HYPER-AI

Revolutionising the Cognitive Computing Continuum with AI and Automation

Technical Approach: The Computing Swarms Concept

Jacopo Castellini, HES-SO Geneva

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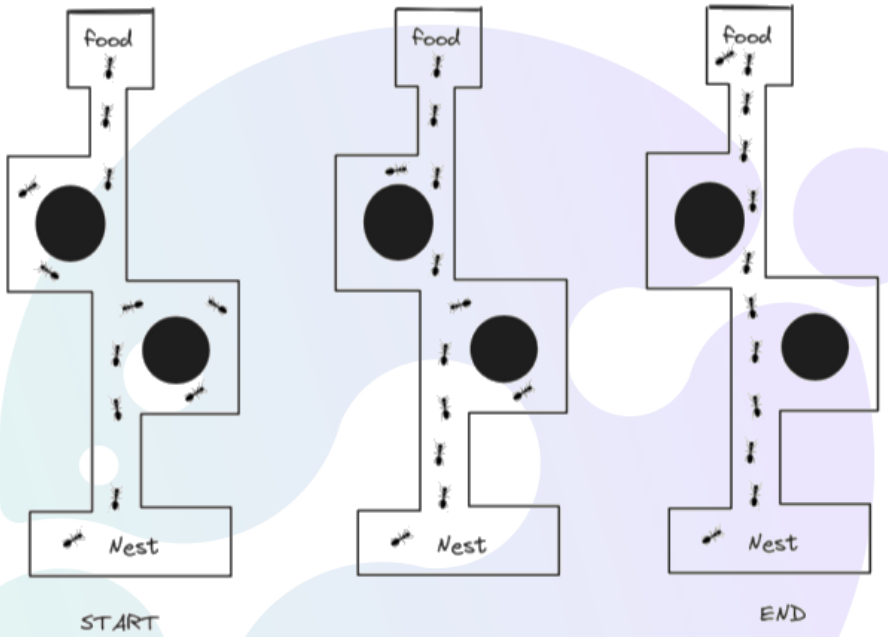
- **Swarm intelligence** is the collective behaviour of decentralized, self-organized agents, either natural or artificial.

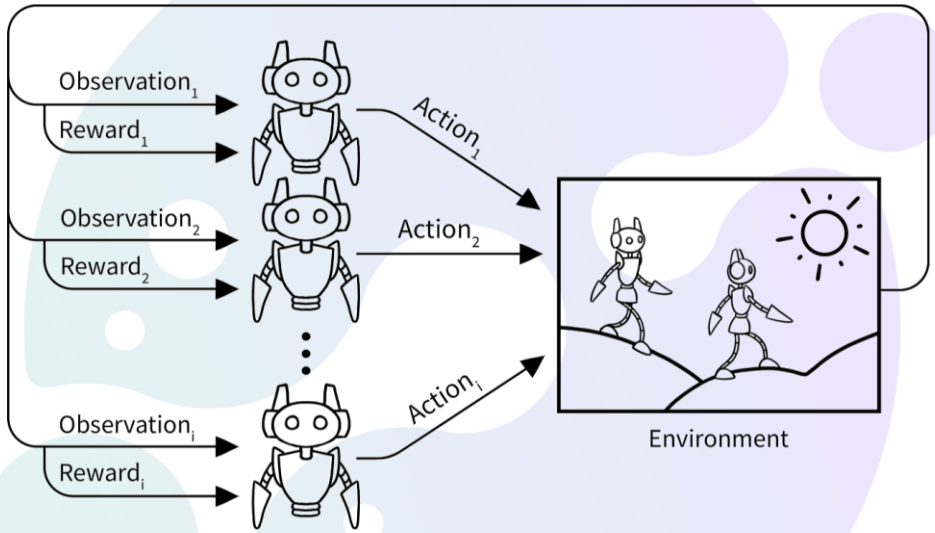
- Interactions between such agents lead to the **emergence of "intelligent" global behaviour**, unknown to the individuals.



Taken from: https://muthu.co/ant-colony-optimization-aco/

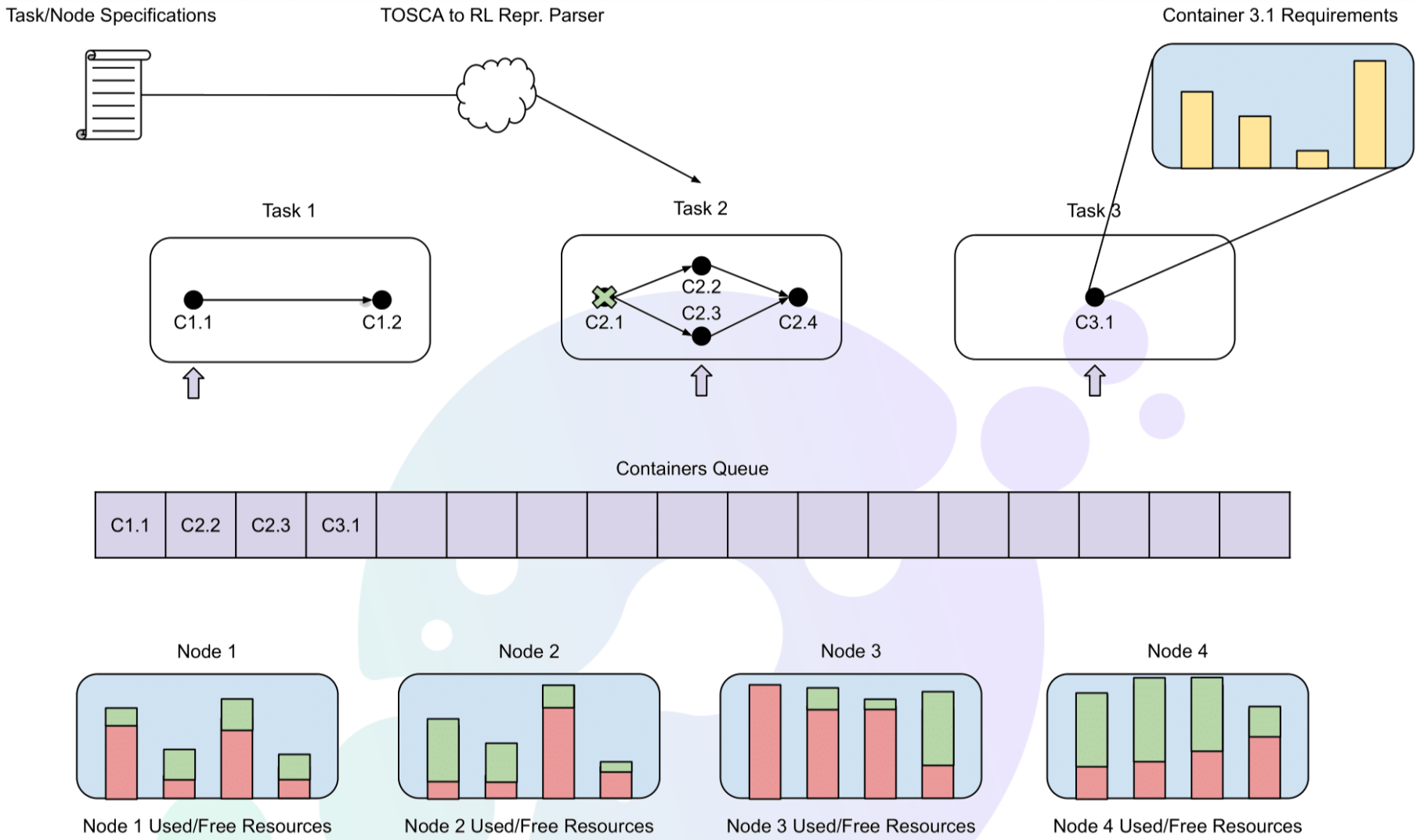
- Inspiration for many **artificial intelligence strategies** to address complex computational problems (e.g., optimization problems) in a **scalable manner**.
- Genetic or evolutionary algorithms, particle swarm optimization, ant colony optimization, just to name a few...
- These are however **non-learning** strategies, i.e. they compute the solution for a specific problem instance.
- No flexibility to new situations, and no adaptation or **generalization of the computed solution**.
- This could not do it for our setting, which is constantly changing...

- We can resort to **machine learning** to achieve such a generalising solution!
- **Multi-agent reinforcement learning** (MARL) combines the idea of decentralized, local agents and learning only from rewards/penalties by trial-and-error.
- This would allow us to obtain behaviours that operate in isolation, but combined together are capable of solving the complex problem we are facing, while adapting to different or changing situations.



Taken from: https://towardsdatascience.com/multi-agent-deep-reinforcement-learning-in-15-lines-of-code-using-pettingzoo-e0b963c0820b

- Each agents perceives only a limited view of the system state, its **observation**.
- Agents have a set of **actions** that they can select and perform in the system.
- The collection of the performed actions by each agent influences the system itself, which moves to a new state and provides the agents with some numerical **reward**.
- The agents learn from this value (using statistical formulae) and the whole process repeats.
- Our aim is to **learn an optimal behaviour** for each agent, mapping each observation to the corresponding action to select, so that they collectively maximize the sequence of obtained rewards along a series of such interactions.


Task/Node Specifications
TOSCA to RL Repr. Parser
Container 3.1 Requirements
Task 1
Task 2
Task 3
C1.1
C1.2
C2.1
C2.2
C2.3
C2.4
C3.1
Containers Queue
C1.1
C2.2
C2.3
C3.1
Node 1
Node 2
Node 3
Node 4
Node 1 Used/Free Resources
Node 2 Used/Free Resources
Node 3 Used/Free Resources
Node 4 Used/Free Resources

- Each node acts as an individual agent, thus allowing for **decentralized execution**.
- Its observations are formed by relevant information such as its internal level of free and used resources, the requirements of the queued containers and the state of the queue itself.
- Its actions correspond to **selecting one of the containers in the queue**, or doing nothing.
- The environment (cloud-edge continuum) updates its internal state based on what the devices have selected and which new tasks have arrived from the users.
- Reward may be optimizing the **overall execution time**, the average delay, or any (combination of) measure of cost or efficiency.

- Application of artificial intelligence and machine learning techniques to **task scheduling or resource allocation** have already been investigated in many works.
- However, these are usually restricted to simulated and simplified settings.
- Conversely, we aim at developing a working solution for real-world systems, through the **integration with a commercial orchestration product** (i.e., Kubernetes).
- We have to face a new set of challenges and difficulties that come from the **complexity of such real-world application**, other than those intrinsic to the use of machine learning itself.
- Computing swarms may prove helpful in addressing these!

- As a remark, here are some success stories of computing swarms and multi-agent reinforcement learning in real-world applications.
- Swarm intelligence has been used in **controlling unmanned vehicles** by the U.S. military.
- The Lord of the Rings film trilogy (which I love!) made use of a similar technology, known as Massive, during battle scenes.
- Finally, AlphaStar, using (amongst other techniques) population-based and multi-agent reinforcement learning, has managed to **beat 5-0 a top professional player of StarCraft II**, under professional match conditions on a competitive ranking map and without any game restriction.

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Thank you