Marco Barletta

Research directions for container orchestration in Industry 4.0
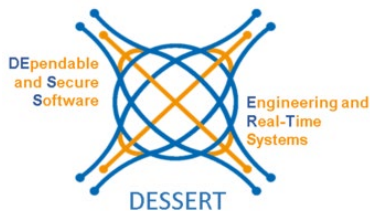
Tutor: Marcello Cinque

Cycle: XXXVII   Year: First

My background

- MSc degree in Computer Engineering (October 2021)
- Research group: DESSERT
- PhD start date: 01/11/2022
- Scholarship type: UNINA

Research field of interest

Industry 4.0 is characterized by the **integration** of the information and communication technologies into production systems.

I4.0 is all about **flexible manifacturing**, continuous reconfiguration and adaptation to changeable production goals.

The flexiblity is enabled by the **softwarization**, **virtualization**, and **orchestration** of industrial components, along with new computing paradigms (edge/fog cloud).
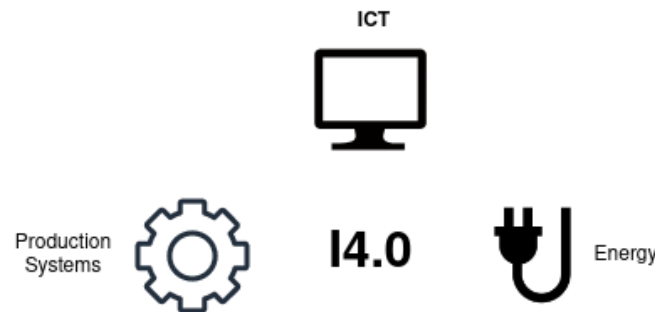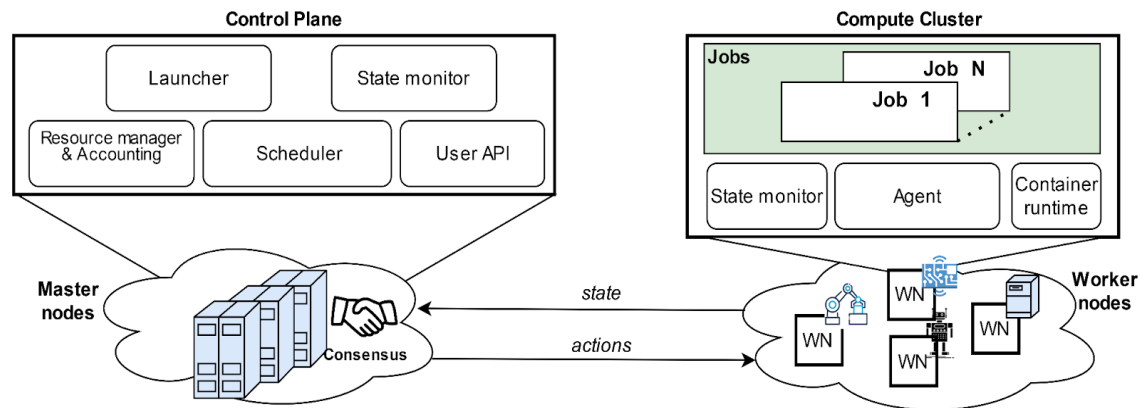
Research field of interest

Orchestration systems are distributed systems that automatically **manage** the packaged software **lifecycle** over the computing infrastructure.

They provide:
1. Automatic placement and deployment
2. Monitoring of the state of the cluster
3. Migration and re-deploy of the containers

Orchestration systems are designed and used in cloud environments, behaving as Cloud-OSes.

Summary of study activities

Ad hoc PhD courses:

- Virtualization technologies and their applications
- Statistical data analysis for science and engineering research
- Imprenditorialità accademica

Courses borrowed from MSc curricula :

- Quantum Information
- Real-Time Industrial Systems

Conferences / events attended:

- 34th Euromicro Conference on Real-Time Systems (ECRTS 2022) Modena, Italy, 05/07/2022 to 08/07/2022, *presenting author*

Research activity: Overview

Problem:

Orchestration systems need a complete re-design to meet **industrial requirements.**

Limitations:

1. Containers suffer from reduced **isolation**;
2. Unsuitable **abstractions** of nodes and workloads;
3. **Monitoring** and **failure mitigation** policies designed for best-effort environments;
4. Networking and computing resources are managed **indipendently**;
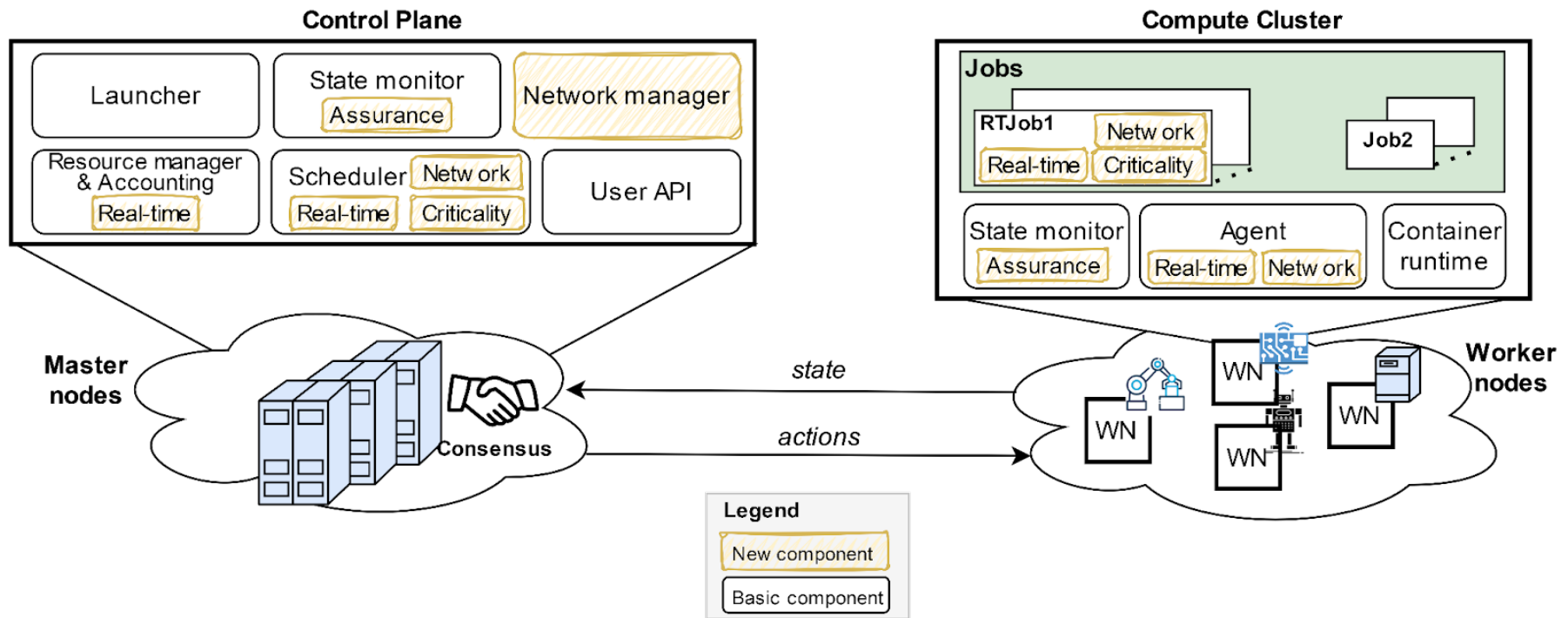
Research activity: Overview

Objective:

Design and **implement** and **evaluate** an orchestration system that solves listed problems, to be applied in I4.0.

Specifically, there is the need to:

1. Enable orchestration for **partitioned** multi-criticality containers;
2. Define suitable **placement** strategies, based on new abstractions for criticality-aware deployments to reduce SLA violations;
3. Design appropriate **monitoring** and **failure mitigation** policies to guarantee carrier grade availability and sub-second downtimes;
4. Design a placement algorithm to **jointly** mange networking and computing resources.

Research activity: Overview

Research activity: Overview

**Methodology*:*

1. **Measure** the behaviour under **stress** of different hypervisors/OSes useful to implement partitioned containers.
2. **Derive** the most important **metrics** to quantify the isolation level of a system.
3. **Design** and implement policies based on these metrics, along with dependability techniques.
4. **Evaluate** the behaviour of the overall system under stress, measure **downtimes** and achievable **dependability**.

Products

[C1]	*"Achieving isolation in mixed-criticality industrial edge systems with real-time containers"* *"Achieving isolation in mixed-criticality industrial edge systems with real-time containers (Artifact)"* *M. Barletta, M. Cinque, L. De Simone, R. Della Corte* *34th Euromicro Conference on Real-Time Systems (ECRTS 2022)*
[C2]	*"Introducing k4. 0s: a Model for Mixed-Criticality Container Orchestration in Industry 4.0"* *M. Barletta, M. Cinque, L. De Simone, R. Della Corte* *7th IEEE Cyber Science and Technology Congress (CyberSciTech 2022)*
[C3]	*"RunPHI: Enabling Mixed-criticality Containers via Partitioning Hypervisors in Industry 4.0"* *M. Barletta, M. Cinque, L. De Simone, R. Della Corte, G. Farina, D. Ottaviano* *33rd IEEE International Symposium on Software Reliability Engineering (ISSRE 2022) – Fast Abstracts*
[C4]	*"Hierarchical Scheduling for Real-Time Containers in Mixed-Criticality Systems"* *M. Barletta, M. Cinque, R. Della Corte* *32nd IEEE International Symposium on Software Reliability Engineering (ISSRE 2021) – Fast Abstracts*