Contents

ROS2 Homework #1

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0 Setup

Since I am using Arch Linux, I modified the `install.sh` script accordingly. On Arch Linux, Python packages are named with the prefix `python-` and, once installed, they are available for the system's Python 3 intepreter.

```
...
# install python modules
sudo pacman -Sy python-argcomplete \
                python-docker \
                python-prettytable \
                python-yaml
...
```

Activate shell completion:

```
activate-global-python-argcomplete
source /etc/bash_completion.d/python-argcomplete
```

Build needed image:

```
nturt_docker image build nturacing/nturt_ros:host-devel
```

Create a new container:

```
nturt_docker container create 0731 nturacing/nturt_ros:host-devel
   host
```

Attach shell into container:

```
nturt_docker container shell 0731
```

1 Beginner: CLI tools

1.1 Configuring environment

Most of the environment configuration is done automatically when starting the Docker container. However, it is important to note that the `ROS_DISTRO` is set to `iron`, so when installing packages, I need to make sure to use the package repositories corresponding to the Iron distribution instead of Humble distribution.

1.2 Using `turtlesim`, `ros2` and `rqt`

1. Install `turtlesim`
   I found the password for root and user "docker" is `docker` in `Dockerfile/nturt_ros/host/devel/Dockerfile` .

   ```
   sudo apt update
   sudo apt install ros-iron-turtlesim
   ```

   And I found that it has been installed already in the container.

   ```
   docker@host-devel:~$ sudo apt install ros-iron-turtlesim
   Reading package lists... Done
   Building dependency tree... Done
   Reading state information... Done
   ros-iron-turtlesim is already the newest version (1.6.1-1jammy.20240213.160912).
   ros-iron-turtlesim set to manually installed.
   0 upgraded, 0 newly installed, 0 to remove and 187 not upgraded.
   ```

   Double check whether the package is installed:

   ```
   ros2 pkg executables turtlesim
   ```

   ```
   docker@host-devel:~$ ros2 pkg executables turtlesim
   turtlesim draw_square
   turtlesim mimic
   turtlesim turtle_teleop_key
   turtlesim turtlesim_node
   ```

2. Start turtlesim

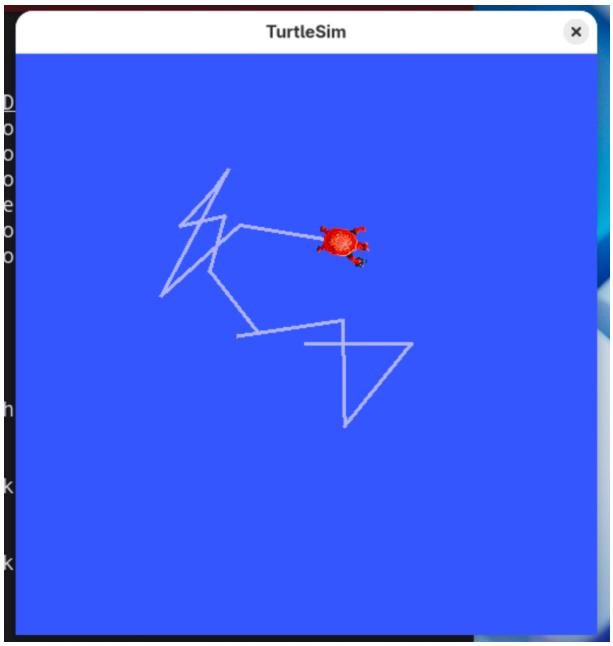
   ```
   ros2 run turtlesim turtlesim_node
   ```

   ```
   docker@host-devel:~$ ros2 run turtlesim turtlesim_node
   QStandardPaths: XDG_RUNTIME_DIR not set, defaulting to '/tmp/runtime-docker'
   [INFO] [1754039084.932637403] [turtlesim]: Starting turtlesim with node name /turtlesim
   [INFO] [1754039084.937605542] [turtlesim]: Spawning turtle [turtle1] at x=[5.544445], y=[5.544445], theta=[0.000000]
   ```

3. Use turtlesim

```
ros2 run turtlesim turtle_teleop_key
```

```
docker@host-devel:~$ ros2 run turtlesim turtle_teleop_key
Reading from keyboard
---------------------------
Use arrow keys to move the turtle.
Use G|B|V|C|D|E|R|T keys to rotate to absolute orientations. 'F' to cancel a rotation.
'Q' to quit.
```



By using the `list` subcommands, I can see the nodes, topics, services, and actions.

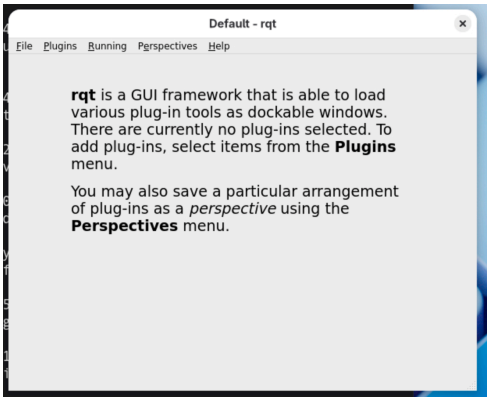
```
ros2 node list
ros2 topic list
ros2 service list
ros2 action list
```

```
docker@host-devel:~$ ros2 node list
/teleop_turtle
/turtlesim
docker@host-devel:~$ ros2 topic list
/parameter_events
/rosout
/turtle1/cmd_vel
/turtle1/color_sensor
/turtle1/pose
docker@host-devel:~$ ros2 service list
/clear
/kill
/reset
/spawn
/teleop_turtle/describe_parameters
/teleop_turtle/get_parameter_types
/teleop_turtle/get_parameters
/teleop_turtle/get_type_description
/teleop_turtle/list_parameters
/teleop_turtle/set_parameters
/teleop_turtle/set_parameters_atomically
/turtle1/set_pen
/turtle1/teleport_absolute
/turtle1/teleport_relative
/turtlesim/describe_parameters
/turtlesim/get_parameter_types
/turtlesim/get_parameters
/turtlesim/get_type_description
/turtlesim/list_parameters
/turtlesim/set_parameters
/turtlesim/set_parameters_atomically
docker@host-devel:~$ ros2 action list
/turtle1/rotate_absolute
```

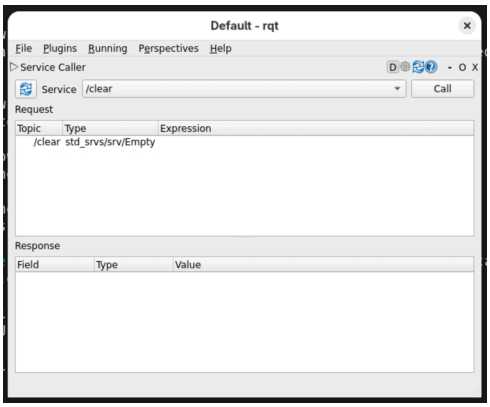
4. Install rqt
   Similarly, after checking, the `ros2-iron-rqt` packages has been installed in the container.
   Run `rqt`:

```
rqt
```

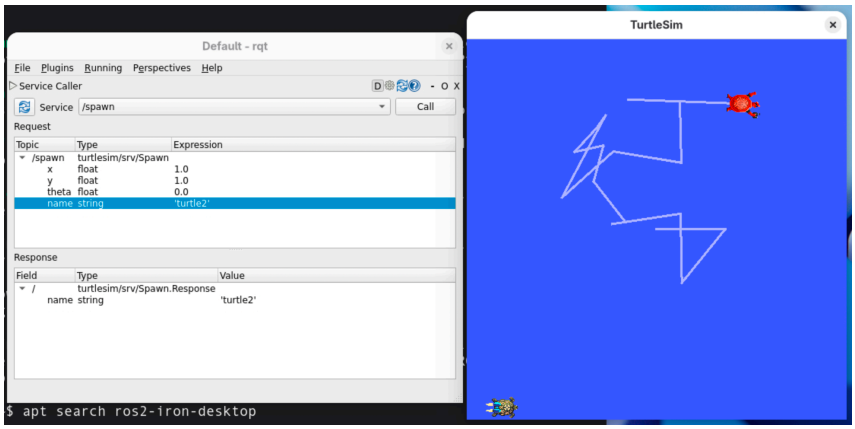
```
docker@host-devel:~$ rqt
QStandardPaths: XDG_RUNTIME_DIR not set, defaulting to '/tmp/runtime-docker'
```



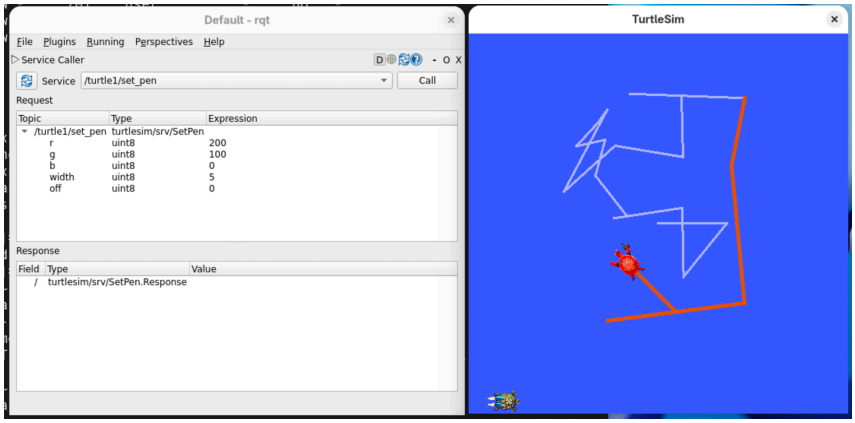
5. Use rqt
   Select `Plugins` > `Services` > `Service Caller`:



   (a) Try the spawn service



   (b) Try the set_pen service



6. Remapping
   In order to control `turtle2`, I can't use the same command before, because it wil also contorl `turtle1` too. Instead, use the new command to remap the topic `cmd_vel`:

```
ros2 run turtlesim turtle_teleop_key --ros-args --remap turtle1/
   cmd_vel:=turtle2/cmd_vel
```

```
docker@host-devel:~$ ros2 run turtlesim turtle_teleop_key --ros-args --remap turtle1/cmd_vel:=turtle2/cmd_vel
Reading from keyboard
---------------------------
Use arrow keys to move the turtle.
Use G|B|V|C|D|E|R|T keys to rotate to absolute orientations. 'F' to cancel a rotation.
'Q' to quit.
```

7. Close turtlesim
   Use `Ctrl+C` and `q` to close the terminals.

1.3 Understanding nodes

1. ros2 run
   To launch an executable from a package:

   ```
   ros2 run <package> <executable>
   ```

   For instance:

   ```
   ros2 run turtlesim turtlesim_node
   ```

   And I got same result as the previous section got.

2. ros2 node list
   Show the running nodes:

   ```
   ros2 node list
   ```

   - Remapping
     Allow me to reassign default node properties, e.g. node name(by using `__node`):

     ```
     ros2 run turtlesim turtlesim_node --ros-args --remap __node:
        myturtle
     ```

     There will be a new node:

     ```
     docker@host-devel:~$ ros2 node list
     /myturtle
     /teleop_turtle
     /turtlesim
     ```

3. ros2 node info

   ```
   ros2 node info /myturtle
   ```

   ```
   docker@host-devel:~$ ros2 node info /myturtle
   /myturtle
     Subscribers:
       /parameter_events: rcl_interfaces/msg/ParameterEvent
       /turtle1/cmd_vel: geometry_msgs/msg/Twist
     Publishers:
       /parameter_events: rcl_interfaces/msg/ParameterEvent
       /rosout: rcl_interfaces/msg/Log
       /turtle1/color_sensor: turtlesim/msg/Color
       /turtle1/pose: turtlesim/msg/Pose
     Service Servers:
       /clear: std_srvs/srv/Empty
       /kill: turtlesim/srv/Kill
       /myturtle/describe_parameters: rcl_interfaces/srv/DescribeParameters
       /myturtle/get_parameter_types: rcl_interfaces/srv/GetParameterTypes
       /myturtle/get_parameters: rcl_interfaces/srv/GetParameters
       /myturtle/get_type_description: type_description_interfaces/srv/GetTypeDescription
       /myturtle/list_parameters: rcl_interfaces/srv/ListParameters
       /myturtle/set_parameters: rcl_interfaces/srv/SetParameters
       /myturtle/set_parameters_atomically: rcl_interfaces/srv/SetParametersAtomically
       /reset: std_srvs/srv/Empty
       /spawn: turtlesim/srv/Spawn
       /turtle1/set_pen: turtlesim/srv/SetPen
       /turtle1/teleport_absolute: turtlesim/srv/TeleportAbsolute
       /turtle1/teleport_relative: turtlesim/srv/TeleportRelative
     Service Clients:

     Action Servers:
       /turtle1/rotate_absolute: turtlesim/action/RotateAbsolute
     Action Clients:
   ```

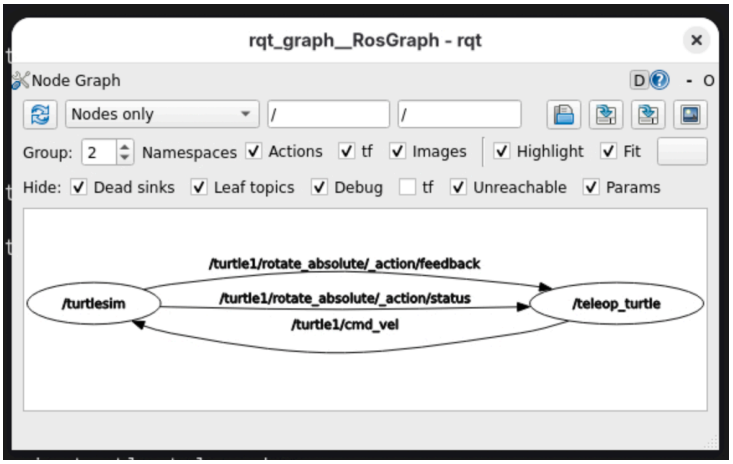
1.4 Understanding topics

1. Setup

```
ros2 run turtlesim turtlesim_node
ros2 run turtlesim turtlesim_teleop_key
```

2. rqt_graph

```
rqt_graph
```



We can discover that `/teleop_turtle` publishes data to the topic `/turtle1/cmd_vel`, and `/turtlesim` is subscribed to it.

3. ros2 topic list

```
ros2 ropic list
```

Return currently active topics: With the flag `-t`, I get more information of topic

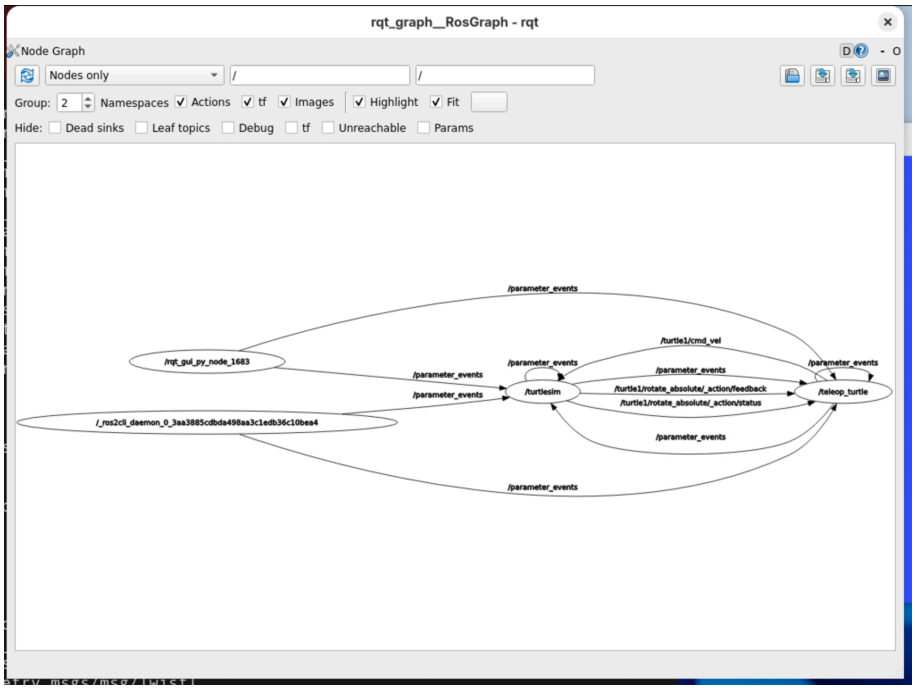
```
docker@host-devel:~$ ros2 topic list
/parameter_events
/rosout
/turtle1/cmd_vel
/turtle1/color_sensor
/turtle1/pose
```

type appended in bracket.

```
ros2 topic list -t
```

```
docker@host-devel:~$ ros2 topic list -t
/parameter_events [rcl_interfaces/msg/ParameterEvent]
/rosout [rcl_interfaces/msg/Log]
/turtle1/cmd_vel [geometry_msgs/msg/Twist]
/turtle1/color_sensor [turtlesim/msg/Color]
/turtle1/pose [turtlesim/msg/Pose]
```

Uncheck all boxes under Hider can see all topics on `rqt_graph`:



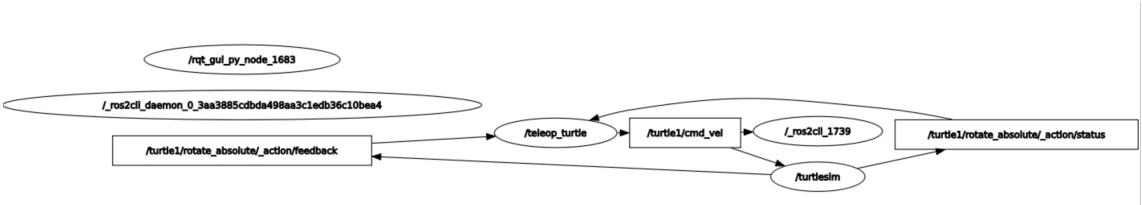
4. ros2 topic echo

```
ros2 topic echo /turtle1/cmd_vel
```

And we can see the data published to the topic `/turtle1/cmd_vel`:

```
docker@host-devel:~$ ros2 topic echo /turtle1/cmd_vel
linear:
  x: -2.0
  y: 0.0
  z: 0.0
angular:
  x: 0.0
  y: 0.0
  z: 0.0
---
```

Uncheck the Debug box on `rqt_graph`, we can see that `/_ros2cli_1739` is created by previous command, and there are two nodes subscribed to `/turtle1/cmd_vel`:



5. ros2 topic info

```
ros2 topic info /turtle1/cmd_vel
```

```
docker@host-devel:~$ ros2 topic info /turtle1/cmd_vel
Type: geometry_msgs/msg/Twist
Publisher count: 1
Subscription count: 2
```

It returns the information including the amount of publishers and subscriptions of `/turtle1/cmd_vel`.

6. ros2 interface show

```
ros2 interface show geometry_msgs/msg/Twist
```

It shows the detail of the type "`geometry_msgs/msg/Twist`".

```
docker@host-devel:~$ ros2 interface show geometry_msgs/msg/Twist
# This expresses velocity in free space broken into its linear and angular parts.

Vector3  linear
        float64 x
        float64 y
        float64 z
Vector3  angular
        float64 x
        float64 y
        float64 z
```

7. ros2 topic pub
   I can directly publish a data to a topic by command:

```
ros2 topic pub /turtle1/cmd_vel geometry_msgs/msg/Twist "{linear
   : {x: 2.0, y: 0.0, z: 0.0}, angular: {x: 0.0, y: 0.0, z:
   1.8}}"
```

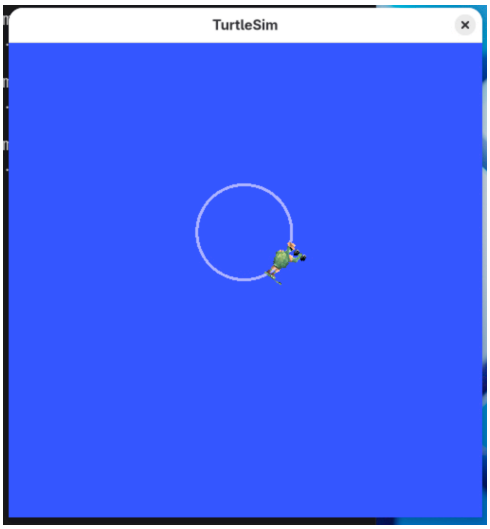
With no other options, it will publish in a steady stream 1Hz.

```
docker@host-devel:~$ ros2 topic pub /turtle1/cmd_vel geometry_msgs/msg/Twist "{linear: {x:
 2.0, y: 0.0, z: 0.0}, angular: {x: 0.0, y: 0.0, z: 1.8}}"
publisher: beginning loop
publishing #1: geometry_msgs.msg.Twist(linear=geometry_msgs.msg.Vector3(x=2.0, y=0.0, z=0.
0), angular=geometry_msgs.msg.Vector3(x=0.0, y=0.0, z=1.8))

publishing #2: geometry_msgs.msg.Twist(linear=geometry_msgs.msg.Vector3(x=2.0, y=0.0, z=0.
0), angular=geometry_msgs.msg.Vector3(x=0.0, y=0.0, z=1.8))

publishing #3: geometry_msgs.msg.Twist(linear=geometry_msgs.msg.Vector3(x=2.0, y=0.0, z=0.
0), angular=geometry_msgs.msg.Vector3(x=0.0, y=0.0, z=1.8))

publishing #4: geometry_msgs.msg.Twist(linear=geometry_msgs.msg.Vector3(x=2.0, y=0.0, z=0.
0), angular=geometry_msgs.msg.Vector3(x=0.0, y=0.0, z=1.8))
```



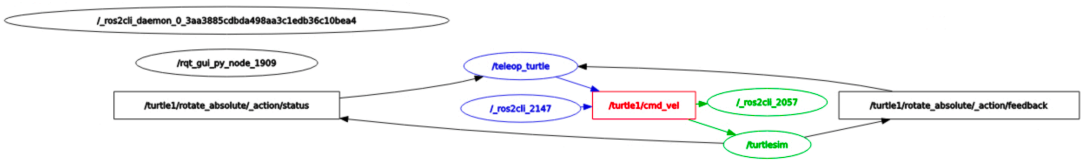
By using `--once`(publish one message then exit) and `-w 2`(wait for 2 matching subscriptions):

```
ros2 topic pub /turtle1/cmd_vel geometry_msgs/msg/Twist "{linear
   : {x: 2.0, y: 0.0, z: 0.0}, angular: {x: 0.0, y: 0.0, z:
   1.8}}" --once -w 2
```

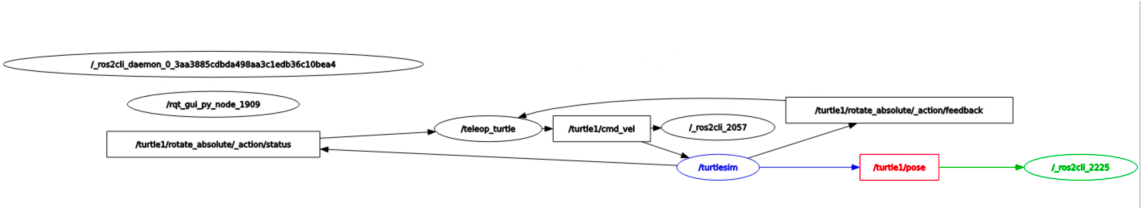
```
docker@host-devel:~$ ros2 topic pub /turtle1/cmd_vel geometry_msgs/msg/Twist "{linear: {x:
 2.0, y: 0.0, z: 0.0}, angular: {x: 0.0, y: 0.0, z: 1.8}}" --once -w 2
publisher: beginning loop
publishing #1: geometry_msgs.msg.Twist(linear=geometry_msgs.msg.Vector3(x=2.0, y=0.0, z=0.
0), angular=geometry_msgs.msg.Vector3(x=0.0, y=0.0, z=1.8))

docker@host-devel:~$
```

Refresh the `rqt_graph`, and we can see that the node `/_ros2cli_2147`(`ros2 topic pub...`) also published data to the topic `/turtle1/cmd_vel`:



Run `echo` on the `pose` topic and recheck `rqt_graph`: We can see that `/turtlesim`



also publishing to the topic `/turtle1/pose`, which the new `echo` node (`/_ros2cli_2225`) subscribed to.

8. ros2 topic hz
   We can see the rate at which data is published:

```
ros2 topic hz /turtle1/pose
```

```
docker@host-devel:~$ ros2 topic hz /turtle1/pose
average rate: 62.509
        min: 0.015s max: 0.017s std dev: 0.00055s window: 64
```

9. ros2 topic bw
   To view the bandwith of a topic:

```
ros2 topic bw /turtle1/pose
```

```
^Cdocker@host-devel:~$ ros2 topic bw /turtle1/pose
Subscribed to [/turtle1/pose]
1.51 KB/s from 57 messages
        Message size mean: 0.02 KB min: 0.02 KB max: 0.02 KB
1.52 KB/s from 100 messages
        Message size mean: 0.02 KB min: 0.02 KB max: 0.02 KB
```

10. ros2 topic find Give the topics available for specific type of messages:

```
ros2 topic find geometry_msgs/msg/Twist
```

```
docker@host-devel:~$ ros2 topic find geometry_msgs/msg/Twist
/turtle1/cmd_vel
```

11. Clean up
    Use `Ctrl+C` to clean up all terminals.

1.5 Understanding services

1. Setup

```
ros2 run turtlesim turtlesim_node
ros2 run turtlesim turtle_teleop_key
```

2. ros2 service list
   To see current active services:

```
ros2 service list
```

```
docker@host-devel:~$ ros2 service list
/clear
/kill
/reset
/spawn
/teleop_turtle/describe_parameters
/teleop_turtle/get_parameter_types
/teleop_turtle/get_parameters
/teleop_turtle/get_type_description
/teleop_turtle/list_parameters
/teleop_turtle/set_parameters
/teleop_turtle/set_parameters_atomically
/turtle1/set_pen
/turtle1/teleport_absolute
/turtle1/teleport_relative
/turtlesim/describe_parameters
/turtlesim/get_parameter_types
/turtlesim/get_parameters
/turtlesim/get_type_description
/turtlesim/list_parameters
/turtlesim/set_parameters
/turtlesim/set_parameters_atomically
```

   To see the type of a service:

```
ros2 service type <service>
```

   e.g. the type of `/kill`:

```
docker@host-devel:~$ ros2 service type /kill
turtlesim/srv/Kill
```

- ros2 service list -t
  Similar to `topic`, we can add the option `-t`, to see the types of all services.

```
ros2 service list -t
```

```
docker@host-devel:~$ ros2 service list -t
/clear [std_srvs/srv/Empty]
/kill [turtlesim/srv/Kill]
/reset [std_srvs/srv/Empty]
/spawn [turtlesim/srv/Spawn]
/teleop_turtle/describe_parameters [rcl_interfaces/srv/DescribeParameters]
/teleop_turtle/get_parameter_types [rcl_interfaces/srv/GetParameterTypes]
/teleop_turtle/get_parameters [rcl_interfaces/srv/GetParameters]
/teleop_turtle/get_type_description [type_description_interfaces/srv/GetTypeDesc
ription]
/teleop_turtle/list_parameters [rcl_interfaces/srv/ListParameters]
/teleop_turtle/set_parameters [rcl_interfaces/srv/SetParameters]
/teleop_turtle/set_parameters_atomically [rcl_interfaces/srv/SetParametersAtomic
ally]
/turtle1/set_pen [turtlesim/srv/SetPen]
/turtle1/teleport_absolute [turtlesim/srv/TeleportAbsolute]
/turtle1/teleport_relative [turtlesim/srv/TeleportRelative]
/turtlesim/describe_parameters [rcl_interfaces/srv/DescribeParameters]
/turtlesim/get_parameter_types [rcl_interfaces/srv/GetParameterTypes]
/turtlesim/get_parameters [rcl_interfaces/srv/GetParameters]
/turtlesim/get_type_description [type_description_interfaces/srv/GetTypeDescript
ion]
/turtlesim/list_parameters [rcl_interfaces/srv/ListParameters]
/turtlesim/set_parameters [rcl_interfaces/srv/SetParameters]
/turtlesim/set_parameters_atomically [rcl_interfaces/srv/SetParametersAtomically
]
```

3. ros2 service find
   Find all services of a specific type:

```
ros2 service find std_srvs/srv/Empty
```

```
docker@host-devel:~$ ros2 service find std_srvs/srv/Empty
/clear
/reset
```

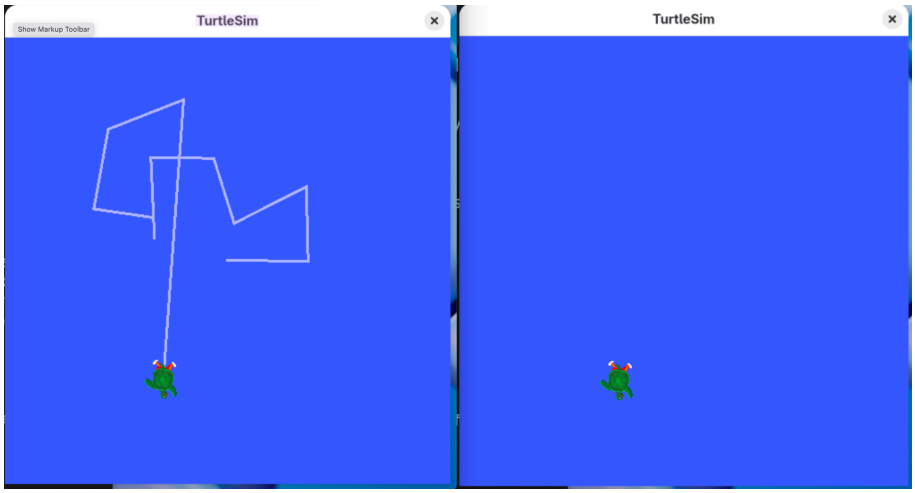
4. ros2 interface show
   Se the detail of a type:

```
ros2 interface show turtlesim/srv/Spawn
```

```
docker@host-devel:~$ ros2 interface show std_srvs/srv/Empty
---
docker@host-devel:~$ ros2 interface show turtlesim/srv/Spawn
float32 x
float32 y
float32 theta
string name # Optional.  A unique name will be created and returned if this is e
mpty
---
string name
```

5. ros2 service call
   Call a service:

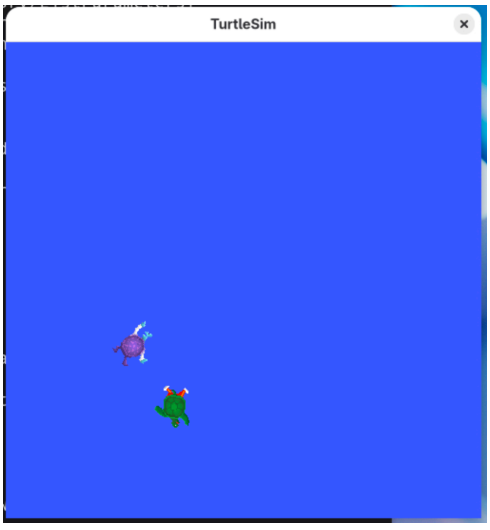
```
ros2 service call /clear std_srvs/srv/Empty
```




```
ros2 service call /spawn turtlesim/srv/Spawn "{x: 3, y: 4, theta
    : 0.5, name: 'hehe'}"
```

```
docker@host-devel:~$ ros2 service call /spawn turtlesim/srv/Spawn "{x: 3, y: 4,
theta: 0.5, name: 'hehe'}"
requester: making request: turtlesim.srv.Spawn_Request(x=3.0, y=4.0, theta=0.5,
name='hehe')

response:
turtlesim.srv.Spawn_Response(name='hehe')
```



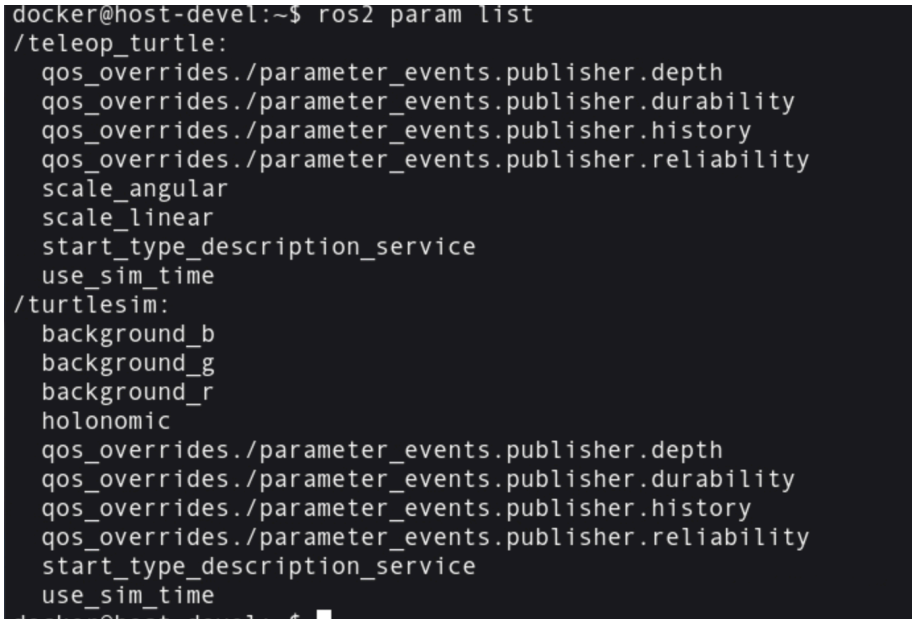
1.6 Understanding parameters

1. Setup

```
ros2 run turtlesim turtlesim_node
ros2 run turtlesim turtle_teleop_key
```

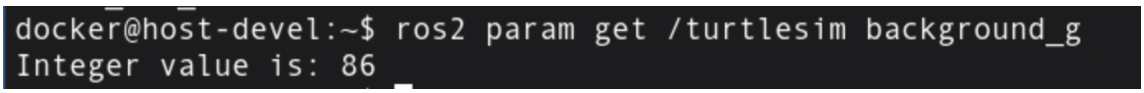
2. ros2 param list
   To see each node's parameters:

```
ros2 param list
```



3. ros2 get param To see the type and value of a node's parameter:

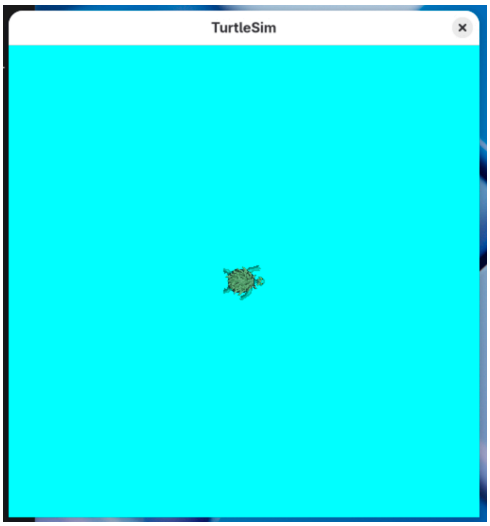
```
ros2 get param /turtlesim backgount_g
```



4. ros2 set param
   To set a parameter of a node:

```
ros2 set param /turtlesim background_g 255
```

```
docker@host-devel:~$ ros2 param set /turtlesim background_g 255
Set parameter successful
```



5. ros2 param dump
   To see all parameters of a node:

```
ros2 param dump /turtlesim
```

   and it can also output to a file by appending `> <filename>`.

```
docker@host-devel:~$ ros2 param dump /turtlesim
/turtlesim:
  ros__parameters:
    background_b: 255
    background_g: 255
    background_r: 69
    holonomic: false
    qos_overrides:
      /parameter_events:
        publisher:
          depth: 1000
          durability: volatile
          history: keep_last
          reliability: reliable
    start_type_description_service: true
    use_sim_time: false
```

6. ros2 param load
   To load a file into a node:

```
ros2 param load /turtlesim turtlesim.yaml
```

```
docker@host-devel:~$ ros2 param load /turtlesim turtlesim.yaml
Set parameter background_b successful
Set parameter background_g successful
Set parameter background_r successful
Set parameter holonomic successful
Set parameter qos_overrides./parameter_events.publisher.depth failed: parameter
'qos_overrides./parameter_events.publisher.depth' cannot be set because it is re
ad-only
Set parameter qos_overrides./parameter_events.publisher.durability failed: param
eter 'qos_overrides./parameter_events.publisher.durability' cannot be set becaus
e it is read-only
Set parameter qos_overrides./parameter_events.publisher.history failed: paramete
r 'qos_overrides./parameter_events.publisher.history' cannot be set because it i
s read-only
Set parameter qos_overrides./parameter_events.publisher.reliability failed: para
meter 'qos_overrides./parameter_events.publisher.reliability' cannot be set beca
use it is read-only
Set parameter start_type_description_service failed: parameter 'start_type_descr
iption_service' cannot be set because it is read-only
Set parameter use_sim_time successful
```

7. Load paramter file on node startup:
   To load a parameter file to a new node:

```
ros2 run turtlesim turtlesim_node --ros-args --params-file
   turtlesim.yaml
```

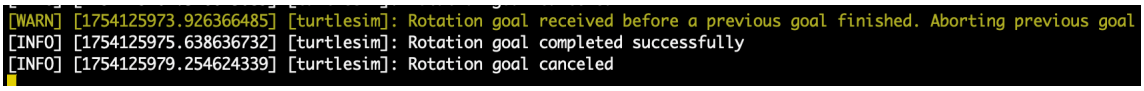
```
docker@host-devel:~$ ros2 run turtlesim turtlesim_node --ros-args --params-file
turtlesim.yaml
QStandardPaths: XDG_RUNTIME_DIR not set, defaulting to '/tmp/runtime-docker'
[INFO] [1754099661.786248715] [turtlesim]: Starting turtlesim with node name /tu
rtlesim
[INFO] [1754099661.808473231] [turtlesim]: Spawning turtle [turtle1] at x=[5.544
445], y=[5.544445], theta=[0.000000]
```

1.7 Understanding actions

1. Setup

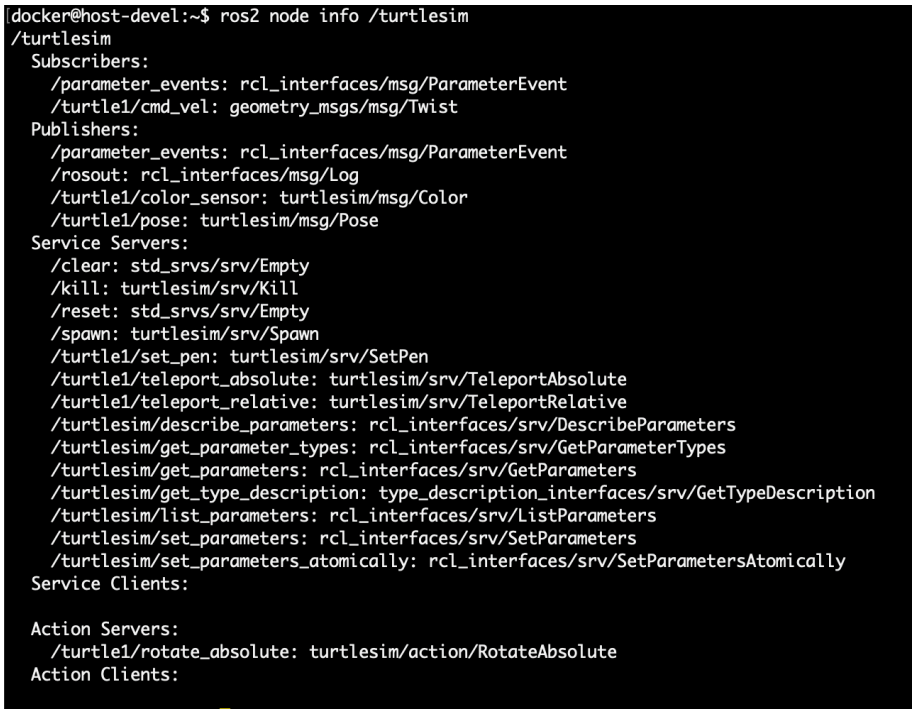
```
ros2 run turtlesim turtlesim_node
ros2 run turtlesim turtle_teleop_key
```

2. Use actions
   Use the operation in the `turtle_teleop_key`'s terminal, and observe the terminal of the node `turtlesim`:



3. ros2 node info
   To see the detail of a node:

```
ros2 node info /turtlesim
```



4. ros2 action list To see all active actions:

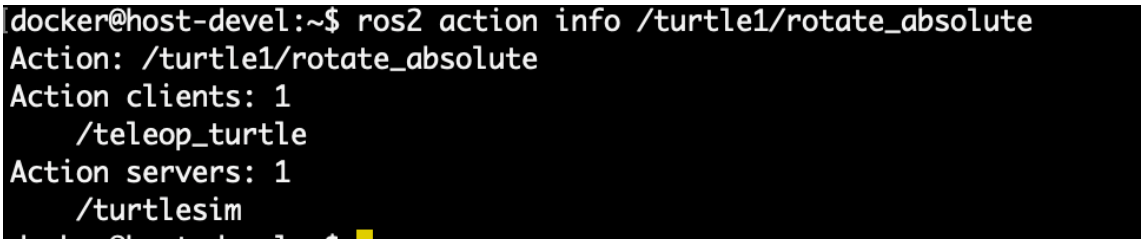
```
ros2 action list
```

   Similarly, `-t` for type:

```
ros2 action list -t
```

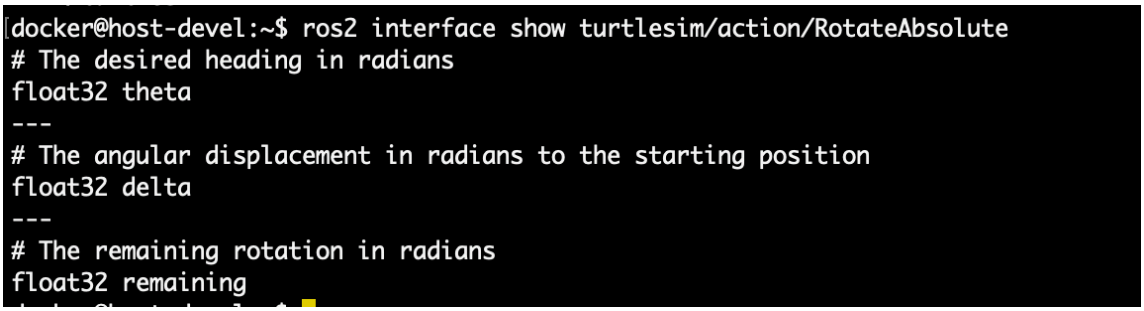
5. ros2 action info: To see more detail about an action:

```
ros2 action info /turtle1/rotate_absolute
```



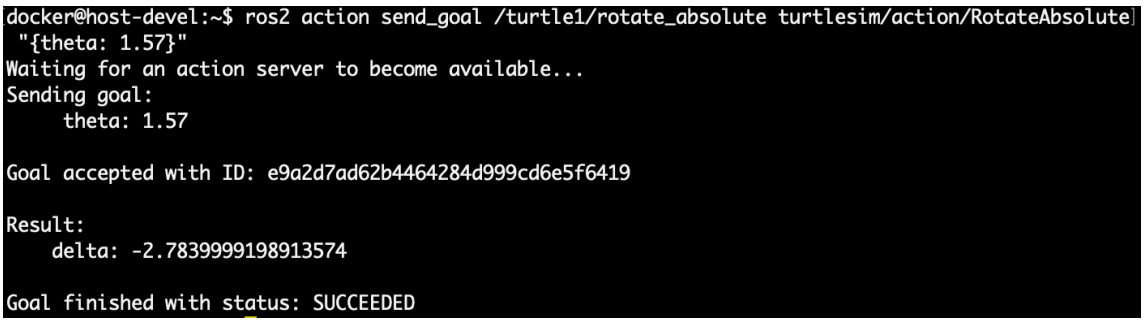
6. ros2 interface show: To see the inerface of a type:

```
ros2 interface show turtlesim/action/RotateAbsolute
```



7. ros2 action send_goal To send an action goal from the command line directly:

```
ros2 action send_goal /turtle1/rotate_absolute turtlesim/action/
   RotateAbsolute "{theta: 1.57}"
```



Add `--feedback` to see feedback:

```
docker@host-devel:~$ ros2 action send_goal /turtle1/rotate_absolute turtlesim/action/RotateAbsolute
 "{theta: 1.58}" --feedback
Waiting for an action server to become available...
Sending goal:
     theta: 1.58

Feedback:
    remaining: 0.027999997138977051

Goal accepted with ID: ef1e9c3d49b043f5bb0573c881280d47

Feedback:
    remaining: 0.012000083923339844

Result:
    delta: -0.016000000759959221

Goal finished with status: SUCCEEDED
```

1.8 Using `rqt_console` to view logs

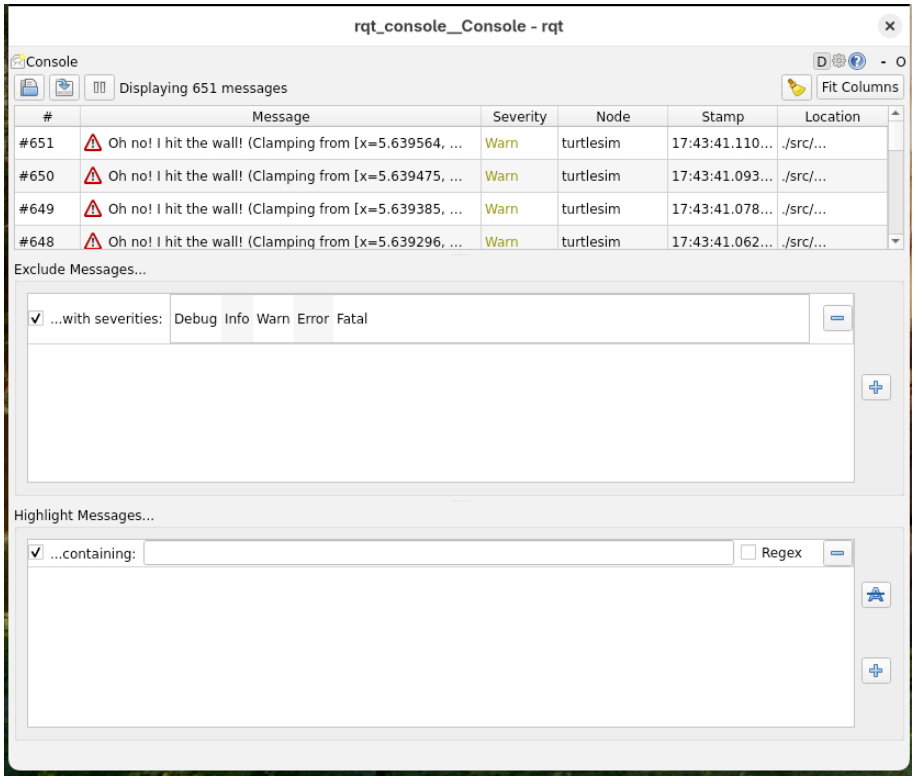
1. Setup

```
ros2 run rqt_console rqt_console
```

2. Messeages on rqt_console

```
ros2 topic pub -r 1 /turtle1/cmd_vel geometry_msgs/msg/Twist "{
   linear: {x: 2.0, y: 0.0, z: 0.0}, angular: {x: 0.0,y: 0.0,z:
   0.0}}"
```

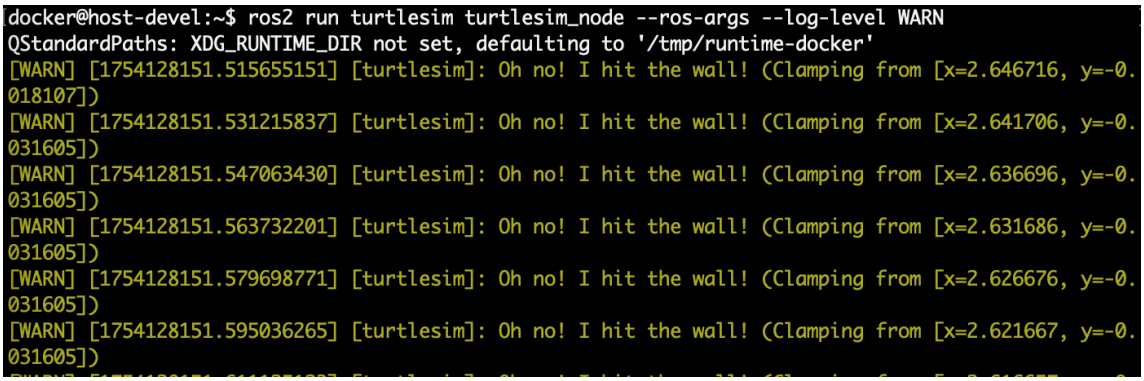
And we can see warning on the console:



We can use `--log-level` to set the logger level:

```
ros2 run turtlesim turtlesim_node --ros-args --log-level WARN
```

And messages with level lower than `[WARN]`(`[INFO]`) cannot be seen.

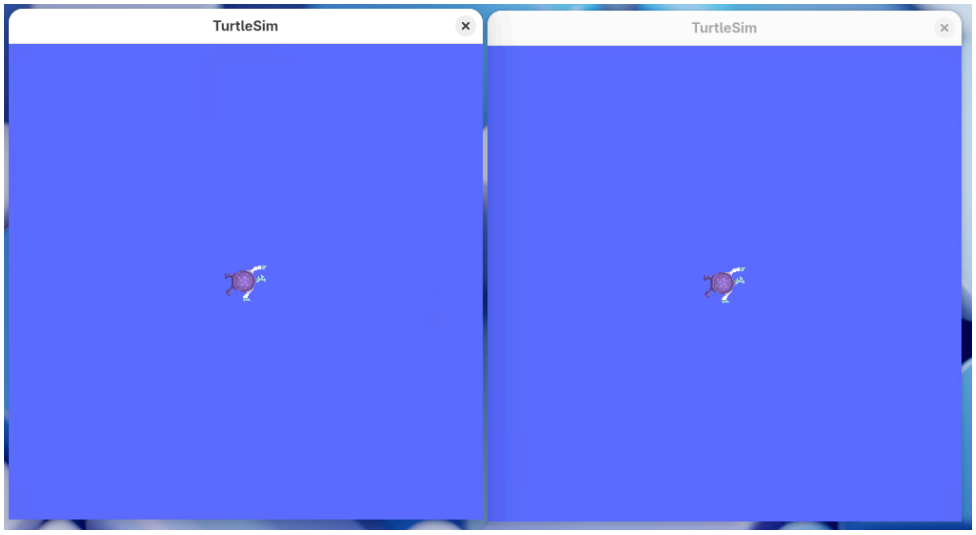


1.9 Launching nodes

- Running a Luanch File

```
ros2 launch turtlesim multisim.launch.py
```

We will see two turtlesim nodes:



1.10 Recording and playing back data

1. Setup

```
ros2 run turtlesim turtlesim_node
ros2 run turtlesim turtle_teleop_key
```

And also create a directory to store recordings.

```
mkdir bag_files
```

2. Choose a topic Use:

```
ros2 topic list
```

We can choose a topic we want to record. Additionally, we can use the `topic echo` command to show the messages published to the topic.

```
ros2 topic echo /turtle1/cmd_vel
```

3. ros2 bag record

   (a) Record a single topic

```
ros2 bag record /turtle1/cmd_vel
```

   (b) Record multilple topics

```
ros2 bag record <topic_1> <topic_2> ...
```

Option `-o` can name the file, and `-a` will record all topics.

4. ros2 bag info

```
ros2 bag info <file_name>
```

```
docker@host-devel:~/bag_files$ ros2 bag info rosbag2_2025_08_02-20_33_23/

Files:             rosbag2_2025_08_02-20_33_23_0.mcap
Bag size:          16.1 KiB
Storage id:        mcap
Duration:          33.891s
Start:             Aug  2 2025 20:33:30.374 (1754138010.374)
End:               Aug  2 2025 20:34:04.266 (1754138044.266)
Messages:          130
Topic information: Topic: /turtle1/cmd_vel | Type: geometry_msgs/msg/Twist | Count: 130 | Serializa
tion Format: cdr
```

5. ros2 bag play To play the recorded file (I reset the condition first):

```
ros2 bag play <file_name>
```

```
docker@host-devel:~/bag_files$ ros2 service call /reset std_srvs/srv/Empty
requester: making request: std_srvs.srv.Empty_Request()

response:
std_srvs.srv.Empty_Response()

docker@host-devel:~/bag_files$ ros2 bag play rosbag2_2025_08_02-20_33_23/
[INFO] [1754138182.736604377] [rosbag2_player]: Set rate to 1
[WARN] [1754138182.736770545] [rclcpp]: A zero depth with KEEP_LAST doesn't make sense; no data cou
ld be stored.This will be interpreted as SYSTEM_DEFAULT
[INFO] [1754138182.741805947] [rosbag2_player]: Adding keyboard callbacks.
[INFO] [1754138182.741832010] [rosbag2_player]: Press SPACE for Pause/Resume
[INFO] [1754138182.741841453] [rosbag2_player]: Press CURSOR_RIGHT for Play Next Message
[INFO] [1754138182.741852070] [rosbag2_player]: Press CURSOR_UP for Increase Rate 10%
[INFO] [1754138182.741860113] [rosbag2_player]: Press CURSOR_DOWN for Decrease Rate 10%
[INFO] [1754138182.741939352] [rosbag2_player]: Playback until timestamp: -1
```

2 Beginner: Client libraries (C++)

2.1 Using colcon to build packages

1. Prerequisites
   Install colcon and ROS2

2. Create a workspace
   Create a directory:

   ```
   mkdir -p ~/ros2_ws/src
   cd ~/ros2_ws$
   ```

3. Add some sources

   ```
   git clone https://github.com/ros2/examples src/examples -b iron
   ```

4. Build the workspace

   ```
   colcon build --symlink-install
   ```

   Run tests

   ```
   colcon test
   ```

   ```
   Summary: 22 packages finished [45.0s]
     10 packages had stderr output: examples_rclpy_executors examples_rclpy_guard_conditions examples_
   rclpy_minimal_action_client examples_rclpy_minimal_action_server examples_rclpy_minimal_client exam
   ples_rclpy_minimal_publisher examples_rclpy_minimal_service examples_rclpy_minimal_subscriber examp
   les_rclpy_pointcloud_publisher launch_testing_examples
   ```

5. source the environment

   ```
   source install/setup.bash
   ```

6. Try a demo

```
ros2 run examples_rclcpp_minimal_subscriber
   subscriber_member_function
ros2 run examples_rclcpp_minimal_publisher
   publisher_member_function
```

```
docker@host-devel:~$ ros2 run examples_rclcpp_minimal_publisher publisher_member_function
[INFO] [1754300286.568197686] [minimal_publisher]: Publishing: 'Hello, world! 0'
[INFO] [1754300287.068041561] [minimal_publisher]: Publishing: 'Hello, world! 1'
[INFO] [1754300287.568028513] [minimal_publisher]: Publishing: 'Hello, world! 2'
[INFO] [1754300288.068202192] [minimal_publisher]: Publishing: 'Hello, world! 3'
[INFO] [1754300288.568217054] [minimal_publisher]: Publishing: 'Hello, world! 4'
[INFO] [1754300289.068174325] [minimal_publisher]: Publishing: 'Hello, world! 5'
[INFO] [1754300289.568162086] [minimal_publisher]: Publishing: 'Hello, world! 6'
^C[INFO] [1754300289.633651500] [rclcpp]: signal_handler(signum=2)
```

```
docker@host-devel:~/ros2_ws$ ros2 run examples_rclcpp_minimal_subscriber subscriber_member_function
[INFO] [1754300286.568873460] [minimal_subscriber]: I heard: 'Hello, world! 0'
[INFO] [1754300287.068308340] [minimal_subscriber]: I heard: 'Hello, world! 1'
[INFO] [1754300287.568520098] [minimal_subscriber]: I heard: 'Hello, world! 2'
[INFO] [1754300288.068676554] [minimal_subscriber]: I heard: 'Hello, world! 3'
[INFO] [1754300288.568671336] [minimal_subscriber]: I heard: 'Hello, world! 4'
[INFO] [1754300289.068648245] [minimal_subscriber]: I heard: 'Hello, world! 5'
[INFO] [1754300289.568585636] [minimal_subscriber]: I heard: 'Hello, world! 6'
```

7. Setup `colcon_cd`

```
echo "source /usr/share/colcon_cd/function/colcon_cd.sh" >> ~/.
   bashrc
echo "export _colcon_cd_root=/opt/ros/iron/" >> ~/.bashrc
```

2.2 Creating a workspace

1. Source ROS 2 environment
   Done in previous section.

2. Create a new directory
   Done in previous section.

3. Clone a sample repo
   In the `ros2_ws/src` direcrtory:

   ```
   git clone https:/github.com/ros/ros_tutorials.git -b iron
   ```

4. Resolve dependencies
   In `ros_ws` directory:

   ```
   rosdep install -i --from-path src --rosdistro iron -y
   ```

   ```
   [docker@host-devel:~/ros2_ws$ rosdep install -i --from-path src --rosdistro iron -y
   #All required rosdeps installed successfully
   ```

5. Build the workspace with colcon

   ```
   colcon build --parallel-workers 1
   ```

   Using option `--parallel-workers 1` to prevent my memory run out of space.

6. source the overlay

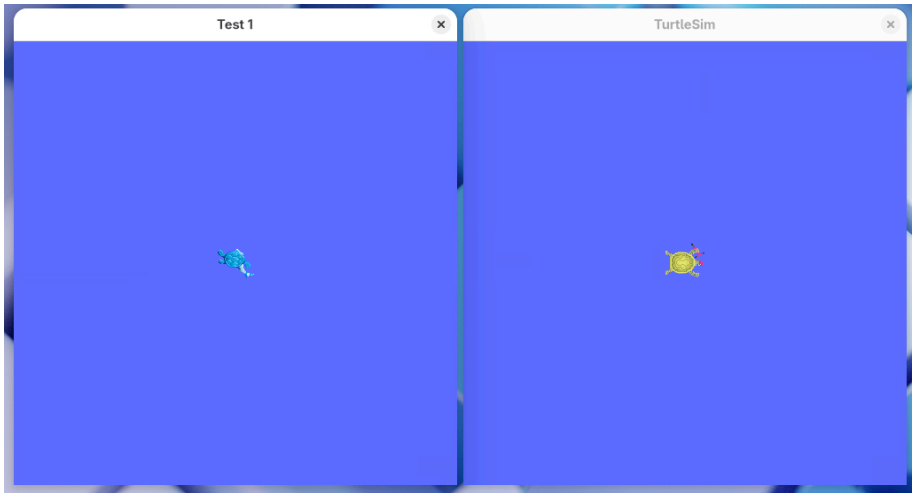
   ```
   source install/local_setup.bash
   ```

7. Modify the overlay
   Find the file `turtle_fram.cpp` in `/ros2_ws/src/ros_tutorials/turtlesim/src`. Find the function `setWindowTitle()` and change the value.

   ```
   ros2 run turtlesim turtlesim_node
   ```

   To see underlay, open a new terminal:

   ```
   ros2 run turtlesim turtlesim_node
   ```

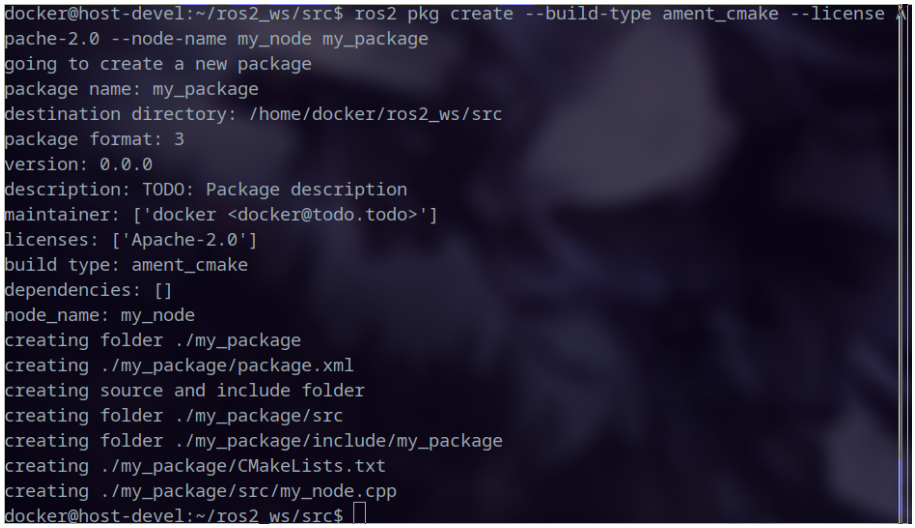


2.3 Creating a package

Before proceeding to this step, I went through the official CMake tutorial to make sure I understand the whole concept.

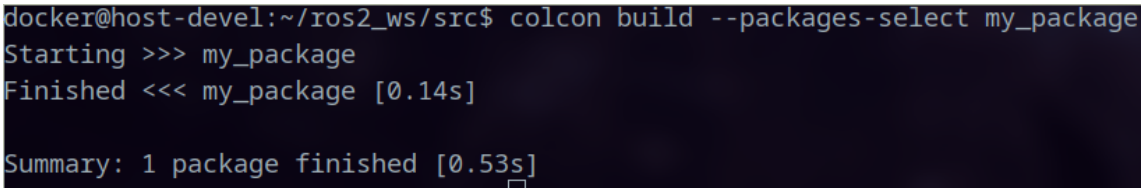
1. Create a package
   In the directory `/ros2_ws/src`:

```
ros2 pkg create --build-type ament_cmake --license Apache-2.0 --
   node-name my_node my_package
```



2. Build a package

```
colcon build --packages-select my_package
```

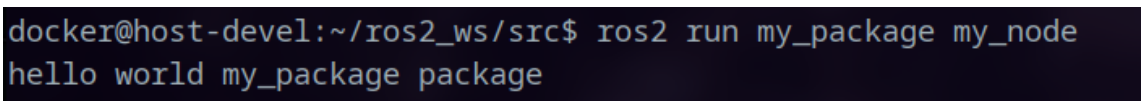


3. Source the setup file

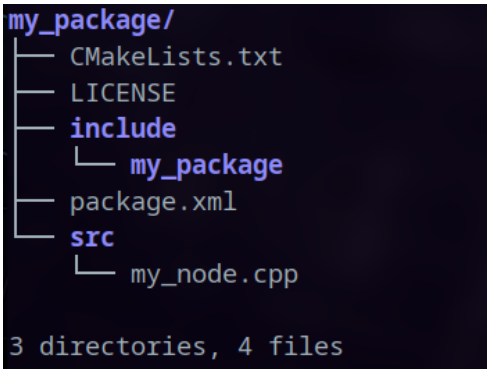
```
source install/local_setup.bash
```

4. Use the package

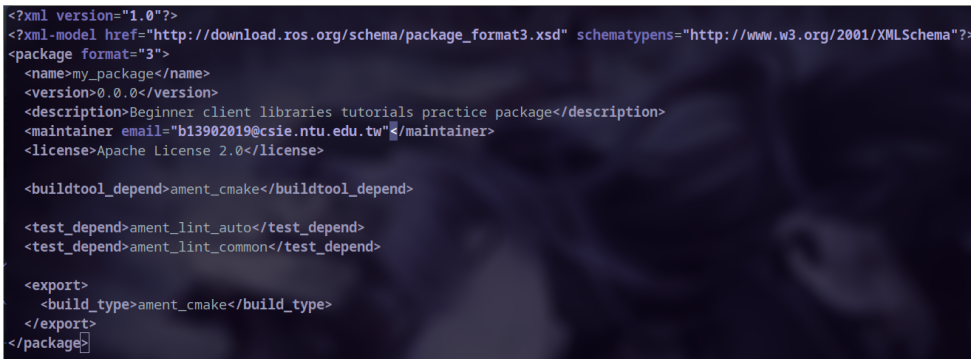
```
ros2 run my_package my_node
```



5. Examine package contents



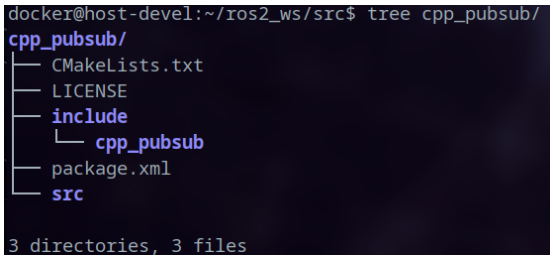
6. Customize `package.xml`



3 Writing a simple publisher and subscriber(C++)

1. Create a package

```
ros2 pkg create --build-type ament_cmake --license Apache-2.0
   cpp_pubsub
```



2. Write the publisher node
   Download the sample code:

```
wget -O publisher_member_function.cpp https://raw.
   githubusercontent.com/ros2/examples/iron/rclcpp/topics/
   minimal_publisher/member_function.cpp
```

   After download it, I spend some time to understand the code.