Cooperation Strategies in a Time-Stepped Simulation of Foraging Robots

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Liam McGuigan

- PhD Researcher at Ulster University
- Researching autonomic robotic swarms

- 11 years software engineering experience
- Interests include AI under real-time constraints

Swarm Robotics

- Large number of cooperating robots
- Cost effective
- Need to be scalable and flexible

Swarm Self-Adaptation

- Research categorised along two lines
- Most research focuses on agent behaviour adaptation
- Swarm-level strategic changes can help with collaboration

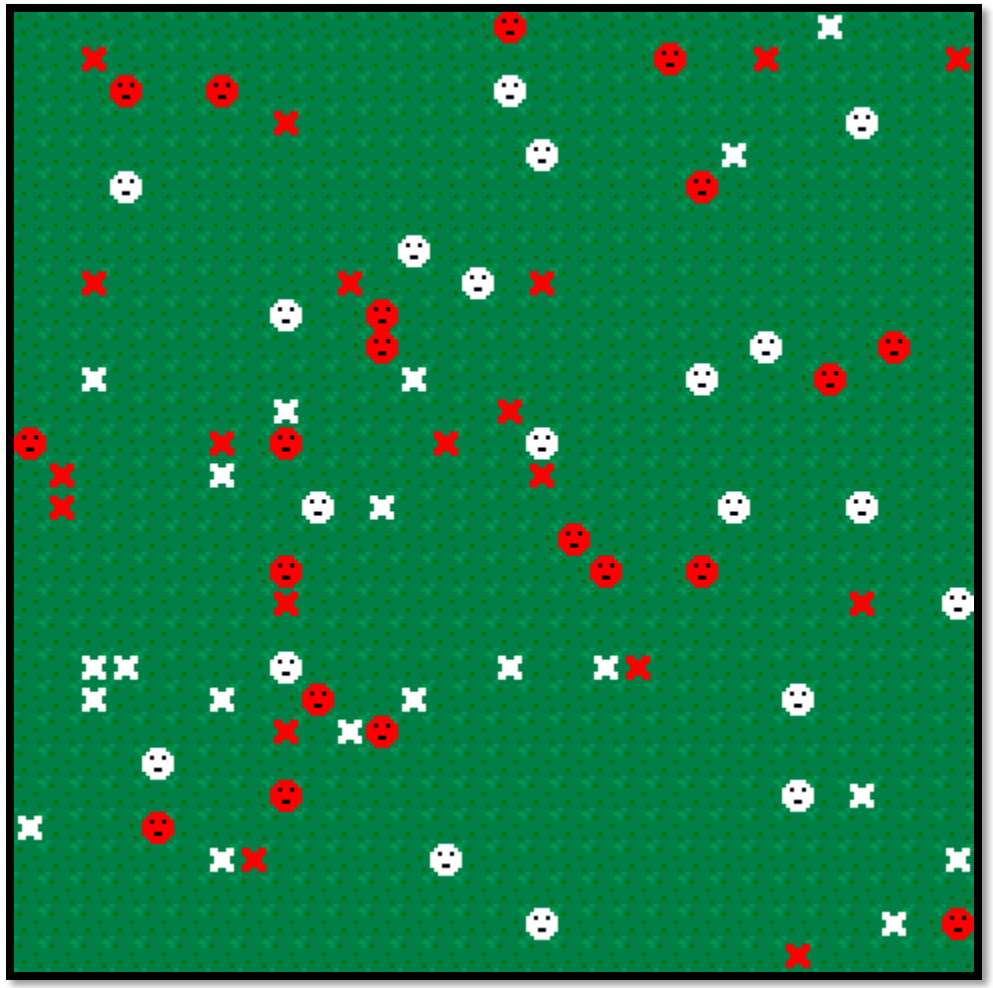
Objectives

- Potential for self-adaptation
- Embedded simulation approach

Cooperation in a Foraging Task

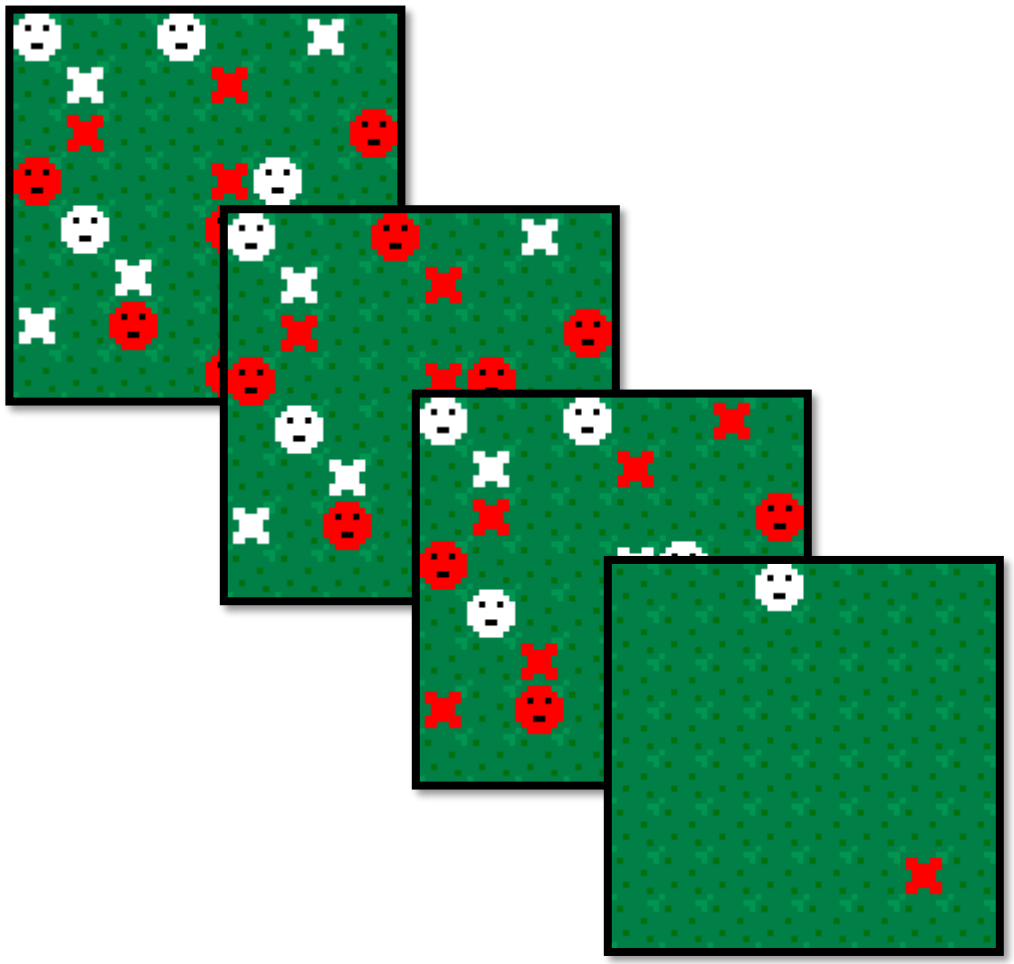
- Specialised robots must find and process items

- Three strategies compared:
  - Multiple responders
  - Selective responders
  - One responder



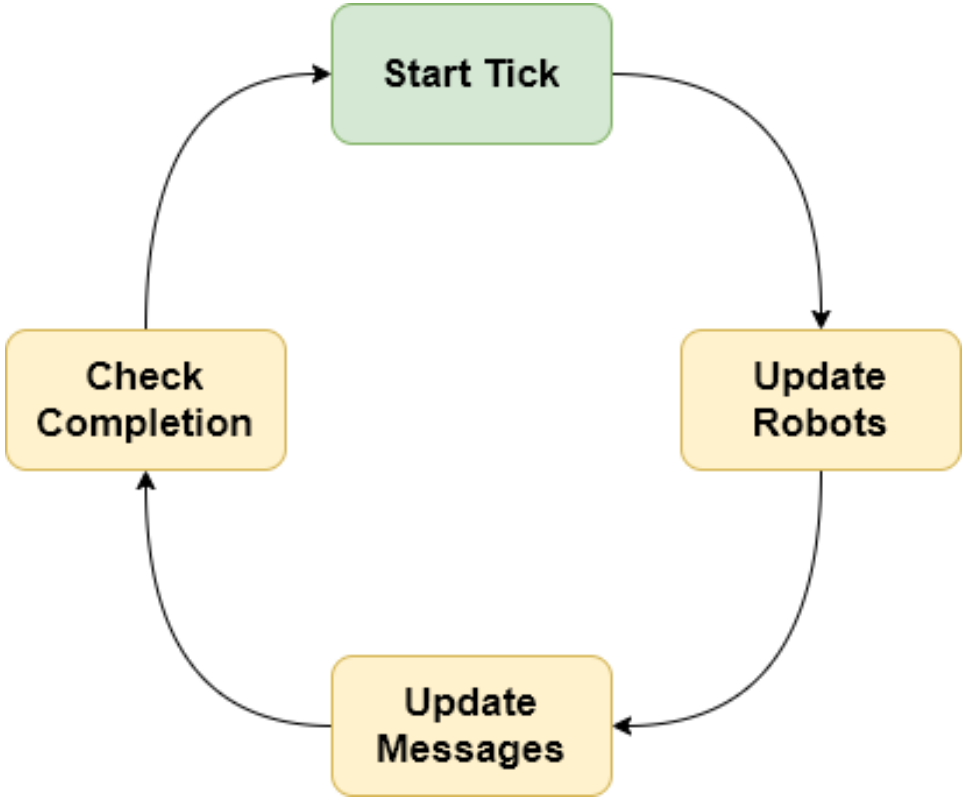
Test Scenarios

- 200 robots, 200 items:
  - Equal balance
  - Robot imbalance
  - Item imbalance
- Two map sizes:
  - 30x30
  - 90x90
- 30 runs per strategy and scenario



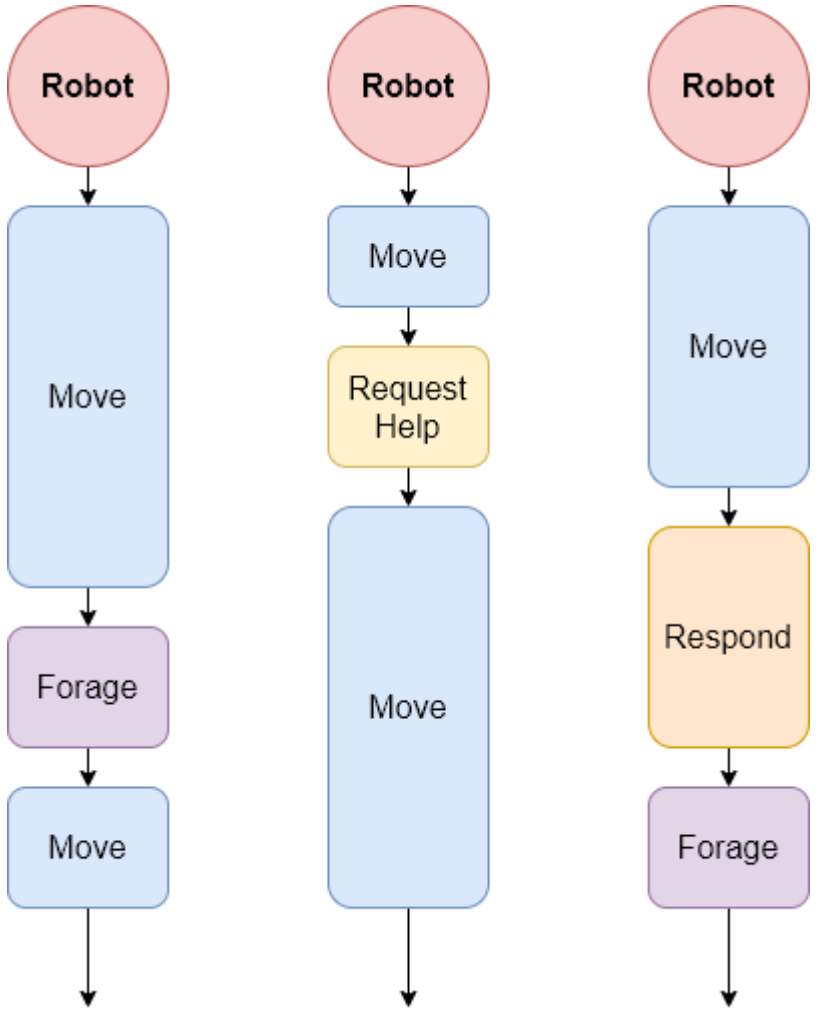
Time-Stepped Simulation

- Updates in discrete ticks
- Each tick, a robot may:
  - Move
  - Process an item
  - Participate in selection strategy
- Continues until task ends



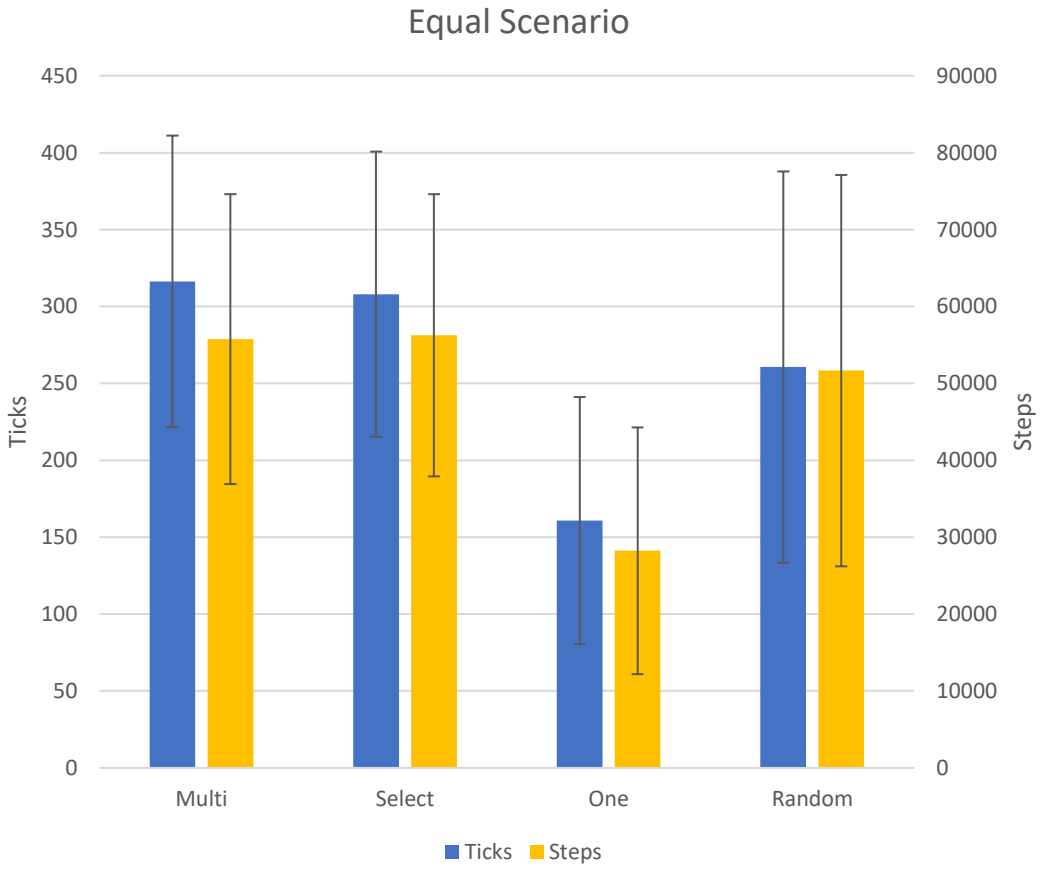
Threaded Simulation

- Each robot simulated on a separate CPU thread
- No synchronisation
- Reliance on real-time delays to simulate robot behaviour



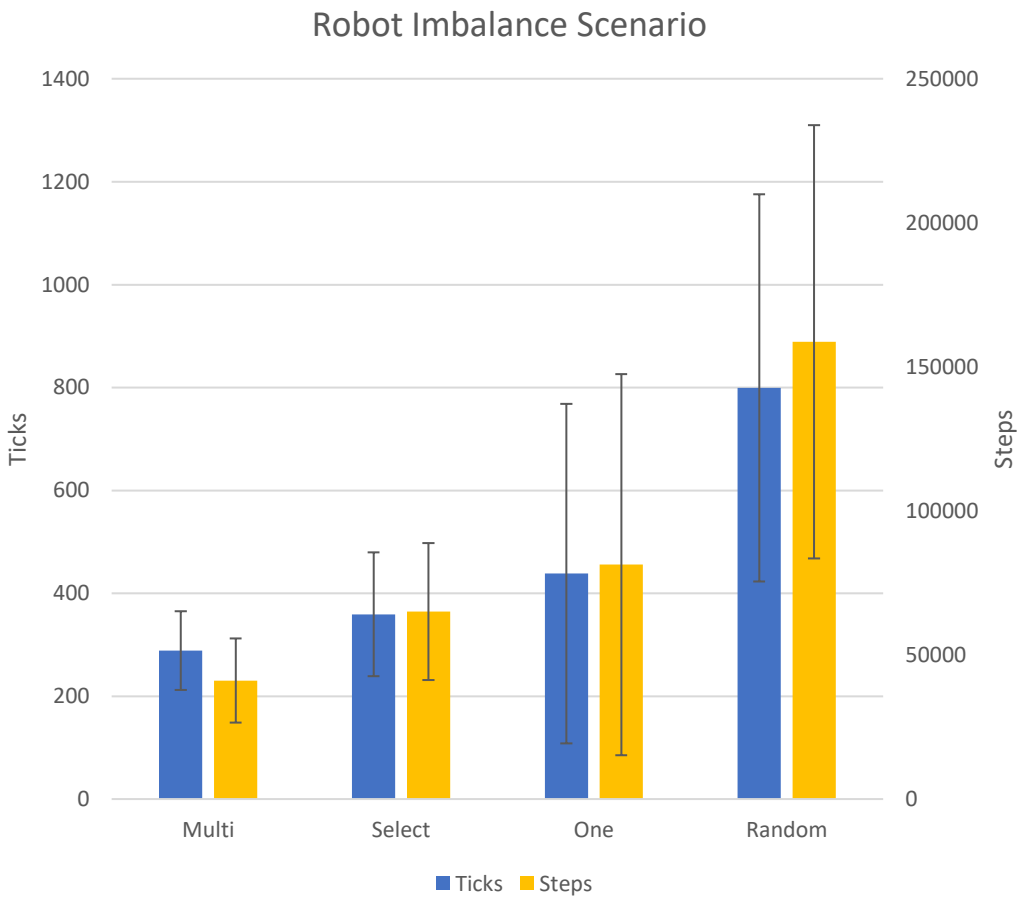
Cooperation Strategy Performance

- One Responder strategy best in Equal or Item Imbalance scenarios
- Multiple and Selective Responder strategies perform worse than no cooperation



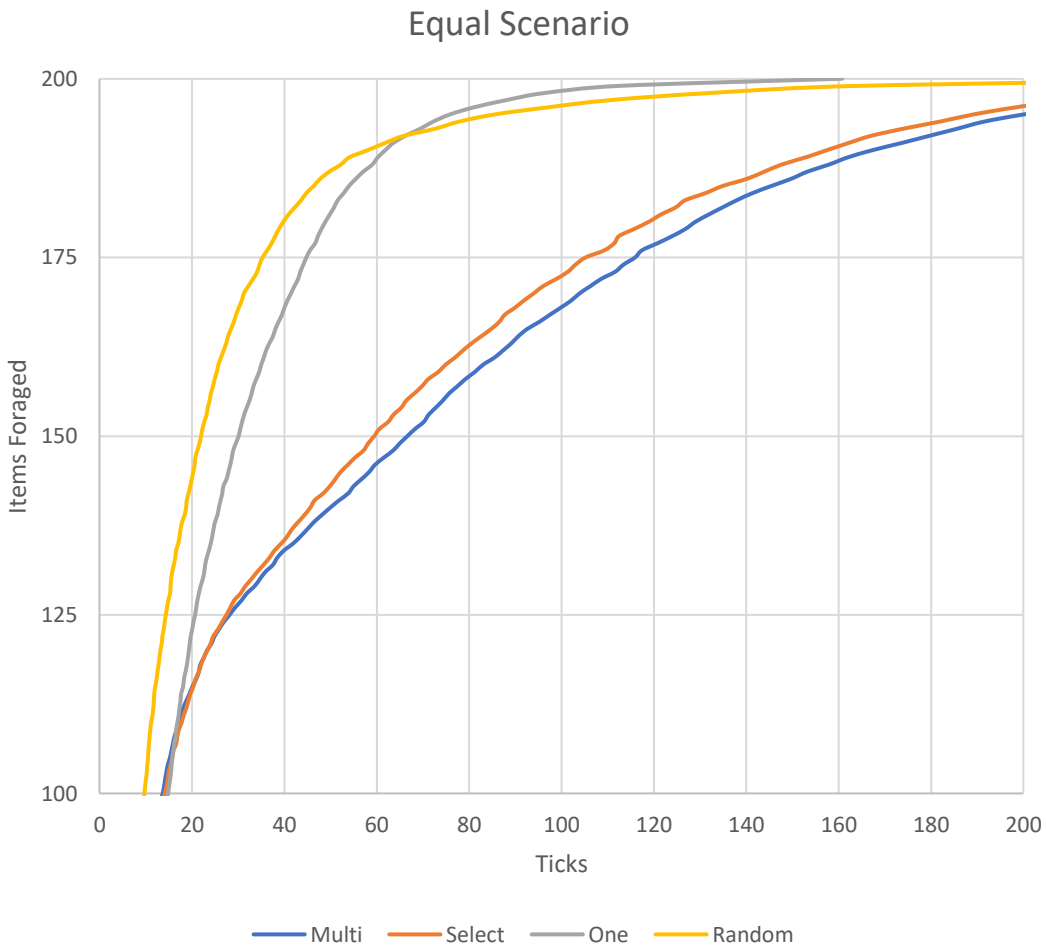
Cooperation Strategy Performance

- Multiple and Selective Responders work better in Robot Imbalance
- Energy cost of each may need calculated to determine true benefit
- Random exploration is overwhelming factor in 90x90 grid



Items Foraged over Time

- Cooperation not useful until final 10%
- Seen most clearly in Equal and Item Imbalance scenarios



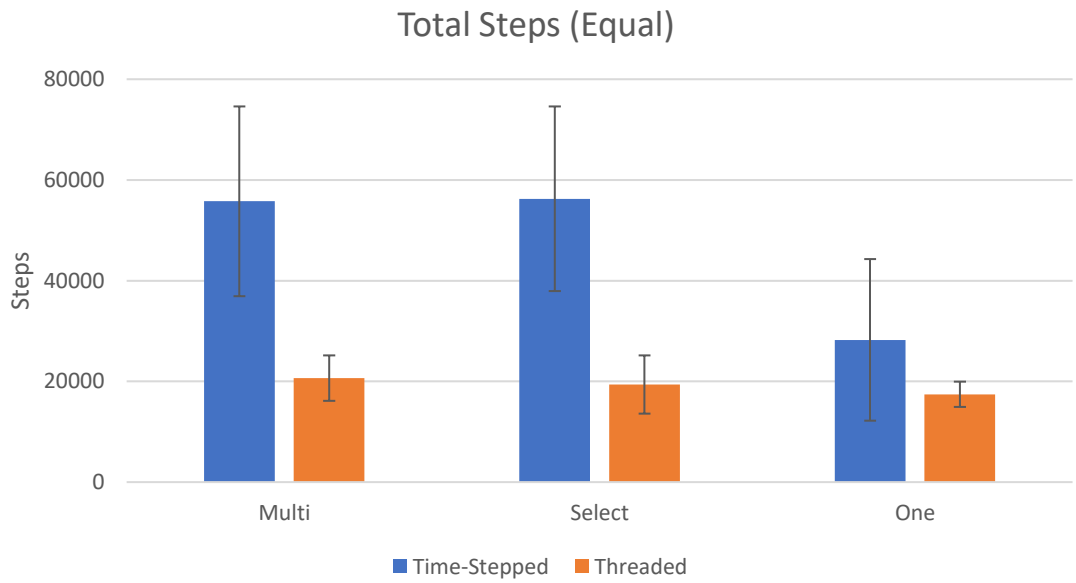
Comparison of Simulations

- Time-stepped simulation is more efficient.

70x Faster

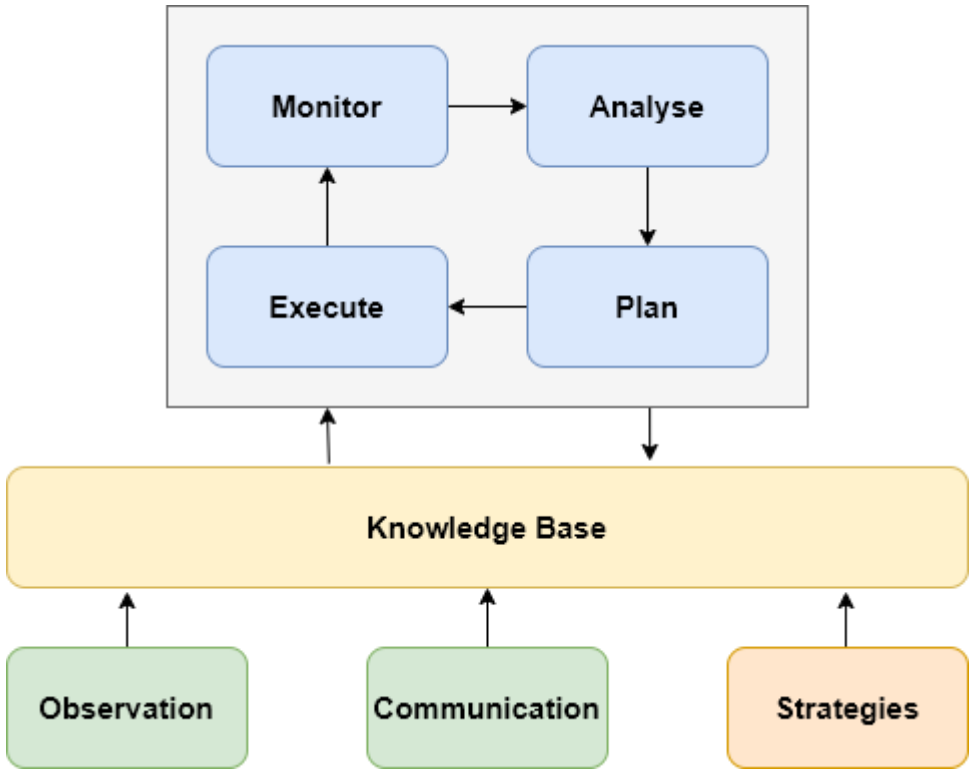
5% RAM Usage

- Threaded sim results in fewer steps to complete task
  - Robots spending more time waiting?



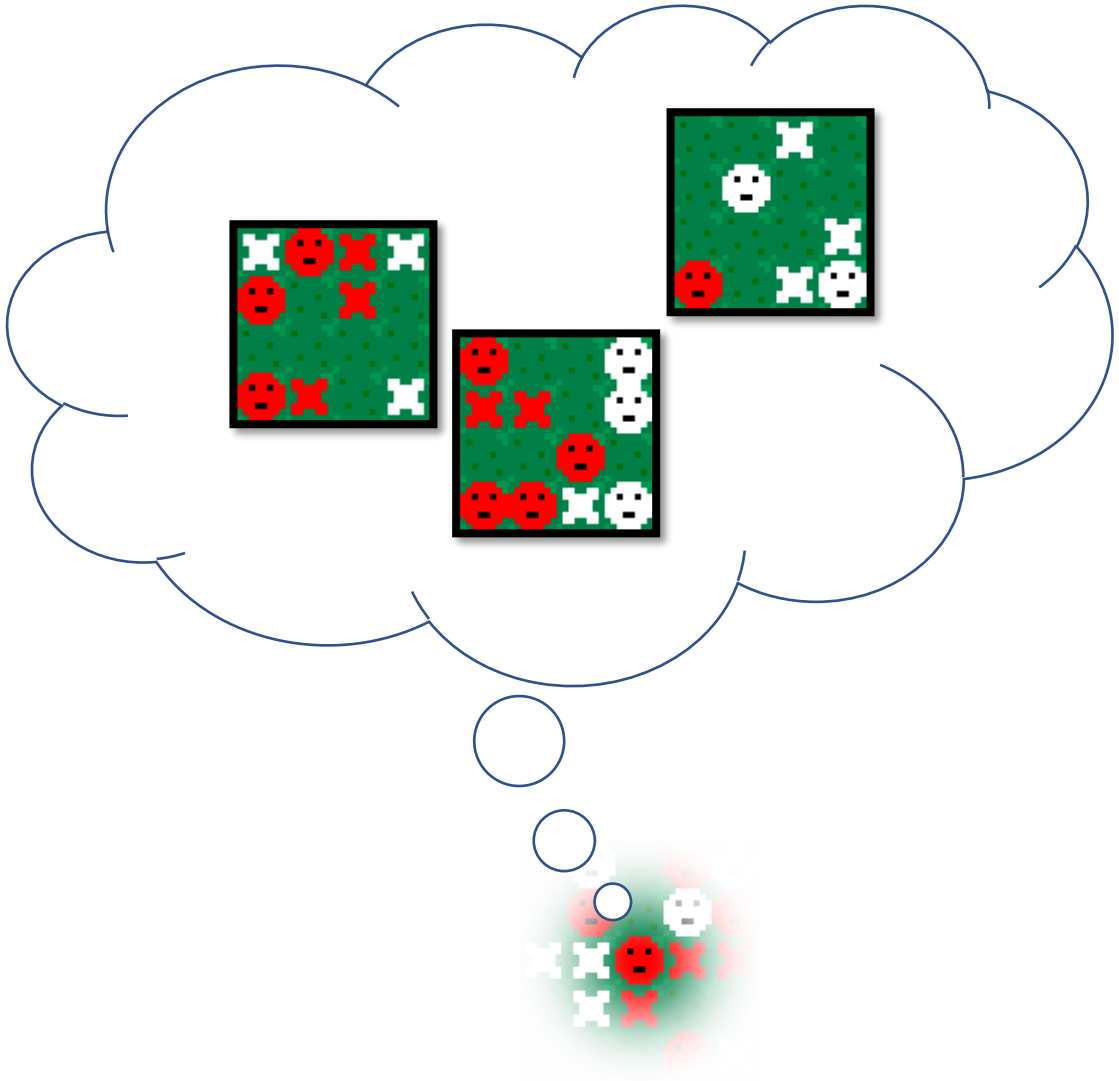
Potential for Autonomic Strategy Selection

- Autonomic Manager on robot
- Make decisions based on known data
- Use knowledge base for selecting strategies



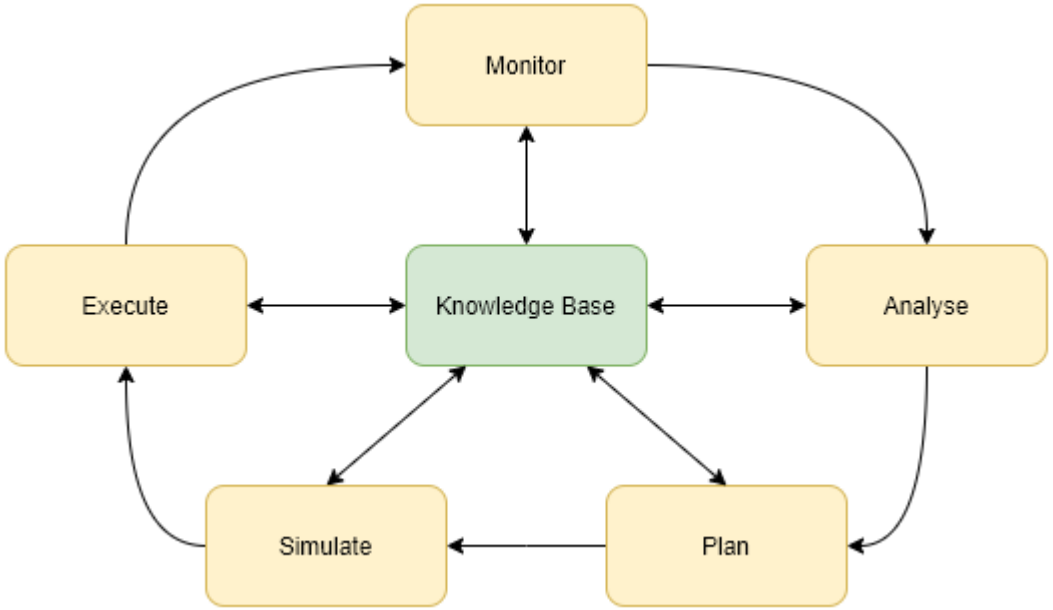
Embedded Simulation

- Time-stepped simulation more suited
- Reduced demands on host
- More simulations can run in same period



Future Work

- Autonomic capability
- Sharing of information
- Adding simulation to MAPE-K loop
- Other factors affecting performance



Summary

- Compared performance of cooperation strategies in a foraging task
- Compared time-stepped and threaded simulations to identify most suitable simulation for embedding within robots
- Identified potential for adjusting behaviour, according to situation, for increased performance
- Aim to develop autonomic capability to consider and select alternative strategies to fit the task and situation at hand

Thank You

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