# ASME
# ROS Workshop

# Prequisites

- Text editor
- Terminal emulator
- Github repository open in browser

# Make Robot Hard.

# What's ROS?

# It's not an actual OS

# A set of software frameworks for robot software development

# Why use ROS?

- A lot of prebuilt packages
- Modular
- Open-source

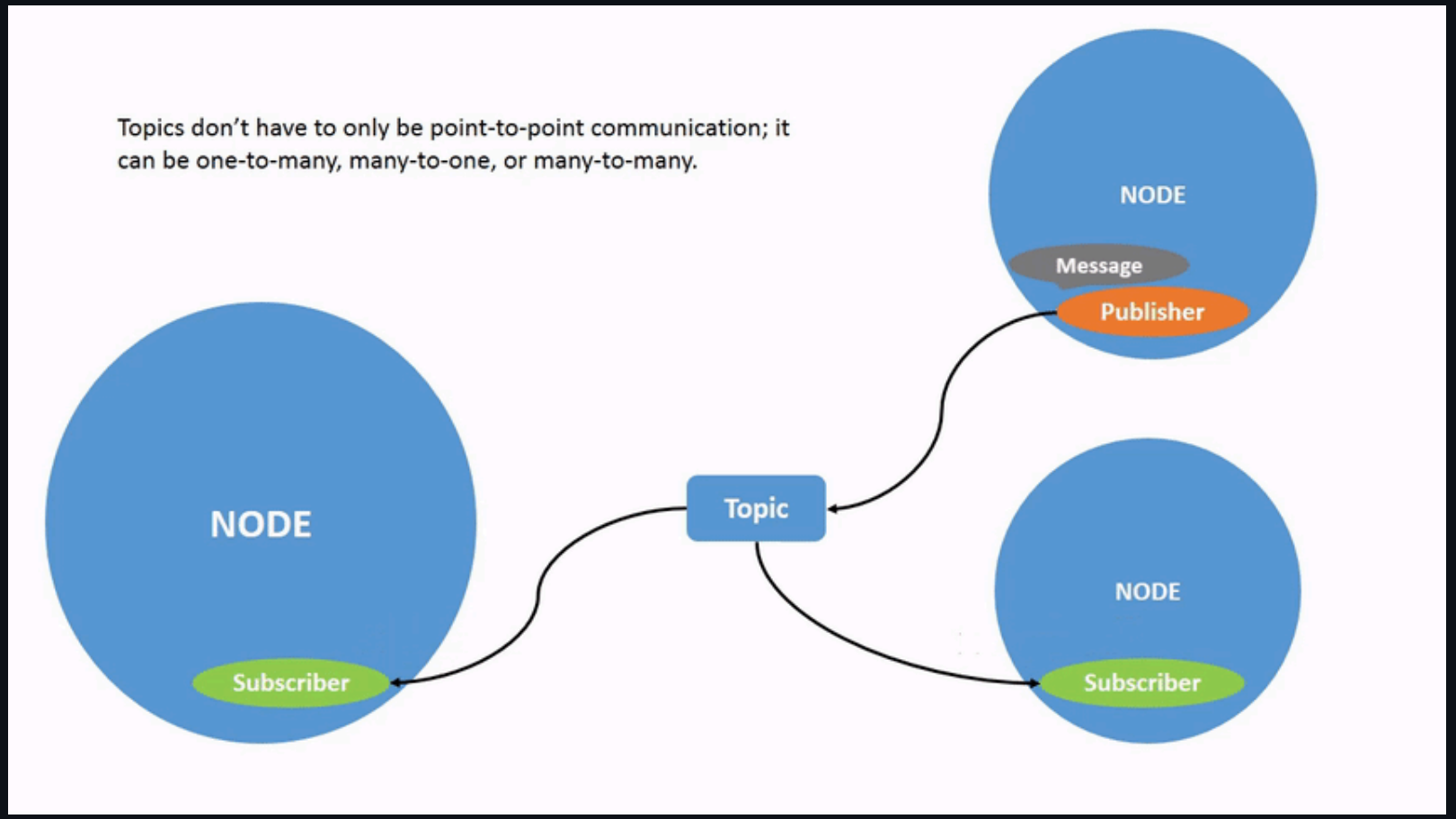
# Nodes

- An executable program or a running process that performs some kind of task
- A single node is responsible for a single, modular task

# Ways to communicate

- Publisher - Subscriber
- Services
- Actions

# Publisher - Subscriber



# Messages

## std_msgs

### std_msgs/String Message

**File:** `std_msgs/String.msg`

#### Raw Message Definition

```
string data
```

#### Compact Message Definition

```
string data
```

*autogenerated on Mon, 28 Feb 2022 23:49:59*

# sensor_msgs

## sensor_msgs/LaserScan Message

### File: sensor_msgs/LaserScan.msg

### Raw Message Definition

```
# Single scan from a planar laser range-finder
#
# If you have another ranging device with different behavior (e.g. a sonar
# array), please find or create a different message, since applications
# will make fairly laser-specific assumptions about this data

Header header            # timestamp in the header is the acquisition time of
                         # the first ray in the scan.
                         #
                         # in frame frame_id, angles are measured around
                         # the positive Z axis (counterclockwise, if Z is up)
                         # with zero angle being forward along the x axis

float32 angle_min        # start angle of the scan [rad]
float32 angle_max        # end angle of the scan [rad]
float32 angle_increment  # angular distance between measurements [rad]

float32 time_increment   # time between measurements [seconds] - if your scanner
                         # is moving, this will be used in interpolating position
                         # of 3d points
float32 scan_time        # time between scans [seconds]

float32 range_min        # minimum range value [m]
float32 range_max        # maximum range value [m]

float32[] ranges         # range data [m] (Note: values < range_min or > range_max should be discarded)
float32[] intensities    # intensity data [device-specific units].  If your
                         # device does not provide intensities, please leave
                         # the array empty.
```

### Compact Message Definition

```
std_msgs/Header header
float32 angle_min
float32 angle_max
float32 angle_increment
float32 time_increment
float32 scan_time
float32 range_min
float32 range_max
float32[] ranges
float32[] intensities
```

# ROS Workspaces

- Directory containing ROS2 packages
- Sourcing the installation workspace to have the packages in that workspace available to you `source ./install/local_setup.bash`
- 3 types of workspaces
  - Python
  - C++
  - Python & C++

## Python Workspace

```
ros_ws/
├── build/
│   └── ...
├── install/
│   └── ...
├── log/
│   └── ...
└── src/
    └── my_package/
        ├── package.xml
        ├── resource/my_package
        ├── setup.cfg
        ├── setup.py
        └── my_package/
            └── package.py
```

## C++ Workspace

```
ros_ws/
├── build
├── install
├── log
└── src/
    ├── CMakeLists.txt
    ├── include/my_package/
    ├── package.xml
    └── src/
        └── my_package.cpp
```

## Python & C++

```
ros_ws/
├── build/
│   └── ...
├── install/
│   └── ...
├── log/
│   └── ...
└── src/
    └── my_package/
        ├── CMakeLists.txt
        ├── package.xml
        ├── include/
        │   └── header_file.hpp
        ├── src/
        │   └── my_package.cpp
        ├── my_package/
        │   └── module_to_import.py
        └── scripts/
            └── my_package.py
```

# What's a package?

- Organisational unit for ROS code
- Makes it easier to share your ROS work with others

# Some Terminal Stuff

## General Command Line Tools

```
cd <folder/path_to_folder> # Change Directory
cd ~/Documents # Example (~/ describes your home directory)

ls # List files

mv <path_to_file> <path_to_new_location> # Move
mv ~/Downloads/file_to_be_moved ~/Documents/ # Example

cp <path_to_file> <path_to_new_location> # Copies files or folders

mkdir <folder_name> # Make Directory a.k.a Creates a new folder
mkdir ~/new_folder/ # example

touch <file_name> # Creates a blank file
touch new_file_name # Example
```

> NOTE: Use `CTRL+C` to interrupt a running process

# Building a ROS2 package

```
mkdir -p /jackal_files/github_dir/ros_ws/src
cd /jackal_files/github_dir/ros_ws/src
ros2 pkg create --build-type ament_python pub_sub
```

> NOTE: pub_sub can be changed to any name you want

# Minimal Publisher

```
import rclpy
from rclpy.node import Node

from std_msgs.msg import String
```

```python
class MinimalPublisher(Node):

    def __init__(self):
        super().__init__('minimal_publisher')
        # TODO: Replace <topic_name> with desired topic name
        self.publisher_ = self.create_publisher(String, '<topic_name>', 10)
        # TODOL Replace <period> with desired timer period in seconds
        timer_period = <period>  # seconds
        self.timer = self.create_timer(timer_period, self.timer_callback)
        self.i = 0
```

```
    def timer_callback(self):
        msg = String()
        # TODO: Replace <custom_msg> with desired message or uncomment the line below
        # msg.data = 'Hello World: %d' % self.i
        msg.data = '<custom_msg> %d' % self.i
        self.publisher_.publish(msg)
        self.get_logger().info('Publishing: "%s"' % msg.data)
        self.i += 1
```

```python
def main(args=None):
    rclpy.init(args=args)

    minimal_publisher = MinimalPublisher()

    rclpy.spin(minimal_publisher)

    # Destroy the node explicitly
    # (optional - otherwise it will be done automatically
    # when the garbage collector destroys the node object)
    minimal_publisher.destroy_node()
    rclpy.shutdown()

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

# Minimal Subscriber

```
import rclpy
from rclpy.node import Node

from std_msgs.msg import String
```

```
class MinimalSubscriber(Node):

    def __init__(self):
        super().__init__("minimal_subscriber")
        # TODO: replace '<topic_name>' with desired topic name
        self.subscription = self.create_subscription(
            String, "<topic_name>", self.listener_callback, 10
        )
        self.subscription  # prevent unused variable warning

    def listener_callback(self, msg):
        self.get_logger().info('I heard: "%s"' % msg.data)
```

```
def main(args=None):
    rclpy.init(args=args)

    minimal_subscriber = MinimalSubscriber()

    rclpy.spin(minimal_subscriber)

    # Destroy the node explicitly
    # (optional - otherwise it will be done automatically
    # when the garbage collector destroys the node object)
    minimal_subscriber.destroy_node()
    rclpy.shutdown()


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

# Copy code to the package directory

```
cd pub_sub/pub_sub
cp ~/jackal_files/github_dir/part_1/python_scripts/* ./
```

# Modifying setup.py

## Copy the file into the package directory

```
cd /jackal_files/github_dir/
cp part_1/setup.py ros_ws/src/pub_sub/
```

## Or add these lines to the `setup.py` file in the package directory

```
import os # Added
from glob import glob # Added
from setuptools import setup
```

```
    entry_points={
        "console_scripts": [
            "minimal_publisher = pub_sub.minimal_publisher:main", # Added
            "minimal_subscriber = pub_sub.minimal_subscriber:main", # Added
        ],
```

# Building the ROS Workspace

```
cd /jackal_files/github_dir/ros_ws/
colcon build
```

```
ros_ws/
├── build
├── install
├── log
└── src
```

# Running the nodes

## Using ros2 run

```
source /opt/ros/foxy/setup.bash
source ./install/local_setup.bash
ros2 run pub_sub minimal_publisher.py
```

> NOTE: To run the subscriber just replace minimal_publisher with minimal_subscriber

## Executing it directly

```
cd /jackal_files/github_dir/ros_ws/src/pub_sub/pub_sub
python3 minimal_publisher.py
```

> NOTE: Same thing applies here

# What are launch files?

- Used to run many nodes at the same time using one command `ros2 launch ...`

# Writing launch files

- Python
- YAML
- XML

## Python

```python
from launch import LaunchDescription
from launch_ros.actions import Node


def generate_launch_description():
    return LaunchDescription(
        [
            Node(
                package="pub_sub",
                executable="minimal_publisher",
            ),
            Node(
                package="pub_sub",
                executable="minimal_subscriber",
            ),
        ]
    )
```

## YAML

```yaml
launch:

- node:
    pkg: "pub_sub"
    exec: "minimal_publisher"

- node:
    pkg: "pub_sub"
    exec: "minimal_subscriber"
```

## XML

```xml
<launch>
  <node pkg="pub_sub" exec="minimal_publisher"/>
  <node pkg="pub_sub" exec="minimal_subscriber"/>
</launch>
```

## Copy the launch folder

```
cp -r /jackal_files/github_dir/part_1/launch/ /jackal_files/github_dir/ros_ws/src/pub_sub/
```

## Edit setup.py file in the package directory

```
    data_files=[
        ('share/ament_index/resource_index/packages',
            ['resource/' + package_name]),
        ('share/' + package_name, ['package.xml']),
        (os.path.join('share', package_name, 'launch'), glob(os.path.join('launch', '*launch.[pxy][yma]*'))) # Add
    ],
```

> Skip this step if you copied the `setup.py` file earlier

## Running the launch file

```
ros2 launch pub_sub launch.py
```

> NOTE: file extension depends on which launch file you want to use (launch.xml/launch.yaml)

# Simulations

# Why

- Expensive and time consuming to test on physical robot
- Jackal is an open source, robotic platform which is built on ROS and Gazebo
- Gazebo is a simulation software not made specifically for ROS but can be used with it

# Commands to run sim and teleop

## Move the jackal_ws into the github directory

```
mv /jackal_files/jackal_ws/ /jackal_files/github_dir
cd /jackal_files/github_dir/jackal_ws
rm -rf build/ install/ log/
colcon build
```

## Launch the jackal simulator

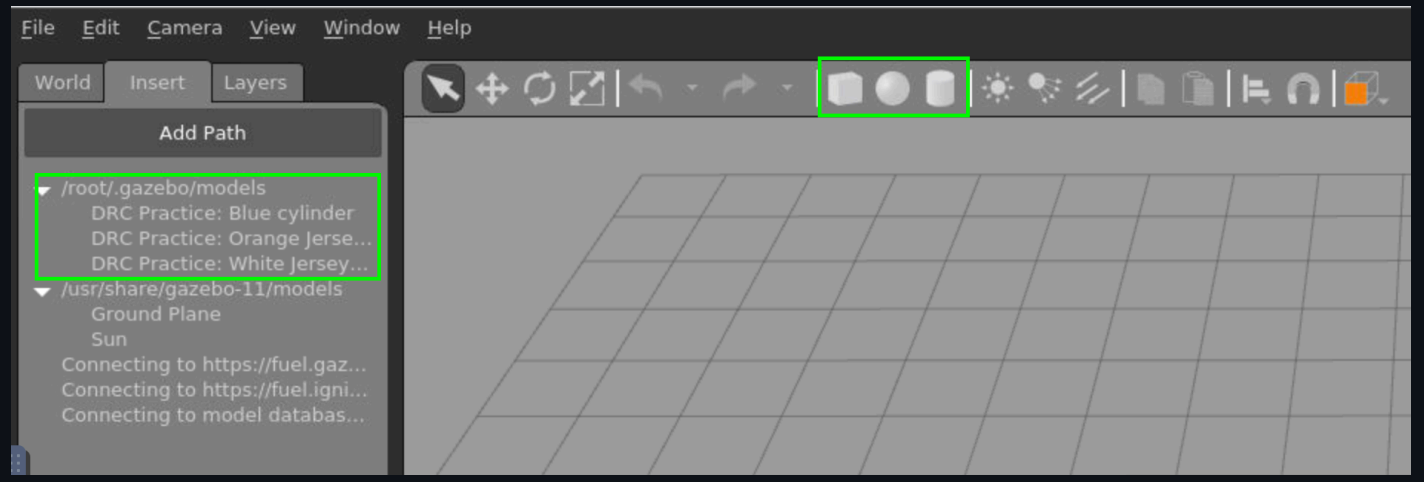
```
source /opt/ros/foxy/setup.bash
source ./install/local_setup.bash
ros2 launch jackal_gazebo jackal_world.launch.py
```

## Run the pre-built teleop node

```
ros2 run teleop_twist_keyboard teleop_twist_keyboard
```

# Build map in gazebo

1. Launch gazebo
2. Place models or shapes




3. Then save the file by navigating to `File > Save World As` and name it `custom_world.world`.

   Then save it at this directory

   `/jackal_files/jackal_ws/src/jackal_simulator/jackal_gazebo/worlds/`

# Use newly built map

## Copy the launch file and rename it

```
cd /jackal_files/jackal_ws/src/jackal_simulator/jackal_gazebo/launch/
cp jackal_world.launch.py custom_world.launch.py
```

## Edit the launch file

```
def generate_launch_description():

    world_file = PathJoinSubstitution(
        [FindPackageShare('jackal_gazebo'),
        'worlds',
        'custom_world.world'], # Changed
    )
```

## Rebuild the workspace

```
cd jackal_files/github_dir/jackal_ws/
colcon build
```

> Make sure you're at the root of the workspace `jackal_ws/`

## Launch the new file

```
source ./install/local_setup.bash
ros2 launch jackal_gazebo custom_world.launch.py
```

# Debugging

# Looking at topics and messages

```
ros2 topic echo <topic_name>
ros2 topic hz <topic_name>
ros2 topic info <topic_name>
```

## Twist

```
ros2 topic echo /cmd_vel
```

```
linear:
  x: 0.5
  y: 0.0
  z: 0.0
angular:
  x: 0.0
  y: 0.0
  z: 0.0
```

## LaserScan

```
ros2 topic echo /front/scan
```

```
header:
  stamp:
    sec: 1541
    nanosec: 197000000
  frame_id: front_laser
angle_min: -2.356189966201782
angle_max: 2.356189966201782
angle_increment: 0.006554075051099062
time_increment: 0.0
scan_time: 0.0
range_min: 0.10000000149011612
range_max: 30.0
ranges:
- 3.672072410583496
- ...
```

## Odometry

```
ros2 topic echo --no-arr /odom
```

## Header

```
header:
  stamp:
    sec: 1712668434
    nanosec: 829049376
  frame_id: odom
child_frame_id: base_link
```

## Pose

```
pose:
  pose:
    position:
      x: 2.1441852005195785
      y: 1.408813177853442
      z: 0.0
    orientation:
      x: 0.0
      y: 0.0
      z: 0.06435134457900855
      w: 0.9979273041914796
  covariance: '<array type: double[36]>'
```

## Twist

```
twist:
  twist:
    linear:
      x: 3.7634551129476595e-06
      y: 0.0
      z: 0.0
    angular:
      x: 0.0
      y: 0.0
      z: -1.3571082599241658e-08
  covariance: '<array type: double[36]>'
```

```
ros2 topic hz /front/scan
```

```
average rate: 49.326
        min: 0.019s max: 0.023s std dev: 0.00080s window: 51
```

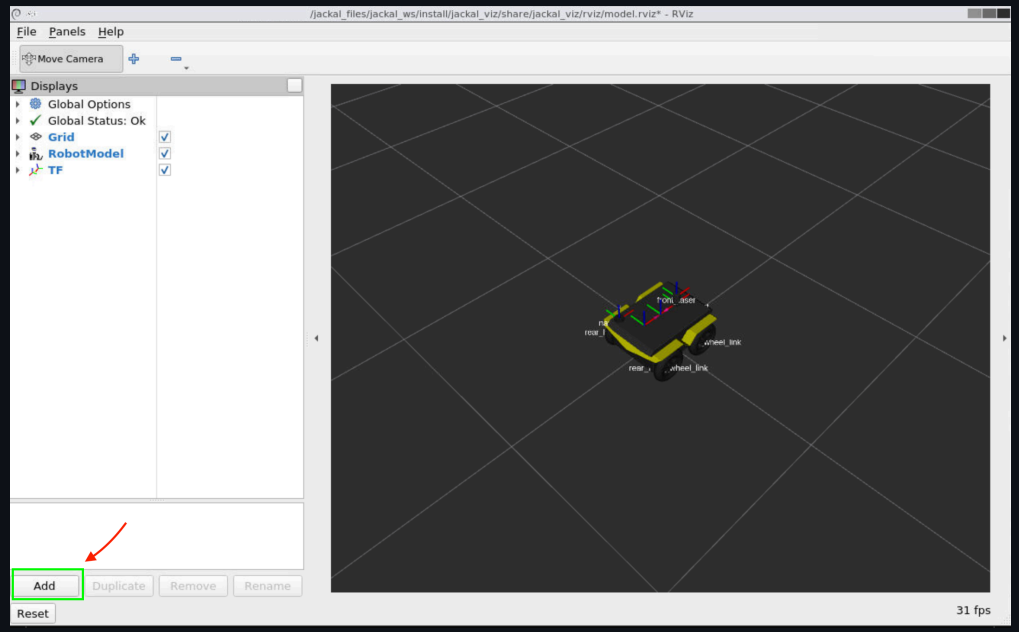
```
ros2 topic info /front/scan
```

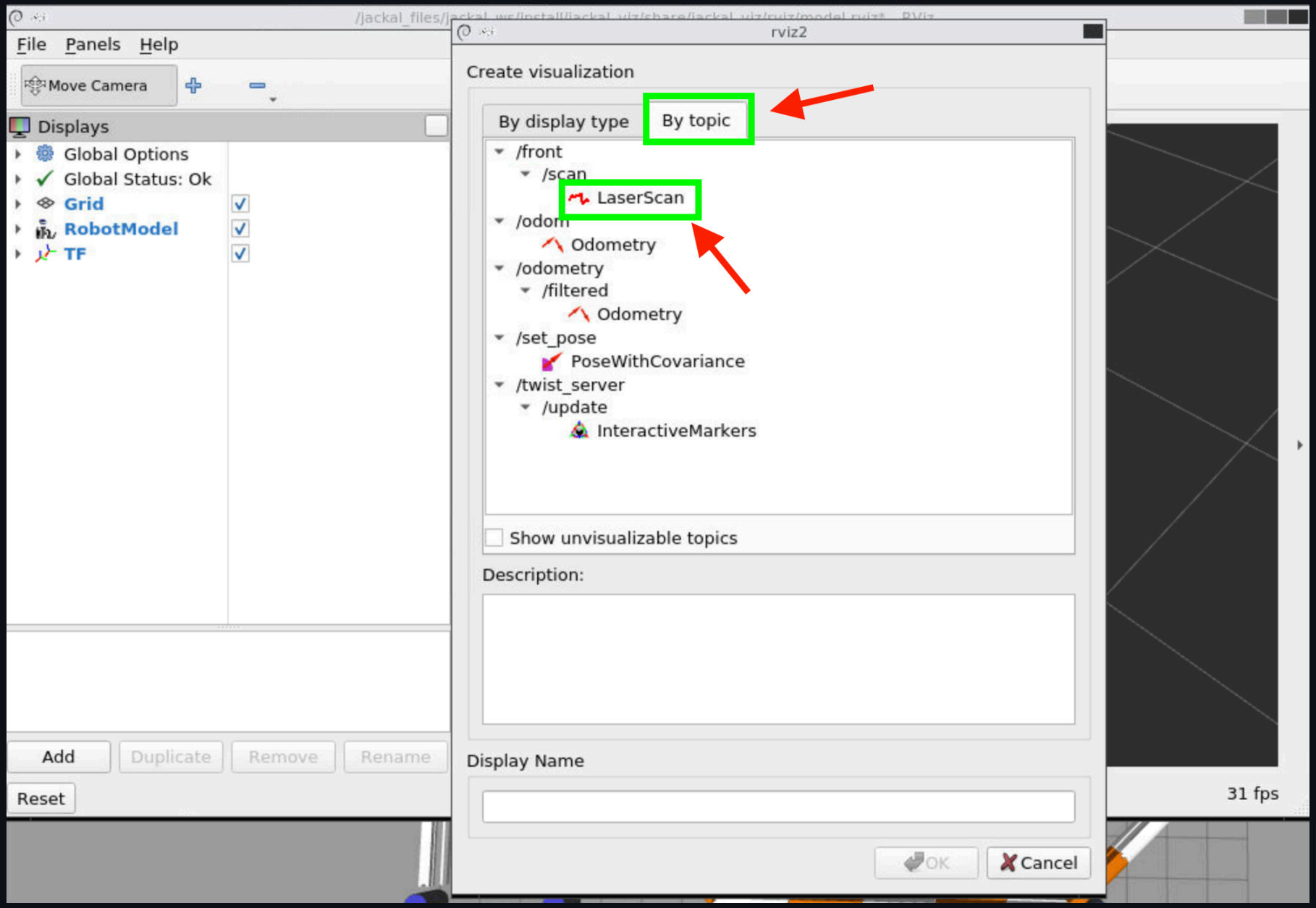
```
Type: sensor_msgs/msg/LaserScan
Publisher count: 1
Subscription count: 0
```

# Visualize LaserScan in Rviz

## Jackal View Model

```
ros2 launch jackal_viz view_model.launch.py
```




File Panels Help
Move Camera
Displays
Global Options
Global Status: Ok
Grid
RobotModel
TF
Add
Duplicate
Remove
Rename
Reset
rviz2
Create visualization
By display type
By topic
/front
/scan
LaserScan
/odom
Odometry
/odometry
/filtered
Odometry
/set_pose
PoseWithCovariance
/twist_server
/update
InteractiveMarkers
Show unvisualizable topics
Description:
Display Name
OK
Cancel
31 fps

# Examples

# Local Planners

- Hueristic-based planning
- Rule-based planning

# wall_follow

## Run wall_follow in jackal sim

```
python3 wall_follow.py
```

# Additional resources (and References)

## ros2 (foxy) tutorials

> Note ros2 foxy is EOL

## jackal

## F1Tenth Team