Centralised Autonomic Self-Adaptation in a Foraging Robot Swarm

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Liam McGuigan

- PhD Researcher at Ulster University
- Researching autonomic robotic swarms

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

Swarm Robotics

- Large number of cooperating robots
- Need to be scalable and flexible
- Needs to be self-adaptive
  - Cannot rely on human input

Swarm-Level Self-Adaptation

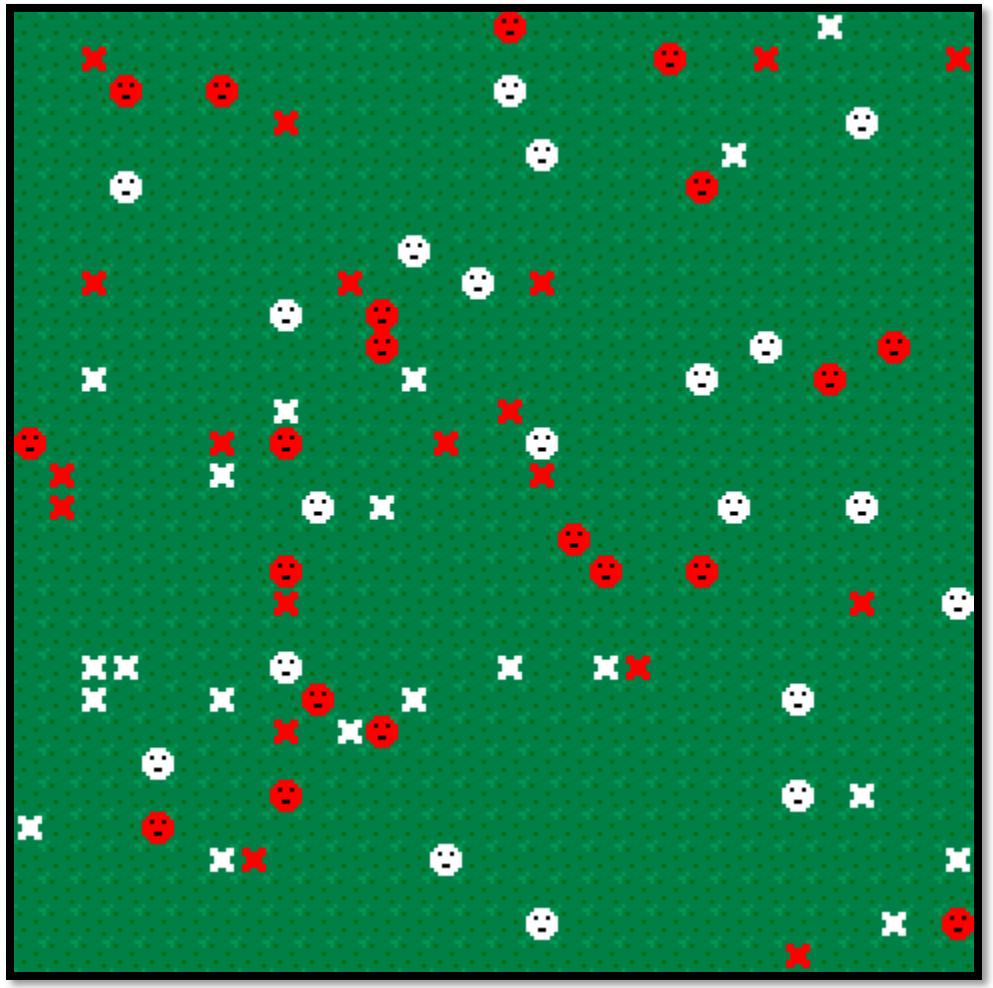
- Most research focuses on agent behaviour adaptation
- Swarm can use aggregate information
- Can see the overall picture
- Swarm-level strategic changes can help with collaboration

Objectives

- Centralised system to explore potential for self-adaptation
- Improve performance through modifying inter-swarm communication range
- Set initial parameters and react to changes

Foraging Task Simulation

- Swarm of robots must find and process items
- Task ends when all items in the map are found
- Time-stepped simulation

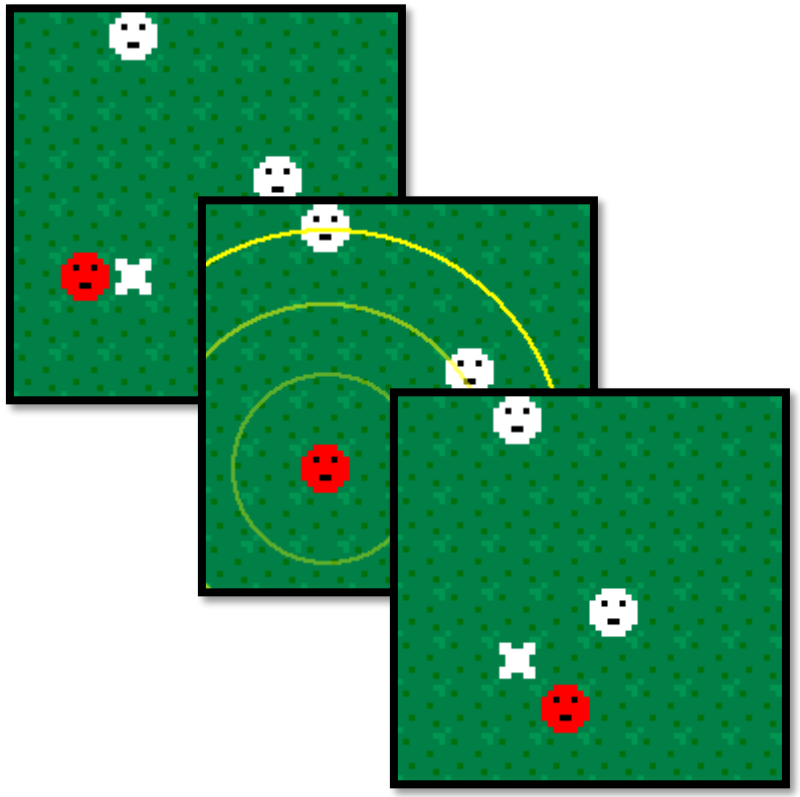


Help Recruitment Strategy

- Robots require assistance if an item is the wrong type

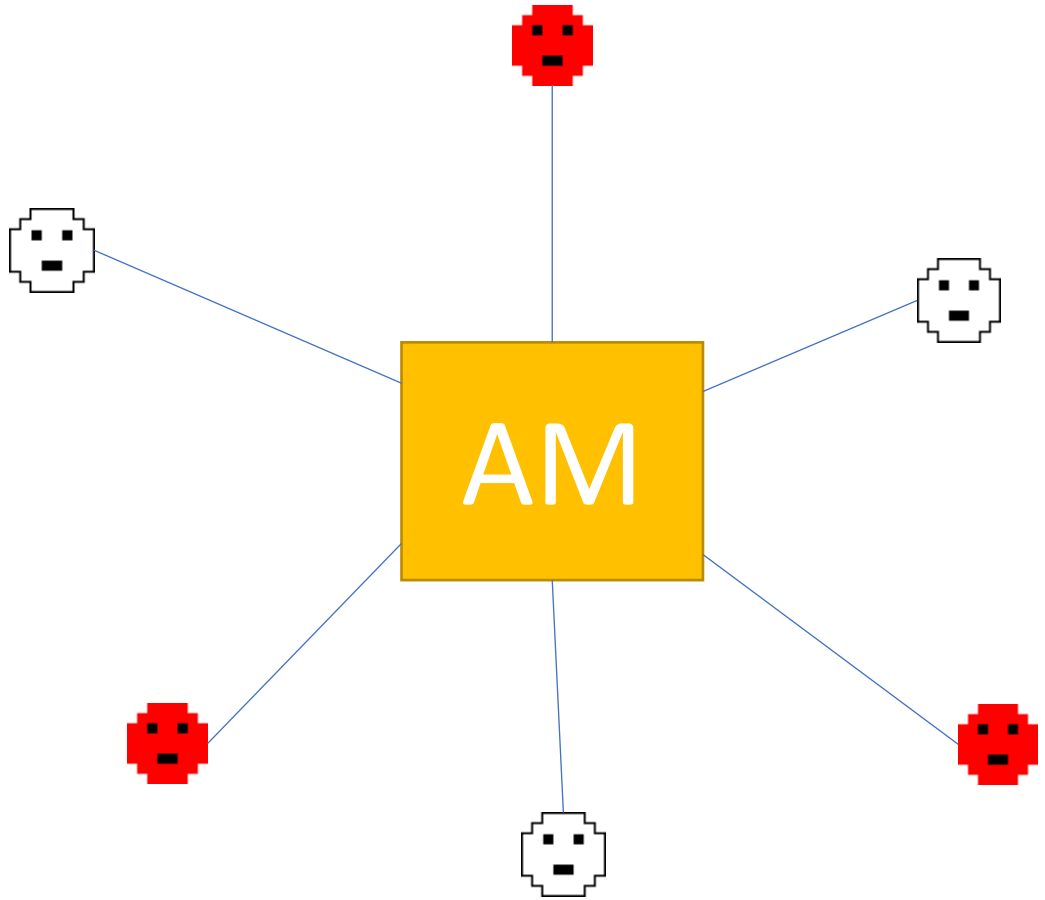
- Broadcast for help
- Select the nearest suitable responder.

- How far should a robot broadcast?



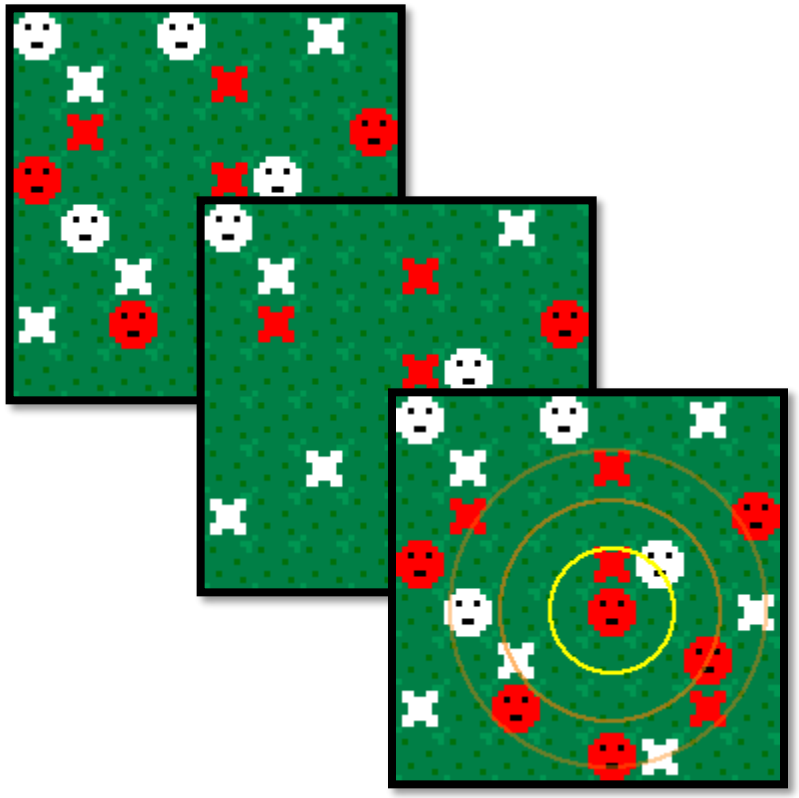
Autonomic Manager

- Initial centralised system
- Collects aggregate information from robots
  - Robot counts per type
  - Bounds of explored area
  - Max distance of neighbour pings
- Information can be used to set broadcast range



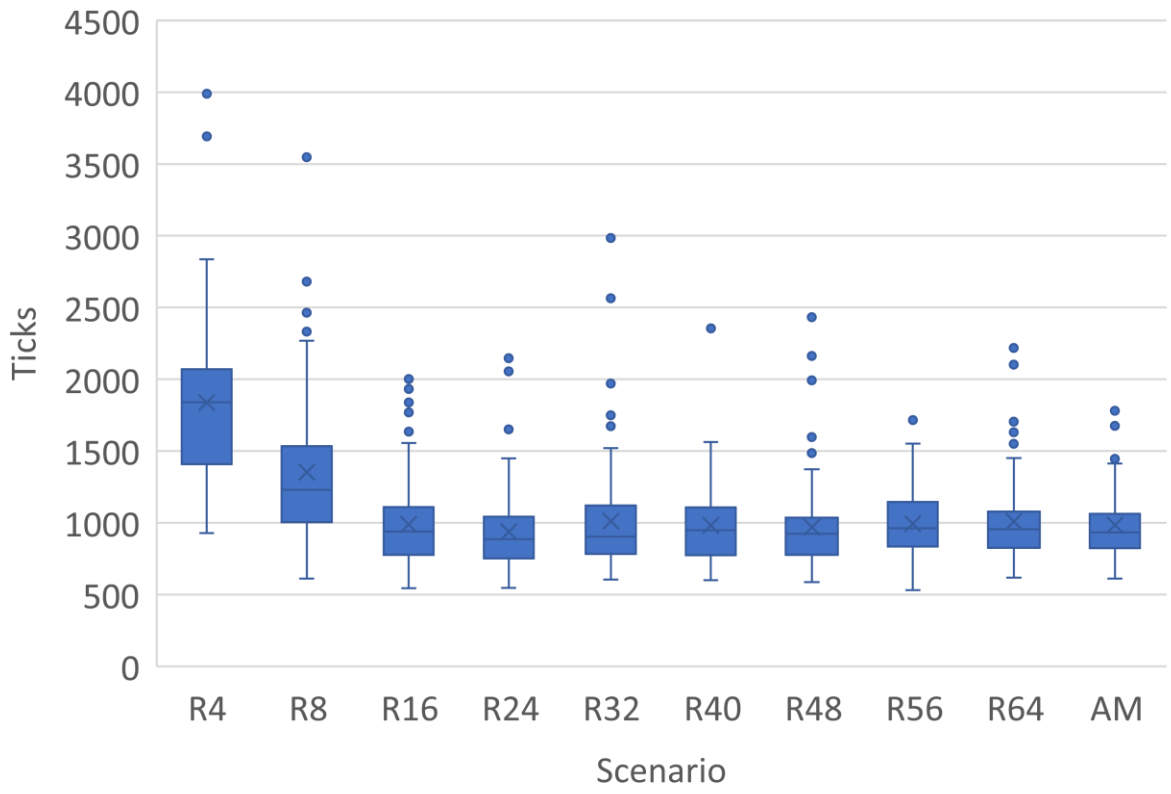
Test Scenarios

- Central AM Performance
  - 64 / 128 / 256 robots
  - Can AM determine suitable range?
- Robot destruction
  - 256 robots start
  - 25% / 50% / 75% / 90% destroyed after short period
  - Can AM react to event?
- Communications Quality change
  - Effective range of communications reduced
  - Can AM detect this and compensate?



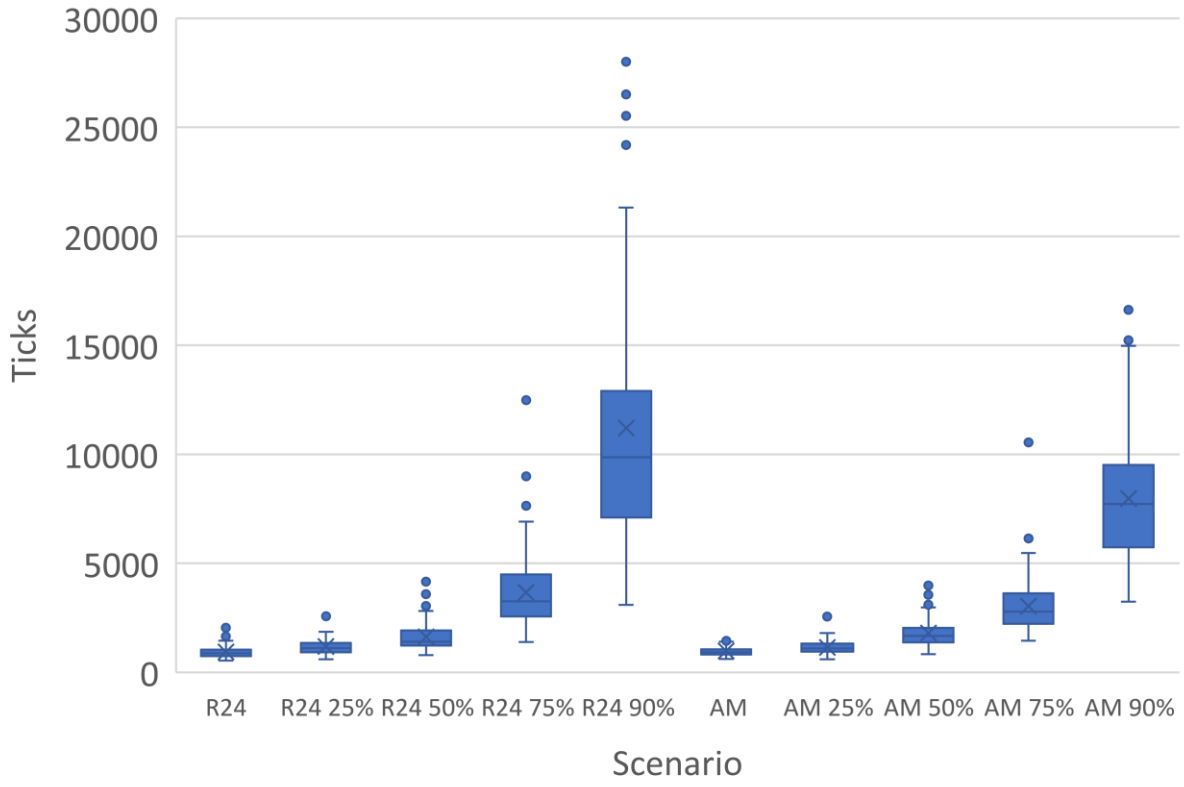
Results – Central AM Performance

- AM is capable of selecting appropriate range
- Achieves performance similar to an ideal fixed range.



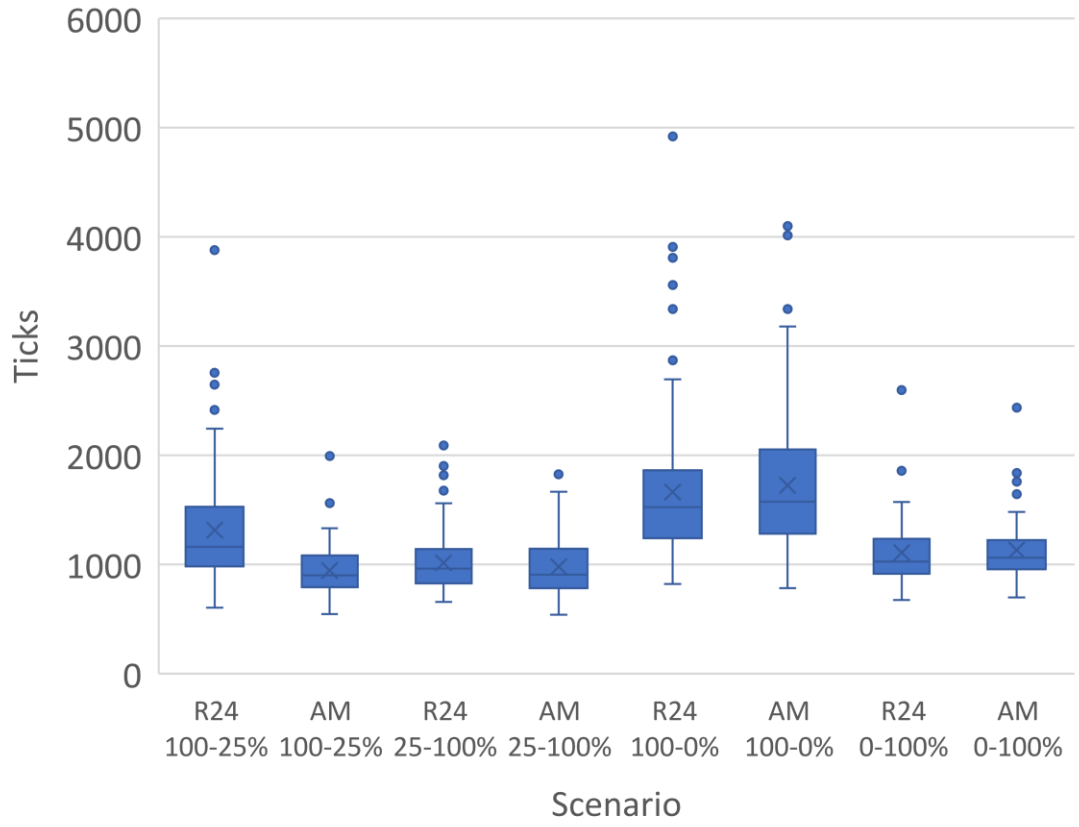
Results - Robot Destruction

- AM is capable of detecting the change in robot density
- Benefits to performance only seen at 75% and 90% level



Results – Communications Quality Change

- AM is able to detect the change and adjust
- Benefits seen only in 100% to 25% drop.
- Other cases show no change in performance, but energy usage may be increased



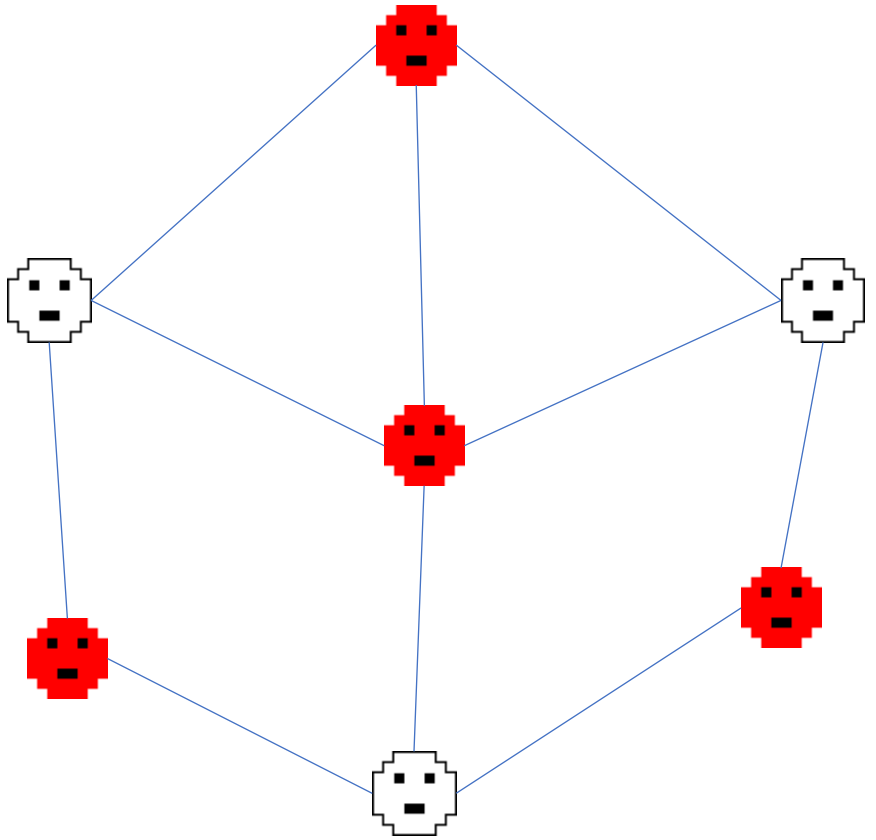
Conclusions

- Centralised AM can achieve swarm-level self-adaptation
  - Can set initial parameters
  - Can recognise changes and adjust
- Benefits to performance can be seen
- Results indicate benefits of using aggregate information

Future Work

- Decentralised autonomic layer
  - No central system
  - More robust
  - Scalable

- Periodic communication between robots to share information and processing



Summary

- Used a centralised autonomic manager to achieve swarm-level adaptation
- Tested its capability at setting an initial broadcast range for help requests, and to react to changes.
- Centralised system not ideal but shows potential for using aggregate information
- Future research will focus on a decentralised implementation for scalability and robustness

Thank You

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