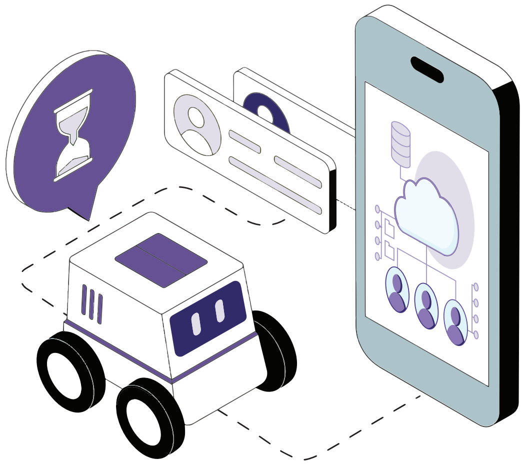
Robotic Logistics



Mobile robots for Industry 4.0, smart logistics, and retail are resource-constrained and battery-powered mobile robots that operate in shared spaces with humans and other IoT devices, such as elevators, automatic doors, and other mobile robots. For autonomous operation, mobile robots are equipped with sensors and high-performance computational algorithms that (1) need considerable computing power and (2) need to be executed at the highest speed.

PROBLEM

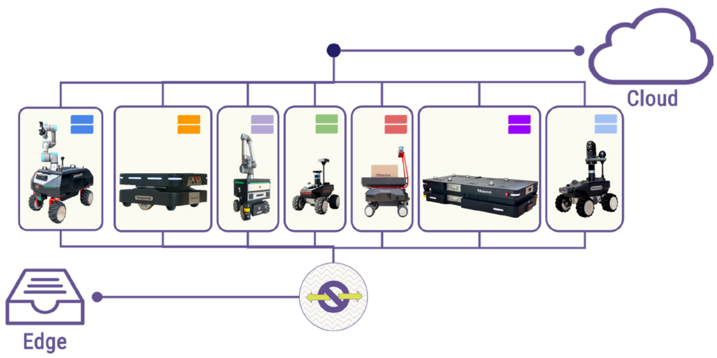
This kind of robotics, by definition, uses battery-powered devices, unlike stationary robot arms. This adds constraints to an already complicated application. In robotics logistics, idle robots are not productive. And intrinsically, robots need to charge their batteries to continue working. During this time, the robot is not available to move things around.

The robot's software is complex and requires heavy computation, so it is mandatory to equip the robot with powerful enough computing engines that, however, should limit the consumed power. Onboarding an ultra-low-resource device will lead to a robot that is not capable of processing the required tasks, and onboarding an ultra-high-resource device will deplete the battery very quickly.

There is an additional relationship between the computer load and the battery drain. Heavy computational tasks drain the battery faster.

CURRENT APPROACH

To solve the above computing problem with the current technology, we can follow either one of the following two approaches: **(a) CENTRALIZED PROCESSING**, **(b) INDIVIDUAL COMPUTING**.



a Centralized Processing

The robot fleet operates under a centralized communication architecture, whereby the intelligence (i.e., processing resources and software) is placed in a central component, such as the fleet manager (or orchestration system). All communication between the individual robots and the fleet manager is routed through an intermediary edge or cloud device. In this setup, the central device acts as a hub that (a) implements processing algorithms, and (b) facilitates and controls the communication flow within the network.

This centralized approach may introduce a single point of failure and potential latency issues as all communications must pass through the central hub, and it is not appropriate when robots may experience connectivity issues (e.g., poorly connected area in a factory).

b Individual Computation

In this approach, robots typically compute everything on the device itself. This practice, however, may lead at least to three main problems.

First, computational inefficiency, as it may result in scenarios where some robots remain idle and underused, while others are overwhelmed with computational tasks, nearing the point of overloading their onboard computers.

Secondly, over-dimension of the available computing resources (or, alternatively, the necessity to deploy simplest computing algorithms), given that the necessary hardware resources to comply with peak computing demands must be available on the robot itself; alternatively, to save on the cost of the above hardware, simplest (and less resource-hungry algorithms, but also less efficient) should be used.

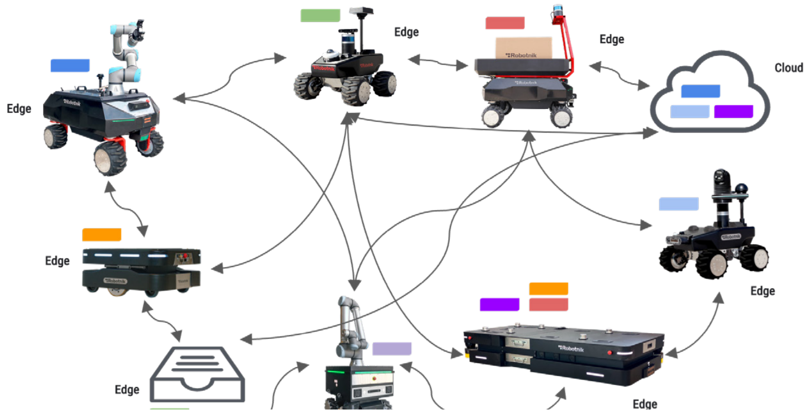
Thirdly, excessive battery usage, as all the processing happens on the robot itself, substantially draining the battery power, which is particularly important on small robots (with a small-size battery, while computing power for robot navigation and other algorithms is an invariant with respect to the size of the robot.

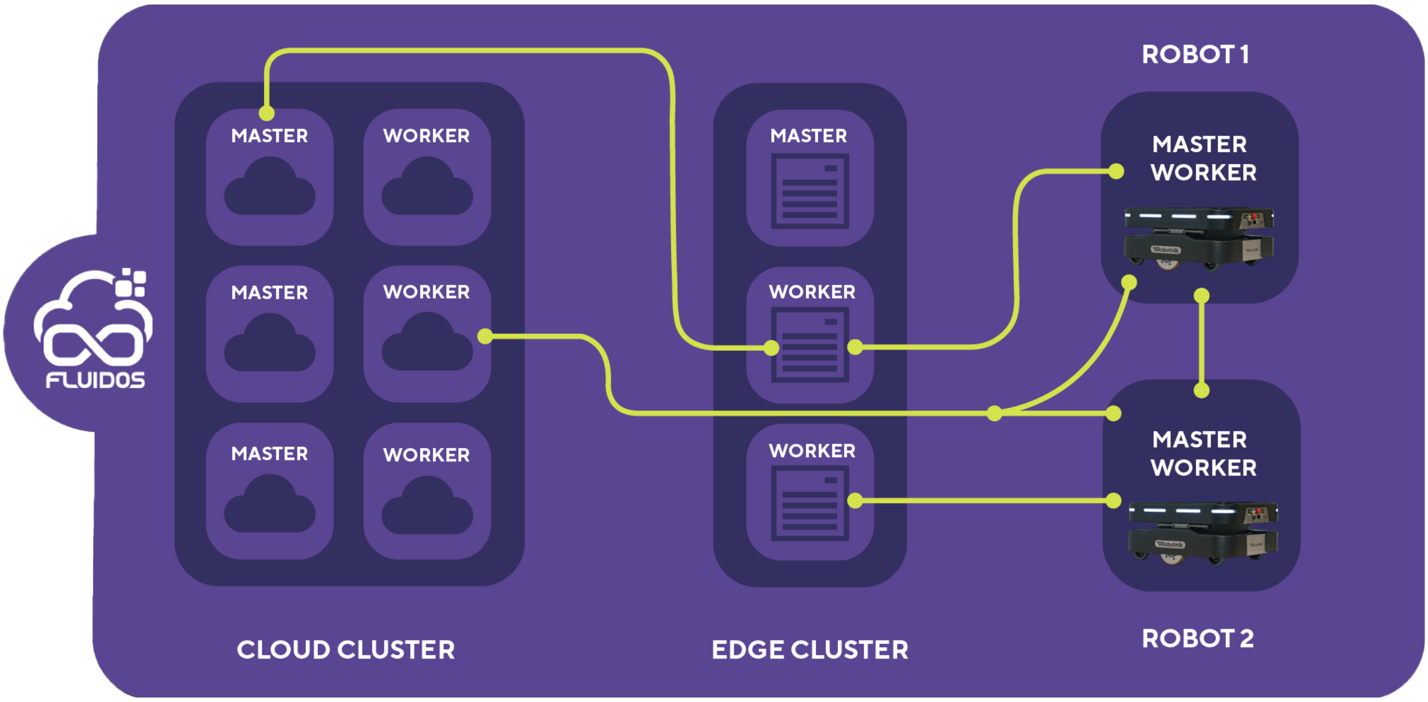
FLUIDOS APPROACH

The FLUIDOS continuum has the capability to transparently use computing resources nearby, increasing the overall system‘s productivity by intelligently and dynamically externalizing the robotics workload to other devices (e.g., a server at the factory premises) and/or using the robot‘s idle time (i.e., when the robot is docked in the battery charging station) to increase the entire system‘s computational capabilities. Each robot can leverage this approach when it is well-connected to the network, while it can rely on its sole onboard computing capabilities (which are turned on only upon necessity) when moving in a poorly connected area.

This approach will lead to a significant decrease in battery usage and an increase in the robot's computational capabilities beyond its onboard limits, with the capability to dynamically adapt its computing behavior (i.e., onboard or offloaded) based on the actual operating conditions.
With FLUIDOS, we can apply the cloud continuum computing approach by considering each robot as an edge device and intelligently and dynamically outsourcing robotics workloads to other robots or devices depending on the environment. This can be achieved without interfering with the robotics task, so robot developers will be able to run their applications without changing their way of working.

Instead of using monolithic bare-metal workloads, the robots will use cloud-native technologies like containerization and Kubernetes to split and dynamically place the workloads in different devices. All robots will be treated as edge devices that can accept or externalize workloads, instead of being isolated devices





Given the potential capability of the FLUIDOS intent-based orchestrator to pursue different objectives, workload distribution among the different available systems can be optimized to achieve diverse goals such as:

- Maximize the battery life of the robots.
- Minimize the time it takes for the robots to complete their tasks.
- Ensure that all of the robots are evenly utilized.
- Avoid overloading any individual robot.

Highly dynamic decisions can be envisioned as well. For example, if a robot is low on battery, FLUIDOS might move its workloads to other robots with more battery power. Or, if a robot is overloaded, FLUIDOS might move some of its workloads to other robots that are less busy.
In a nutshell, the FLUIDOS approach to robot workload orchestration enables to improve the performance, efficiency, and reliability of your entire system.

FLUIDOS ADVANTAGES

- Increased robot capabilities by using more powerful stationary devices without compromising battery life.
- Ability to use the robot fleet for non-robotic tasks, increasing the value of the fleet.
- Decreased battery usage and increased robotic fleet productivity.
- Reduced deployment time using cloud-native technologies.
- Reduced costs by onboarding lower-resource computational devices.

KEY PERFORMANCE INDICATORS (KPI'S)

Improved lifetime of running vehicles, due to better usage of the battery: at least 15%.

Increased speed of the moving robots due to the capability to leverage smarter services running at the edge: at least 15%.

Potential reduction of the number of robots required to serve a factory: at least 10%.

Reduction of the cost of the computing hardware installed on each robot: at least 10%.