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Robot Operating System Middleware in System Architecture for Lab Automation

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1 Motivation

Increase laboratory autonomy using *task specific machines* and *general-purpose robots*:
- Generalize **device agnostic** equipment interfaces
- **Mapping** process level and automation level
- Definition and implementation of a multi-layer **reference automation framework**, like *LAPP*[A]

2 System Architecture

The referenced *LAPP* framework utilizes both SiLa as a device communication protocol and ROS2 as a **robotics middleware**. Table 2 shows a blueprint of which features to expose at which abstraction level.

Table 1: The role of ROS2 in the *LAPP* framework. The example is a general-purpose robot used for liquid transfer.

Protocol	Controller Level [Location]	Methods
SiLa	Automation Scheduler [Lab]	**Task** – Transfer labware
SiLa	Action Controller [Arm]	**Action** – pick – place
ROS-SiLa Bridge: SiLa Server & ROS Client		
ROS2	Motion Sequencer [Arm]	**Motion Sequence** – follow trajectory sequence – grip labware
ROS2 (*MoveIt*)	Motion Controller [Arm]	**Motion Primitives** – follow trajectory (joint/cartesian) – get/set gripper width
Hardware Interface (Custom/Manufacturer Provided)		
I2C, UART, CAN, ...	Embedded (Sensors/Actuators) [Joint]	**Joint Primitives** – get/set joint position/velocity – get/set gripper joint position

Robot Operating System (ROS2) Collection of open software libraries and tools for robotic control. Role of a middleware, bridging the gap between device specific automation control and device-agnostic procedures. **Industry standard** in research and highly active development community. Deploying ROS2 to all general-purpose manipulators in the lab reduces necessity of custom drivers. Hardware manufacturers publish control packages for their products to promote **interoperability**.

Standardization in Lab Automation (SiLa) Open, device agnostic communication standard for laboratory automation on abstract process levels. Devices can expose a SiLa Server which wraps the device API ensuring compatibility with a broader range of clients.

3 BIOSCARA - DIY Robotic Manipulator

With a total material cost of **6000 kr.** a low-cost labware handling robot used for **testing** and **validation** of autonomous workflows. Currently undergoing modification to deploy the ROS2 middleware which includes writing a custom hardware interface. Target scenario could be machine tending with a Opentron liquid handler.

Figure 1: Bioscara - The DIY SCARA Manipulator

[A] Zsoldos, Wolf, Széll, Galambos, Towards robotic Laboratory Automation Plug & Play: LAPP reference implementation with the TIAGo mobile manipulator, SLAS Tech., Vol. 31, 2025