Swiss-Scale Multi-Mode Transport Simulation

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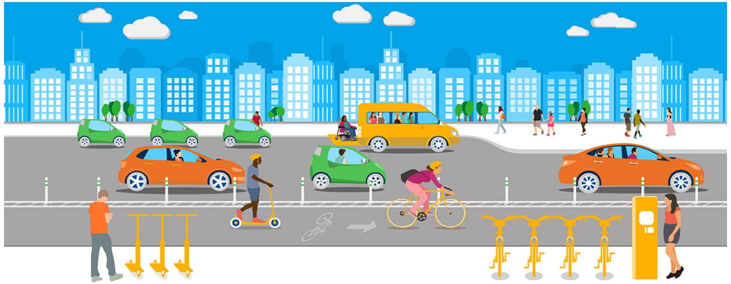
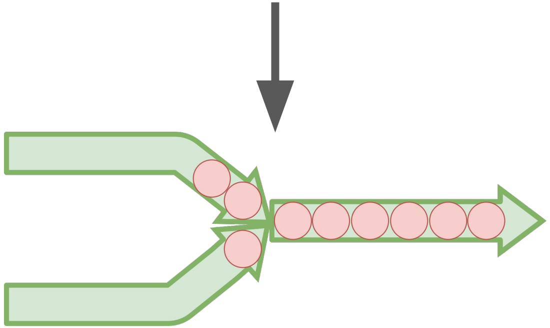
Multi-Agent Transport Simulation





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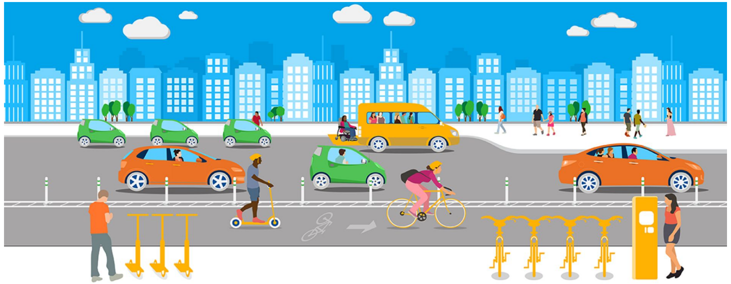
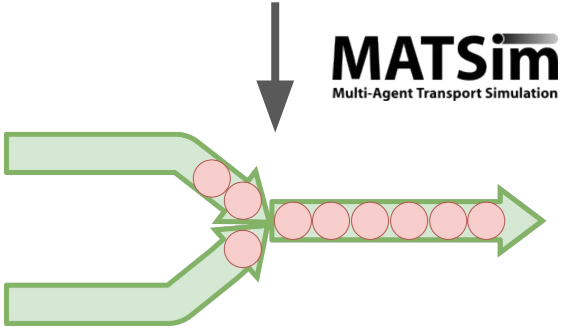
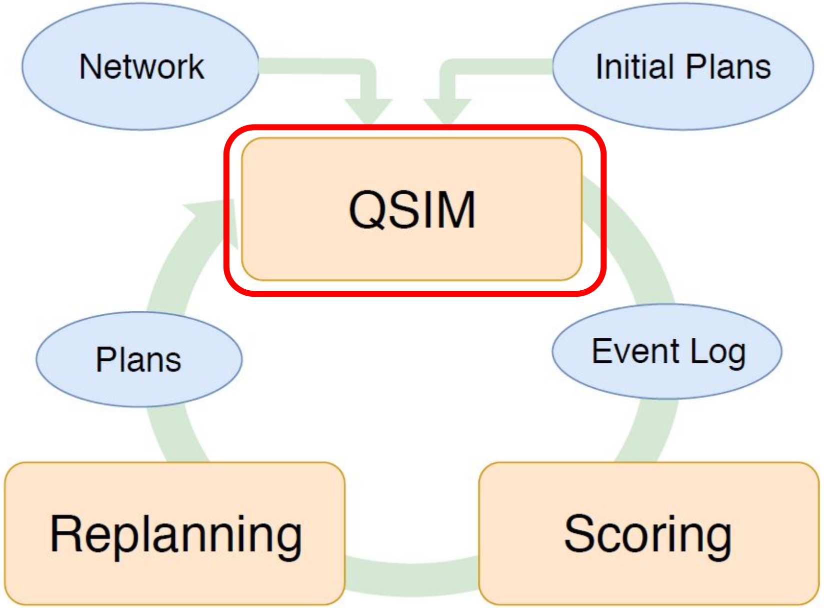


MATSim
Multi-Agent Transport Simulation



MATSim Recap



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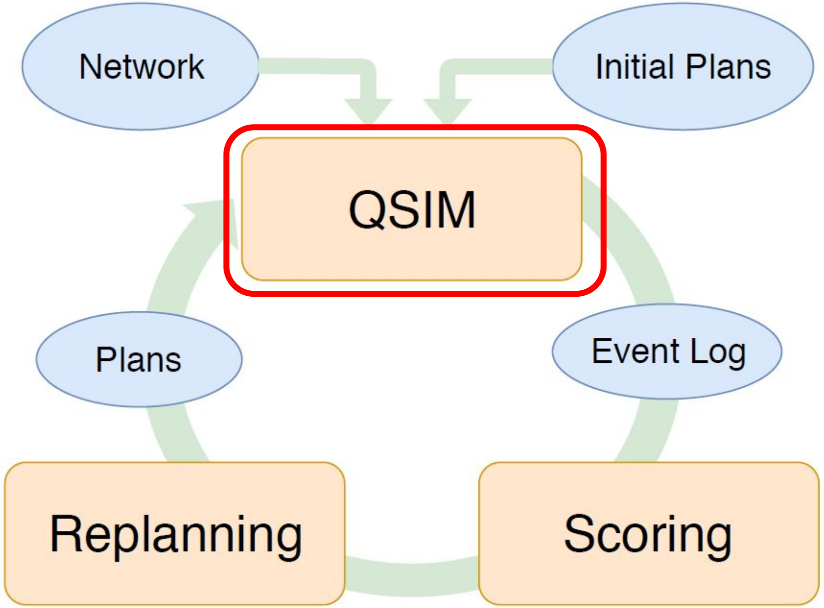

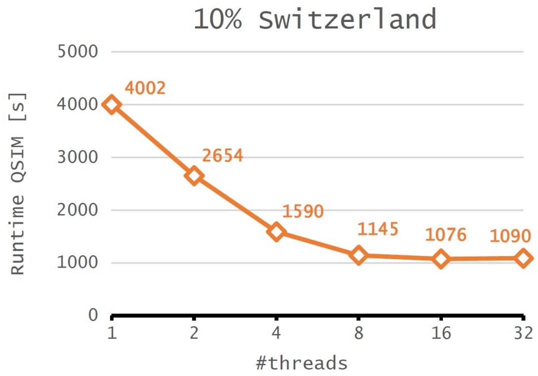

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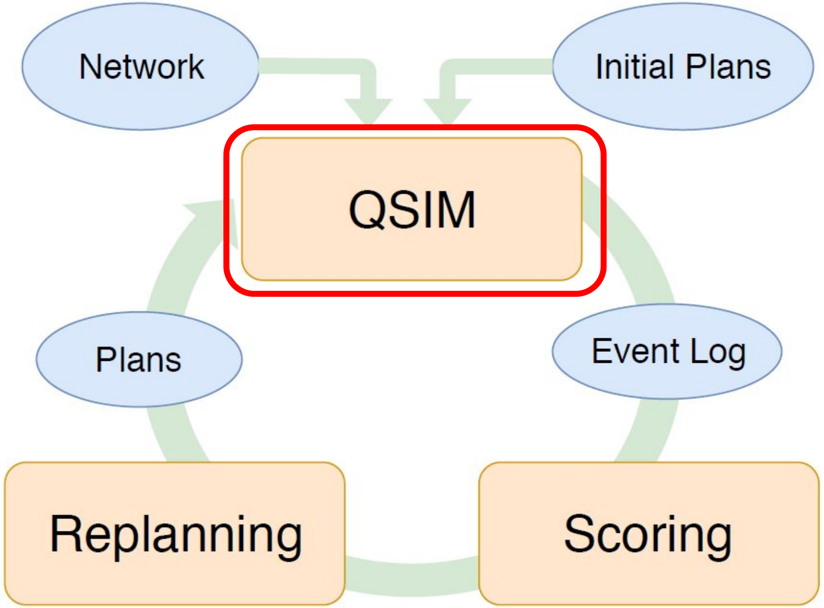

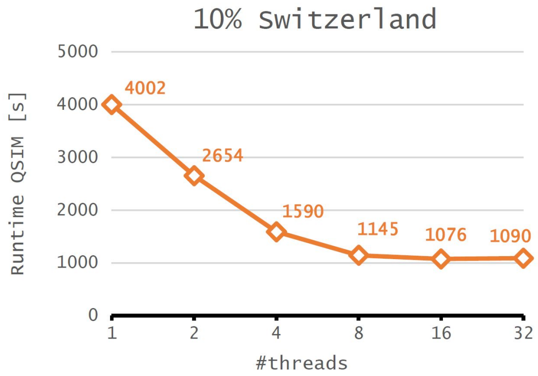

Can we scale to 100% CH?

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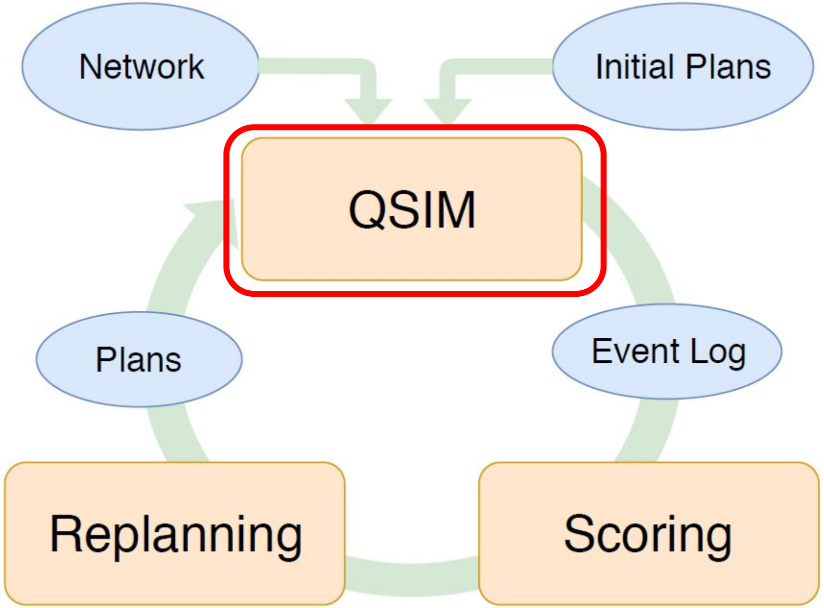

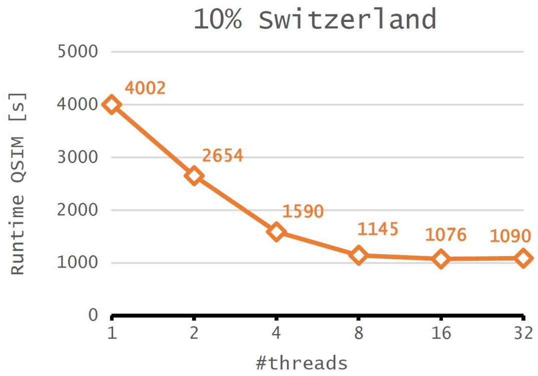

Can we scale to 100% CH?

10 x more agents * 1,000 iterations / seconds in day

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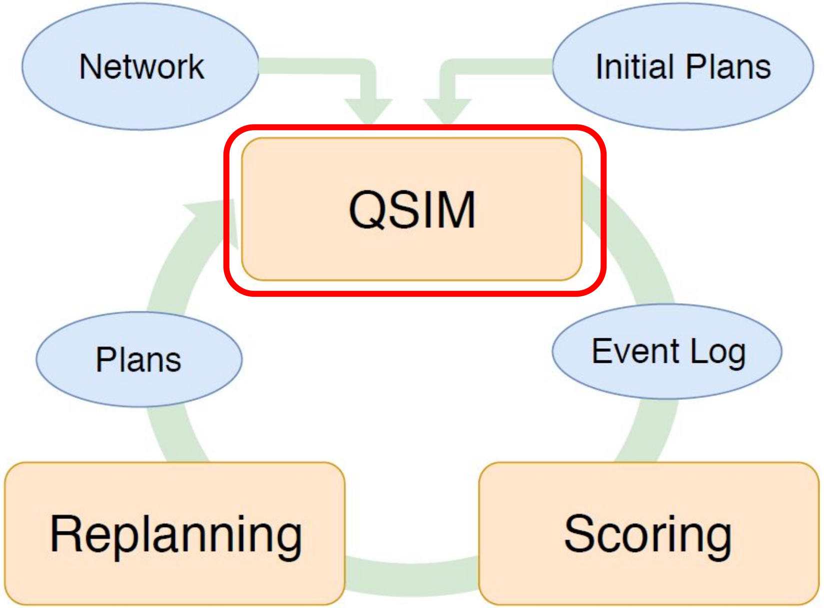

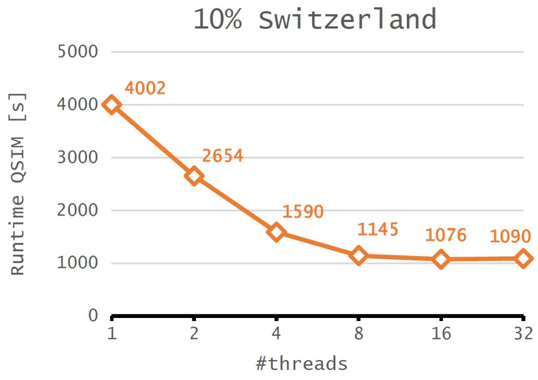

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~= 10 * 1,000 * 1,076 / 86,400

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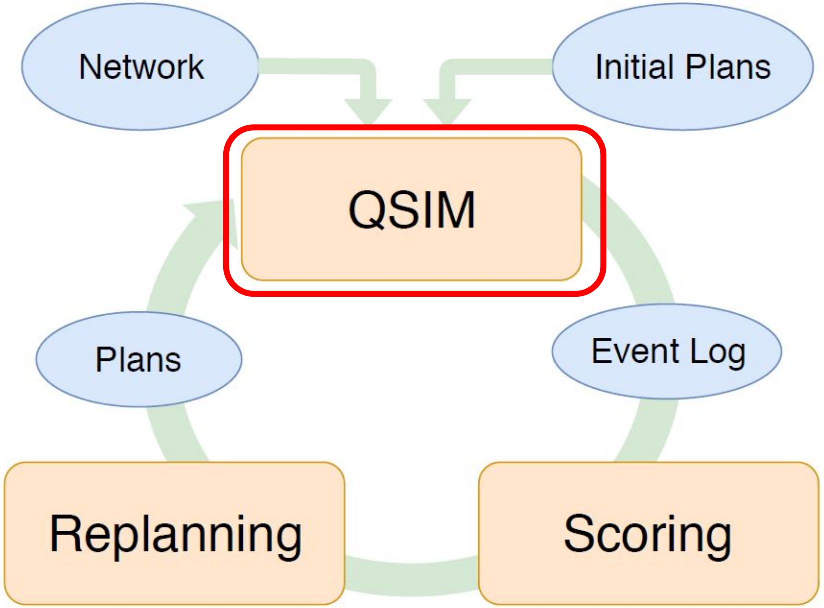

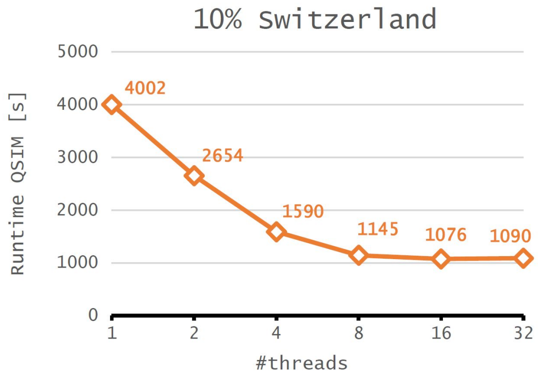

Can we scale to 100% CH?

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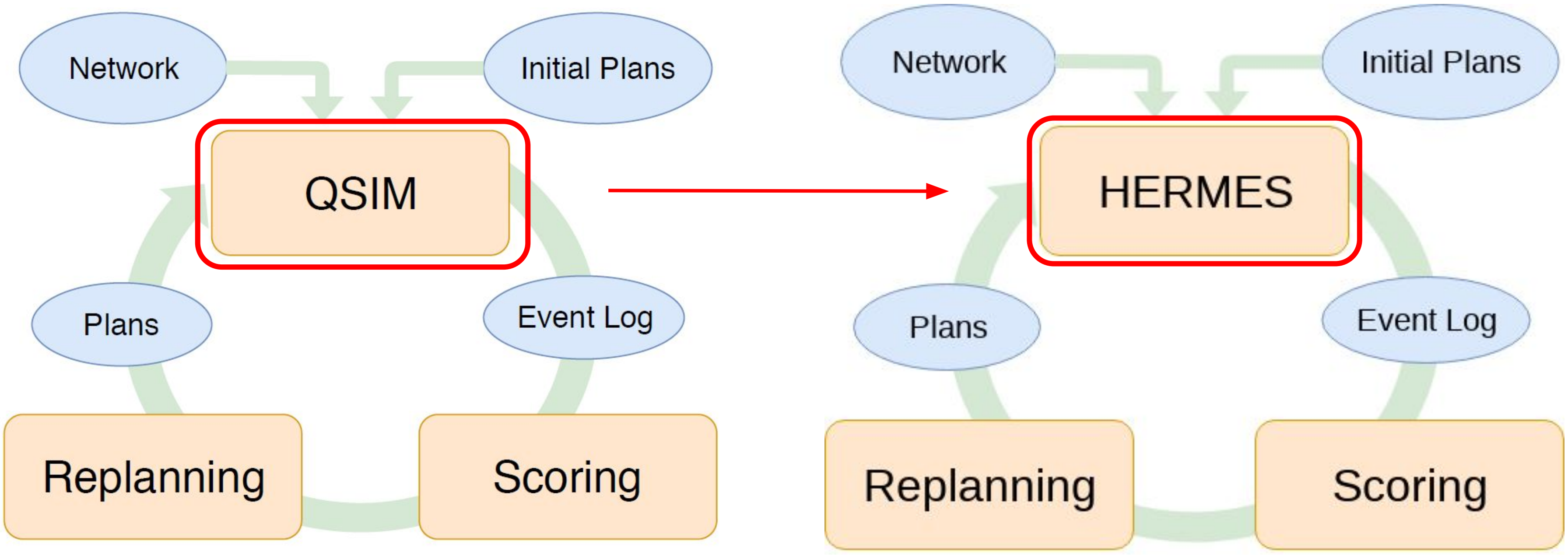
~= 10 * 1,000 * 1,076 / 86,400

~= **116 days**

High pERformance Multi-mode transport nEtwork Simulation



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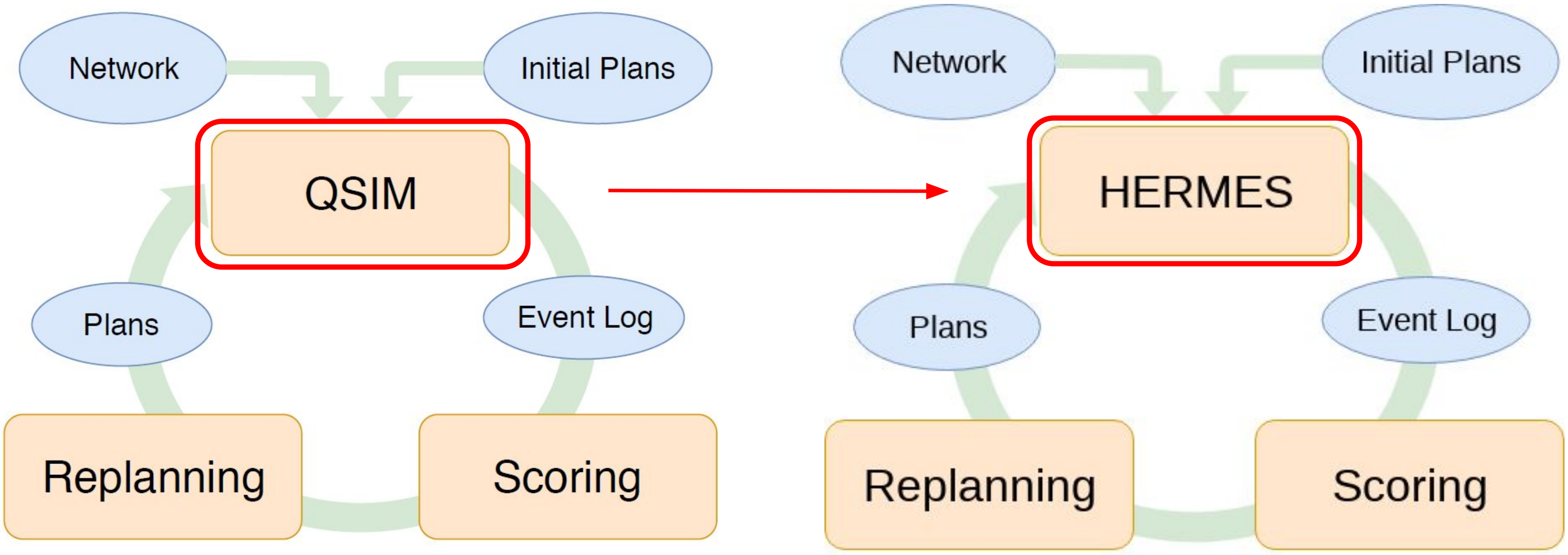


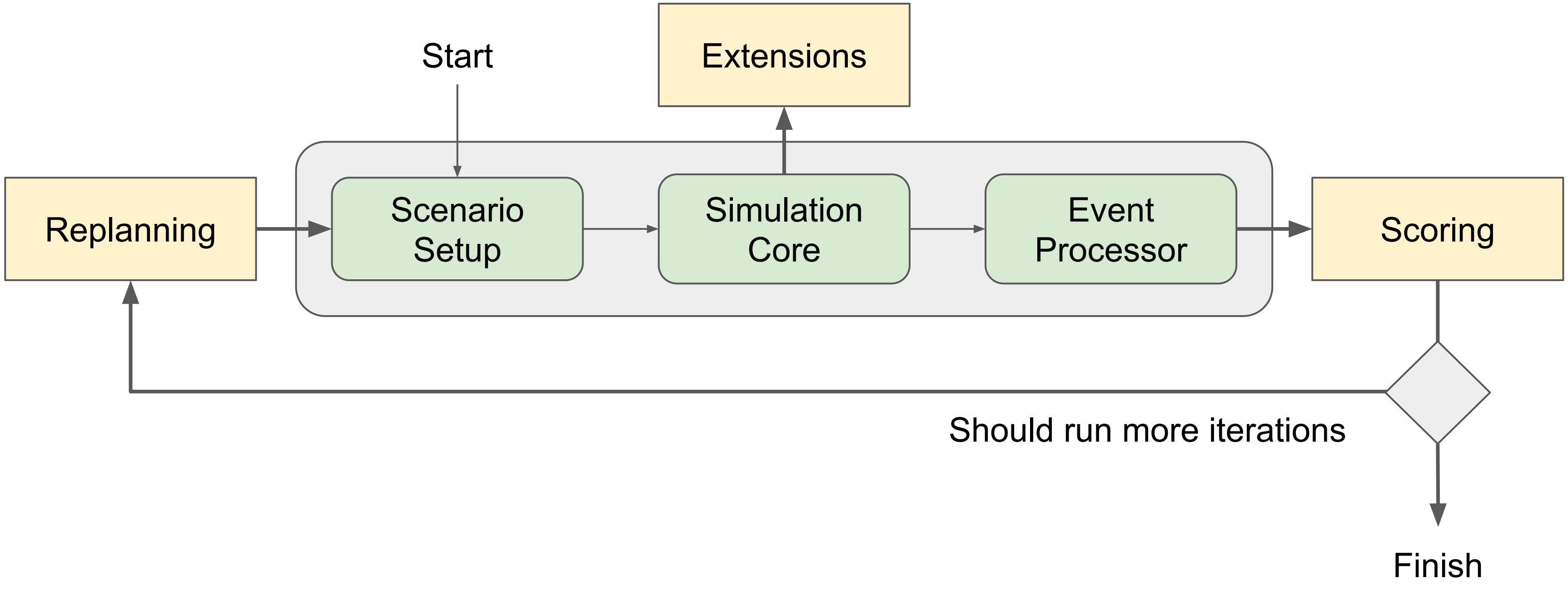
Goal: Faster end-to-end simulation for large scale scenarios!

HERMES - Design Principles

- **Event driven simulation**
  - simulation effort is proportional to the number of triggered events
  - HERMES reacts when something “happens” in the network (similar to Charypar et al.)

- **Optimize for the Common Case**
  - Very optimized fast-path for the common/standard simulation features
  - Non-standard features execute outside the optimized core
    - Easy to extend

HERMES - Architecture



Scenario Setup (MATSim to HERMES)

- **Data is compressed as much as possible**
  - No String identifiers -> only 32 bit integers
  - Plan is an array of 64 bit values that encode a network interaction

- **Data is stored to avoid multiple hops in memory**
  - No use of lists and limited use of maps
  - Algorithms are designed to use only identifiers and other pre-computed values

- **Data structures are only built once (first iteration)**
  - Further iterations only update the plans

Core Simulation Algorithm (HERMES)

Algorithm 1 Hermes Simulation Algorithm

```
procedure SIMULATE
    for step in iteration do
        for agent in delayed_agents(step) do
            Process_Agent(agent)
        for link in delayed_links(step) do
            Process_Link(link)
procedure PROCESS_AGENT(agent)
    switch agent.plan.top do
        case leg
            // handle agent leg, push to link
        case activity
            // handle agent activity, add to delayed_agents
        case pt
            // handle public transport interaction
        case default
            // call extension code to process plan entry
procedure PROCESS_LINK(link)
    while can_process_agent(link.top) do
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Event-driven

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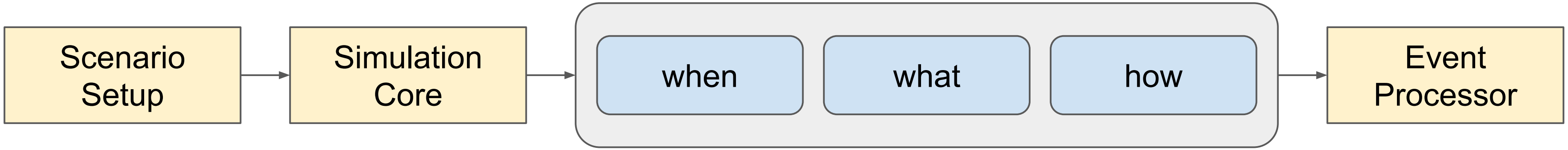
Time of the next activation is calculated for links and agents

Event Generation (HERMES to MATSim)



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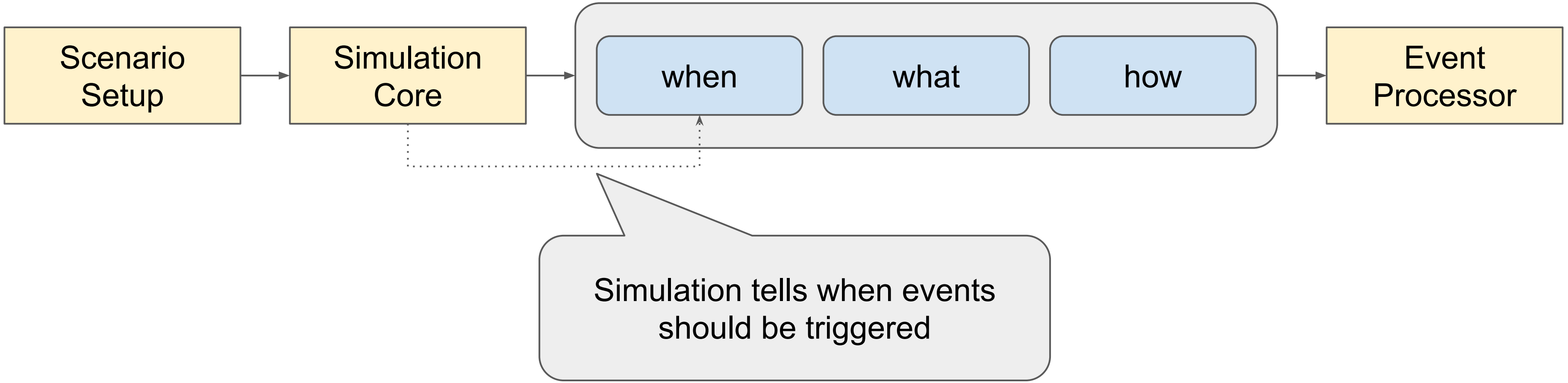

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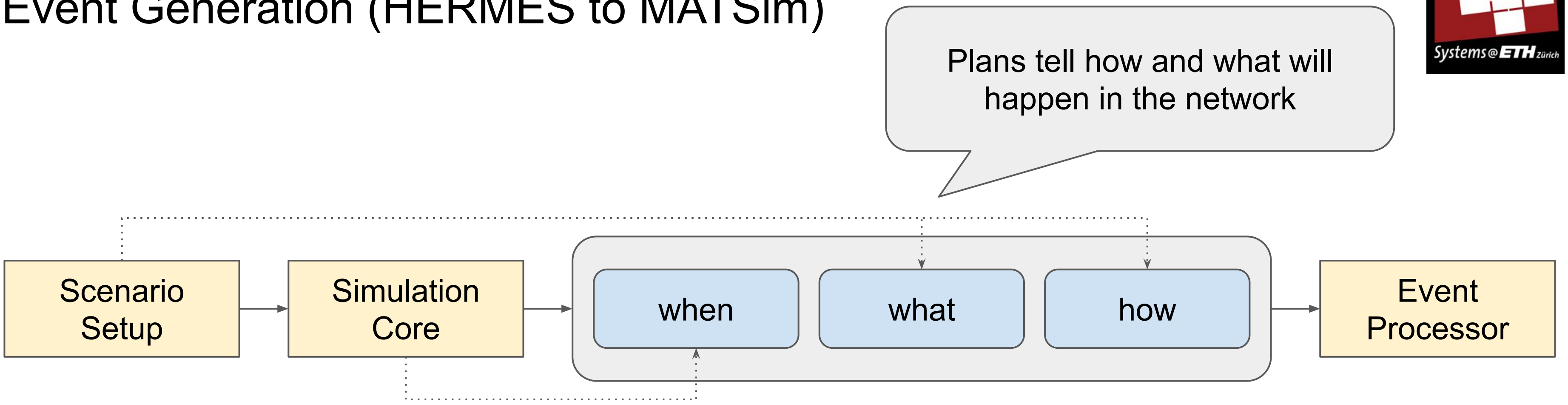

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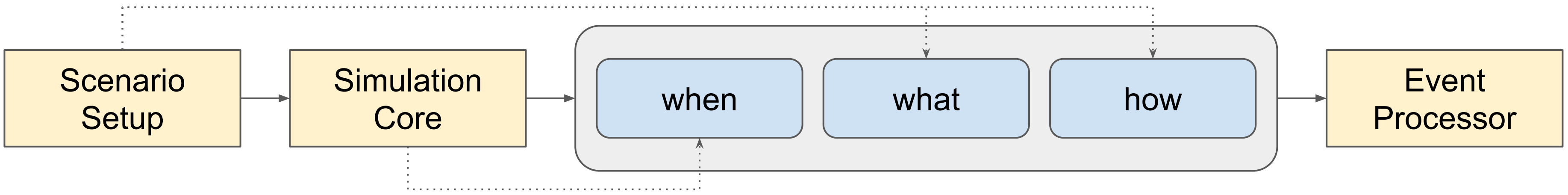
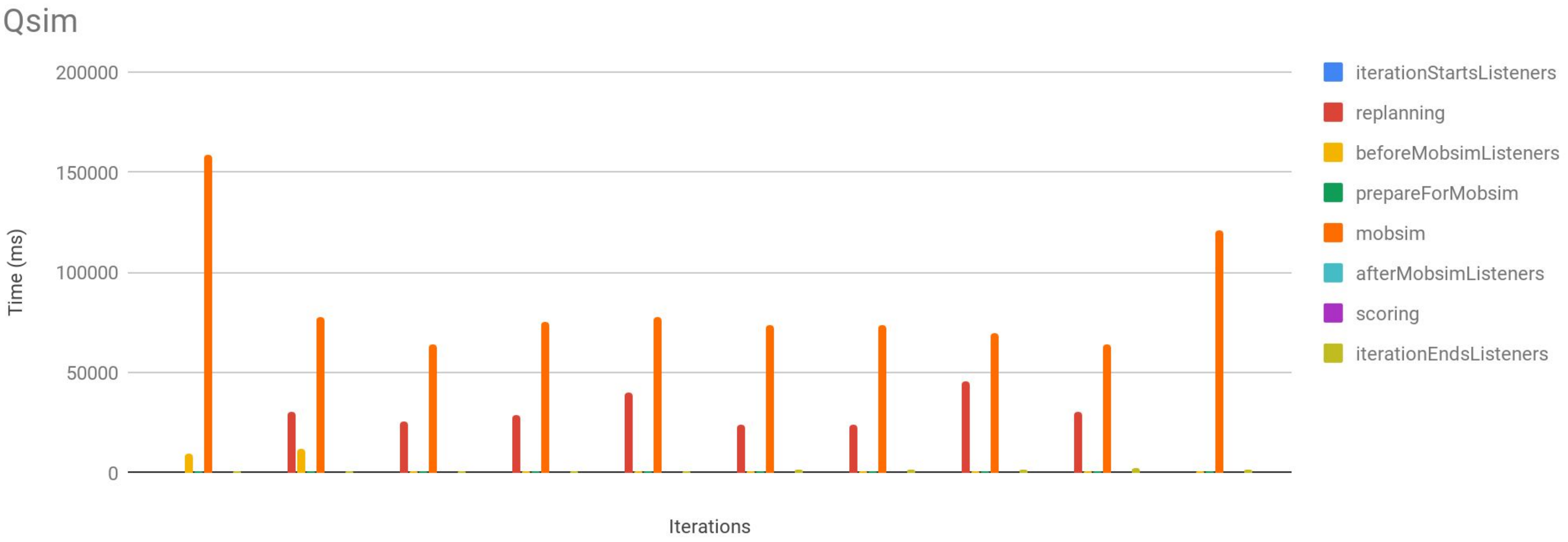


Events are pre-generated at Scenario Setup. Simulation only tags the time.

Performance Analysis (Berlin 1%)



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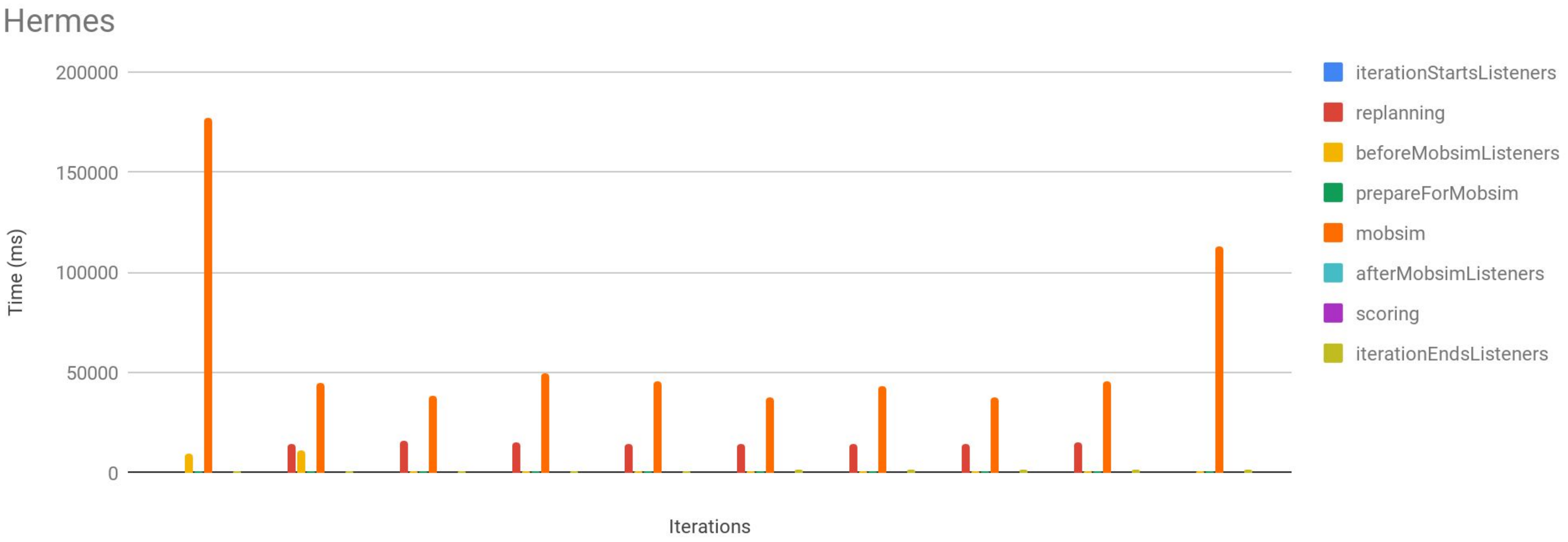

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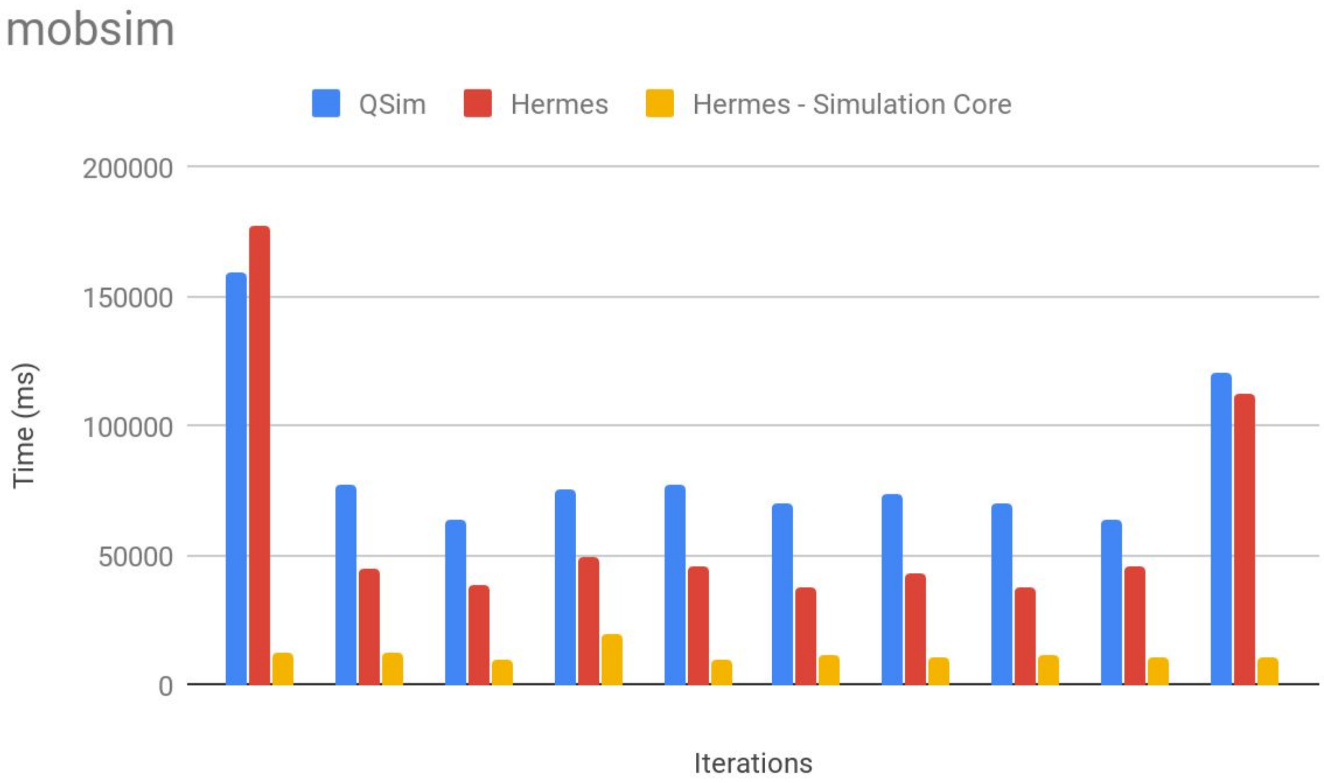

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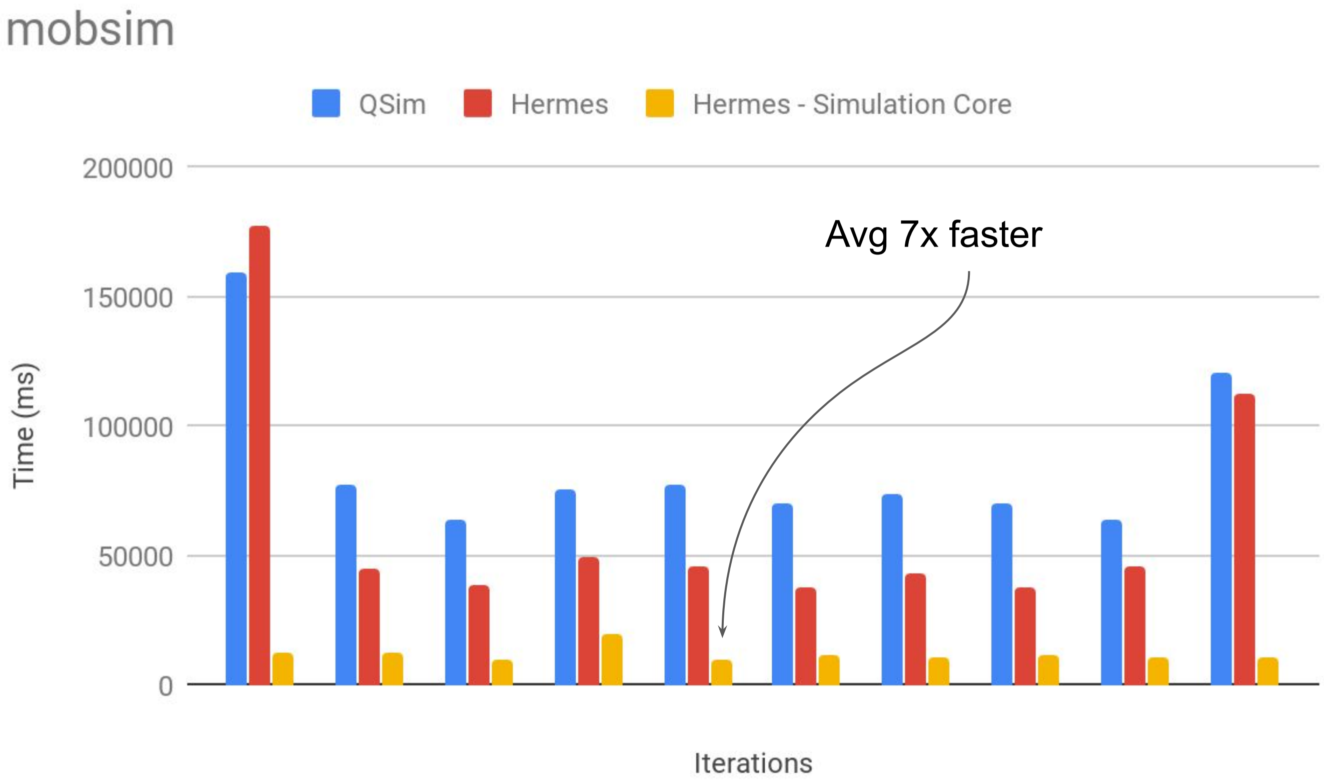

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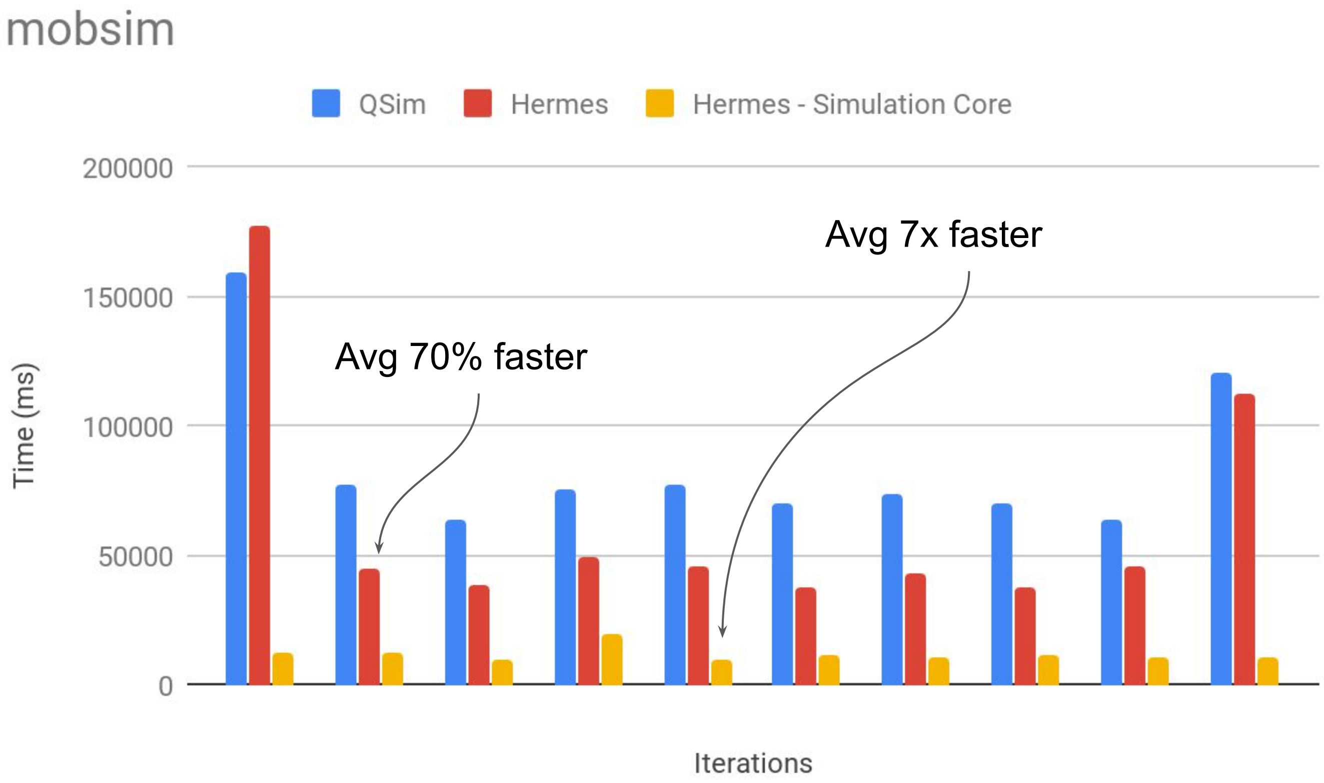

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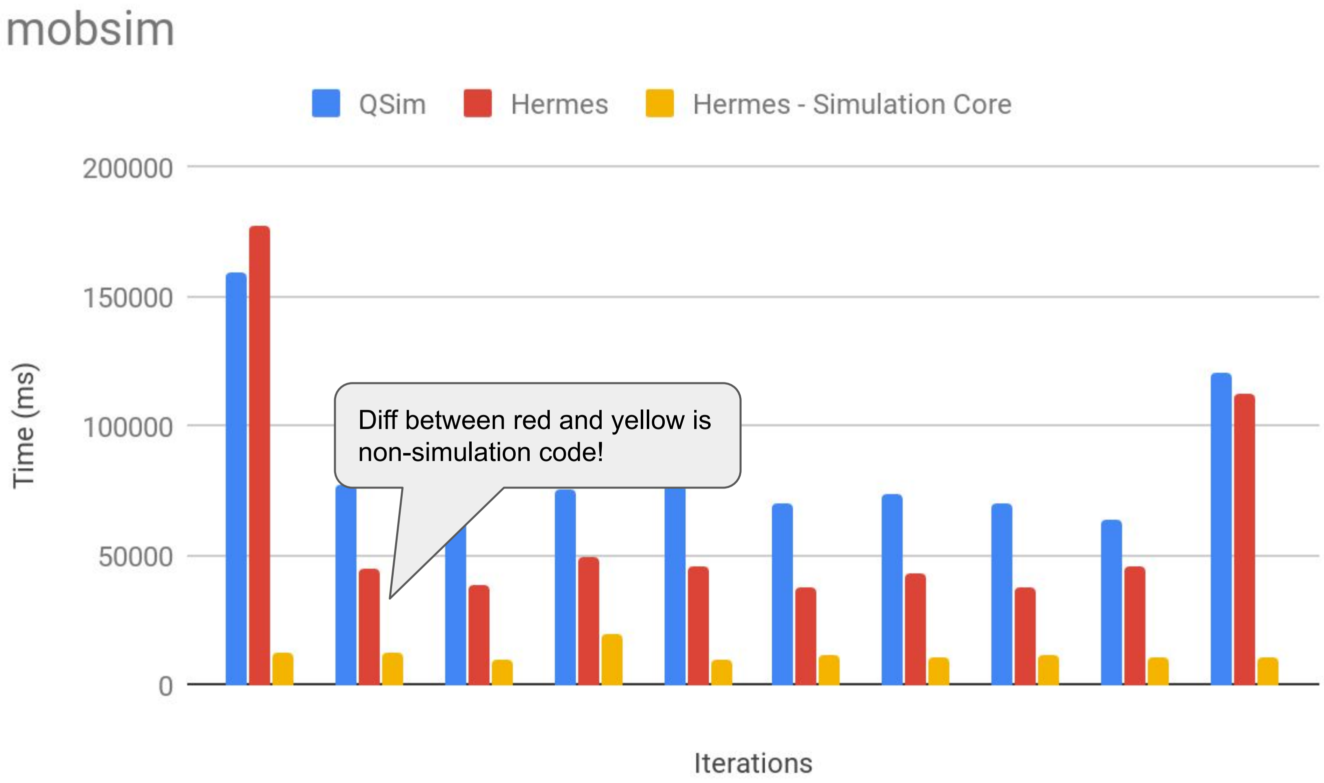

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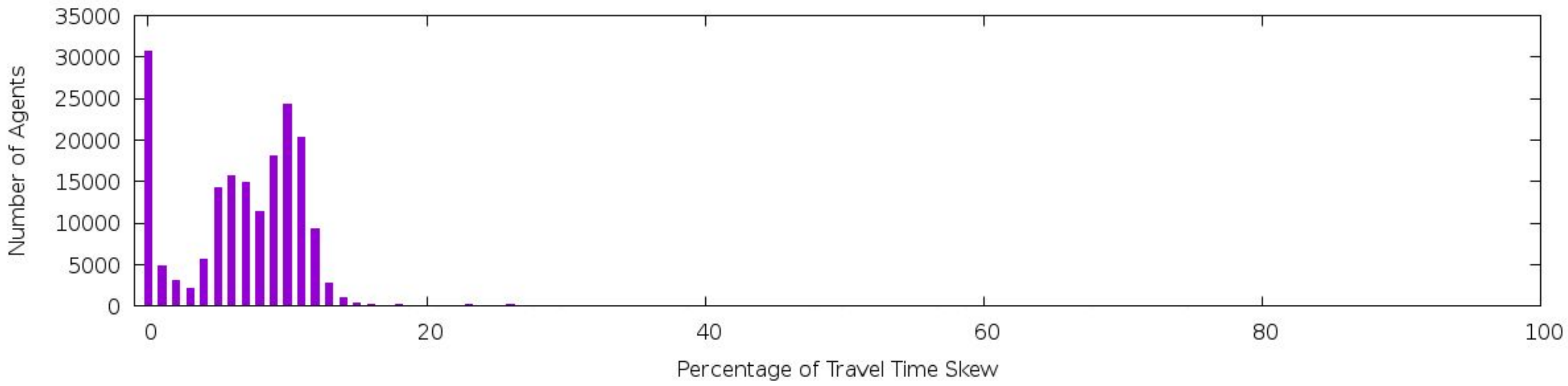

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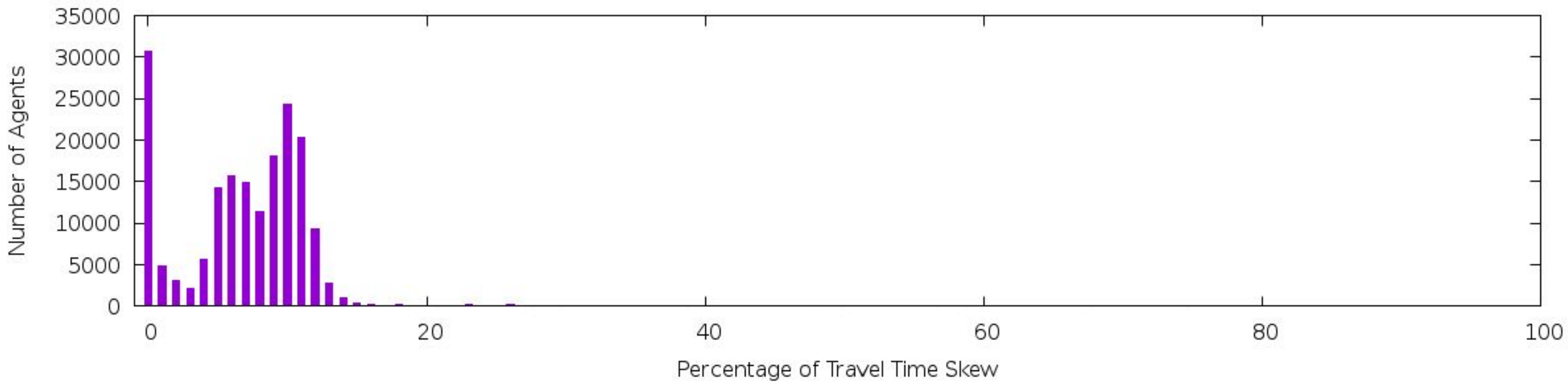

Reasons for high skew include (WIP):

- Using integers instead of doubles
- Not waiting for the time of departure
- ...

Performance Analysis

- Multithreaded implementation of Hermes is currently WIP

- Insight so far:
  - After making single-threaded version very efficient
    - synchronization becomes bottleneck quickly
  - Four ways to deal with this:
    - More work (100% scenario, more features)
    - Larger timesteps (tradeoff between error and performance, analysis required)
    - Keep improving workload-balancing, synching overhead
    - Relax synchronization for tbd. time windows (hard, can be research project)

Conclusions

- Hermes is a new simulator for MATSim
- Implementing HPC systems is hard
  - Requires constant re-evaluation and potential redesign to cope with new data/workloads
- The performance delta we see vs. QSIM motivates redesign
- Significant work to fully integrate, but not detrimental to success

Next Steps

- Improve MATSim event processing
- Keep implementing features and validating Hermes
- Propose improvements for faster event processing
- Ensemble runs
- Experiment with larger scenarios
    - HPC requires data - algorithms & data structures - hardware

Try Hermes

```
$> git clone https://github.com/muellermichel/matsim
$> cd matsim
$> git checkout hermes
$> ./Build.sh
$> ./Run.sh
```

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webpage: rodrigo-bruno.github.io