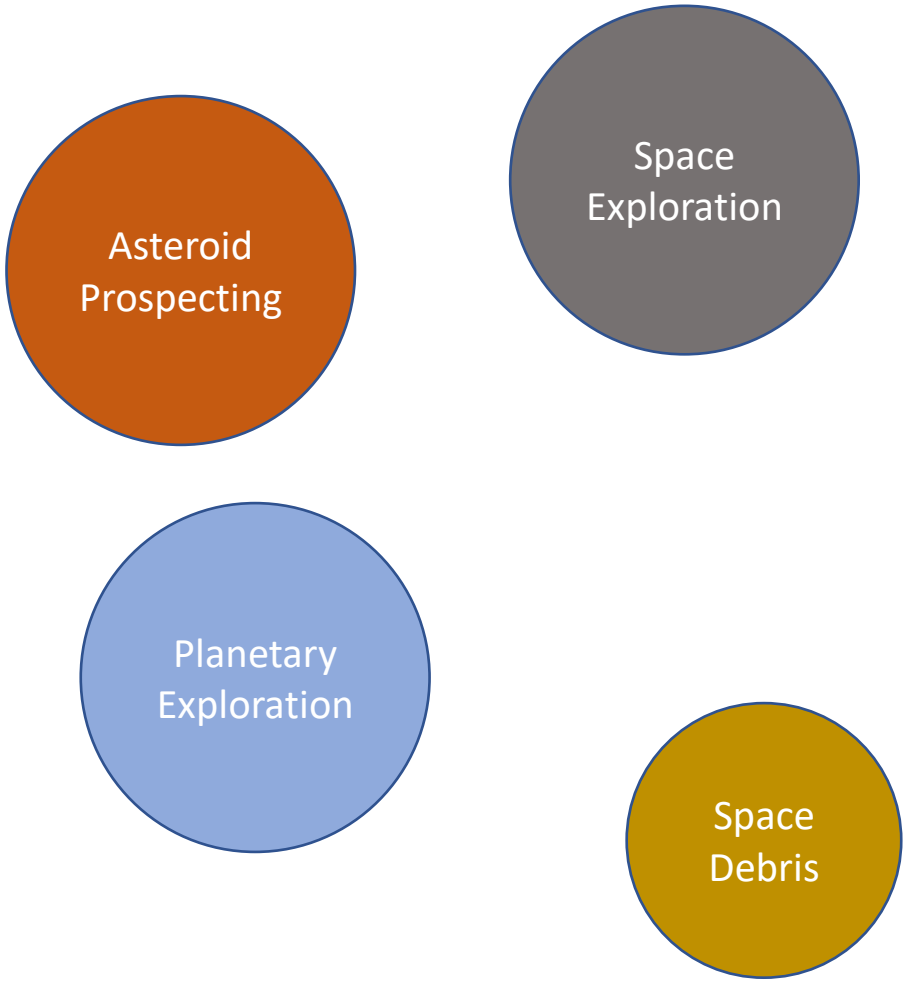
A Decentralised Approach to Autonomic Self-Adaptation in a Robot Swarm

Liam McGuigan, Roy Sterritt, George Wilkie

Presented by Liam McGuigan
School of Computing
Faculty of Computing, Engineering
and the Built Environment
Ulster University
mcguigan-l8@ulster.ac.uk
SMC-IT 2021

Swarm Robotics in Space

- Large number of cooperating robots
- Need to be scalable and flexible
- More cost effective than single, all-capable craft

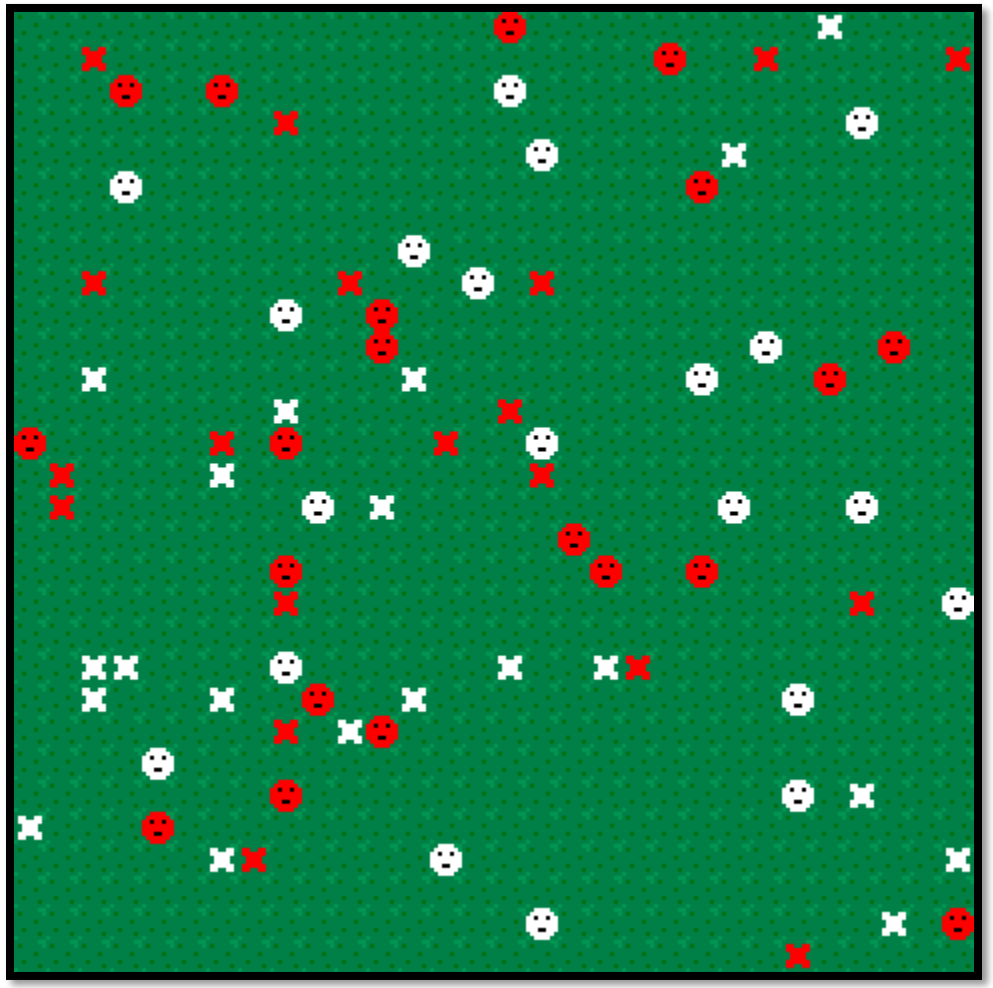


Swarm Self-Adaptation

- Swarm cannot always rely on human input
- Distances involved may mean round-trip time prevents quick reactions
- Composition of the swarm on arrival at mission location may differ from that when it left

Foraging Task Simulation

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

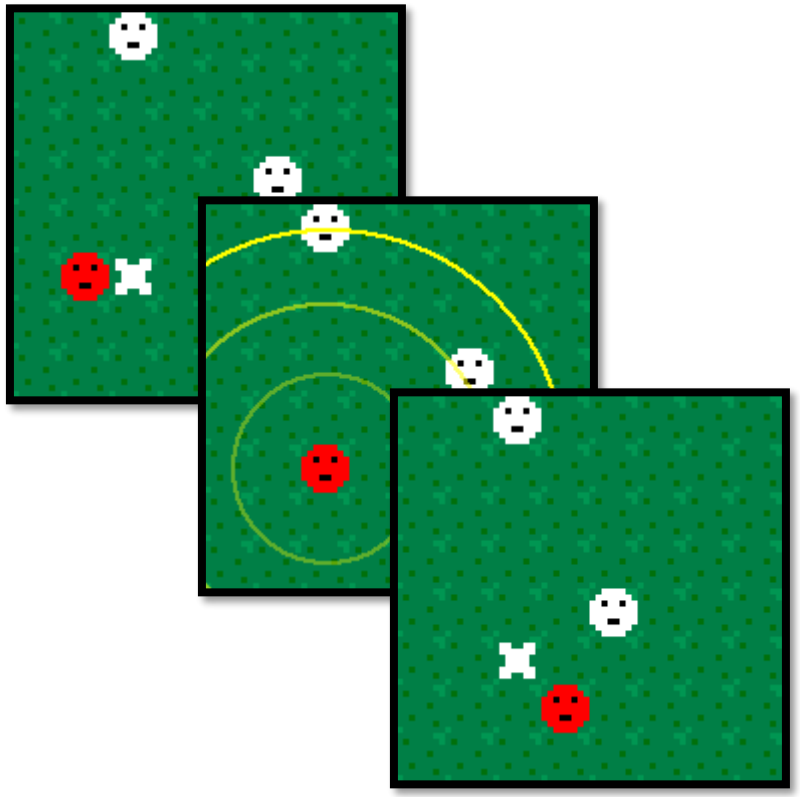


Help Recruitment Strategy

- Robots require assistance if an item is the wrong type

- Broadcast for help
- Select the nearest suitable responder.

- How far should a robot broadcast?

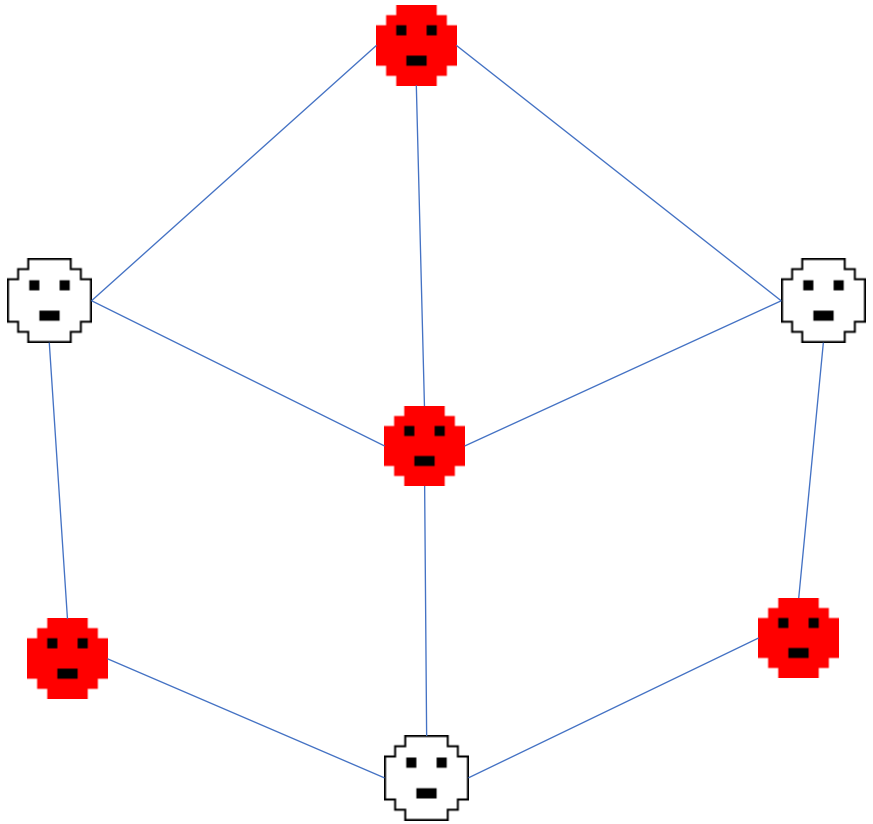


Objectives

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

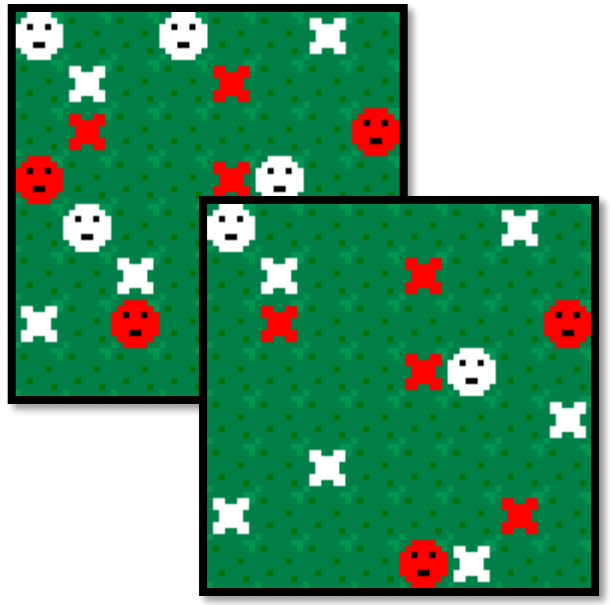
Decentralised Autonomic Management

- Each robot equipped with Autonomic Manager
- Pulse messages sent to neighbours at fixed range
- Received messages used to estimate density of robot swarm
- Information can be used to set broadcast range



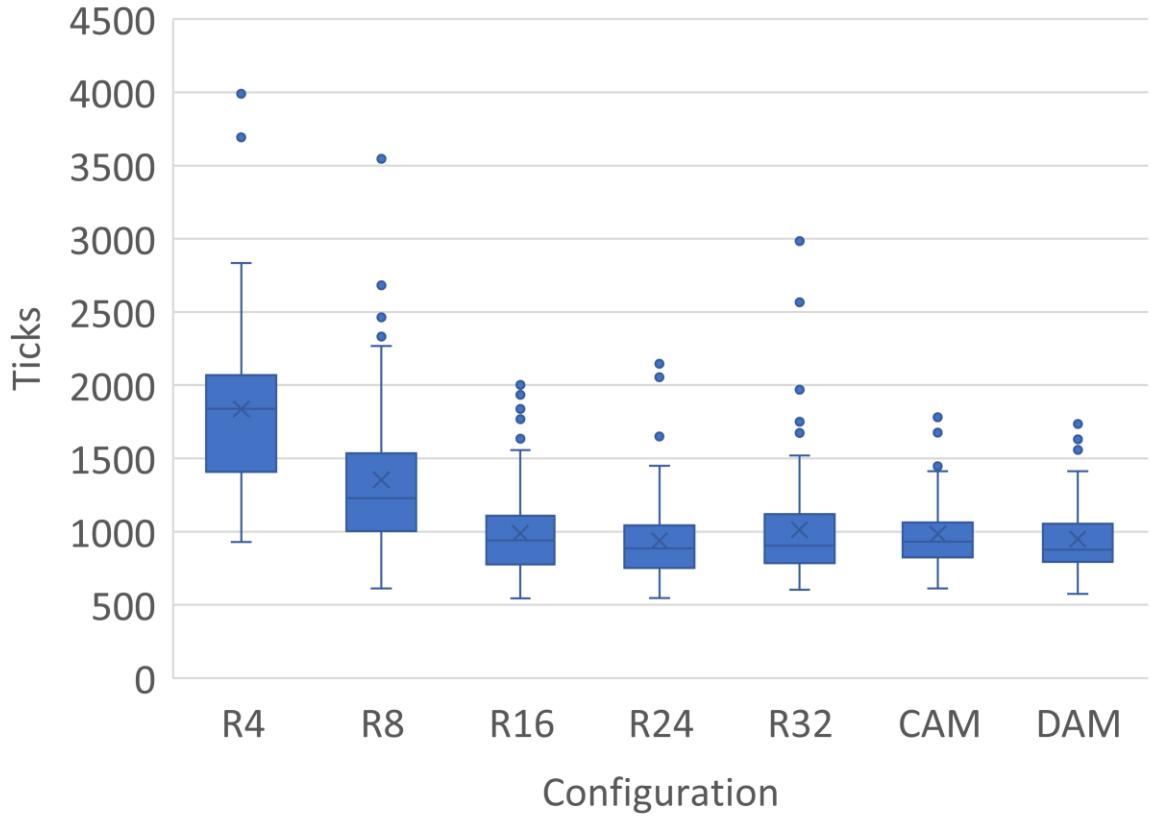
Test Scenarios

- 128x128 grid, 256 items
- Performance
  - 64 / 128 / 256 robots
  - Can AM determine suitable range?
- Robot destruction
  - 256 robots start
  - 25% / 50% / 75% / 90% destroyed after 300 ticks
  - Can AM react to event?
- Results compared to fixed range, and centralised AM



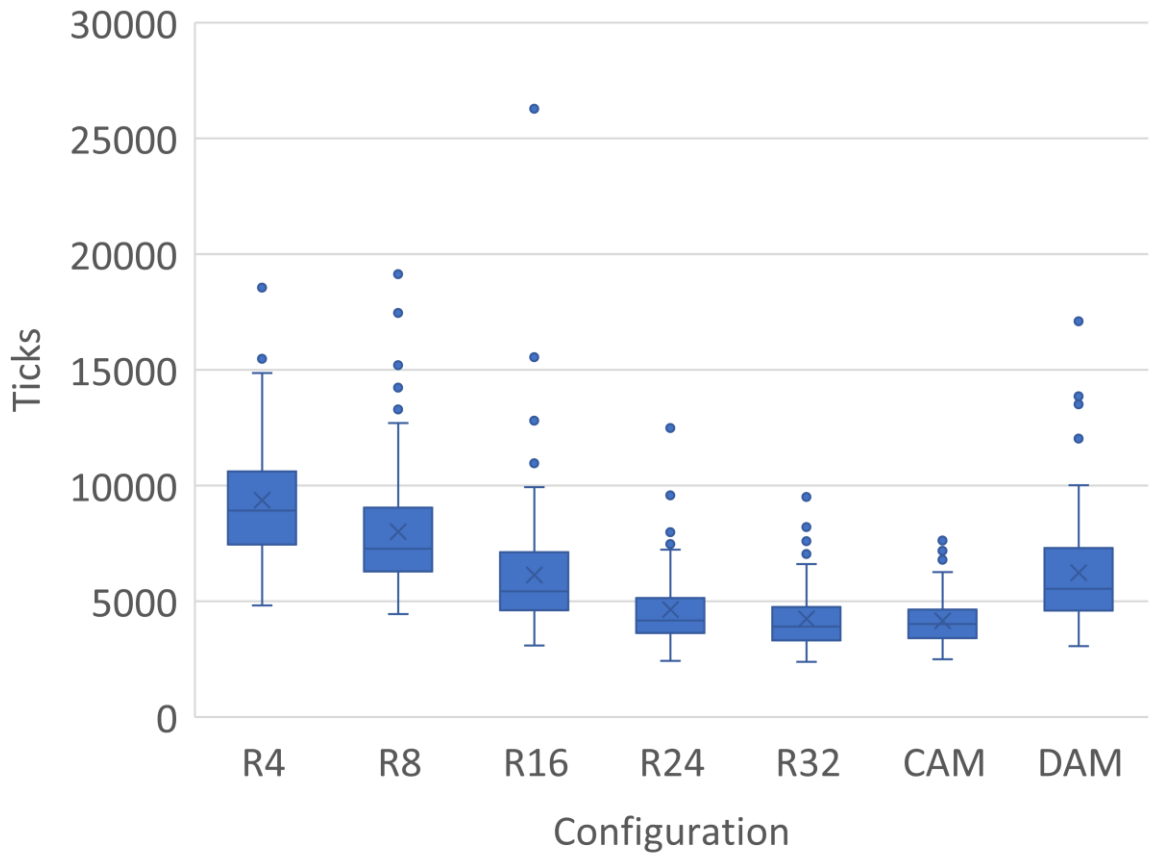
Performance – 256 Robots

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



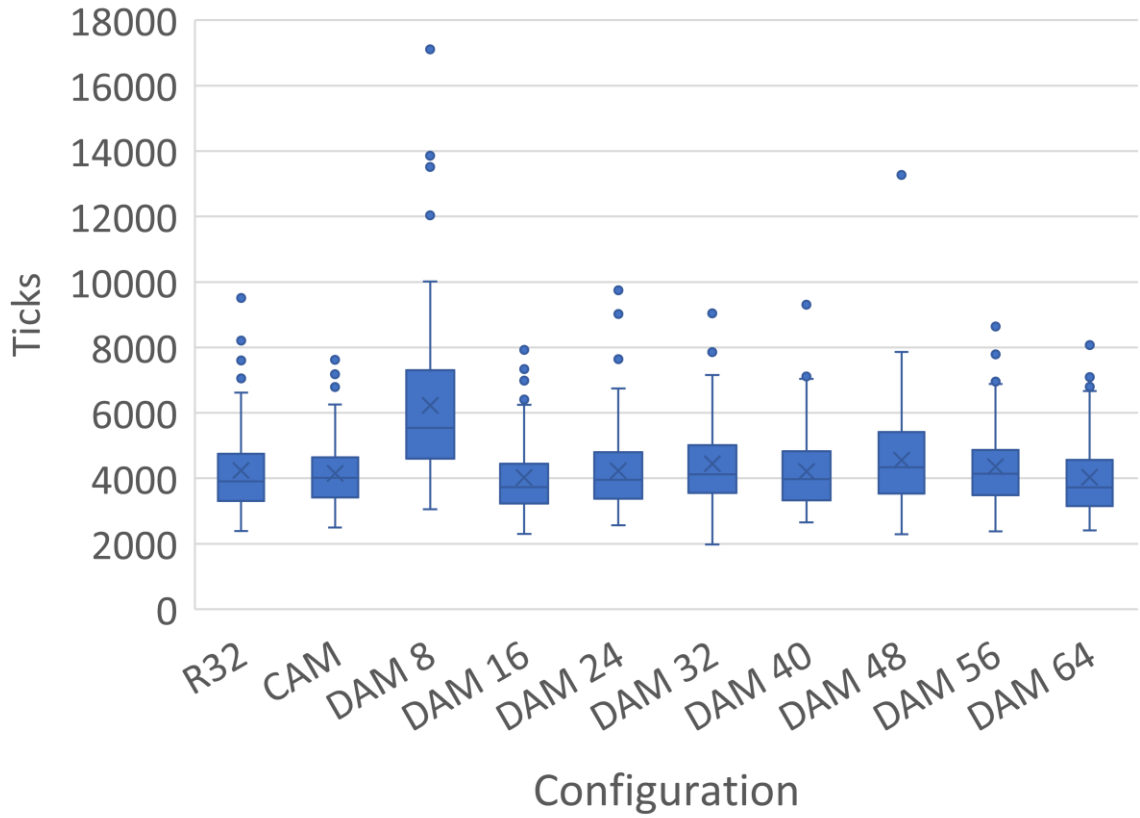
Performance – 64 Robots

- AM does not select most suitable broadcast range
- Centralised AM was capable of doing so
- Pulse range may need adjusting?



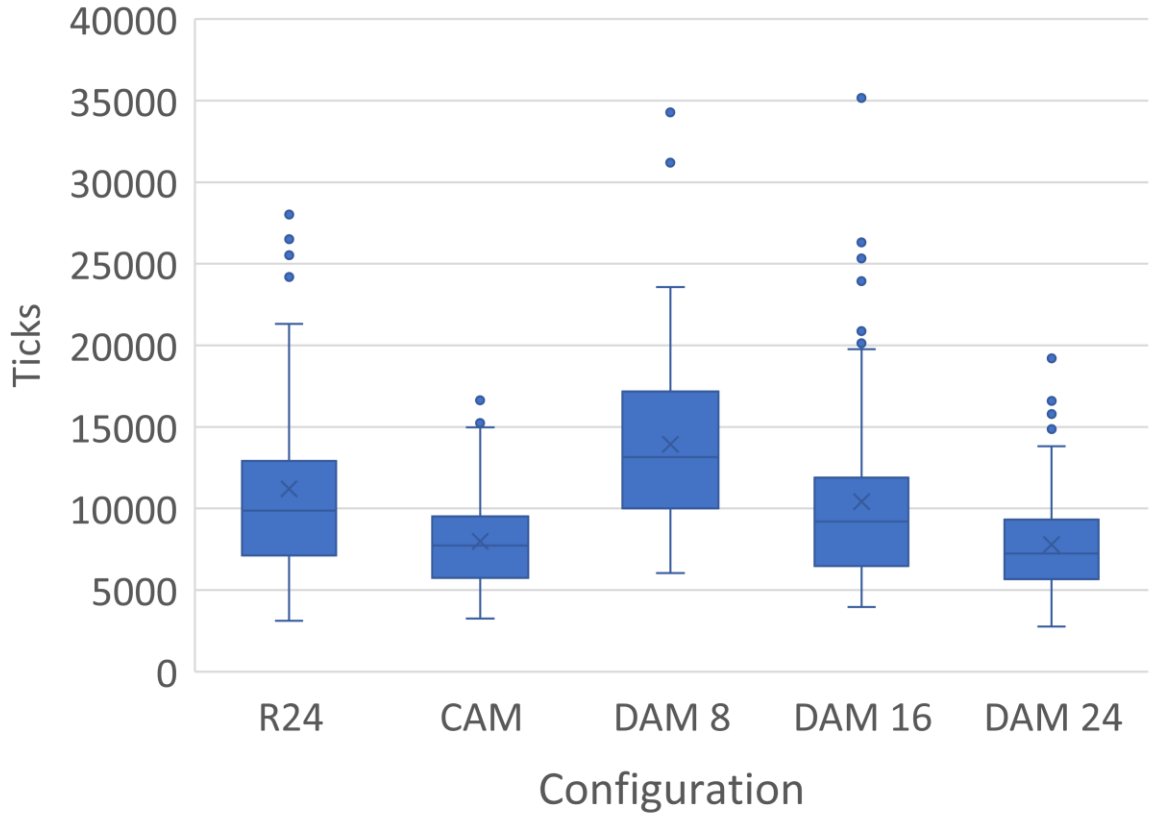
Performance – 64 Robots + Pulse Range

- Increasing pulse range allows suitable help range to be found
- A minimum suitable pulse range exists
- Higher ranges give no performance benefit



Robot Destruction – 90%

- AM is capable of detecting the change in robot density
- Benefits most apparent at 90% destruction level
- Pulse range again needs adjusted to achieve best results



Conclusions

- Decentralised swarms are capable of adaptation
- Benefits to performance can be seen, without the need for a centralised system
- Pulse range will also need dynamic control by AM

Future Work

- Dynamic control of the pulse range
- Use of weighted information from neighbours in the decision making
- Sharing of information and decision-making throughout the swarm to allow swarm-level changes in strategy

Summary

- Decentralised self-adaptation of swarm behaviour
- Setting initial broadcast range and reacting to changes
- Decentralised approach can achieve results on par with centralised system
- Future research will focus on sharing information for swarm-level changes

Thank You

Presented by Liam McGuigan
School of Computing
Faculty of Computing, Engineering
and the Built Environment
Ulster University
mcguigan-l8@ulster.ac.uk
SMC-IT 2021