ROS & ROS2: What, why, how...?

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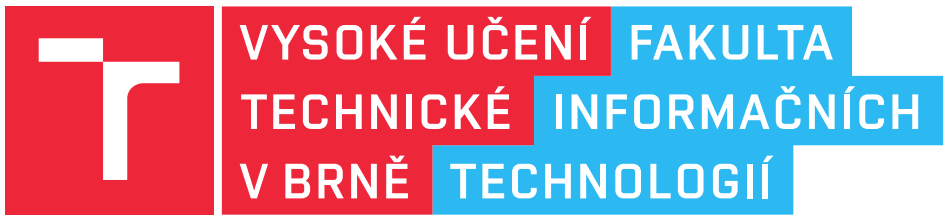

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Overview

ROS

- Basics
- Simple demo
- Commands, tools
- Packages demo
- Turtlebot demo

ROS2

- Differences
- Turtlebot2 demo
- PubSub2 demo

ROS

What is ROS?

According to ChatGPT:

ROS stands for Robot Operating System. It's a flexible framework for writing robot software. Despite its name, ROS is not an actual operating system; rather, it provides services like hardware abstraction, device drivers, communication between processes, and package management. It's widely used in the field of robotics for developing and controlling robots.

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- In other words...
  - (Not only) open–source framework used in robotics.
  - Also tools, libraries, wrappers, adapters and conventions.
  - Node–based, centralised (will be covered later today).
  - Three main ways of how the nodes can exchange the data: publisher–subscriber, service, action. (will be covered).
  - Currently being put aside in favor of ROS2 :((will be covered, incl. why we are talking mainly about ROS 1).

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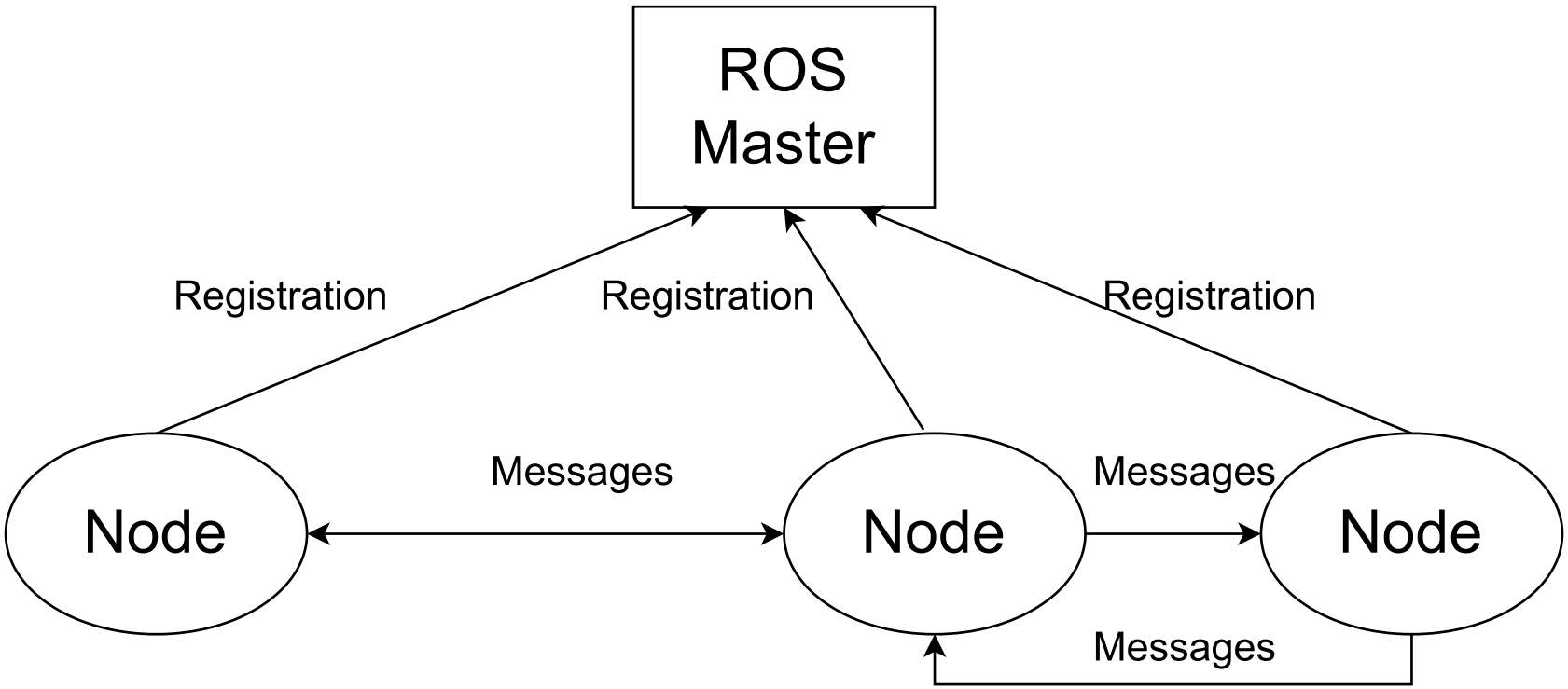
  - `http://wiki.ros.org/Documentation`

(Basics of) ROS in one picture



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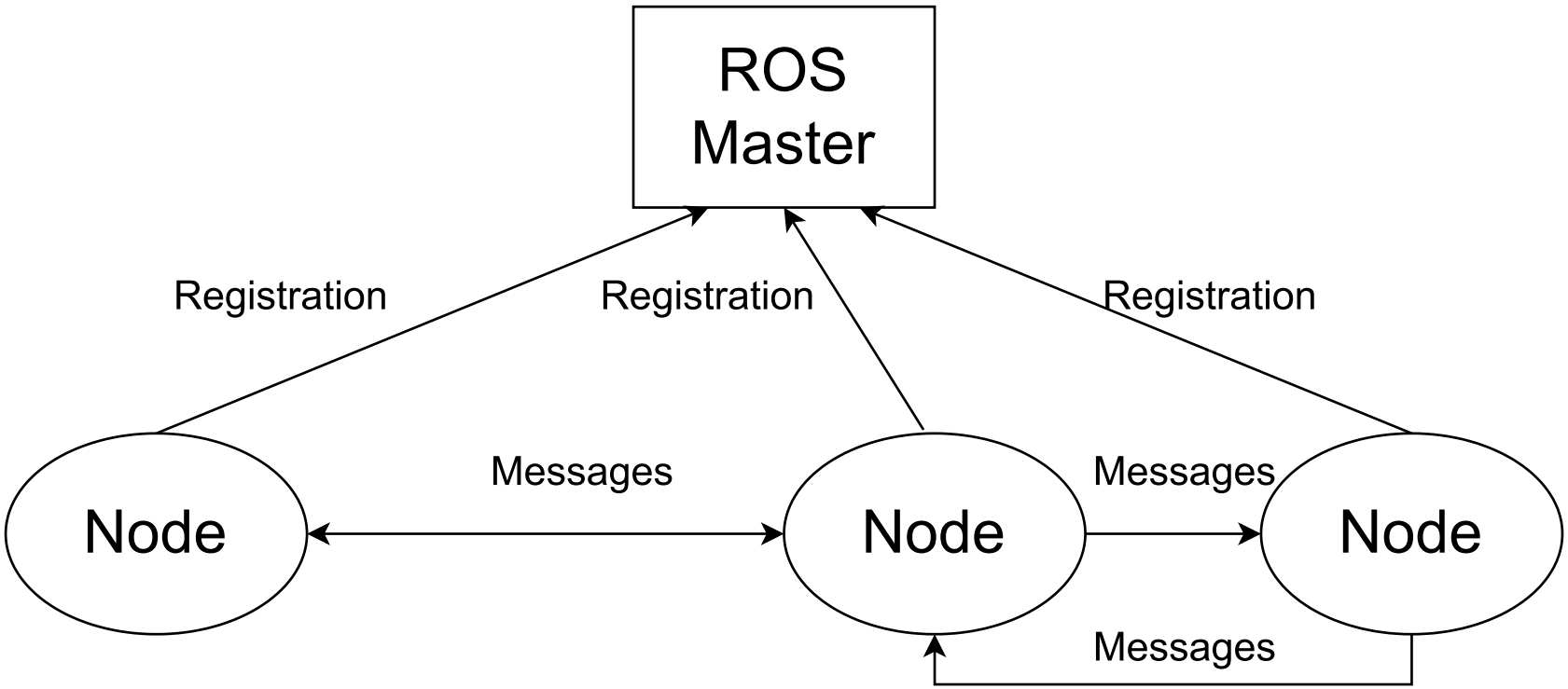


Not entirely true... You will see.

Why ROS?

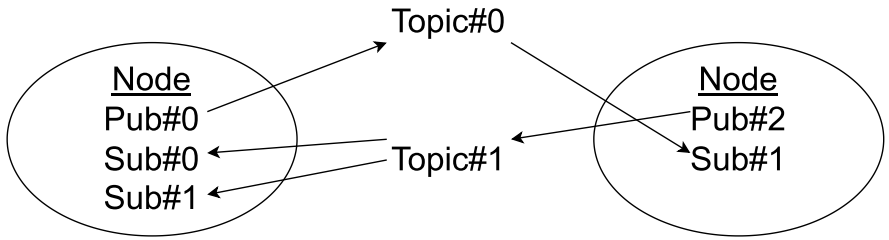
- Open–source
- Very versatile, widely used
- Many algorithms already implemented, clear, debug–friendly structure
- Functionality isolated into nodes and packages
- Used in space!
  - Robonaut2
  - `https://robots.ros.org/robonaut2/`

- **ROS master:** registers other nodes. Enables other nodes to locate one another[1].
  - You are mostly shadowed from it... Just run `roscore` and you are fine.
  - Wanna know more?
    -> `http://wiki.ros.org/ROS/Technical%20Overview`
- **Nodes:** One program in C++/Python which does one thing (moving, translating, reading from sensors...)
- **Topics:** "channels" used for communication. Structured like this: *general/specific/more-specific* (*robot/arm/joints/femur*). Every topic has defined...
- **...Message:** data structure, describing the format of data sent via the topic.

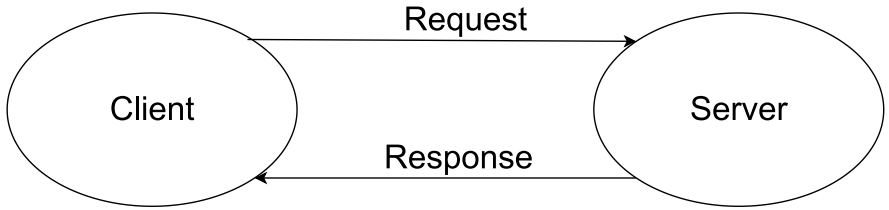
[1] The communication per se is P2P

Three ways of communication

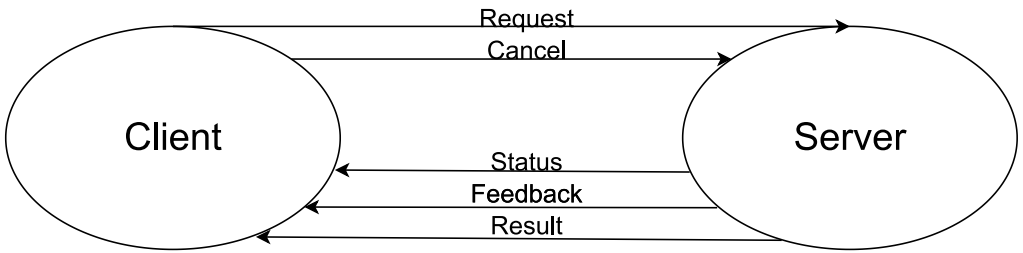
1. **Publisher–subscriber** via **topics** and **messages**
   - `http://wiki.ros.org/Topics`



2. **Services**
   - `http://wiki.ros.org/Services`



3. **(Actions)**
   - `http://wiki.ros.org/actionlib`



- Data structures (almost identical to C–like structures)
- Specify the data sent via specific topics
- **Use standard messages if available:**
  - `rosmsg show std_msgs` or `rosmsg show common_msgs`
  - `http://wiki.ros.org/std_msgs` (basic messages and datatypes)
  - `http://wiki.ros.org/common_msgs` (more complex widely used messages)

geometry_msgs/Pose Message

File: geometry_msgs/Pose.msg

Raw Message Definition

```
# A representation of pose in free space, composed of position and orientation.
Point position
Quaternion orientation
```

Compact Message Definition

```
geometry_msgs/Point position
geometry_msgs/Quaternion orientation
```

geometry_msgs/Point Message

File: geometry_msgs/Point.msg

Raw Message Definition

```
# This contains the position of a point in free space
float64 x
float64 y
float64 z
```

Compact Message Definition

```
float64 x
float64 y
float64 z
```

Simple demo

Every command in new terminal window:

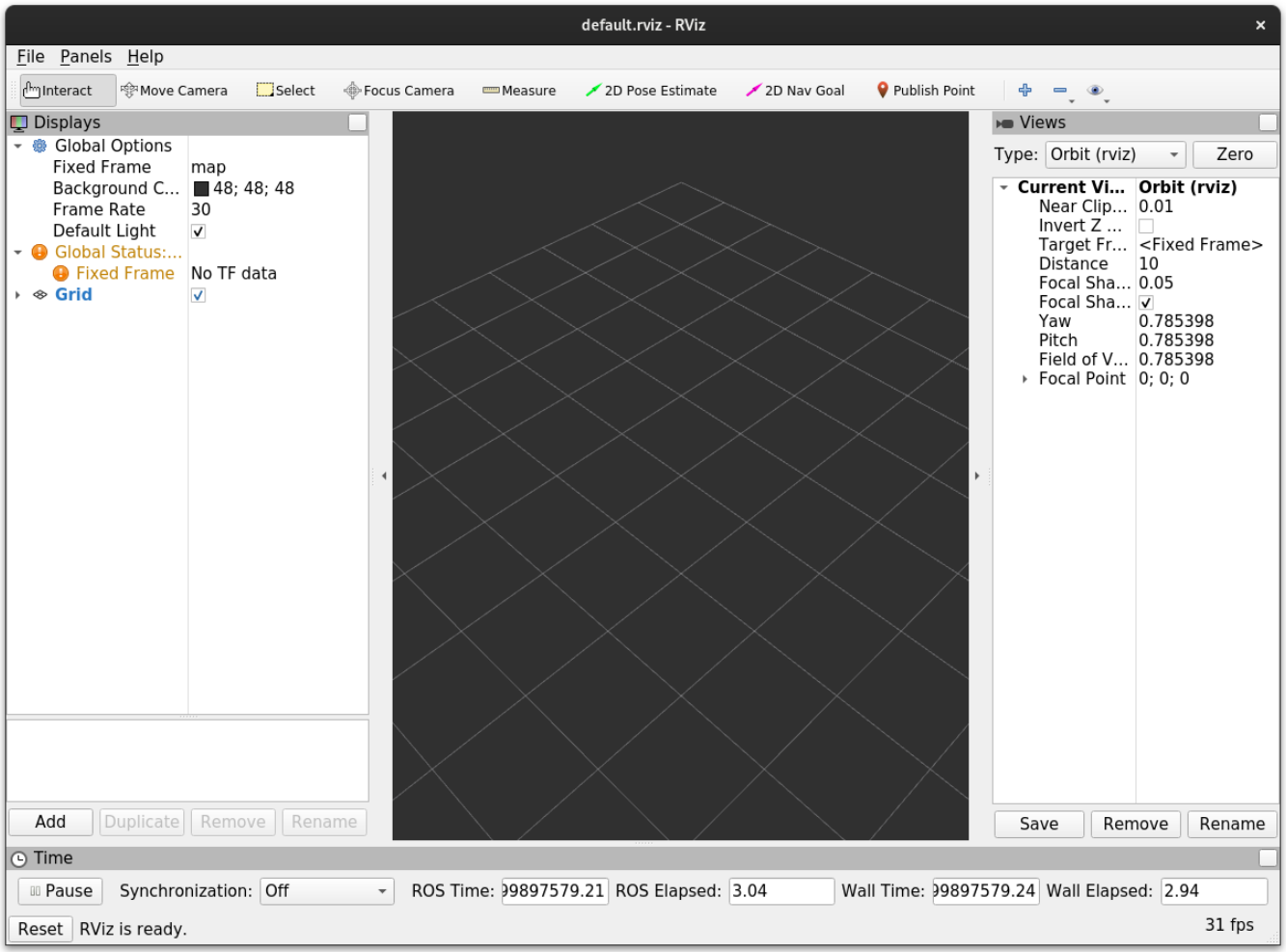
- `source /opt/ros/noetic/setup.bash`
- Run ROS master: `roscore`
- Make periodic publisher:
  `rostopic pub -r 1 /ROS/demo std_msgs/Int32 "data: 42"`
  - `-r 1` means 1 message per second
- Subscribe: `rostopic echo /ROS/demo`
- Check what topics are available: `rostopic list`
- Show info about some topic: `rostopic info /ROS/demo`
- Visualize the graph: `rqt_graph`

Commands, tools...

Commands

- `roscore`: starts ROS master node – first command you run.
- `rostopic`: work with topics and messages from command line
  - `pub [-r rate] topic message data`: publish messages to `topic`
  - `echo topic`: print messages to stdout from `topic`
  - `list`: list all available topics
  - `info topic`: get info about `topic` (pubs, subs, message type...
- `rosrun package node`: run one `node` from given `package`
- `roslaunch package launchfile`: run pre–made set of nodes (no need to run `roscore` separately).
- `roscd package`: like `cd`, but moves you directly to ROS `package`

- `rqt_graph`: visualizes nodes and topics.
- Other `rqt`–based commands.
- `rviz`
- `https://www.youtube.com/watch?v=34n1tF5OtQU`



Demo with packages and Python

How to make a ROS package

- http://wiki.ros.org/catkin/Tutorials/create_a_workspace
- http://wiki.ros.org/ROS/Tutorials/CreatingPackage
- http://wiki.ros.org/ROS/Tutorials/BuildingPackages
- mkdir -p /catkin_ws/src
- cd /catkin_ws/
- source devel/setup.bash
- catkin_create_pkg <package_name> <dependency1> <dependency2>...
- catkin_make

Demo with packages and Python

- `http://wiki.ros.org/ROS/Tutorials/WritingPublisherSubscriber%28python%29`
- Using Python, we will mimic:
  - `rostopic pub` with `talker.py`
  - `rostopic echo` with `listener.py`

```python
#!/usr/bin/env python3
import rospy
from std_msgs.msg import String

def talk():
    pub = rospy.Publisher("ROS_demo/talker", String,
                          queue_size=10)
    rospy.init_node("talker_node", anonymous=True)
    rate = rospy.Rate(2)
    cnt = 0
    while not rospy.is_shutdown():
        pub.publish("Hello World! {}".format(cnt))
        cnt += 1
        rate.sleep()

if __name__ == "__main__":
    try:
        talk()
    except rospy.ROSInterruptException: pass
```

```python
#!/usr/bin/env python3
import rospy
from std_msgs.msg import String


def callback(data):
    print("I received this: {}".format(data.data))


def listen():
    rospy.Subscriber("ROS_demo/talker", String, callback)
    rospy.init_node("listener_node", anonymous=True)
    rospy.spin()


if __name__ == "__main__":
    listen()
```

Turtlebot demo

- Beginner–friendly simulator
- (`roscore`)
- `rosrun turtlesim turtlesim_node`: start basic node
- `rosrun turtlesim turtle_teleop_key`: start teleoperation (move by keyboard)

- Robots needs to move themselves and their parts
- Every part has its own coordinate frame (start of coordinates)
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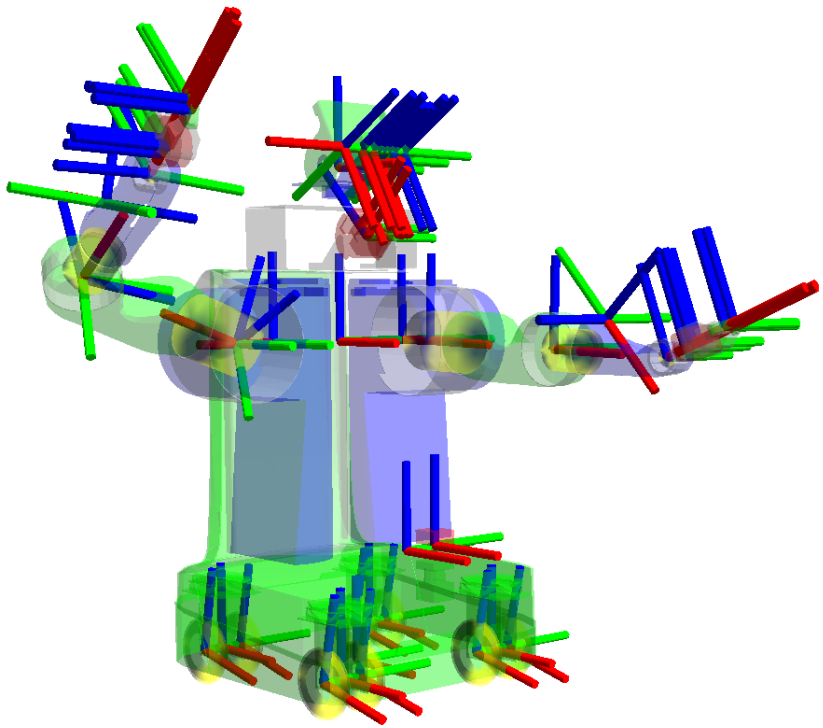
- `tf`!
- = library that represents and translates coordinate frames of every parts of the robot



- `sudo apt-get install ros-$ROS_DISTRO-rosserial-arduino`
- `sudo apt-get install ros-$ROS_DISTRO-rosserial`
- install Arduino IDE from source
- `cd ~/Arduino/libraries; rosrun rosserial_arduino make_libraries.py .`

ROS2

Why new ROS?

- ROS 1 started as a research project (and almost as a hobby).
- Some decisions locked ROS in previous decade:
  - Centralization
  - Custom protocols TCPROS and UDPROS
  - Poor network performance
- ROS2 fixes most of these things.

- Completely new communication paradigm: **DDS**.
  - Decentralized
  - Standardized
  - Several implementations(!)
- New paradigm, commands, workflow... :(

DDS in ROS2

- ROS2 using its own middleware over DDS: rmw.
- DDS itself can be of different implementations
- Distributed by implementation
- Nodes organized into domains (areas of communication)

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- ROS 1 is still widely used in existing projects.
- Some technologies do not work in ROS 2 (e.g. 8–bit MCUs, such as Arduino UNO/Mega)
- ROS 2 is still not as widely adopted as ROS 1 (something like Windows XP problem :))

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- TLDR: Don’t. :)
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- Some technologies do not work in ROS 2 (e.g. 8–bit MCUs, such as Arduino UNO/Mega)
- ROS 2 is still not as widely adopted as ROS 1 (something like Windows XP problem :))
- **–> Do not use ROS 1 in new project, but learn it because of existing ones! There are plenty of them – and they will be here for years and decades!**

Turtlebot2 demo

- `export ROS_DOMAIN_ID=<your_domain_id>`
- If you do not want to use ROS2 on multiple machines: `export ROS_LOCALHOST_ONLY=1`
- `ros2 run turtlesim turtlesim_node`
- `ros2 run turtlesim turtle_teleop_key`
- `/opt/ros/foxy/bin/rqt`[2]
  - Plugins –> Services –> Service caller
  - /spawn (change X,Y, name – to turtle42)
- `ros2 run turtlesim turtle_teleop_key -ros-args -remap turtle1/cmd_vel:=turtle42/cmd_vel`

[2] Because I have two ROS instances, `rqt` does not work.

PubSub2 demo

PubSub2 demo

- (close terminal and disable sourcing ROS1 in .bashrc)
- `https://docs.ros.org/en/foxy/Tutorials/Beginner-Client-Libraries/Writing-A-Simple-Py-Publisher-And-Subscriber.html`
- `https://docs.ros.org/en/foxy/Tutorials/Beginner-Client-Libraries/Creating-A-Workspace/Creating-A-Workspace.html#new-directory`
- `mkdir -p ~/ros2_ws/src`
- `cd ~/ros2_ws/src`
- `ros2 pkg create –build-type ament_python py_pubsub`
- *do some magic...*[3]
- `sudo apt install python3-colcon-common-extensions`
- `source install/setup.bash`
- `ros2 run py_pubsub talker`
- `ros2 run py_pubsub listener`

[3] Actually create the publisher and subscriber according to the tutorials above.

Questions?