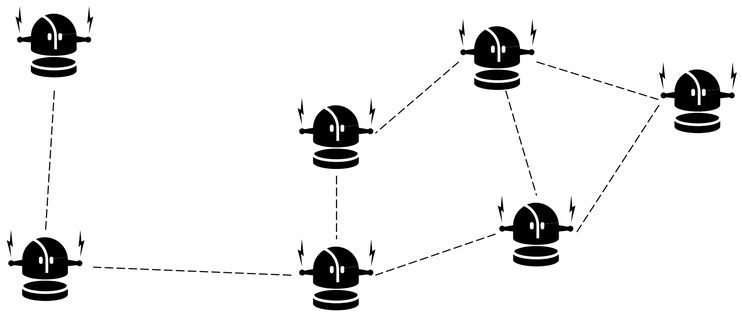
Foundations of Adaptive Networked Societies of Tiny Artefacts

Funded by the European Commission under the FET Proactive Initiative Pervasive Adaptation.

Building simple formations in large societies of tiny mobile robots

Vision: Mathematical foundations of swarm robotics

cooperation



Tiny robot
- Small
- Limited sensing
- Limited computational power
- Limited communication capabilities
- Limited energy

Large society of tiny robots
- Accomplish difficult tasks
- Adapt to changing environment
- Are robust against failures
- Adapt to different tasks

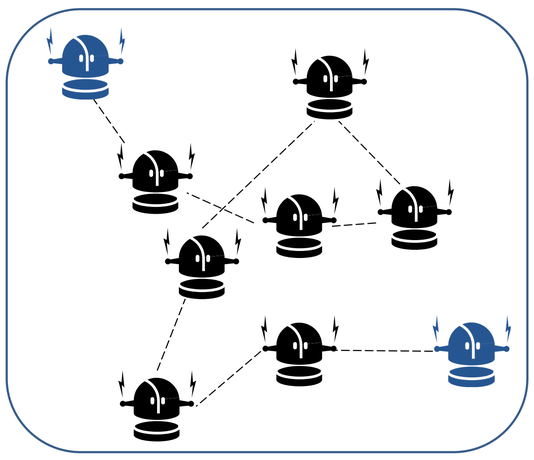
- No central control
- Distributed execution
- Each robot has only limited local information

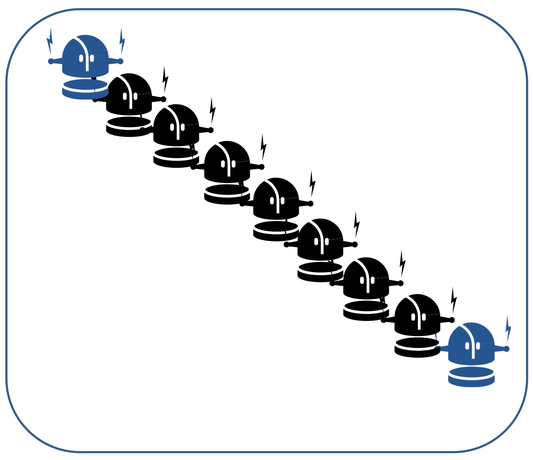
How do we achieve good global behaviour? → Which formations can the robots build?

Challenge: Design and **rigorous mathematical analysis** of local strategies for robotic swarm formation

- Correctness
- Time efficiency
- Energy efficiency

Example: Line between two stations





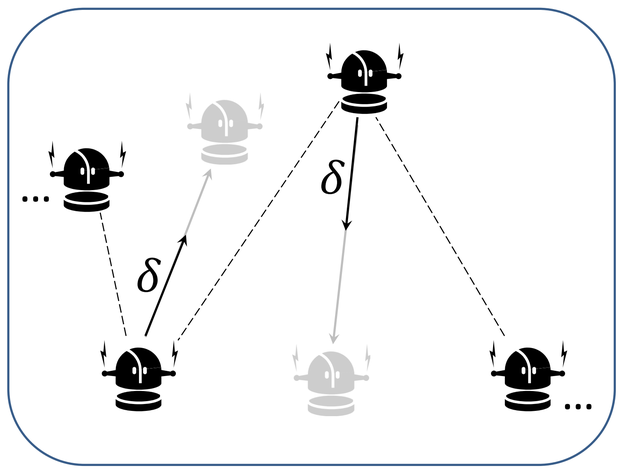
Start
- Robots already organized in a chain → each robots knows two neighbours
- Chain is arbitrarily long and winding

Goal
- Each robots is between ist two neighbours
- The robots form a straight line between the two stations

➔ **Spend as little energy as possible!**
- Sense environment
- movement

A Strategy: δ-Go-To-The-Middle

Model assumptions
- Discrete time
- synchronous execution of the strategy
- n robots



Results
- Energy spent for sensing environment: proportional to $n^2 \log n + \frac{n}{\delta}$
- Energy spent for moving: proportional to $\delta n^2 + n$

→ Choose $\delta = \frac{1}{n}$:
- Energy for sensing proportional to $n^2 \log n$
- Energy for moving proportional to n

Conclusion: Exploring the step size can be helpful for energy reduction

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SEVENTH FRAMEWORK PROGRAMME

- Research Academic Computer Technology Institute (RACTI)
- University of Athens (UOA)
- Braunschweig University of Technology (TUBS)
- Universität Paderborn (UPB)
- University of Lübeck (UZL)
- Universita di Roma "La Sapienza" (UDRLS)
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