## micro-ROS Market

micro-ROS is contributing to the faster growth of a competitive industry of small robots and robot components manufacturers, enabling European companies to rapidly deliver robotic products integrating highly resource-constrained devices.

*Bringing all the benefits from the ROS technology into robotics product development*

*Accelerate the adoption of robotics in multiple domains*

*Increase development efficiency*

*Reduce costs*


## Why adopting it?

***ROS interoperability***
micro-ROS is joining forces with all the capabilities of ROS by bringing the ROS APIs to microcontrollers. Porting of advanced application-level software (e.g., for self-localization, obstacle avoidance) is simplified.

***Reduce development costs and risks***
By integrating microcontrollers into ROS, the developer can benefit from all ROS tools and advanced introspection, diagnostics, runtime configuration and monitoring features.

***Faster time to market***
micro-ROS is enabling rapid delivery of robotic products that integrate highly resource-constrained devices.

***Wide community support***
micro-ROS is enjoying a broad support from the ROS community. It is accessing a large base of users already working with the platform and bringing to Europe a key feature of this big robotic initiative.

***Widening verticals adoption***
micro-ROS redefines the boundaries of the ROS ecosystem by extending the range of applications (Industry 4.0, IoT, ...).

μROS

- *Global open-source project under permissive licenses*
- *Receives contributions from the world-wide ROS community*
- *Well-aligned with the on-going development of ROS 2*

***micro-ros.github.io***
*Getting started • Tutorials • Concepts • Blog*

***github.com/micro-ROS***
*Source code • Issue tracking • Developers*

***discourse.ros.org** and **answers.ros.org***
*Tag your micro-ROS questions/discussions with #embedded*

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European Commission

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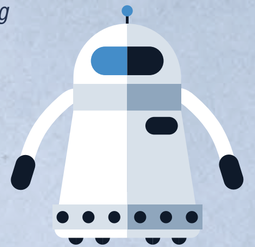
# micro-ROS: a robotic framework

*bridging the gap between resource constrained and larger processing units in robotic applications*



*Microcontrollers no longer being inflexible black boxes*

*Brings ROS programming interface to resource-constrained devices*

*Seamless integration into ROS 2 based systems*


*Lowers market entry barriers*

μROS

# micro-ROS: at a glance

***1. micro-ROS*** is the robotic framework that bridges the gap between resource constrained and larger processing units in robotic applications.

***2. micro-ROS*** is compatible with the Robot Operating System (ROS 2), the de facto standard for robot application development.

***3. micro-ROS*** empowers resource constrained devices and brings ROS 2 programming interfaces into them. This makes resource constrained devices first class participants of the ROS ecosystem, reducing the cost and size of robots.

***4. micro-ROS*** enables the interoperability that distributed robotic systems demand to exploit the increasing overlap between robotics, embedded devices and IoT.

ROS

***Plumbing***
*Process management*
*Communication*
*Device drivers*
*Data models*
*Language-independence*

***Tools***
*Visualization*
*Simulation*
*Data recording*
*Monitoring*

***Capabilities***
*Control*
*Perception*
*Planning*
*Manipulation*

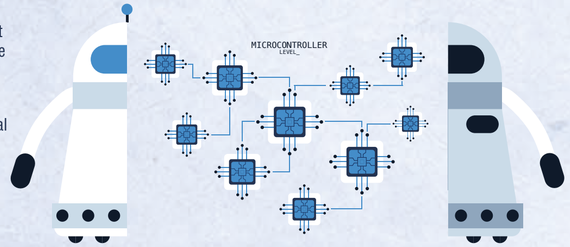
***Ecosystem***
*Shared development*
*Robot models*
*Documentation*
*Exchange*
*Market*

# What is the Robot Operating System?

ROS is a middleware, development framework and toolbox for robotics software development. It has a huge, continuously growing and fast-paced community behind it and has probably become the largest open-source initiative undertaking in robotics. Its main contributions are:

- A service oriented architecture and communication mechanisms to support the assembly and orchestration of robotic software components as well as their interoperability with hardware drivers.
- A rich set of tools to develop, visualize, operate and maintain robot applications.
- Multi-language support: C++, Python, Java, C#, JavaScript, Ruby, ...
- Ready-to-use software components with functional capabilities for robot perception, control, planning, navigation and manipulation.

***New to ROS? Start your journey at www.ros.org***




# Microcontrollers in robotics

Most robots are networks of microcontrollers and larger microprocessors. There are many reasons for the use of microcontrollers in robotics:

***Hardware access***
Microcontrollers provide rich input/output capabilities including GPIOs, AD converters, and PWM generators. They feature hardware support for communication buses such as CAN, UART, SPI, or I²C.

***Hard, low-latency real-time***
Real-time operating systems (RTOS) for microcontrollers allow context switching in less than 100 cycles - a magnitude less than with common desktop operating systems. Most RTOS require only few milliseconds to boot.

***Power saving***
Microcontrollers consume 10 to 100x less power than single-board computers for desktop operating systems. Many microcontrollers feature several low-power sleep modes.

***Safety***
There exists a rich variety of microcontrollers for safety-critical applications. Similarly, a number of safety-certified RTOSs are available.

***Integrated motor drive***



***Packaged sensor component / Safety module***



***Power-efficient infrastructure sensor***



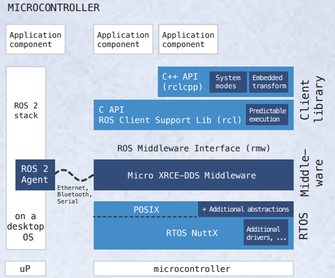
***Ultra-light motion controller***

# Microcontrollers and ROS

The ROS community has tried to support microcontrollers in the past and as part of the redesigned upcoming release ROS 2. These attempts unveiled various design choices in ROS and ROS 2 that render such porting impossible. These choices include the use of the DDS middleware in ROS 2, which is not intended for highly resource-constrained devices, the non-consideration of power efficiency requirements and the lack of advanced real-time scheduling capabilities, amongst others.

***This is, where micro-ROS comes into play ...***

# micro-ROS features and architecture

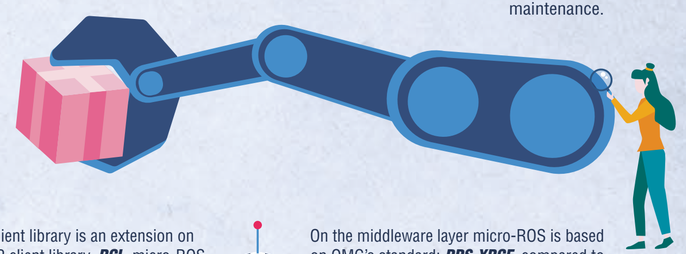



The most important differences of the ***micro-ROS*** stack compared to standard ROS 2 are on the lower layers:

micro-ROS uses a real-time operating system (***RTOS***) and not a desktop operating system like Linux. Currently, micro-ROS supports NuttX and FreeRTOS.

***DDS-XRCE*** instead of standard DDS.

Apart of those layers, micro-ROS uses ROS 2 core stack layers, granting compatibility and ensuring long-term maintenance.



***micro-ROS*** client library is an extension on existing ROS 2 client library, ***RCL***. micro-ROS will add dedicated modules to the existing approach adding concepts appealing to microcontrollers such as:

- A new predictable execution model.
- A model-based approach for runtime system configuration:

On the middleware layer micro-ROS is based on OMG's standard: ***DDS-XRCE***, compared to ROS 2 DDS base layer, micro-ROS underlying middleware layer is:
Designed and created to bridge DDS and embedded devices Client-Server architecture.
Focused on low resource consumption.

Micro-ROS is focused on embedded devices and more concrete, microcontrollers used with an RTOS. The use of an ***RTOS***.
Provide HW abstraction.
Provide already known APIs, like POSIX.
Use of tools to configure-build-deploy firmwares.


***Benchmarking*** of embedded environments is also a point of interest for micro-ROS and several benchmarking tools will be provided.