Parallel Agent Based Models

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Outline

- Motivation
- Pedantic Background
- Examples
- Physics Models & Domain Decomposition
- Next Steps

Motivation

- Original Research Question:

  Can we efficiently increase the number of agents in a simulation ?

Motivation

- Original Research Question:

  Can we efficiently increase the number of agents in a simulation ?

- Reformulation:

  What are the (dynamical) effects of scaling the number of agents and/or domain size in a simulation?

Background

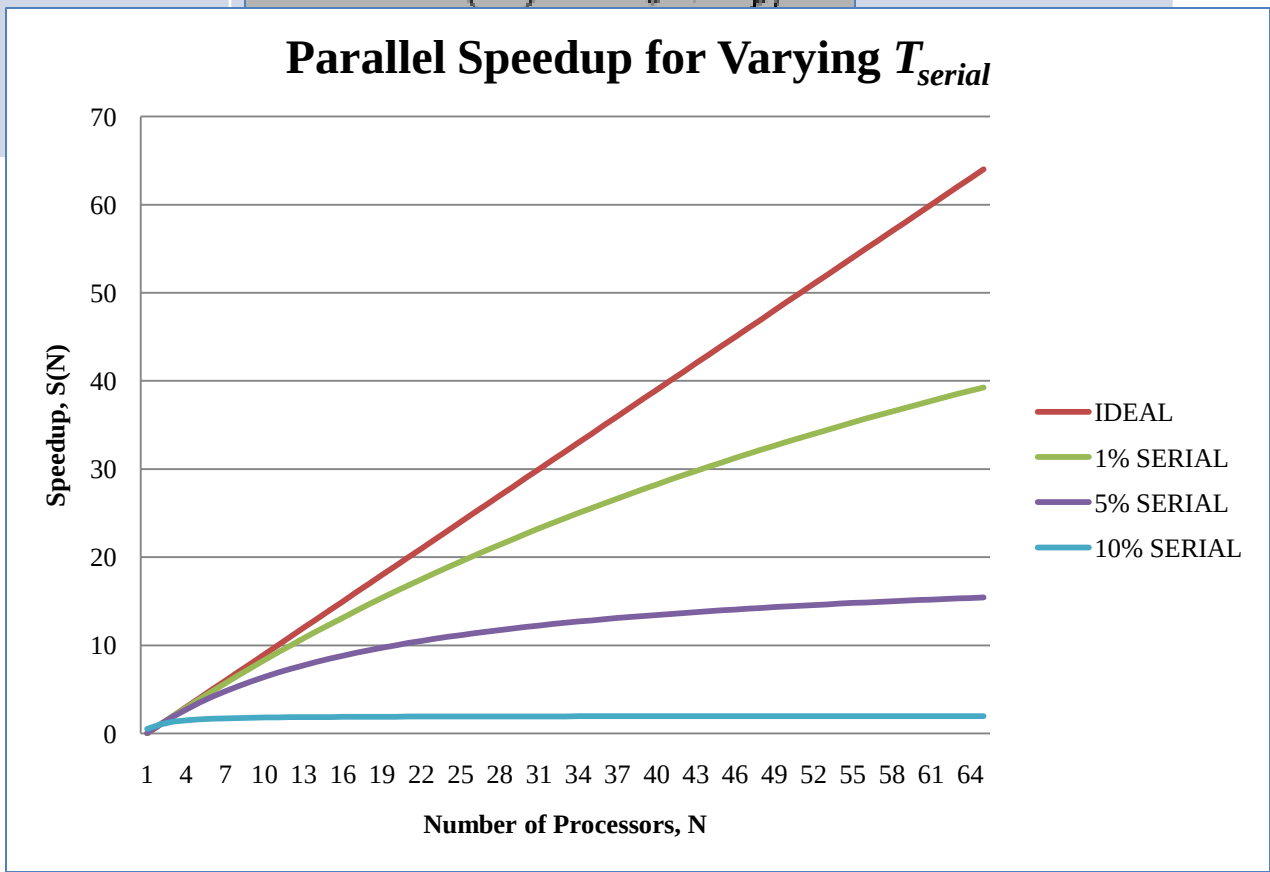
Parallelizing a model

- **Decompose model into Independent Processes**
- Distribute the Processes to Parallel Processors
- Execute a time step(s)
- Amalgamate Results
- …

Amdahl's Law

Time to execute = *Tserial* + *Tparallel*,
Speedup on N processors = S(N

$$S(N) = \frac{T(1)}{T(N)} = \frac{T_s + T_p}{T_s + T_p/N}.$$



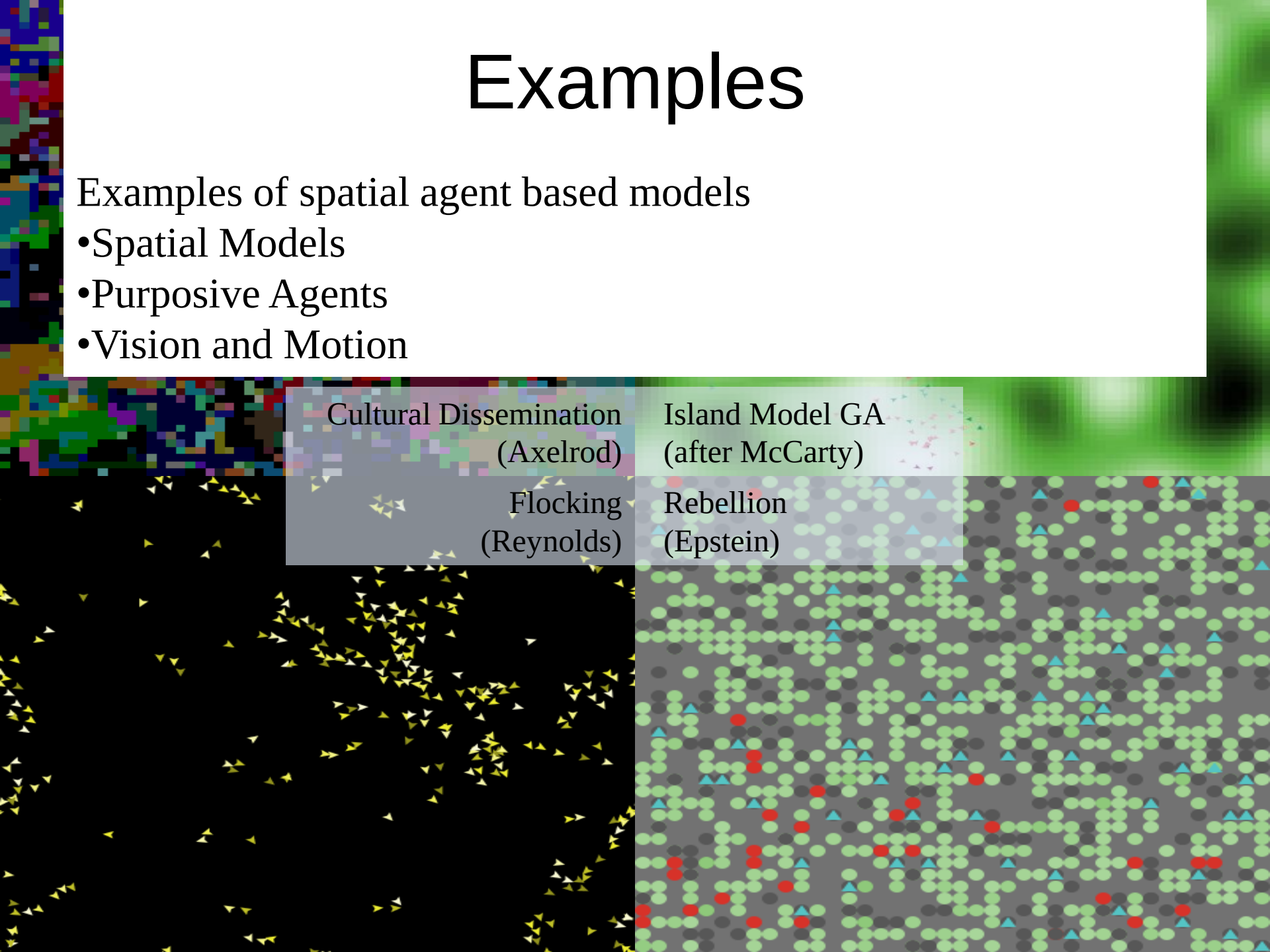
Examples

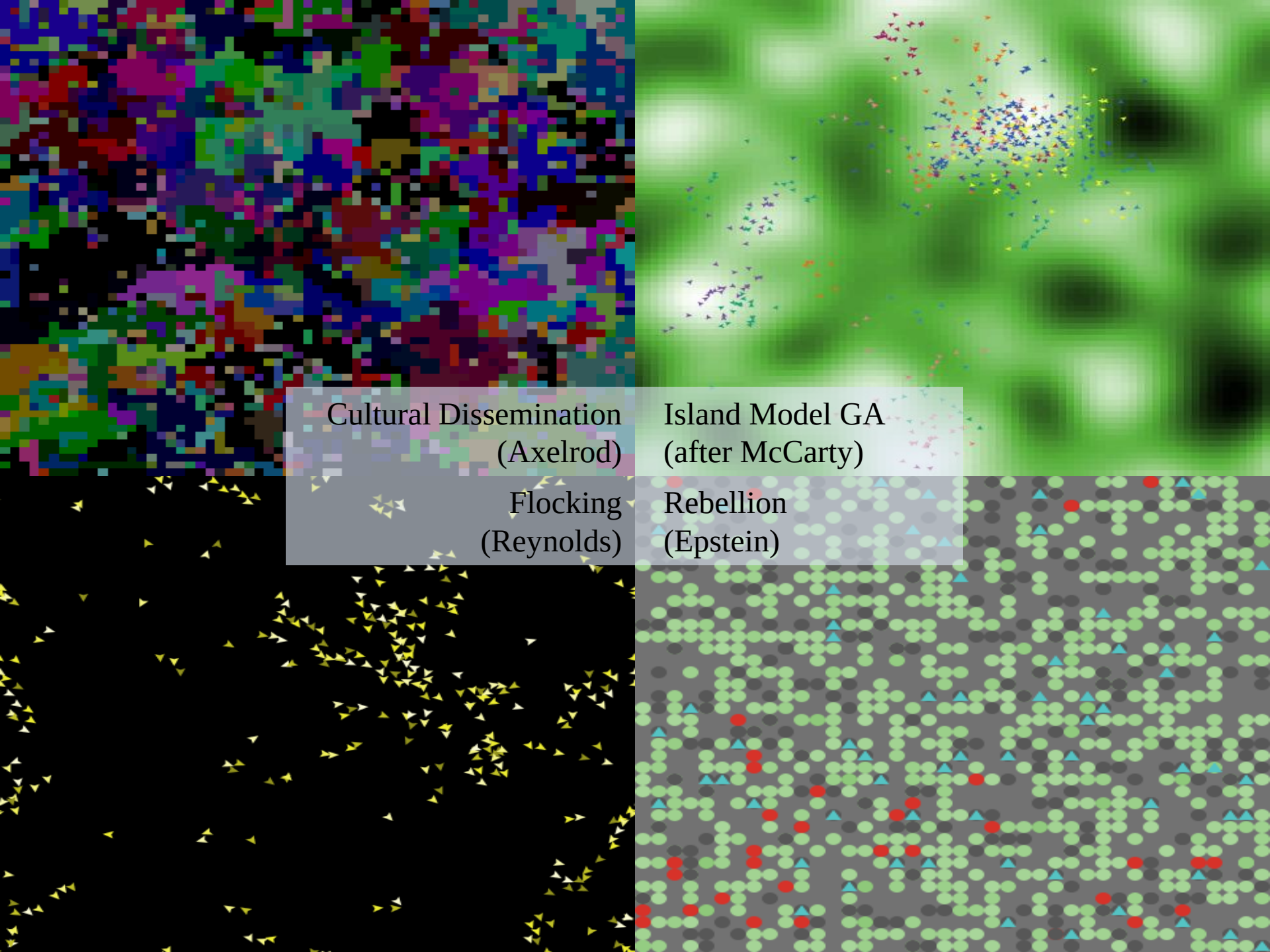
- Examples of spatial agent based models
- Some examples used in government and industry

Examples

Examples of spatial agent based models

- Spatial Models
- Purposive Agents
- Vision and Motion



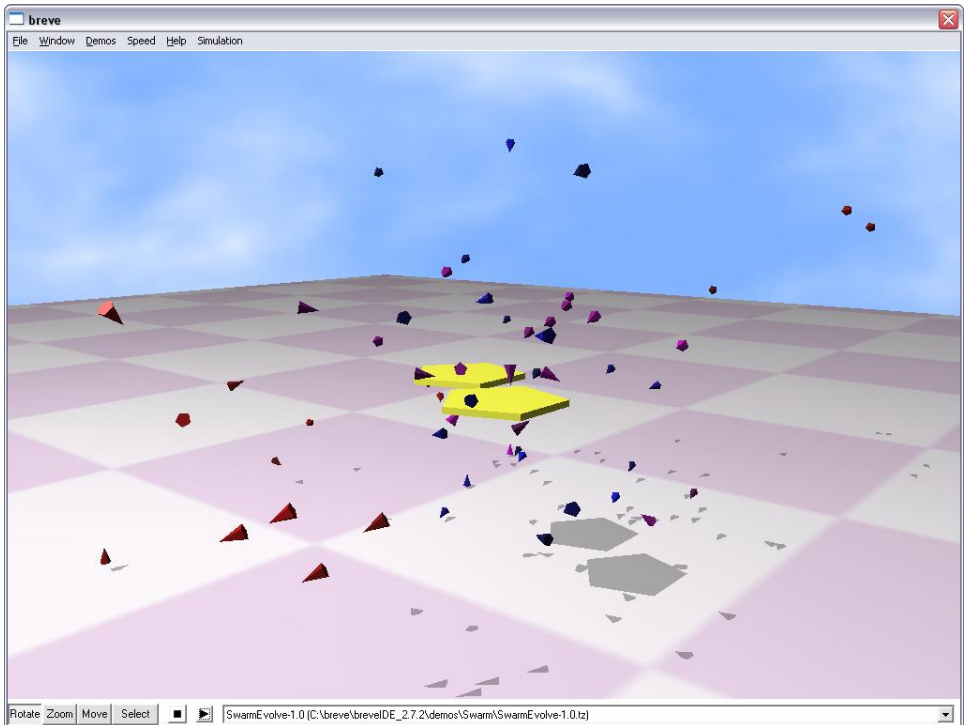

Cultural Dissemination
(Axelrod)
Island Model GA
(after McCarty)
Flocking
(Reynolds)
Rebellion
(Epstein)

Examples

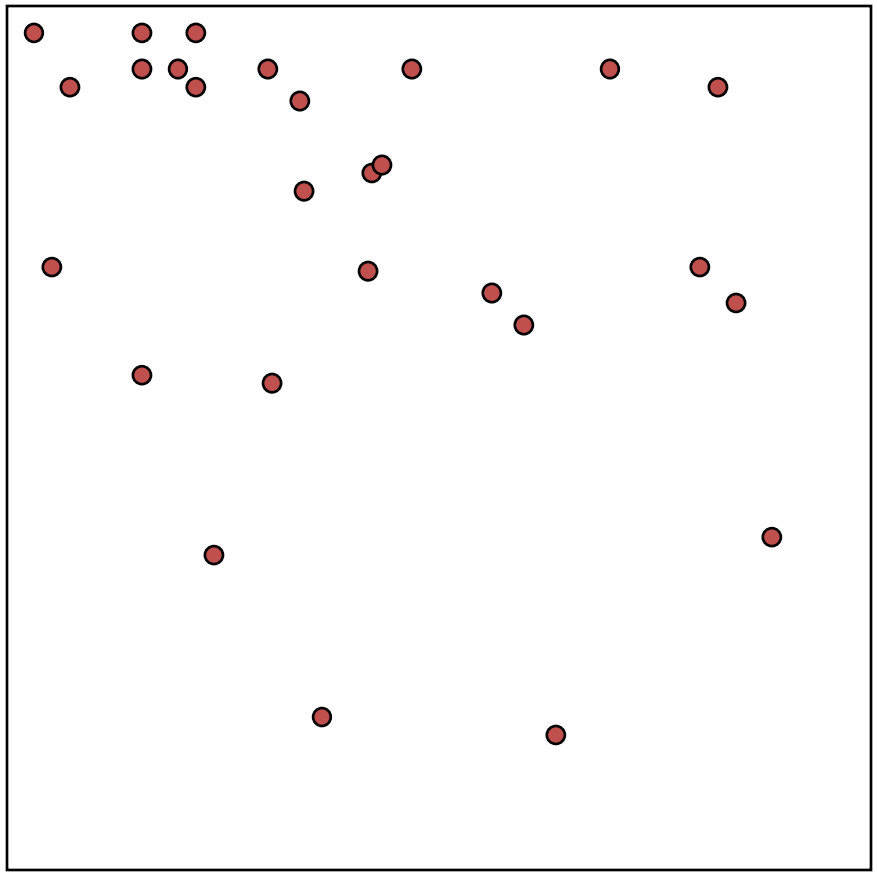
Examples used in government and industry

- IRS—taxation models
- FAA—national airspace models
- Very large scale geographic models

- "3d" physics simulations and game engines

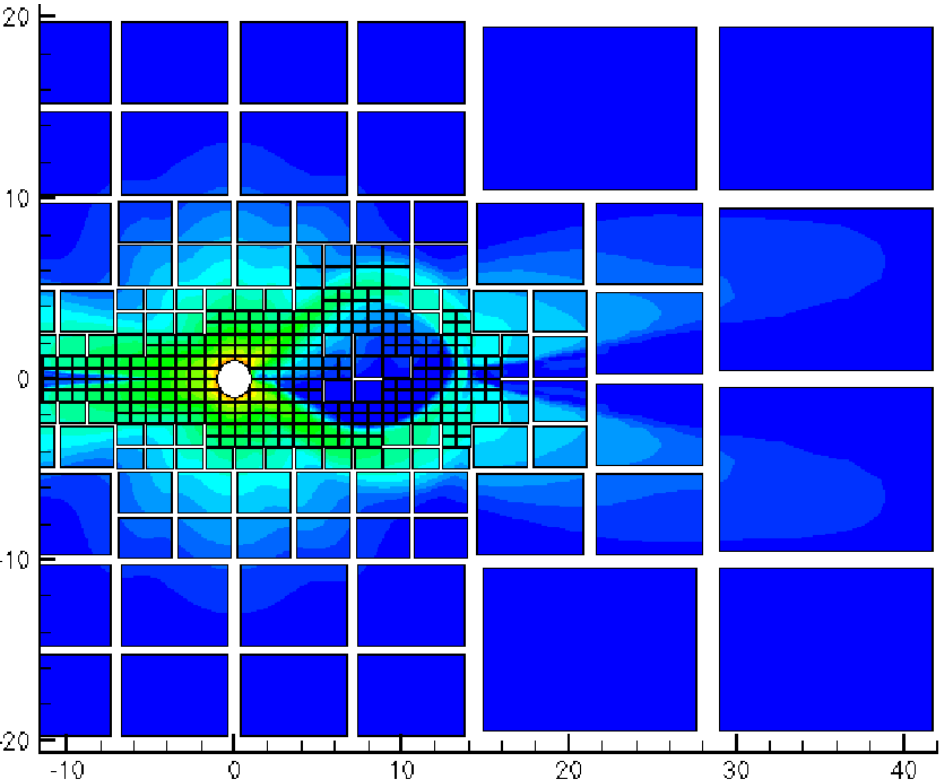


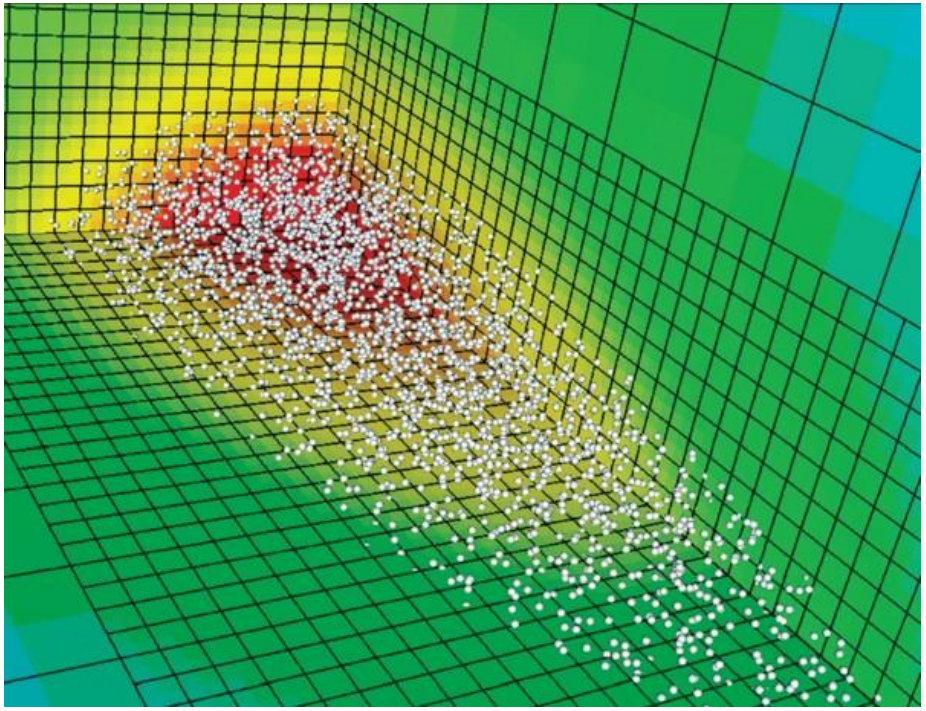
Domain Decomposition



Particle Dynamics Simulations

- NASA's PARAMESH toolkit

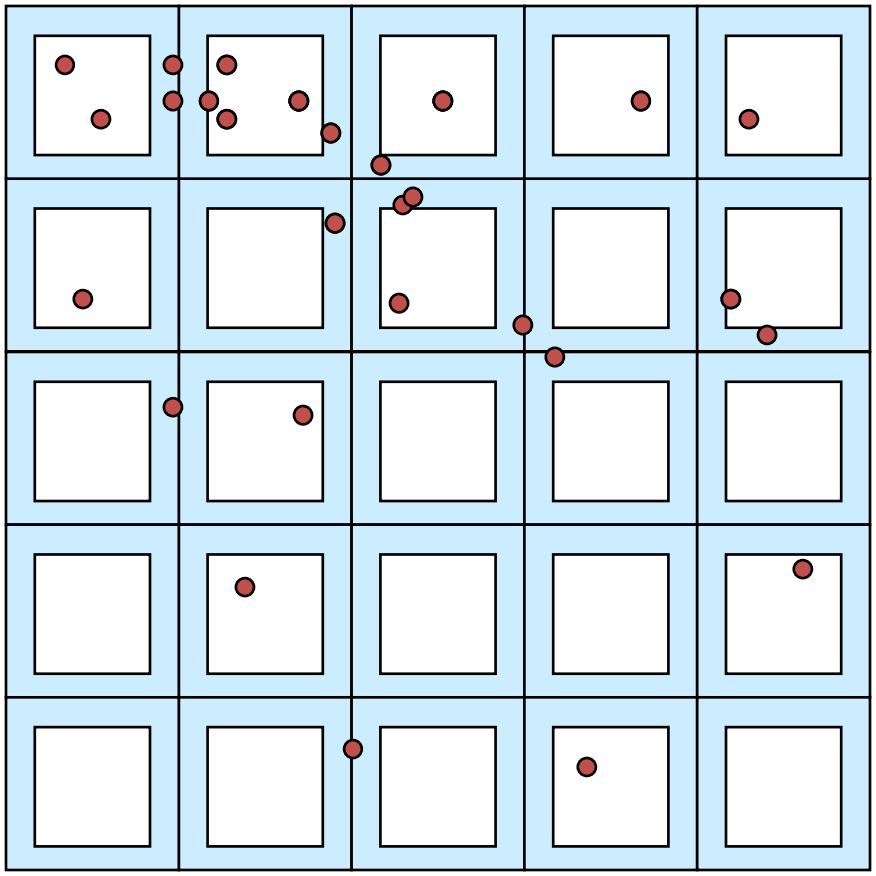


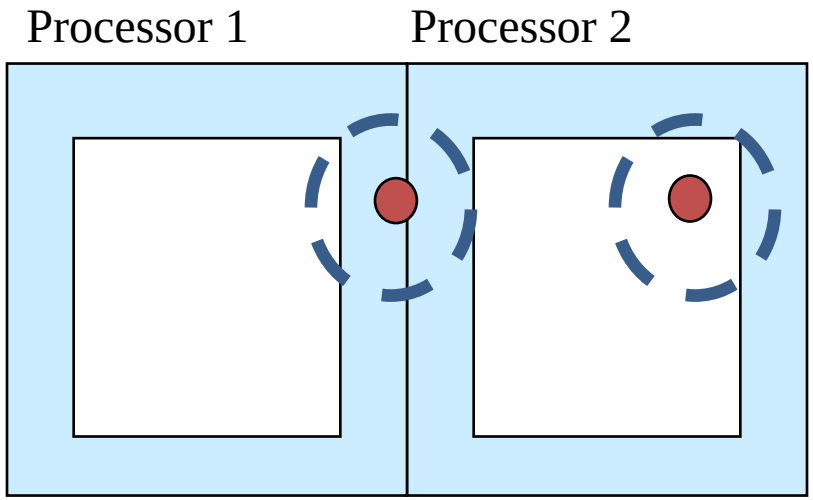


Particle-in-cell (PIC) calculation

Coronal mass ejection

Domain Decomposition

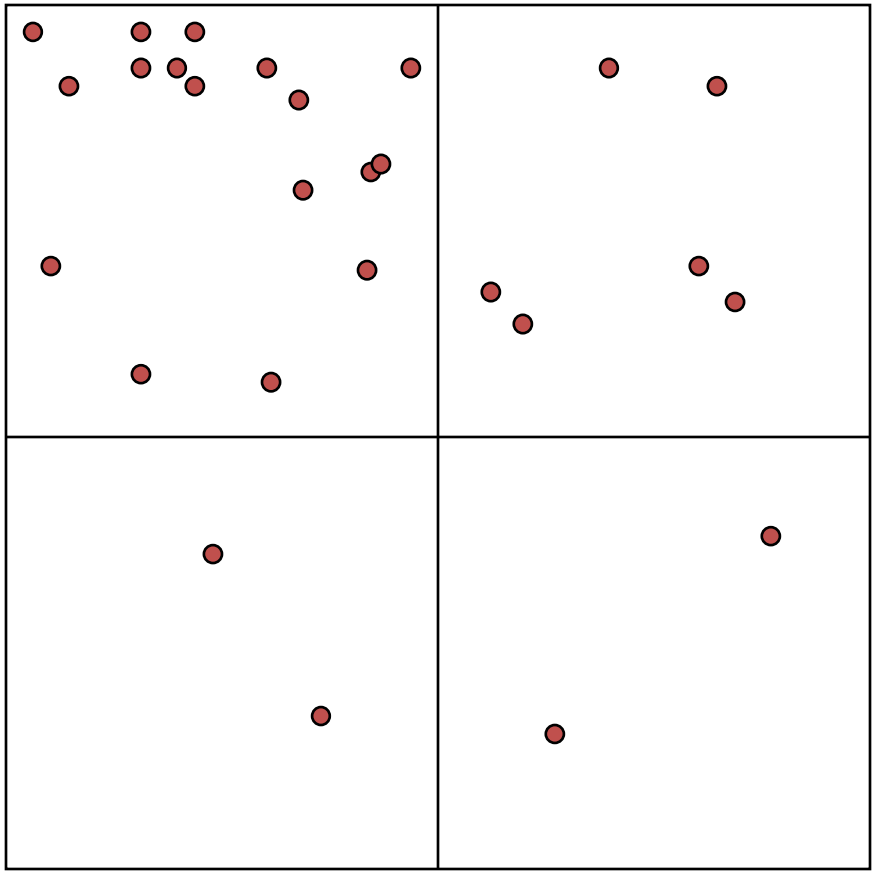




For agents in a spatial domain:

- Subdivide the spatial domain into a mesh
- Implement enough overlap to enable dealing with boundary conditions (i.e. vision)

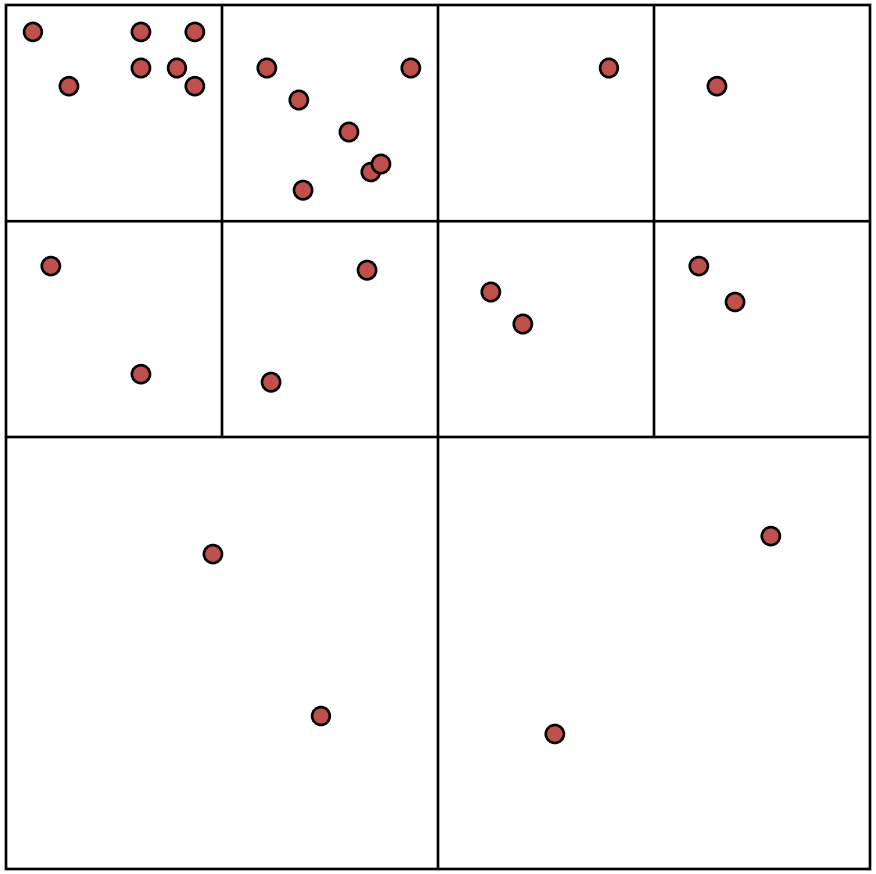
Load Balancing—Quad Tree



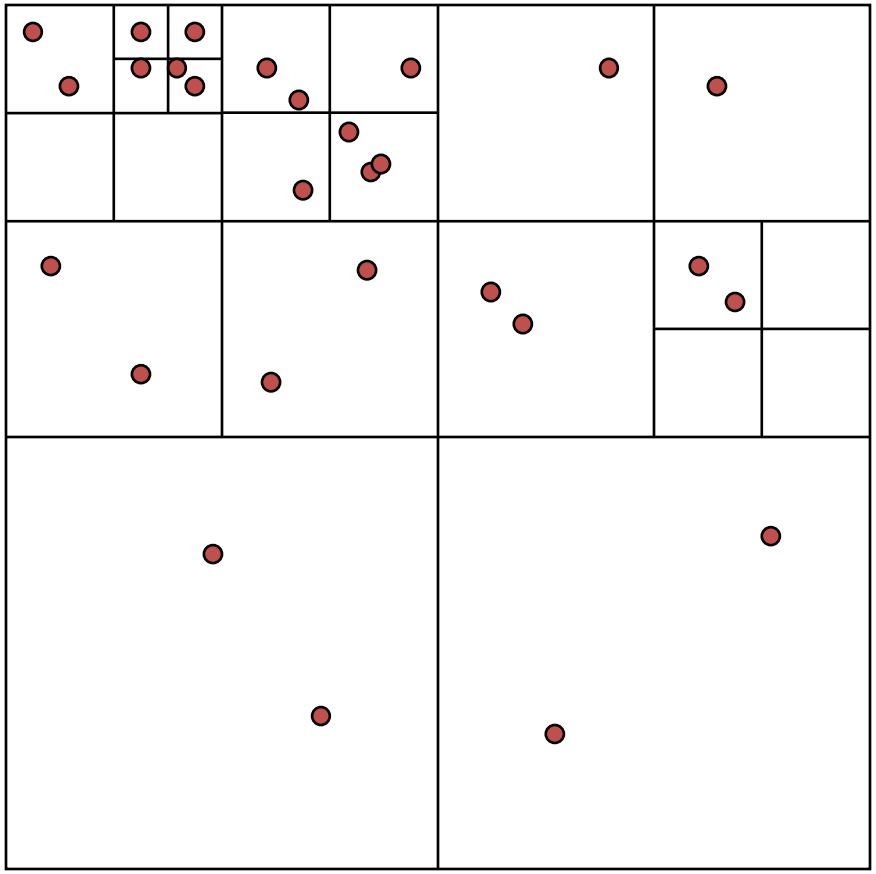
For non-uniformly distributed agents in a spatial domain:

- Successively subdivide into subdomains
- Goal is equal density per subdomain

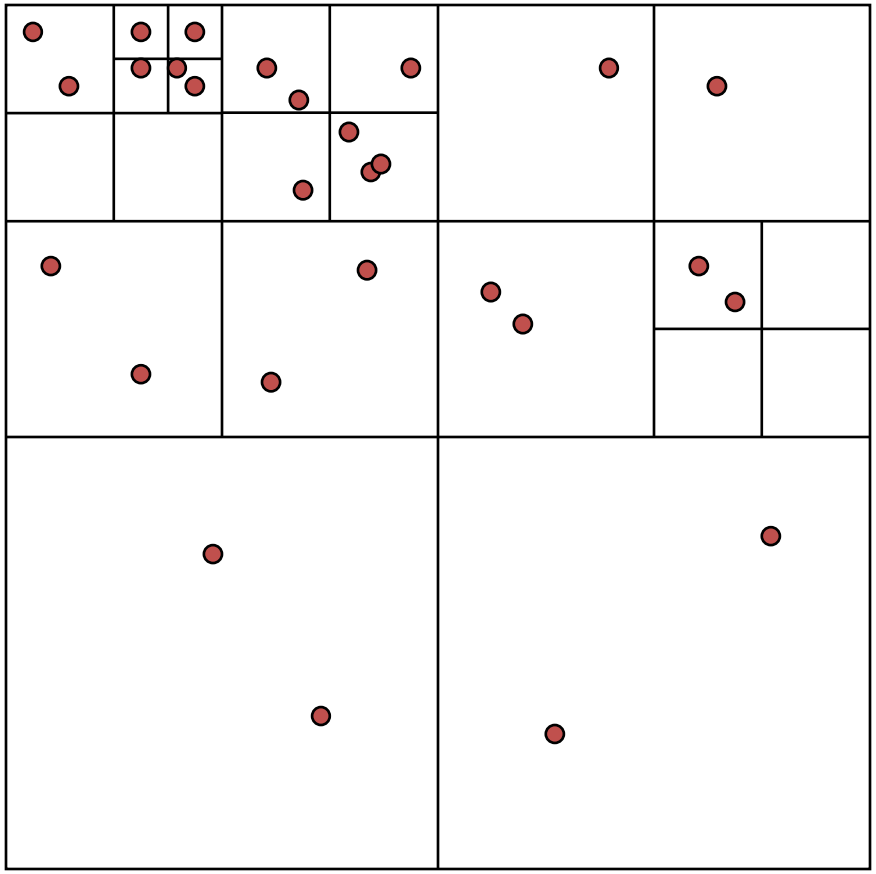
Load Balancing—Quad Tree



Load Balancing—Quad Tree

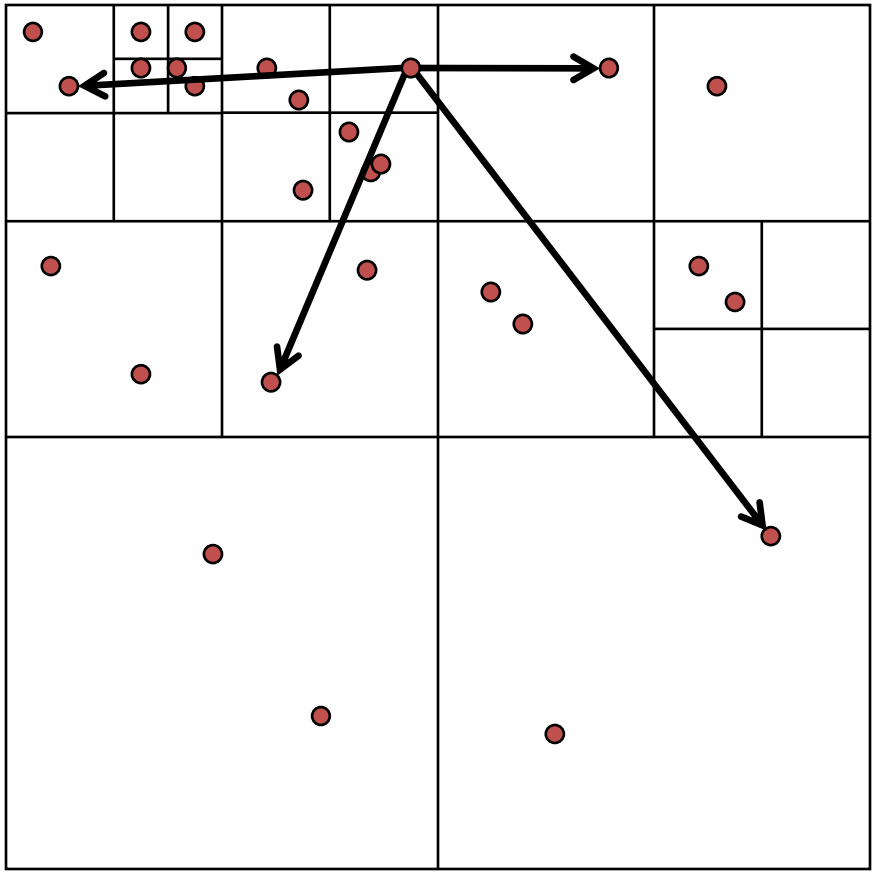


Next Steps



- Deploy to a cluster computer
  - Determine best approaches to AMR
  - Distributed versus centralized

Next Steps



- Deploy to a cluster computer
  - Determine best approaches to AMR
  - Distributed versus centralized
- Investigate applying to other agent domains (e.g. networks)