02. Linux, ROS introduction

Lecture

Linux principles

- (Was) the only OS supported by ROS
- Security
- Efficieny
- Open-source
- Community support
- User freedom
- Distributions: **Ubuntu**, Linux Mint, Debian, etc.
- Terminal usage more dominant

Suggestion

Install **Terminator** terminal emulator:

```
sudo apt update
sudo apt install terminator
```

Linux commands

See some basic commands below:

- Run as administrator with `sudo`
- Manual of command `man`, e.g. `man cp`
- Package management `apt`, e.g. `apt update`, `apt install`
- Navigation `cd`
- List directory contents `ls`
- Create file `touch`
- Copy file `cp`
- Move file `mv`
- Remove file `rm`
- Make directory `mkdir`
- Remove directory `rmdir`
- Make a file executable `chmod +x <filename>`
- Safe restart: Crtl + Alt + PrtScr + REISUB
- If not sure, just google the command

ROS 1 → ROS 2

- ROS 2 was rewritten from scratch
- More modular architecture
- Improved support for real-time systems
- Support for multiple communication protocols
- Better interoperability with other robotic systems
- Focus on standardization and industry collaboration
- No ROS Master
- No Devel space
- `rclpy`, `rclcpp`
- More structured code (`Node` class)

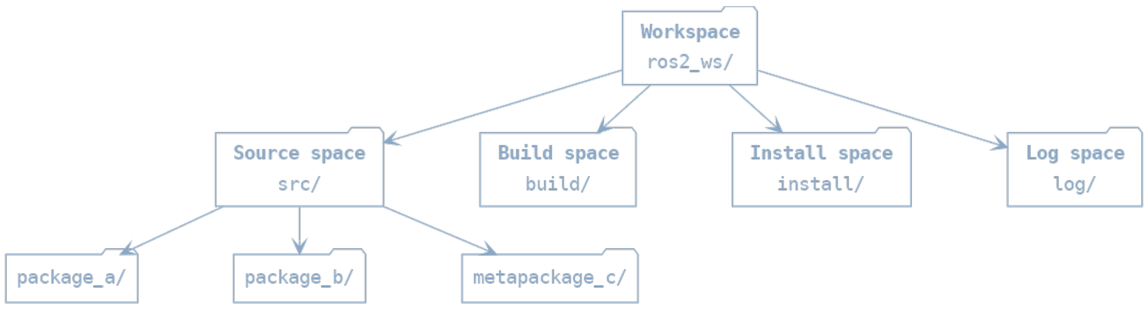
- Different build system
- Platforms: Windows, OS X, Linux

ROS principles

ROS workspace

Colcon workspace

A folder where packages are modified, built, and installed.



- Source space:
  - Source code of colcon packages
  - Space where you can extract/checkout/clone source code for the packages you want to build
- Build space
  - Colcon is invoked here to build packages
  - Colcon and CMake keep intermediate files here
- Install space:
  - Each package will be installed here; by default each package will be installed into a separate subdirectory
- Log space:
  - Contains various logging information about each colcon invocation

ROS package principle

Enough functionality to be useful, but not too much that the package is heavyweight and difficult to use from other software.

ROS dependencies

After cloning a new package, use the following command to install depenencies:

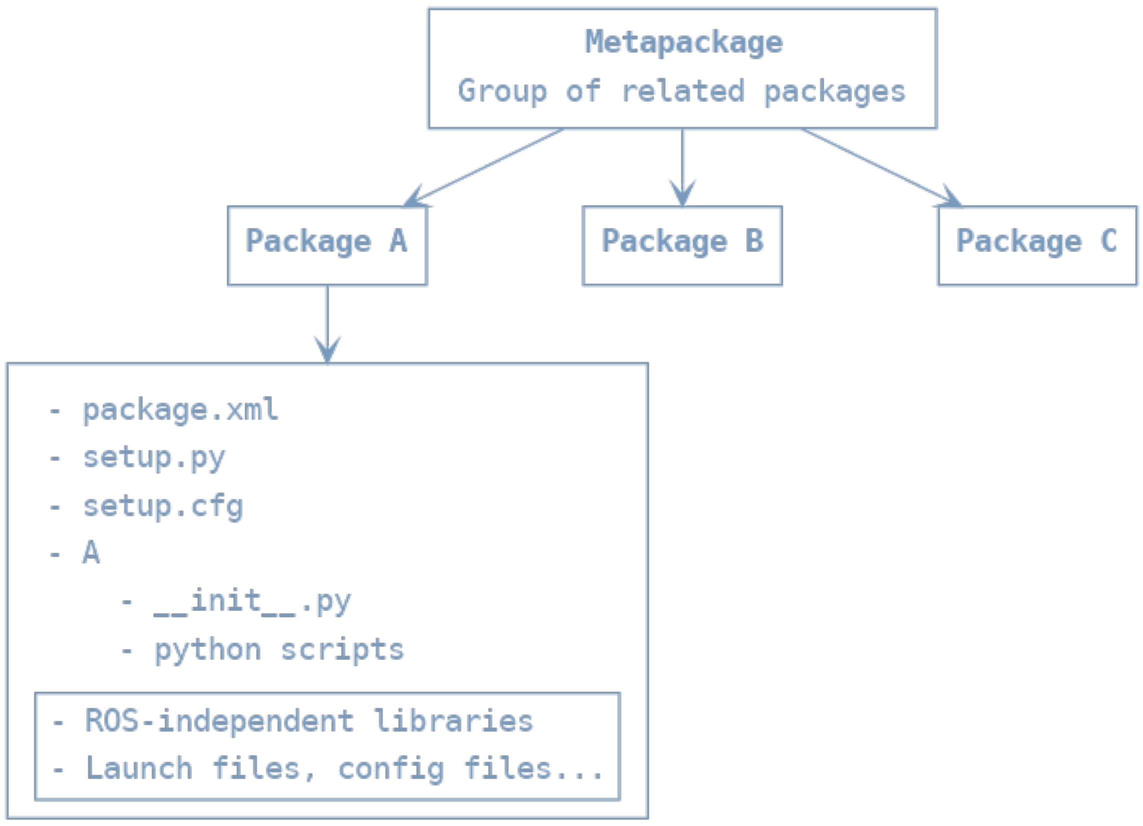
```
rosdep install --from-paths src --ignore-src -r -y
```

ROS package

- Main unit to organize software in ROS
- Buildable and redistributible unit of ROS code
- Consists of (in the case of Python packages):
    - `package.xml` file containing meta information about the package
        - name
        - version
        - description
        - dependencies
        - etc.
    - `setup.py` containing instructions for how to install the package
    - `setup.cfg` is required when a package has executables, so ros2 run can find them
    - `/<package_name>` - a directory with the same name as your package, used by ROS 2 tools to find your package, contains `__init__.py`
    - Anything else
- `ros2 run turtlesim turtlesim_node`

CMake

For CMake packages (C++), the package contents will be different.



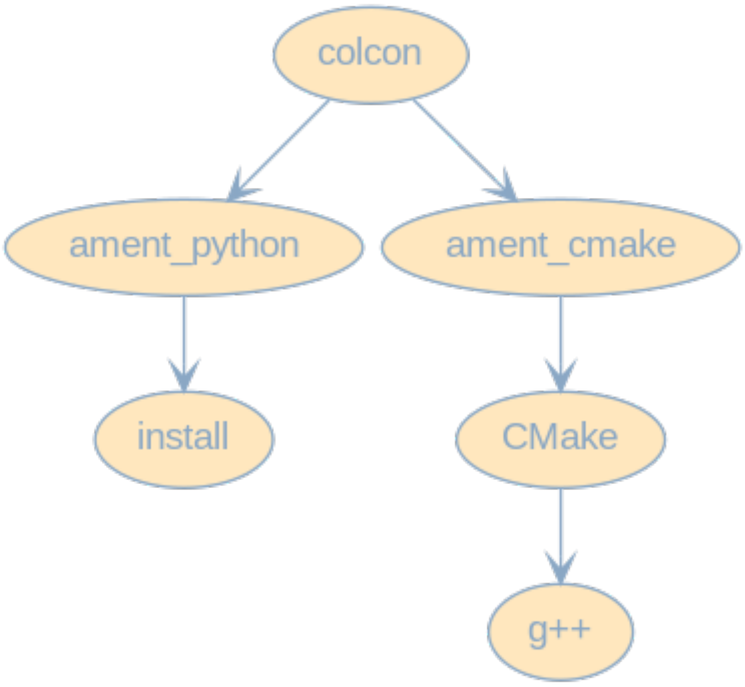
ROS node

- Executable part of ROS:
  - python scripts
  - compiled C++ code
- A process that performs computation
- Inter-node communication:
  - ROS topics (streams)
  - ROS parameter server
  - Remote Procedure Calls (RPC)
  - ROS services
  - ROS actions
- Meant to operate at a fine-grained scale
- Typically, a robot control system consists of many nodes, like:
  - Trajectory planning
  - Localization

- Read sensory data
- Process sensory data
- Motor control
- User interface
- etc.

ROS build system---Colcon

- System for building software packages in ROS



Environmental setup file

- setup.bash
- generated during init process of a new workspace
- extends shell environment
- ROS can find any resources that have been installed or built to that location

```
source ~/ros2_ws/install/setup.bash
```

Practice

1: Turtlesim

1. Start `turtlesim_node` and `turtle_teleop_key` nodes with the following commands, in separate terminal windows:

   ```
   ros2 run turtlesim turtlesim_node
   ```

   ```
   ros2 run turtlesim turtle_teleop_key
   ```

   Tip

   In **Terminator**, you can further divide the given window with Ctrl-Shift-O, Ctrl-Shift-E key combinations. Ctrl-Shift-W closes the active window.

   Abort execution

   `Ctrl-C`

2. Running the following ROS commands can provide useful information:

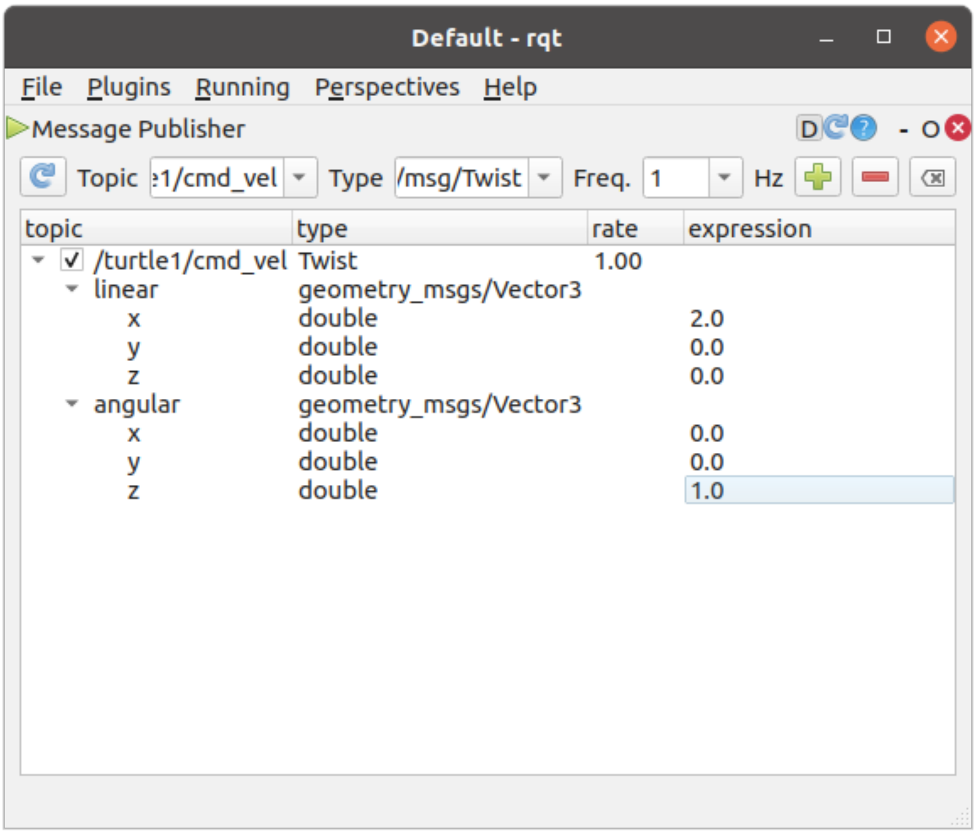
   ```
   ros2 wtf
   ros2 node list
   ros2 node info /turtlesim
   ros2 topic list
   ros2 topic info /turtle1/cmd_vel
   ros2 interface show geometry_msgs/msg/Twist
   ros2 topic echo /turtle1/cmd_vel
   ```

3. Start `rqt_gui` with the following command:

   ```
   ros2 run rqt_gui rqt_gui
   ```

4. Display the running nodes and topics in `rqt_gui`: Plugins → Introspection → Node Graph.

5. Publish to the `/turtle1/cmd_vel` topic also using `rqt_gui`: Plugins → Topics → Message Publisher.



Topic :1/cmd_vel Type /msg/Twist Freq. 1 Hz

topic	type	rate	expression
✓ /turtle1/cmd_vel	Twist	1.00	
linear	geometry_msgs/Vector3		
x	double		2.0
y	double		0.0
z	double		0.0
angular	geometry_msgs/Vector3		
x	double		0.0
y	double		0.0
z	double		1.0

2: ROS 2 workspace creation

1. Let's create a new ROS2 workspace with the name `ros2_ws`.

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

3: ROS 2 package creation

1. Let's create a new ROS2 package with the name `ros2_course` and a Hello World.

```
cd ~/ros2_ws/src
ros2 pkg create --build-type ament_python --node-name hello ros2_course
```

Syntax

`ros2 pkg create --build-type ament_python <package_name>`

2. Build the workspace.

```
cd ~/ros2_ws
colcon build --symlink-install
```

Symlink

The option `--symlink-install` links the source scripts to the Install space, so we don't have to build again after modification.

3. Insert the following line at the end of the `~/.bashrc` file:

```
source ~/ros2_ws/install/setup.bash
```

Import to QtCreator

New file or project → Other project → ROS Workspace. Select Colcon as Build System and `ros2_ws` as Workspace path.

Import to CLion

Set the Python interpreter to Python 3.8, `/usr/bin/python3`. Add the follwong path: `/opt/ros/foxy/lib/python3.8/site-packages`. Hozzuk létre a `compile_commands.json` fájlt a `~/ros2_ws/build` könyvtárban az alábbi tartalommal:

```
[
]
```

4. Test Hello World:

```
ros2 run ros2_course hello
```

4: Implementing a Publisher in Python

1. Navigate to the `ros2_ws/src/ros2_course/ros2_course` folder and create the `talker.py` file with the content below.

```python
import rclpy
from rclpy.node import Node

from std_msgs.msg import String


class MinimalPublisher(Node):

    def __init__(self):
        super().__init__('minimal_publisher')
        self.publisher_ = self.create_publisher(String, 'chatter', 10)
        timer_period = 0.5  # seconds
        self.timer = self.create_timer(timer_period, self.timer_callback)
        self.i = 0

    def timer_callback(self):
        msg = String()
        msg.data = 'Hello World: %d' % self.i
        self.publisher_.publish(msg)
        self.get_logger().info('Publishing: "%s"' % msg.data)
        self.i += 1


def main(args=None):
    rclpy.init(args=args)
    minimal_publisher = MinimalPublisher()
    rclpy.spin(minimal_publisher)

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


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

2. Add a new entry point in the `setup.py` file:

```
'talker = ros2_course.talker:main',
```

1. Build and run the node:

   ```
   cd ~/ros2_ws
   colcon build --symlink-install
   ros2 run ros2_course talker
   ```

2. Check the output of the node using `ros2 topic echo` command or `rqt_gui`.

5: Implementing a Subscriber in Python

1. Navigate to the `ros2_ws/src/ros2_course/ros2_course` folder and create the `listener.py` file with the content below.

   ```python
   import rclpy
   from rclpy.node import Node
   from std_msgs.msg import String


   class MinimalSubscriber(Node):

       def __init__(self):
           super().__init__('minimal_subscriber')
           self.subscription = self.create_subscription(
               String,
               'chatter',
               self.listener_callback,
               10)
           self.subscription  # prevent unused variable warning

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


   def main(args=None):
       rclpy.init(args=args)
       minimal_subscriber = MinimalSubscriber()
       rclpy.spin(minimal_subscriber)

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

```python
    rclpy.shutdown()

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

2. Add a new entry point in the `setup.py` file:

```
'listener = ros2_course.listener:main',
```

3. Build and run both nodes:

```
cd ~/ros2_ws
colcon build --symlink-install
ros2 run ros2_course talker
```

```
ros2 run ros2_course listener
```

1. Use `rqt_gui` to display the nodes and topics of the running system:

```
ros2 run rqt_gui rqt_gui
```

Useful links

- ROS 2 Tutorials
- What is a ROS 2 package?