# Comparative Analysis of ROS-1, ROS-2 and ROS-I

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# Overview

- Robot Operating System (ROS) is a meta-OS
  - **Plumbing:** communication middleware (e.g. nodes, topics, messages, services, etc.)
  - **Tools:** monitor, visualize and debug (e.g. rqt, rviz, etc.)
  - **Capabilities:** out-of-the-box support for robot mobility and manipulation (e.g. perception, planning, control)
  - **Community:** developers and contributors across the globe (e.g. Open Robotics, Autoware, F1Tenth, etc.)


Source: ROS.org

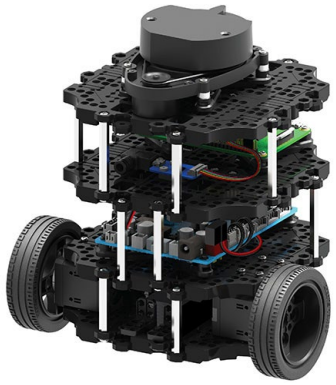
# Overview

- ROS roadmap
  - **ROS-1:** Developed for PR2, extended for academic R&D
  - **ROS-2:** Extension of ROS with new, lightweight middleware
  - **µ-ROS:** Support for embedded and real-time applications
  - **ROS-I:** Extension of ROS to industrial robots and standards

# Applications

- ROS-1
  - Hobby and academic robots (manipulator + mobile) across varying scales
  - ROS official robot - TurtleBot
  - List of robots supported by ROS
  - List of companies using ROS
- ROS-2
  - Most/all ROS-1 robots are migrating to ROS-2
  - List of robots running ROS-2
- ROS-I
  - Industrial robots (mostly manipulators as of now)  and equipment (PLC, HMI, IO Networks, etc.)
  - List of supported hardware

**From hobby projects to industrial robots, and everything in between!**



Source: ROBOTIS

Source: Clearpath

Source: Bitcraze

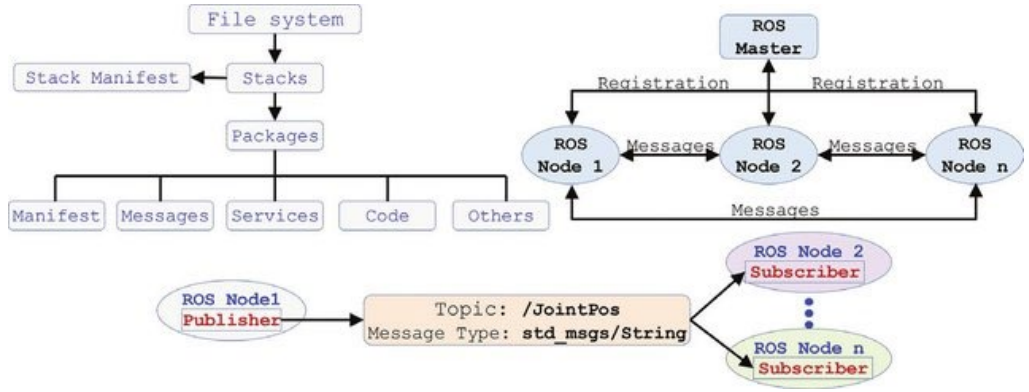
Source: Unitree

Source: BlueRobotics

Source: ABB

# Deployment Architecture

## ROS-1

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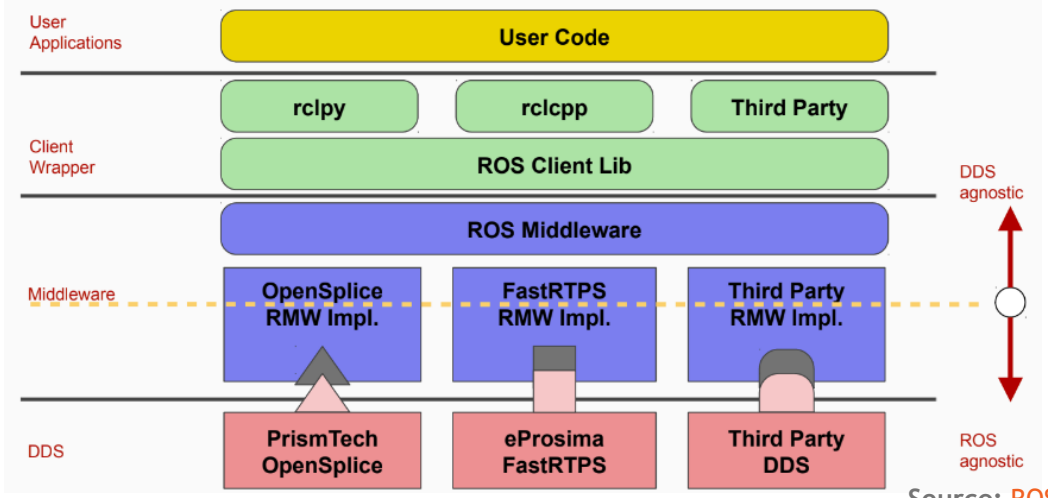
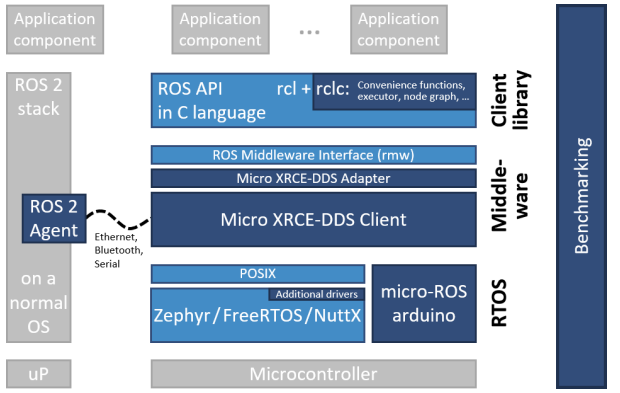
## ROS-2



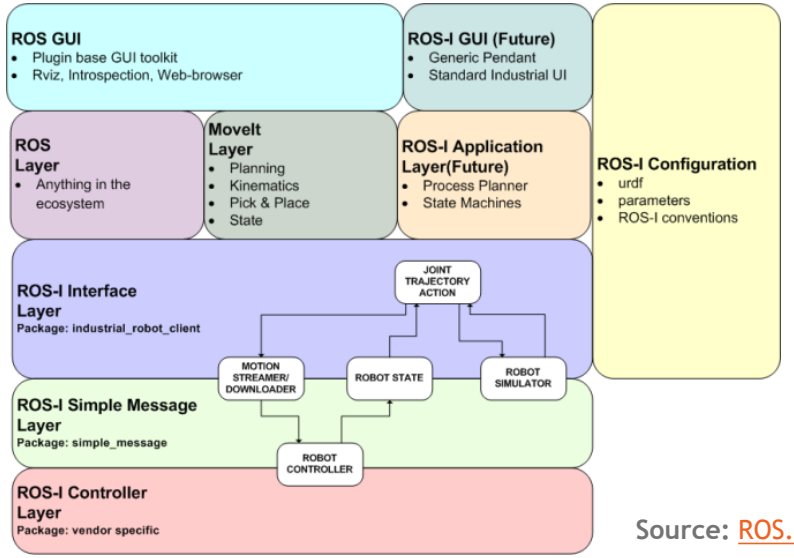

Source: ROS.org

## μ-ROS




Source: ROS.org

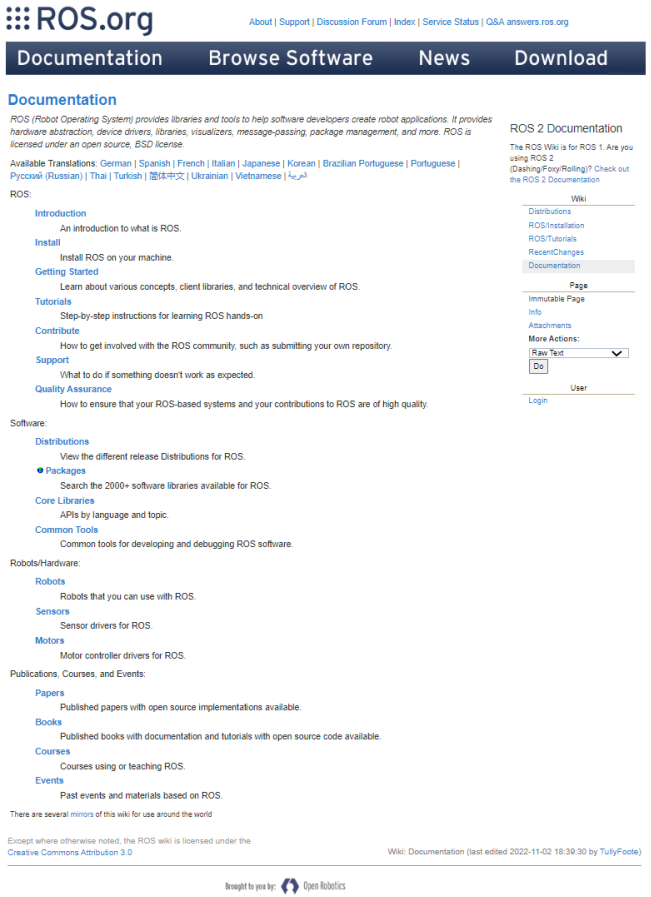
## ROS-I




Source: ROS.org

# Resources

- Documentation homepage (ROS-1 + ROS-2): https://docs.ros.org
- ROS wiki, installation and tutorials; ROS-I wiki
- YouTube videos
  - ROS Tutorials by Justin Huang
  - ROS-TurtleBot Tutorials by Tinker Twins
- MOOCs centred around ROS-1 and ROS-2
  - Programming for Robotics - ROS, ETH Zurich
  - Hello (Real) World with ROS – Robot Operating System, TU Delft
  - Udemy courses
- Books for learning ROS
  - ROS Robot Programming, A Handbook is written by TurtleBot3 Developers



# Comparative Analysis

| Criteria | ROS-1 | ROS-2 | ROS-I |
|---|---|---|---|
| Architecture | Centralized Discovery | Distributed Discovery | Centralized Discovery |
| Multi-Agent Support | Not ideally | Yes | Future |
| Real-Time Capability | No | Yes | Future |
| Embedded Platforms | Partially | Yes | Yes |
| Non-Ideal Networks | No | Yes | Future |
| Life-Cycle Management | No | Yes | Future |
| Industrial Support | No | No | Yes |
| Documentation | Mature | Increasing | Ongoing |
| Maintenance Support | Nearing EOL | Increasing | Increasing |
| Language Support | C++03/11, Python2 | C++11/14/17, Python3 | C++03/11, Python2 |
| OS Support | Linux, macOS | Linux, macOS, Windows, RTOS | Linux, macOS |
| Recommended Scope* | Hobby, Academic | Professional, Real-Time | Industrial |

*Recommendation is based on critical analysis presented in rows 1-11

# References

1. M. Quigley, K. Conley, B. Gerkey, J. Faust, T. Foote, J. Leibs, R. Wheeler, and A. Ng, “ROS: an open-source Robot Operating System,” in ICRA 2009 Workshop on Open Source Software, vol. 3, Jan 2009. [Online]. Available: http://robotics.stanford.edu/~ang/papers/icraoss09-ROS.pdf
2. S. Macenski, T. Foote, B. Gerkey, C. Lalancette, and W. Woodall, “Robot operating system 2: Design, architecture, and uses in the wild,” Science Robotics, vol. 7, no. 66, p. eabm6074, 2022. [Online]. Available: https://www.science.org/doi/abs/10.1126/scirobotics.abm6074
3. R. R. Shamshiri, I. A. Hameed, and M. K. a. Weltzien, "Robotic Harvesting of Fruiting Vegetables: A Simulation Approach in V-REP, ROS and MATLAB", in Automation in Agriculture - Securing Food Supplies for Future Generations. London, United Kingdom: IntechOpen, 2018 [Online]. Available: https://www.intechopen.com/chapters/59402 doi: 10.5772/intechopen.73861

# Thank You!