10.ROS2 navigation and avoid

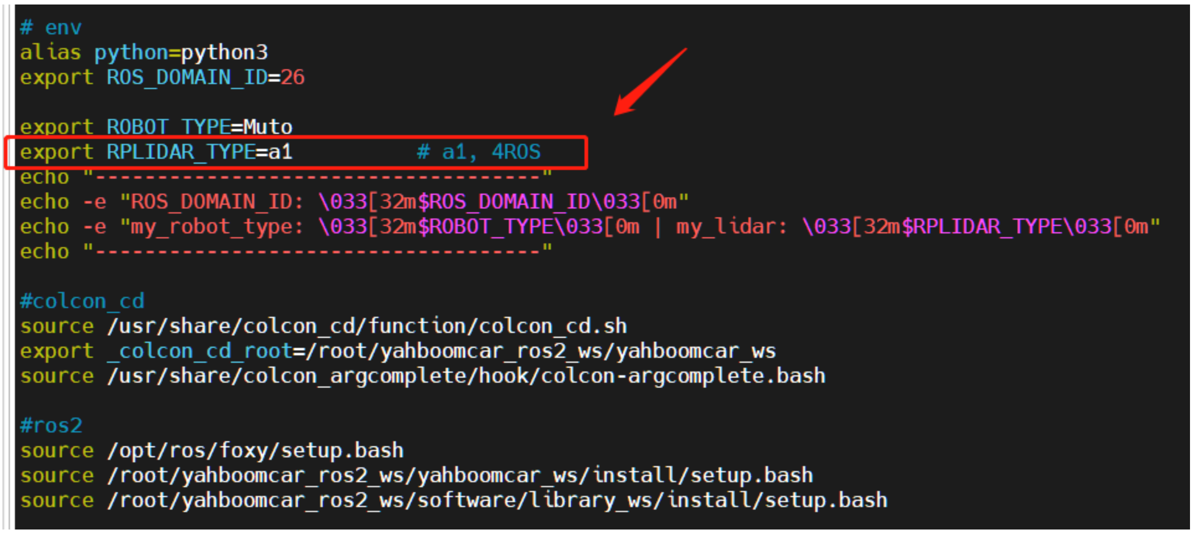
1. Use

1.1. Configuration before use

Note: Since the Muto series robots are equipped with multiple lidar devices, the factory system has been configured with routines for multiple devices. However, since the product cannot be automatically recognized, the lidar model needs to be manually set.

After entering the container: Make the following modifications according to the lidar type:

```
root@ubuntu:/# cd
root@ubuntu:~# vim .bashrc
```



```
# env
alias python=python3
export ROS_DOMAIN_ID=26

export ROBOT_TYPE=Muto
export RPLIDAR_TYPE=a1          # a1, 4ROS
echo "------------------------------------"
echo -e "ROS_DOMAIN_ID: \033[32m$ROS_DOMAIN_ID\033[0m"
echo -e "my_robot_type: \033[32m$ROBOT_TYPE\033[0m | my_lidar: \033[32m$RPLIDAR_TYPE\033[0m"
echo "------------------------------------"

#colcon_cd
source /usr/share/colcon_cd/function/colcon_cd.sh
export _colcon_cd_root=/root/yahboomcar_ros2_ws/yahboomcar_ws
source /usr/share/colcon_argcomplete/hook/colcon-argcomplete.bash

#ros2
source /opt/ros/foxy/setup.bash
source /root/yahboomcar_ros2_ws/yahboomcar_ws/install/setup.bash
source /root/yahboomcar_ros2_ws/software/library_ws/install/setup.bash
```

After the modification is completed, save and exit vim, and then execute:

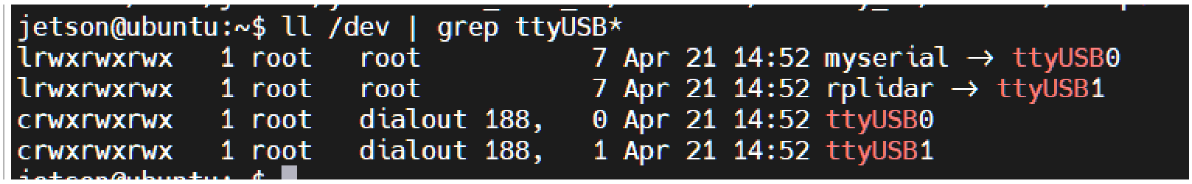
```
root@jetson-desktop:~# source .bashrc
------------------------------------
ROS_DOMAIN_ID: 26
my_robot_type: Muto | my_lidar: a1
------------------------------------
root@jetson-desktop:~#
```

You can see the current modified lidar type.

1.2. Start chassis and lidar related nodes

First, the port binding operation needs to be performed on the host machine [that is, Muto's jetson]. The two devices of lidar and serial port are mainly used here;

Then check whether the lidar and serial device are in the port binding state: on the host machine [that is, Muto's jetson] refer to the following command to execute the check. The successful binding is as follows:



```
jetson@ubuntu:~$ ll /dev | grep ttyUSB*
lrwxrwxrwx   1 root   root          7 Apr 21 14:52 myserial -> ttyUSB0
lrwxrwxrwx   1 root   root          7 Apr 21 14:52 rplidar -> ttyUSB1
crwxrwxrwx   1 root   dialout 188,   0 Apr 21 14:52 ttyUSB0
crwxrwxrwx   1 root   dialout 188,   1 Apr 21 14:52 ttyUSB1
```

If it shows that the lidar or serial device is not bound, you can plug and unplug the USB cable to check again.

Enter the docker container and execute in a terminal:

```
ros2 launch yahboomcar_nav laser_bringup_launch.py
```

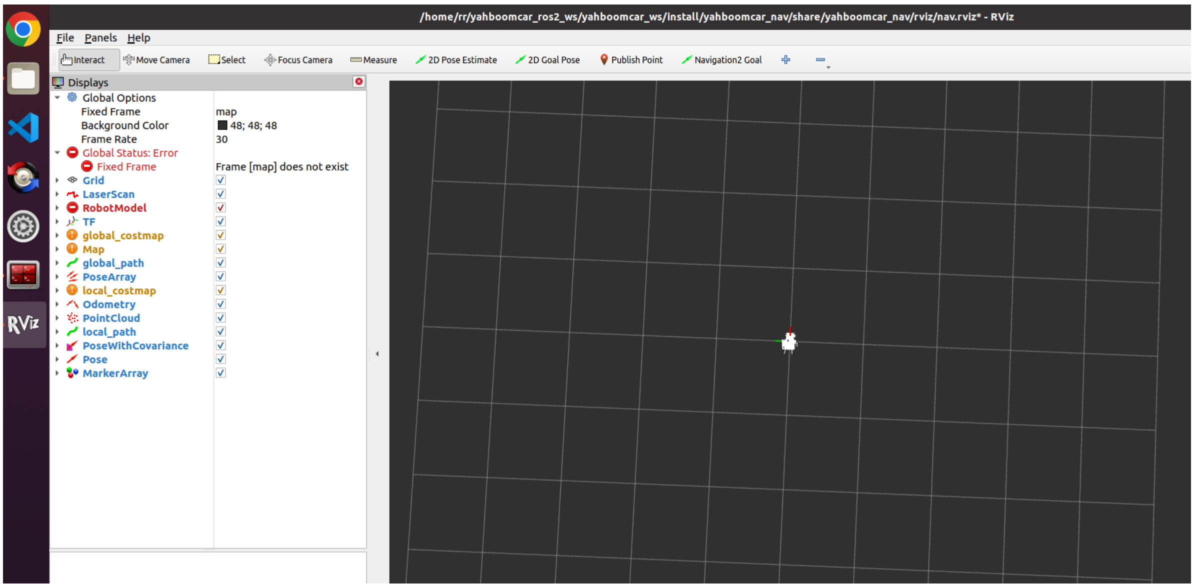
1.3. Start rviz to display the map

Configure multi-machine communication in Ubuntu virtual machine and docker container

It is recommended to start this step in a virtual machine: to maintain time synchronization and reduce resource consumption, because if you use vnc, it is very dependent on the network and may cause navigation failure.

[Note that you must first start the node that displays the map, and then start the navigation node in step 3.This is because the navigation2 terminal map topic is only published once. If you start the navigation node first and then start the rviz display, you may not be able to subscribe to the map topic published only once, resulting in the map not being displayed]

```
ros2 launch yahboomcar_nav display_nav_launch.py
```



Global Options	
Fixed Frame	map
Background Color	■ 48; 48; 48
Frame Rate	30
Global Status: Error	
Fixed Frame	Frame [map] does not exist
Grid	☑
LaserScan	☑
RobotModel	☑
TF	☑
global_costmap	☑
Map	☑
global_path	☑
PoseArray	☑
local_costmap	☑
Odometry	☑
PointCloud	☑
local_path	☑
PoseWithCovariance	☑
Pose	☑
MarkerArray	☑

At this time, the map will not be displayed on the screen, and there is no need to worry about the red topics of each node on the left, because the navigation node has not been started yet.

1.4. Start navigation node

- There are two navigation algorithms: DWA and TEB
- Navigation can be divided into single-point navigation and multi-point navigation, which will be introduced below.

Enter the docker container and execute in a terminal:

1. Start the lidar odometer

```
ros2 launch rf2o_laser_odometry rf2o_laser_odometry.launch.py
```

2. Start the navigation node

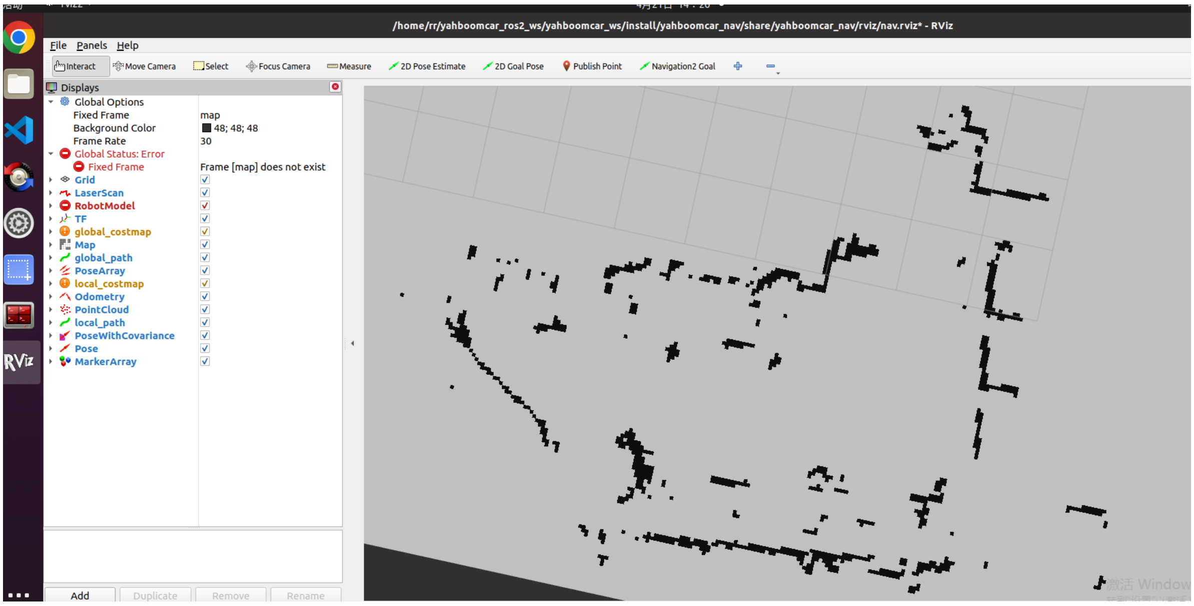
```
ros2 launch yahboomcar_nav navigation_dwa_launch.py   # dwb navigation
Or
ros2 launch yahboomcar_nav navigation_teb_launch.py   # teb navigation

#The above method loads the yahboomcar map by default. If you need to load other
maps, please use the following method to start:
# dwb navigation
ros2 launch yahboomcar_nav navigation_dwa_launch.py
map:=/root/yahboomcar_ros2_ws/yahboomcar_ws/src/yahboomcar_nav/maps/test.yaml
#The path of the map above is the path of the map that you want to load during
navigation. test.yaml is the name of the map, which means that the test map is
loaded during navigation. If it is another name, it should be changed
accordingly.

#or

# teb navigation
```

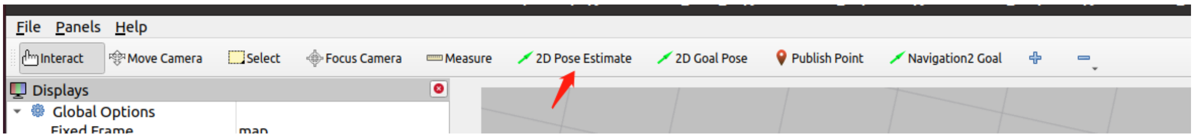
```
ros2 launch yahboomcar_nav navigation_teb_launch.py
map:=/root/yahboomcar_ros2_ws/yahboomcar_ws/src/yahboomcar_nav/maps/test.yaml
#The path of the map above is the path of the map that you want to load during
navigation. test.yaml is the name of the map, which means that the test map is
loaded during navigation. If it is another name, it should be changed
accordingly.
```



/home/rr/yahboomcar_ros2_ws/yahboomcar_ws/install/yahboomcar_nav/share/yahboomcar_nav/rviz/nav.rviz* - RViz

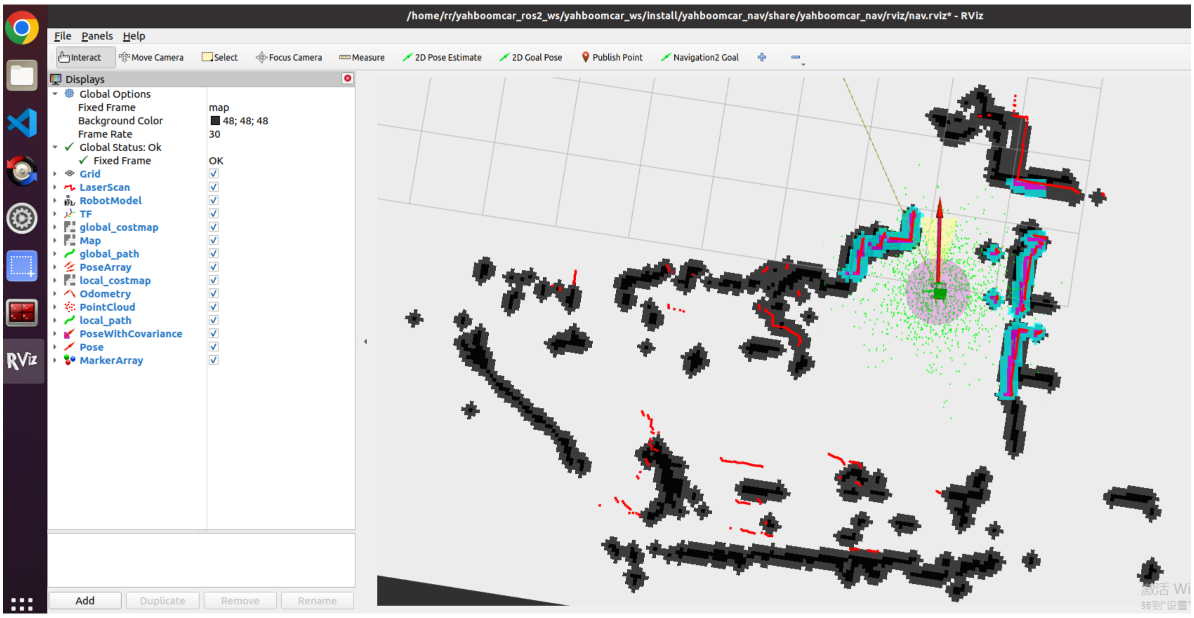
Displays
Global Options
Fixed Frame map
Background Color 48; 48; 48
Frame Rate 30
Global Status: Error
Fixed Frame Frame [map] does not exist
Grid ☑
LaserScan ☑
RobotModel ☑
TF ☑
global_costmap ☑
Map ☑
global_path ☑
PoseArray ☑
local_costmap ☑
Odometry ☑
PointCloud ☑
local_path ☑
PoseWithCovariance ☑
Pose ☑
MarkerArray ☑

3. Click [2D Pose Estimate] on rviz, then compare the pose of the car and mark an initial pose for the car on the map;



Displays
Global Options
Fixed Frame map

The display after marking is as follows:



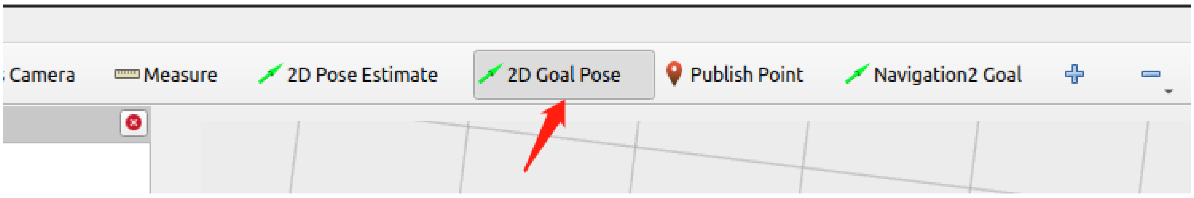
/home/rr/yahboomcar_ros2_ws/yahboomcar_ws/install/yahboomcar_nav/share/yahboomcar_nav/rviz/nav.rviz* - RViz

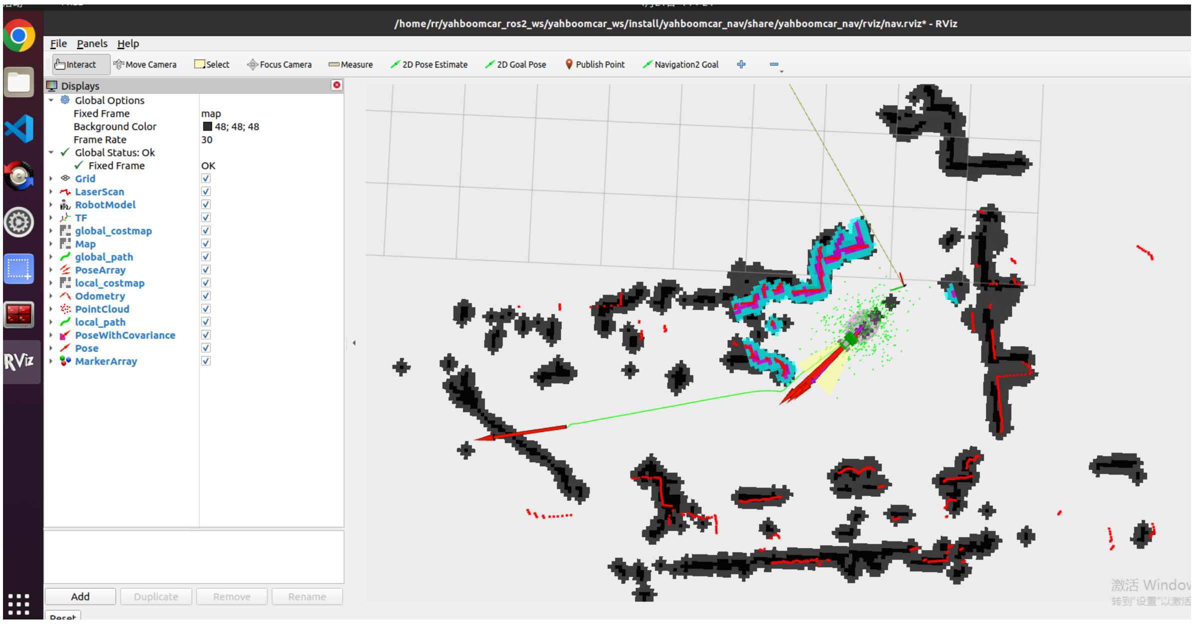
Displays
Global Options
Fixed Frame map
Background Color 48; 48; 48
Frame Rate 30
Global Status: Ok
Fixed Frame OK
Grid ☑
LaserScan ☑
RobotModel ☑
TF ☑
global_costmap ☑
Map ☑
global_path ☑
PoseArray ☑
local_costmap ☑
Odometry ☑
PointCloud ☑
local_path ☑
PoseWithCovariance ☑
Pose ☑
MarkerArray ☑

4. Compare the overlap between the lidar scanning point and the obstacle, and set the initial pose of the car multiple times until the lidar scanning point and the obstacle roughly coincide;

1.5. Single-point navigation

After the initial pose is set, you can click [2D Goal Pose] to set a navigation target point, and the car will start single-point navigation;

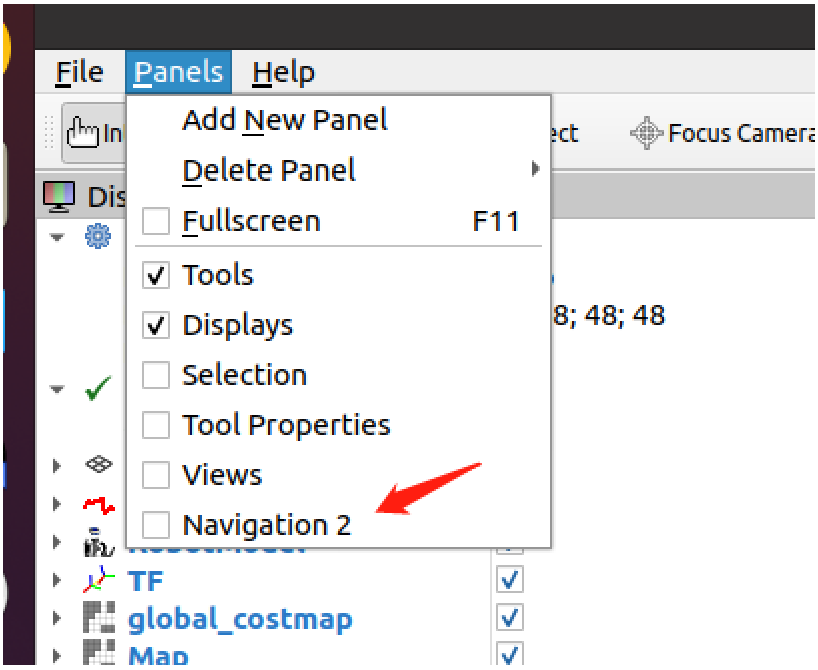


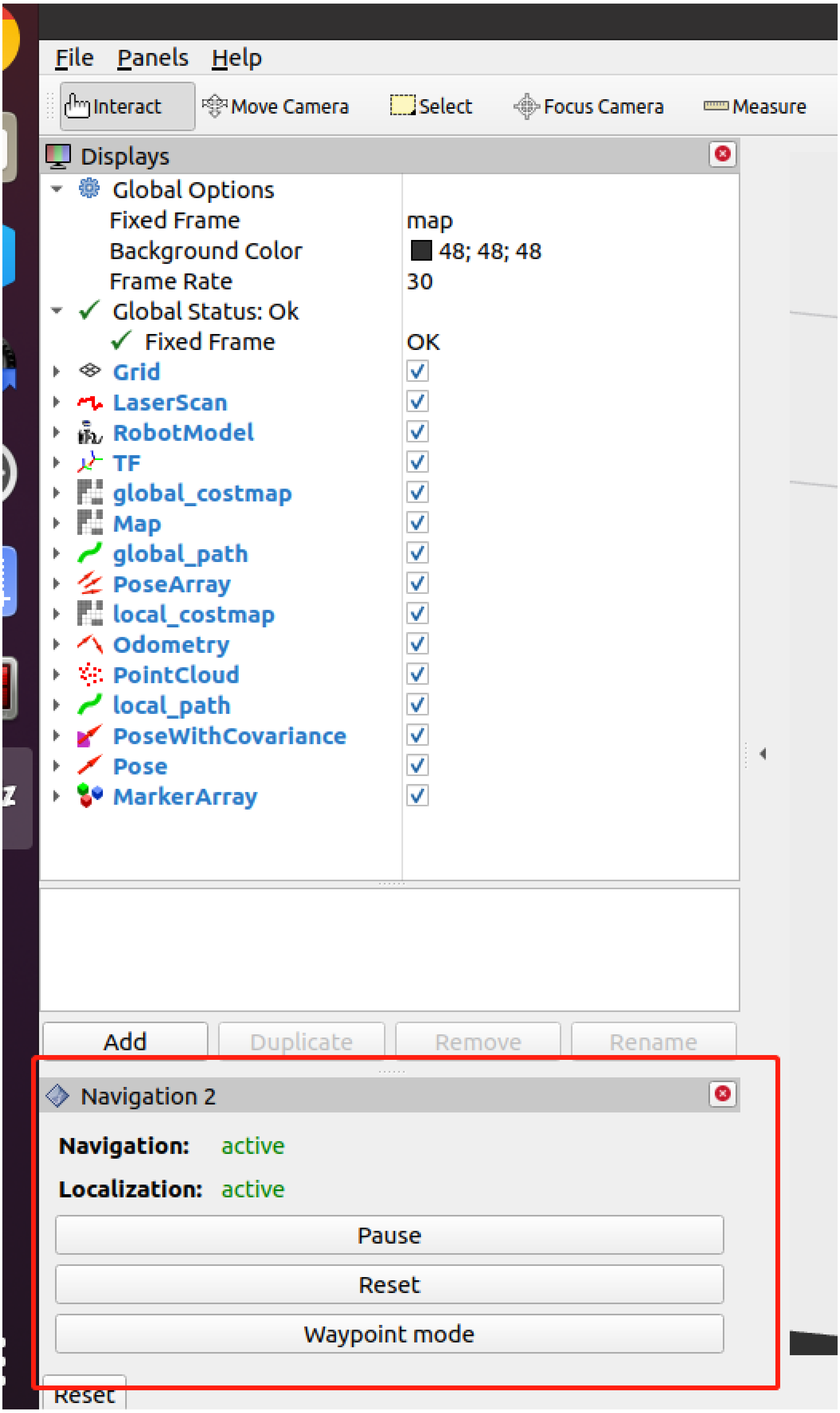

/home/rr/yahboomcar_ros2_ws/yahboomcar_ws/install/yahboomcar_nav/share/yahboomcar_nav/rviz/nav.rviz* - RViz

```
Global Options
  Fixed Frame          map
  Background Color     48; 48; 48
  Frame Rate           30
✓ Global Status: Ok
  ✓ Fixed Frame        OK
Grid                   ☑
LaserScan              ☑
RobotModel             ☑
TF                     ☑
global_costmap         ☑
Map                    ☑
global_path            ☑
PoseArray              ☑
local_costmap          ☑
Odometry               ☑
PointCloud             ☑
local_path             ☑
PoseWithCovariance     ☑
Pose                   ☑
MarkerArray            ☑
```

1.6. Multi-point navigation

1. After the initial pose is set, you can click [Panels] in the upper left corner of rviz --- select [Navigation 2], and the [Navigation 2] panel will be displayed.


File
Panels
Help
Add New Panel
Delete Panel
□ Fullscreen F11
☑ Tools
☑ Displays
□ Selection
□ Tool Properties
□ Views
□ Navigation 2
Focus Camera
TF
global_costmap
Map
8; 48; 48



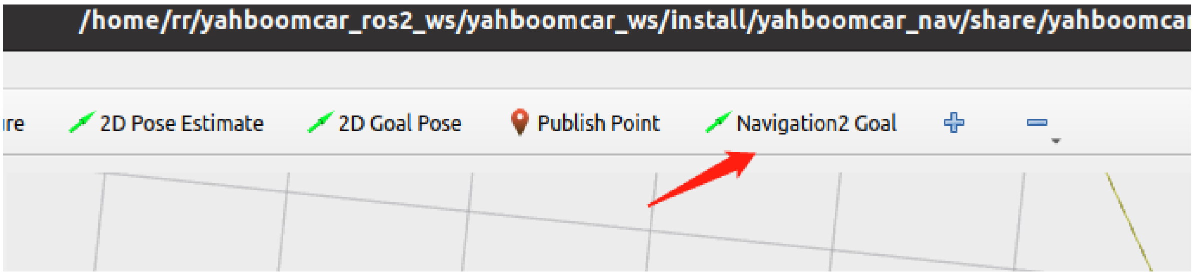
Global Options

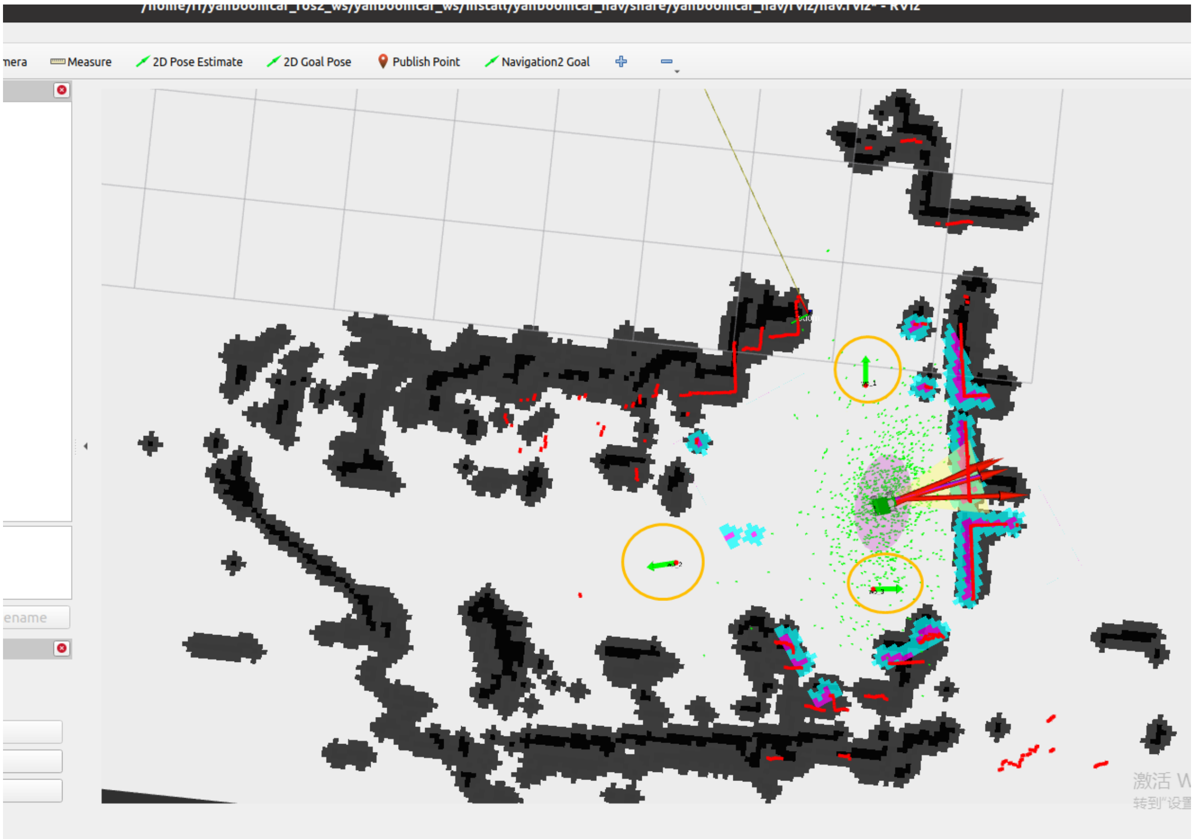
Fixed Frame	map
Background Color	■ 48; 48; 48
Frame Rate	30
✓ Global Status: Ok	
✓ Fixed Frame	OK
Grid	☑
LaserScan	☑
RobotModel	☑
TF	☑
global_costmap	☑
Map	☑
global_path	☑
PoseArray	☑
local_costmap	☑
Odometry	☑
PointCloud	☑
local_path	☑
PoseWithCovariance	☑
Pose	☑
MarkerArray	☑

Navigation: active

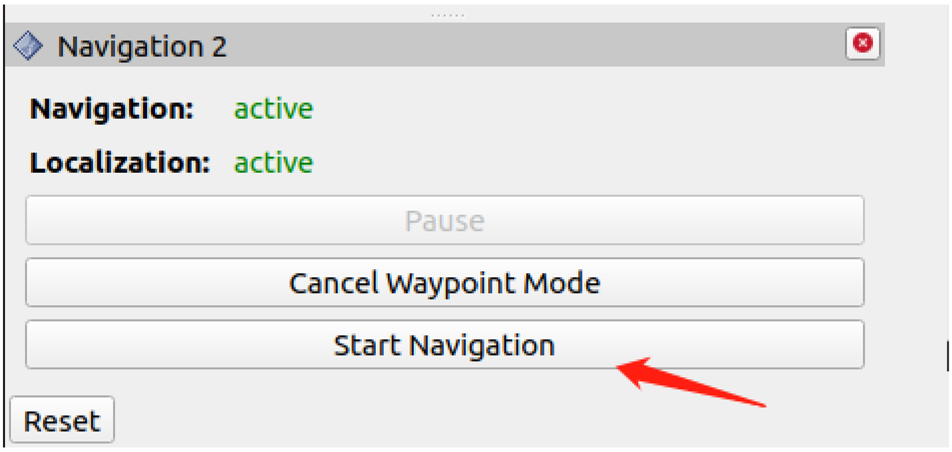
Localization: active

2. Click [Waypoint mode] in the picture above, then click [Navigation2 Goal] on rviz to mark a target point on the map. Click [Navigation2 Goal] again to mark the second target point on the map, and the cycle continues, you can mark multiple target points at one time;


/home/rr/yahboomcar_ros2_ws/yahboomcar_ws/install/yahboomcar_nav/share/yahboomcar
re
2D Pose Estimate
2D Goal Pose
Publish Point
Navigation2 Goal


/home/rr/yahboomcar_ros2_ws/yahboomcar_ws/install/yahboomcar_nav/share/yahboomcar_nav/rviz/nav.rviz - RViz
mera
Measure
2D Pose Estimate
2D Goal Pose
Publish Point
Navigation2 Goal
ename

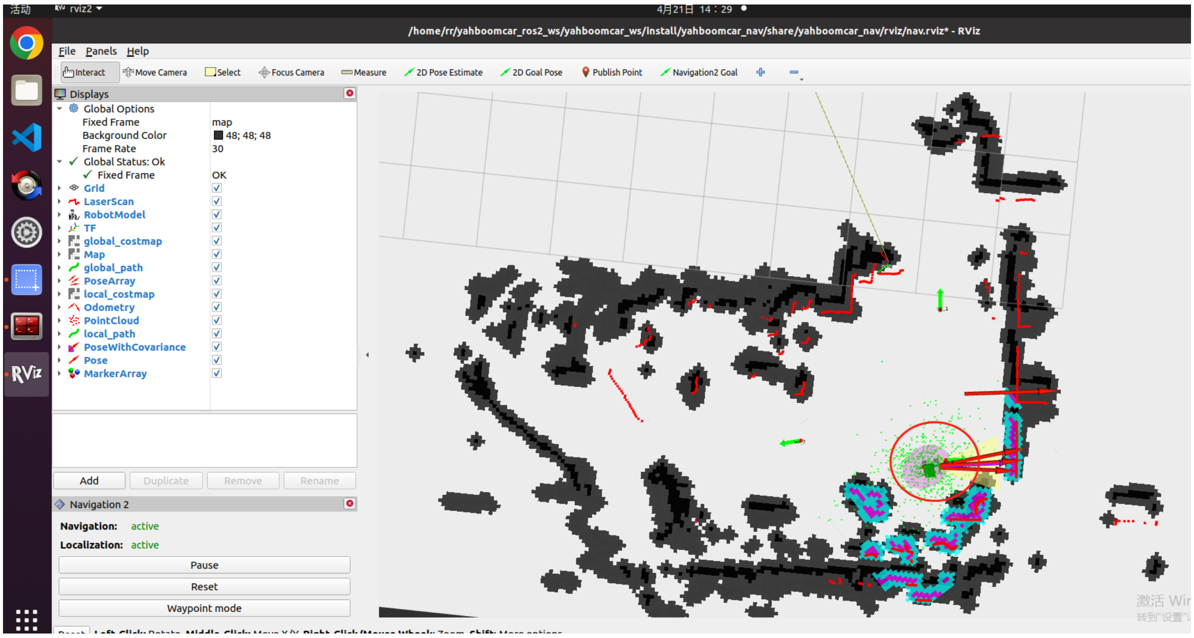
3. After marking multiple target points, click [Start Navigation] to start multi-point navigation;



Navigation: active

Localization: active

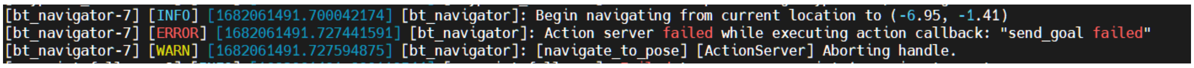
4. After the multi-point navigation is completed, the car will stay at the position of the last target point;



Global Options
Fixed Frame: map
Background Color: 48; 48; 48
Frame Rate: 30
Global Status: Ok
Fixed Frame: OK

Navigation: active
Localization: active

5. It may appear during the navigation process. This is due to the navigation2 itself in the ros-foxy version. The subsequent ros2 version has been fixed.

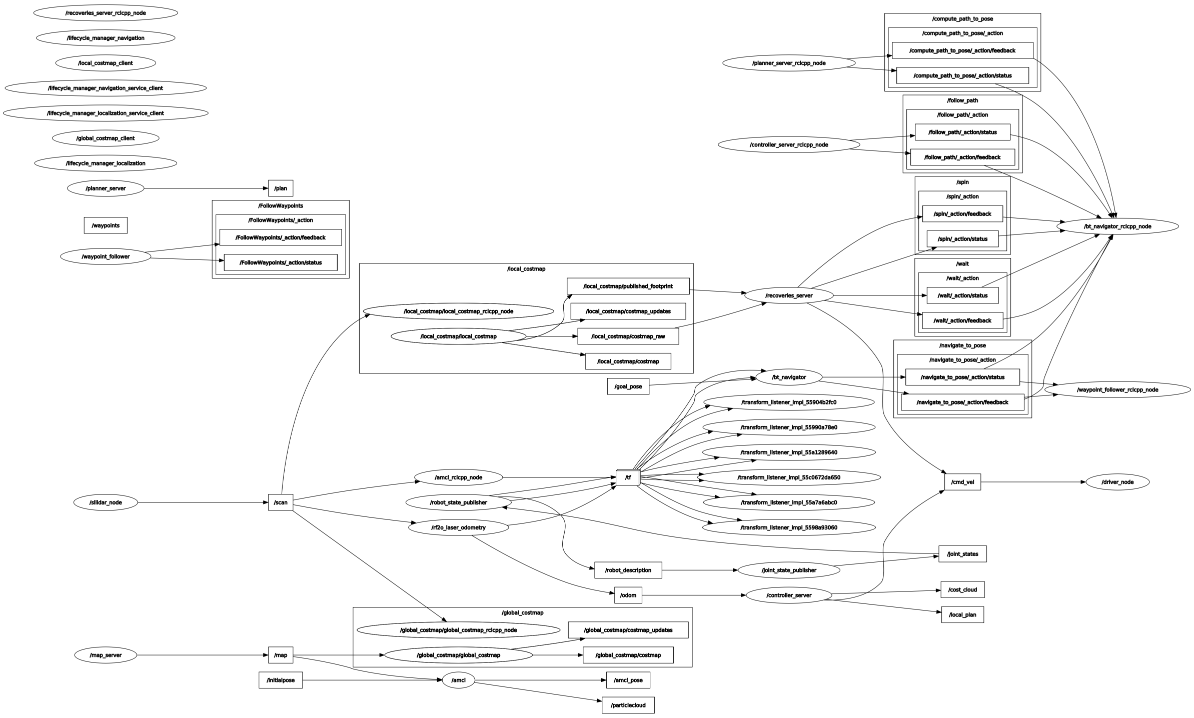


```
[bt_navigator-7] [INFO] [1682061491.700042174] [bt_navigator]: Begin navigating from current location to (-6.95, -1.41)
[bt_navigator-7] [ERROR] [1682061491.727441591] [bt_navigator]: Action server failed while executing action callback: "send_goal failed"
[bt_navigator-7] [WARN] [1682061491.727594875] [bt_navigator]: [navigate_to_pose] [ActionServer] Aborting handle.
```

2. Node analysis

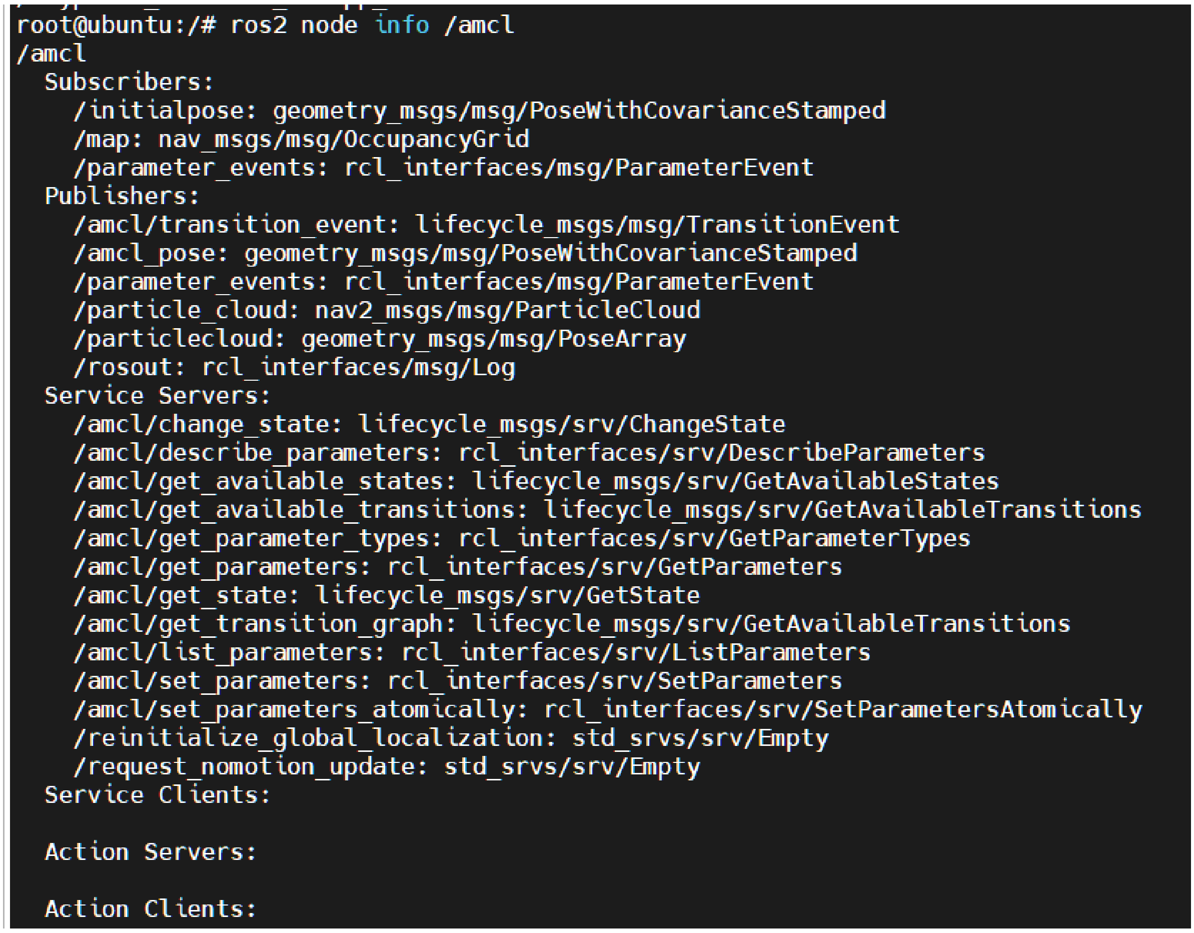
2.1. Display calculation graph

```
rqt_graph
```


/recoveries_server_rclcpp_node
/lifecycle_manager_navigation
/local_costmap_client
/lifecycle_manager_navigation_service_client
/lifecycle_manager_localization_service_client
/global_costmap_client
/lifecycle_manager_localization
/planner_server
/plan
/waypoints
/waypoint_follower
/FollowWaypoints
/FollowWaypoints/_action
/FollowWaypoints/_action/feedback
/FollowWaypoints/_action/status
/compute_path_to_pose
/compute_path_to_pose/_action
/compute_path_to_pose/_action/feedback
/compute_path_to_pose/_action/status
/planner_server_rclcpp_node
/follow_path
/follow_path/_action
/follow_path/_action/status
/follow_path/_action/feedback
/controller_server_rclcpp_node
/spin
/spin/_action
/spin/_action/feedback
/spin/_action/status
/bt_navigator_rclcpp_node
/wait
/wait/_action
/wait/_action/status
/wait/_action/feedback
/navigate_to_pose
/navigate_to_pose/_action
/navigate_to_pose/_action/status
/navigate_to_pose/_action/feedback
/waypoint_follower_rclcpp_node
/local_costmap
/local_costmap/local_costmap_rclcpp_node
/local_costmap/local_costmap
/local_costmap/published_footprint
/local_costmap/costmap_updates
/local_costmap/costmap_raw
/local_costmap/costmap
/recoveries_server
/goal_pose
/bt_navigator
/transform_listener_impl_55904b2fc0
/transform_listener_impl_55990a78e0
/transform_listener_impl_55a1289640
/transform_listener_impl_55c0672da650
/transform_listener_impl_55a7a6abc0
/transform_listener_impl_5598a93060
/sllidar_node
/scan
/amcl_rclcpp_node
/robot_state_publisher
/rf2o_laser_odometry
/tf
/cmd_vel
/driver_node
/joint_states
/robot_description
/joint_state_publisher
/odom
/controller_server
/cost_cloud
/local_plan
/global_costmap
/global_costmap/global_costmap_rclcpp_node
/global_costmap/global_costmap
/global_costmap/costmap_updates
/global_costmap/costmap
/map_server
/map
/initialpose
/amcl
/amcl_pose
/particlecloud

2.2. Navigate details of each node

/amcl

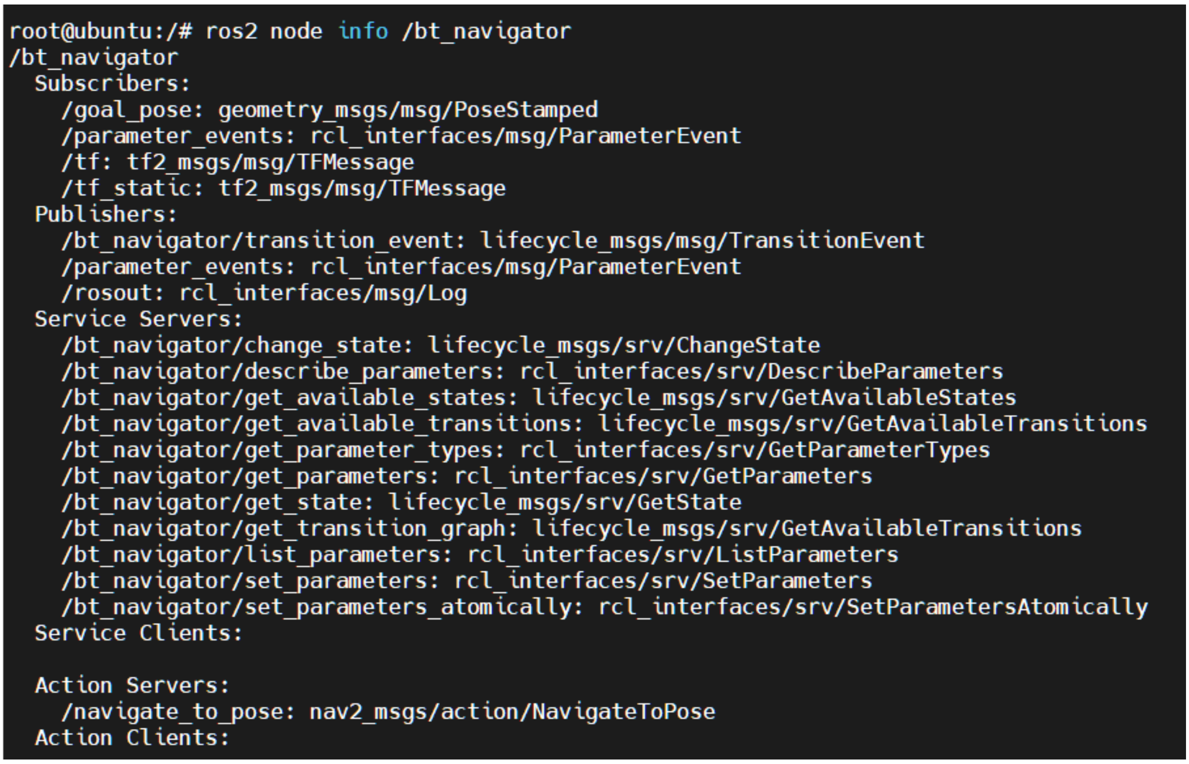


```
root@ubuntu:/# ros2 node info /amcl
/amcl
  Subscribers:
    /initialpose: geometry_msgs/msg/PoseWithCovarianceStamped
    /map: nav_msgs/msg/OccupancyGrid
    /parameter_events: rcl_interfaces/msg/ParameterEvent
  Publishers:
    /amcl/transition_event: lifecycle_msgs/msg/TransitionEvent
    /amcl_pose: geometry_msgs/msg/PoseWithCovarianceStamped
    /parameter_events: rcl_interfaces/msg/ParameterEvent
    /particle_cloud: nav2_msgs/msg/ParticleCloud
    /particlecloud: geometry_msgs/msg/PoseArray
    /rosout: rcl_interfaces/msg/Log
  Service Servers:
    /amcl/change_state: lifecycle_msgs/srv/ChangeState
    /amcl/describe_parameters: rcl_interfaces/srv/DescribeParameters
    /amcl/get_available_states: lifecycle_msgs/srv/GetAvailableStates
    /amcl/get_available_transitions: lifecycle_msgs/srv/GetAvailableTransitions
    /amcl/get_parameter_types: rcl_interfaces/srv/GetParameterTypes
    /amcl/get_parameters: rcl_interfaces/srv/GetParameters
    /amcl/get_state: lifecycle_msgs/srv/GetState
    /amcl/get_transition_graph: lifecycle_msgs/srv/GetAvailableTransitions
    /amcl/list_parameters: rcl_interfaces/srv/ListParameters
    /amcl/set_parameters: rcl_interfaces/srv/SetParameters
    /amcl/set_parameters_atomically: rcl_interfaces/srv/SetParametersAtomically
    /reinitialize_global_localization: std_srvs/srv/Empty
    /request_nomotion_update: std_srvs/srv/Empty
  Service Clients:

  Action Servers:

  Action Clients:
```

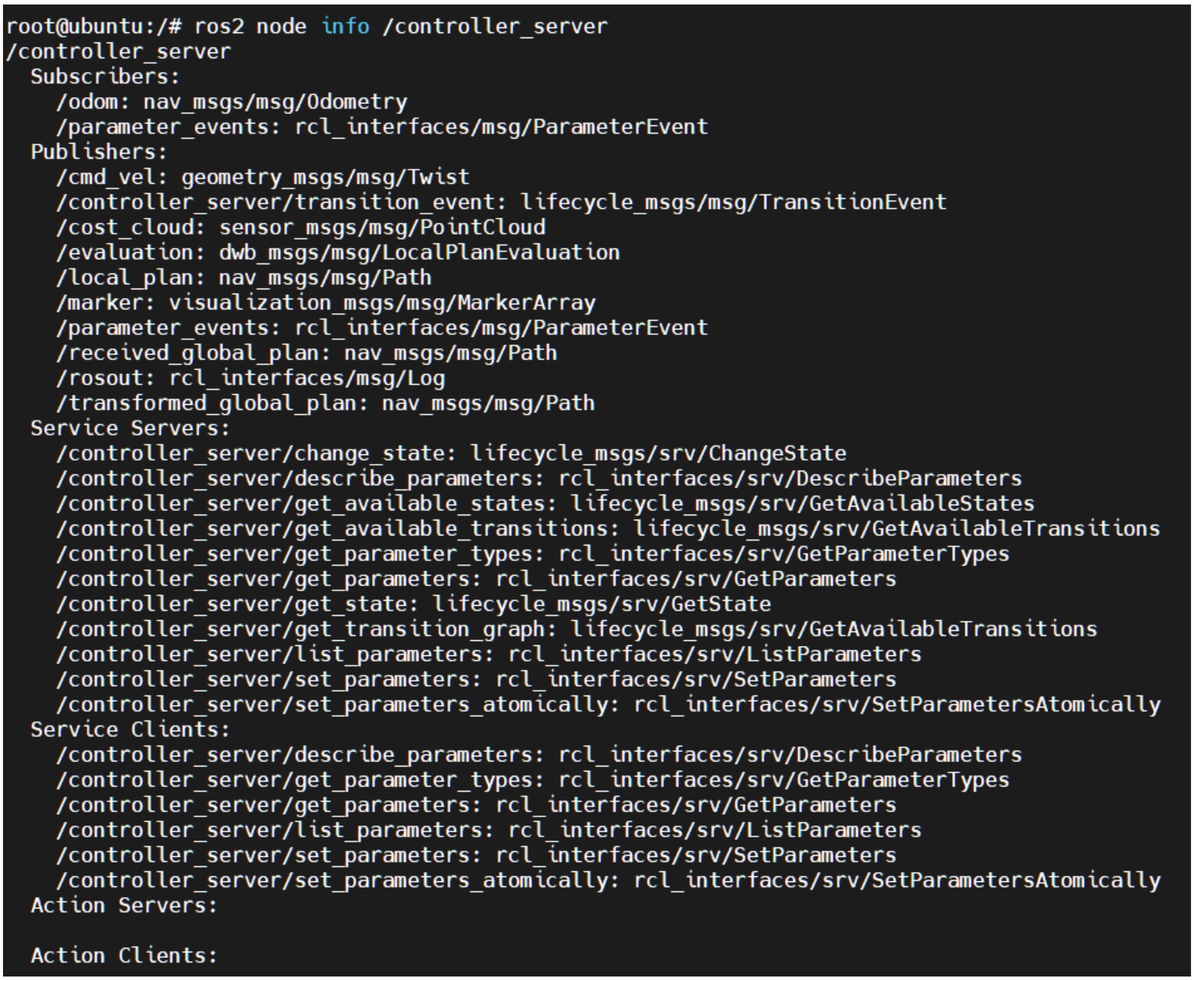
/bt_navigator



```
root@ubuntu:/# ros2 node info /bt_navigator
/bt_navigator
  Subscribers:
    /goal_pose: geometry_msgs/msg/PoseStamped
    /parameter_events: rcl_interfaces/msg/ParameterEvent
    /tf: tf2_msgs/msg/TFMessage
    /tf_static: tf2_msgs/msg/TFMessage
  Publishers:
    /bt_navigator/transition_event: lifecycle_msgs/msg/TransitionEvent
    /parameter_events: rcl_interfaces/msg/ParameterEvent
    /rosout: rcl_interfaces/msg/Log
  Service Servers:
    /bt_navigator/change_state: lifecycle_msgs/srv/ChangeState
    /bt_navigator/describe_parameters: rcl_interfaces/srv/DescribeParameters
    /bt_navigator/get_available_states: lifecycle_msgs/srv/GetAvailableStates
    /bt_navigator/get_available_transitions: lifecycle_msgs/srv/GetAvailableTransitions
    /bt_navigator/get_parameter_types: rcl_interfaces/srv/GetParameterTypes
    /bt_navigator/get_parameters: rcl_interfaces/srv/GetParameters
    /bt_navigator/get_state: lifecycle_msgs/srv/GetState
    /bt_navigator/get_transition_graph: lifecycle_msgs/srv/GetAvailableTransitions
    /bt_navigator/list_parameters: rcl_interfaces/srv/ListParameters
    /bt_navigator/set_parameters: rcl_interfaces/srv/SetParameters
    /bt_navigator/set_parameters_atomically: rcl_interfaces/srv/SetParametersAtomically
  Service Clients:

  Action Servers:
    /navigate_to_pose: nav2_msgs/action/NavigateToPose
  Action Clients:
```

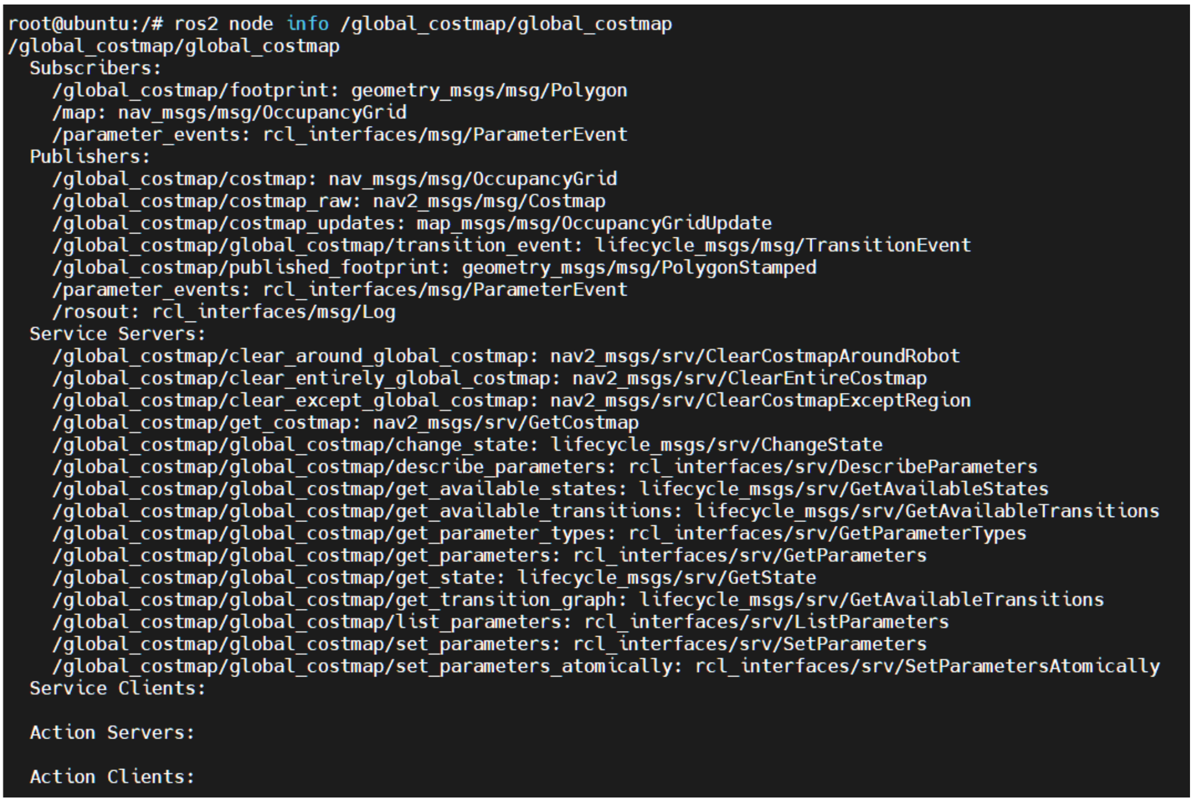
/controller_server



```
root@ubuntu:/# ros2 node info /controller_server
/controller_server
  Subscribers:
    /odom: nav_msgs/msg/Odometry
    /parameter_events: rcl_interfaces/msg/ParameterEvent
  Publishers:
    /cmd_vel: geometry_msgs/msg/Twist
    /controller_server/transition_event: lifecycle_msgs/msg/TransitionEvent
    /cost_cloud: sensor_msgs/msg/PointCloud
    /evaluation: dwb_msgs/msg/LocalPlanEvaluation
    /local_plan: nav_msgs/msg/Path
    /marker: visualization_msgs/msg/MarkerArray
    /parameter_events: rcl_interfaces/msg/ParameterEvent
    /received_global_plan: nav_msgs/msg/Path
    /rosout: rcl_interfaces/msg/Log
    /transformed_global_plan: nav_msgs/msg/Path
  Service Servers:
    /controller_server/change_state: lifecycle_msgs/srv/ChangeState
    /controller_server/describe_parameters: rcl_interfaces/srv/DescribeParameters
    /controller_server/get_available_states: lifecycle_msgs/srv/GetAvailableStates
    /controller_server/get_available_transitions: lifecycle_msgs/srv/GetAvailableTransitions
    /controller_server/get_parameter_types: rcl_interfaces/srv/GetParameterTypes
    /controller_server/get_parameters: rcl_interfaces/srv/GetParameters
    /controller_server/get_state: lifecycle_msgs/srv/GetState
    /controller_server/get_transition_graph: lifecycle_msgs/srv/GetAvailableTransitions
    /controller_server/list_parameters: rcl_interfaces/srv/ListParameters
    /controller_server/set_parameters: rcl_interfaces/srv/SetParameters
    /controller_server/set_parameters_atomically: rcl_interfaces/srv/SetParametersAtomically
  Service Clients:
    /controller_server/describe_parameters: rcl_interfaces/srv/DescribeParameters
    /controller_server/get_parameter_types: rcl_interfaces/srv/GetParameterTypes
    /controller_server/get_parameters: rcl_interfaces/srv/GetParameters
    /controller_server/list_parameters: rcl_interfaces/srv/ListParameters
    /controller_server/set_parameters: rcl_interfaces/srv/SetParameters
    /controller_server/set_parameters_atomically: rcl_interfaces/srv/SetParametersAtomically
  Action Servers:

  Action Clients:
```

/global_costmap/global_costmap

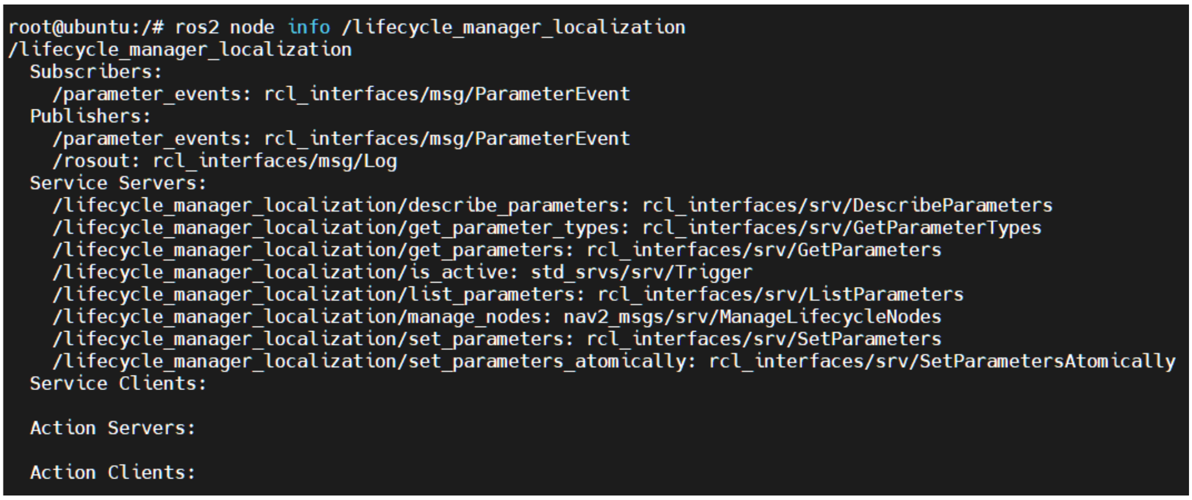


```
root@ubuntu:/# ros2 node info /global_costmap/global_costmap
/global_costmap/global_costmap
  Subscribers:
    /global_costmap/footprint: geometry_msgs/msg/Polygon
    /map: nav_msgs/msg/OccupancyGrid
    /parameter_events: rcl_interfaces/msg/ParameterEvent
  Publishers:
    /global_costmap/costmap: nav_msgs/msg/OccupancyGrid
    /global_costmap/costmap_raw: nav2_msgs/msg/Costmap
    /global_costmap/costmap_updates: map_msgs/msg/OccupancyGridUpdate
    /global_costmap/global_costmap/transition_event: lifecycle_msgs/msg/TransitionEvent
    /global_costmap/published_footprint: geometry_msgs/msg/PolygonStamped
    /parameter_events: rcl_interfaces/msg/ParameterEvent
    /rosout: rcl_interfaces/msg/Log
  Service Servers:
    /global_costmap/clear_around_global_costmap: nav2_msgs/srv/ClearCostmapAroundRobot
    /global_costmap/clear_entirely_global_costmap: nav2_msgs/srv/ClearEntireCostmap
    /global_costmap/clear_except_global_costmap: nav2_msgs/srv/ClearCostmapExceptRegion
    /global_costmap/get_costmap: nav2_msgs/srv/GetCostmap
    /global_costmap/global_costmap/change_state: lifecycle_msgs/srv/ChangeState
    /global_costmap/global_costmap/describe_parameters: rcl_interfaces/srv/DescribeParameters
    /global_costmap/global_costmap/get_available_states: lifecycle_msgs/srv/GetAvailableStates
    /global_costmap/global_costmap/get_available_transitions: lifecycle_msgs/srv/GetAvailableTransitions
    /global_costmap/global_costmap/get_parameter_types: rcl_interfaces/srv/GetParameterTypes
    /global_costmap/global_costmap/get_parameters: rcl_interfaces/srv/GetParameters
    /global_costmap/global_costmap/get_state: lifecycle_msgs/srv/GetState
    /global_costmap/global_costmap/get_transition_graph: lifecycle_msgs/srv/GetAvailableTransitions
    /global_costmap/global_costmap/list_parameters: rcl_interfaces/srv/ListParameters
    /global_costmap/global_costmap/set_parameters: rcl_interfaces/srv/SetParameters
    /global_costmap/global_costmap/set_parameters_atomically: rcl_interfaces/srv/SetParametersAtomically
  Service Clients:

  Action Servers:

  Action Clients:
```

/lifecycle_manager_localization

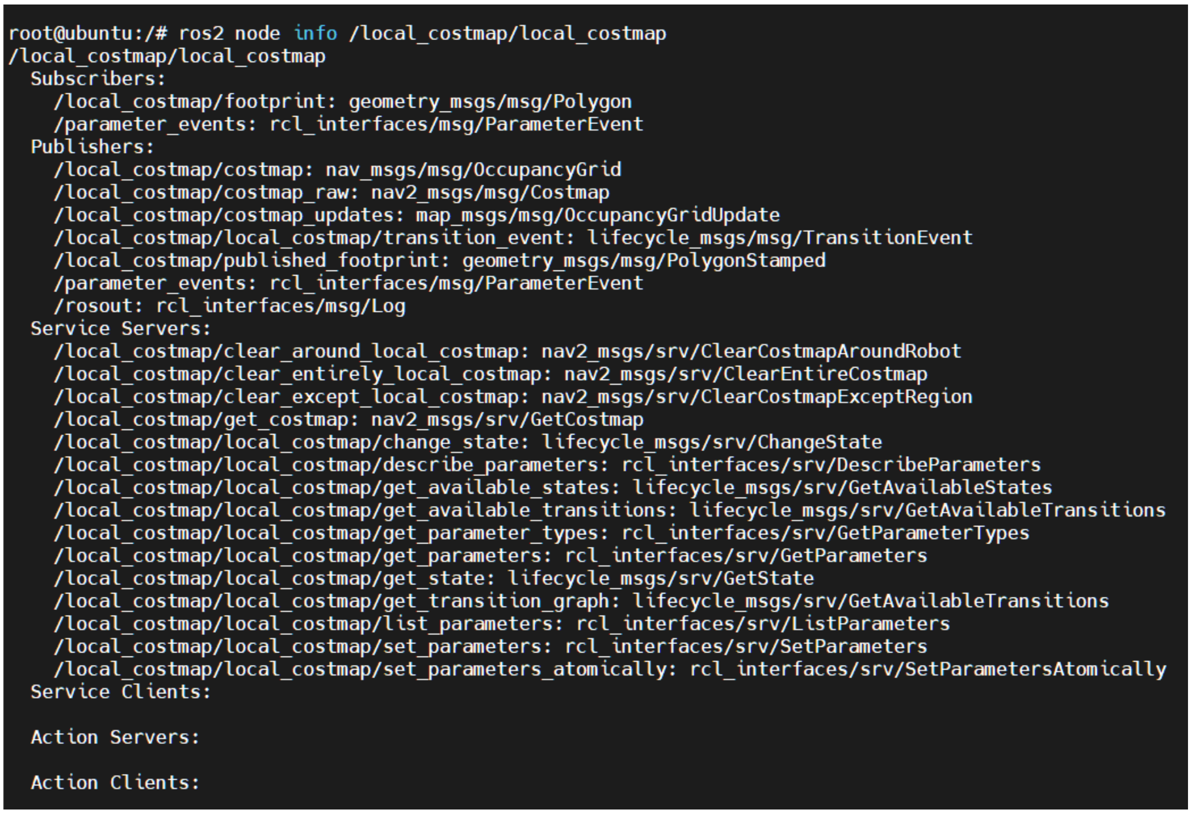


```
root@ubuntu:/# ros2 node info /lifecycle_manager_localization
/lifecycle_manager_localization
  Subscribers:
    /parameter_events: rcl_interfaces/msg/ParameterEvent
  Publishers:
    /parameter_events: rcl_interfaces/msg/ParameterEvent
    /rosout: rcl_interfaces/msg/Log
  Service Servers:
    /lifecycle_manager_localization/describe_parameters: rcl_interfaces/srv/DescribeParameters
    /lifecycle_manager_localization/get_parameter_types: rcl_interfaces/srv/GetParameterTypes
    /lifecycle_manager_localization/get_parameters: rcl_interfaces/srv/GetParameters
    /lifecycle_manager_localization/is_active: std_srvs/srv/Trigger
    /lifecycle_manager_localization/list_parameters: rcl_interfaces/srv/ListParameters
    /lifecycle_manager_localization/manage_nodes: nav2_msgs/srv/ManageLifecycleNodes
    /lifecycle_manager_localization/set_parameters: rcl_interfaces/srv/SetParameters
    /lifecycle_manager_localization/set_parameters_atomically: rcl_interfaces/srv/SetParametersAtomically
  Service Clients:

  Action Servers:

  Action Clients:
```

/local_costmap/local_costmap

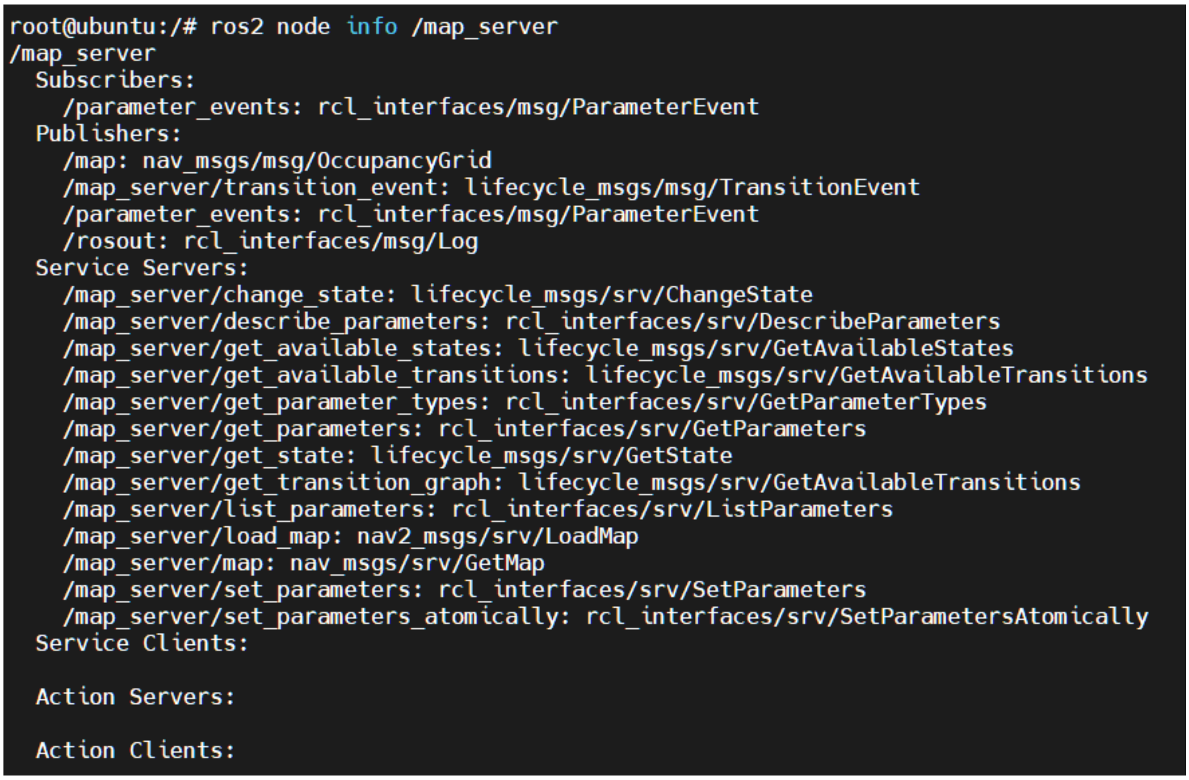


```
root@ubuntu:/# ros2 node info /local_costmap/local_costmap
/local_costmap/local_costmap
  Subscribers:
    /local_costmap/footprint: geometry_msgs/msg/Polygon
    /parameter_events: rcl_interfaces/msg/ParameterEvent
  Publishers:
    /local_costmap/costmap: nav_msgs/msg/OccupancyGrid
    /local_costmap/costmap_raw: nav2_msgs/msg/Costmap
    /local_costmap/costmap_updates: map_msgs/msg/OccupancyGridUpdate
    /local_costmap/local_costmap/transition_event: lifecycle_msgs/msg/TransitionEvent
    /local_costmap/published_footprint: geometry_msgs/msg/PolygonStamped
    /parameter_events: rcl_interfaces/msg/ParameterEvent
    /rosout: rcl_interfaces/msg/Log
  Service Servers:
    /local_costmap/clear_around_local_costmap: nav2_msgs/srv/ClearCostmapAroundRobot
    /local_costmap/clear_entirely_local_costmap: nav2_msgs/srv/ClearEntireCostmap
    /local_costmap/clear_except_local_costmap: nav2_msgs/srv/ClearCostmapExceptRegion
    /local_costmap/get_costmap: nav2_msgs/srv/GetCostmap
    /local_costmap/local_costmap/change_state: lifecycle_msgs/srv/ChangeState
    /local_costmap/local_costmap/describe_parameters: rcl_interfaces/srv/DescribeParameters
    /local_costmap/local_costmap/get_available_states: lifecycle_msgs/srv/GetAvailableStates
    /local_costmap/local_costmap/get_available_transitions: lifecycle_msgs/srv/GetAvailableTransitions
    /local_costmap/local_costmap/get_parameter_types: rcl_interfaces/srv/GetParameterTypes
    /local_costmap/local_costmap/get_parameters: rcl_interfaces/srv/GetParameters
    /local_costmap/local_costmap/get_state: lifecycle_msgs/srv/GetState
    /local_costmap/local_costmap/get_transition_graph: lifecycle_msgs/srv/GetAvailableTransitions
    /local_costmap/local_costmap/list_parameters: rcl_interfaces/srv/ListParameters
    /local_costmap/local_costmap/set_parameters: rcl_interfaces/srv/SetParameters
    /local_costmap/local_costmap/set_parameters_atomically: rcl_interfaces/srv/SetParametersAtomically
  Service Clients:

  Action Servers:

  Action Clients:
```

/map_server

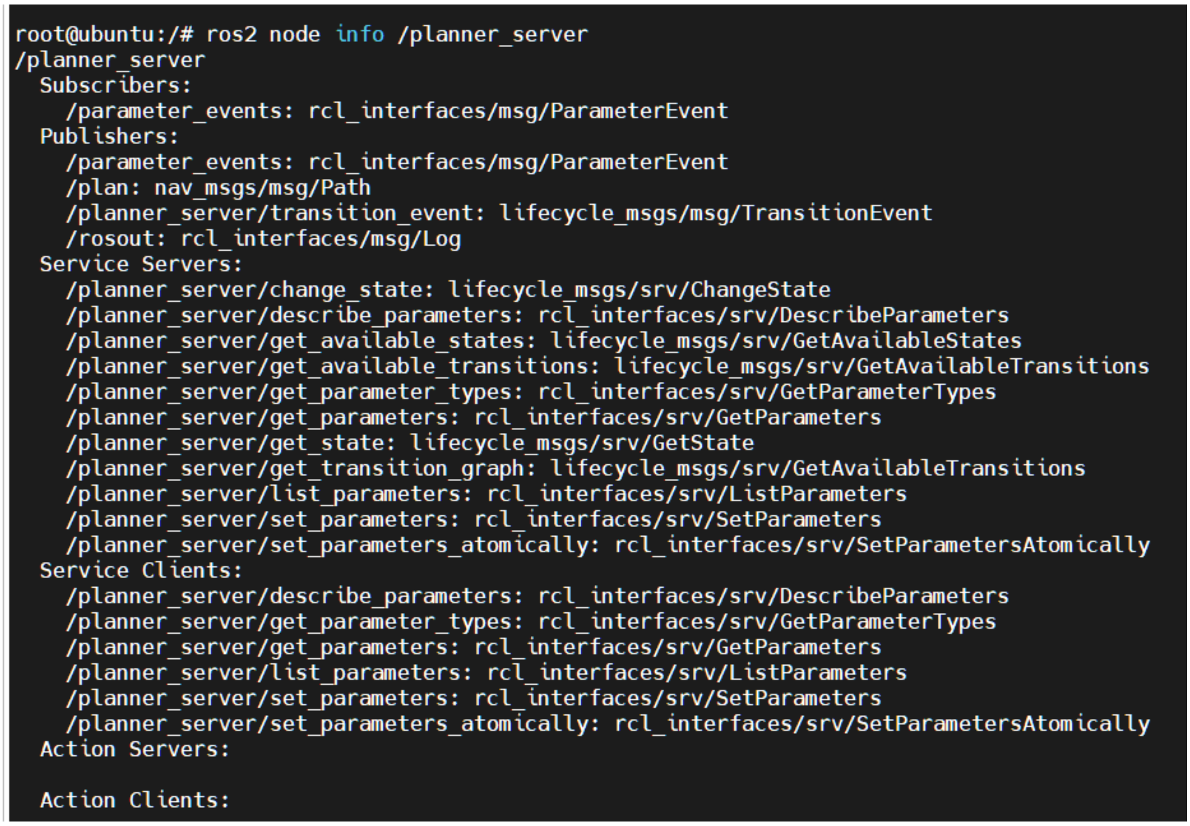


```
root@ubuntu:/# ros2 node info /map_server
/map_server
  Subscribers:
    /parameter_events: rcl_interfaces/msg/ParameterEvent
  Publishers:
    /map: nav_msgs/msg/OccupancyGrid
    /map_server/transition_event: lifecycle_msgs/msg/TransitionEvent
    /parameter_events: rcl_interfaces/msg/ParameterEvent
    /rosout: rcl_interfaces/msg/Log
  Service Servers:
    /map_server/change_state: lifecycle_msgs/srv/ChangeState
    /map_server/describe_parameters: rcl_interfaces/srv/DescribeParameters
    /map_server/get_available_states: lifecycle_msgs/srv/GetAvailableStates
    /map_server/get_available_transitions: lifecycle_msgs/srv/GetAvailableTransitions
    /map_server/get_parameter_types: rcl_interfaces/srv/GetParameterTypes
    /map_server/get_parameters: rcl_interfaces/srv/GetParameters
    /map_server/get_state: lifecycle_msgs/srv/GetState
    /map_server/get_transition_graph: lifecycle_msgs/srv/GetAvailableTransitions
    /map_server/list_parameters: rcl_interfaces/srv/ListParameters
    /map_server/load_map: nav2_msgs/srv/LoadMap
    /map_server/map: nav_msgs/srv/GetMap
    /map_server/set_parameters: rcl_interfaces/srv/SetParameters
    /map_server/set_parameters_atomically: rcl_interfaces/srv/SetParametersAtomically
  Service Clients:

  Action Servers:

  Action Clients:
```

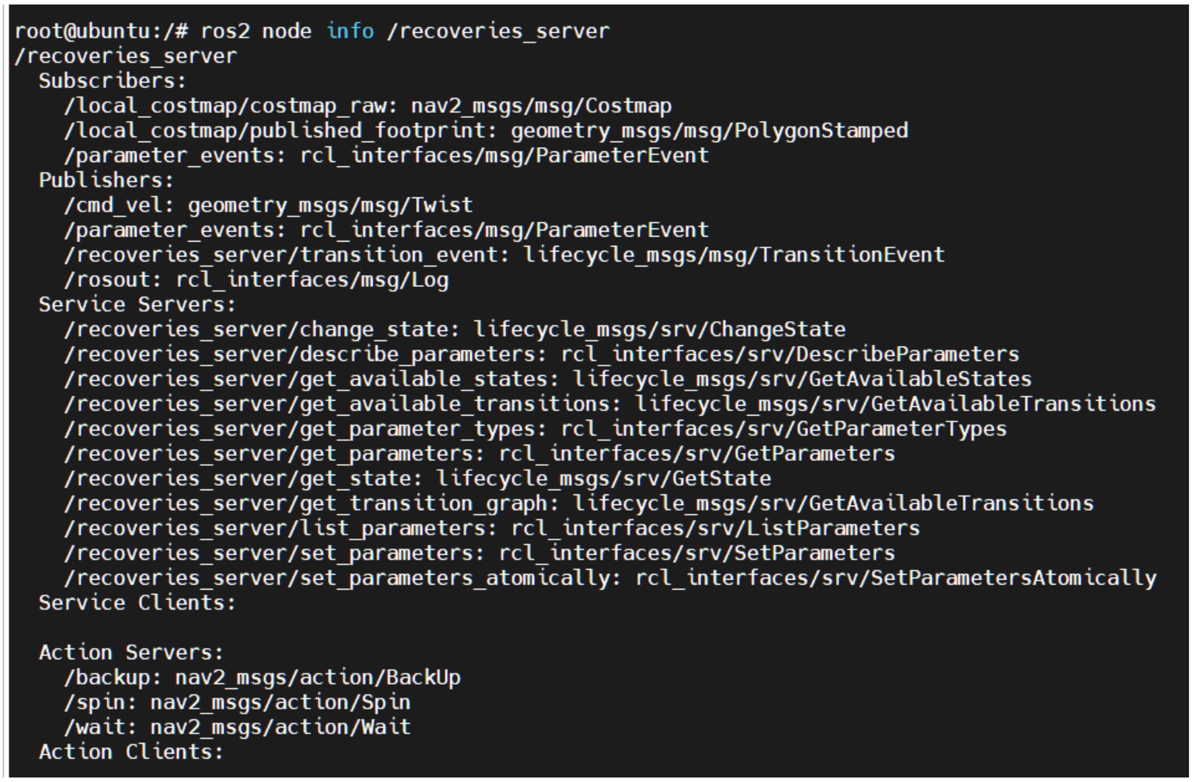
/planner_server



```
root@ubuntu:/# ros2 node info /planner_server
/planner_server
  Subscribers:
    /parameter_events: rcl_interfaces/msg/ParameterEvent
  Publishers:
    /parameter_events: rcl_interfaces/msg/ParameterEvent
    /plan: nav_msgs/msg/Path
    /planner_server/transition_event: lifecycle_msgs/msg/TransitionEvent
    /rosout: rcl_interfaces/msg/Log
  Service Servers:
    /planner_server/change_state: lifecycle_msgs/srv/ChangeState
    /planner_server/describe_parameters: rcl_interfaces/srv/DescribeParameters
    /planner_server/get_available_states: lifecycle_msgs/srv/GetAvailableStates
    /planner_server/get_available_transitions: lifecycle_msgs/srv/GetAvailableTransitions
    /planner_server/get_parameter_types: rcl_interfaces/srv/GetParameterTypes
    /planner_server/get_parameters: rcl_interfaces/srv/GetParameters
    /planner_server/get_state: lifecycle_msgs/srv/GetState
    /planner_server/get_transition_graph: lifecycle_msgs/srv/GetAvailableTransitions
    /planner_server/list_parameters: rcl_interfaces/srv/ListParameters
    /planner_server/set_parameters: rcl_interfaces/srv/SetParameters
    /planner_server/set_parameters_atomically: rcl_interfaces/srv/SetParametersAtomically
  Service Clients:
    /planner_server/describe_parameters: rcl_interfaces/srv/DescribeParameters
    /planner_server/get_parameter_types: rcl_interfaces/srv/GetParameterTypes
    /planner_server/get_parameters: rcl_interfaces/srv/GetParameters
    /planner_server/list_parameters: rcl_interfaces/srv/ListParameters
    /planner_server/set_parameters: rcl_interfaces/srv/SetParameters
    /planner_server/set_parameters_atomically: rcl_interfaces/srv/SetParametersAtomically
  Action Servers:

  Action Clients:
```

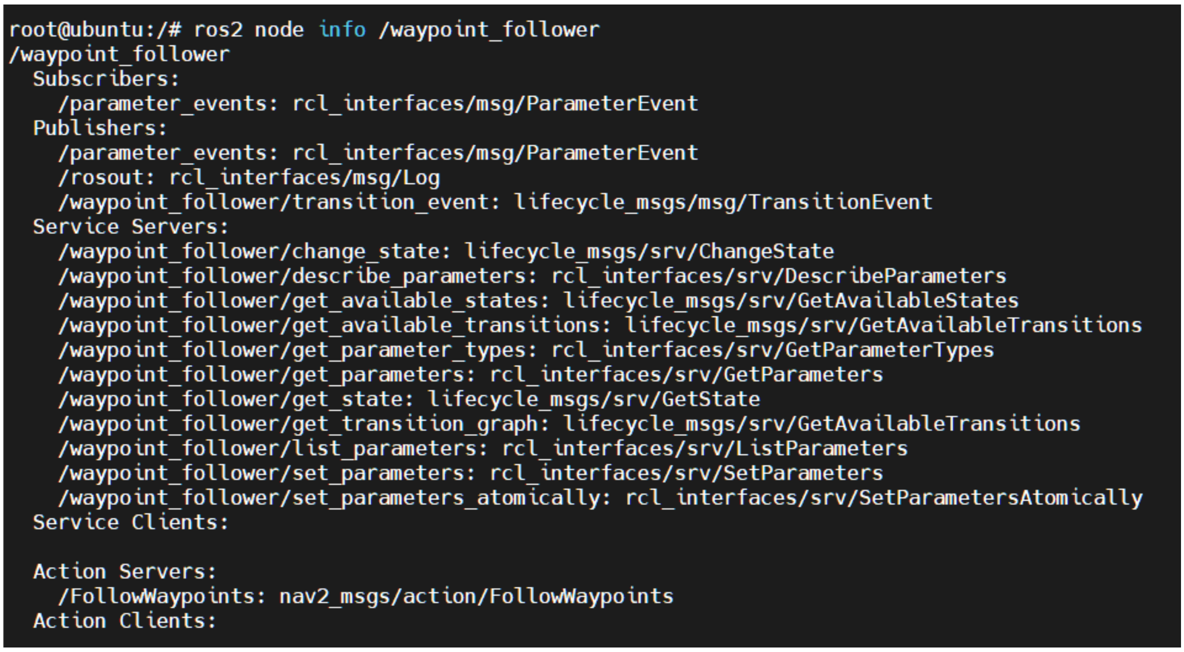
/recoveries_server



```
root@ubuntu:/# ros2 node info /recoveries_server
/recoveries_server
  Subscribers:
    /local_costmap/costmap_raw: nav2_msgs/msg/Costmap
    /local_costmap/published_footprint: geometry_msgs/msg/PolygonStamped
    /parameter_events: rcl_interfaces/msg/ParameterEvent
  Publishers:
    /cmd_vel: geometry_msgs/msg/Twist
    /parameter_events: rcl_interfaces/msg/ParameterEvent
    /recoveries_server/transition_event: lifecycle_msgs/msg/TransitionEvent
    /rosout: rcl_interfaces/msg/Log
  Service Servers:
    /recoveries_server/change_state: lifecycle_msgs/srv/ChangeState
    /recoveries_server/describe_parameters: rcl_interfaces/srv/DescribeParameters
    /recoveries_server/get_available_states: lifecycle_msgs/srv/GetAvailableStates
    /recoveries_server/get_available_transitions: lifecycle_msgs/srv/GetAvailableTransitions
    /recoveries_server/get_parameter_types: rcl_interfaces/srv/GetParameterTypes
    /recoveries_server/get_parameters: rcl_interfaces/srv/GetParameters
    /recoveries_server/get_state: lifecycle_msgs/srv/GetState
    /recoveries_server/get_transition_graph: lifecycle_msgs/srv/GetAvailableTransitions
    /recoveries_server/list_parameters: rcl_interfaces/srv/ListParameters
    /recoveries_server/set_parameters: rcl_interfaces/srv/SetParameters
    /recoveries_server/set_parameters_atomically: rcl_interfaces/srv/SetParametersAtomically
  Service Clients:

  Action Servers:
    /backup: nav2_msgs/action/BackUp
    /spin: nav2_msgs/action/Spin
    /wait: nav2_msgs/action/Wait
  Action Clients:
```

/waypoint_follower

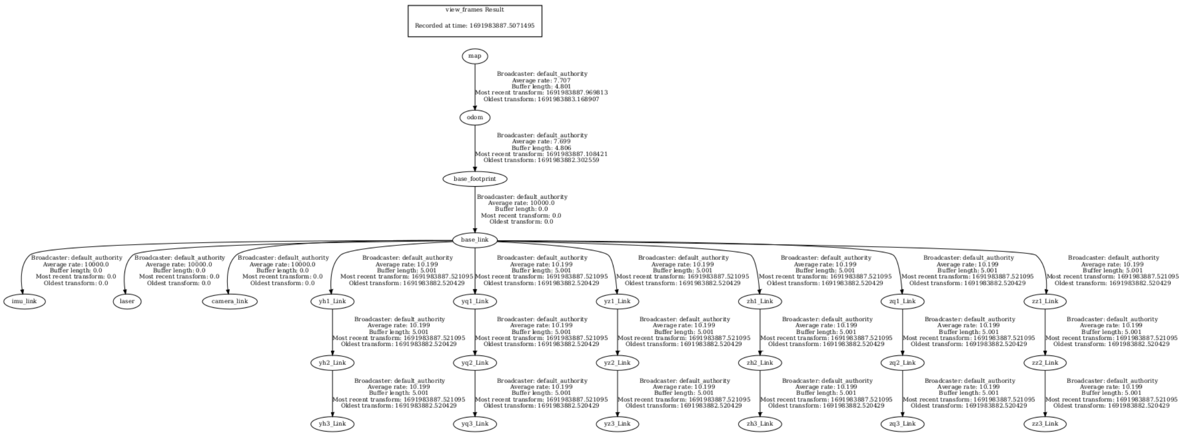


```
root@ubuntu:/# ros2 node info /waypoint_follower
/waypoint_follower
  Subscribers:
    /parameter_events: rcl_interfaces/msg/ParameterEvent
  Publishers:
    /parameter_events: rcl_interfaces/msg/ParameterEvent
    /rosout: rcl_interfaces/msg/Log
    /waypoint_follower/transition_event: lifecycle_msgs/msg/TransitionEvent
  Service Servers:
    /waypoint_follower/change_state: lifecycle_msgs/srv/ChangeState
    /waypoint_follower/describe_parameters: rcl_interfaces/srv/DescribeParameters
    /waypoint_follower/get_available_states: lifecycle_msgs/srv/GetAvailableStates
    /waypoint_follower/get_available_transitions: lifecycle_msgs/srv/GetAvailableTransitions
    /waypoint_follower/get_parameter_types: rcl_interfaces/srv/GetParameterTypes
    /waypoint_follower/get_parameters: rcl_interfaces/srv/GetParameters
    /waypoint_follower/get_state: lifecycle_msgs/srv/GetState
    /waypoint_follower/get_transition_graph: lifecycle_msgs/srv/GetAvailableTransitions
    /waypoint_follower/list_parameters: rcl_interfaces/srv/ListParameters
    /waypoint_follower/set_parameters: rcl_interfaces/srv/SetParameters
    /waypoint_follower/set_parameters_atomically: rcl_interfaces/srv/SetParametersAtomically
  Service Clients:

  Action Servers:
    /FollowWaypoints: nav2_msgs/action/FollowWaypoints
  Action Clients:
```

2.3. TF transformation

```
ros2 run tf2_tools view_frames.py
```



view_frames Result
Recorded at time: 1691983887.5071495
map
Broadcaster: default_authority
Average rate: 7.707
Buffer length: 4.801
Most recent transform: 1691983887.969813
Oldest transform: 1691983883.168907
odom
Broadcaster: default_authority
Average rate: 7.699
Buffer length: 4.806
Most recent transform: 1691983887.108421
Oldest transform: 1691983882.302559
base_footprint
Broadcaster: default_authority
Average rate: 10000.0
Buffer length: 0.0
Most recent transform: 0.0
Oldest transform: 0.0
base_link
Broadcaster: default_authority
Average rate: 10000.0
Buffer length: 0.0
Most recent transform: 0.0
Oldest transform: 0.0
Broadcaster: default_authority
Average rate: 10000.0
Buffer length: 0.0
Most recent transform: 0.0
Oldest transform: 0.0
Broadcaster: default_authority
Average rate: 10000.0
Buffer length: 0.0
Most recent transform: 0.0
Oldest transform: 0.0
Broadcaster: default_authority
Average rate: 10.199
Buffer length: 5.001
Most recent transform: 1691983887.521095
Oldest transform: 1691983882.520429
Broadcaster: default_authority
Average rate: 10.199
Buffer length: 5.001
Most recent transform: 1691983887.521095
Oldest transform: 1691983882.520429
Broadcaster: default_authority
Average rate: 10.199
Buffer length: 5.001
Most recent transform: 1691983887.521095
Oldest transform: 1691983882.520429
Broadcaster: default_authority
Average rate: 10.199
Buffer length: 5.001
Most recent transform: 1691983887.521095
Oldest transform: 1691983882.520429
Broadcaster: default_authority
Average rate: 10.199
Buffer length: 5.001
Most recent transform: 1691983887.521095
Oldest transform: 1691983882.520429
Broadcaster: default_authority
Average rate: 10.199
Buffer length: 5.001
Most recent transform: 1691983887.521095
Oldest transform: 1691983882.520429
imu_link
laser
camera_link
yh1_Link
yq1_Link
yz1_Link
zh1_Link
zq1_Link
zz1_Link
Broadcaster: default_authority
Average rate: 10.199
Buffer length: 5.001
Most recent transform: 1691983887.521095
Oldest transform: 1691983882.520429
Broadcaster: default_authority
Average rate: 10.199
Buffer length: 5.001
Most recent transform: 1691983887.521095
Oldest transform: 1691983882.520429
Broadcaster: default_authority
Average rate: 10.199
Buffer length: 5.001
Most recent transform: 1691983887.521095
Oldest transform: 1691983882.520429
Broadcaster: default_authority
Average rate: 10.199
Buffer length: 5.001
Most recent transform: 1691983887.521095
Oldest transform: 1691983882.520429
Broadcaster: default_authority
Average rate: 10.199
Buffer length: 5.001
Most recent transform: 1691983887.521095
Oldest transform: 1691983882.520429
Broadcaster: default_authority
Average rate: 10.199
Buffer length: 5.001
Most recent transform: 1691983887.521095
Oldest transform: 1691983882.520429
yh2_Link
yq2_Link
yz2_Link
zh2_Link
zq2_Link
zz2_Link
Broadcaster: default_authority
Average rate: 10.199
Buffer length: 5.001
Most recent transform: 1691983887.521095
Oldest transform: 1691983882.520429
Broadcaster: default_authority
Average rate: 10.199
Buffer length: 5.001
Most recent transform: 1691983887.521095
Oldest transform: 1691983882.520429
Broadcaster: default_authority
Average rate: 10.199
Buffer length: 5.001
Most recent transform: 1691983887.521095
Oldest transform: 1691983882.520429
Broadcaster: default_authority
Average rate: 10.199
Buffer length: 5.001
Most recent transform: 1691983887.521095
Oldest transform: 1691983882.520429
Broadcaster: default_authority
Average rate: 10.199
Buffer length: 5.001
Most recent transform: 1691983887.521095
Oldest transform: 1691983882.520429
Broadcaster: default_authority
Average rate: 10.199
Buffer length: 5.001
Most recent transform: 1691983887.521095
Oldest transform: 1691983882.520429
yh3_Link
yq3_Link
yz3_Link
zh3_Link
zq3_Link
zz3_Link