University of Idaho
Department of Computer Science
Coeur d'Alene

A Vandalized Introduction to ROS2

written by barbarians for barbarians!

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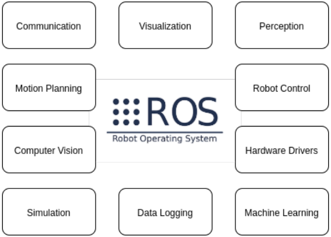
Table of Contents

- What is ROS2?
  - Abstracting Machines as Data
  - The ROS2 Stack
- ROS2 Concepts
  - Topics
    - Topic Illustration
  - Actions
  - Services
  - Client Libraries
  - Workspaces
- Installing ROS2!

What is ROS2?

From the Horse's Mouth

The Robot Operating System (ROS) is a set of software libraries and tools for building robot applications. From drivers and state-of-the-art algorithms to powerful developer tools, ROS has the open source tools you need for your next robotics project.



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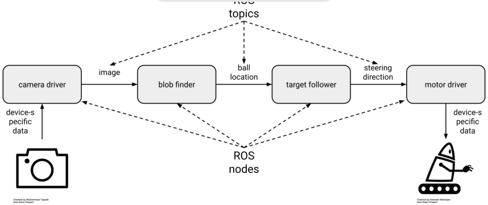
- Open source software! Whoopee!
- Tries to abstract robots and sensors as **producers** and **consumers** of data
- Solves *almost* as many problems as it creates

Abstracting Machines as Streams of Data

what we see

what ros sees



Abstracting Machines as Streams of Data

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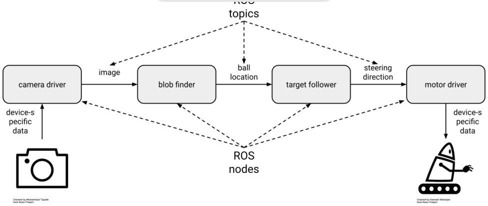


Created by Muhammad Tajudin from Noun Project

Created by Kamesh Maharjan from Noun Project

What is a Node?

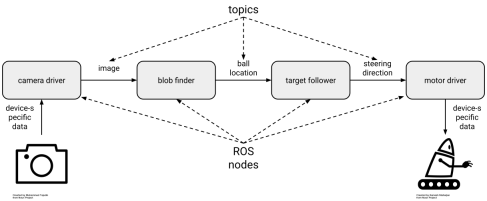
A node is a participant in the ROS 2 graph, which uses a client library to communicate with other nodes. Nodes can communicate with other nodes within the same process, in a different process, or on a different machine. Nodes are typically the unit of computation in a ROS graph; each node should do one logical thing.

ROS Concepts Documentation Link

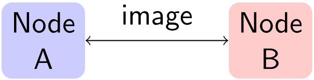
Abstracting Machines as Streams of Data

what we see

what ros sees



Nodes in Example: camera driver, blob finder, target follower, motor driver



Abstracting Machines as Streams of Data

what we see

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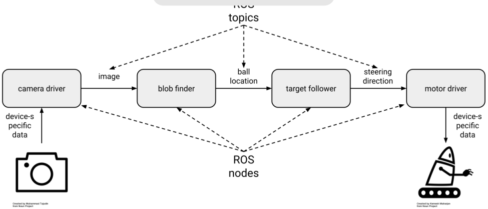

- **camera driver :** **producer** interfaces with hardware to capture image, then publishes to topic (**image**)

Abstracting Machines as Streams of Data

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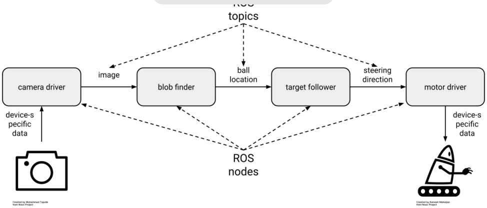
what ros sees



- **camera driver :** **producer** interfaces with hardware to capture image, then publishes to topic (**image**)
- **motor driver :** **consumer** consumes data from topic (**steering direction**) and then interfaces with motors to move forward

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Abstracting Machines as Streams of Data

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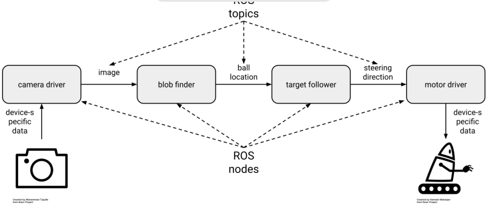
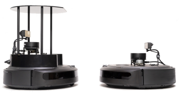


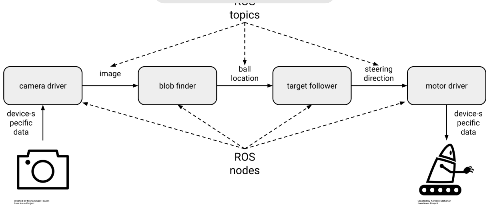
- ROS2 refers to nodes that are **producers** as **publishers**
- can publish as needed or at a frequency, ex. 10Hz
- topics are identified with a path, ex. */robot/odom*

Abstracting Machines as Streams of Data

what we see

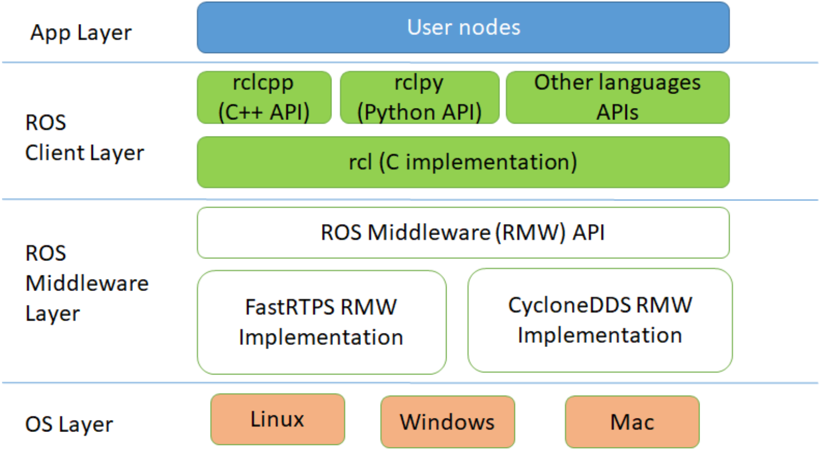


what ros sees

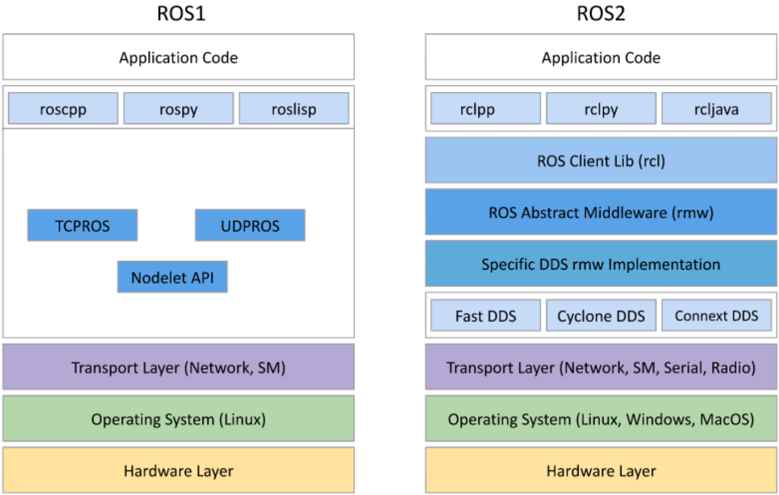


- ROS2 refers to nodes that are **consumers** as **subscribers**
- subscribers use path to subscribe to a topic

The ROS2 Stack



The ROS2 Stack



ROS2 Concepts

Topics, Actions, Servers, Workspaces, and Client Libraries

Topics

- topics created by publishing/subscribing nodes
- available to all devices on network
- topics are forward slash separated paths
- messages are strongly typed structs
- messages are anonymous by default

ROS2 Topics Example Link

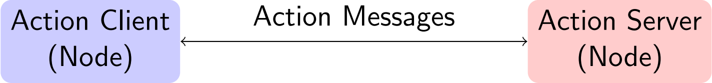
Topic Illustration: Using A Standard ROS2 Topic

So what does a topic message consist of?

topic: `/odom [nav_msgs/msg/Odometry]`
topic message:

```
# This represents an estimate of a position and velocity in free space.
# The pose in this message should be specified in the coordinate frame given by header.frame_id.
# The twist in this message should be specified in the coordinate frame given by the child_frame_id
Header header
string child_frame_id
geometry_msgs/PoseWithCovariance pose
geometry_msgs/TwistWithCovariance twist
```

Actions



Action Client (Node)

Action Messages

Action Server (Node)

Action

Consists of three parts:

- Goal: *a message containing what you wish to be done*
- Feedback: *a message from the action server*
- Result: *the success/failure message from server*

Check out the example tutorial and documentation:

ROS2 Actions Documentation Link

Services are call and response versions of topics

Services

While topics allow nodes to subscribe to data streams and get continual updates, services **only provide data when they are specifically called by a client**.

Used to request that computation heavy tasks be completed by another node. (Google, tell me the 10th digit of Pi!)

- consist of a *request* and a *response*

Services GIF Link

Client Libraries provide access to the ROS2 API including:

- Node functions
- topic pub/sub functions
- actions
- services

available for C++, Python, and more!

ROS Client Libraries Link

RCL Example

```
node = rclpy.create_node('minimal_publisher')
publisher = node.create_publisher(String, 'topic', 10)
```

GitHub RCL Examples Link

RCL Inheritance

```
import rclpy
from rclpy.node import Node

from std_msgs.msg import String


class MinimalPublisher(Node):

    def __init__(self):
        super().__init__(’minimal_publisher’)
        self.publisher_ = self.create_publisher(String, ’topic’, 10)
        timer_period = 0.5  # seconds
        self.timer = self.create_timer(timer_period, self.timer_callback)
        self.i = 0
```

Example Source Code

Workspaces

Workspaces

A workspace is a directory containing ROS 2 packages. Before using ROS 2, it's necessary to **source** your ROS 2 installation workspace in the terminal you plan to work in. This makes ROS 2's packages available for you to use in that terminal.

Package

A package is an organizational unit (directory) for your ROS 2 code. Packages may contain metadata and scripts that help run and build the package.

Example Workspace Structure: Pre-Build

```
workspace_folder/
    src/
      cpp_package_1/
          CMakeLists.txt
          include/cpp_package_1/
          package.xml
          src/

      py_package_1/
          package.xml
          resource/py_package_1
          setup.cfg
          setup.py
          py_package_1/
      ...
      cpp_package_n/
          CMakeLists.txt
          include/cpp_package_n/
          package.xml
          src/
```

Workspaces Expanded

Workspaces:

- start as a directory with a `src/` subdirectory
- use `ros2` CLI to generate package metadata files `src/<pkg_name>`
- building generates more files, which are placed in the root of the workspace directory

Workspaces Expanded

Package Dependencies

Packages may have dependencies on other packages in the workspace/ROS2 install! How will packages in `ros_ws/src/<pkg_name>` resolve dependencies??

Workspaces Expanded

Sourcing!

Sourcing refers to the `source` command in Linux. Sourcing causes the system shell (ex. bash) to execute the contents of a file, *making the contents available to the system.*

Example

After building a package, `local_setup.sh` is generated and placed in `ros_ws/install`, running `source install/local_setup.sh` allows ROS2 code to be run inside the workspace.

```
$ source local_setup.sh
```

Installing ROS2

So. . . what next?

Guides and Resources

- ROS2 Humble Hawksbill Installation Guide Link
- ROS2 Humble Hawksbill Documentation Link
- ROS2 REPs Link
- ROS Community Forums Link

Tutorials

- ROS2 CLI Beginner Tutorial
- ROS2 Beginner Client Libraries