Tutorial on ROS

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Outline

1. Our first node in ROS;
2. Compile and run nodes.

Our first node

In order to demonstrate how a ROS node is implemented, let’s look at a simple example which does the following :

- Interfaces with a sensor :
  - receives laser data from the LIDAR scanner
  - stores it in some data structures
- Does something with the sensor data:
  - reads the range values
  - displays them as text on the terminal
- Sends some data from this node to other nodes :
  - sends graphical display points so that we can display them on the RVIZ graphical interface

Our first node

Let's see how a simple node can be implemented !

- Right click on the folder `Home/ros2_ws/src/tutorial_ros` and open it with VSCode
- Open `src/laser_graphical_display_node.cpp`

```
class laser_graphical_display_node : public rclcpp::Node
{
protected:
  // ROS subscriptions
  rclcpp::Subscription<sensor_msgs::msg::LaserScan>::SharedPtr sub_scan_;

  // Visualization markers
  visualization_msgs::msg::Marker marker_field_of_view_, marker_laser_;

  // ROS publishers
  rclcpp::Publisher<visualization_msgs::msg::Marker>::SharedPtr pub_field_of_view_marker_;
  rclcpp::Publisher<visualization_msgs::msg::Marker>::SharedPtr pub_laser_graphical_display_marker_;

    // Laser scan data
    int nb_beams_;
    bool init_laser_, new_laser_; //to check if new data of laser is available or not
    float range_min_, range_max_;
    float angle_min_, angle_max_, angle_inc_;
    float r_[tab_size], theta_[tab_size];
    geometry_msgs::msg::Point current_scan_[tab_size];
```

Creation of a node subclass

Declaring subscribers/publishers to receive/send data between nodes

Data structures to store laser data

Our first node

- Our first node will subscribe to the topic called « scan »;
- « scan » is the topic on which messages are published by the laser, containing the laser data;
- Each time a new message is published on the topic called « scan », our first node will receive and store this message with the method « scanCallback »

```
// Subscribers
// Preparing a subscriber to the "scan" topic, in order to receive data from the laser scanner.
sub_scan_ = this->create_subscription<sensor_msgs::msg::LaserScan>(
  "scan", qos, std::bind(&laser_graphical_display_node::scan_callback, this, _1));
```

Our first node

- Our first node will publish to the topic called « laser_graphical_display_marker »;
- It is a topic on which messages are published by our node so that other ROS nodes can receive them;
- The type of the message is `visualization_msgs::msg_marker`, which represents visual marker points with colours.

```
// Publishers
// Preparing a topic to publish our results. This will be used by the visualization tool rviz
pub_laser_graphical_display_marker_ = this->create_publisher<visualization_msgs::msg::Marker>("laser_graphical_display_marker", 1);
pub_field_of_view_marker_           = this->create_publisher<visualization_msgs::msg::Marker>("field_of_view_marker", 1);
```

Our first node

```
void scanCallback(const sensor_msgs::LaserScan::ConstPtr& scan) {

    new_laser = true;
    // store the important data related to laserscanner
    range_min = scan->range_min;
    range_max = scan->range_max;
    angle_min = scan->angle_min;
    angle_max = scan->angle_max;
    angle_inc = scan->angle_increment;
    nb_beams = ((-1 * angle_min) + angle_max)/angle_inc;

    // store the range and the coordinates in cartesian framework of each hit
    float beam_angle = angle_min;
    for ( int loop=0 ; loop < nb_beams; loop++, beam_angle += angle_inc ) {
        if ( ( scan->ranges[loop] < range_max ) && ( scan->ranges[loop] > range_min ) )
            r[loop] = scan->ranges[loop];
        else
            r[loop] = range_max;
        theta[loop] = beam_angle;

        //transform the scan in cartesian framework
        current_scan[loop].x = r[loop] * cos(beam_angle);
        current_scan[loop].y = r[loop] * sin(beam_angle);
        current_scan[loop].z = 0.0;
    }

}//scanCallback
```

The type of messages published by the laser

Our first node

- Our first node is an infinite loop that will run at 10 hz

1. It will check if a new message from the laser has been published (`spin_some`);
2. If a new message has been received on the scan topic, it will call the method `scanCallback` to collect the data of the laser;
3. The method « `update` » will process the data of the laser

```
// 4) Taux de boucle à 10Hz
rclcpp::Rate rate(10 /*Hz*/);

// 5) Boucle principale : on tourne les callbacks et on appelle update()
while (rclcpp::ok()) {
  // Exécute une itération de callback sans bloquer
  rclcpp::spin_some(node);
  // Votre méthode d'update périodique
  node->update();
  rate.sleep();
}
```

Our first node

- The method « update » will check if new message of the laser has arrived with the boolean `new_laser`;
- It will loop over the beams, display their data in the terminal, and publish a marker corresponding to the hits;

```
void laser_graphical_display_node::update() {
    // If we have received a new laser scan at this node cycle, process it.
    if ( new_laser_ )
    {
        new_laser_ = false;

        RCLCPP_INFO(this->get_logger(), "\n\n New data of laser received");

        std_msgs::msg::ColorRGBA color;
        marker_laser_.points.clear();
        marker_laser_.colors.clear();

        // Process the laser data
        for (int loop_hit = 0; loop_hit < nb_beams_; loop_hit++)
        {
            // Display laser hit information in the terminal to understand the data structure and types
            RCLCPP_INFO(this->get_logger(),"r[%i] = %f, theta[%i] (in degrees) = %f, x[%i] = %f, y[%i] = %f",
                        loop_hit, r_[loop_hit], loop_hit, theta_[loop_hit]*180/M_PI, loop_hit, current_scan_[loop_hit].x, loop_hit, current_scan_[loop_hit].y);

            // Add a marker based on the position of the laser hits in current_scan_
            marker_laser_.points.push_back(current_scan_[loop_hit]);

            // Determine the color of the marker
            color.r = 0; color.g = 0; color.b = 1.0; color.a = 1.0;
            marker_laser_.colors.push_back(color);
        }

        {…

        // Publish the marker_ message using the Publisher, making it available to other nodes, such as Rviz
        pub_laser_graphical_display_marker_->publish(marker_laser_);

        // Publish markers showing the lidar's field of view
        display_field_of_view();
    }
}// update
```

Function to print information on the terminal

Add a new point to the marker array

Publish the the marker array

Outline

1. Our first node in ROS;
2. Compile and run nodes.

Compile and run nodes

Now we've seen what a ROS node looks like, how do we compile and run them ?

- To compile the node: open a terminal*

```
cd ~/ros2_ws
colcon build
```

- To run the node: open a terminal

```
cd ~/ros2_ws
source install/local_setup.bash
ros2 run tutorial_ros laser_graphical_display_node
```

note: *the terminal in which you compile using* `colcon build` *should NOT be one where you have previously executed* `source install/local_setup.bash`*.*
*We recommend you always keep the **same terminal** open for compiling, and use it **ONLY** for compiling.*

Compile and run nodes

- Our node is now running, but we need to pass laser data to it as input, and we want to visualise the graphical markers it publishes as output.
- To run a rosbag : open a terminal :

```
ros2 bag play <data_file>.bag2
```

Replace <data_file>.bag2 with the name of the file to play,

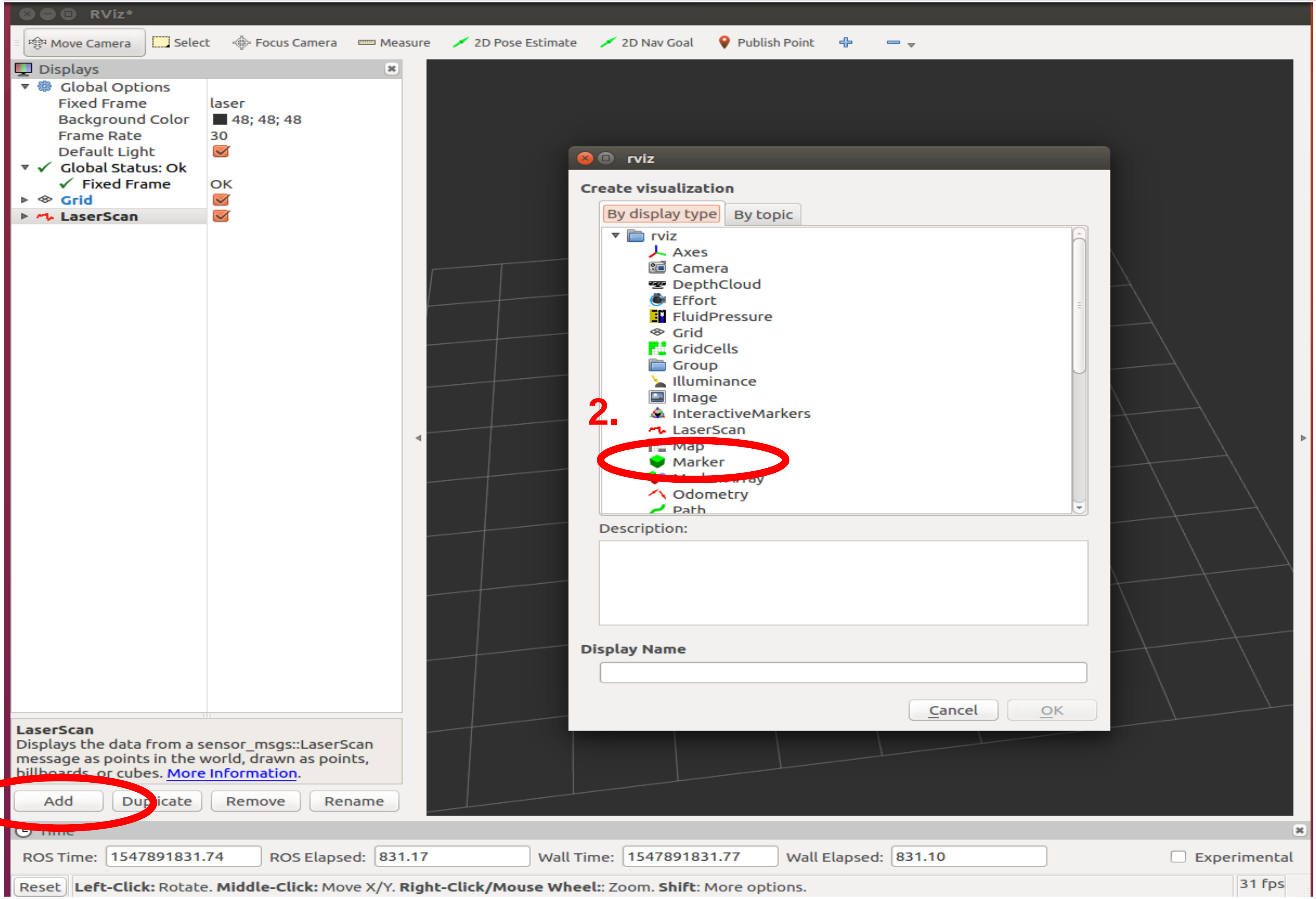
for instance : detection01.bag2

- To run rviz : open a terminal :

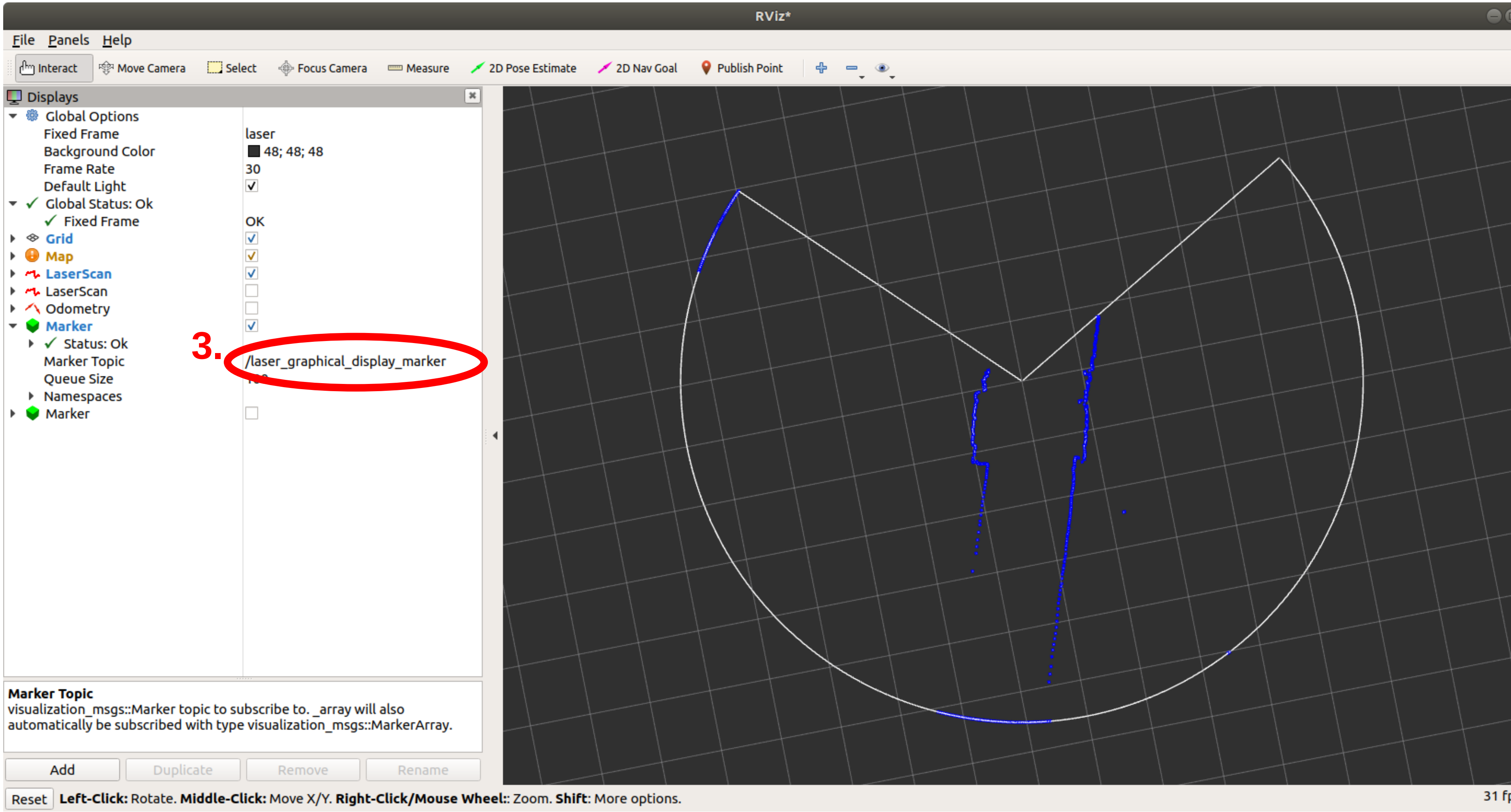
```
ros2 run rviz2 rviz2
```

In Rviz, Open the config file located in
~/ros2_ws/src/tutorial_ros/config/laser_only.rviz

Rviz configuration : adding markers



Rviz configuration : adding markers



General reminders and information :

- A folder in ~/ros2_ws/src is called a package;
- A package contains some source files;
- These source files will be compiled to create nodes;
- To compile: `colcon build` from ~/ros2_ws
  For instance, in the package tutorial_ros, there is one source file that will generate one node.

- To run a node:
  `ros2 run <package_name> <node_name>` from ~/ros2_ws, after having done the `source` command once in that terminal.
  For instance, we used the command
  `ros2 run tutorial_ros laser_graphical_display_node`
  to run the node *laser_graphical_display_node* which is part of the package *tutorial_ros.*