

ROKEY BOOT CAMP

ROS2 기초-5차시

Apr, 2025

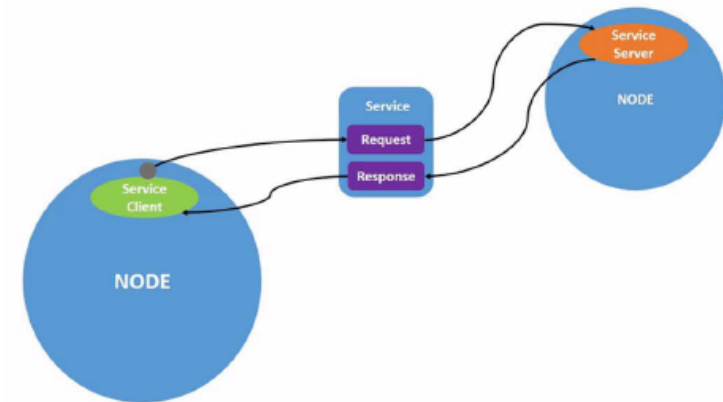
훈련 일정

	오전	오후
1차시	- 로봇의 역사 - 컴퓨터 구조(Booting, CPU 작동원리, POST)	- 리눅스와 운영체제 - 리눅스 CLI 실습(디렉토리, 계정, 기본 명령어등), Terminator, 커널, 쉘, gedit, bash
	Application 작동원리(마이크로 프로세서, 메모리, 저장장치)	리눅스 CLI 실습
2차시	리눅스 CLI 실습	네트워크와 통신(IPV4, IPV6, 소켓, 노드, Hub, TCP, UDP)
	- API, Library, Framework, 프로세스와 Thread - 인터프리터, 컴파일러(소스코드 → Build → 실행파일)	- 소켓프로그래밍 실습 - OSI7 Layer, 프로토콜(RS-232C, RS-485, Ethernet, TCP/UDP, IP)
3차시	센서 기초, IoT와 Embedded	로봇기초, 좌표계
	로봇 센서 활용 및 로봇의 구성(기계기구, 전기전자, 소프트웨어)	- ROS2 소개 및 활용 - ROS2 설치(ros.org) 및 demo_node
4차시	ROS2 소개 및 활용	ROS2 실습(Talker, Listener)
	ROS2 패키지 설명	ROS2 실습(Turtlesim, teleop_key)
5차시	ROS2 실습(Turtlesim, Teleop_key 여러 개 만들기)	Topic, Service, Action, Parameter, RQT, RQT_Graph 이론 및 실습
	ROS2 실습(Turtlesim, Namespace 여러 개 만들기)	- Ros bag and play 실습, my first package build 실습 - Turtlesim subscribing 실습, ROS의 중요한 개발도구(Rviz, GAZEBO 소개)

Message

[Topic]

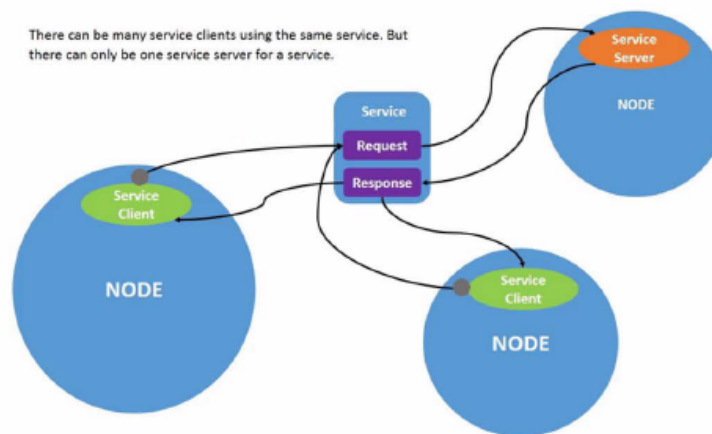
- 비동기식 단방향 메시지 송수신 방식으로, msg 인터페이스 형태의 메시지를 보내는 Publisher와 메시지를 받는 Subscriber 간의 통신
- 이는 1:1 통신을 기본으로 하지만 N:N 통신도 가능하며, ROS 메시지 통신에서 가장 많이 사용
- 비동기성과 연속성을 가지기 때문에 센서 값 전송이나 항시 정보를 주고받아야 하는 부분에서 주로 사용



Message

[Service]

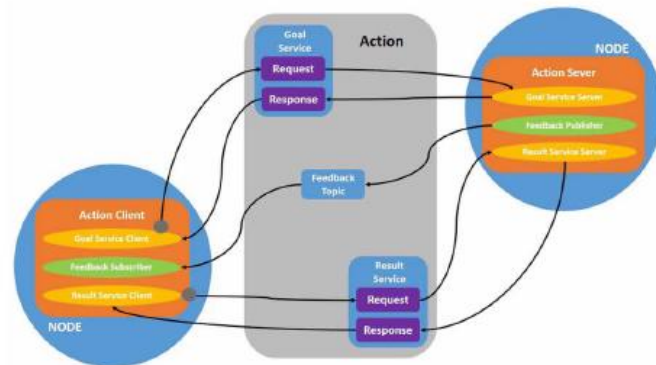
- 동기식 양방향 메시지 송수신 방식으로, 서비스 요청(Request) 하는 쪽을 Service Client, 요청 받은 서비스를 수행한 후 서비스 응답(Response)을 하는 쪽을 Service Server
- 특정 요청을 하는 클라이언트 단과 요청 받은 일을 수행한 후에 결과값을 전달하는 서버 단과의 통신이다. 인터페이스는 srv를 사용
- 동일한 서비스 서버에 대해 복수의 클라이언트를 가질 수 있도록 설계되었지만, 서비스 응답은 서비스 요청이 있었던 서비스 클라이언트에 대해서만 응답하는 형태



Message

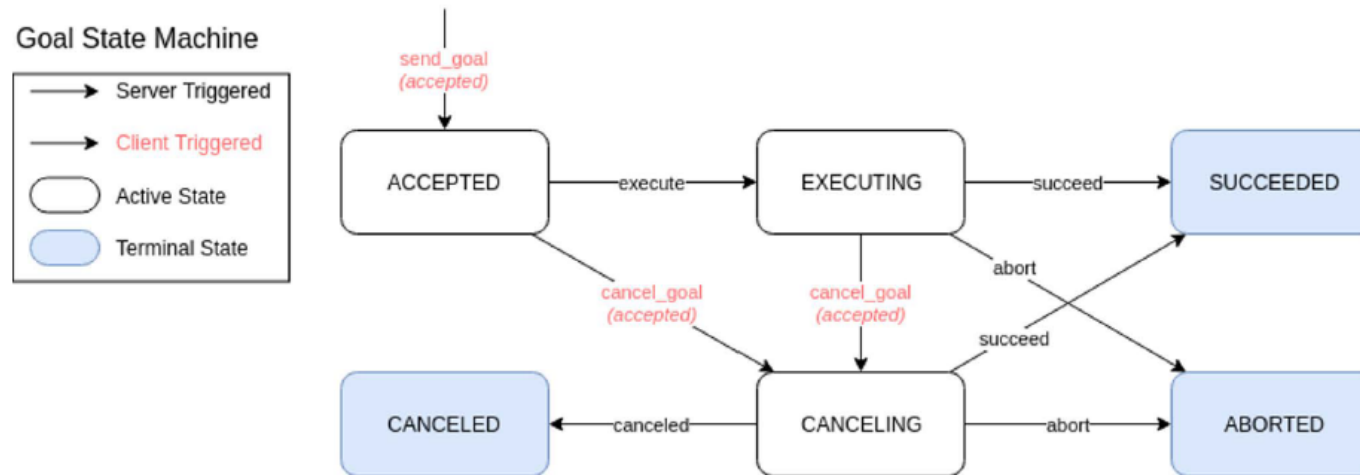
[Action]

- 비동기식, 동기식 양방향 메시지 송수신 방식
- 액션 목표를 지정하는 Action Client와, 액션 목표(Goal)를 받아 특정 태스크를 수행하면서 중간 결과값을 전송하는 액션 피드백(Feedback), 최종 결과값을 담은 액션 결과(Result)를 전송하는 Action Server 간의 통신



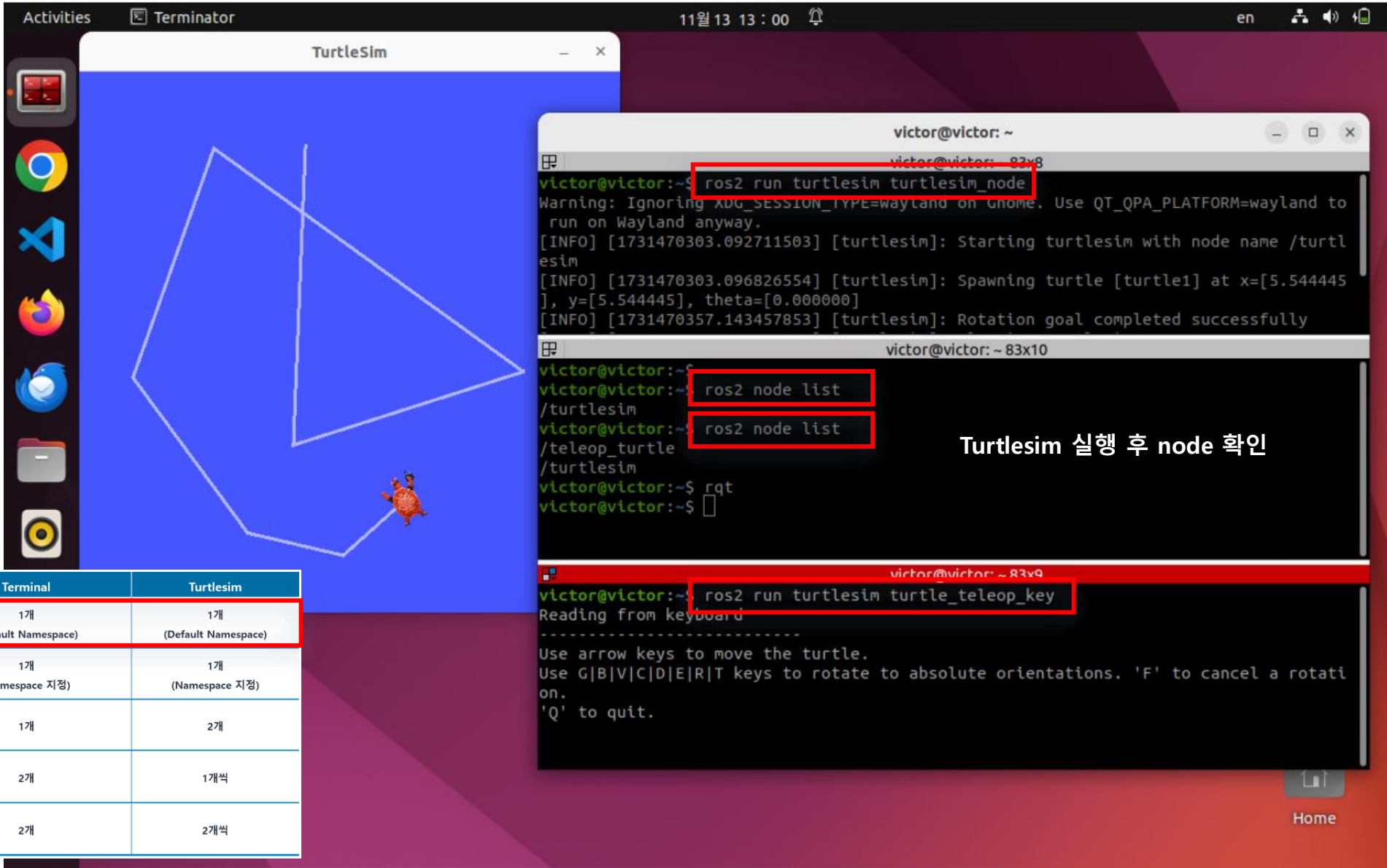
Message

- ROS2에서의 액션은 목표 전달(send_goal), 표 취소(cancel_goal), 결과 받기(get_result)를 위한 서비스 통신을 사용하기 위하여 토픽과 서비스 방식을 혼합하여 사용
- 비동기 방식에서 원하는 타이밍에 적절한 액션을 수행하기 위하여 목표상태(goal_state)를 도입, 이는 목표값을 전달한 후 상태 머신을 구동하여 액션의 프로세스를 쫓음
- 즉, 액션 목표 전달 이후 액션의 상태값을 액션 클라이언트에 전달함에 따라, 비동기 및 동기 방식이 혼재된 액션의 처리를 원할하게 해준다.



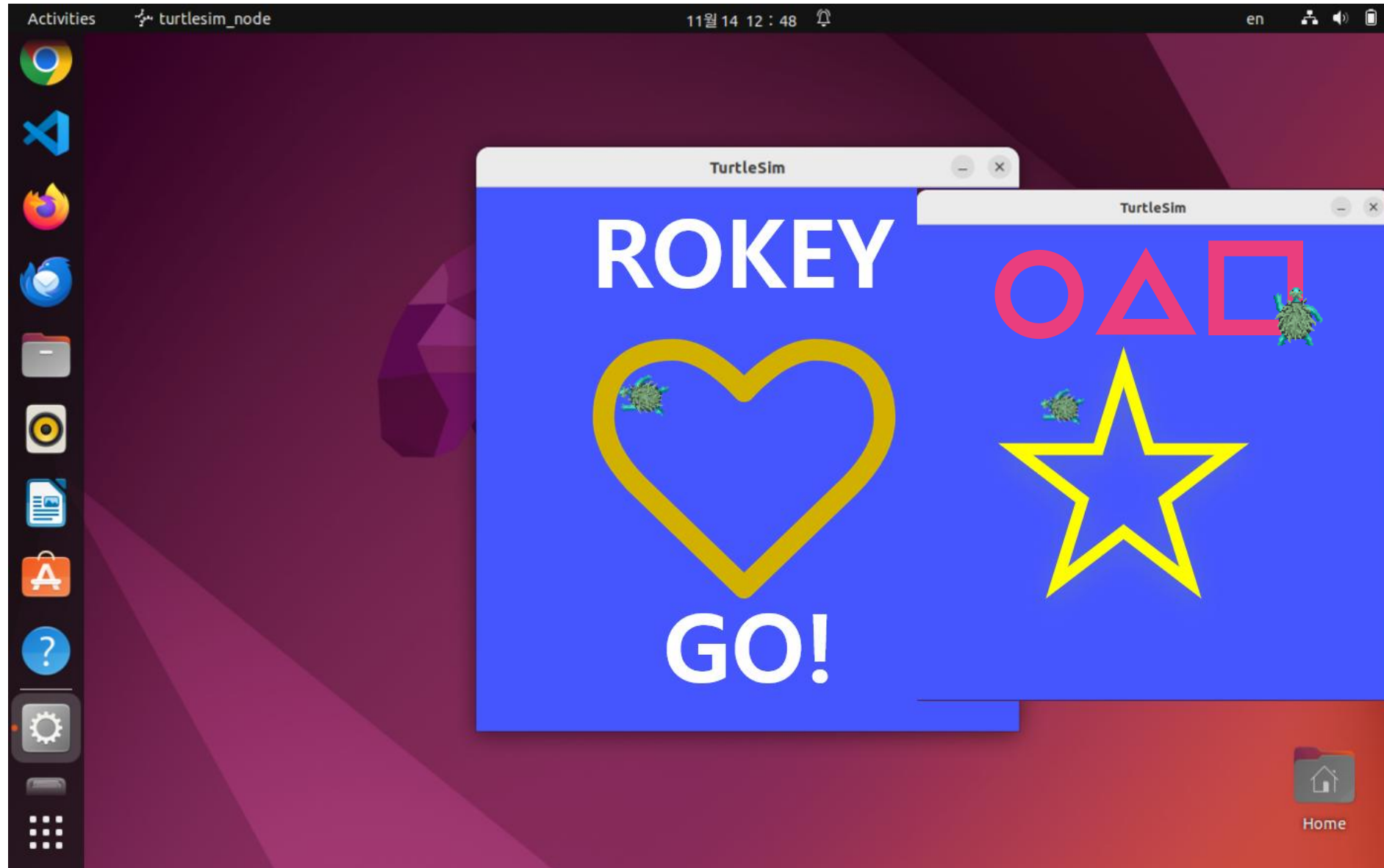
	Terminal	Turtlesim
1단계	1개 (Default Namespace)	1개 (Default Namespace)
2단계	1개 (Namespace 지정)	1개 (Namespace 지정)
3단계	1개	2개
4단계	2개	1개씩
5단계	2개	2개씩

ROS2 실습 - turtlesim 1단계



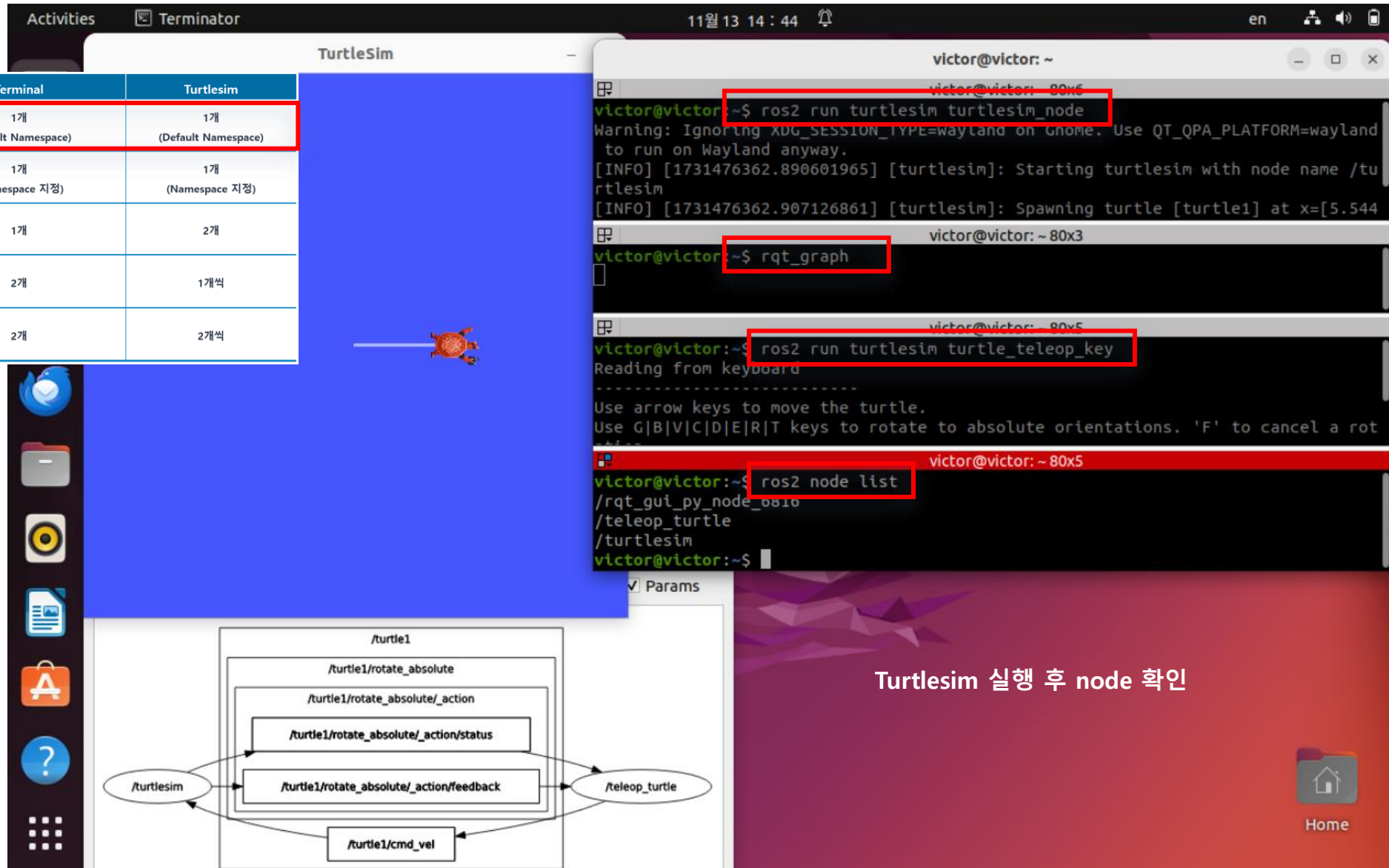
	Terminal	Turtlesim
1단계	1개 (Default Namespace)	1개 (Default Namespace)
2단계	1개 (Namespace 지정)	1개 (Namespace 지정)
3단계	1개	2개
4단계	2개	1개씩
5단계	2개	2개씩

Turtlesim 실행 후 node 확인



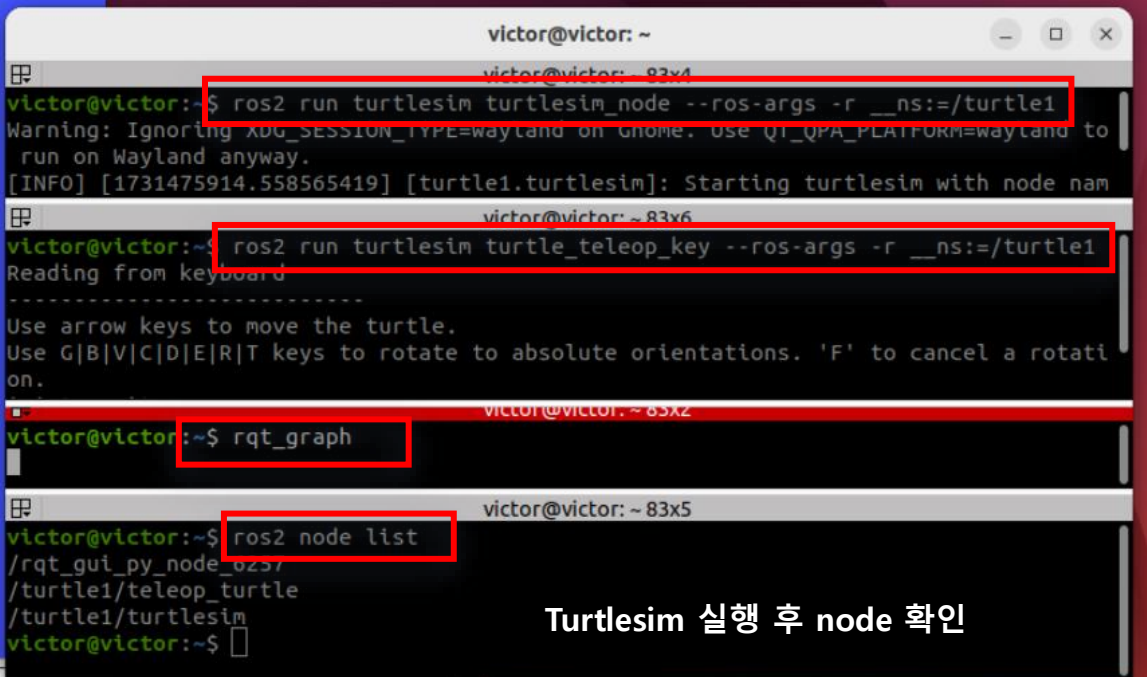
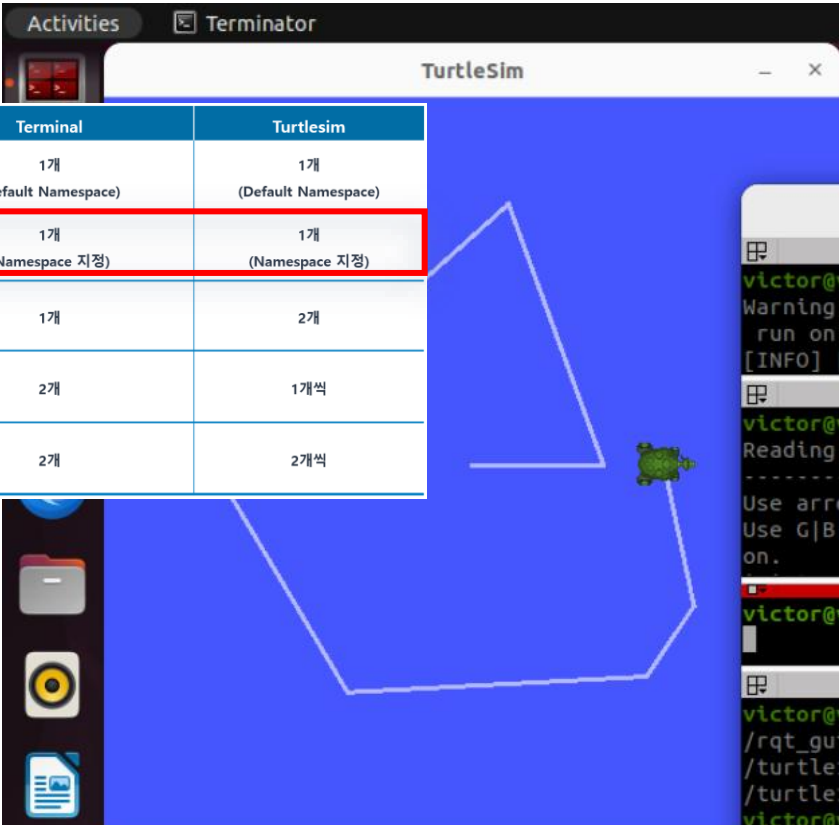
ROS2 실습 - turtlesim

	Terminal	Turtlesim
1단계	1개 (Default Namespace)	1개 (Default Namespace)
2단계	1개 (Namespace 지정)	1개 (Namespace 지정)
3단계	1개	2개
4단계	2개	1개씩
5단계	2개	2개씩

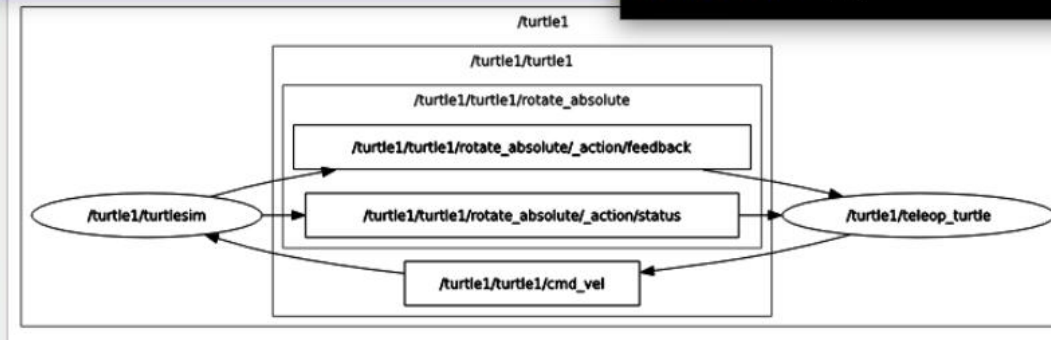


Turtlesim 실행 후 node 확인

	Terminal	Turtlesim
1단계	1개 (Default Namespace)	1개 (Default Namespace)
2단계	1개 (Namespace 지정)	1개 (Namespace 지정)
3단계	1개	2개
4단계	2개	1개씩
5단계	2개	2개씩



```
victor@victor: ~  
victor@victor: ~$ ros2 run turtlesim turtlesim_node --ros-args -r __ns:=/turtle1  
Warning: Ignoring XDG_SESSION_TYPE=wayland on Gnome. Use QT_QPA_PLATFORM=wayland to  
run on Wayland anyway.  
[INFO] [1731475914.558565419] [turtle1.turtlesim]: Starting turtlesim with node nam  
victor@victor: ~$ ros2 run turtlesim turtle_teleop_key --ros-args -r __ns:=/turtle1  
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 rotati  
on.  
victor@victor: ~$ rqt_graph  
victor@victor: ~$ ros2 node list  
/rqt_gui_py_node_6237  
/turtle1/teleop_turtle  
/turtle1/turtlesim  
victor@victor: ~$
```



Turtlesim 실행 후 node 확인

Namespace 설정

The screenshot displays a ROS2 environment with a turtle simulation window, a terminal window, and a node graph window.

Terminal Window (Top):

```
victor@victor:~$ ros2 run turtlesim turtlesim_node --ros-args -r __ns:=/rokey1 -r __node:=victor1
Warning: Ignoring XDG_SESSION_TYPE=wayland on Gnome. Use QT_QPA_PLATFORM=wayland to run on Wayland and
anyway.
[INFO] [1731749969.381169742] [rokey1.victor1]: Starting turtlesim with node name /rokey1/victor1
[INFO] [1731749969.389922522] [rokey1.victor1]: Spawning turtle [turtle1] at x=[5.544445], y=[5.544445], theta=[0.000000]
```

Terminal Window (Bottom):

```
victor@victor:~$ ros2 run turtlesim turtle_teleop_key --ros-args -r __ns:=/rokey1 -r __node:=victor1 -r cmd_vel:=/rokey1/victor1/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.
```

Node Graph Window:

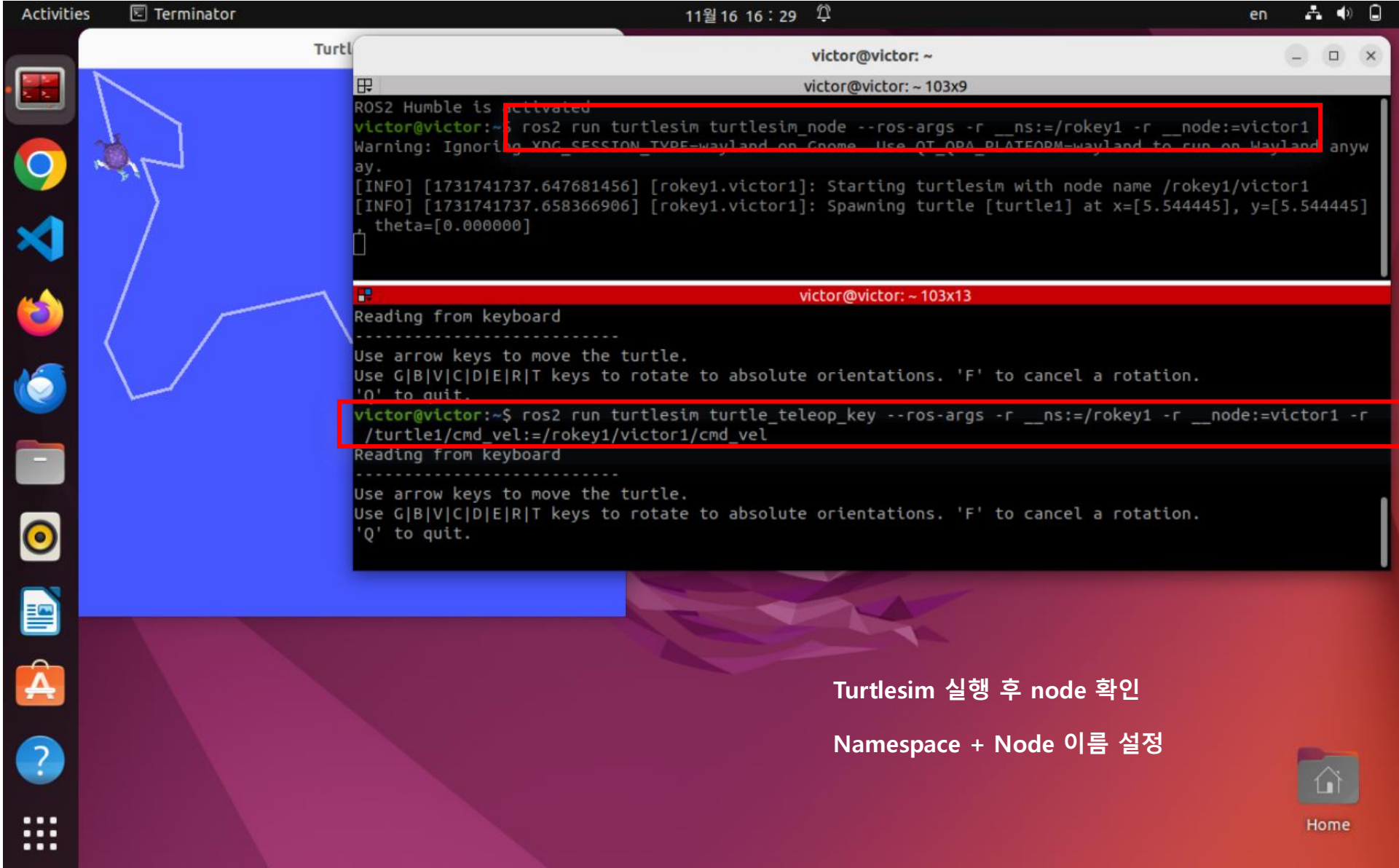
The node graph shows the following structure:

- /rokey1** (Namespace)
 - /rokey1/turtle1** (Namespace)
 - /rokey1/turtle1/rotate_absolute** (Action)
 - /rokey1/turtle1/rotate_absolute/action/feedback** (Topic)
 - /rokey1/turtle1/rotate_absolute/action/status** (Topic)
 - /rokey1/turtle1/color_sensor** (Topic)
 - /rokey1/turtle1/cmd_vel** (Topic)
 - /rokey1/turtle1/pose** (Topic)
 - /rokey1/victor1** (Node)
 - Connected to **/rokey1/turtle1/rotate_absolute**
 - Connected to **/rokey1/turtle1/color_sensor**
 - Connected to **/rokey1/turtle1/cmd_vel**
 - Connected to **/rokey1/turtle1/pose**

Turtlesim 실행 후 node 확인
Namespace + Node 이름 설정

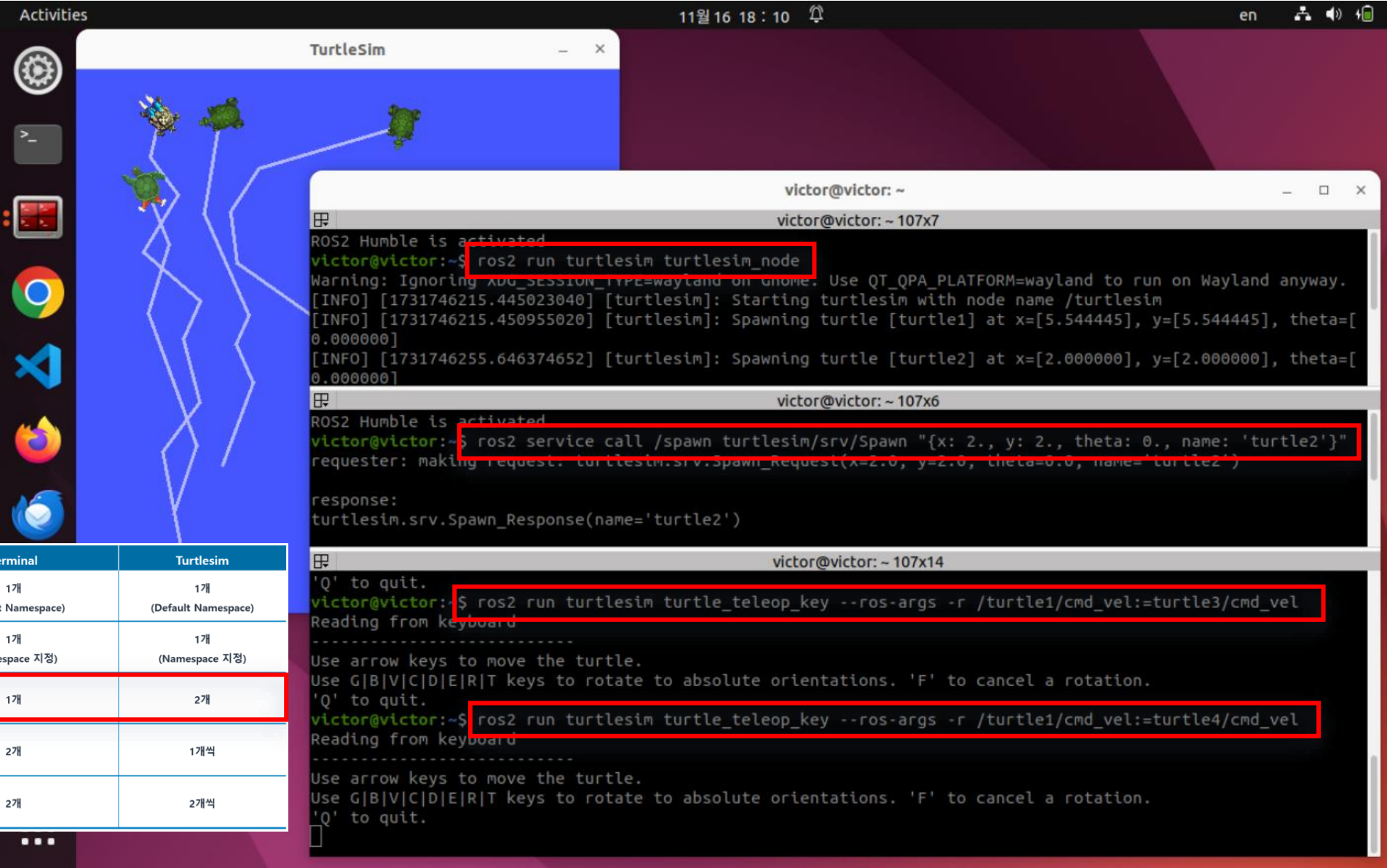


Home



Turtlesim 실행 후 node 확인

Namespace + Node 이름 설정



	Terminal	Turtlesim
1단계	1개 (Default Namespace)	1개 (Default Namespace)
2단계	1개 (Namespace 지정)	1개 (Namespace 지정)
3단계	1개	2개
4단계	2개	1개씩
5단계	2개	2개씩

Activities

rqt_graph

11월 16 17 : 41

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TurtleSim

Terminal

```
victor@victor: ~
victor@victor: ~ 80x5
ROS2 Humble is activated
victor@victor:~$ ros2 run turtlesim turtlesim_node
Warning: Ignoring XDG_SESSION_TYPE=wayland on Gnome. Use QT_QPA_PLATFORM=wayland to run on Wayland by default.
```

rqt_graph_RosGraph - rqt

Node Graph

Nodes/Topics (all)

Group: 3

Namespaces

Actions

tf

Images

Highlight

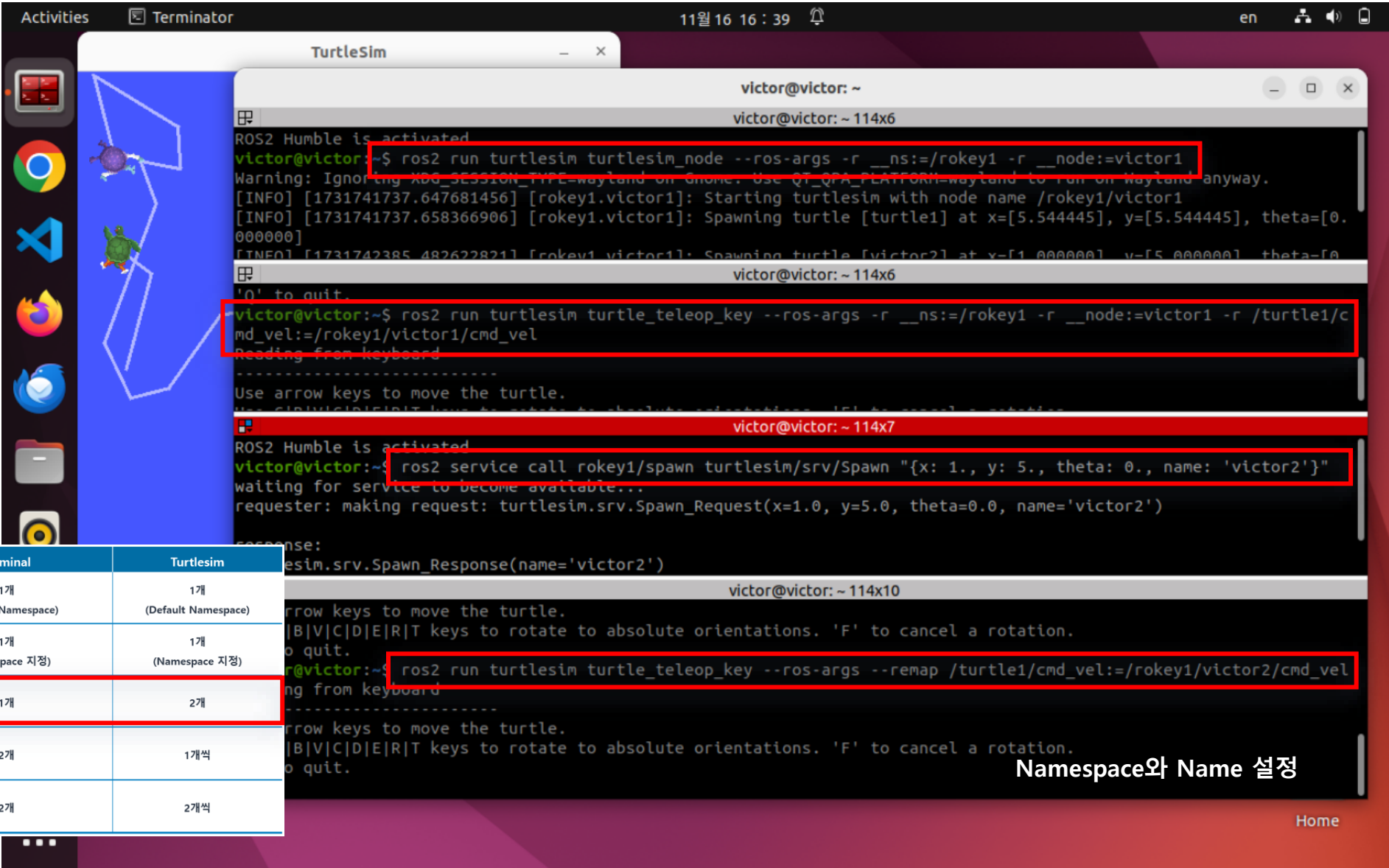
Fit

Hide: ☒ Dead sinks ☐ Leaf topics ☒ Debug ☒ tf ☒ Unreachable ☒ Params

```
graph LR
    subgraph /turtle2
        C2[/turtle2/cmd_vel/]
    end
    subgraph /turtle3
        C3[/turtle3/cmd_vel/]
    end
    subgraph /turtle4
        C4[/turtle4/cmd_vel/]
    end
    subgraph /turtle1
        subgraph /turtle1/rotate_absolute
            A[/turtle1/rotate_absolute/_action/]
            subgraph /turtle1/rotate_absolute/_action/
                FB[/turtle1/rotate_absolute/_action/feedback/]
                ST[/turtle1/rotate_absolute/_action/status/]
            end
            C1[/turtle1/cmd_vel/]
        end
    end
    /turtlesim((/turtlesim))
    teleop_turtle((/teleop_turtle))

    C2 --> /turtlesim
    C3 --> /turtlesim
    C4 --> /turtlesim
    /turtlesim --> A
    A --> ST
    ST --> C1
    teleop_turtle --> C1
```

	Terminal	Turtlesim
1단계	1개 (Default Namespace)	1개 (Default Namespace)
2단계	1개 (Namespace 지정)	1개 (Namespace 지정)
3단계	1개	2개
4단계	2개	1개씩
5단계	2개	2개씩



```
ROS2 Humble is activated
victor@victor:~$ ros2 run turtlesim turtlesim_node --ros-args -r __ns:=/rokey1 -r __node:=victor1
Warning: Ignoring XDG_SESSION_TYPE=wayland on Gnome. Use QT_QPA_PLATFORM=wayland to run on Wayland anyway.
[INFO] [1731741737.647681456] [rokey1.victor1]: Starting turtlesim with node name /rokey1/victor1
[INFO] [1731741737.658366906] [rokey1.victor1]: Spawning turtle [turtle1] at x=[5.544445], y=[5.544445], theta=[0.000000]
[INFO] [1731742385.482622821] [rokey1.victor1]: Spawning turtle [victor2] at x=[1.000000], y=[5.000000], theta=[0.000000]
victor@victor:~ 114x6

victor@victor:~$ ros2 run turtlesim turtle_teleop_key --ros-args -r __ns:=/rokey1 -r __node:=victor1 -r /turtle1/cmd_vel:=/rokey1/victor1/cmd_vel
Reading from keyboard
Use arrow keys to move the turtle.
victor@victor:~ 114x7

ROS2 Humble is activated
victor@victor:~$ ros2 service call rokey1/spawn turtlesim/srv/Spawn "{x: 1., y: 5., theta: 0., name: 'victor2'}"
waiting for service to become available...
requester: making request: turtlesim.srv.Spawn_Request(x=1.0, y=5.0, theta=0.0, name='victor2')
response:
turtlesim.srv.Spawn_Response(name='victor2')
victor@victor:~ 114x10

victor@victor:~$ ros2 run turtlesim turtle_teleop_key --ros-args --remap /turtle1/cmd_vel:=/rokey1/victor2/cmd_vel
Reading from keyboard
Use arrow keys to move the turtle.
[B|V|C|D|E|R|T keys to rotate to absolute orientations. 'F' to cancel a rotation.
to quit.
```

Namespac와 Name 설정

	Terminal	Turtlesim
1단계	1개 (Default Namespace)	1개 (Default Namespace)
2단계	1개 (Namespace 지정)	1개 (Namespace 지정)
3단계	1개	2개
4단계	2개	1개씩
5단계	2개	2개씩

The screenshot displays the ROS2 TurtleSim environment. The main window shows a 2D simulation with two turtles on a blue field. A terminal window in the foreground shows the command `ros2 run turtlesim turtlesim_node` being executed, with output indicating the start of the simulation and the spawning of a turtle. A Node Graph window is also open, showing the network of nodes and topics. The graph includes nodes for `/turtlesim`, `/turtle1/rotate_absolute`, `/turtle1/rotate_absolute/action`, `/turtle1/rotate_absolute/action/feedback`, `/turtle1/rotate_absolute/action/status`, `/teleop_turtle`, and `/turtle3/cmd_vel`.

	Terminal	Turtlesim
1단계	1개 (Default Namespace)	1개 (Default Namespace)
2단계	1개 (Namespace 지정)	1개 (Namespace 지정)
3단계	1개	2개
4단계	2개	1개씩
5단계	2개	2개씩

	Terminal	Turtlesim
1단계	1개 (Default Namespace)	1개 (Default Namespace)
2단계	1개 (Namespace 지정)	1개 (Namespace 지정)
3단계	1개	2개
4단계	2개	1개씩
5단계	2개	2개씩

Activities Terminator 11월 16 11 : 48 en

Turtlesim

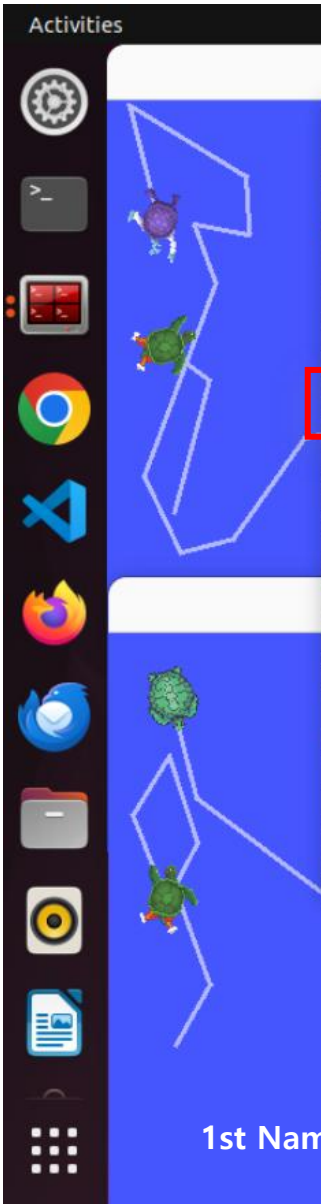
vector@vector: ~
vector@vector: ~ 100x6

```
ROS2 Humble is activated
vector@vector:~$ ros2 run turtlesim turtlesim_node --ros-args -r __ns:=/rokey1 -r __node:=victor1
Warning: Ignoring XDG_SESSION_TYPE=wayland on GNOME. Use QT_QPA_PLATFORM=wayland to run on wayland a
nyway.
[INFO] [1731723703.680594856] [rokey1.victor1]: Starting turtlesim with node name /rokey1/victor1
[INFO] [1731723703.684280548] [rokey1.victor1]: Spawning turtle [turtle1] at x=[5.544445], y=[5.5444
45], theta=[0.000000]
vector@vector:~$
vector@vector:~$ ros2 run turtlesim turtle_teleop_key --ros-args -r __ns:=/rokey1 -r __node:=victor1
-r cmd_vel:=/rokey1/victor1/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
```

Turtlesim

vector@vector: ~
vector@vector: ~ 100x8

```
ROS2 Humble is activated
vector@vector:~$ ros2 run turtlesim turtlesim_node --ros-args -r __ns:=/rokey2 -r __node:=victor1
Warning: Ignoring XDG_SESSION_TYPE=wayland on GNOME. Use QT_QPA_PLATFORM=wayland to run on wayland a
nyway.
[INFO] [1731723829.746958922] [rokey2.victor1]: Starting turtlesim with node name /rokey2/victor1
[INFO] [1731723829.754363388] [rokey2.victor1]: Spawning turtle [turtle1] at x=[5.544445], y=[5.5444
45], theta=[0.000000]
vector@vector:~$
vector@vector:~$ ros2 run turtlesim turtle_teleop_key --ros-args -r __ns:=/rokey2 -r __node:=victor1
-r cmd_vel:=/rokey2/victor1/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
```



1st Namespace와 Name 각각 설정

```
victor@victor: ~  
victor@victor: ~ 114x4  
ROS2 Humble is activated  
victor@victor:~$ ros2 run turtlesim turtlesim_node --ros-args -r __ns:=/rokey1 -r __node:=victor1  
Warning: Ignoring XDG_SESSION_TYPE=wayland on Gnome. Use QT_QPA_PLATFORM=wayland to run on wayland anyway.  
[INFO] [1731741737.647681456] [rokey1.victor1]: Starting turtlesim with node name /rokey1/victor1  
[INFO] [1731741737.658366906] [rokey1.victor1]: Spawning turtle [turtle1] at x=[5.544445], y=[5.544445], theta=[0.  
'Q' to quit  
victor@victor:~$ ros2 run turtlesim turtle_teleop_key --ros-args -r __ns:=/rokey1 -r __node:=victor1 -r /turtle1/c  
md_vel:=/rokey1/victor1/cmd_vel  
Reading from keyboard  
-----  
victor@victor: ~ 114x5  
ROS2 Humble is activated  
victor@victor:~$ ros2 service call rokey1/spawn turtlesim/srv/Spawn "{x: 1., y: 5., theta: 0., name: 'victor2'}"  
waiting for service to become available...  
requester: making request: turtlesim.srv.Spawn_Request(x=1.0, y=5.0, theta=0.0, name='victor2')  
-----  
victor@victor: ~ 114x7  
'Q' to quit.  
victor@victor:~$ ros2 run turtlesim turtle_teleop_key --ros-args --remap /turtle1/cmd_vel:=/rokey1/victor2/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.
```

	Terminal	Turtlesim
1단계	1개 (Default Namespace)	1개 (Default Namespace)
2단계	1개 (Namespace 지정)	1개 (Namespace 지정)
3단계	1개	2개
4단계	2개	1개씩
5단계	2개	2개씩

Activities

Terminator

11월 16 17 : 02

TurtleSim

victor@victor: ~

victor@victor: ~ 114x6

ROS2 Humble is activated

victor@victor:~\$ ros2 run turtlesim turtlesim_node --ros-args -r __ns:=/rokey1 -r __node:=victor1

Warning: Ignoring XDG_SESSION_TYPE=wayland on Gnome. Use QT_QPA_PLATFORM=wayland to run on wayland anyway.

[INFO] [1731741737.647681456] [rokey1.victor1]: Starting turtlesim with node name /rokey1/victor1

[INFO] [1731741737.658366906] [rokey1.victor1]: Spawning turtle [turtle1] at x=[5.54444, y=[0.000000]

[INFO] [1731742385.482622821] [rokey1.victor1]: Spawning turtle [victor2] at x=[1.000000, y=[0.000000]

victor@victor: ~ 114x6

Reading from keyboard

victor@victor: ~

victor@victor: ~ 117x4

ROS2 Humble is activated

victor@victor:~\$ ros2 run turtlesim turtlesim_node --ros-args -r __ns:=/rokey2 -r __node:=victor1

Warning: Ignoring XDG_SESSION_TYPE=wayland on Gnome. Use QT_QPA_PLATFORM=wayland to run on wayland anyway.

[INFO] [1731743415.571241856] [rokey2.victor1]: Starting turtlesim with node name /rokey2/victor1

victor@victor: ~ 117x4

ROS2 Humble is activated

victor@victor:~\$ ros2 run turtlesim turtle_teleop_key --ros-args -r __ns:=/rokey2 -r __node:=victor1 -r /turtle1/cmd_vel:=/rokey2/victor1/cmd_vel

Reading from keyboard

victor@victor: ~ 117x12

ROS2 Humble is activated

victor@victor:~\$ ros2 service call rokey2/spawn turtlesim/srv/Spawn "{x: 1., y: 5., theta: 0., name: 'victor2'}"

requester: making request: turtlesim.srv.Spawn_Request(x=1.0, y=5.0, theta=0.0, name='victor2')

response:

turtlesim.srv.Spawn_Response(name='victor2')

victor@victor:~\$ ros2 run turtlesim turtle_teleop_key --ros-args --remap /turtle1/cmd_vel:=/rokey2/victor2/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.

2nd Namespace와 Name 각각 설정

	Terminal	Turtlesim
1단계	1개 (Default Namespace)	1개 (Default Namespace)
2단계	1개 (Namespace 지정)	1개 (Namespace 지정)
3단계	1개	2개
4단계	2개	1개씩
5단계	2개	2개씩

Activities

rqt_graph

11월 16 17 : 28

en

TurtleSim

rqt_graph__RosGraph - rqt

Node Graph

Nodes/Topics (all)

Group: 3

Namespaces

Actions

tf

Images

Highlight

Fit

Hide: ☒ Dead sinks

☐ Leaf topics

☒ Debug

☒ tf

☒ Unreachable

☒ Params

/rokey1

/rokey1/victor2

/rokey1/victor2/cmd_vel

/rokey1/turtle1

/rokey1/turtle1/cmd_vel

/rokey1/victor1

/turtle1

/turtle1/rotate_absolute

/turtle1/rotate_absolute/_action

rtle1/rotate_absolute/_action/status

le1/rotate_absolute/_action/feedback

/teleop_turtle

/rokey2

/rokey2/victor2

/rokey2/victor2/cmd_vel

/rokey2/turtle1

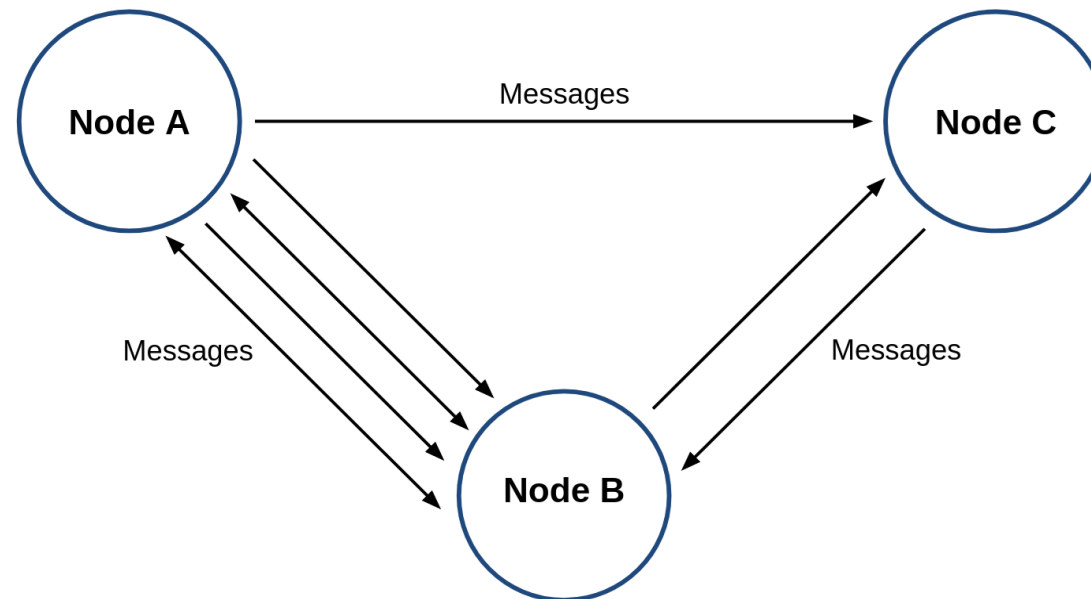
/rokey2/turtle1/cmd_vel

/rokey2/victor1

	Terminal	Turtlesim
1단계	1개 (Default Namespace)	1개 (Default Namespace)
2단계	1개 (Namespace 지정)	1개 (Namespace 지정)
3단계	1개	2개
4단계	2개	1개씩
5단계	2개	2개씩

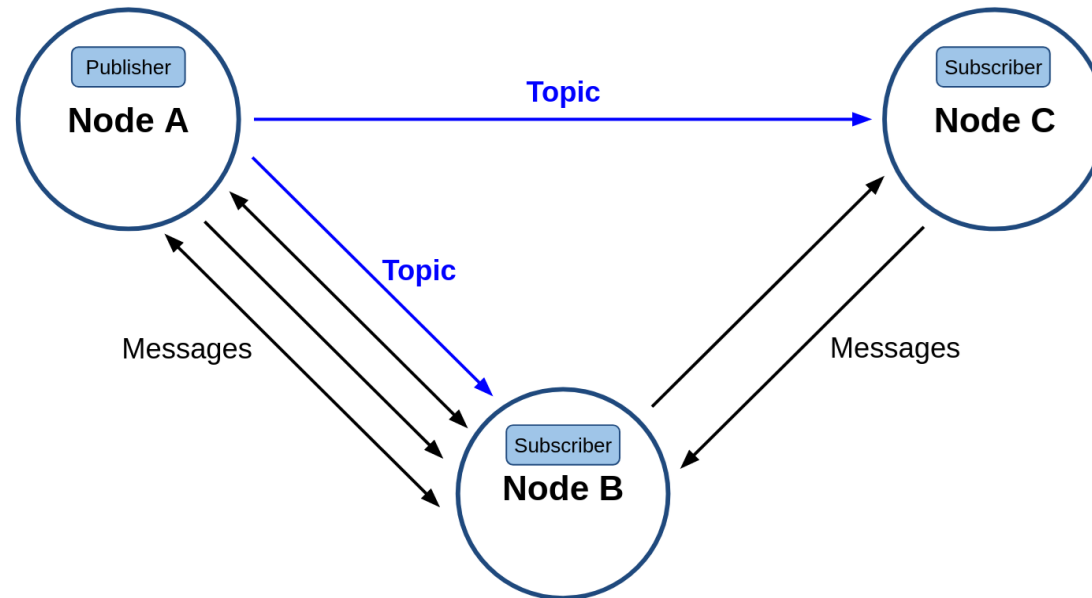
노드(node)

- 아래 그림처럼 Node A, Node B, Node C 각각의 노드들은 서로 유기적으로 Message로 연결
- 수행하고자 하는 태스크가 많아질수록 메시지로 연결되는 노드가 늘어나며 시스템이 확장



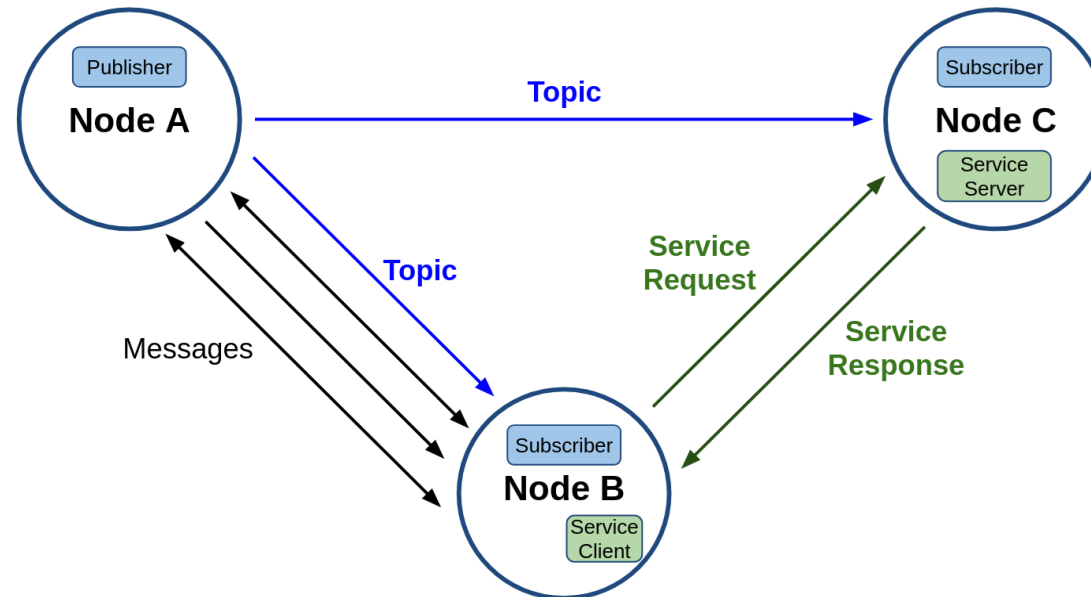
토픽(topic)

- 아래 그림의 `Node A – Node B`, `Node A – Node C`처럼 비동기식 단방향 메시지 송수신 방식
- msg 메시지 형태의 메시지를 발간하는 Publisher
- 메시지를 구독하는 Subscriber 간의 통신
- 이는 1:N, N:1, N:N 통신도 가능
- ROS 메시지 통신에서 가장 널리 사용되는 통신 방법이다.



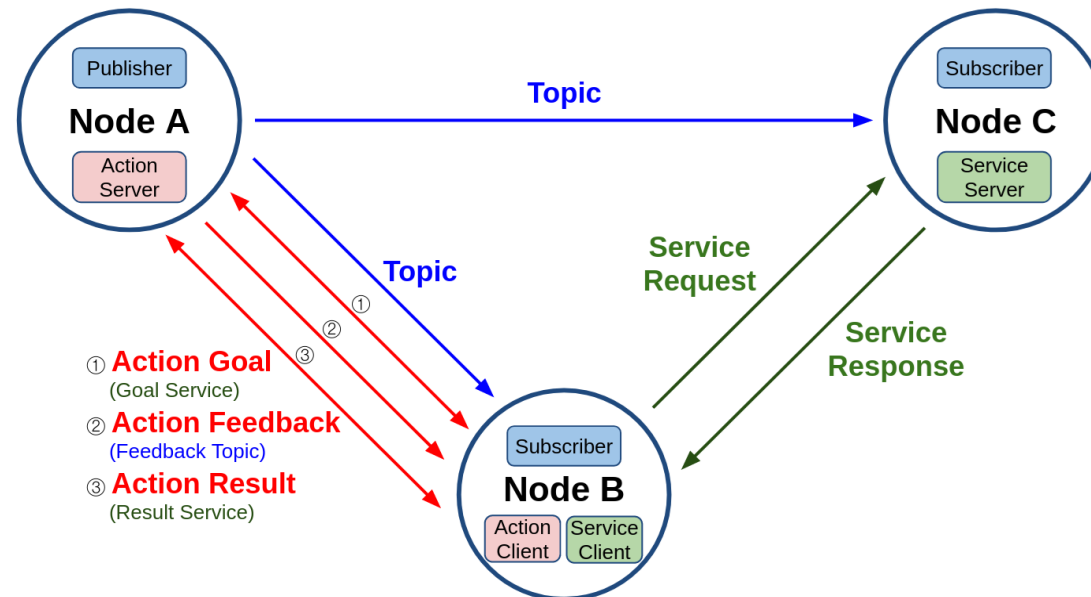
서비스(Service)

- 아래 그림의 `Node B - Node C`처럼 동기식 양방향 메시지 송수신 방식
- 서비스의 요청(Request)을 하는 쪽은 Service client
- 서비스의 응답(Response)을 하는 쪽을 Service server
- 특정 요청을 하는 클라이언트 단과 요청받은 일 수행 후 결과 값을 전달하는 서버 단과의 통신
- 서비스 요청 및 응답(Request/Response) 또한 위에서 언급한 msg 메시지의 변형으로 srv 메시지라고 함.



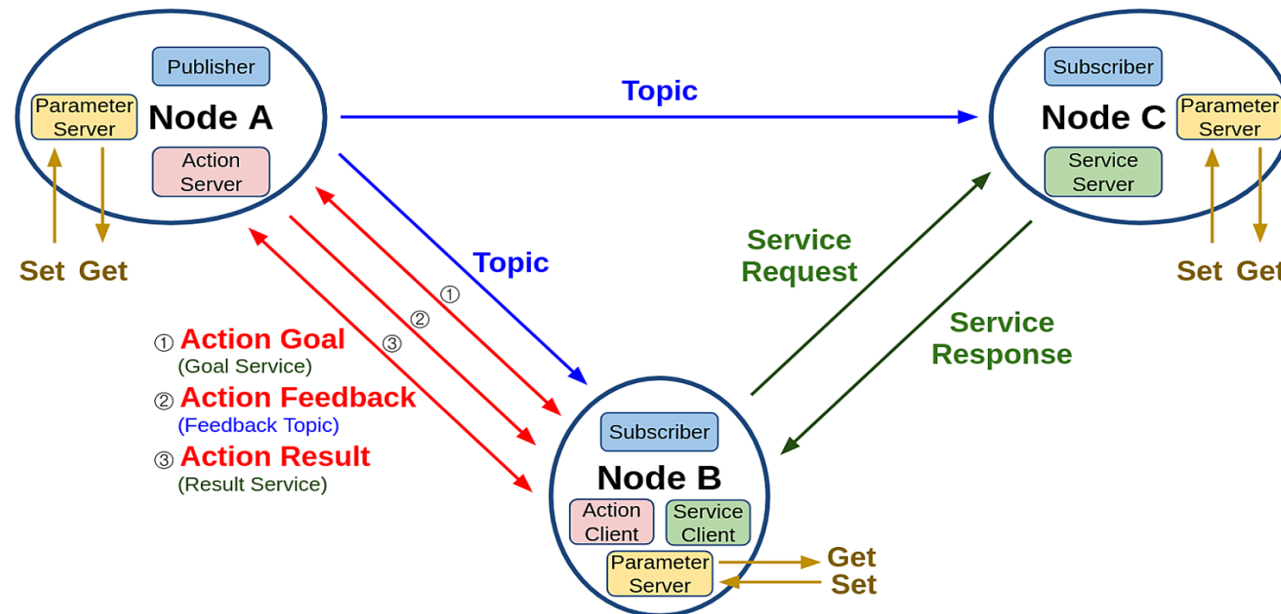
액션(Action)

- 토픽(topic)과 서비스(service)의 혼합
- 액션 목표 및 액션 결과를 전달하는 방식은 서비스와 같고,
- 액션 피드백은 토픽과 같은 메시지 전송 방식
- 액션 목표/피드백/결과(Goal/Feedback/Result) 메시지 또한 위에서 언급한 msg 메시지의 변형으로 action 메시지라고 함.



파라미터(Parameter)

- 각 노드에 파라미터 관련 Parameter server를 실행시켜 외부의 Parameter client 간의 통신으로 파라미터를 변경하는 것으로 서비스와 동일
- 노드 내 매개변수 또는 글로벌 매개변수를 서비스 메시지 통신 방법을 사용하여 노드 내부 또는 외부에서 쉽게 지정(Set) 하거나 변경할 수 있고, 쉽게 가져(Get)와서 사용할 수 있게 하는 점에서 목적이 다름



ROS2 실습 – 노드와 메시지 통신(10장)

```
$ ros2 node list
/turtlesim
/teleop_turtle

$ ros2 topic list
/parameter_events
/rosout
/turtle1/cmd_vel
/turtle1/color_sensor
/turtle1/pose

$ ros2 action list
/turtle1/rotate_absolute

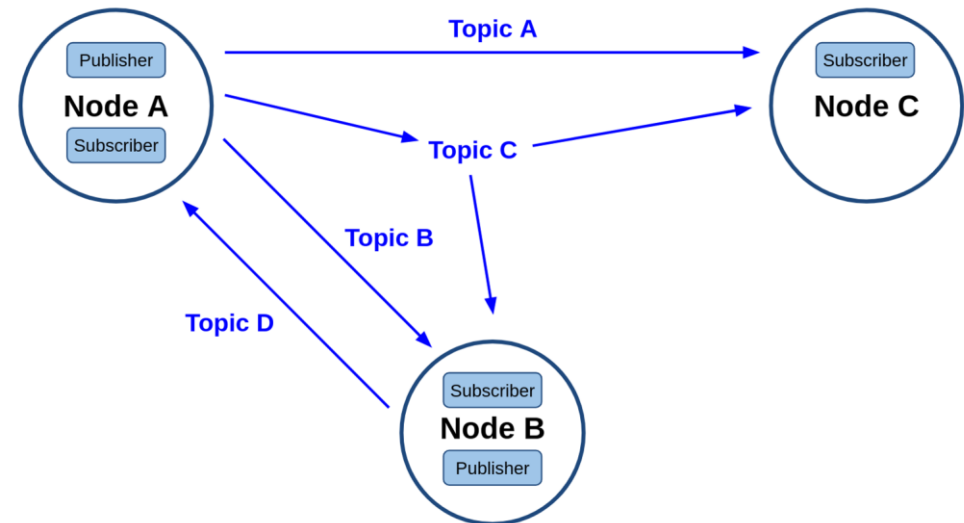
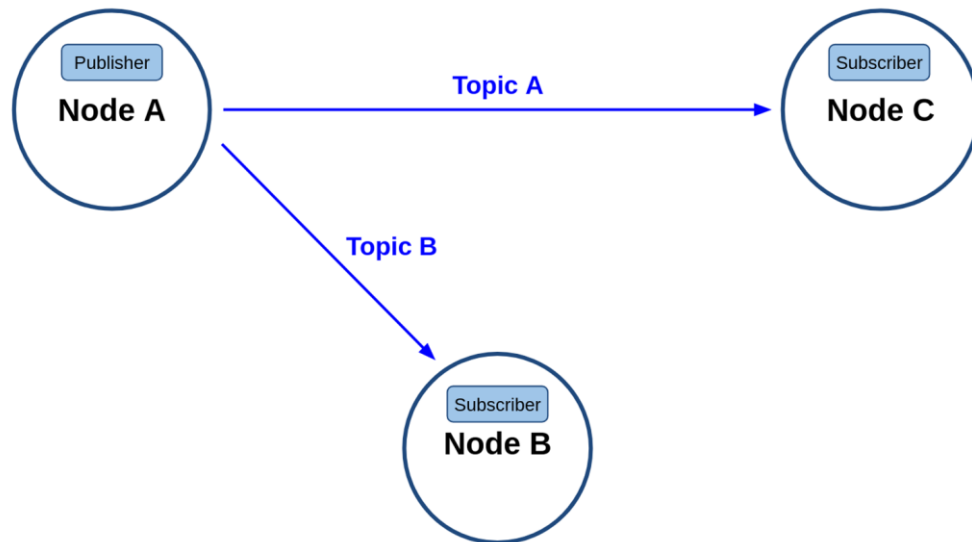
$ ros2 node info /turtlesim
/turtlesim
  Subscribers:
.....

$ ros2 node info /teleop_turtle
/turtlesim
  Subscribers:
...
```

```
$ ros2 service list
/clear
/kill
/reset
/spawn
/teleop_turtle/describe_parameters
/teleop_turtle/get_parameter_types
/teleop_turtle/get_parameters
/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/list_parameters
/turtlesim/set_parameters
/turtlesim/set_parameters_atomically
```

ROS2 실습 - ROS2 Topic(11장)

- `Node A`처럼 하나의 이상의 토픽을 발행
- `Publisher` 기능과 동시에 토픽(예: Topic D)을 구독하는 `Subscriber` 역할도 동시에 수행
- 자신이 발행한 토픽을 셀프 구독할 수 있게 구성할 수도 있음
- 토픽 기능은 목적에 따라 다양한 방법으로 사용할 수 있으며 이런 유연성으로 다양한 곳에 사용 중
- ROS 프로그래밍시에 70% 이상이 토픽으로 사용됨
- 통신 방식 중에 가장 기본이 되며 가장 널리쓰이는 방법
- 비동기성과 연속성을 가지기에 센서 값 전송 및 항시 정보를 주고 받아야 하는 부분에 주로 사용

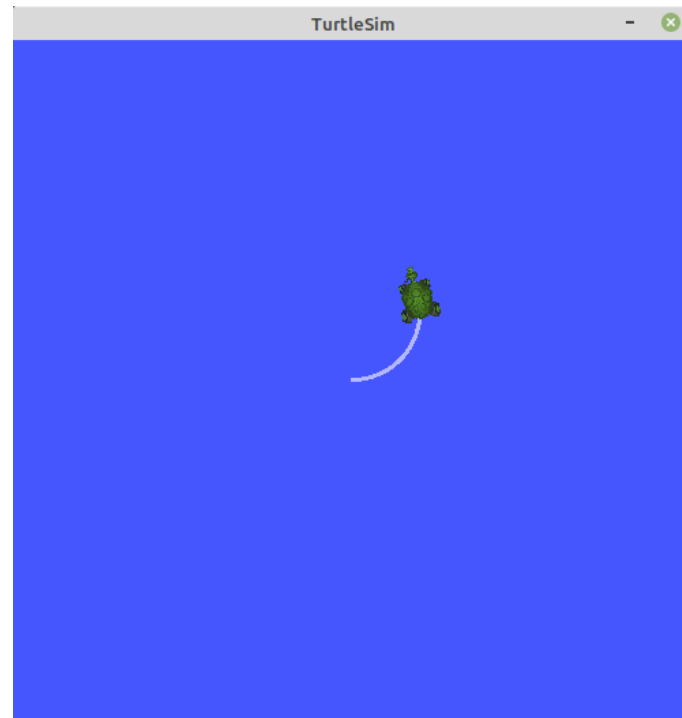


```
$ ros2 topic list -t  
/parameter_events [rcl_interfaces/msg/ParameterEvent]  
/rosout [rcl_interfaces/msg/Log]  
/turtle1/cmd_vel [geometry_msgs/msg/Twist]  
/turtle1/color_sensor [turtlesim/msg/Color]  
/turtle1/pose [turtlesim/msg/Pose]
```

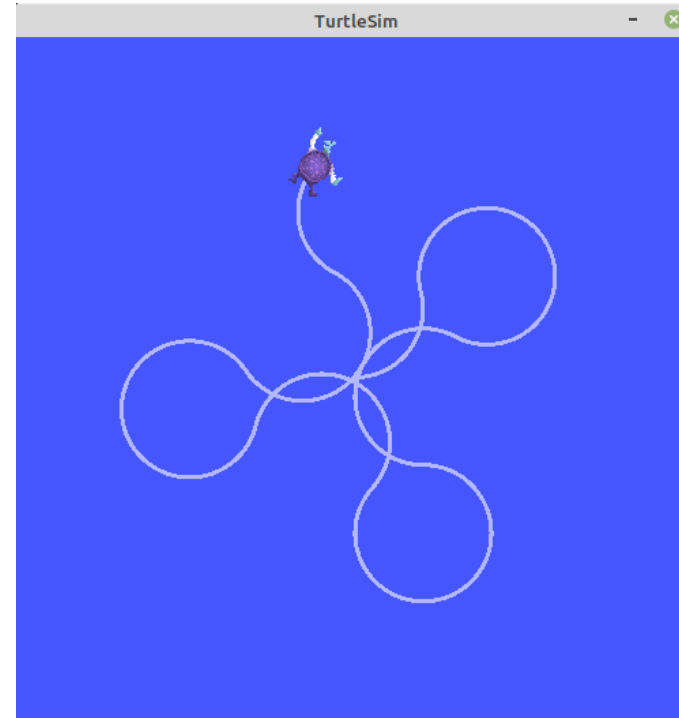
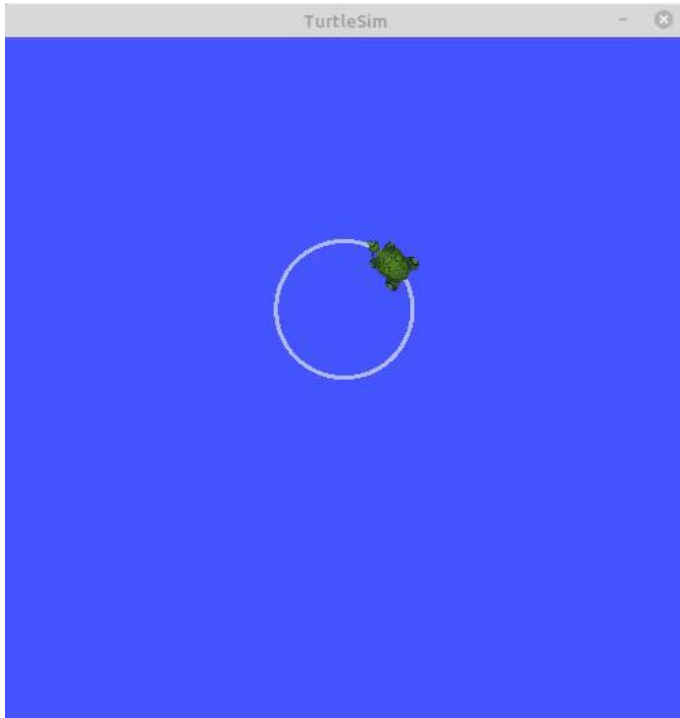
```
$ ros2 topic info /turtle1/cmd_vel  
Type: geometry_msgs/msg/Twist  
Publisher count: 1  
Subscriber count: 1
```

```
$ ros2 topic echo /turtle1/cmd_vel  
linear:  
x: 1.0  
y: 0.0  
z: 0.0  
angular:  
x: 0.0  
y: 0.0  
z: 0.0
```

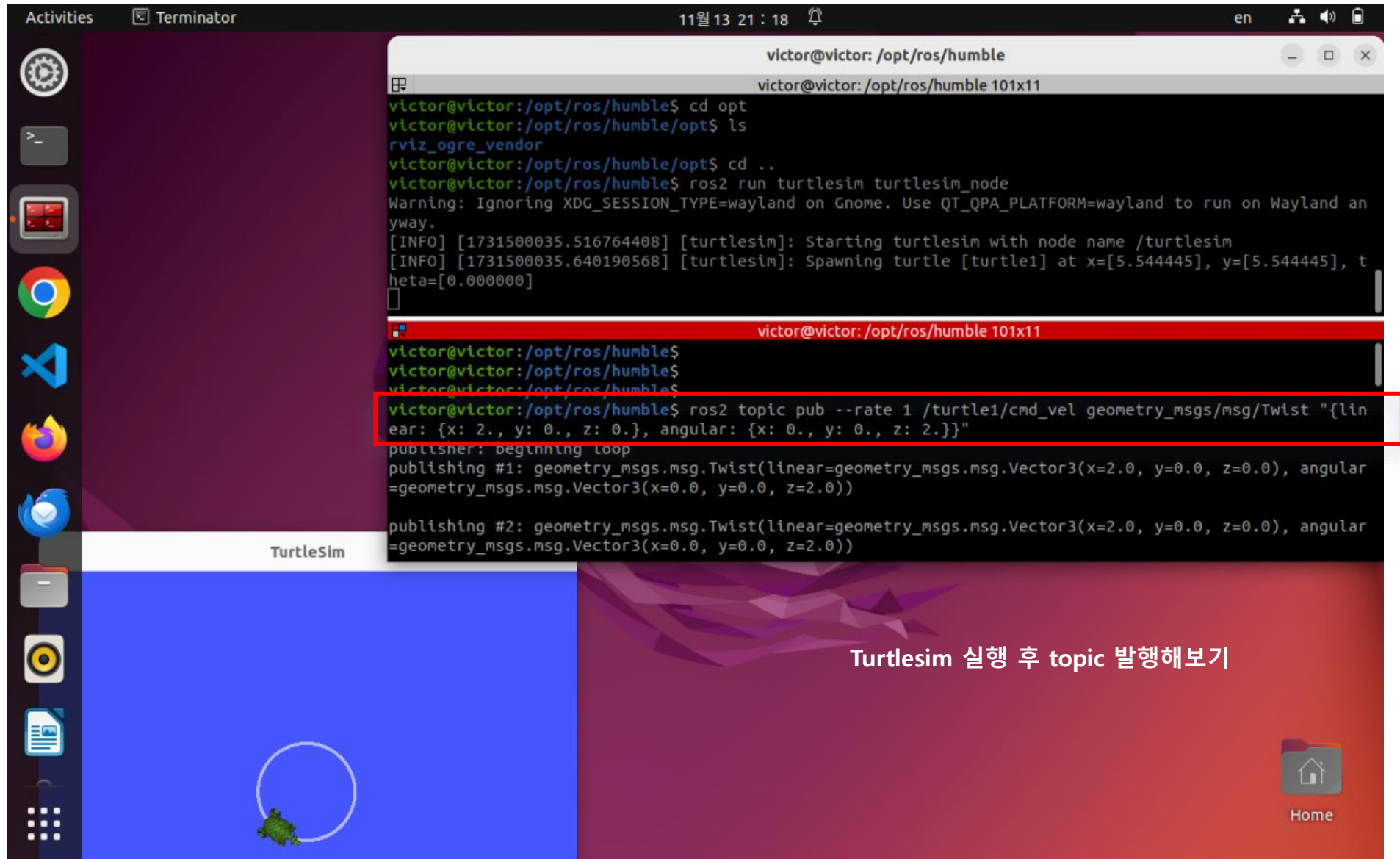
```
$ ros2 topic pub --once /turtle1/cmd_vel geometry_msgs/msg/Twist "{linear: {x: 2.0, y: 0.0, z: 0.0}, angular: {x: 0.0, y: 0.0, z: 1.8}}"
```



```
$ ros2 topic pub --rate 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: 1.8}}"
```



ROS2 실습 - Topic



The screenshot shows a Linux desktop with a sidebar on the left containing icons for Activities, Terminator, and various applications. The main window is a terminal titled "Terminator" with the prompt "victor@victor: /opt/ros/humble". The terminal output shows the following commands and results:

```
victor@victor: /opt/ros/humble
victor@victor: /opt/ros/humble$ cd opt
victor@victor: /opt/ros/humble/opt$ ls
rviz_ogre_vendor
victor@victor: /opt/ros/humble/opt$ cd ..
victor@victor: /opt/ros/humble$ ros2 run turtlesim turtlesim_node
Warning: Ignoring XDG_SESSION_TYPE=wayland on Gnome. Use QT_QPA_PLATFORM=wayland to run on Wayland an
yway.
[INFO] [1731500035.516764408] [turtlesim]: Starting turtlesim with node name /turtlesim
[INFO] [1731500035.640190568] [turtlesim]: Spawning turtle [turtle1] at x=[5.544445], y=[5.544445], t
heta=[0.000000]
victor@victor: /opt/ros/humble$
victor@victor: /opt/ros/humble$
victor@victor: /opt/ros/humble$ ros2 topic pub --rate 1 /turtle1/cmd_vel geometry_msgs/msg/Twist "{lin
ear: {x: 2., y: 0., z: 0.}, angular: {x: 0., y: 0., z: 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=2.0))
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=2.0))
```

Below the terminal window, there is a window titled "TurtleSim" showing a blue background with a white circle and a small green turtle icon. To the right of the terminal window, there is a red banner with the text "Turtlesim 실행 후 topic 발행해보기".

Turtlesim 실행 후 topic 발행해보기

ROS2 실습 – Topic with RQT

The screenshot shows a ROS2 environment with the TurtleSim window in the background. In the foreground, the RQT (ROS2 Query Tool) window is open, displaying a MatPlot of the /turtle1/pose/ topic. The plot shows two sinusoidal waves: a red line for /turtle1/pose//x and a blue line for /turtle1/pose//y. The x-axis ranges from 152.5 to 170.0, and the y-axis ranges from 4 to 8. Below the plot, a terminal window shows an error message: [ERROR] [1731501893.955183749] [get_message_class]: Malformed msg message_type: turtlesim/action/RotateAbsolute_FeedbackMessage. TopicCompleter.update_topics(): could not get message class for topic type "turtlesim/action/RotateAbsolute_FeedbackMessage" on topic "/turtle1/rotate_absolute/action/feedback".

Activities rqt 11월 13 21 : 47 en

TurtleSim

victor@victor: ~
victor@victor: ~80x11

Default - rqt

File Plugins Running Perspectives Help

MatPlot

Topic /turtle1/pose/ + -

autoscroll

8 6 4

152.5 155.0 157.5 160.0 162.5 165.0 167.5 170.0

— /turtle1/pose//x
— /turtle1/pose//y

victor@victor: ~
victor@victor: ~80x6

[ERROR] [1731501893.955183749] [get_message_class]: Malformed msg message_type: turtlesim/action/RotateAbsolute_FeedbackMessage
TopicCompleter.update_topics(): could not get message class for topic type "turtlesim/action/RotateAbsolute_FeedbackMessage" on topic "/turtle1/rotate_absolute/action/feedback"

Plugins → Visualization → Plot

RQT 실행 후 pose/x, pose/y 확인

ROS2 실습 – Topic Message with RQT

The screenshot shows a ROS2 environment with a TurtleSim window displaying a turtle on a blue background. A terminal window in the background shows the command `ros2 run turtlesim turtlesim_node` and its output, including the spawning of a turtle named `turtle1` at `x=[5.544445], y=[5.544445], theta=[0.000000]`. In the foreground, the RQT (Robot Query Tool) interface is open, showing the 'Message Publisher' tab. The 'Topic' is set to `/parameter_events` and the 'Type' is `rcl_interfaces/msg/ParameterEvent`. A table of available topics is displayed, with `/turtle1/pose` highlighted by a red box.

topic	type	rate	expression
✓ <code>/turtle1/cmd_vel</code>	Twist	1.00	
linear	geometry_msgs/Vector3		
angular	geometry_msgs/Vector3		
x	double		0.0
y	double		0.0
z	double		5.0
✓ <code>/turtle1/pose</code>	Pose	1.00	
x	float		0.0
y	float		0.0
theta	float		0.0
linear_velocity	float		0.0
angular_velocity	float		0.0

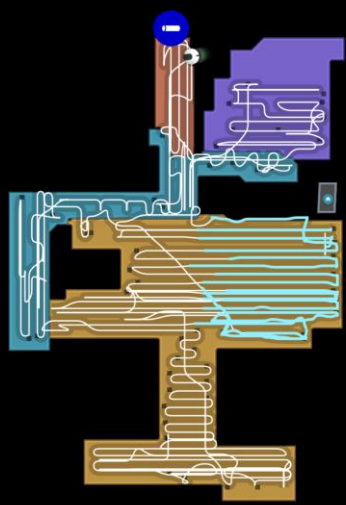
Plugins → Topics → Message Publisher

ROS2 실습 – ros bag

← 오전 9:14

41분 35초
전체 청소 45m²

도면 정보 ①



도면에 나타난 선은 로봇청소기가 이동한 경로에
요. 실제 청소 면적과 다를 수 있어요.

▶ | X1



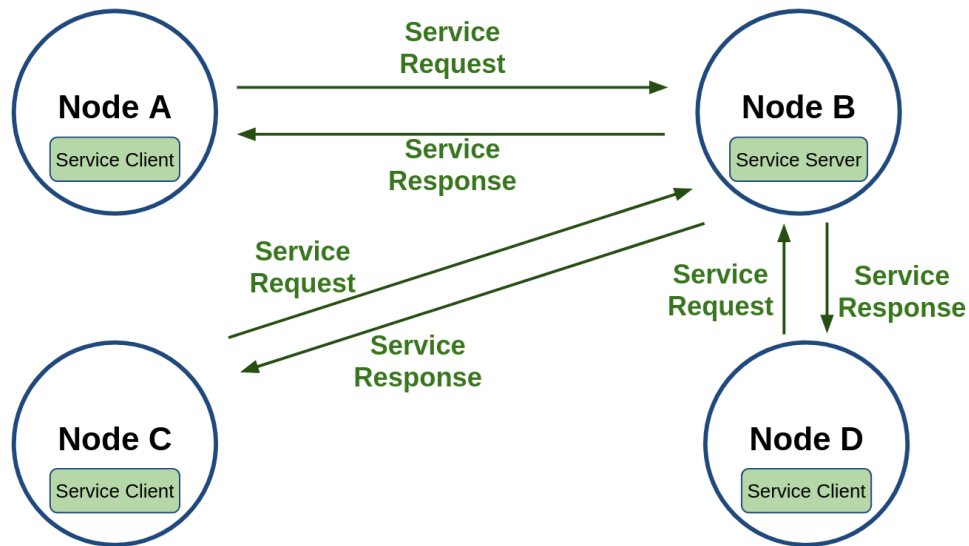
ROKEY BOOT CAMP



ROKEY BOOT CAMP



- 서비스는 다음 그림과 같이 동일 서비스에 대해 복수의 클라이언트를 가질 수 있도록 설계되었다.
- 단, 서비스 응답은 서비스 요청이 있었던 서비스 클라이언트에 대해서만 응답을 하는 형태
- Node C의 Service Client가 Node B의 Service Server에게 서비스 요청을 하였다면 Node B의 Service Server는 요청 받은 서비스를 수행한 후 Node C의 Service Client에게만 서비스 응답



```
$ ros2 run turtlesim turtlesim_node
```

```
$ ros2 service list
```

```
/clear
```

```
/kill
```

```
/reset
```

```
/spawn
```

```
/turtle1/set_pen
```

```
/turtle1/teleport_absolute
```

```
/turtle1/teleport_relative
```

```
/turtlesim/describe_parameters
```

```
/turtlesim/get_parameter_types
```

```
/turtlesim/get_parameters
```

```
/turtlesim/list_parameters
```

```
/turtlesim/set_parameters
```

```
/turtlesim/set_parameters_atomically
```

ROS2 실습 - Service

```
$ ros2 service type /clear  
std_srvs/srv/Empty
```

```
$ ros2 service type /kill  
turtlesim/srv/Kill
```

```
$ ros2 service type /spawn  
turtlesim/srv/Spawn
```

```
$ ros2 service list -t  
/clear [std_srvs/srv/Empty]  
/kill [turtlesim/srv/Kill]  
/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]  
(생략)
```

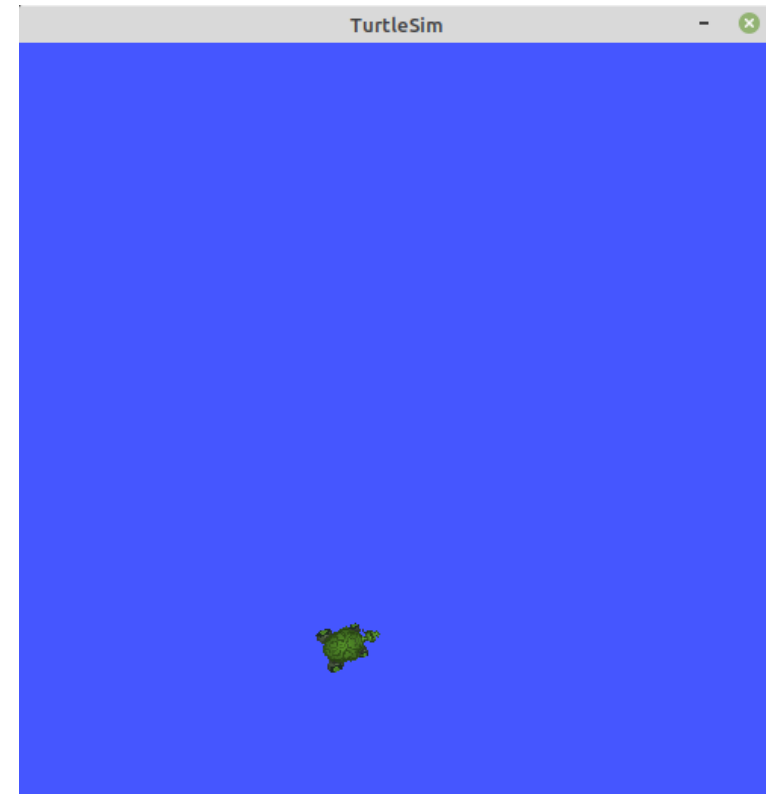
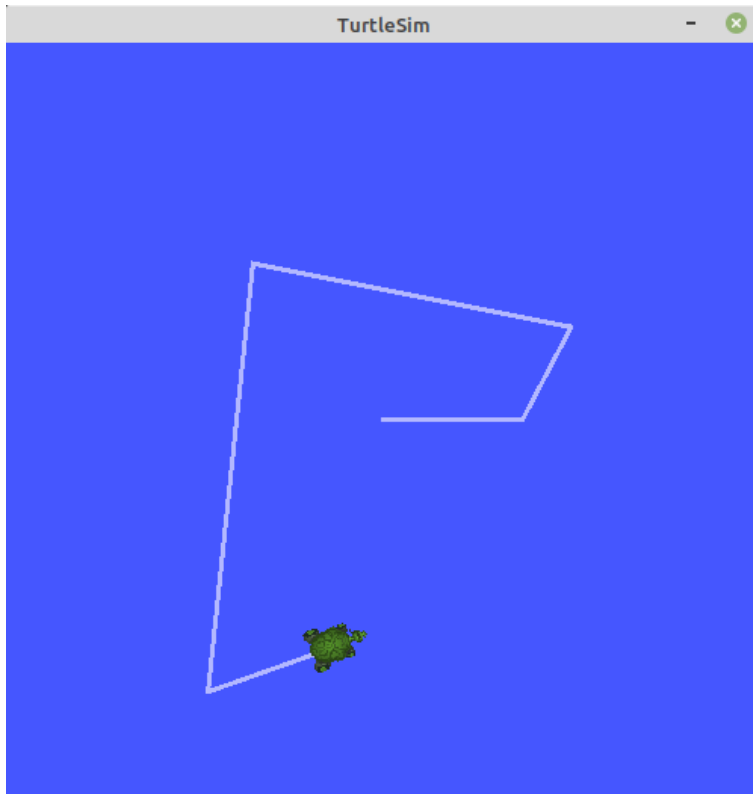
```
$ ros2 service find std_srvs/srv/Empty  
/clear  
/reset
```

```
$ ros2 service find turtlesim/srv/Kill  
/kill
```

ROS2 실습 - Service

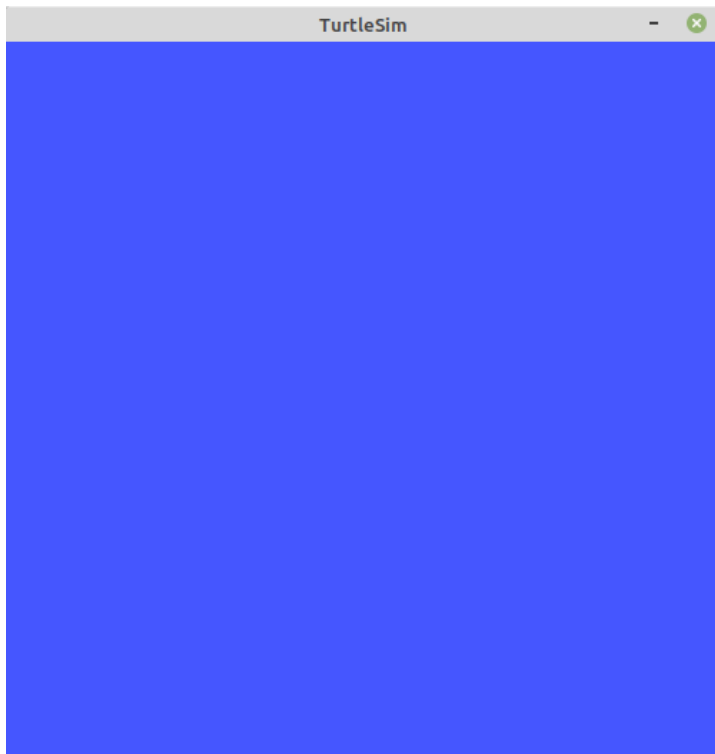
```
$ ros2 run turtlesim turtle_teleop_key
```

```
$ ros2 service call /clear std_srvs/srv/Empty  
requester: making request: std_srvs.srv.Empty_Request()  
response:  
std_srvs.srv.Empty_Response()
```

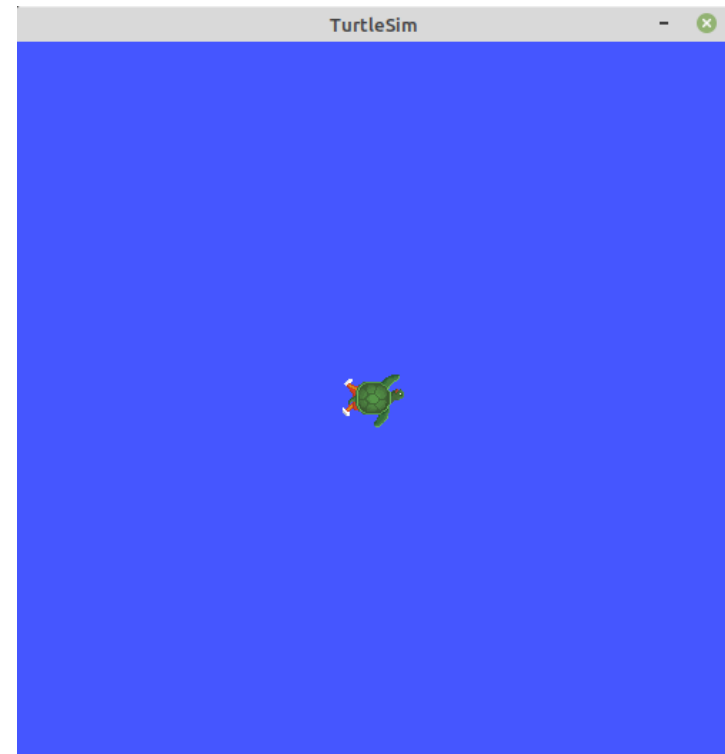


ROS2 실습 - Service

```
$ ros2 service call /kill turtlesim/srv/Kill "name: 'turtle1'"
requester: making request:
turtlesim.srv.Kill_Request(name='turtle1')
response:
turtlesim.srv.Kill_Response()
```

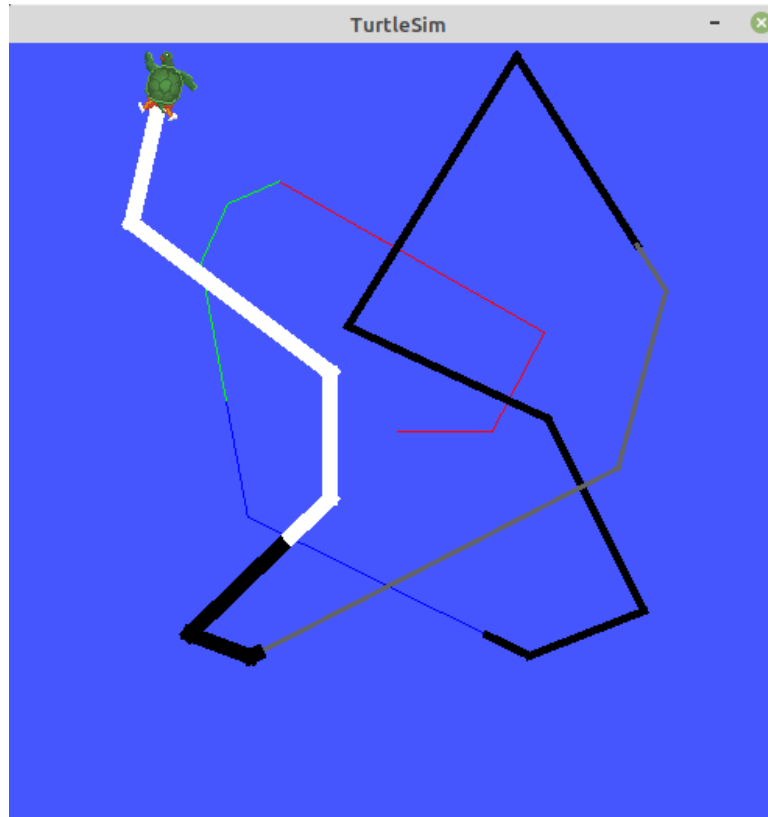


```
$ ros2 service call /reset std_srvs/srv/Empty
requester: making request: std_srvs.srv.Empty_Request()
response:
std_srvs.srv.Empty_Response()
```

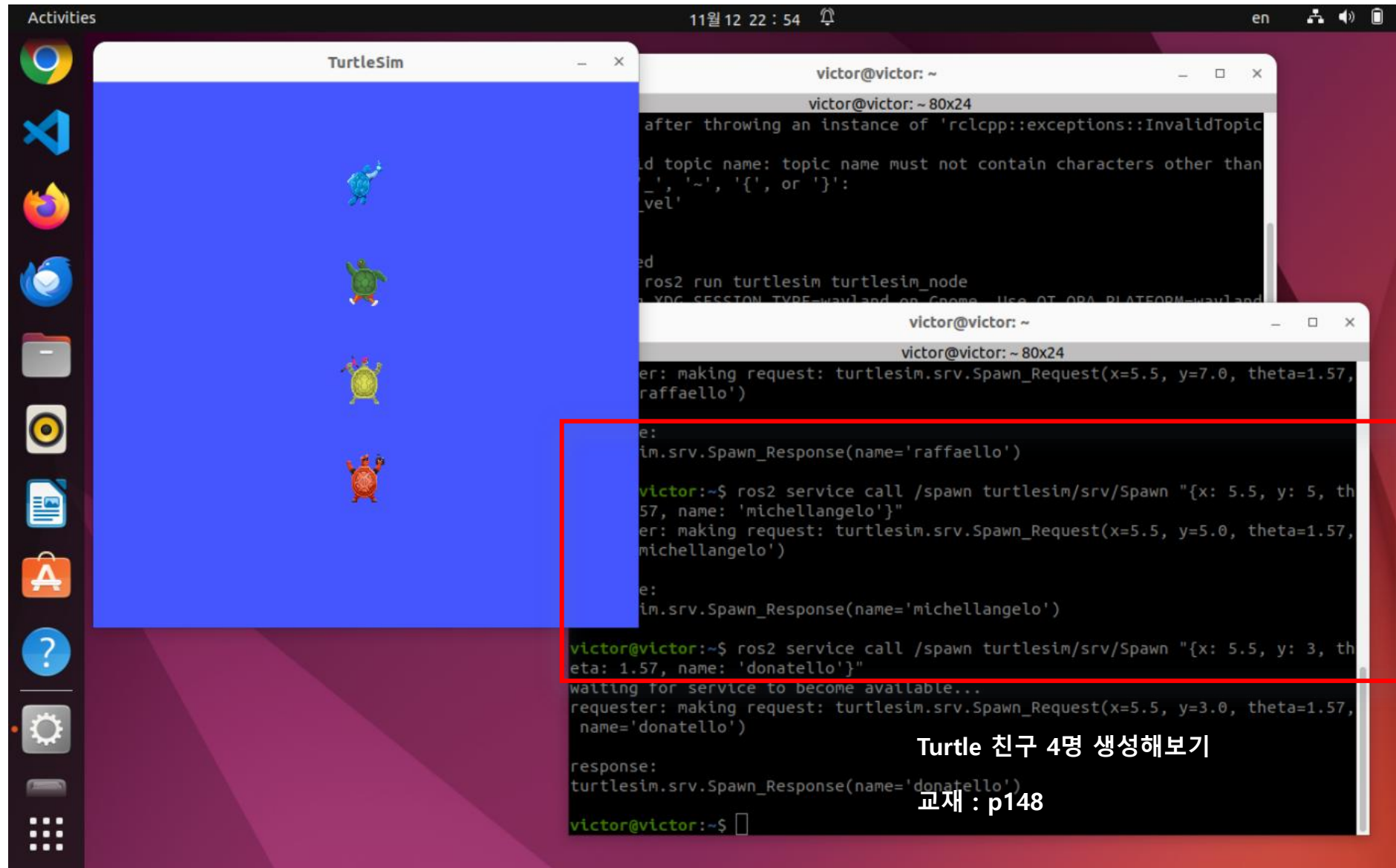


ROS2 실습 - Service

```
$ ros2 service call /turtle1/set_pen turtlesim/srv/SetPen "{r: 255, g: 255, b: 255, width: 10}"  
requester: making request: turtlesim.srv.SetPen_Request(r=255, g=255, b=255, width=10, off=0)  
response:  
turtlesim.srv.SetPen_Response()
```



ROS2 실습 - Service



ROS2 실습 – Service with RQT

The screenshot shows a ROS2 environment with a TurtleSim window and an RQT (Robot Query Tool) window. The TurtleSim window displays a blue field with a green turtle and two white circles connected by a line. The RQT window, titled "Default - rqt", has a "Service Caller" tab selected. A red box highlights the "Service" dropdown menu, which is set to "/turtle1/teleport_absolute". Below the dropdown, the "Request" section shows a table with the following data:

Topic	Type	Expression
▼ /turtle1/teleport_absolute	turtlesim/srv/TeleportAbsolute	
x	float	2
y	float	2
theta	float	0.0

The "Response" section shows a table with the following data:

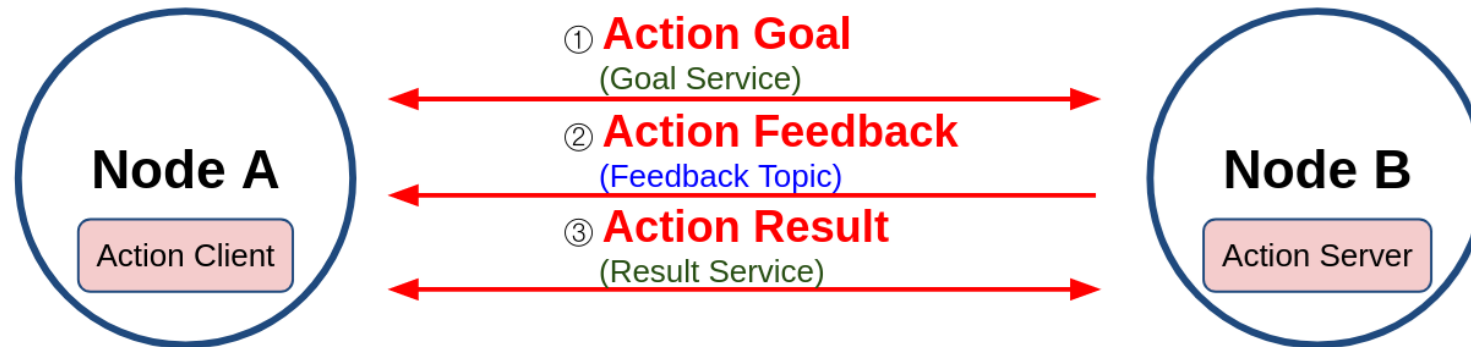
Field	Type	Value
/	turtlesim/srv/TeleportAbsolute.Response	

In the background, a terminal window shows the following output:

```
victor@victor: ~  
victor@victor: ~ 80x5  
[INFO] [1731504945.290710348] [turtlesim]: Starting turtlesim with node name /tu  
rtlesim  
[INFO] [1731504945.376033575] [turtlesim]: Spawning turtle [turtle1] at x=[5.544  
445], y=[5.544445], theta=[0.000000]  
victor@victor: ~ 80x5  
turtlesim/action/RotateAbsolute_FeedbackMessage  
TopicCompleter.update_topics(): could not get message class for topic type "turt  
lesim/action/RotateAbsolute_FeedbackMessage" on topic "/turtle1/rotate_absolute/  
_action/feedback"  
victor@victor: ~ 80x11
```

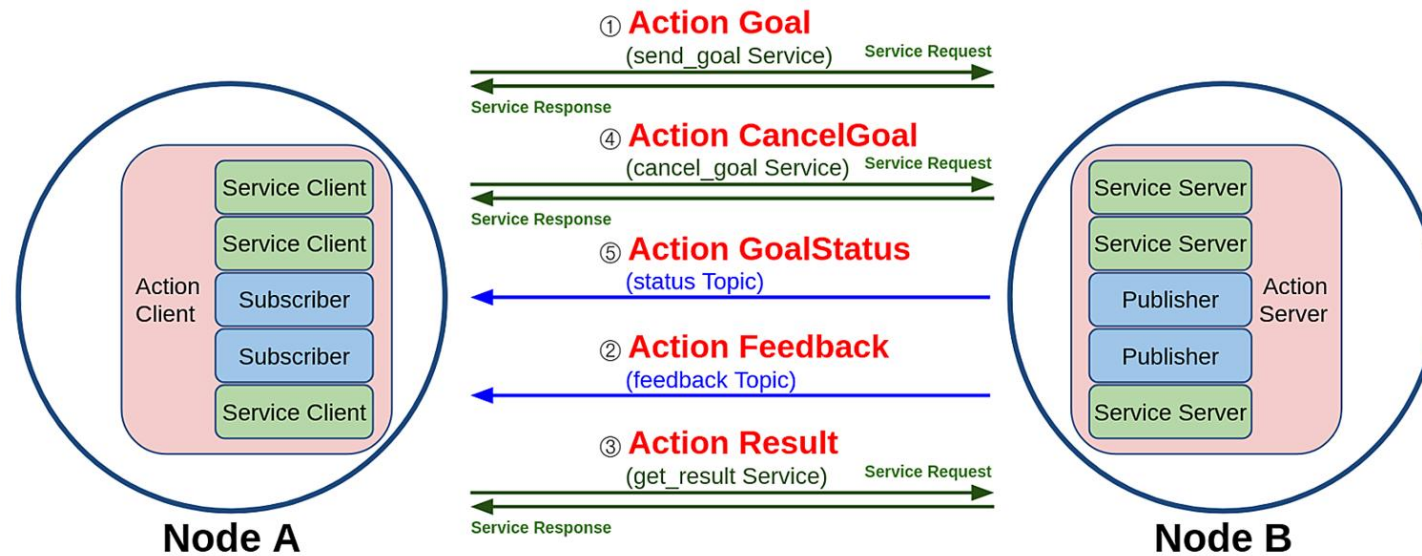
액션(Action)

- 토픽(topic)과 서비스(service)의 혼합
- 액션 목표 및 액션 결과를 전달하는 방식은 서비스와 같고,
- 액션 피드백은 토픽과 같은 메시지 전송 방식
- 액션 목표/피드백/결과(Goal/Feedback/Result) 메시지 또한 위에서 언급한 msg 메시지의 변형으로 action 메시지라고 함.



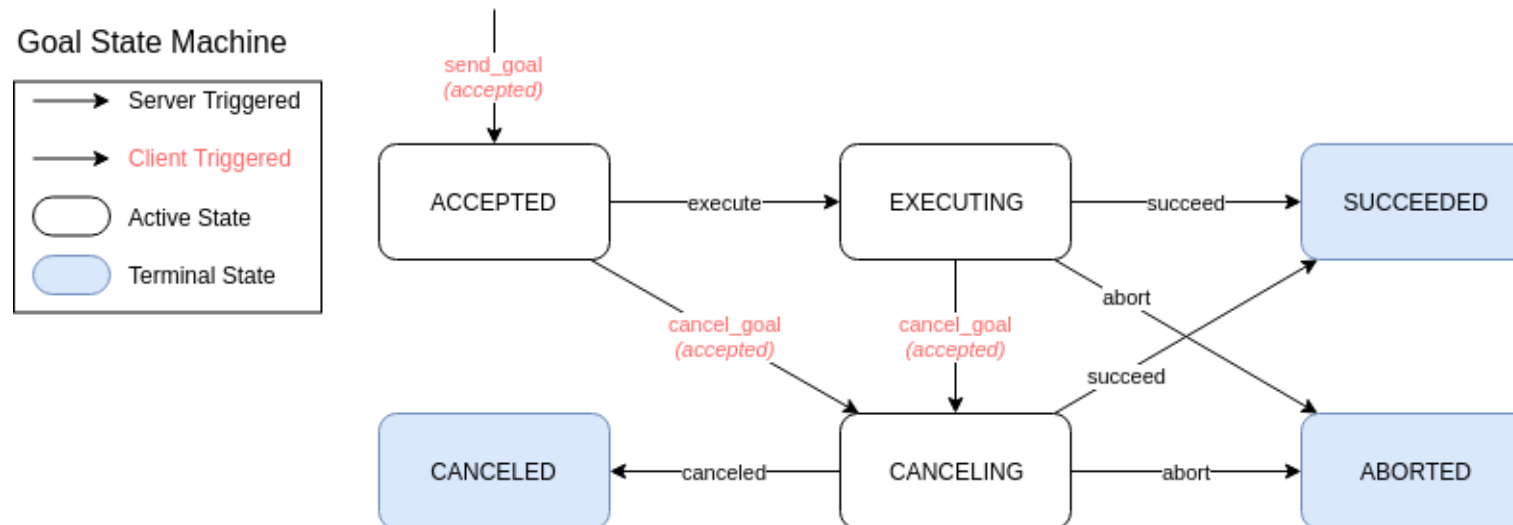
액션의 구현 방식을 더 자세히 살펴보면 다음 그림과 같이 토픽과 서비스의 혼합이라고 볼 수 있는데 ROS 1이 토픽만을 사용하였다면 ROS 2에서는 액션 목표, 액션 결과, 액션 피드백은 토픽과 서비스가 혼합되어 있다.

즉, 다음 그림과 같이 Action Client는 Service Client 3개와 Topic Subscriber 2개로 구성되어있으며, Action Server는 Service Server 3개와 Topic Publisher 2개로 구성된다. 액션 목표/피드백/결과(goal/feedback/result) 데이터는 msg 및 srv 인터페이스의 변형으로 action 인터페이스라고 한다.

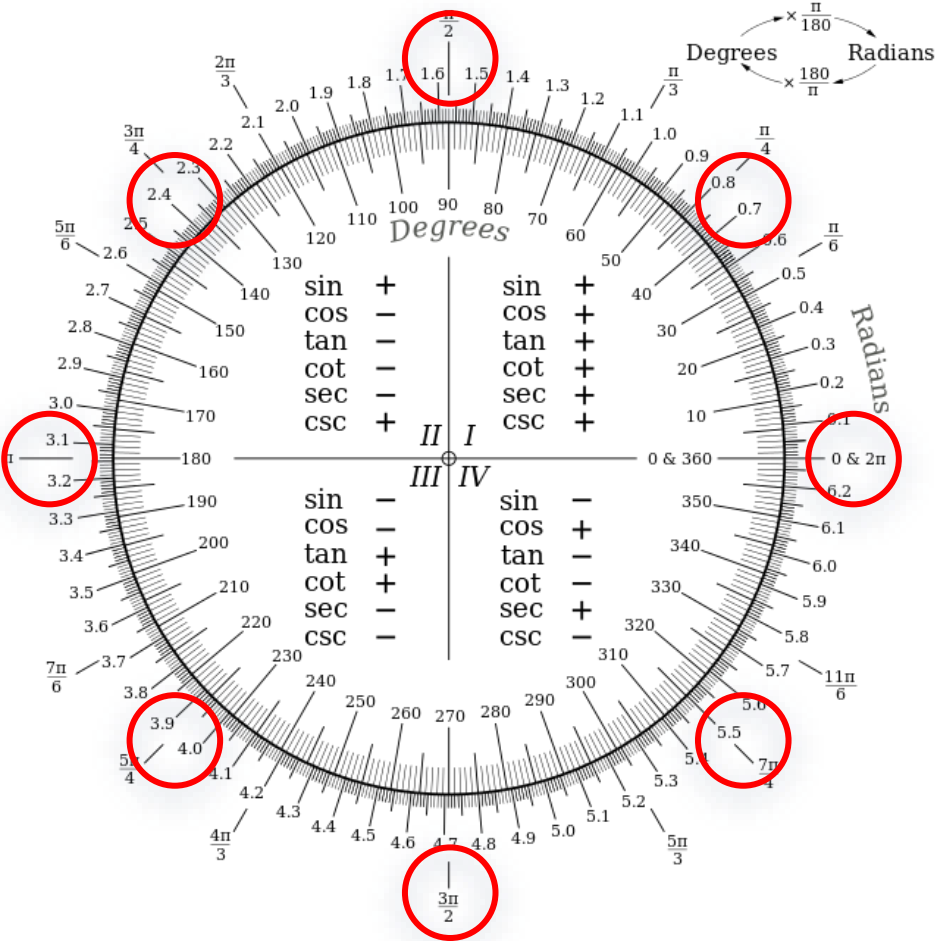
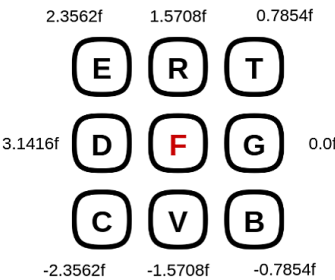
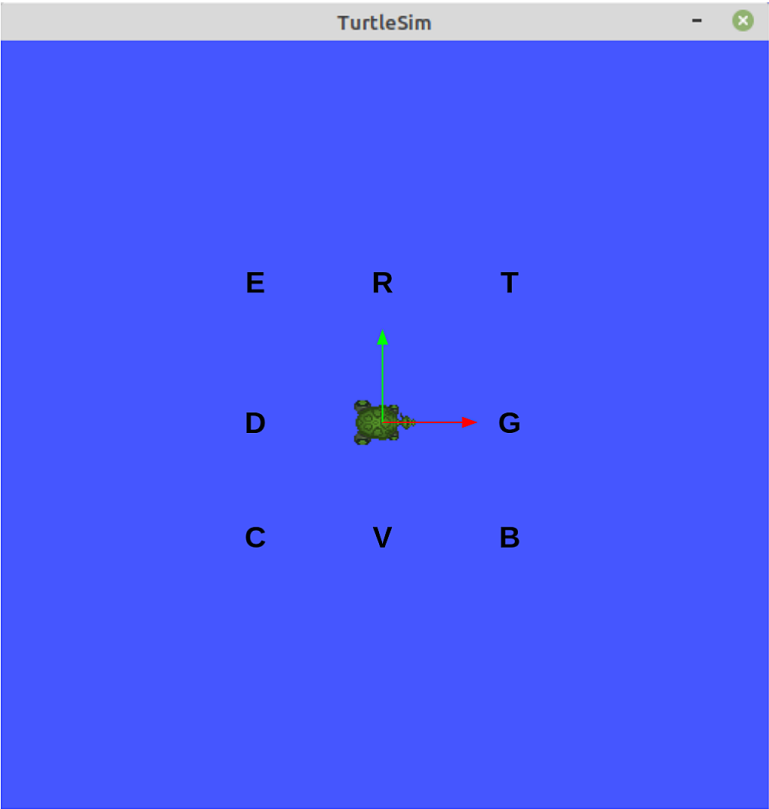


ROS2 실습 - Action

ROS 1에서의 액션은 목표, 피드백, 결과 값을 토픽으로만 주고 받았는데 **ROS 2에서는 토픽과 서비스 방식을 혼합하여 사용하였다.** 그 이유로 토픽으로만 액션을 구성하였을 때 토픽의 특징인 비동기식 방식을 사용하게 되어 ROS 2 액션에서 새롭게 선보이는 **목표 전달(send_goal), 목표 취소(cancel_goal), 결과 받기(get_result)**를 동기식인 서비스를 사용하기 위해서이다. 이런 비동기 방식을 이용하다보면 원하는 타이밍에 적절한 액션을 수행하기 어려운데 이를 원활히 구현하기 위하여 **목표 상태(goal_state)**라는 것이 ROS 2에서 새롭게 선보였다. 목표 상태는 **목표 값을 전달 한 후의 상태 머신을 구동하여 액션의 프로세스를 쫓는 것이다.** 여기서 말하는 상태머신은 **Goal State Machine**으로 다음 그림과 같이 액션 목표 전달 이후의 액션의 상태 값을 액션 클라이언트에게 전달할 수 있어서 비동기, 동기 방식이 혼재된 액션의 처리를 원활하게 할 수 있게 되어 있다.



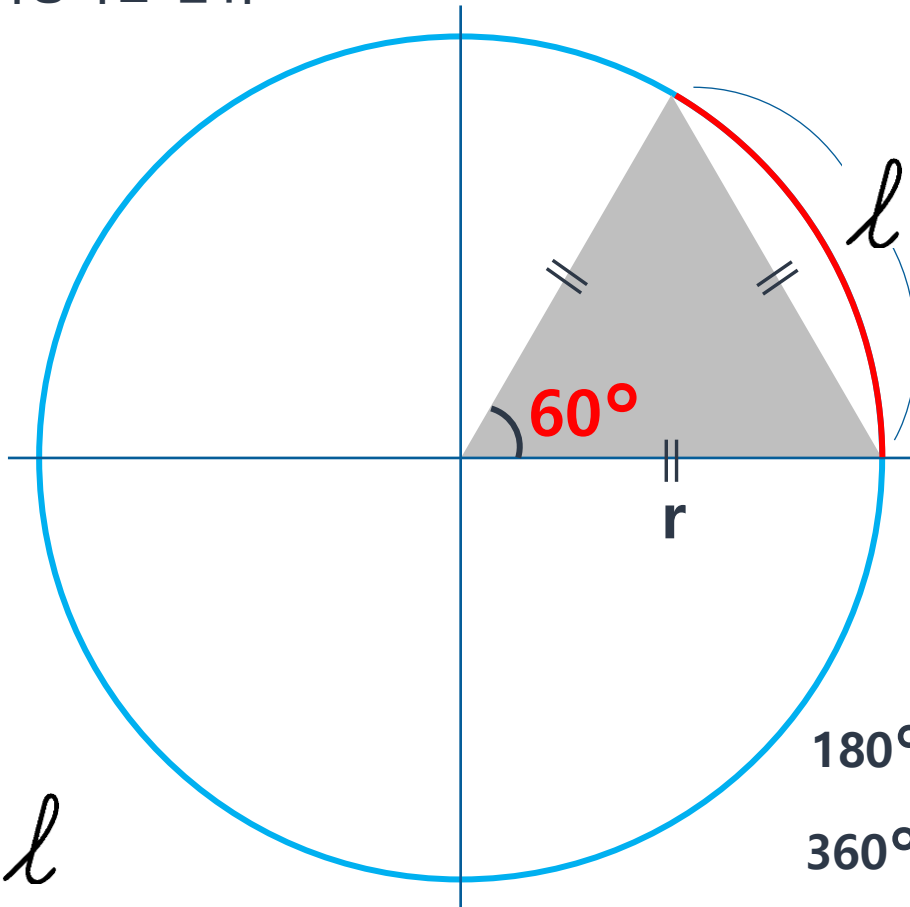
교재 p153



Ros2에서 사용하는 단위

- Kg
- Sec
- Meter
- Radian

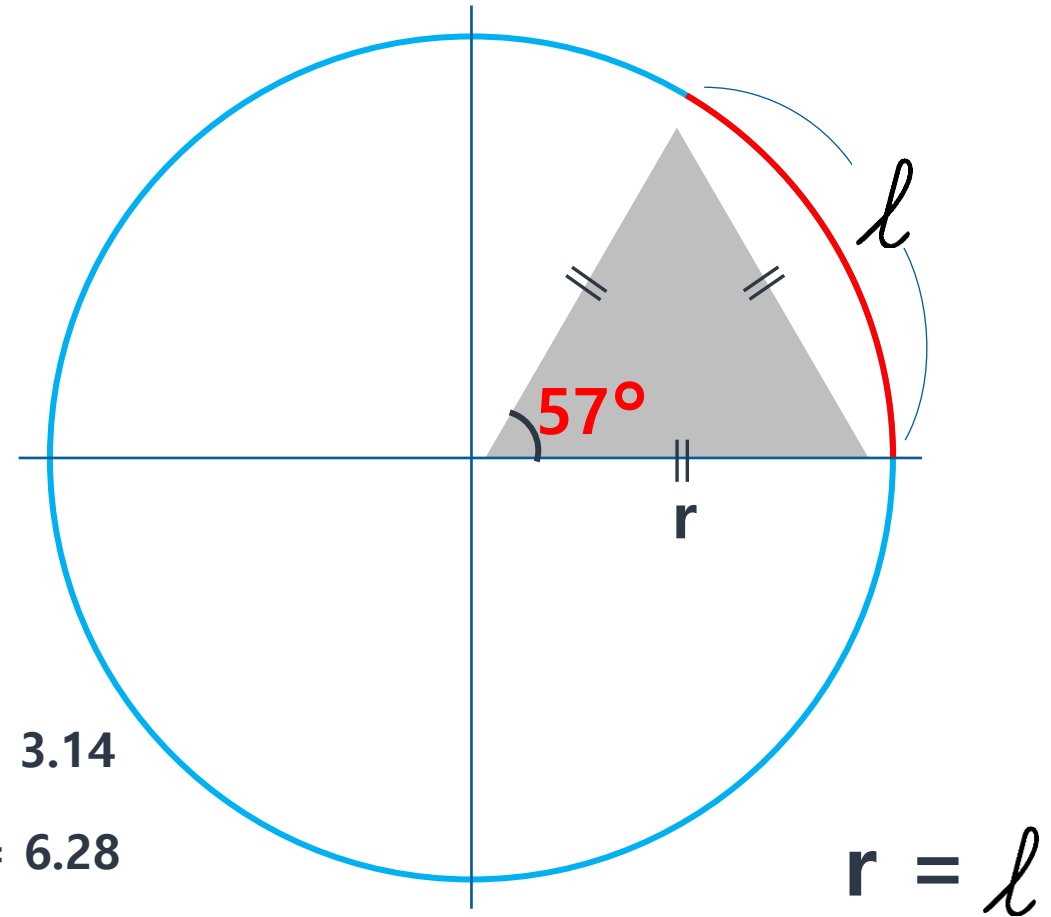
Degree vs Radian



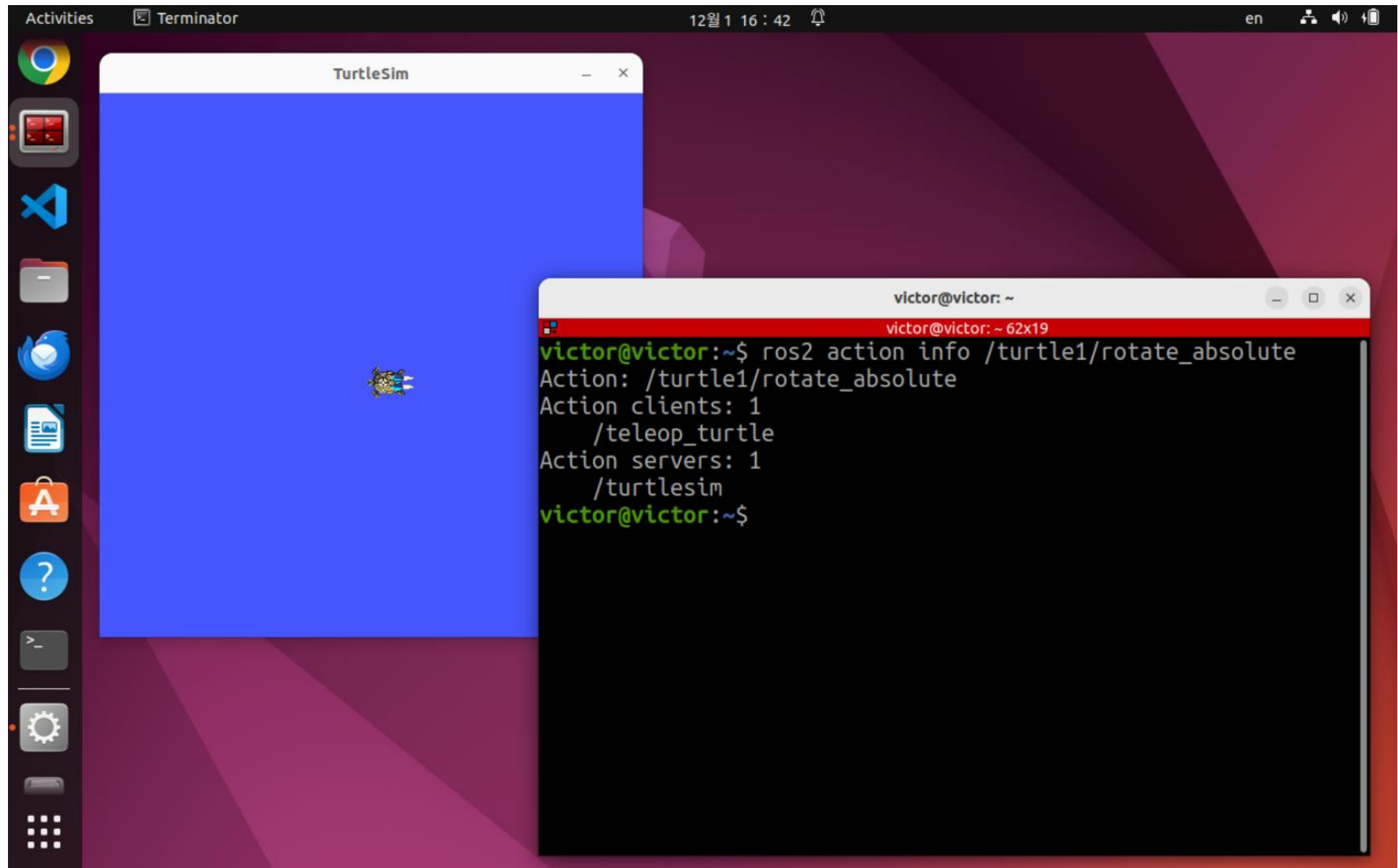
$$180^\circ = \pi = 3.14$$

$$360^\circ = 2\pi = 6.28$$

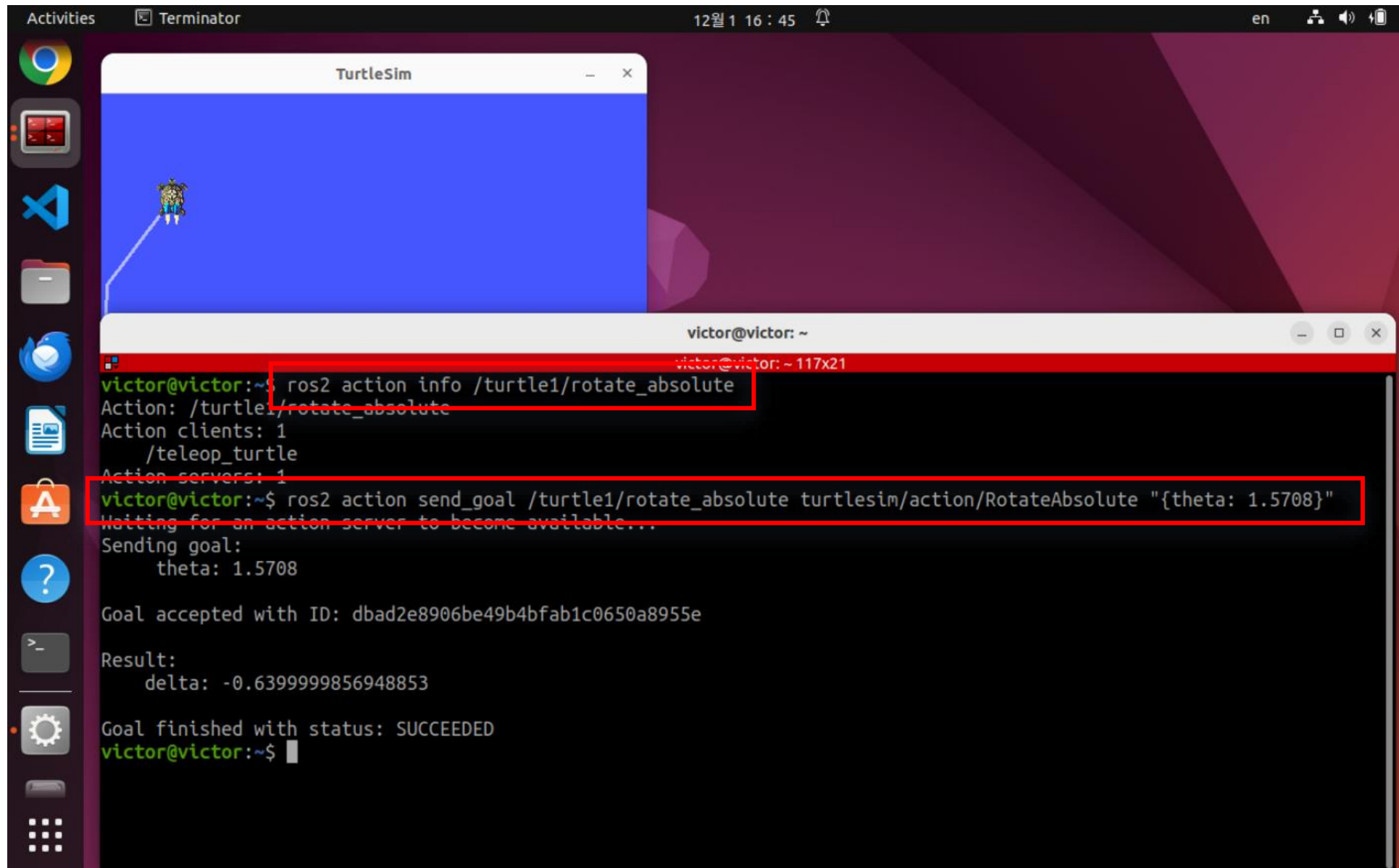
$$1 \text{ rad} \doteq 180^\circ / 3.14 \doteq 57^\circ$$



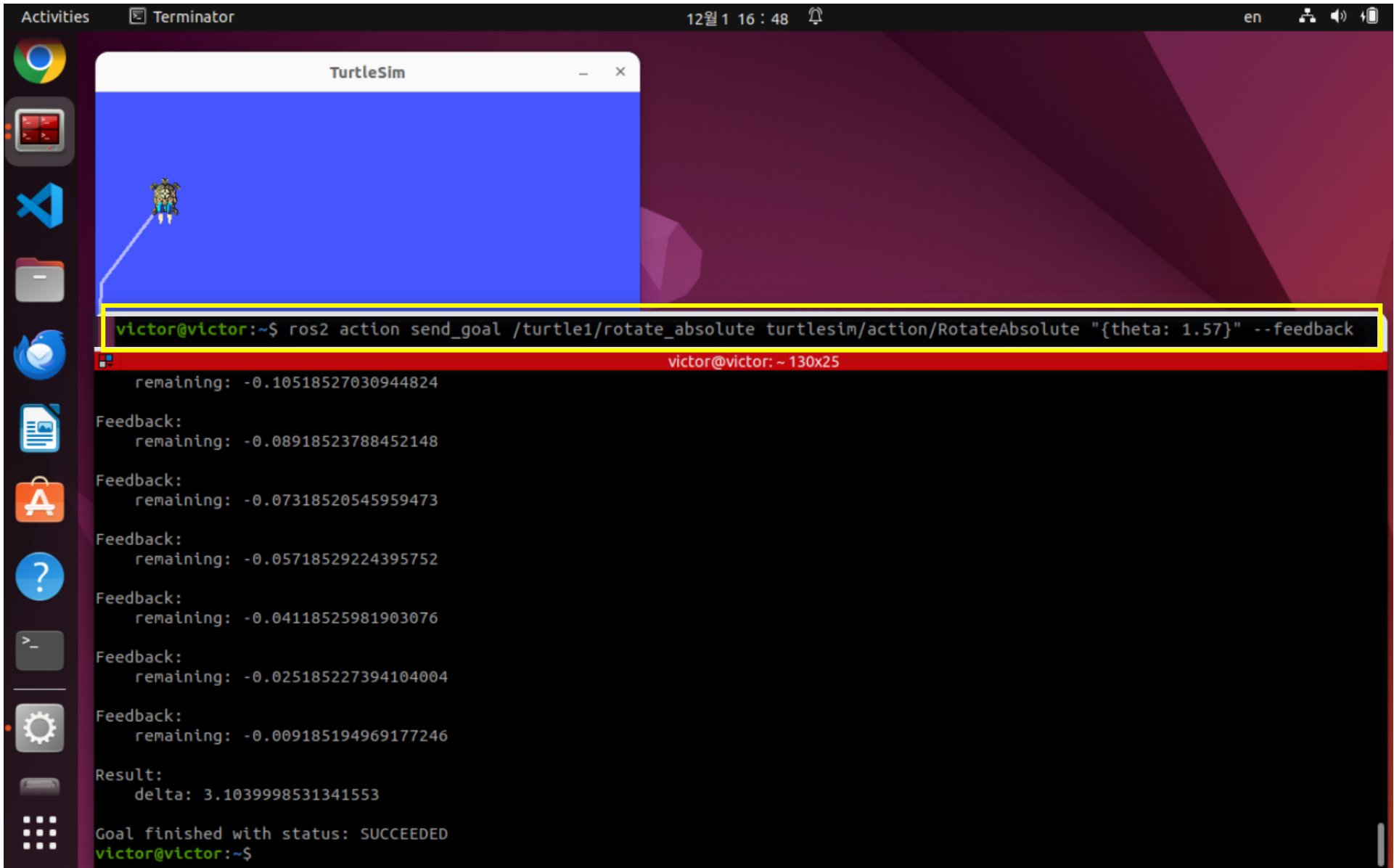
ROS2 실습 - Action



ROS2 실습 - Action



ROS2 실습 - Action



ROS의 노드 간에 데이터를 주고받을 때에는 **토픽, 서비스, 액션**이 사용되는데 이 때 사용되는 데이터의 형태를 **ROS 인터페이스(interface)** 이라고 한다. ROS 인터페이스에는 ROS 2에 새롭게 추가된 **IDL**(interface definition language)과 ROS 1부터 ROS 2까지 널리 사용 중인 **msg**, **srv**, **action** 이 있다. 토픽, 서비스, 액션은 각각 msg, srv, action interface를 사용하고 있으며 정수, 부동 소수점, 불리언과 같은 단순 자료형을 기본으로 하여 메시지 안에 메시지를 품고 있는 간단한 데이터 구조 및 메시지들이 나열된 배열과 같은 구조도 사용할 수 있다.

[단순 자료형]

- 예) 정수(integer), 부동 소수점(floating point), 불(boolean)
- https://github.com/ros2/common_interfaces/tree/humble/std_msgs

[메시지 안에 메시지를 품고 있는 간단한 데이터 구조]

- 예) geometry_msgs/msg/Twist의 `Vector3 linear`
- https://github.com/ros2/common_interfaces/blob/humble/geometry_msgs/msg/Twist.msg

[메시지들이 나열된 배열과 같은 구조]

- 예) sensor_msgs/msg/LaserScan 의 `float32[] ranges`
- https://github.com/ros2/common_interfaces/blob/humble/sensor_msgs/msg/LaserScan.msg

```
1      # This expresses velocity in free space broken into :
2
3      Vector3  linear
4      Vector3  angular
```

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

[common_interfaces / geometry_msgs / msg / Vector3.msg](#) 

```
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
```

- [Bool](#)
- [Byte](#)
- [Char](#)
- [Float32](#)
- [Float64](#)
- [Int8](#)
- [Int16](#)
- [Int32](#)
- [Int64](#)
- [String](#)
- [UInt8](#)
- [UInt16](#)
- [UInt32](#)
- [UInt64](#)

ROS2 실습 - Interface

토픽은 고유의 인터페이스를 가지고 있는데 이를 **메시지 인터페이스**라 부르며, 파일로는 **msg** 파일을 가르킨다.

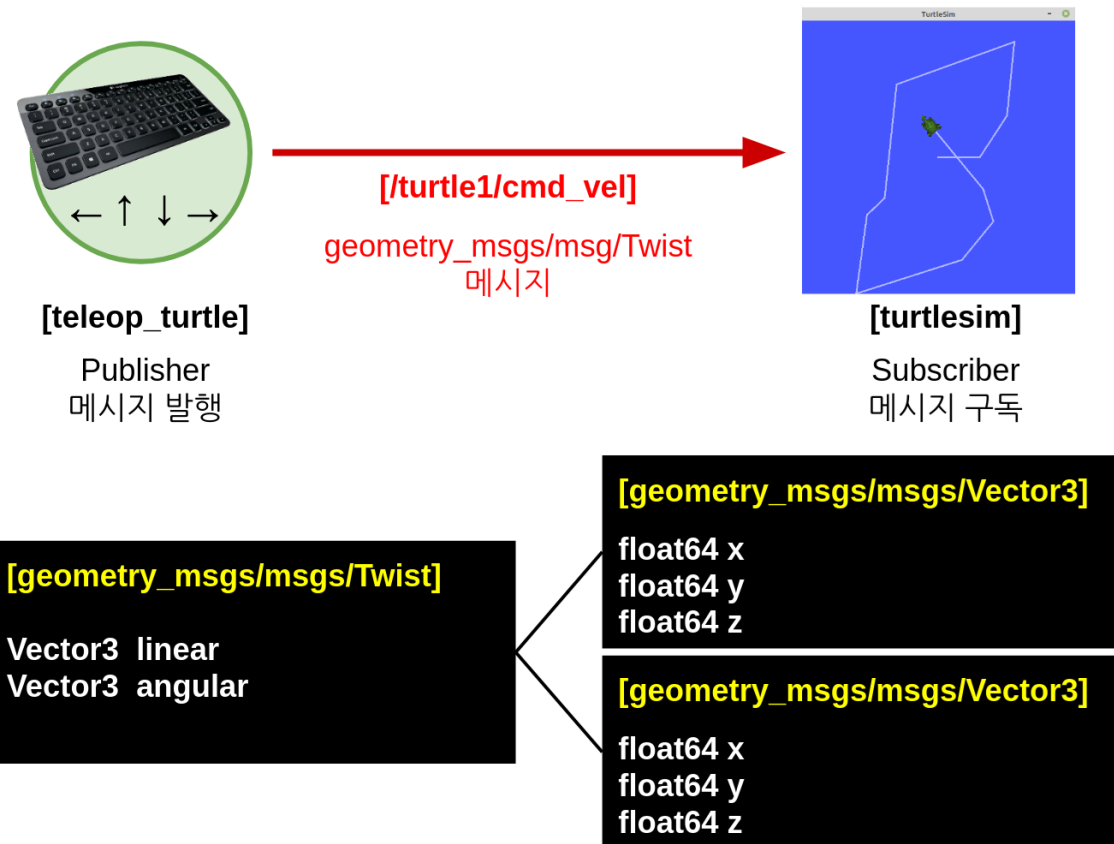
예를 들어, 위 예제에서 /turtle1/cmd_vel 토픽은 geometry_msgs/msg/Twist 형태이다. 이름이 좀 긴데 풀어서 설명하면 기하학 관련 메시지를 모아둔 geometry_msgs 패키지의 msgs 분류의 Twist 데이터 형태라는 것이다.

토픽은 고유의 인터페이스를 가지고 있는데 이를 **메시지 인터페이스**라 부르며, 파일로는 **msg** 파일을 가르킨다.

예를 들어, 위 예제에서 /turtle1/cmd_vel 토픽은 geometry_msgs/msg/Twist 형태이다. 이름이 좀 긴데 풀어서 설명하면 기하학 관련 메시지를 모아둔 geometry_msgs 패키지의 msgs 분류의 Twist 데이터 형태라는 것이다.

Twist 데이터 형태를 자세히 보면 Vector3 linear과 Vector3 angular 이라고 되어 있다. 이는 메시지 안에 메시지를 품고 있는 것으로 Vector3 형태에 linear 이라는 이름의 메시지와 Vector3 형태에 angular 이라는 이름의 메시지, 즉 2개의 메시지가 있다는 것이며 Vector3는 다시 float64 형태에 x, y, z 값이 존재한다.

다시 말해 **geometry_msgs/msg/Twist** 메시지 형태는 float64 자료형의 **linear.x, linear.y, linear.z, angular.x, angular.y, angular.z** 라는 이름의 메시지인 것이다. 이를 통해 병진 속도 3개, 회전 속도 3개를 표현할 수 있게 된다.



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The screenshot shows the GitHub web interface for the repository `ros2/common_interfaces`. The repository is public and has 22 issues and 6 pull requests. The `Code` tab is selected. On the left, the file explorer shows the directory structure: `humble` (selected) > `common_interfaces` > `geometry_msgs` > `msg` > `Twist.msg`. The file `Twist.msg` is selected, and its content is displayed on the right. The content is a message definition for `Twist`, which expresses velocity in free space broken into linear and angular components, each represented by a `Vector3`.

직접 코드로 보는 방법과 `$ros2 interface show` 명령으로 보는 방법

`ros2 / common_interfaces` Public

<> Code Issues 22 Pull requests 6 Actions Projects Security Insights

Files

humble

Go to file

Pose.msg

Pose2D.msg

PoseArray.msg

PoseStamped.msg

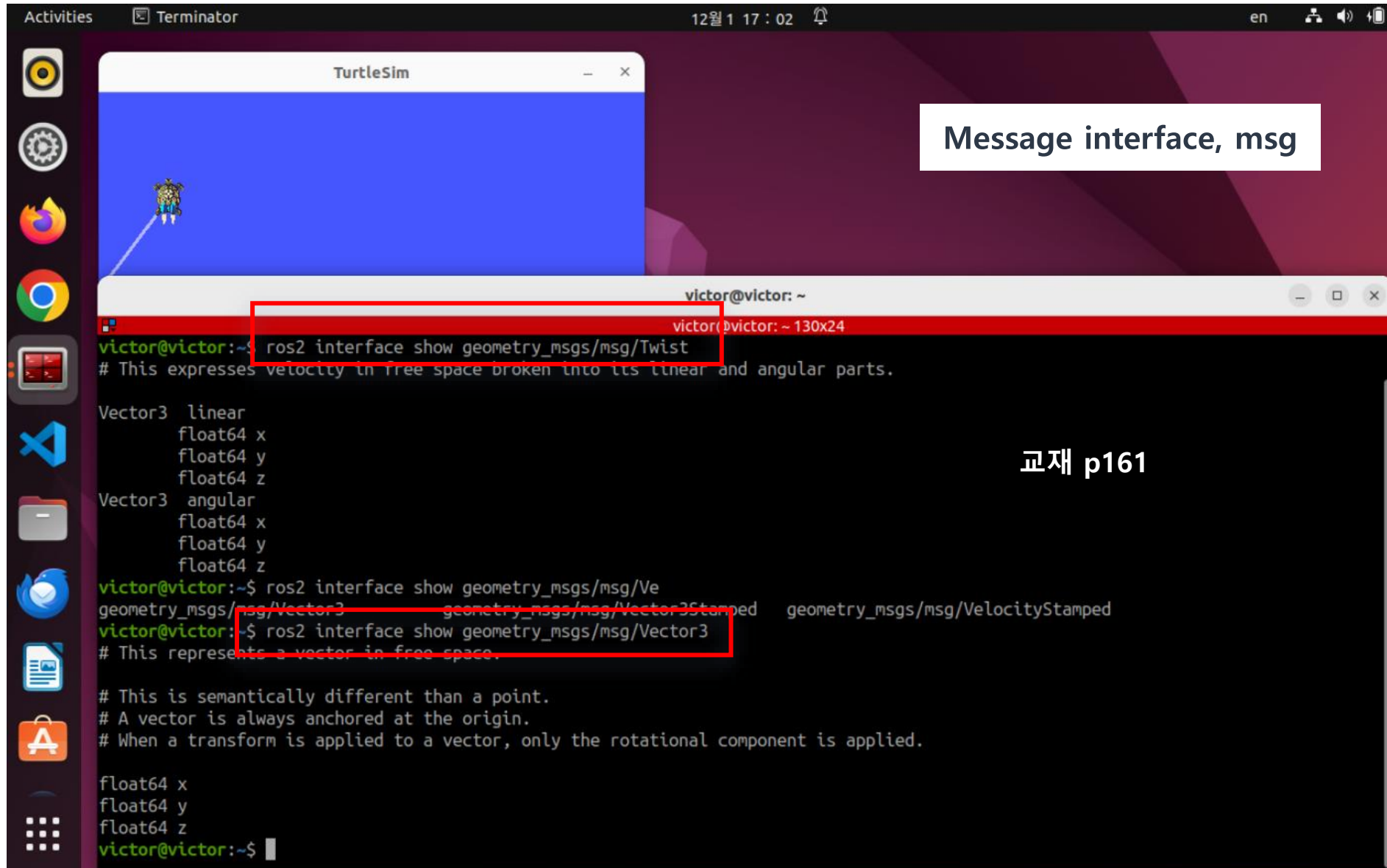
common_interfaces / geometry_msgs / msg / Twist.msg

dirk-thomas rename message packages

Code Blame 4 lines (3 loc) · 116 Bytes

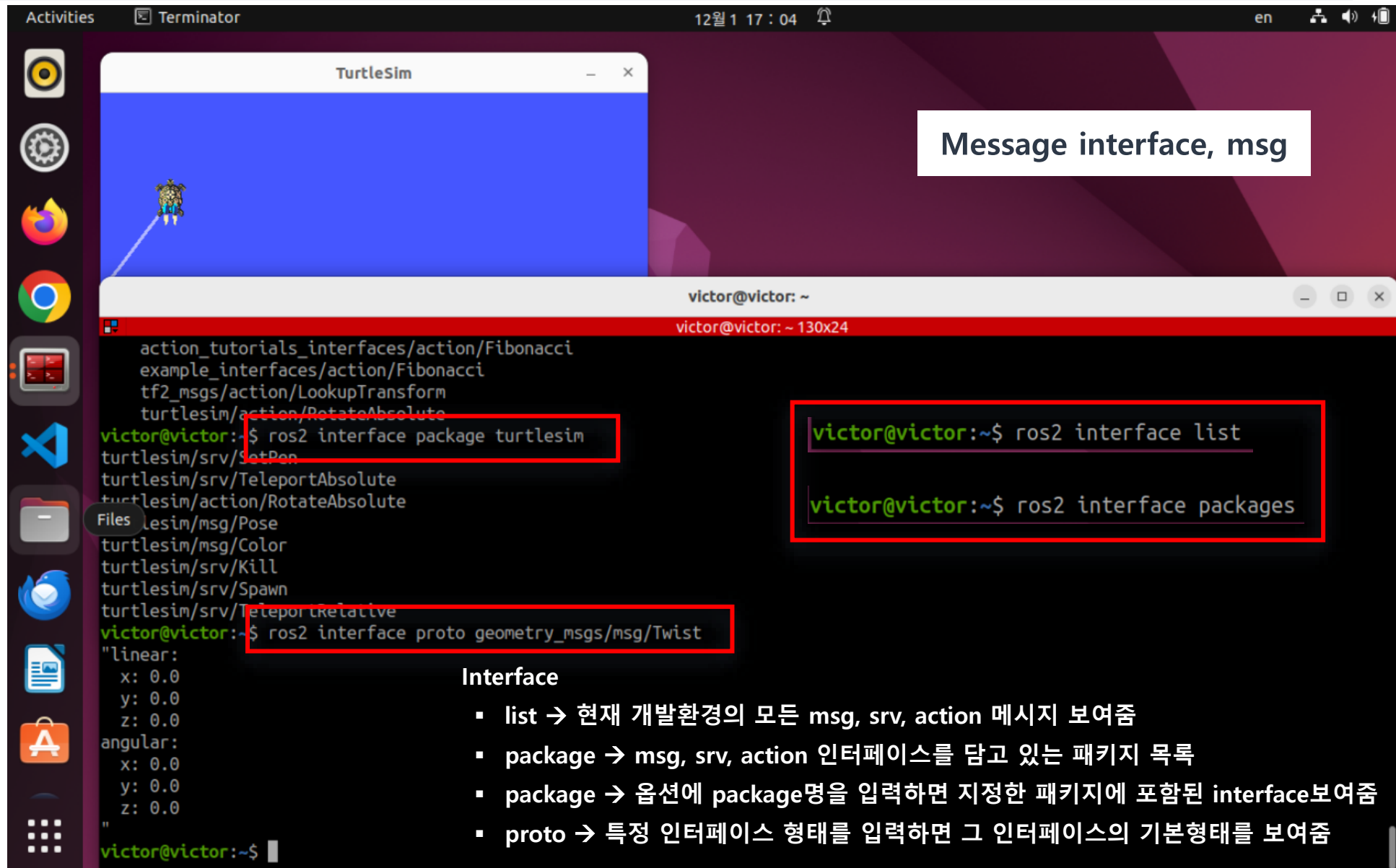
```
1 # This expresses velocity in free space broken into
2
3 Vector3 linear
4 Vector3 angular
```

ROS2 실습 - Interface



교재 p161

ROS2 실습 - Interface



The screenshot shows a Ubuntu desktop environment with a terminal window open. The terminal displays the output of the `ros2 interface package turtlesim` command, listing various interfaces for the `turtlesim` package. A text box labeled "Message interface, msg" points to the `turtlesim/msg/Pose` entry. Two red boxes highlight specific commands: `ros2 interface package turtlesim` and `ros2 interface proto geometry_msgs/msg/Twist`. A separate box on the right shows the commands `ros2 interface list` and `ros2 interface packages`.

Message interface, msg

```
action_tutorials_interfaces/action/Fibonacci
example_interfaces/action/Fibonacci
tf2_msgs/action/LookupTransform
turtlesim/action/RotateAbsolute
victor@victor:~$ ros2 interface package turtlesim
turtlesim/srv/SetPen
turtlesim/srv/TeleportAbsolute
turtlesim/action/RotateAbsolute
turtlesim/msg/Pose
turtlesim/msg/Color
turtlesim/srv/Kill
turtlesim/srv/Spawn
turtlesim/srv/TeleportRelative
victor@victor:~$ ros2 interface proto geometry_msgs/msg/Twist
"linear:
  x: 0.0
  y: 0.0
  z: 0.0
angular:
  x: 0.0
  y: 0.0
  z: 0.0
"
```

Interface

- list → 현재 개발환경의 모든 msg, srv, action 메시지 보여줌
- package → msg, srv, action 인터페이스를 담고 있는 패키지 목록
- package → 옵션에 package명을 입력하면 지정한 패키지에 포함된 interface보여줌
- proto → 특정 인터페이스 형태를 입력하면 그 인터페이스의 기본형태를 보여줌

ROS2 실습 - Interface

Service interface, srv

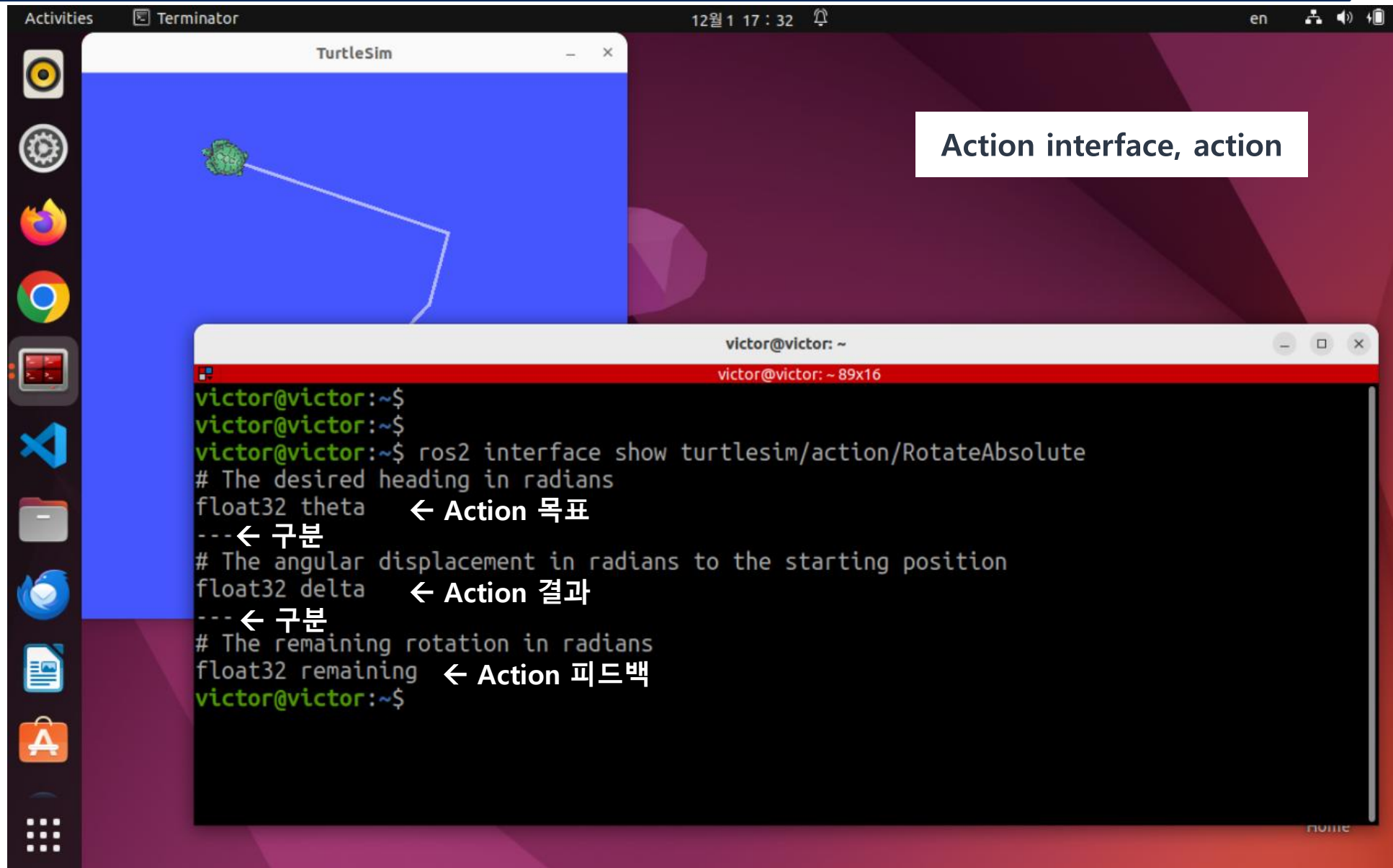
```
victor@victor: ~  
victor@victor: ~ 89x16  
z: 0.0  
angular:  
x: 0.0  
y: 0.0  
z: 0.0  
"  
victor@victor:~$ ros2 interface show turtlesim/srv/S  
turtlesim/srv/SetPen turtlesim/srv/Spawn  
victor@victor:~$ ros2 interface show turtlesim/srv/Spawn  
float32 x  
float32 y  
float32 theta  
string name # Optional. A unique name will be created and returned if this is empty  
---  
string name  
victor@victor:~$
```

← 요청(Request)

← 구분

← 응답(Response)

ROS2 실습 - Interface



ROS2 실습 - Interface

```
$ ros2 node info /turtlesim
```

```
/turtlesim
```

```
(생략)
```

```
Action Servers:
```

```
  /turtle1/rotate_absolute: turtlesim/action/RotateAbsolute
```

```
Action Clients:
```

Node 정보 확인

```
$ ros2 node info /teleop_turtle
```

```
/teleop_turtle
```

```
(생략)
```

```
Action Servers:
```

```
Action Clients:
```

```
  /turtle1/rotate_absolute: turtlesim/action/RotateAbsolute
```

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

```
Action: /turtle1/rotate_absolute
```

```
Action clients: 1
```

```
  /teleop_turtle
```

```
Action servers: 1
```

```
  /turtlesim
```

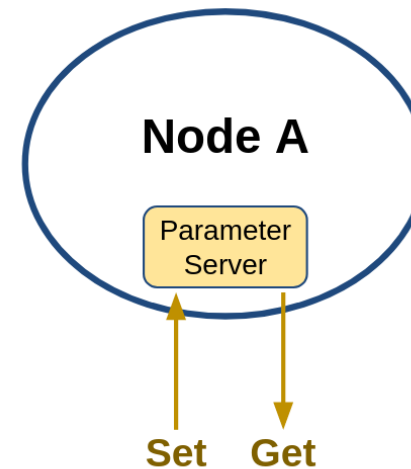
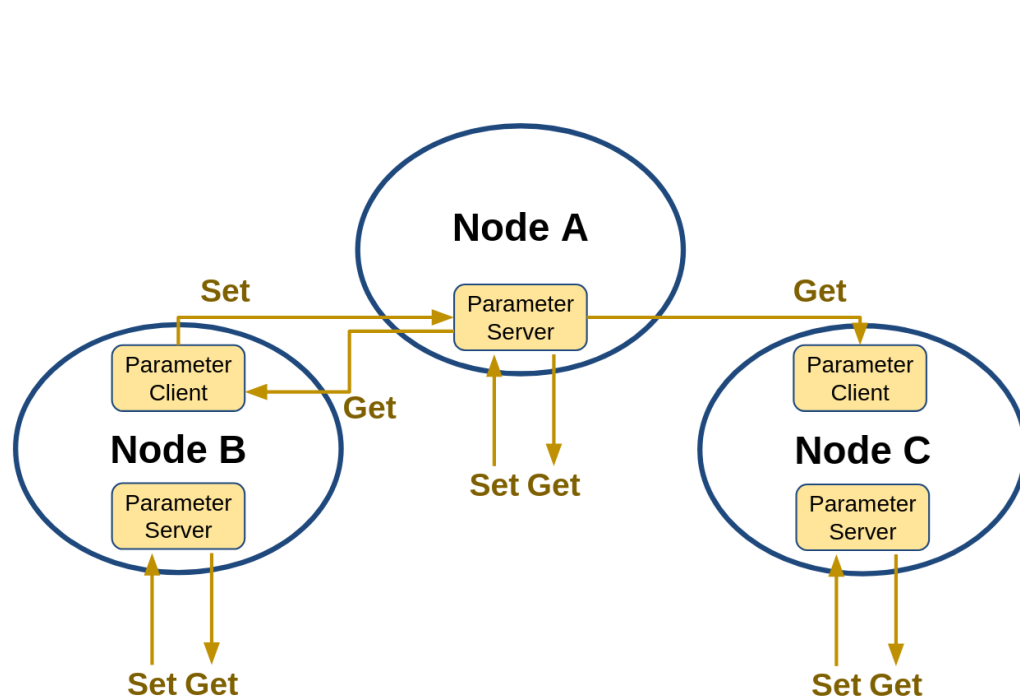
```
$ ros2 action list -t
```

```
/turtle1/rotate_absolute [turtlesim/action/RotateAbsolute]
```

Action list

ROS2 실습 - Parameter

파라미터 관련 기능은 RCL(ROS Client Libraries)의 기본 기능으로 다음 그림과 같이 모든 노드가 자신만의 **Parameter server**를 가지고 있고, 그림과 같이 각 노드는 **Parameter client**도 포함시킬 수 있어서 자기 자신의 파라미터 및 다른 노드의 파라미터를 읽고 쓸수 있게 된다. 이를 활용하면 각 노드의 다양한 매개변수를 글로벌 매개변수처럼 사용할 수 있게 되어 추가 프로그래밍이나 컴파일 없이 능동적으로 변화 가능한 프로세스를 만들 수 있게 된다. 그리고 각 파라미터는 yaml 파일 형태의 파라미터 설정 파일을 만들어 초기 파라미터 값 설정 및 노드 실행시에 파라미터 설정 파일을 불러와서 사용할 수 있기에 ROS 2 프로그래밍에 매우 유용하게 사용할 수 있다.



```
name: John Doe
age: 30
address:
  street: 123 Main St
  city: Springfield
  zip: 12345
languages:
  - English
  - Spanish
  - French
```

YAML(YAML Ain't Markup Language 또는 Yet Another Markup Language)은 사람이 읽기 쉬운 데이터 직렬화 형식입니다. 주로 구성 파일, 데이터 전송, 설정 파일 등을 저장하는 데 사용됩니다. YAML은 JSON과 유사하지만, 더 간결하고 가독성이 뛰어난 문법을 제공합니다

ROS2 실습 – Parameter get & set

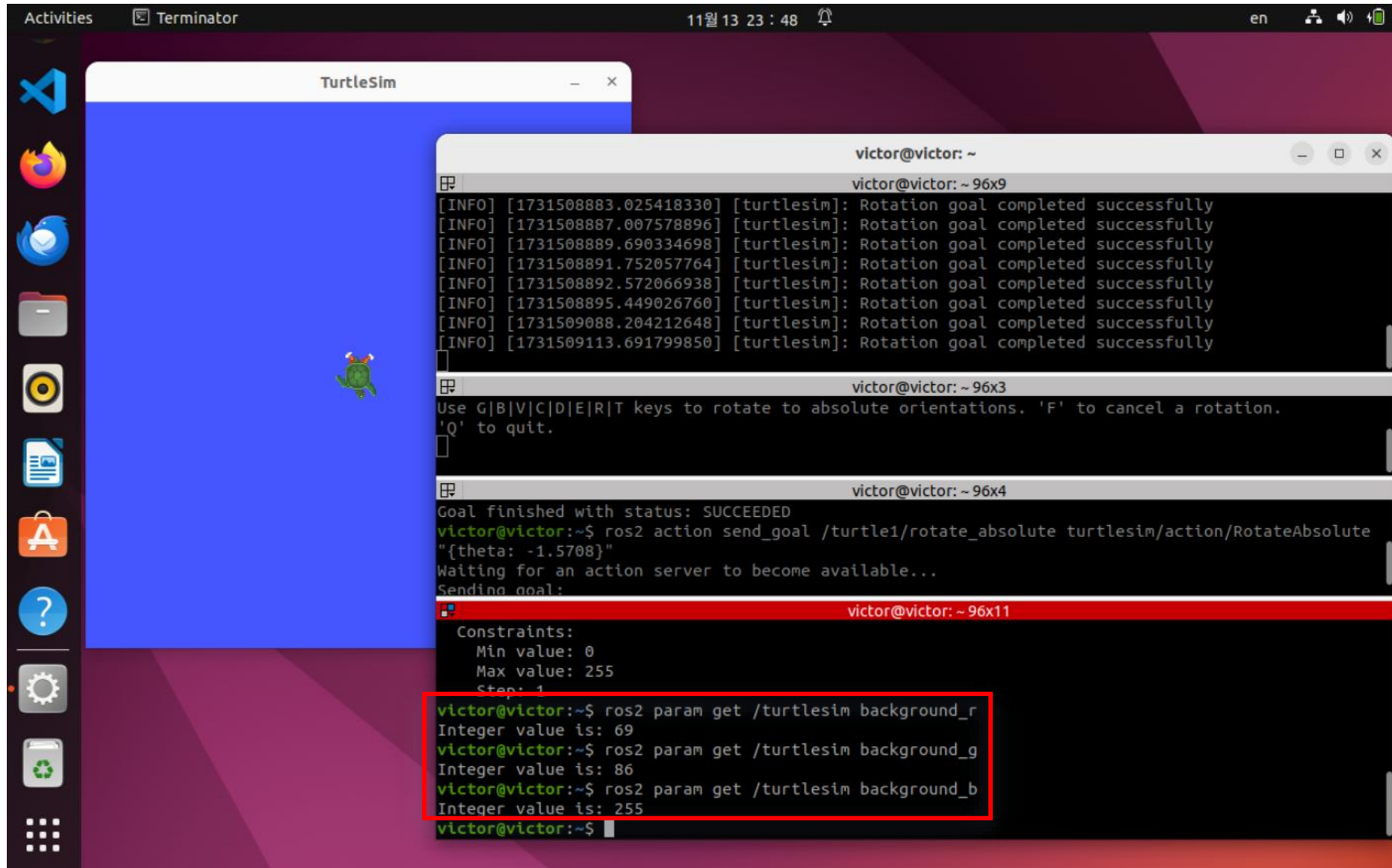
```
$ ros2 run turtlesim turtlesim_node
```

```
$ ros2 run turtlesim turtle_teleop_key
```

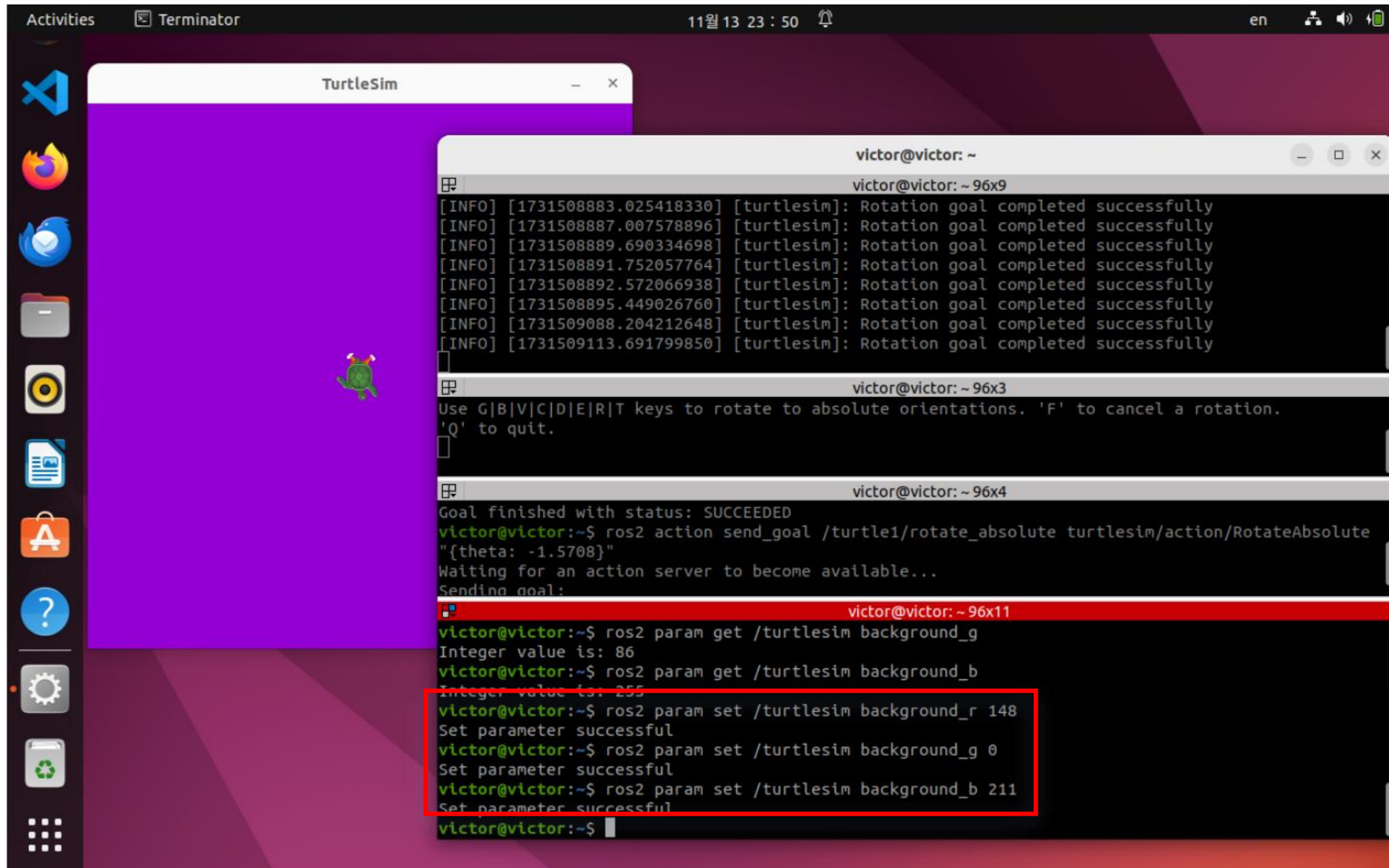
```
$ ros2 param list  
/teleop_turtle:  
  scale_angular  
  scale_linear  
  use_sim_time  
/turtlesim:  
  background_b  
  background_g  
  background_r  
  use_sim_time
```

```
$ ros2 param describe /turtlesim background_b  
Parameter name: background_b  
Type: integer  
Description: Blue channel of the background color  
Constraints:  
  Min value: 0  
  Max value: 255  
  Step: 1
```

ROS2 실습 – Parameter get & set



ROS2 실습 – Parameter get & set



ROS2 실습 – Parameter get & set

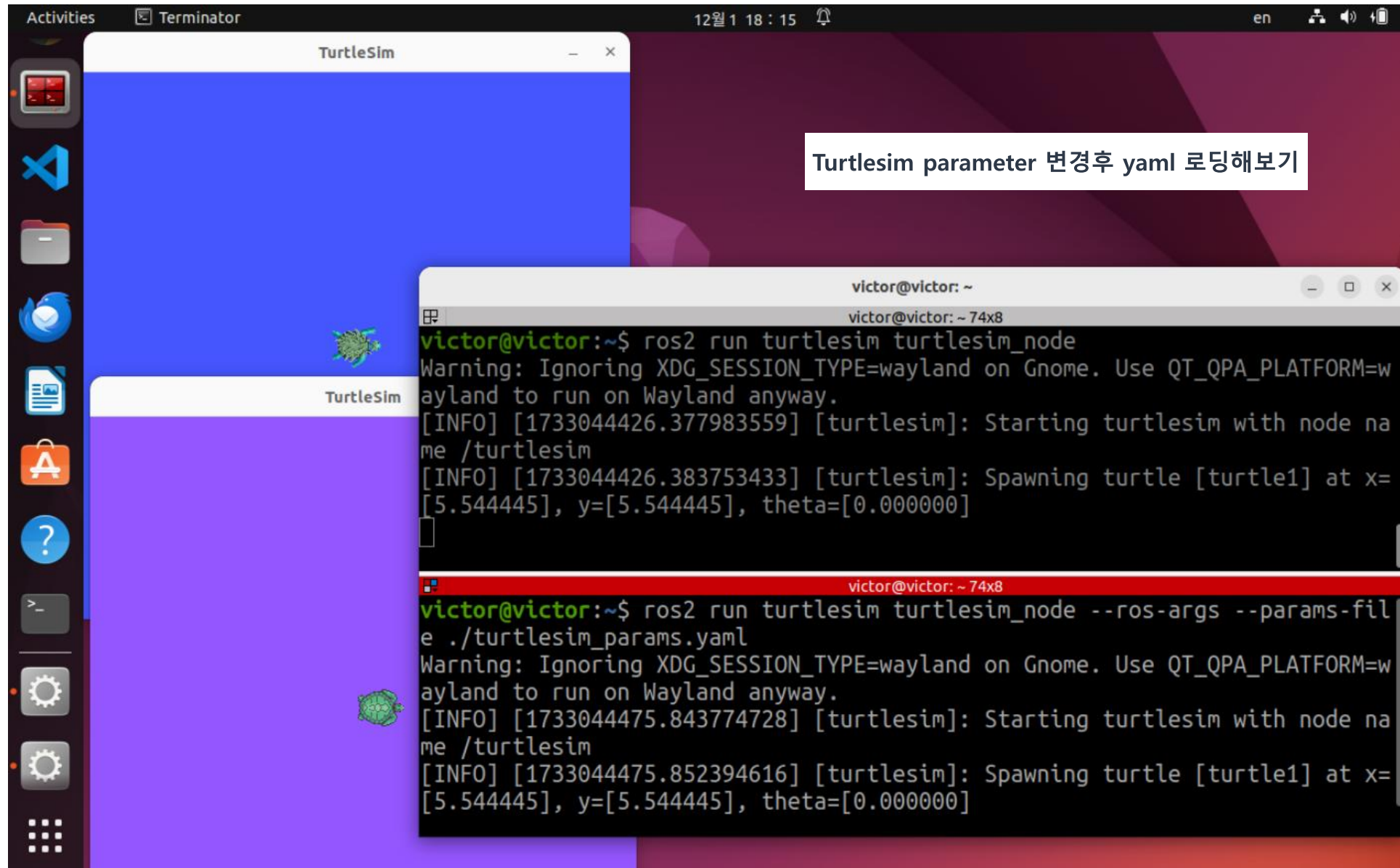
```
victor@victor: ~  
victor@victor: ~ 89x16  
victor@victor:~$ ros2 param dump /turtlesim  
/turtlesim:  
  ros__parameters:  
    background_b: 255  
    background_g: 86  
    background_r: 69  
    qos_overrides:  
      /parameter_events:  
        publisher:  
          depth: 1000  
          durability: volatile  
          history: keep_last  
          reliability: reliable  
    use_sim_time: false  
victor@victor:~$
```

```
victor@victor:~$ ros2 param dump /turtlesim > turtlesim_params.yaml
```

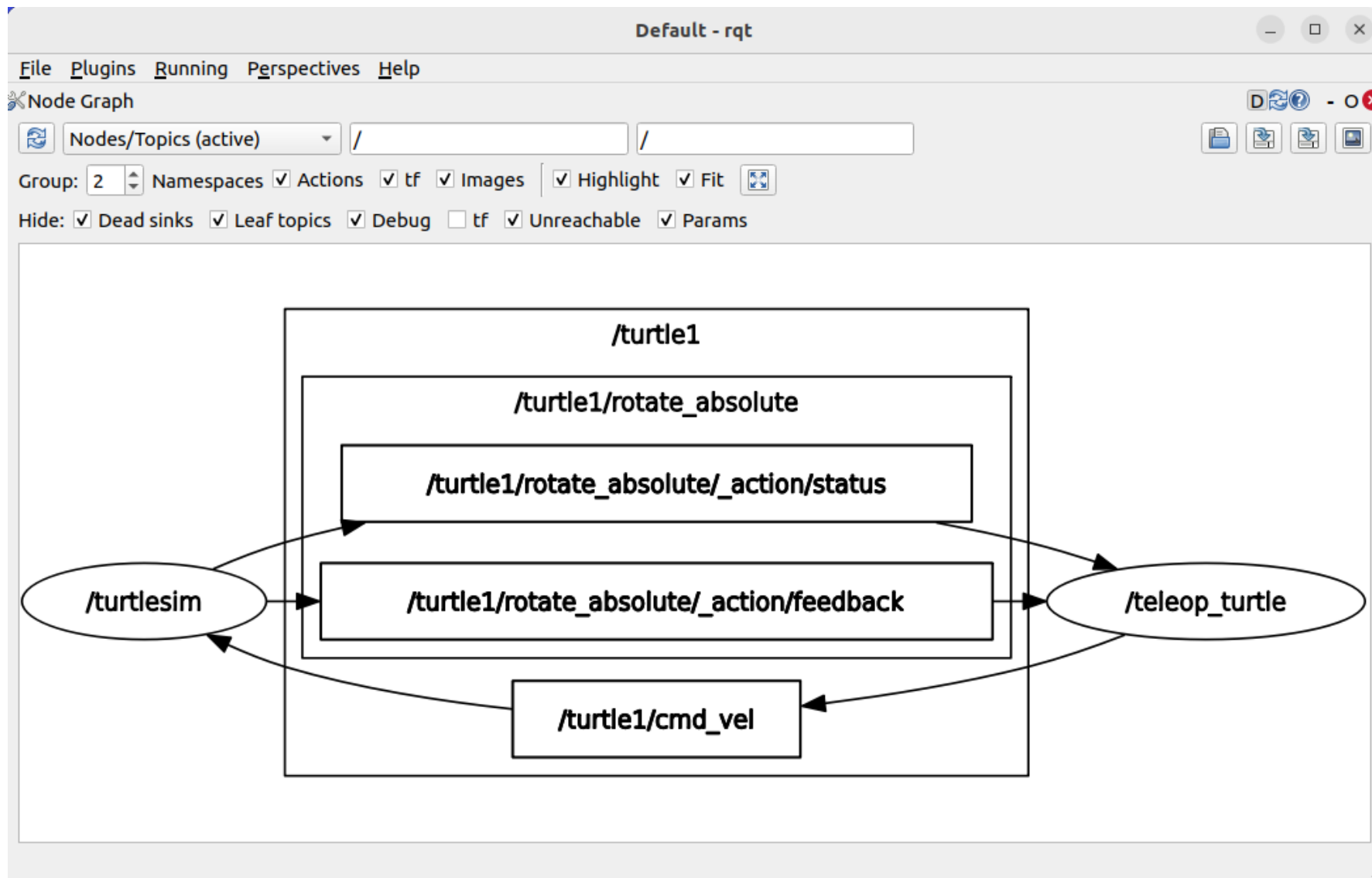
```
victor@victor: ~  
victor@victor: ~ 89x21  
drwxr-xr-x  2 victor victor    4096 6월 2 17:27 Templates/  
-rw-rw-r--  1 victor victor    297 12월 1 18:08 turtlesim_params.yaml  
-rw-rw-r--  1 victor victor   1990 6월 2 21:26 Untitled.ipynb  
drwxr-xr-x  2 victor victor    4096 6월 2 17:27 Videos/  
drwxrwxr-x  4 victor victor    4096 6월 2 21:36 .vscode/  
victor@victor:~$ cat turtlesim_params.yaml  
/turtlesim:  
  ros__parameters:  
    background_b: 255  
    background_g: 86  
    background_r: 69  
    qos_overrides:  
      /parameter_events:  
        publisher:  
          depth: 1000  
          durability: volatile  
          history: keep_last  
          reliability: reliable  
    use_sim_time: false  
victor@victor:~$
```

Turtlesim parameter 변경후 yaml 로딩해보기

ROS2 실습 – Parameter get & set



ROS2 실습 – RQt(Node Graph)



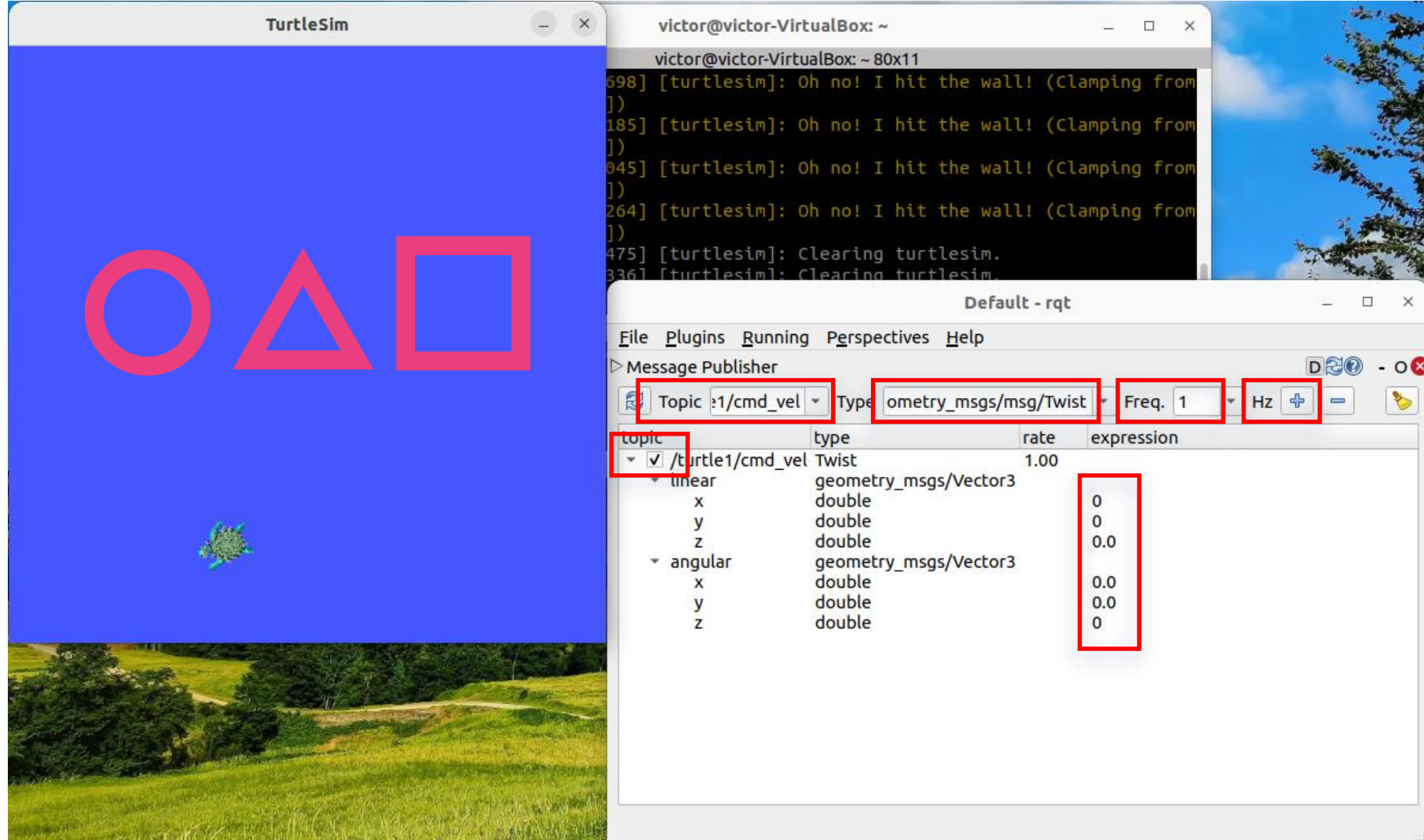
ROS2 실습 – RQt(Topic Monitor)

The screenshot shows a ROS2 TurtleSim environment with a turtle on a blue field. A terminal window in the background shows the command `ros2 run turtlesim turtlesim_node` and its output. In the foreground, the RQt Topic Monitor window is open, displaying a list of topics. The `/turtle1/pose` and `/turtle1/cmd_vel` topics are selected and checked. The `/turtle1/pose` topic is expanded, showing its fields: `x`, `y`, `theta`, `linear_velocity`, and `angular_velocity`. The `/turtle1/cmd_vel` topic is also expanded, showing its fields: `linear` and `angular`.

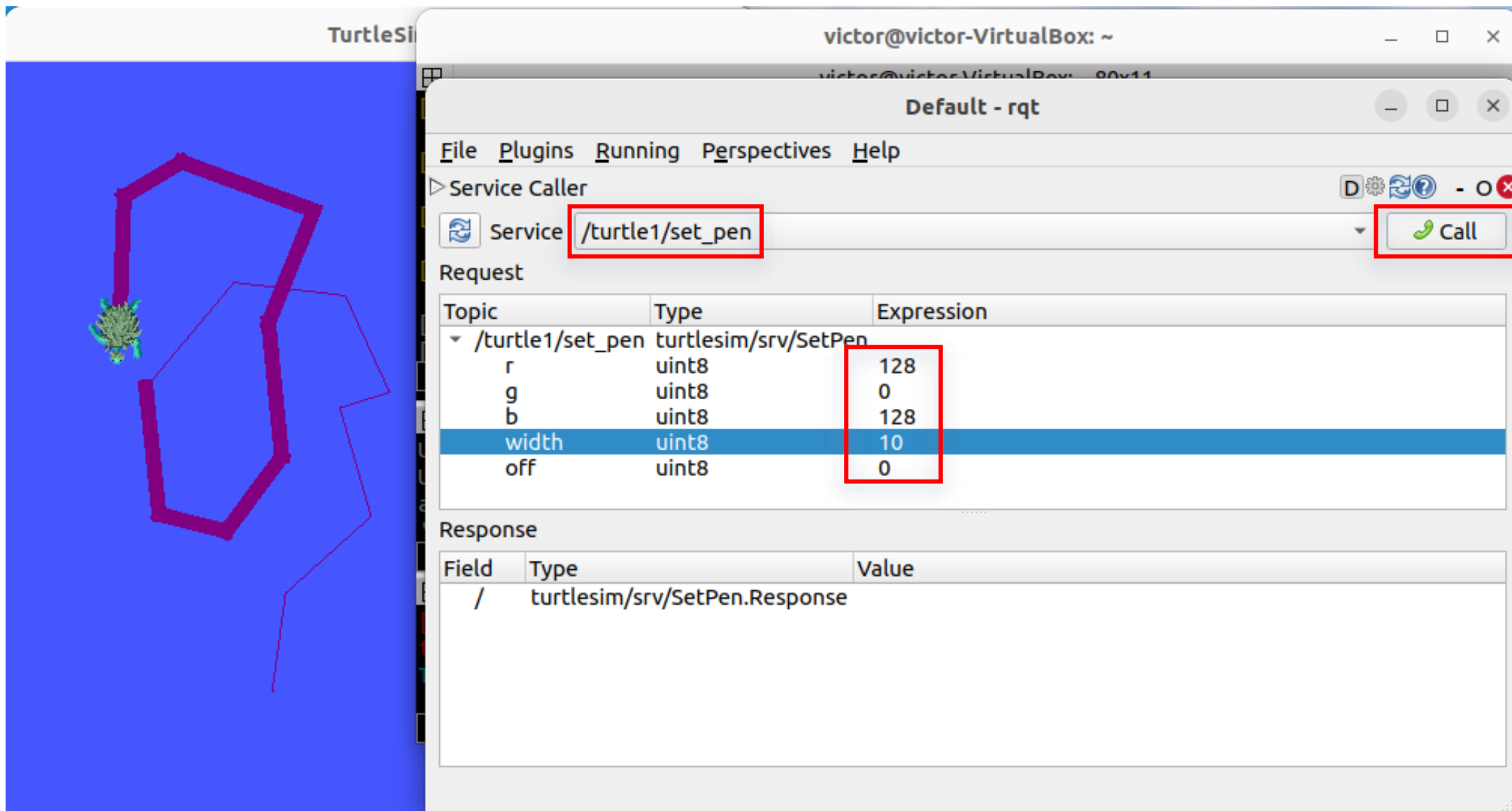
Topic	Type	Bandwidth	Value
☒ /turtle1/pose	turtlesim/msg/Pose	unknown	
x	float		7.174396991729736
y	float		8.647515296936035
theta	float		1.7071852684020996
linear_velocity	float		0.0
angular_velocity	float		0.0
☐ /turtle1/color_sensor	turtlesim/msg/Color		not monitored
☐ /turtle1/rotate_absolute/_action/feedback	turtlesim/action/RotateAbsolute_FeedbackMessage		can not get message class for typ
☐ /parameter_events	rcl_interfaces/msg/ParameterEvent		not monitored
☐ /rosout	rcl_interfaces/msg/Log		not monitored
☒ /turtle1/cmd_vel	geometry_msgs/msg/Twist	unknown	
linear	geometry_msgs/Vector3		
angular	geometry_msgs/Vector3		
☐ /turtle1/rotate_absolute/_action/status	action_msgs/msg/GoalStatusArray		not monitored

1. turtlesim_node 실행
2. teleop_key 실행
3. rqt 실행
4. /turtle1/pose와 /turtle1/cmd_vel 체크
5. 키보드로 움직이면서 value 바뀌는지 확인

ROS2 실습 – RQt(Message Publisher)



ROS2 실습 – RQt(Service Caller)



The screenshot displays the ROS2 RQt interface. On the left, a TurtleSim window shows a turtle on a blue background with a red polygon. On the right, the RQt window is open, showing the 'Service Caller' tab. The service selected is `/turtle1/set_pen`. The 'Request' section shows a table with fields `r`, `g`, `b`, `width`, and `off`, all of type `uint8`. The values for `r`, `g`, and `b` are 128, 0, and 128 respectively. The value for `width` is 10, and for `off` is 0. The 'Response' section shows a table with a single field `/` of type `turtlesim/srv/SetPen.Response`. The 'Call' button is highlighted.

Service Caller

Service: `/turtle1/set_pen`

Call

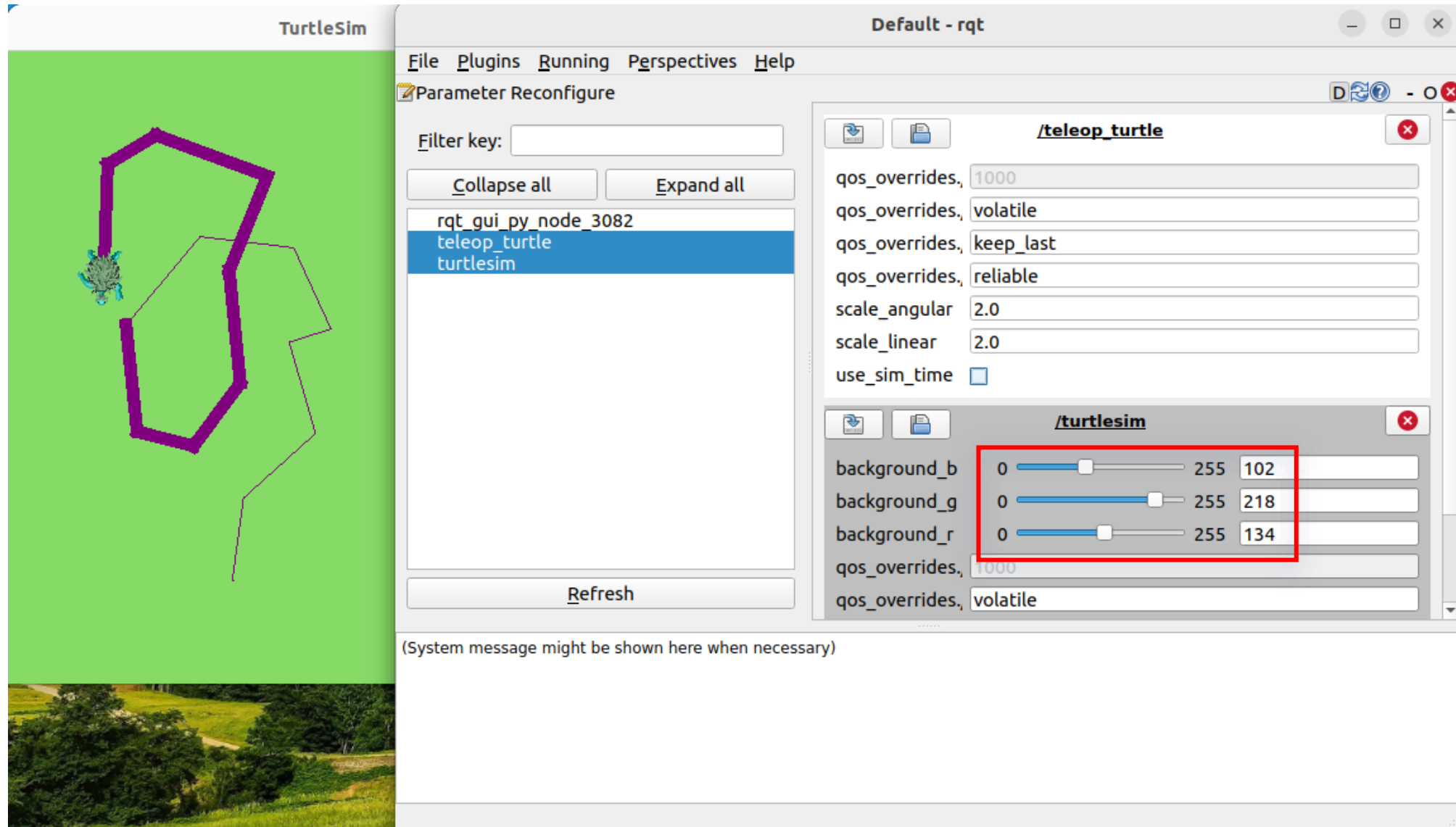
Request

Topic	Type	Expression
<code>/turtle1/set_pen</code>	<code>turtlesim/srv/SetPen</code>	
<code>r</code>	<code>uint8</code>	128
<code>g</code>	<code>uint8</code>	0
<code>b</code>	<code>uint8</code>	128
<code>width</code>	<code>uint8</code>	10
<code>off</code>	<code>uint8</code>	0

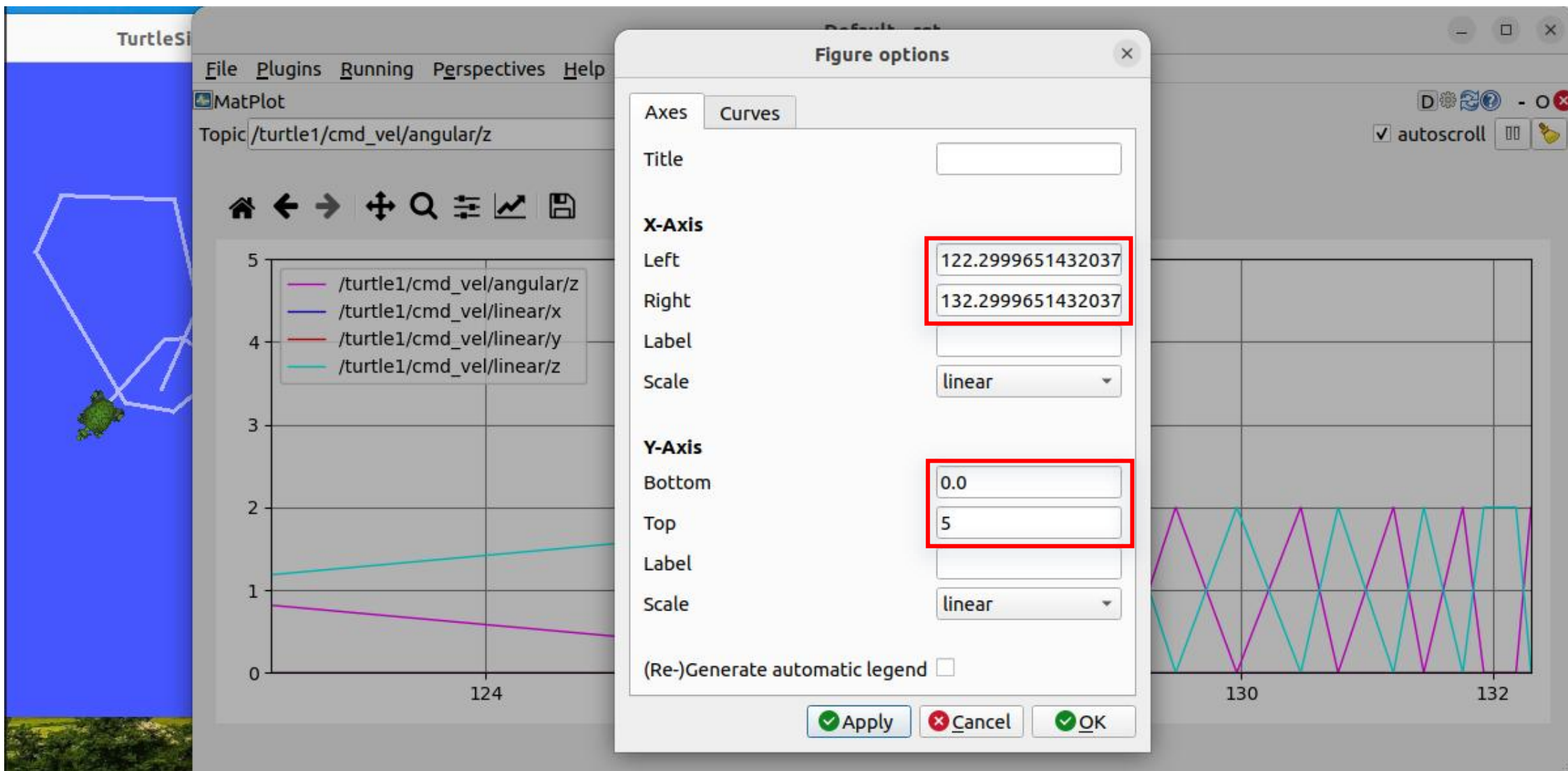
Response

Field	Type	Value
<code>/</code>	<code>turtlesim/srv/SetPen.Response</code>	

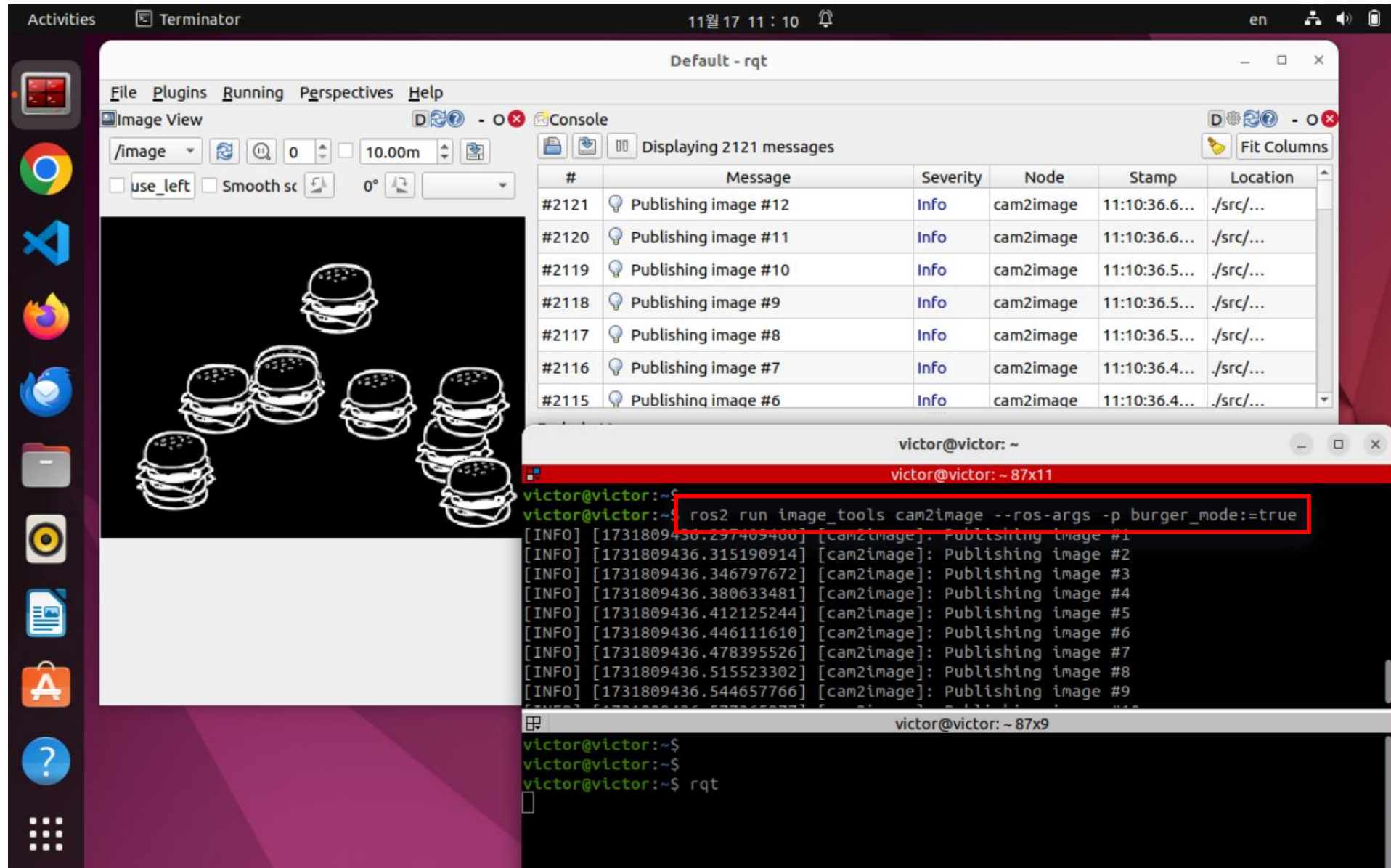
ROS2 실습 – RQt(Parameter Reconfigure)



ROS2 실습 – RQt(Plot)



ROS2 실습 – RQt(image & console)



The screenshot displays the ROS2 RQt interface within a Linux desktop environment. The interface is divided into two main panes: the Image View on the left and the Console on the right.

Image View: The top bar shows the path `/image` and a zoom level of `10.00m`. Below this, there are checkboxes for `use_left` and `Smooth sc`, and a dropdown menu set to `0°`. The main image area shows a black background with several white line-art drawings of burgers.

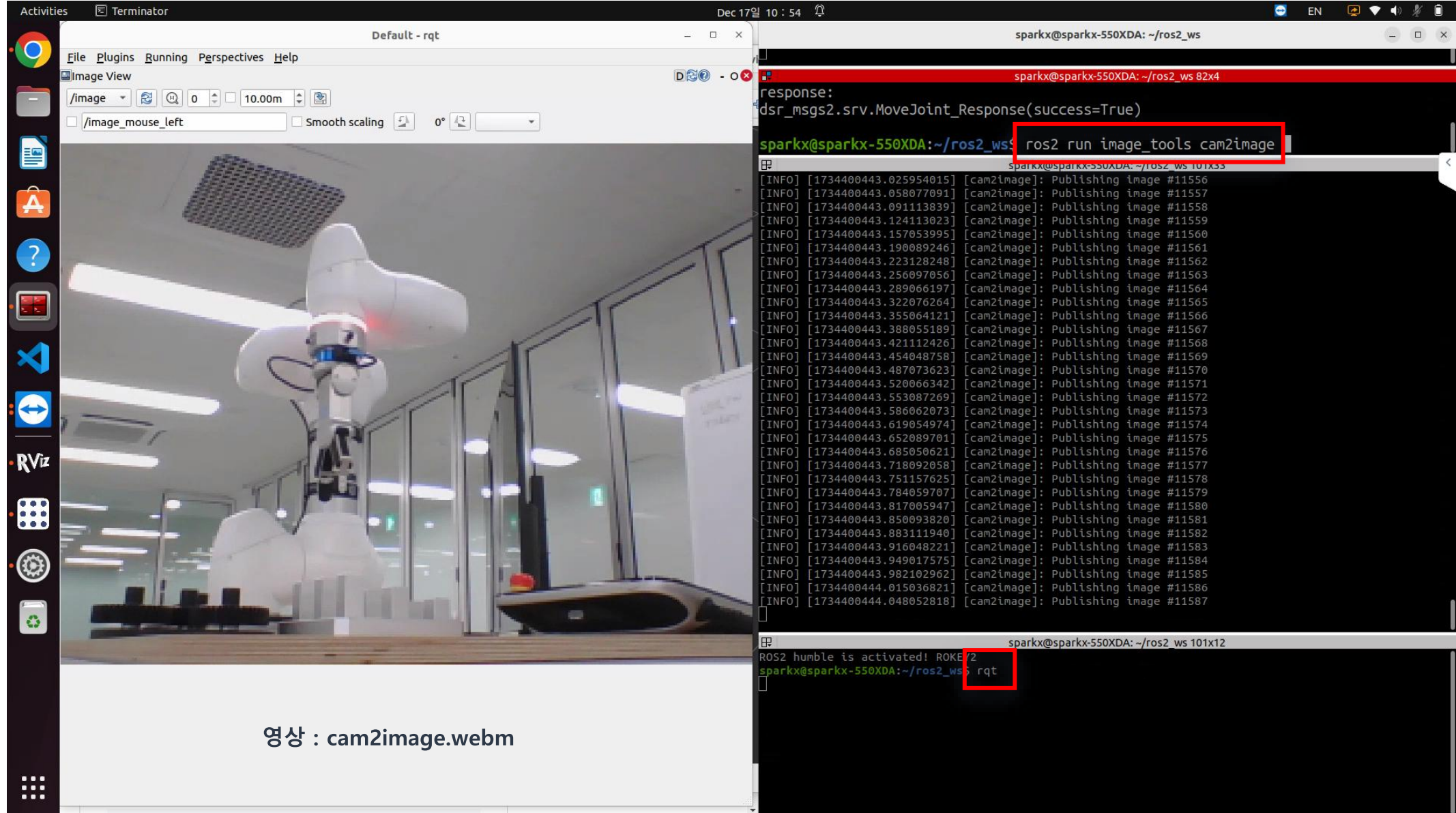
Console: The top bar indicates "Displaying 2121 messages". Below this is a table with columns: #, Message, Severity, Node, Stamp, and Location. The table shows a list of messages from `cam2image` publishing images #6 through #12.

Terminal: A terminal window is open at the bottom, showing the command `ros2 run image_tools cam2image --ros-args -p burger_mode:=true` being executed. The terminal output shows a series of INFO messages from `cam2image` publishing images #1 through #9.

#	Message	Severity	Node	Stamp	Location
#2121	Publishing image #12	Info	cam2image	11:10:36.6...	./src/...
#2120	Publishing image #11	Info	cam2image	11:10:36.6...	./src/...
#2119	Publishing image #10	Info	cam2image	11:10:36.5...	./src/...
#2118	Publishing image #9	Info	cam2image	11:10:36.5...	./src/...
#2117	Publishing image #8	Info	cam2image	11:10:36.5...	./src/...
#2116	Publishing image #7	Info	cam2image	11:10:36.4...	./src/...
#2115	Publishing image #6	Info	cam2image	11:10:36.4...	./src/...

```
victor@victor: ~  
victor@victor: ~ 87x11  
victor@victor: ~$  
victor@victor: ~$ ros2 run image_tools cam2image --ros-args -p burger_mode:=true  
[INFO] [1731809436.297409400] [cam2image]: Publishing image #1  
[INFO] [1731809436.315190914] [cam2image]: Publishing image #2  
[INFO] [1731809436.346797672] [cam2image]: Publishing image #3  
[INFO] [1731809436.380633481] [cam2image]: Publishing image #4  
[INFO] [1731809436.412125244] [cam2image]: Publishing image #5  
[INFO] [1731809436.446111610] [cam2image]: Publishing image #6  
[INFO] [1731809436.478395526] [cam2image]: Publishing image #7  
[INFO] [1731809436.515523302] [cam2image]: Publishing image #8  
[INFO] [1731809436.544657766] [cam2image]: Publishing image #9  
victor@victor: ~ 87x9  
victor@victor: ~$  
victor@victor: ~$  
victor@victor: ~$ rqt
```

ROS2 실습 – RQt(Image)



The screenshot displays the ROS2 RQt interface. On the left, the 'Image View' window shows a live video feed of a robotic arm in a laboratory setting. The interface includes a toolbar with icons for zooming, panning, and other image manipulation functions. Below the video feed, the text '영상 : cam2image.webm' is visible.

On the right, a terminal window shows the command `ros2 run image_tools cam2image` being executed. The terminal output displays a series of log messages indicating that the `cam2image` node is publishing images. The messages are formatted as `[INFO] [timestamp] [cam2image]: Publishing image #11556` through `#11587`.

Below the terminal window, another terminal window shows the command `ros2 run rqt rqt` being executed, which starts the RQt interface.

ROS2 실습 – RQt(Console)

Default - rqt

File Plugins Running Perspectives Help

Console (2)

Displaying 1586 messages

Fit Columns

#	Message	Severity	Node	Stamp	Location
#70	Publishing image #110	Info	cam2image	22:01:57.470479413 (2025-04-01)	./src/cam2image.cpp:timerCallb
#69	Publishing image #109	Info	cam2image	22:01:57.438032490 (2025-04-01)	./src/cam2image.cpp:timerCallb
#68	Spawning turtle [turtle1] at x=[5.544445], y=[5.544445], theta=[0.000000]	Info	turtlesim	22:01:57.413282566 (2025-04-01)	./src/turtle_frame.cpp:spawnTu
#67	Publishing image #108	Info	cam2image	22:01:57.383623420 (2025-04-01)	./src/cam2image.cpp:timerCallb
#66	Publishing image #107	Info	cam2image	22:01:57.333842712 (2025-04-01)	./src/cam2image.cpp:timerCallb
#65	Publishing image #106	Info	cam2image	22:01:57.286826829 (2025-04-01)	./src/cam2image.cpp:timerCallb
#64	Starting turtlesim with node name /turtlesim	Info	turtlesim	22:01:57.235410846 (2025-04-01)	./src/turtle_frame.cpp:TurtleFra
#63	Publishing image #105	Info	cam2image	22:01:57.213697974 (2025-04-01)	./src/cam2image.cpp:timerCallb
#62	Publishing image #104	Info	cam2image	22:01:57.163159695 (2025-04-01)	./src/cam2image.cpp:timerCallb
#61	Publishing image #103	Info	cam2image	22:01:57.137713564 (2025-04-01)	./src/cam2image.cpp:timerCallb
#60	Publishing image #102	Info	cam2image	22:01:57.092702603 (2025-04-01)	./src/cam2image.cpp:timerCallb
#59	Publishing image #101	Info	cam2image	22:01:57.057371243 (2025-04-01)	./src/cam2image.cpp:timerCallb

Exclude Messages...

☒ ...with severities: Debug Info Warn Error Fatal

Highlight Messages...

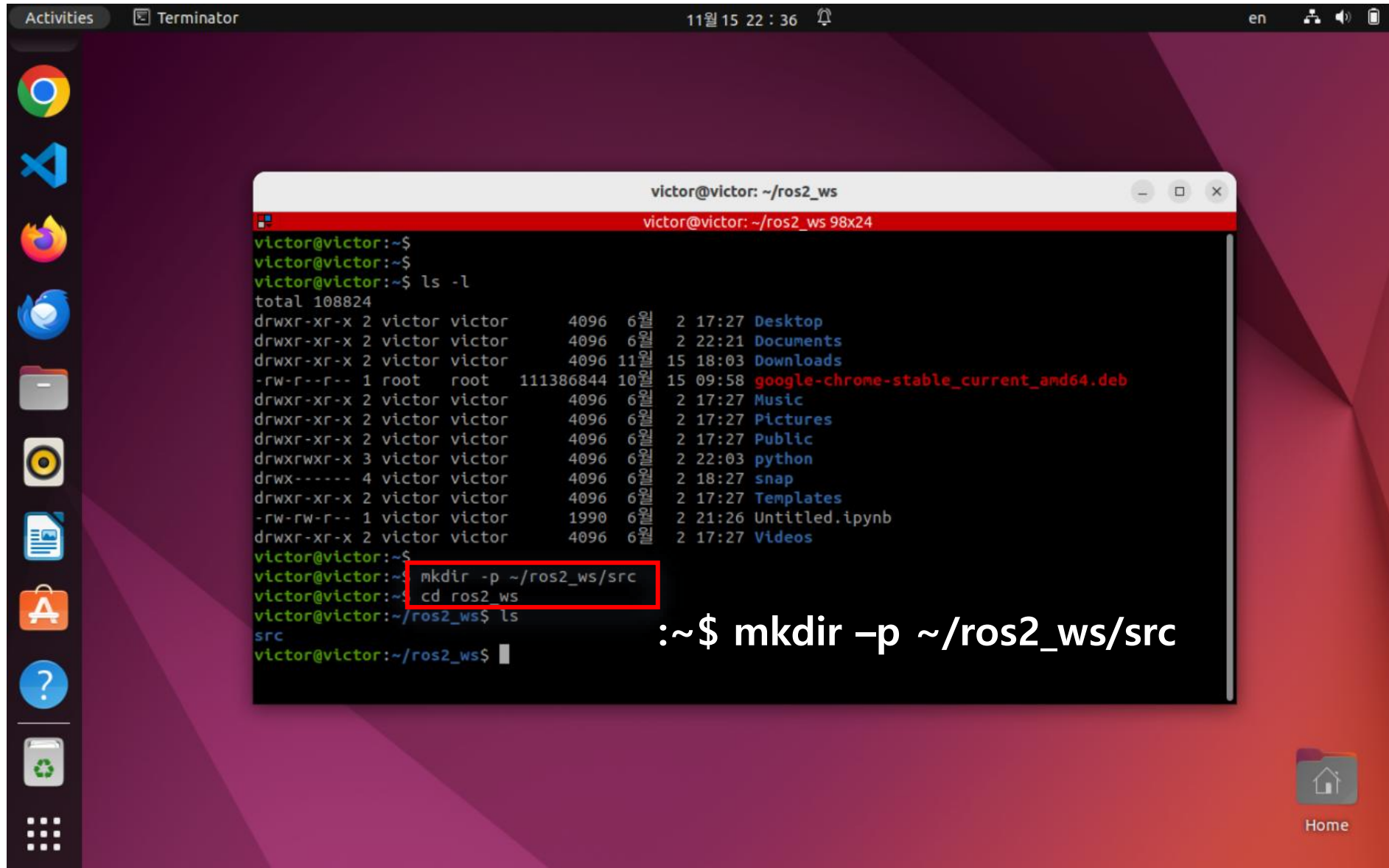
☒ ...containing:

Regex

1. Turtlesim과 teleop_key 실행
2. cam2image 실행
3. rqt → Logging → Console에서 확인



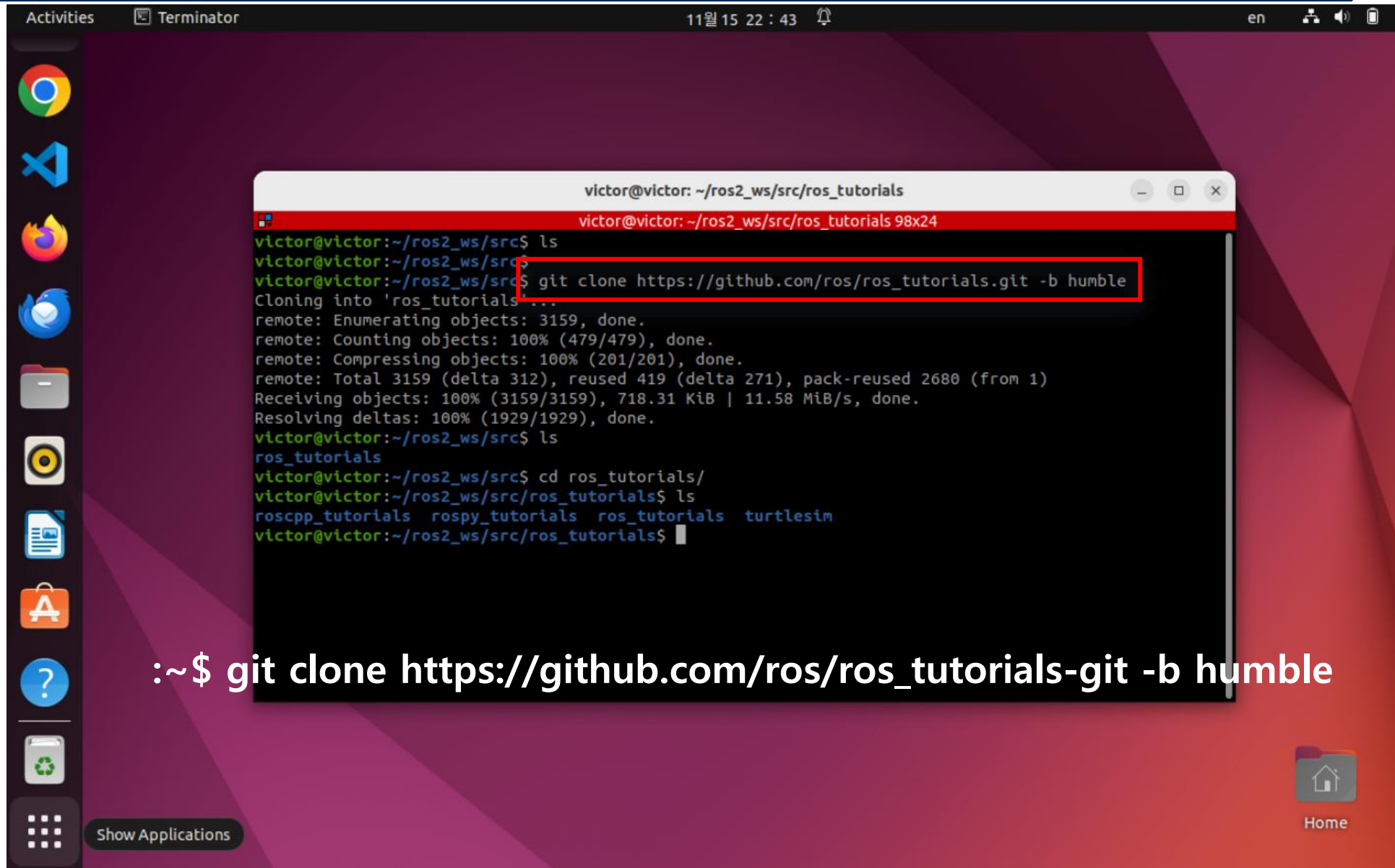
ROS2 실습 - Build



The screenshot shows a Linux desktop with a purple and red geometric background. On the left is a vertical dock with icons for Chrome, VS Code, Firefox, Telegram, Files, LibreOffice, and a question mark. At the top, a 'Terminator' window title bar shows the date '11월 15 22 : 36'. A terminal window titled 'victor@victor: ~/ros2_ws' is open, displaying the following commands and output:

```
victor@victor:~$  
victor@victor:~$  
victor@victor:~$ ls -l  
total 108824  
drwxr-xr-x 2 victor victor 4096 6월 2 17:27 Desktop  
drwxr-xr-x 2 victor victor 4096 6월 2 22:21 Documents  
drwxr-xr-x 2 victor victor 4096 11월 15 18:03 Downloads  
-rw-r--r-- 1 root root 111386844 10월 15 09:58 google-chrome-stable_current_amd64.deb  
drwxr-xr-x 2 victor victor 4096 6월 2 17:27 Music  
drwxr-xr-x 2 victor victor 4096 6월 2 17:27 Pictures  
drwxr-xr-x 2 victor victor 4096 6월 2 17:27 Public  
drwxrwxr-x 3 victor victor 4096 6월 2 22:03 python  
drwx----- 4 victor victor 4096 6월 2 18:27 snap  
drwxr-xr-x 2 victor victor 4096 6월 2 17:27 Templates  
-rw-rw-r-- 1 victor victor 1990 6월 2 21:26 Untitled.ipynb  
drwxr-xr-x 2 victor victor 4096 6월 2 17:27 Videos  
victor@victor:~$  
victor@victor:~$ mkdir -p ~/ros2_ws/src  
victor@victor:~$ cd ros2_ws  
victor@victor:~/ros2_ws$ ls  
src  
victor@victor:~/ros2_ws$
```

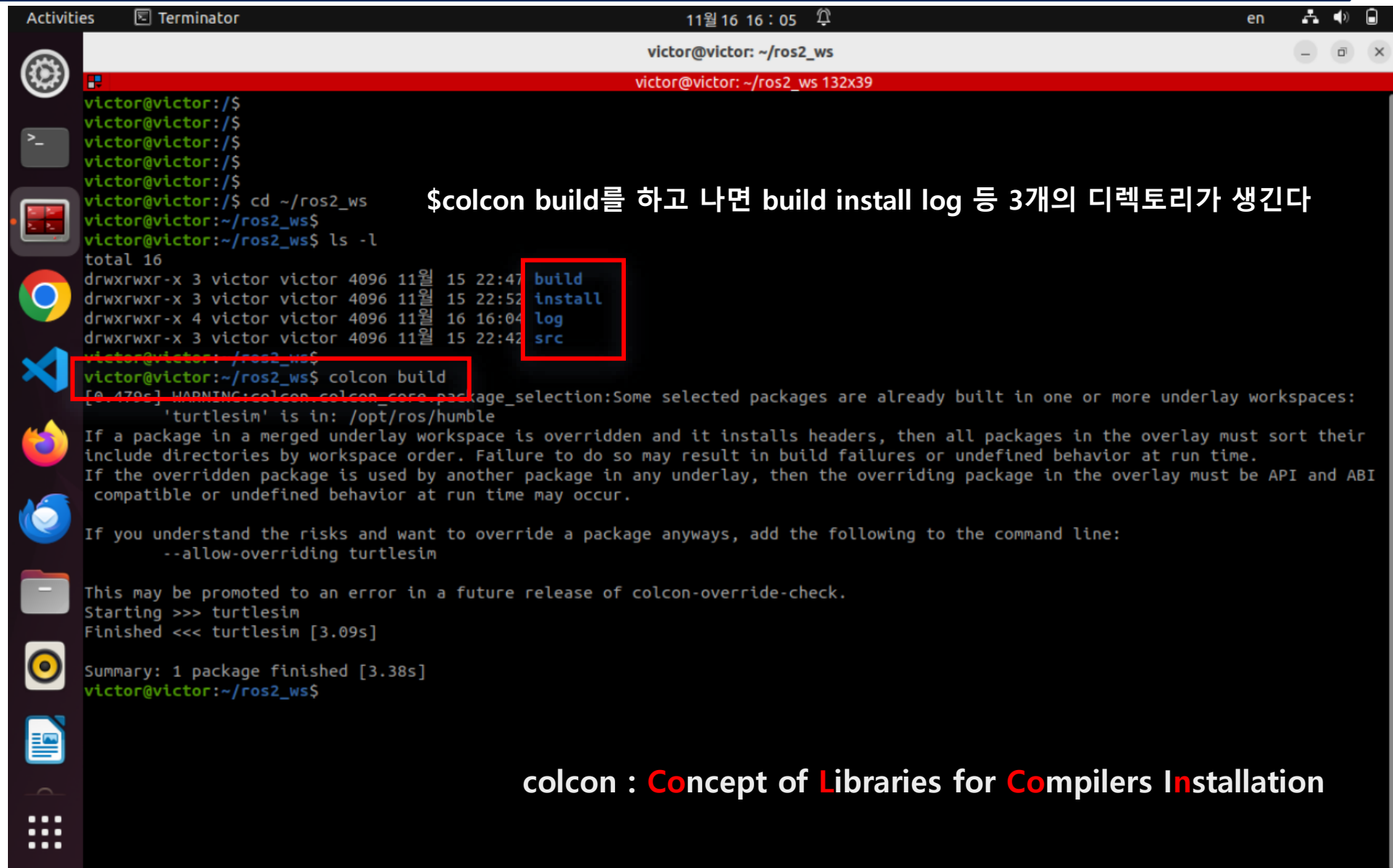
A red box highlights the command `mkdir -p ~/ros2_ws/src` and the subsequent `cd ros2_ws` command. To the right of the terminal, the command `:~$ mkdir -p ~/ros2_ws/src` is displayed in a large white font.



The screenshot shows a Linux desktop with a dark theme. A terminal window titled "victor@victor: ~/ros2_ws/src/ros_tutorials" is open. The terminal output shows the following commands and their results:

```
victor@victor:~/ros2_ws/src$ ls
victor@victor:~/ros2_ws/src$ git clone https://github.com/ros/ros_tutorials.git -b humble
Cloning into 'ros_tutorials'...
remote: Enumerating objects: 3159, done.
remote: Counting objects: 100% (479/479), done.
remote: Compressing objects: 100% (201/201), done.
remote: Total 3159 (delta 312), reused 419 (delta 271), pack-reused 2680 (from 1)
Receiving objects: 100% (3159/3159), 718.31 KiB | 11.58 MiB/s, done.
Resolving deltas: 100% (1929/1929), done.
victor@victor:~/ros2_ws/src$ ls
ros_tutorials
victor@victor:~/ros2_ws/src$ cd ros_tutorials/
victor@victor:~/ros2_ws/src/ros_tutorials$ ls
roscpp_tutorials rospy_tutorials ros_tutorials turtlesim
victor@victor:~/ros2_ws/src/ros_tutorials$
```

A red box highlights the command `git clone https://github.com/ros/ros_tutorials.git -b humble` in the terminal. Below the terminal window, the command `:~$ git clone https://github.com/ros/ros_tutorials-git -b humble` is displayed in large white text.

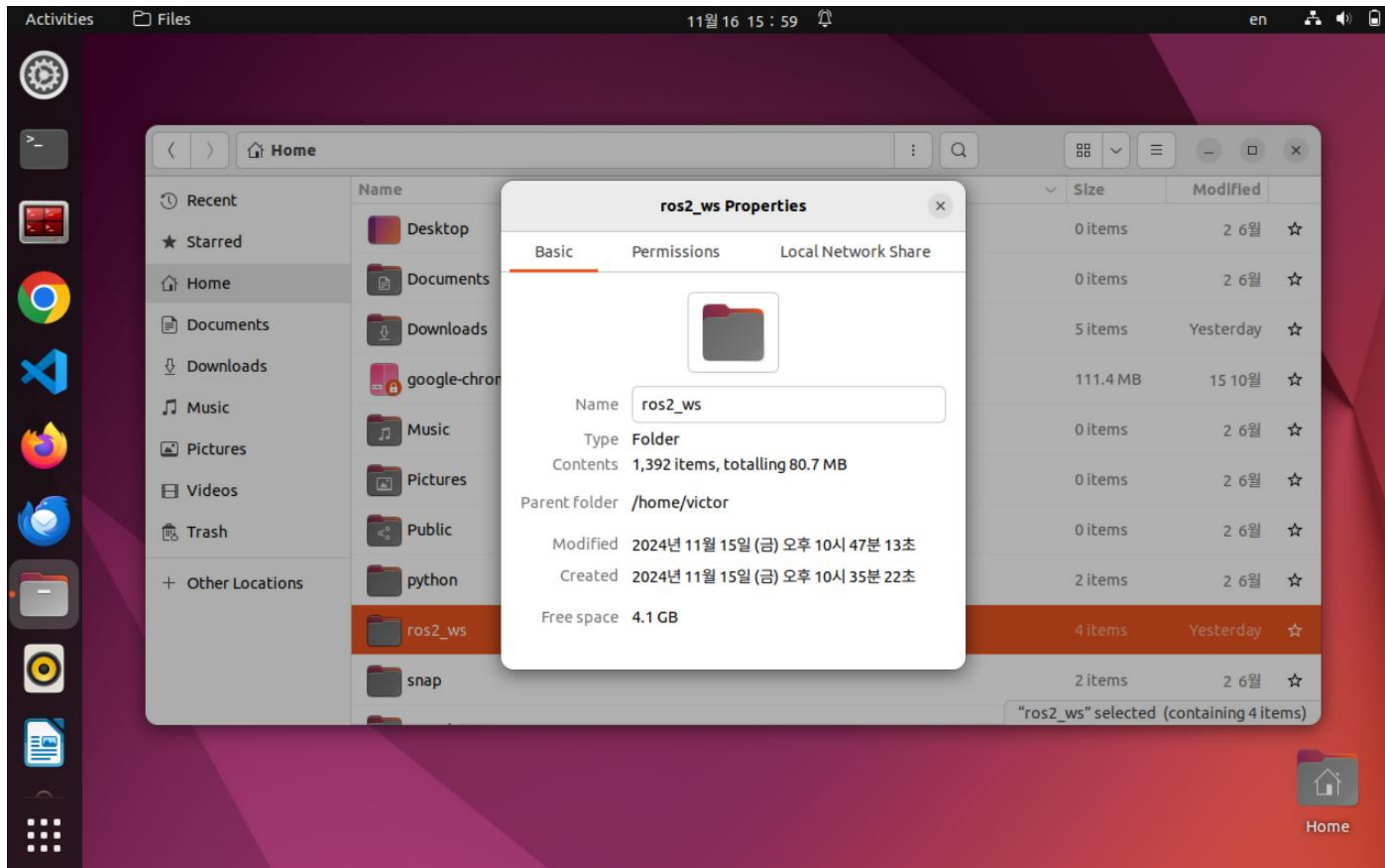


The screenshot shows a terminal window titled "Terminator" with the prompt "victor@victor: ~/ros2_ws". The terminal output shows the user navigating to the workspace and running `colcon build`. The command prompt `victor@victor:~/ros2_ws$ colcon build` is highlighted with a red box. The output shows a warning about package selection and a summary of the build process. A red box highlights the output of the `ls -l` command, showing the creation of `build`, `install`, `log`, and `src` directories. The text "\$colcon build를 하고 나면 build install log 등 3개의 디렉토리가 생긴다" is overlaid on the terminal output.

```
victor@victor:/$
victor@victor:/$
victor@victor:/$
victor@victor:/$
victor@victor:/$
victor@victor:/$ cd ~/ros2_ws
victor@victor:~/ros2_ws$
victor@victor:~/ros2_ws$ ls -l
total 16
drwxrwxr-x 3 victor victor 4096 11월 15 22:47 build
drwxrwxr-x 3 victor victor 4096 11월 15 22:52 install
drwxrwxr-x 4 victor victor 4096 11월 16 16:04 log
drwxrwxr-x 3 victor victor 4096 11월 15 22:42 src
victor@victor:~/ros2_ws$
victor@victor:~/ros2_ws$ colcon build
[0.470s] WARNING:colcon.colcon_core.package_selection:Some selected packages are already built in one or more underlay workspaces:
'turtlesim' is in: /opt/ros/humble
If a package in a merged underlay workspace is overridden and it installs headers, then all packages in the overlay must sort their
include directories by workspace order. Failure to do so may result in build failures or undefined behavior at run time.
If the overridden package is used by another package in any underlay, then the overriding package in the overlay must be API and ABI
compatible or undefined behavior at run time may occur.
If you understand the risks and want to override a package anyways, add the following to the command line:
--allow-overriding turtlesim
This may be promoted to an error in a future release of colcon-override-check.
Starting >>> turtlesim
Finished <<< turtlesim [3.09s]
Summary: 1 package finished [3.38s]
victor@victor:~/ros2_ws$
```

\$colcon build를 하고 나면 build install log 등 3개의 디렉토리가 생긴다

colcon : Concept of Libraries for Compilers Installation



Turtle_teleop_key.py(for test only)

```

import rclpy
from rclpy.node import Node
from geometry_msgs.msg import Twist
import sys
import termios
import tty

# 키보드 입력을 처리하는 클래스
class TurtleTeleopKey(Node):
    def __init__(self):
        super().__init__('turtle_teleop_key')
        self.publisher = self.create_publisher(Twist, '/turtle1/cmd_vel', 10)
        self.msg = Twist()
        self.print_instructions()

    def print_instructions(self):
        print("Control Your Turtle!")
        print("Use arrow keys to move: ")
        print("↑ : Forward, ↓ : Backward, →: Turn Right, ←: Turn Left")
        print("Press 'q' to quit.")

    def get_key(self):
        fd = sys.stdin.fileno()
        old_settings = termios.tcgetattr(fd)
        try:
            tty.setraw(sys.stdin.fileno())
            key = sys.stdin.read(1)
        finally:
            termios.tcsetattr(fd, termios.TCSADRAIN, old_settings)
        return key

```

```

def run(self):
    while True:
        key = self.get_key()
        if key == 'q': # 종료
            break
        elif key == '\x1b[A': # ↑
            self.msg.linear.x = 2.0
            self.msg.angular.z = 0.0
        elif key == '\x1b[B': # ↓
            self.msg.linear.x = -2.0
            self.msg.angular.z = 0.0
        elif key == '\x1b[C': # →
            self.msg.linear.x = 0.0
            self.msg.angular.z = -2.0
        elif key == '\x1b[D': # ←
            self.msg.linear.x = 0.0
            self.msg.angular.z = 2.0
        else:
            self.msg.linear.x = 0.0
            self.msg.angular.z = 0.0

        self.publisher.publish(self.msg)

    print("Exiting...")

def main():
    rclpy.init()
    node = TurtleTeleopKey()
    node.run()
    node.destroy_node()
    rclpy.shutdown()

if __name__ == '__main__':
    main()

```

Activities Text Editor 11월 17 12 : 42 en

teleop_turtle_key.cpp
~/ros2_ws/src/ros_tutorials/turtlesim/tutorials

Save

Turtle_teleop_key.cpp

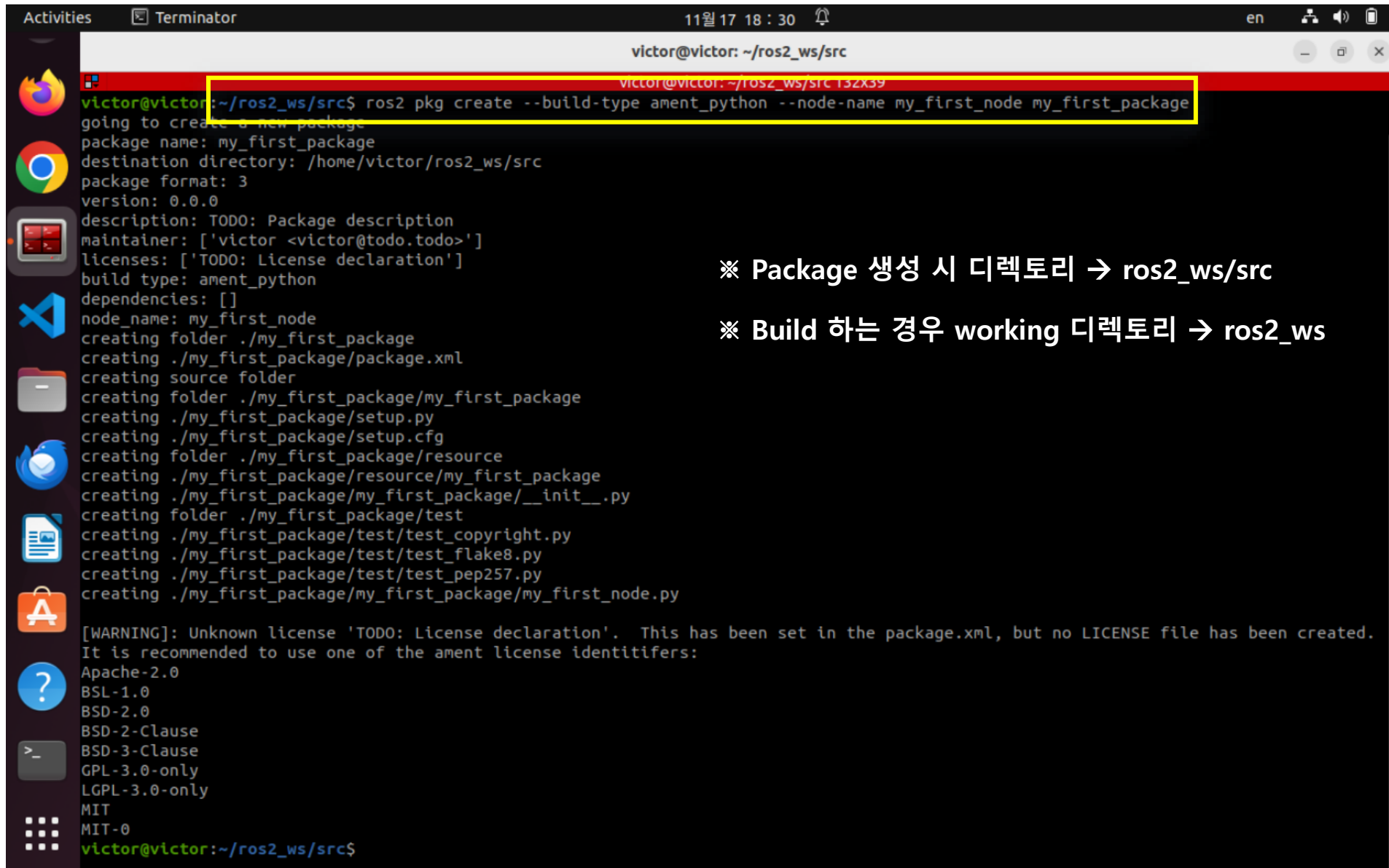
```

199
200 int keyLoop()
201 {
202     char c;
203
204     std::thread{std::bind(&TeleopTurtle::spin, this)}.detach();
205
206     puts("Reading from keyboard");
207     puts("-----");
208     puts("Use arrow keys to move the turtle.");
209     puts("Use G|B|V|C|D|E|R|T keys to rotate to absolute orientations. 'F' to cancel a rotation.");
210     puts("'Q' to quit.");
211
212     while (running)
213     {
214         // get the next event from the keyboard
215         try
216         {
217             c = input_.readOne();
218         }
219         catch (const std::runtime_error &)
220         {
221             perror("read()");
222             return -1;
223         }
224
225         double linear = 0.0;
226         double angular = 0.0;
227
228         RCLCPP_DEBUG(nh_ -> get_logger(), "value: 0x%02X\n", c);
229
230         switch(c)
231         {
232             case KEYCODE_LEFT:
233                 RCLCPP_DEBUG(nh_ -> get_logger(), "LEFT");
234                 angular = 1.0;
235                 break;
236             case KEYCODE_RIGHT:
237                 RCLCPP_DEBUG(nh_ -> get_logger(), "RIGHT");

```

C++ Tab Width: 8 Ln 1, Col 1 INS

ROS2 실습 – package build - my_first_package



```
Activities Terminator 11월 17 18:30 en
victor@victor: ~/ros2_ws/src
victor@victor: ~/ros2_ws/src 132X39
victor@victor:~/ros2_ws/src$ ros2 pkg create --build-type ament_python --node-name my_first_node my_first_package
going to create a new package
package name: my_first_package
destination directory: /home/victor/ros2_ws/src
package format: 3
version: 0.0.0
description: TODO: Package description
maintainer: ['victor <victor@todo.todo>']
licenses: ['TODO: License declaration']
build type: ament_python
dependencies: []
node_name: my_first_node
creating folder ./my_first_package
creating ./my_first_package/package.xml
creating source folder
creating folder ./my_first_package/my_first_package
creating ./my_first_package/setup.py
creating ./my_first_package/setup.cfg
creating folder ./my_first_package/resource
creating ./my_first_package/resource/my_first_package
creating ./my_first_package/my_first_package/__init__.py
creating folder ./my_first_package/test
creating ./my_first_package/test/test_copyright.py
creating ./my_first_package/test/test_flake8.py
creating ./my_first_package/test/test_pep257.py
creating ./my_first_package/my_first_package/my_first_node.py

[WARNING]: Unknown license 'TODO: License declaration'. This has been set in the package.xml, but no LICENSE file has been created.
It is recommended to use one of the ament license identifiers:
Apache-2.0
BSL-1.0
BSD-2.0
BSD-2-Clause
BSD-3-Clause
GPL-3.0-only
LGPL-3.0-only
MIT
MIT-0
victor@victor:~/ros2_ws/src$
```

※ Package 생성 시 디렉토리 → ros2_ws/src

※ Build 하는 경우 working 디렉토리 → ros2_ws

1) 전체 패키지를 빌드할 때

```
$ cd ~/robot_ws && colcon build --symlink-install
```

2) 해당 패키지만 빌드할 때

```
$ cd ~/robot_ws && colcon build --symlink-install --packages-select [패키지 이름]
```

▪ vcstool (버전 컨트롤 시스템 툴)

```
$ wget https://raw.githubusercontent.com/ros2/ros2/humble/ros2.repos  
$ vcs import src < ros2.repos
```

▪ rosdep (의존성 관리 툴)

```
$ sudo rosdep init  
$ rosdep update  
$ rosdep install --from-paths src -y --ignore-src
```

▪ bloom (바이너리 패키지 관리 툴)

```
$ bloom-release --ros-distro humble --track humble awesome_pkg
```

패키지 파일 사용 방법 ROS 2 프로그래밍 전에 알아둬야 할 필수 사전 정보

- 패키지 설정 파일 package.xml(ROS pkg의 필수 구성요소)
- 빌드 설정 파일 CMakeLists.txt(순수 Python pkg는 CMakeLists.txt 파일 없음)
- 파이썬 패키지 설정 파일 setup.py(순수한 ROS2 Python pkg에만 사용하는 배포를 위한 설정 파일)
- 파이썬 패키지 환경 설정 파일 setup.cfg(순수한 ROS2 Python pkg에만 사용하는 배포를 위한 구성 파일)
- RQt 플러그인 설정 파일 plugin.xml(RQT plugin으로 pkg를 작성할때의 필수 구성요소)
- 패키지 변경로그 파일 CHANGELOG.rst(pkg업데이트 내역 기술, 개발 이력 추적)
- 라이선스 파일 LICENSE(pkg코드에 사용된 라이선스 기술)
- 패키지 설명 파일 README.md(markdown 파일)

ROS2 실습 – 패키지 설정파일(package.xml)

패키지 설정 파일은 ROS 패키지의 필수 구성 요소로서 패키지의 정보를 기술하는 파일
기술하는 내용으로는 패키지 이름, 저작자, 라이선스, 의존성 패키지 등이 있으며,
XML 형식으로 기술하고 파일명은 `package.xml`을 사용
사용되는 빌드 툴, 의존성 패키지들이 모두 기술되기에 빌드 및 패키지 설치, 사용에 있어서 매우 중요한 파일
모든 ROS 패키지의 필수 파일로 각 패키지당 무조건 1개의 패키지 설정 파일 (package.xml)을 포함

```
<?xml version="1.0"?>
<?xml-model href="http://download.ros.org/schema/package_format3.xsd"
schematypens="http://www.w3.org/2001/XMLSchema"?>
<package format="3">
  <name>my_first_ros_rclcpp_pkg</name>
  <version>0.0.0</version>
  <description>TODO: Package description</description>
  <maintainer email="pyo@robotis.com">pyo</maintainer>
  <license>TODO: License declaration</license>

  <buildtool_depend>ament_cmake</buildtool_depend>

  <depend>rclcpp</depend>
  <depend>std_msgs</depend>

  <test_depend>ament_lint_auto</test_depend>
  <test_depend>ament_lint_common</test_depend>

  <export>
    <build_type>ament_cmake</build_type>
  </export>
</package>
```

```
<?xml version="1.0"?>
<?xml-model href="http://download.ros.org/schema/package_format3.xsd"
schematypens="http://www.w3.org/2001/XMLSchema"?>
<package format="3">
  <name>my_first_ros_rclpy_pkg</name>
  <version>0.0.0</version>
  <description>TODO: Package description</description>
  <maintainer email="pyo@robotis.com">pyo</maintainer>
  <license>TODO: License declaration</license>

  <depend>rclpy</depend>
  <depend>std_msgs</depend>

  <test_depend>ament_copyright</test_depend>
  <test_depend>ament_flake8</test_depend>
  <test_depend>ament_pep257</test_depend>
  <test_depend>python3-pytest</test_depend>

  <export>
    <build_type>ament_python</build_type>
  </export>
</package>
```

ROS2 실습 – 패키지 설정파일(package.xml)

항목	내용
<?xml>	문서 문법을 정의하는 문구로 아래의 내용은 xml 버전 1.0을 따르고 있다는 것을 알린다.
<package>	이 구문부터 맨 끝의 </package>까지가 ROS 패키지 설정 부분이다. 세부 사항으로 format="3" 이라고 패키지 설정 파일의 버전을 기재한다. ROS 2는 3를 사용하면 된다.
<name>	패키지의 이름이다. 패키지를 생성할 때 입력한 패키지 이름이 사용된다. 다른 옵션도 마찬가지로 이의 사용자가 원할 때 언제든지 변경할 수 있다.
<version>	패키지의 버전이다. 자유롭게 지정할 수 있는데 나중에 패키지를 바이너리 패키지로 공개한다면 버전 관리에 사용되므로 신중할 필요가 있다.
<description>	패키지의 간단한 설명이다. 보통 2~3 문장으로 기술한다.
<maintainer>	패키지 관리자의 이름과 이메일 주소를 기재한다.
<license>	라이선스를 기재한다. Apache 2.0, BSD, MIT, Boost Software License, GPLv2, GPLv3, LGPLv2.1, LGPLv3, Proprietary 등을 기재하면 된다.
<url>	패키지를 설명하는 웹 페이지 또는 버그 관리, 소스 코드 저장소 등의 주소를 기재한다. 이 종류에 따라 type에 website, bugtracker, repository를 대입하면 된다.
<author>	패키지 개발에 참여한 개발자의 이름과 이메일 주소를 적는다. 복수의 개발자가 참여한 경우에는 바로 다음 줄에 <author> 태그를 이용하여 추가로 넣음
<buildtool_depend>	빌드 툴의 의존성을 기술한다.
<build_depend>	패키지를 빌드할 때 필요한 의존 패키지 이름을 적는다.
<exec_depend>	패키지를 실행할 때 필요한 의존 패키지 이름을 적는다.
<test_depend>	패키지를 테스트할 때 필요한 의존 패키지 이름을 적는다.
<export>	위에서 명시하지 않은 확장 태그명을 사용할 때 쓰인다. 빌드 타입을 적는 <build_type>, RViz 플러그인에 사용되는 <rviz>, RQt 플러그인에 사용되는 <rqt_gui>, deprecated되는 패키지일 경우 유저에게 알릴 수 있는 <deprecated> 태그 등이 있다.

ROS2 실습 – 빌드 설정파일(CMakeList.txt)

ROS 2의 빌드 시스템인 ament에서는 **C++ 프로그래밍 언어**를 사용한 패키지나 RQt Plugin의 경우 CMake(Cross Platform Make)를 이용하고 있고 패키지 폴더의 **`CMakeLists.txt`**라는 파일에 **빌드 환경을 기술**하여 사용하고 있다.

이 빌드 설정 파일에 실행 파일 생성, 의존성 패키지 우선 빌드, 링크 생성 등을 설정하게 되어 있다. ROS에서 CMake를 이용하는 이유는 ROS 패키지를 멀티 플랫폼에서 빌드할 수 있게 하기 위함이다. Make가 유닉스 계열만 지원하는 것과 달리, CMake는 유닉스 계열인 리눅스, BSD, OS X뿐만 아니라 윈도우즈 계열도 지원하기 때문이다.

또한 CMakeLists.txt은 Visual Studio, Eclipse, Qt Creator 등 다양한 IDE에서 기본으로 지원하여 쉽게 사용할 수 있다.

```
cmake_minimum_required(VERSION 3.5)
project(my_first_ros_rclcpp_pkg)

# Default to C99
if(NOT CMAKE_C_STANDARD)
  set(CMAKE_C_STANDARD 99)
endif()

# Default to C++14
if(NOT CMAKE_CXX_STANDARD)
  set(CMAKE_CXX_STANDARD 14)
endif()

if(CMAKE_COMPILER_IS_GNUCXX OR CMAKE_CXX_COMPILER_ID MATCHES "Clang")
  add_compile_options(-Wall -Wextra -Wpedantic)
endif()

# find dependencies
find_package(ament_cmake REQUIRED)
find_package(rclcpp REQUIRED)
find_package(std_msgs REQUIRED)

if(BUILD_TESTING)
  find_package(ament_lint_auto REQUIRED)
  # the following line skips the linter which checks for copyrights
  # uncomment the line when a copyright and license is not present in all source files
  #set(ament_cmake_copyright_FOUND TRUE)
  # the following line skips cpplint (only works in a git repo)
  # uncomment the line when this package is not in a git repo
  #set(ament_cmake_cpplint_FOUND TRUE)
  ament_lint_auto_find_test_dependencies()
endif()

ament_package()
```

ROS2 실습 – 패키지 설정파일(package.xml)

항목	내용
name	패키지의 이름
Version	패키지의 버전
Packages	의존하는 패키지, 하나씩 나열해도 되지만 <code>find_packages()</code> 를 기입해주면 자동으로 의존하는 패키지를 찾아준다.
data_files	이 패키지에서 사용되는 파일들을 기입하여 함께 배포한다. 'ROS'에서는 주로 'resource' 폴더 내에 있는 'ament_index'를 위한 패키지의 이름의 빈 파일이나 'package.xml', '*.launch.py', '*.yaml' 등을 기입한다.
install_requires	의존하는 패키지, 이 패키지를 'pip'을 통해 설치할 때 이곳에 기술된 패키지들을 함께 설치하게 된다. 'ROS'에서는 'pip'로 설치하지 않기에 'setuptools', 'launch'만을 기입해준다.
tests_require	테스트에 필요한 패키지, 'ROS'에서는 'pytest'를 사용한다.
zip_safe	설치시 zip 파일로 아카이브할지 여부를 설정한다.
author author_email maintainer maintainer_email	저작자, 관리자의 이름과 이메일을 기입한다.
Keywords	이 패키지의 키워드, Python Package Index (PyPI) 배포시 검색하여 이 패키지를 찾을 수 있도록 한다.
Classifiers	PyPI에 등록될 메타 데이터 설정으로 'PyPI' 페이지의 좌측 Meta란에서 확인 가능하다.
Description	패키지 설명을 기입한다.
License	라이선스 종류를 기입한다.
entry_points	플랫폼 별로 콘솔 스크립트를 설치하도록 콘솔 스크립트 이름과 호출 함수를 기입한다.
name	패키지의 이름

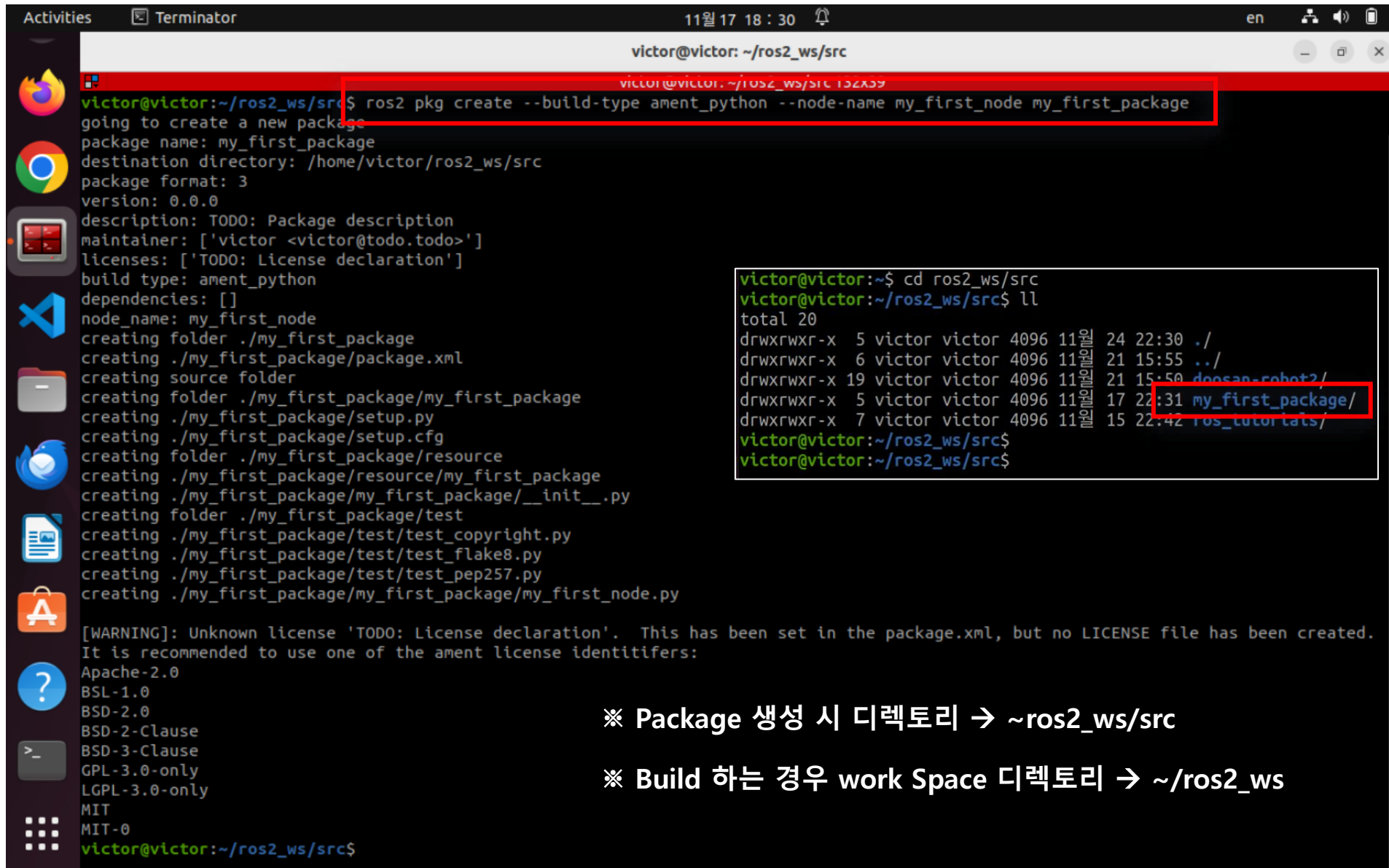
ROS2 실습 – 파이썬 패키지 설정파일(Setup.py)

```
from setuptools import setup

package_name = 'my_first_ros_rclpy_pkg'

setup(
    name=package_name,
    version='0.0.0',
    packages=[package_name],
    data_files=[
        ('share/ament_index/resource_index/packages',
         ['resource/' + package_name]),
        ('share/' + package_name, ['package.xml']),
    ],
    install_requires=['setuptools'],
    zip_safe=True,
    maintainer='pyo',
    maintainer_email='victor@datacore.kr',
    description='TODO: Package description',
    license='TODO: License declaration',
    tests_require=['pytest'],
    entry_points={
        'console_scripts': [
        ],
    },
)
```

ROS2 실습 – Publisher & Subscriber(my_first_package)



The screenshot shows a terminal window titled 'Terminator' with the user 'victor' at host 'victor'. The current directory is `~/ros2_ws/src`. The terminal output is as follows:

```
victor@victor:~/ros2_ws/src$ ros2 pkg create --build-type ament_python --node-name my_first_node my_first_package
going to create a new package
package name: my_first_package
destination directory: /home/victor/ros2_ws/src
package format: 3
version: 0.0.0
description: TODO: Package description
maintainer: ['victor <victor@todo.todo>']
licenses: ['TODO: License declaration']
build type: ament_python
dependencies: []
node_name: my_first_node
creating folder ./my_first_package
creating ./my_first_package/package.xml
creating source folder
creating folder ./my_first_package/my_first_package
creating ./my_first_package/setup.py
creating ./my_first_package/setup.cfg
creating folder ./my_first_package/resource
creating ./my_first_package/resource/my_first_package
creating ./my_first_package/my_first_package/__init__.py
creating folder ./my_first_package/test
creating ./my_first_package/test/test_copyright.py
creating ./my_first_package/test/test_flake8.py
creating ./my_first_package/test/test_pep257.py
creating ./my_first_package/my_first_package/my_first_node.py

[WARNING]: Unknown license 'TODO: License declaration'. This has been set in the package.xml, but no LICENSE file has been created.
It is recommended to use one of the ament license identifiers:
Apache-2.0
BSL-1.0
BSD-2.0
BSD-2-Clause
BSD-3-Clause
GPL-3.0-only
LGPL-3.0-only
MIT
MIT-0
victor@victor:~/ros2_ws/src$
```

On the right side of the terminal, a directory listing is shown:

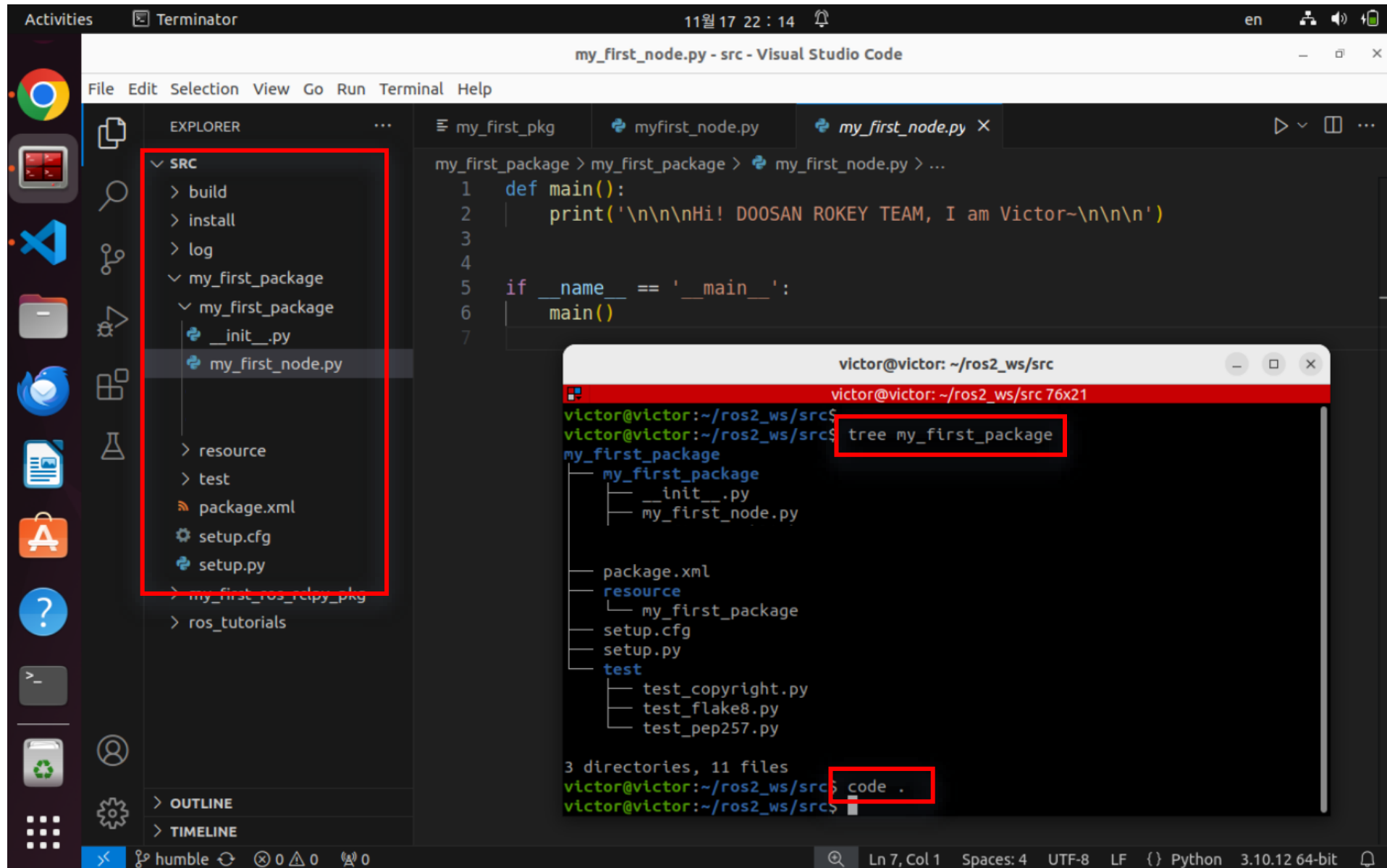
```
victor@victor:~/ros2_ws/src$ ll
total 20
drwxrwxr-x  5 victor victor 4096 11월 24 22:30 ./
drwxrwxr-x  6 victor victor 4096 11월 21 15:55 ../
drwxrwxr-x 19 victor victor 4096 11월 21 15:50 doosan-robot2/
drwxrwxr-x  5 victor victor 4096 11월 17 22:31 my_first_package/
drwxrwxr-x  7 victor victor 4096 11월 15 22:42 ros_tutorials/
```

The terminal output shows the successful creation of the `my_first_package` directory and its contents. The directory listing on the right confirms the creation of `my_first_package` at `~/ros2_ws/src/my_first_package/`.

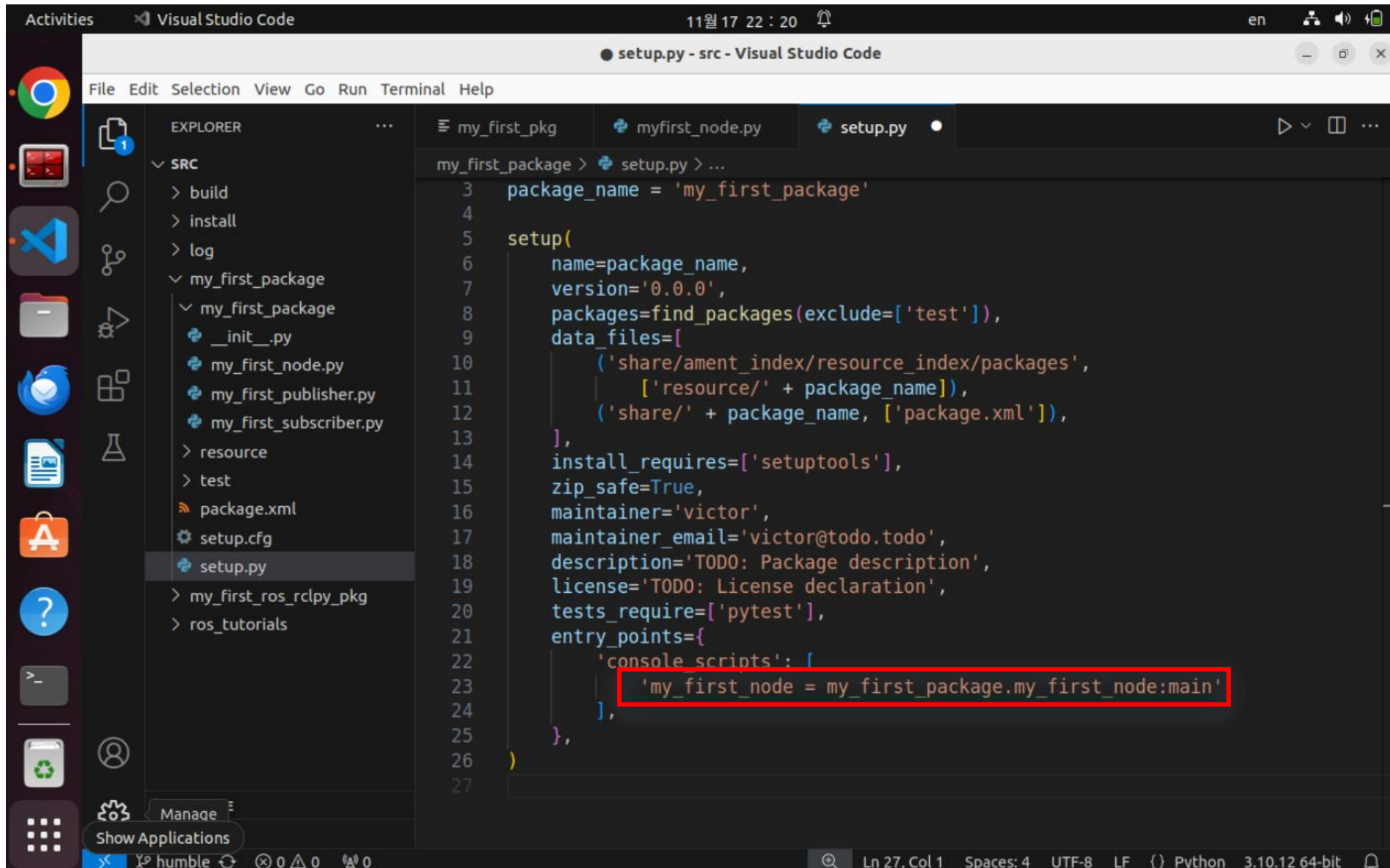
※ Package 생성 시 디렉토리 → `~/ros2_ws/src`

※ Build 하는 경우 work Space 디렉토리 → `~/ros2_ws`

ROS2 실습 – Publisher & Subscriber(my_first_package)

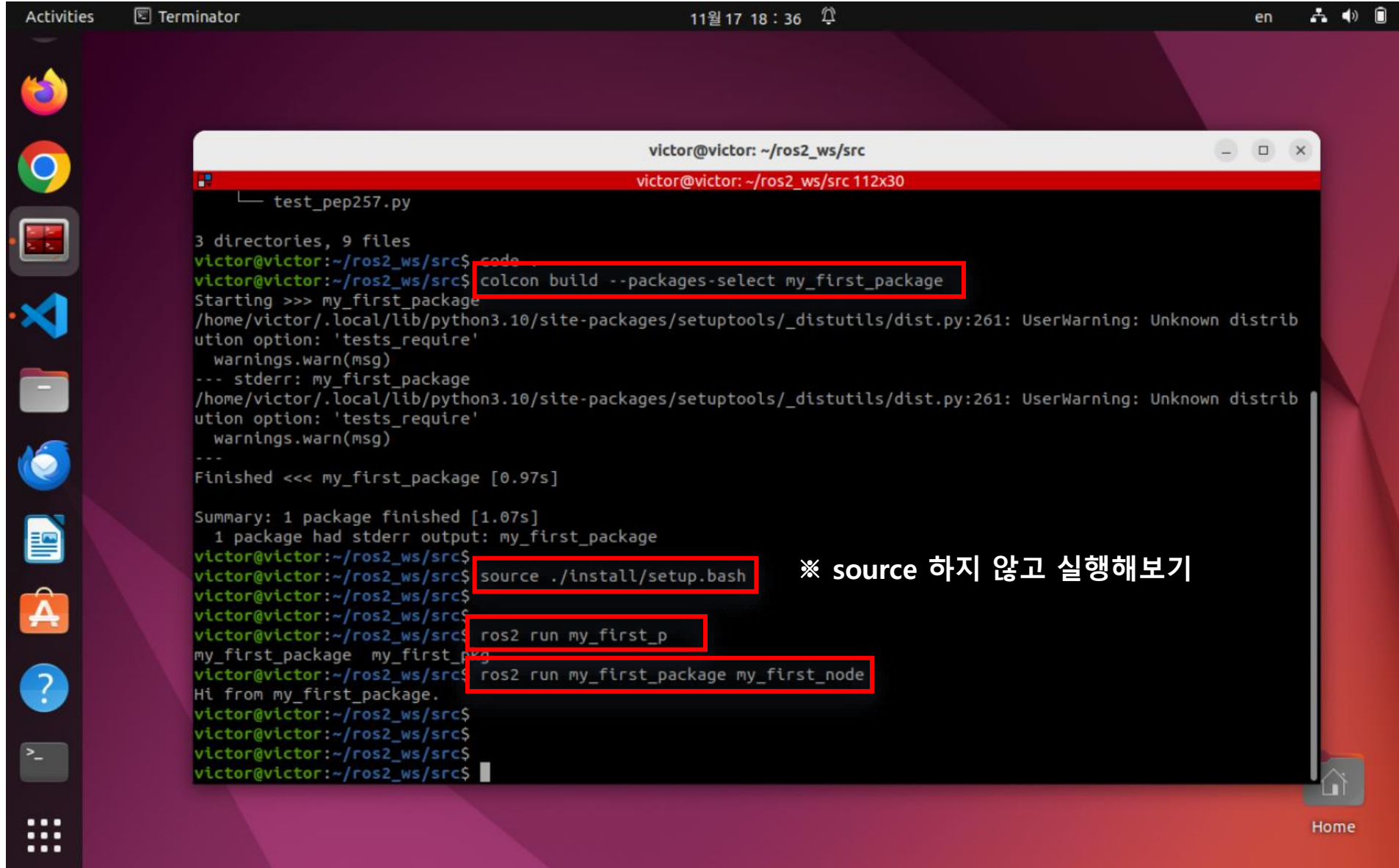


ROS2 실습 – Publisher & Subscriber(my_first_package)



```
3 package_name = 'my_first_package'
4
5 setup(
6     name=package_name,
7     version='0.0.0',
8     packages=find_packages(exclude=['test']),
9     data_files=[
10         ('share/ament_index/resource_index/packages',
11          ['resource/' + package_name]),
12         ('share/' + package_name, ['package.xml']),
13     ],
14     install_requires=['setuptools'],
15     zip_safe=True,
16     maintainer='victor',
17     maintainer_email='victor@todo.todo',
18     description='TODO: Package description',
19     license='TODO: License declaration',
20     tests_require=['pytest'],
21     entry_points={
22         'console_scripts': [
23             'my_first_node = my_first_package.my_first_node:main'
24         ],
25     },
26 )
27
```

ROS2 실습 – Publisher & Subscriber(my_first_package)



The screenshot shows a terminal window titled "victor@victor: ~/ros2_ws/src" with a red title bar. The terminal output shows the following sequence of commands and results:

```
test_pep257.py
3 directories, 9 files
victor@victor:~/ros2_ws/src$ code
victor@victor:~/ros2_ws/src$ colcon build --packages-select my_first_package
Starting >>> my_first_package
/home/victor/.local/lib/python3.10/site-packages/setuptools/_distutils/dist.py:261: UserWarning: Unknown distribution option: 'tests_require'
  warnings.warn(msg)
--- stderr: my_first_package
/home/victor/.local/lib/python3.10/site-packages/setuptools/_distutils/dist.py:261: UserWarning: Unknown distribution option: 'tests_require'
  warnings.warn(msg)
---
Finished <<< my_first_package [0.97s]

Summary: 1 package finished [1.07s]
1 package had stderr output: my_first_package
victor@victor:~/ros2_ws/src$ source ./install/setup.bash
victor@victor:~/ros2_ws/src$ ros2 run my_first_p
my_first_package my_first_p
victor@victor:~/ros2_ws/src$ ros2 run my_first_package my_first_node
Hi from my_first_package.
victor@victor:~/ros2_ws/src$
victor@victor:~/ros2_ws/src$
victor@victor:~/ros2_ws/src$
victor@victor:~/ros2_ws/src$
```

Four commands are highlighted with red boxes: `colcon build --packages-select my_first_package`, `source ./install/setup.bash`, `ros2 run my_first_p`, and `ros2 run my_first_package my_first_node`. A Korean annotation "※ source 하지 않고 실행해보기" (※ Try running without source) is placed next to the `source` command.

ROS2 실습 – Publisher & Subscriber(my_first_package)

```
108 # enable programmable completion features (you don't need to enable
109 # this, if it's already enabled in /etc/bash.bashrc and /etc/profile
110 # sources /etc/bash.bashrc).
111 if ! shopt -oq posix; then
112     if [ -f /usr/share/bash-completion/bash_completion ]; then
113         . /usr/share/bash-completion/bash_completion
114     elif [ -f /etc/bash_completion ]; then
115         . /etc/bash_completion
116     fi
117 fi
```

※ .bashrc example

```
120 source /opt/ros/humble/setup.bash
121 alias sb="source ~/.bashrc; echo \"bashrc is reloaded\""
122 alias humble="source /opt/ros/humble/setup.bash; ros_domain; echo \"ROS2 humble is activated.\""
123 alias ros_domain="export ROS_DOMAIN_ID=32"
124 alias ros2_ws="humble; source ~/ros2_ws/install/local_setup.bash; echo \"ros2_ws workspace is activated.\""
125
```

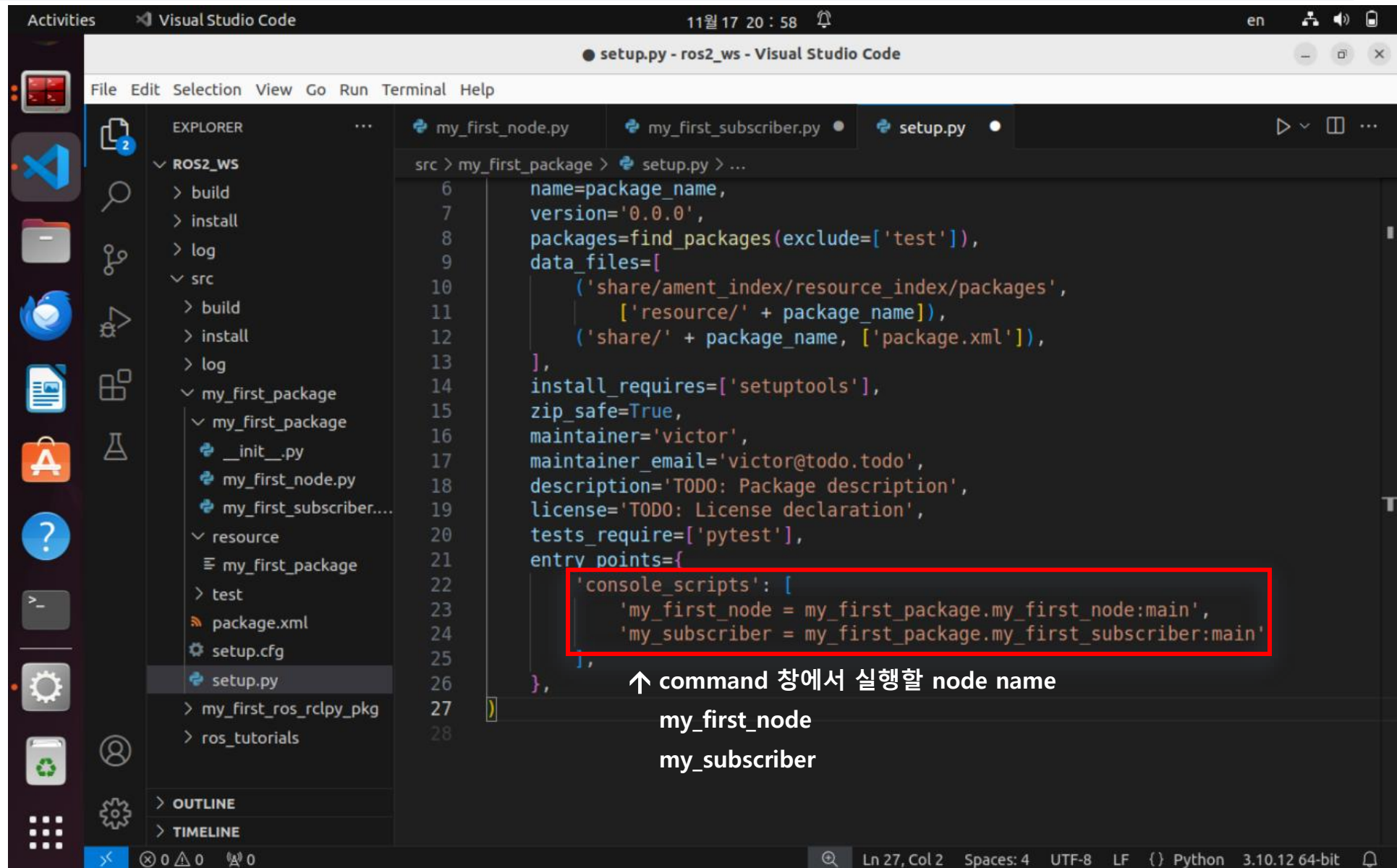
ROS2 실습 – Publisher & Subscriber(my_first_package)

The screenshot shows the Visual Studio Code interface with a ROS2 workspace named 'ros2_ws'. The Explorer sidebar on the left displays the project structure, including the 'my_first_package' directory. The main editor window shows the 'my_first_subscriber.py' file, which contains the following Python code:

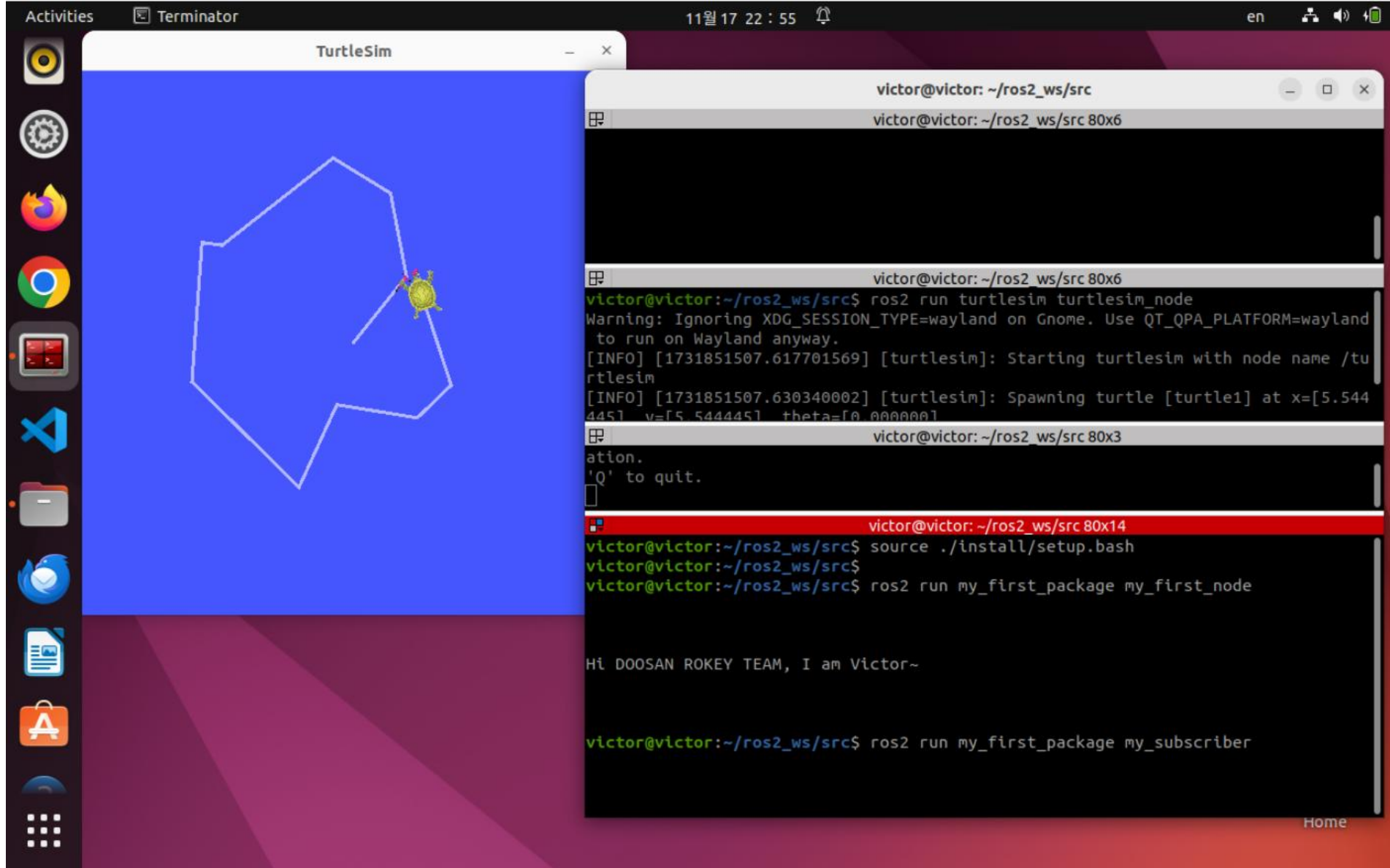
```
src > my_first_package > my_first_package > my_first_subscriber.py > ...
1  import rclpy as rp
2  from rclpy.node import Node
3  from turtlesim.msg import Pose
4
5  class TurtlesimSubscriber(Node):
6
7      def __init__(self):
8          super().__init__('turtlesim_subscriber')
9          self.subscription = self.create_subscription(Pose, '/turtle1/pose', self.callback, 10)
10         self.subscription
11
12         def callback(self, msg):
13             print("x: ", msg.x, ", Y: ", msg.y)
14
15     def main():
16         rp.init(args=None)
17
18         turtlesim_subscriber = TurtlesimSubscriber()
19         rp.spin(turtlesim_subscriber)
20
21         turtlesim_subscriber.destroy_node()
22         rp.shutdown()
23
24     if __name__ == '__main__':
25         main()
26
```

The status bar at the bottom indicates the current position is Line 26, Column 1, with 4 spaces, UTF-8 encoding, LF line endings, and Python 3.10.12 64-bit.

ROS2 실습 – Publisher & Subscriber(my_first_package)



ROS2 실습 – Publisher & Subscriber(my_first_package)



ROS2 실습 – Publisher & Subscriber(my_first_package)

The screenshot displays a ROS2 environment on a Linux desktop. The background is a blue field with a white outline of a polygon. A small green turtle icon is visible in the bottom-left corner of the blue field.

Overlaid on the background are several windows:

- TurtleSim**: A window showing the simulation environment with a blue background and a white outline of a polygon.
- Terminal 1**: A terminal window titled "victor@victor: ~/ros2_ws" showing the command `ros2 run turtlesim turtlesim_node` and its output, including spawning turtle [turtle1] at x=[5.544445], y=[5.544445], theta=[0.000000].
- Terminal 2**: A terminal window titled "victor@victor: ~/ros2_ws" showing the command `ros2 run turtlesim turtle_teleop_key` and its output, including "Reading from keyboard" and "orientations. 'F' to cancel a rotation."
- Node Graph**: A window titled "rqt_graph_RosGraph - rqt" showing a graph of nodes. The graph contains two nodes: `/turtle1` and `/turtlesim`. The `/turtle1` node has two sub-nodes: `/turtle1/cmd_vel` and `/turtle1/pose`. Arrows indicate the flow of data: `/turtle1/cmd_vel` points to `/turtlesim`, and `/turtle1/pose` points to `/turtlesim_subscriber`.

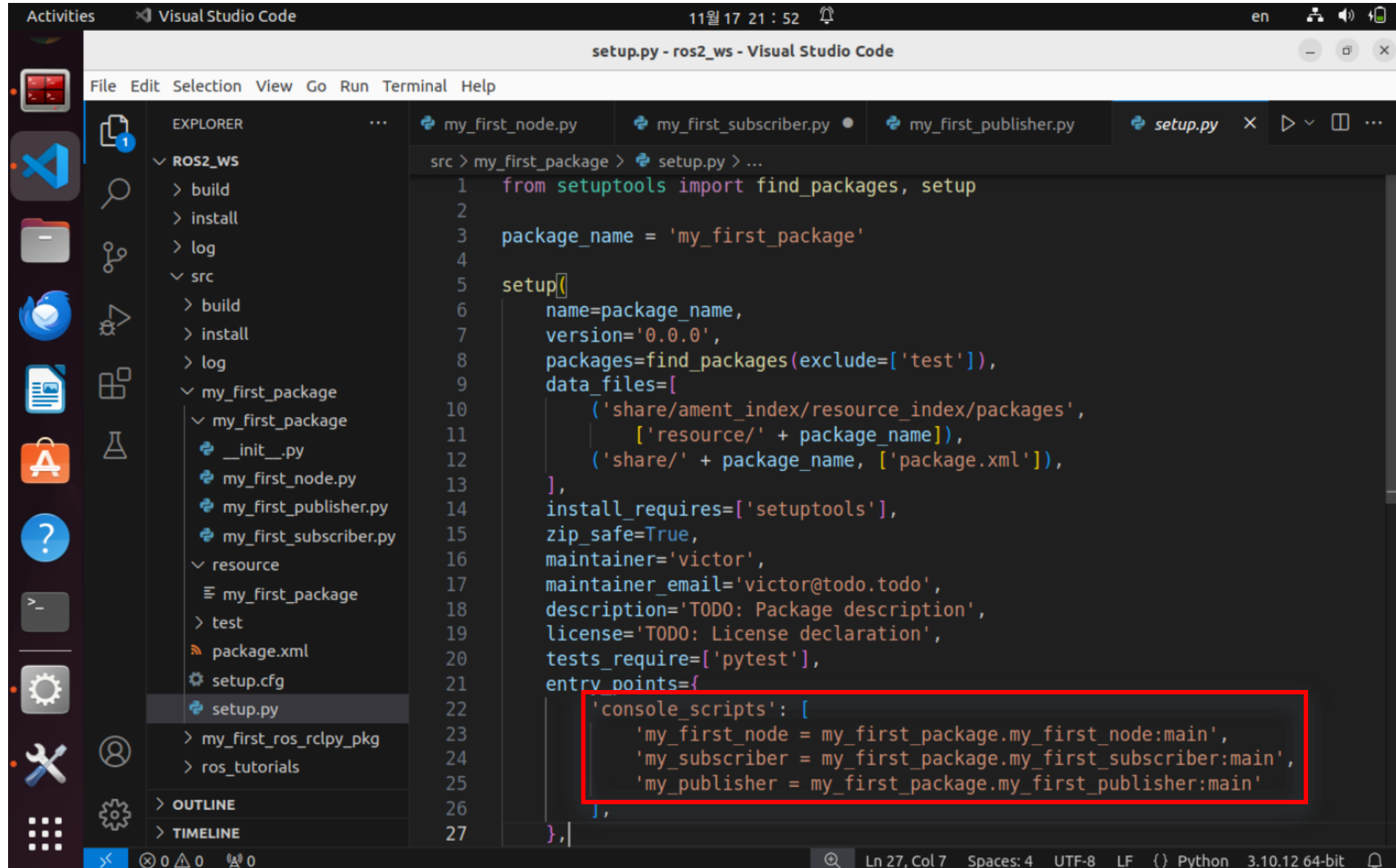
ROS2 실습 – Publisher & Subscriber(my_first_package)

The screenshot shows the Visual Studio Code interface with the following components:

- Explorer:** Displays the file structure of the workspace. The `my_first_package` directory is expanded, showing files like `__init__.py`, `my_first_node.py`, `my_first_publisher.py` (selected), `my_first_subscriber.py`, `package.xml`, `setup.cfg`, `setup.py`, and `test`.
- Editor:** Displays the code for `my_first_publisher.py`. The code is as follows:

```
src > my_first_package > my_first_package > my_first_publisher.py > ...
1  import rclpy as rp
2  from rclpy.node import Node
3  from geometry_msgs.msg import Twist
4
5  class TurtlesimPublisher(Node):
6
7      def __init__(self):
8          super().__init__('turtlesim_publisher')
9          self.publisher = self.create_publisher(Twist, '/turtle1/cmd_vel', 10)
10         timer_period = 0.5
11         self.timer = self.create_timer(timer_period, self.timer_callback)
12
13     def timer_callback(self):
14         msg = Twist()
15         msg.linear.x = 2.0
16         msg.angular.z = 2.0
17         self.publisher.publish(msg)
18
19 def main():
20     rp.init(args=None)
21
22     turtlesim_publisher = TurtlesimPublisher()
23     rp.spin(turtlesim_publisher)
24
25     turtlesim_publisher.destroy_node()
26     rp.shutdown()
27
28 if __name__ == '__main__':
29     main()
30
```
- Terminal:** Currently empty.
- Bottom Bar:** Shows the status bar with "Ln 30, Col 1", "Spaces: 4", "UTF-8", "LF", "Python", and "3.10.12 64-bit".

ROS2 실습 – Publisher & Subscriber(my_first_package)



```
src > my_first_package > setup.py > ...
1  from setuptools import find_packages, setup
2
3  package_name = 'my_first_package'
4
5  setup(
6      name=package_name,
7      version='0.0.0',
8      packages=find_packages(exclude=['test']),
9      data_files=[
10         ('share/ament_index/resource_index/packages',
11          ['resource/' + package_name]),
12         ('share/' + package_name, ['package.xml']),
13     ],
14     install_requires=['setuptools'],
15     zip_safe=True,
16     maintainer='victor',
17     maintainer_email='victor@todo.todo',
18     description='TODO: Package description',
19     license='TODO: License declaration',
20     tests_require=['pytest'],
21     entry_points={
22         'console_scripts': [
23             'my_first_node = my_first_package.my_first_node:main',
24             'my_subscriber = my_first_package.my_first_subscriber:main',
25             'my_publisher = my_first_package.my_first_publisher:main'
26         ],
27     },
28 )
```

ROS2 실습 – Publisher & Subscriber(my_first_package)

The screenshot displays a ROS2 environment with three main windows:

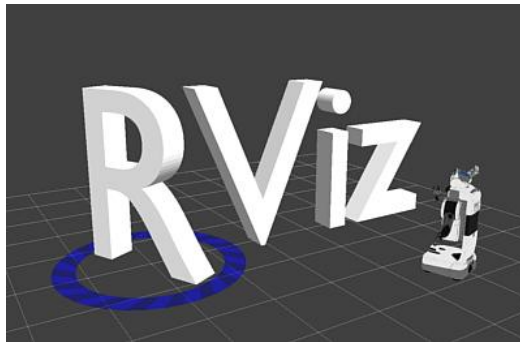
- TurtleSim:** A window showing a green turtle on a blue background, with several white lines representing its movement path.
- rqt_graph_RosGraph - rqt:** A window showing a node graph. The graph includes nodes for `/turtlesim`, `/turtlesim_publisher`, `/turtlesim_subscriber`, `/teleop_turtle`, and `/turtle1`. The `/turtle1` node contains sub-nodes for `/turtle1/pose`, `/turtle1/rotate_absolute_action/feedback`, `/turtle1/rotate_absolute_action/status`, and `/turtle1/cmd_vel`. Arrows indicate the flow of data between these nodes.
- Terminal:** A terminal window showing the execution of ROS2 commands. The commands and their outputs are as follows:

```
victor@victor: ~/ros2_ws
victor@victor: ~/ros2_ws$ ros2 run turtlesim turtlesim_node
my_Warning: Ignoring XDG_SESSION_TYPE=wayland on Gnome. Use QT_QPA_PLATFORM=
on Wayland anyway.
[INFO] [1731843962.222203780] [turtlesim]: Starting turtlesim with node n
victor@victor: ~/ros2_ws$ rqt_graph
victor@victor: ~/ros2_ws 88x2
'Q' to quit.
victor@victor: ~/ros2_ws 88x6
x: 6.2159295082092285 , Y: 7.4060139656066895
x: 6.246010780334473 , Y: 7.416927814483643
x: 6.27572774887085 , Y: 7.428798198699951
x: 6.305049419403076 , Y: 7.441613674163818
x: 6.335049419403076 , Y: 7.4553608894348145
victor@victor: ~/ros2_ws 88x17
victor@victor: ~/ros2_ws$ colcon build --packages-select my_first_package
lib/python3.10/site-packages/setuptools/_distutils/di
tribution option: 'tests_require'
victor@victor: ~/ros2_ws$ source ./install/setup.bash
victor@victor: ~/ros2_ws$ ros2 run my_first_package my_publisher
```

ROS의 중요한 개발도구들

- ROS는 GUI기반이 아닌, 터미널에서 command line 방식으로 동작을 시킬 수 있음
- 여기에 더해서 ROS 사용의 효율을 높이기 위해서 다양한 개발도구를 제공함

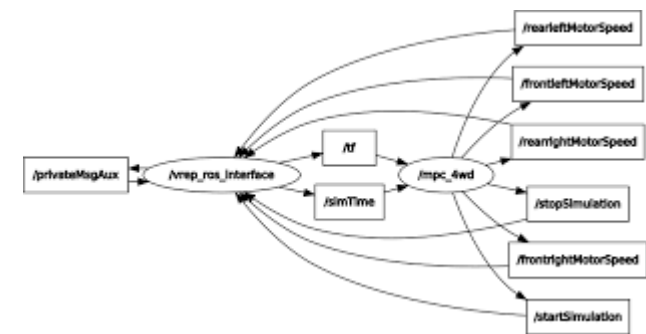
rViz



gazebo

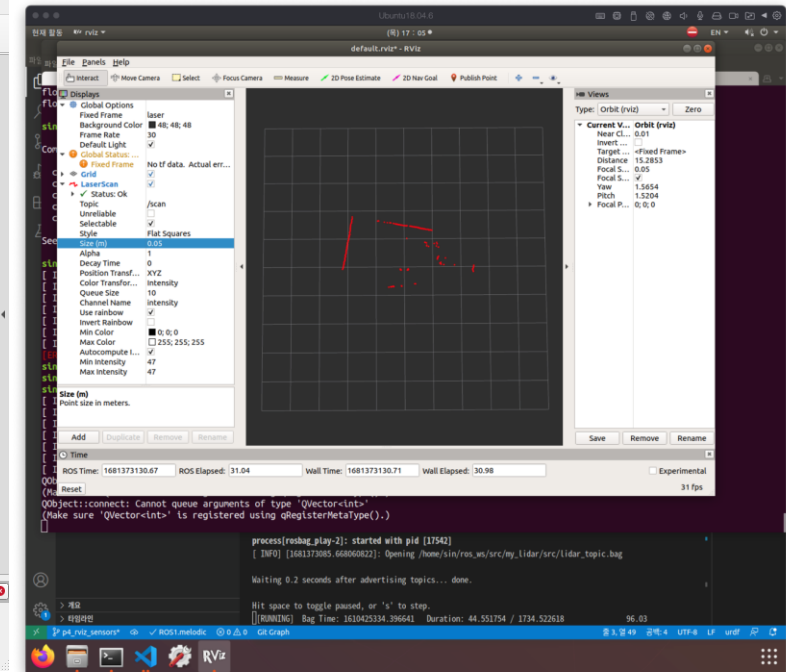
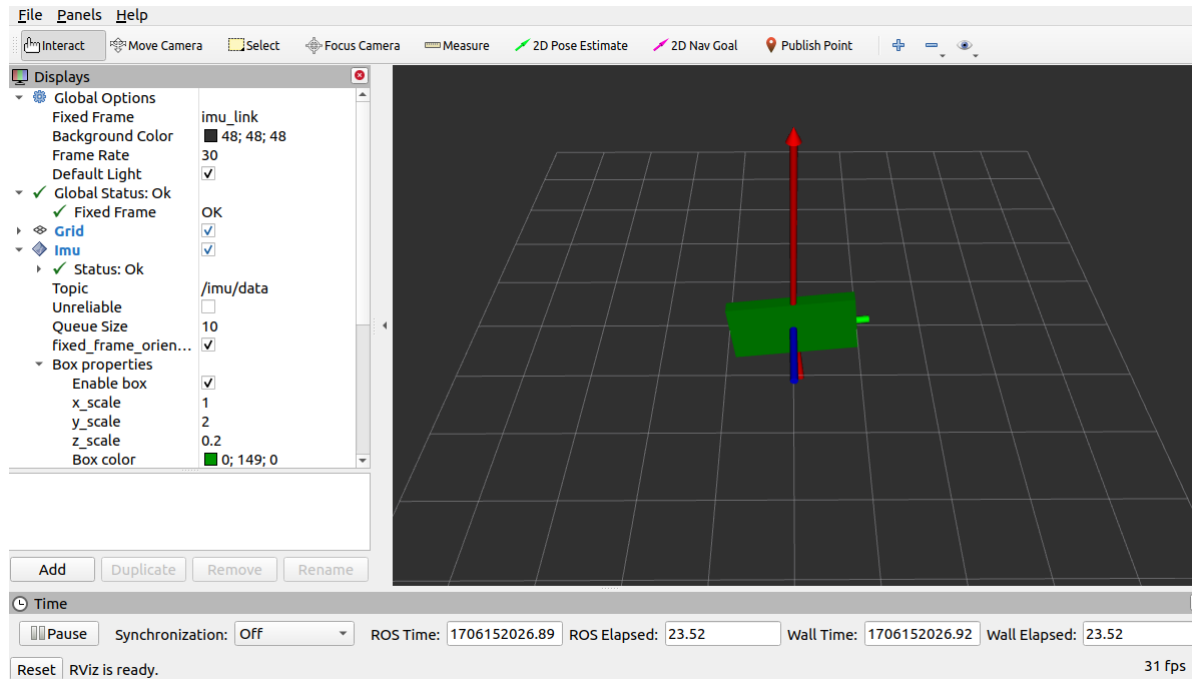


rqt



rViz (ROS Visualization Tool)

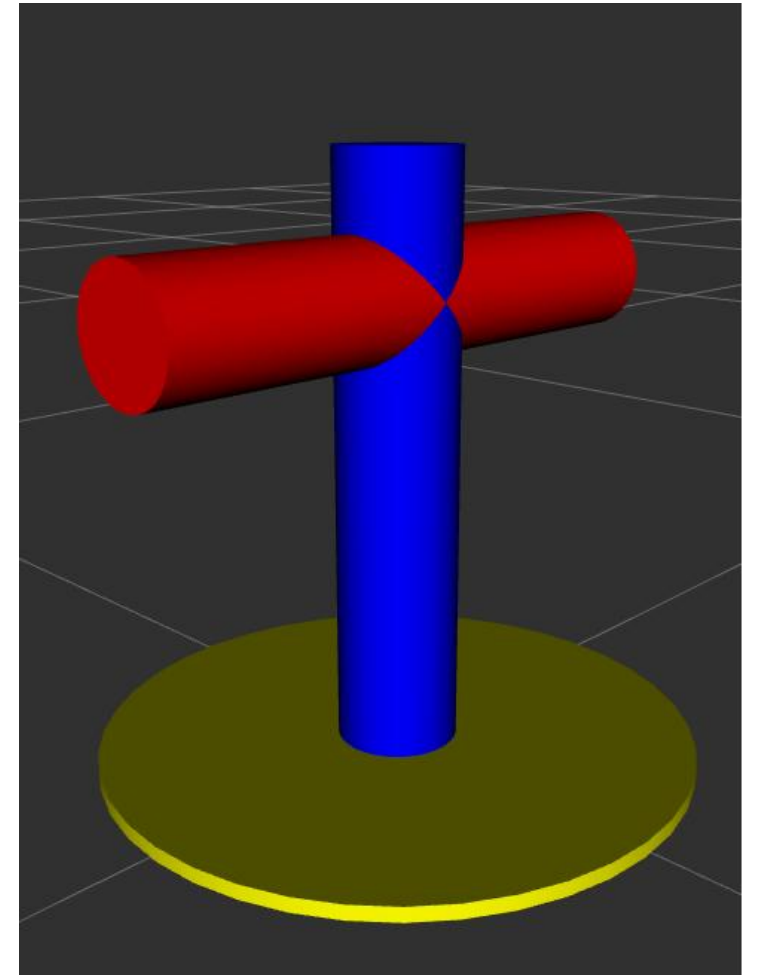
- rViz는 ROS에서 얻어지는 데이터를 시각화(visualization)하는 도구임
- IMU 데이터의 시각화
- URDF 파일을 이용한 로봇암 동작의 시각화
- 라이다 센서 데이터 시각화를 통한 SLAM 적용



<https://velog.io/@y2k4388/rViz%EB%A5%BC-%EC%9D%B4%EC%9A%A9%ED%95%9C-%EC%84%BC%EC%84%9C-%EB%8D%B0%EC%9D%B4%ED%84%B0-%EC%8B%9C%EA%B0%81%ED%99%94>

Robot URDF 파일을 통한 로봇암 시각화

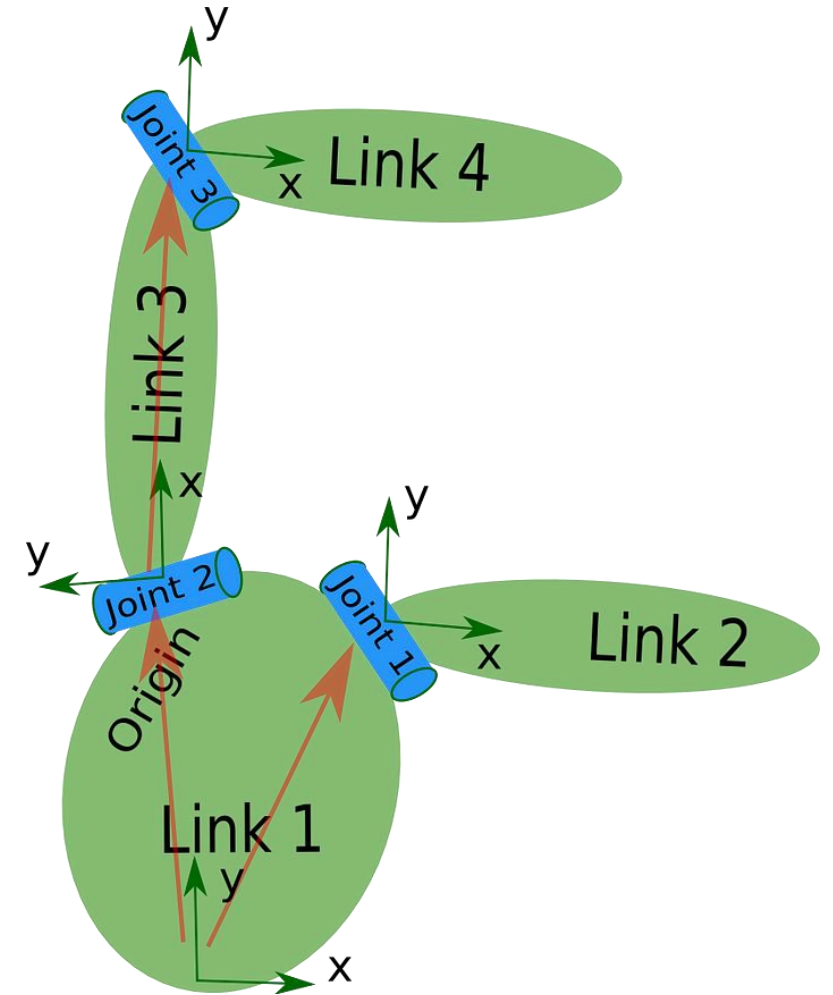
- rViz의 기능 중 URDF 파일을 읽어서 로봇암의 동작을 시각화하는 기능이 있음
-
- URDF(Universal Robot description Format)이란?
 - URDF는 xml기반의 텍스트 파일로, 로봇의 형태와 동작을 정의한 파일임
 - ROS 초보자가 URDF 파일을 작성하기는 어렵지만, 어떤 로봇에 URDF 파일이 존재하면,
 - 이 로봇을 rViz를 통해서 가상으로 동작 시켜 볼 수 있음
- URDF 파일로 할 수 있는 것
 - 로봇의 구조를 정의
 - 로봇 동작의 시각화
 - 로봇의 충돌 모델 정의



Robot URDF 파일의 구성

- URDF 파일은 다음과 같은 요소로 구성되어 있음
- Link, joint
- Link
 - 로봇을 구성하는 구성요소 중 하나, 3가지 속성이 있음
 - <inertial> 링크의 관성 정보. Link의 관성 중심, 질량, 관성계수 등을 기록함
 - <visual> rViz 같은 시각화 도구에서 로봇을 시각화 할 때 사용되는 속성들을 정의함
 - <collision> 물리적인 충돌 속성 정의, 충돌 모델 정의
- Joint
 - Link 와 link를 연결하는 로봇 구성요소. URDF는 6가지 joint 타입이 있음
 - <origin> 부모 link에서 자식 링크에 변환 정보
 - <parent> 부모 link 이름
 - <child> 자식 link 이름

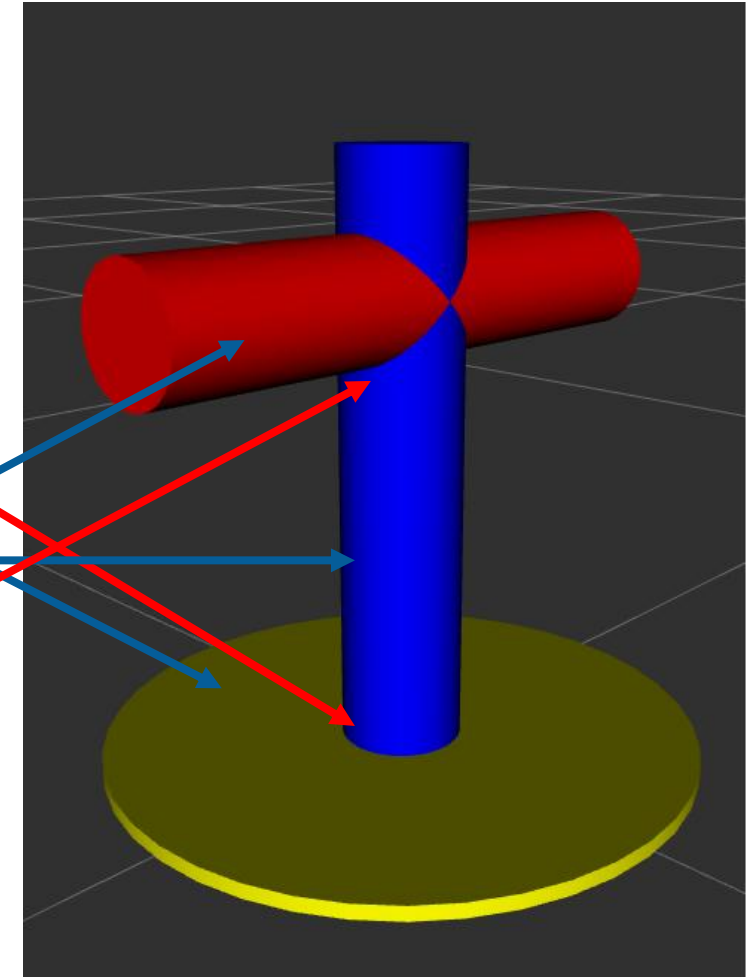
<https://wiki.ros.org/urdf/Examples>



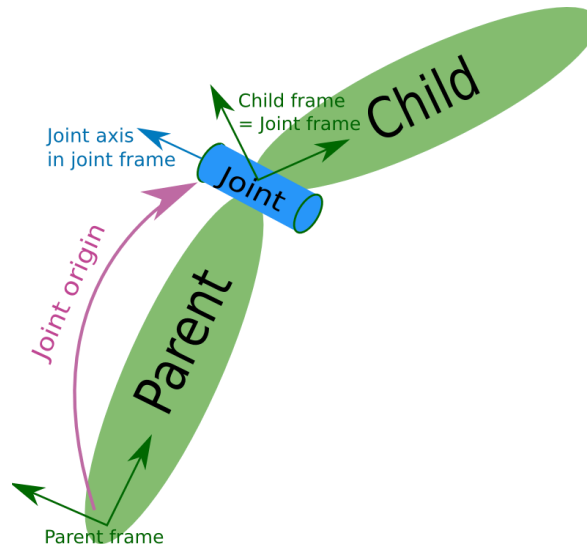
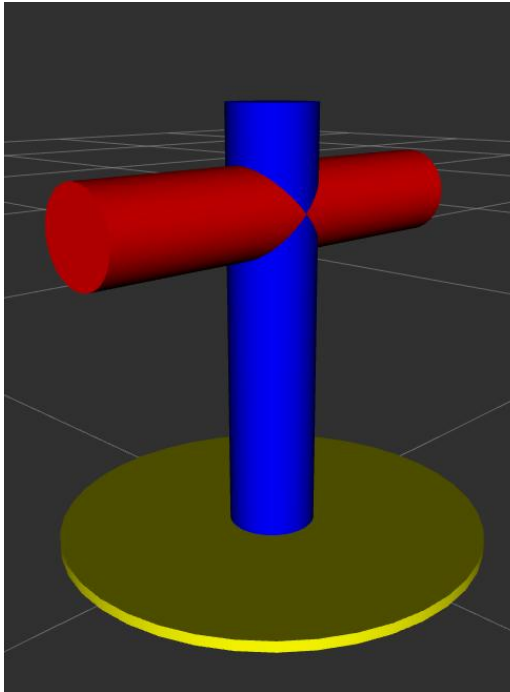
<https://medium.com/newworld-kim/ros-urdf-b6979bfa31aa>

Robot URDF 파일의 예 – pan-tilt 로봇

```
<?xml version="1.0"?>
<robot name="pan_tilt">
  <link name="base_link">
  </link>
  <joint name="pan_joint" type="revolute">
  </joint>
  <link name="pan_link">
  </link>
  <joint name="tilt_joint" type="revolute">
  </joint>
  <link name="tilt_link">
  </link>
</robot>
```



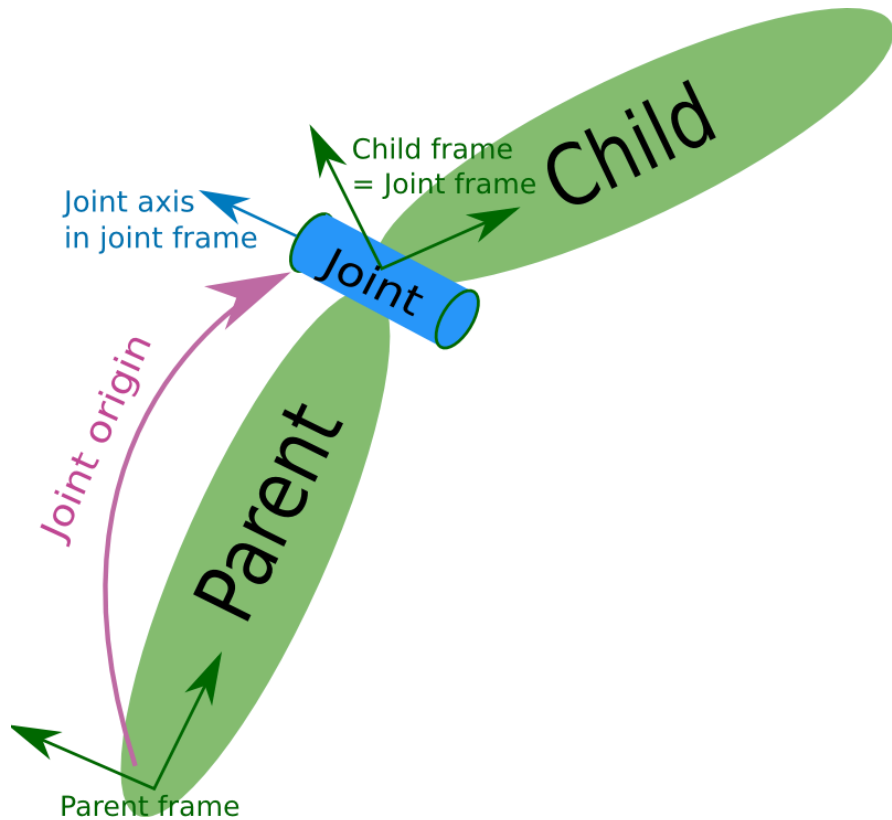
URDF 파일 pan-tilt 로봇 – link - joint 예



```
<link name="base_link">
  <visual>
    중간 생략
  </visual>
  <collision>
    중간 생략
  </collision>
  중간 생략
</link>
<joint name="pan_joint" type="revolute">
  <parent link="base_link"/>
  <child link="pan_link"/>
  중간 생략
</joint>

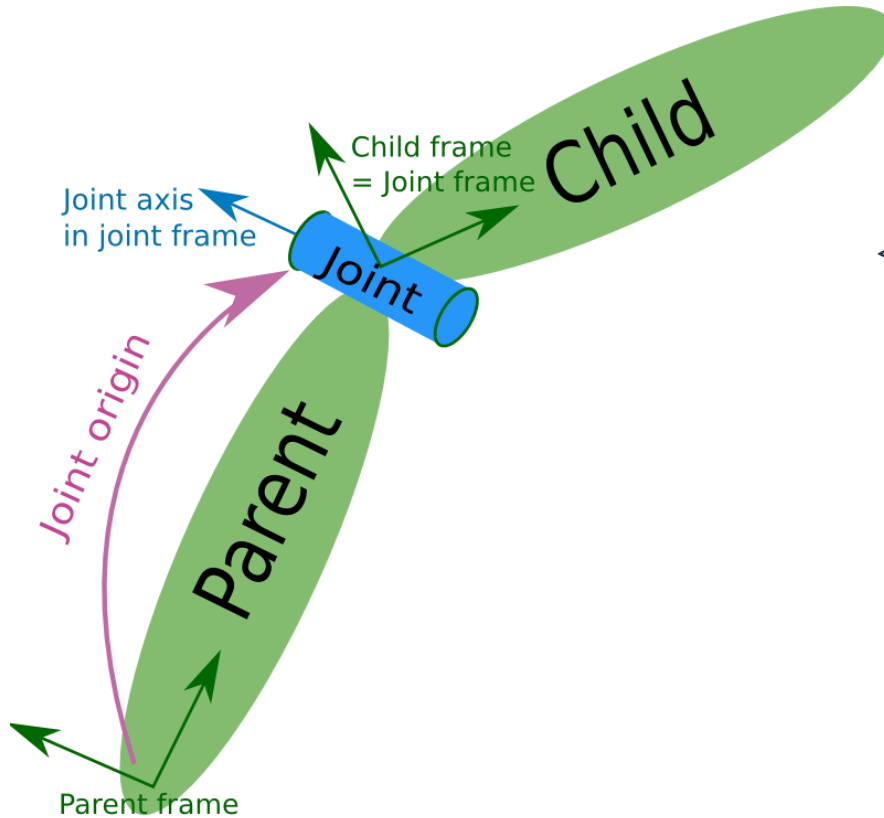
<link name="pan_link">
  중간 생략
</link>
```

URDF 파일 pan-tilt 로봇 – link 상세



```
<link name="base_link">
  <visual>
    <geometry>
      <cylinder length="0.01" radius="0.2"/>
    </geometry>
    <origin rpy="0 0 0" xyz="0 0 0"/>
    <material name="yellow">
      <color rgba="1 1 0 1"/>
    </material>
  </visual>
  <collision>
    <geometry>
      <cylinder length="0.03" radius="0.2"/>
    </geometry>
    <origin rpy="0 0 0" xyz="0 0 0"/>
  </collision>
  <inertial>
    <mass value="1"/>
    <inertia ixx="1.0" ixy="0.0" ixz="0.0" iyy="1.0" iyz="0.0" izz="1.0"/>
  </inertial>
</link>
```

URDF 파일 pan-tilt 로봇 – joint 상세



```
<joint name="pan_joint" type="revolute">  
  <parent link="base_link"/>  
  <child link="pan_link"/>  
  <origin xyz="0 0 0.1"/>  
  <axis xyz="0 0 1" />  
  <limit effort="300" velocity="0.1" lower="-3.14" upper="3.14"/>  
  <dynamics damping="50" friction="1"/>  
</joint>
```

ROKEY BOOT CAMP
수고하셨습니다.