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 = \( T_{\text{serial}} + T_{\text{parallel}} \),

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

**Parallel Speedup for Varying \( T_{\text{serial}} \)**

- IDEAL
- 1% SERIAL
- 5% SERIAL
- 10% SERIAL
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)
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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
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
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Next Steps

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