = 1ms
5   wheather = noRain, noSnow;
6   duration = 30s;
7   cars {
8     AC-SE001: 50° 46' 43.7"N 6° 03' 38.6"E ->
9               50° 46' 49.7"N 6° 04' 32.5"E
10    M-SE003: ... -> ... }

```

Start Position
Target Position



CI Pipeline

```

1 "frames": [
2   {
3     "deltaTime": 33,
4     "position": [
5       5.8806556,
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13    "vehicleID": "45124",
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```

JSON