A Scalable Data-Driven Agent-Based Model for Simulating the COVID-19 Pandemic

Implementation and parallelization for an agent-based model with realistic reproduction of human mobility and contact behavior

sascha.korf@dlr.de

Sascha Korf*, David Kerkmann†, Khoa Nguyen†, Daniel Abele*, Alain Schengen‡, Carlotta Gerstein*, Jens-Henrik Göbbert§, Achim Basermann*, Martin J. Kühn*, Michael Meyer-Hermann†

*Institute for Software Technology, Department of High-Performance Computing, German Aerospace Center, Cologne, Germany †Helmholtz Centre for Infection Research, Brunswick, Germany ‡Institute of Transport Research, German Aerospace Center, Cologne, Germany §Jülich Supercomputing Centre, Forschungszentrum Jülich, Jülich, Germany

MEmilio Repository

Background

- Agent-based models offer great customizability and can model a pandemic setting in great detail [1]
- A fine time resolution and large populations can lead to computationally expensive simulations

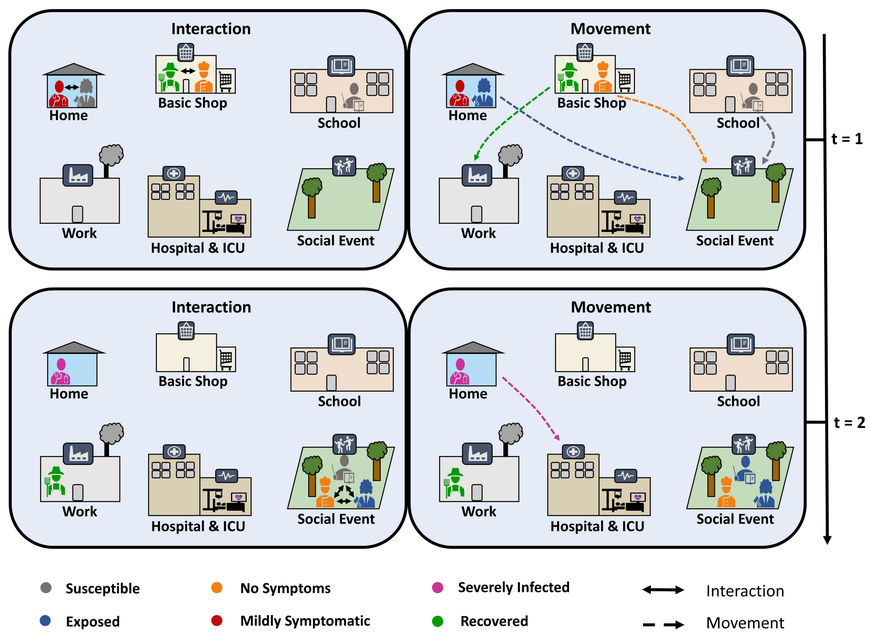
Methods

- Mobility-based agent-based model with households, schools, workplaces and other locations
- Shared memory parallelization for single simulation runs
- Shared and distributed memory parallelization for multiple simultaneous simulation runs

Overview of the Model

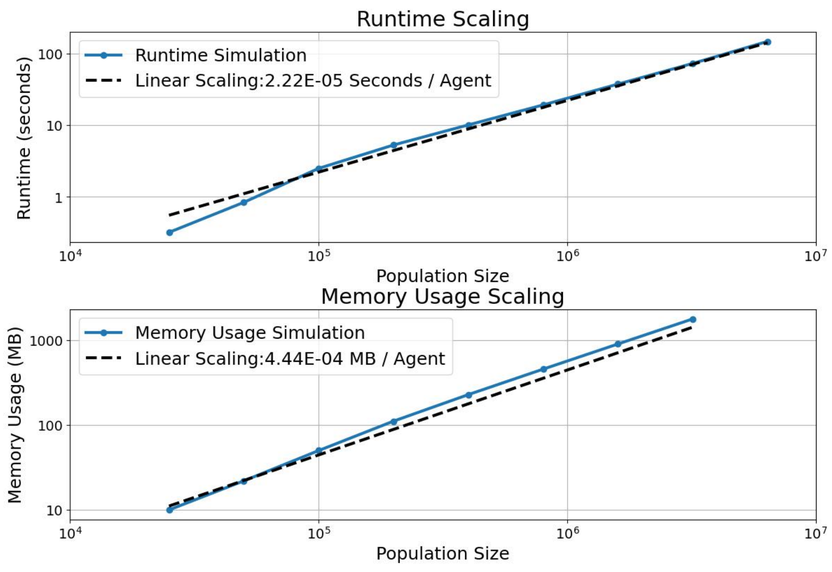
Algorithm 1: Trip-based agent-based simulation

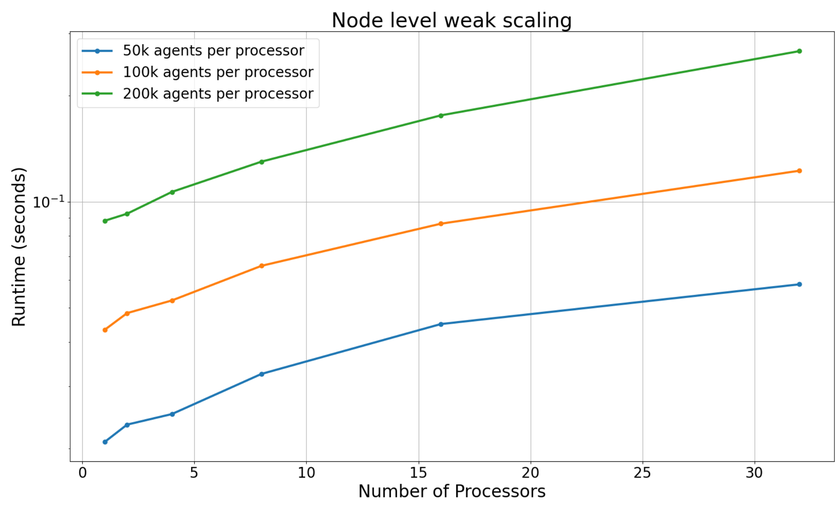
```
t ← t_0 ∈ ℝ
while t ≤ t_max do
    for each location [parallel] do
        Cache exposure rate of location
    for each agent [parallel] do
        Execute individual interactions
    for each agent [parallel with synchronization] do
        Perform individual movement
    t ← t + Δt
```



Results

- Benchmark results based on representative simulations for different amount of agents
- Left: Runtime and memory scaling with 8 threads on a single node
- Right: Node-level weak scaling





- Multiple simulation runs were parallelized on an inter-node level in a recent preprint (in order to parametrize the model parameters to real-world data)
- For this we ran up to 2592 concurrent simulation runs on 27 nodes with each 128 cores
- This allowed us to run 85 536 simulation runs in under eight hours

Our Recent Preprint [2]

REFERENCES

1. Willem, L. *et al.* Optimizing agent-based transmission models for infectious diseases. *BMC Bioinformatics* **16** (June 2015).
2. Kerkmann, D. *et al.* *Agent-based modeling for realistic reproduction of human mobility and contact behavior to evaluate test and isolation strategies in epidemic infectious disease spread.* 2024.