Lecture 3

2021

INFO 802

Master Advanced Mechatronics

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ROS

ROS Command Tools

ROS message

Objectives

At the end of this lecture, you are excepted to :

- Use ROS command line tools to get information on nodes, topics and message type
- Know what a ROS message is made up of.
- Find which library a ROS message comes from.
- Create a custom ROS message file.
- Use messages with an Object in Python code.
- Achieve at least grade 80% of the Assignement

ROS Command Tools

Turtlesim

Turtle_teleop_key node

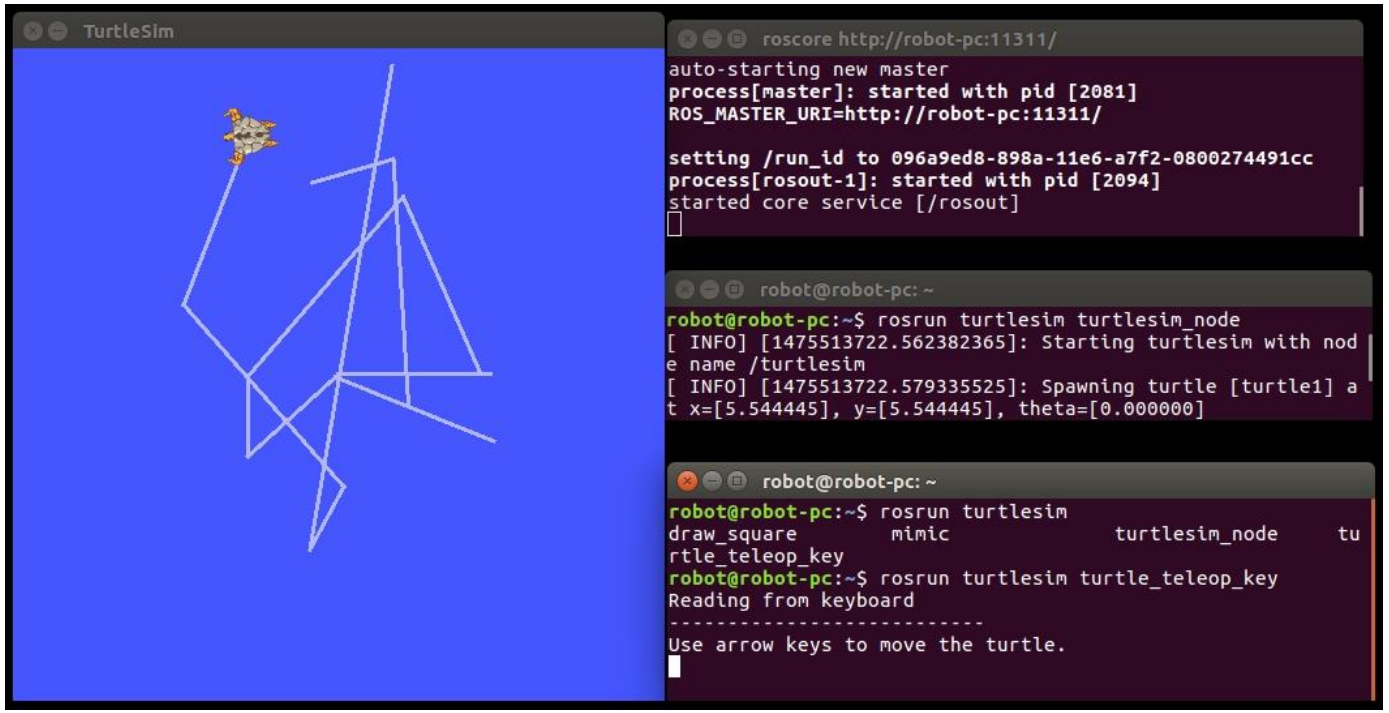
Test moving the turtle
(with the *turtle_teleop_key* node)

Recall: Open a terminal for each command

```
> roscore
```

```
> rosrun turtlesim turtlesim_node
```

```
> rosrun turtlesim turtle_teleop_key
```



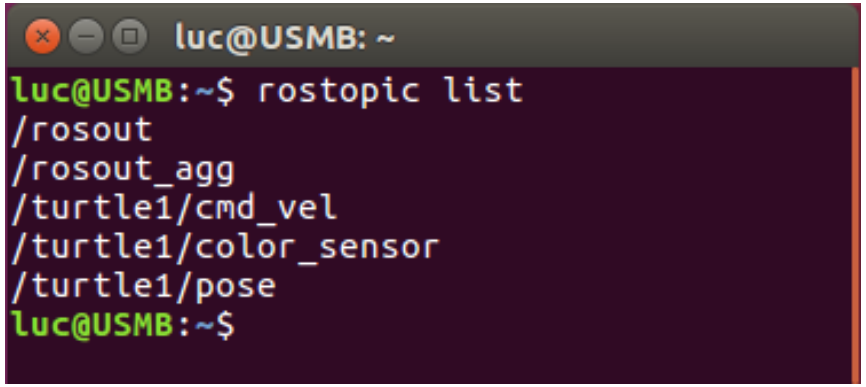
The terminal which *turtle_teleop_key* is running on MUST be selected.
Change the turtle's position by pressing arrow keys on the keyboard.

ROS Command Tools

topic

List all active topics on ROS:

```
> rostopic list
```



Display which message is used on a topic:

```
> rostopic type [topic_name]
```

```
luc@USMB:~$ rostopic type /turtle1/pose
turtlesim/Pose
```

Get more information on a topic:

```
> rostopic info [topic_name]
```

```
luc@USMB:~$ rostopic type /turtle1/pose
Type: turtlesim/Pose

Publishers:
 * /turtlesim (http://localhost:40351/)

Subscribers: None
```

ROS Command Tools

node

List all active node running on ROS:

```
> rosnode list
```

```
luc@USMB:~$ rosnode list
/rosout
/teleop_turtle
/turtlesim
```

Display information including publication/subscription:

```
> rosnode info [node_name]
```

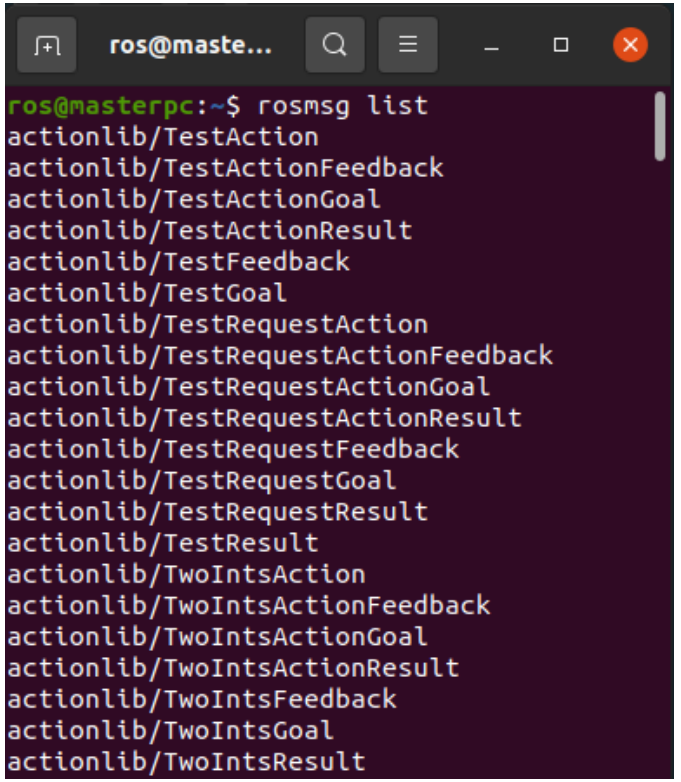
```
luc@USMB:~$ rosnode info turtlesim
--------------------------------------------------------------------------------
Node [/turtlesim]
Publications:
 * /rosout [rosgraph_msgs/Log]
 * /turtle1/color_sensor [turtlesim/Color]
 * /turtle1/pose [turtlesim/Pose]

Subscriptions:
 * /turtle1/cmd_vel [geometry_msgs/Twist]

Services:
 * /clear
 * /kill
 * /reset
 * /spawn
 * /turtle1/set_pen
 * /turtle1/teleport_absolute
```

ROS Command Tools

msg

Show all messages available in ROS:

```
> rosmsg list
```



Show the content of a message type:

```
> rosmsg show [message_type]
```

```
> rosmsg show turtlesim/Pose
```

```
luc@USMB:~$ rosmsg show turtlesim/Pose
[turtlesim/Pose]:
  float64 x
  float64 y
  float64 theta
  float64 linear_velocity
  float64 angular_velocity
```

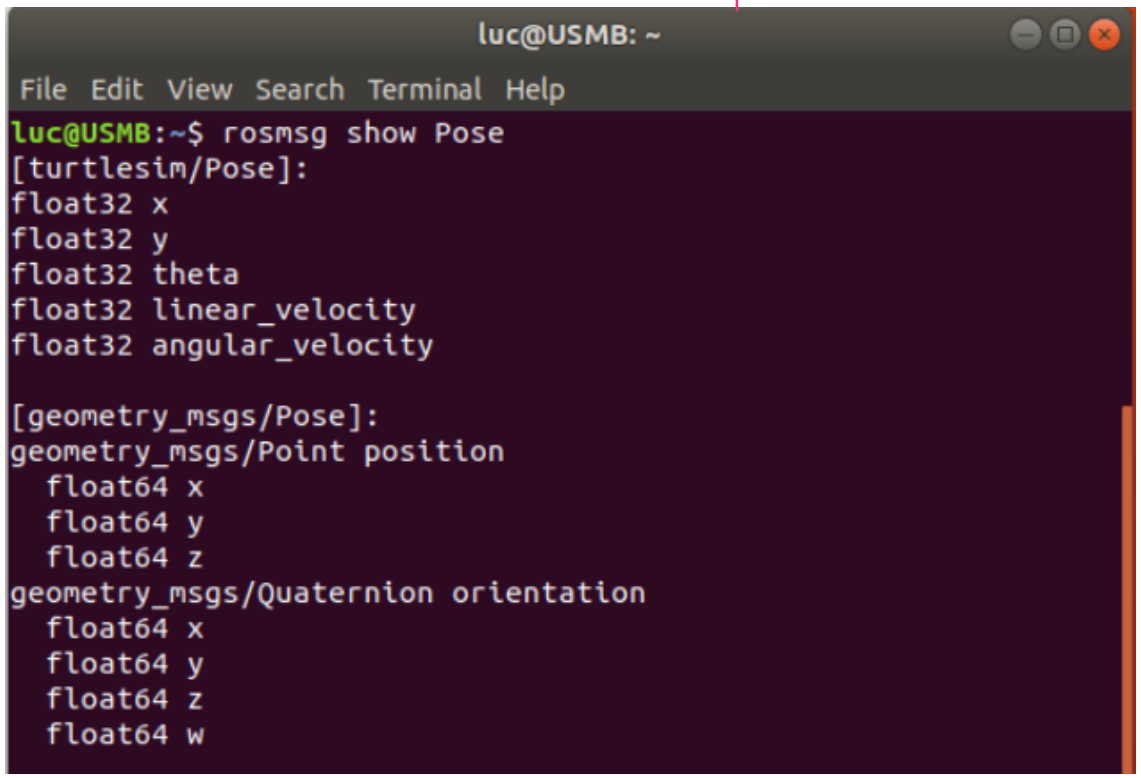
ROS Command Tools

msg

See message definition information:

```
> rosmsg show [message_type]
```

```
> rosmsg show Pose
```



The message of type *Pose* is defined in the package *turtlesim* but also in the package *geometry_msgs* but they are not the sames !

ROS Command Tools

System File

Get information on packages

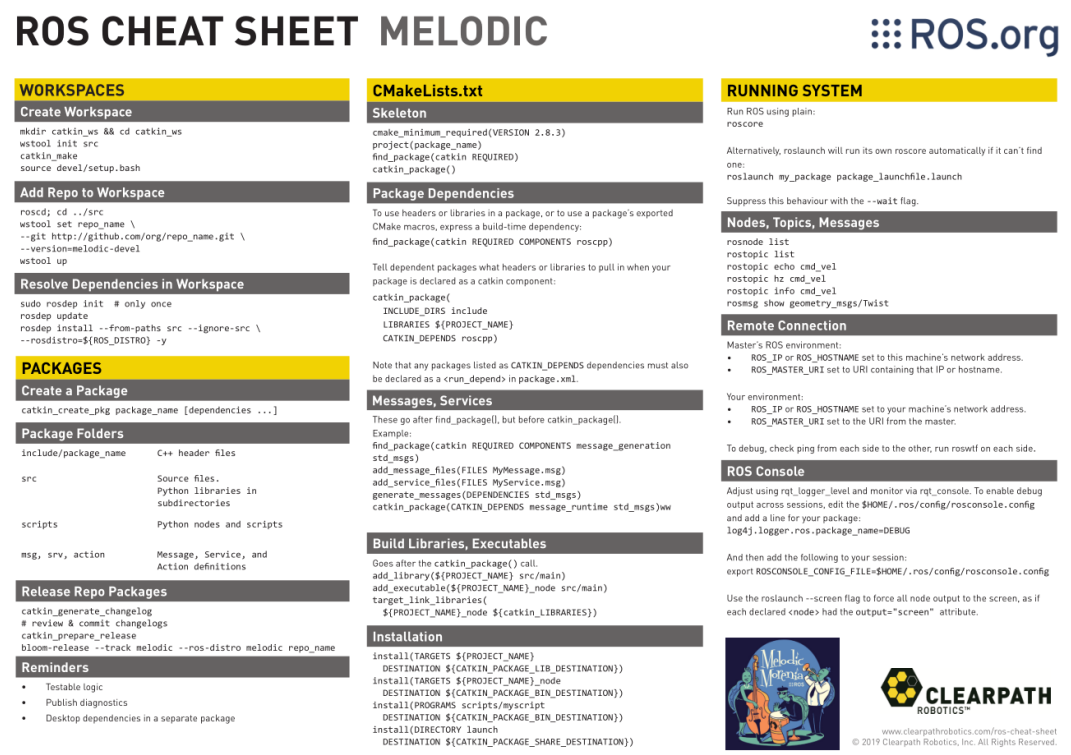
```
> rospack find [package_name]
```

Change directory (cd) directly to a package or a stack

```
> roscd [location_name[/subdir]]
```

ls directly in a package by name rather than by absolute path

```
> rosls [location_name[/subdir]]
```



ROS CHEAT SHEET MELODIC

ROS.org

WORKSPACES

Create Workspace

```
mkdir catkin_ws && cd catkin_ws
wstool init src
catkin_make
source devel/setup.bash
```

Add Repo to Workspace

```
roscd; cd ../src
wstool set repo_name \
--git http://github.com/org/repo_name.git \
--version=melodic-devel
wstool up
```

Resolve Dependencies in Workspace

```
sudo rosdep init  # only once
rosdep update
rosdep install --from-paths src --ignore-src \
--rosdistro=${ROS_DISTRO} -y
```

PACKAGES

Create a Package

```
catkin_create_pkg package_name [dependencies ...]
```

Package Folders

include/package_name	C++ header files
src	Source files. Python libraries in subdirectories
scripts	Python nodes and scripts
msg, srv, action	Message, Service, and Action definitions

Release Repo Packages

```
catkin_generate_changelog
# review & commit changelogs
catkin_prepare_release
bloom-release --track melodic --ros-distro melodic repo_name
```

Reminders

- Testable logic
- Publish diagnostics
- Desktop dependencies in a separate package

CMakeLists.txt

Skeleton

```
cmake_minimum_required(VERSION 2.8.3)
project(package_name)
find_package(catkin REQUIRED)
catkin_package()
```

Package Dependencies

To use headers or libraries in a package, or to use a package's exported CMake macros, express a build-time dependency:

```
find_package(catkin REQUIRED COMPONENTS roscpp)
```

Tell dependent packages what headers or libraries to pull in when your package is declared as a catkin component:

```
catkin_package(
  INCLUDE_DIRS include
  LIBRARIES ${PROJECT_NAME}
  CATKIN_DEPENDS roscpp)
```

Note that any packages listed as CATKIN_DEPENDS dependencies must also be declared as a <run_depend> in package.xml.

Messages, Services

These go after find_package(), but before catkin_package().
Example:

```
find_package(catkin REQUIRED COMPONENTS message_generation
std_msgs)
add_message_files(FILES MyMessage.msg)
add_service_files(FILES MyService.msg)
generate_messages(DEPENDENCIES std_msgs)
catkin_package(CATKIN_DEPENDS message_runtime std_msgs)ww
```

Build Libraries, Executables

Goes after the catkin_package() call.

```
add_library(${PROJECT_NAME} src/main)
add_executable(${PROJECT_NAME}_node src/main)
target_link_libraries(
  ${PROJECT_NAME}_node ${catkin_LIBRARIES})
```

Installation

```
install(TARGETS ${PROJECT_NAME}
  DESTINATION ${CATKIN_PACKAGE_LIB_DESTINATION})
install(TARGETS ${PROJECT_NAME}_node
  DESTINATION ${CATKIN_PACKAGE_BIN_DESTINATION})
install(PROGRAMS scripts/myscript
  DESTINATION ${CATKIN_PACKAGE_BIN_DESTINATION})
install(DIRECTORY launch
  DESTINATION ${CATKIN_PACKAGE_SHARE_DESTINATION})
```

RUNNING SYSTEM

Run ROS using plain:

```
roscore
```

Alternatively, roslaunch will run its own roscore automatically if it can't find one:

```
roslaunch my_package package_launchfile.launch
```

Suppress this behaviour with the --wait flag.

Nodes, Topics, Messages

```
rosnode list
rostopic list
rostopic echo cmd_vel
rostopic hz cmd_vel
rostopic info cmd_vel
rosmsg show geometry_msgs/Twist
```

Remote Connection

Master's ROS environment:

- ROS_IP or ROS_HOSTNAME set to this machine's network address.
- ROS_MASTER_URI set to URI containing that IP or hostname.

Your environment:

- ROS_IP or ROS_HOSTNAME set to your machine's network address.
- ROS_MASTER_URI set to the URI from the master.

To debug, check ping from each side to the other, run roswtf on each side.

ROS Console

Adjust using rqt_logger_level and monitor via rqt_console. To enable debug output across sessions, edit the $HOME/.ros/config/rosconsole.config and add a line for your package:

```
log4j.logger.ros.package_name=DEBUG
```

And then add the following to your session:

```
export ROSCONSOLE_CONFIG_FILE=$HOME/.ros/config/rosconsole.config
```

Use the roslaunch --screen flag to force all node output to the screen, as if each declared <node> had the output="screen" attribute.

CLEARPATH ROBOTICS™

www.clearpathrobotics.com/ros-cheat-sheet

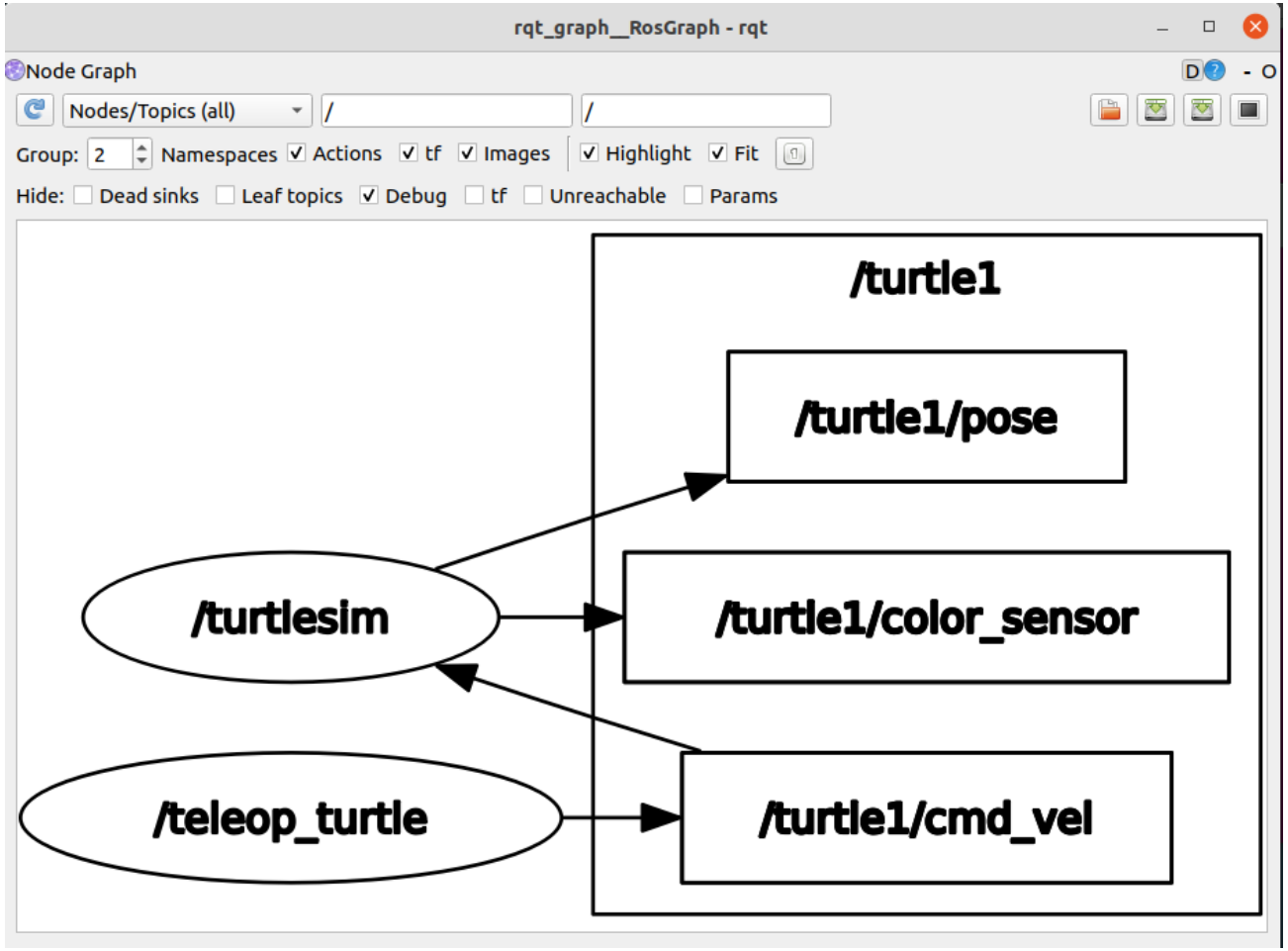
More info

http://wiki.ros.org/ROS/Tutorials/NavigatingTheFilesystem

ROS computation graph *rqt*

Visualize running topics and nodes

```
> rosrun rqt_graph rqt_graph
```

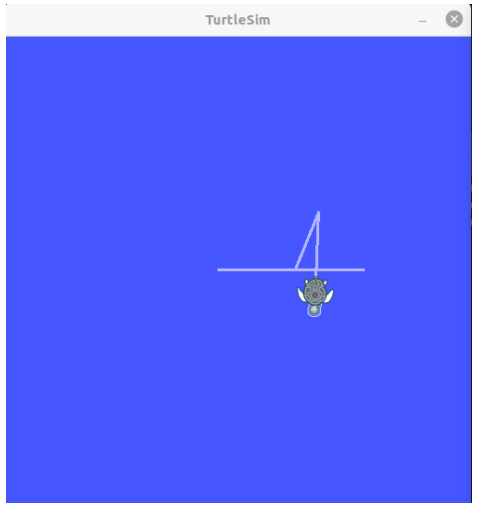


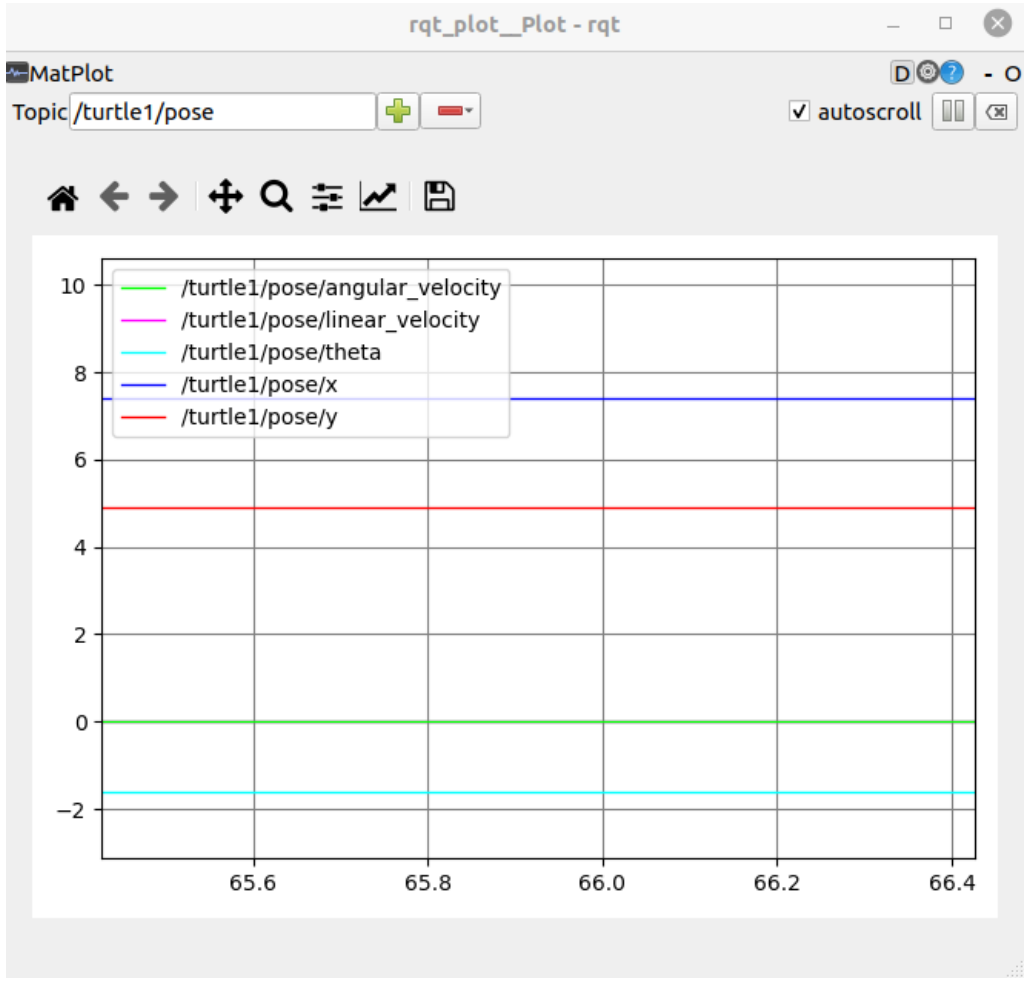
ROS computation graph *rqt*

Visualize running topics and nodes

```
> rosrun rqt_plot rqt_plot
```

It shows the values published on a topic





ROS computation graph *rqt*

- *rqt_graph* creates a dynamic graph of what's going on in the system
- *rqt_console* attaches to ROS's logging framework to display output from nodes. rqt_logger_level allows us to change the verbosity level (DEBUG, WARN, INFO, and ERROR) of nodes as they run.

- Prerequisit: Install rqt package

```
> sudo apt-get install ros-melodic-rqt ros-melodic-rqt-common-plugins
```

Launch rqt_console

```
> rosrun rqt_console rqt_console
```

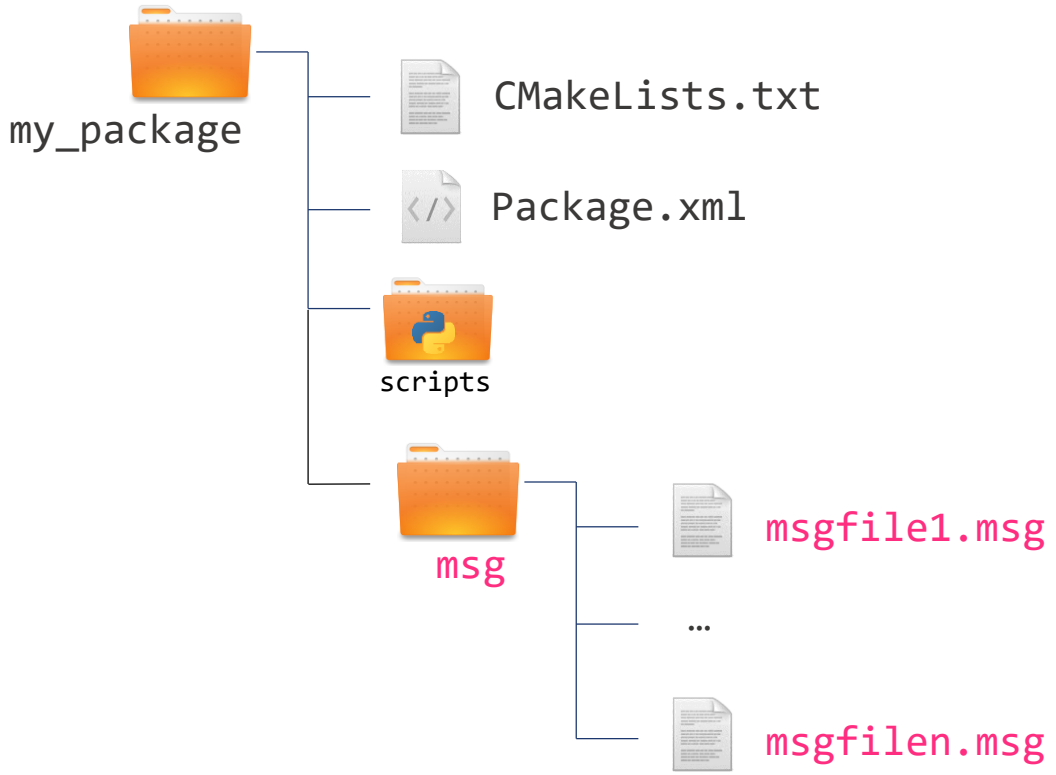
Launch rosrun rqt_logger_level rqt_logger_level (in an other terminal)

```
> rosrun rqt_logger_level rqt_logger_level
```

ROS Message

ROS Messages

- They are files where we put a specification about the type of data to be transmitted and the values of this data.
- Defined in **.msg* files stored in the msg subdirectory of a package



See message definition information with

```
> rosmsg show [message_type]
```

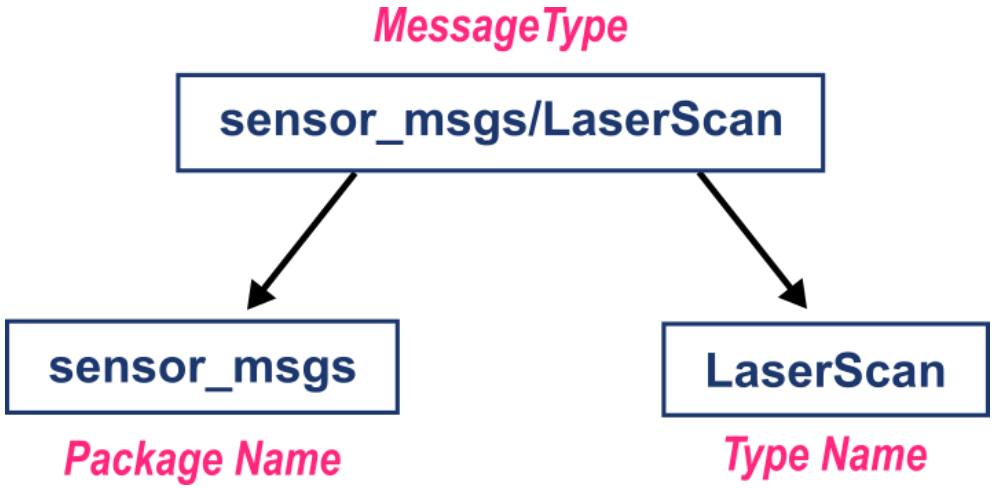
ROS Messages

- Every message type belongs to a specific package

Message type names always contain a slash, and the part before the slash is the name of the containing package:

```
package_name/type_name
```

Example:



ROS Messages

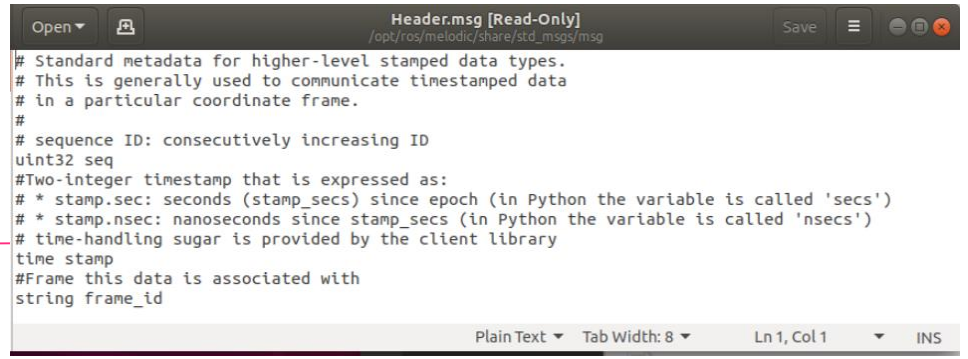
- msgs are just simple text files with a field type and field name per line. The field types you can use are:

```
•int8, int16, int32, int64 (plus uint*)
•float32, float64
•string
•time, duration
•other msg files
•variable-length array[] and fixed-length array[C]
```

- Header: special type in ROS

The header contains a timestamp and coordinate frame information that are commonly used in ROS to communicate timestamped data in a particular coordinate frame.

```
uint32 seq
time stamp
string frame_id
```



ROS Messages

- Standard type to use in message

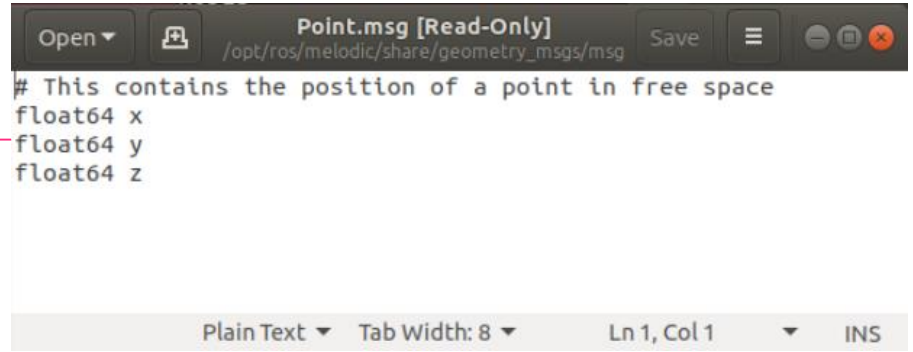
Primitive type	Serialization	C++	Python
bool	Unsigned 8-bit int	uint8_t	bool
int8	Signed 8-bit int	int8_t	int
uint8	Unsigned 8-bit int	uint8_t	int
int16	Signed 16-bit int	int16_t	int
uint16	Unsigned 16-bit int	uint16_t	int
int32	Signed 32-bit int	int32_t	int
uint32	Unsigned 32-bit int	uint32_t	int
int64	Signed 64-bit int	int64_t	long
uint64	Unsigned 64-bit int	uint64_t	long
float32	32-bit IEEE float	float	float
float64	64-bit IEEE float	double	float
string	ASCII string (4-bit)	std::string	string
time	Secs/nsecs signed 32-bit ints	ros::Time	rospy.Time
duration	Secs/nsecs signed 32-bit ints	ros::Duration	rospy.Duration

ROS Messages

- Examples

geometry_msgs/Point.msg

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



geometry_msgs/Quaternions.msg

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

ROS Messages

- Example

geometry_msgs/Point.msg

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

geometry_msgs/Pose.msg

```
geometry_msgs/Point position

geometry_msgs/Quaternion orientation
```

geometry_msgs/Quaternion.msg

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

You can use message type from already existing message

How to use ROS Messages in code?

Import the message type from the msg library

Use the message directly with an oriented object way

Use the message with an Object

```
#!/usr/bin/env python

from geometry_msg.msg import Pose
from beginner_tutorials.msg import My_Custom_Message

# without creating an object
Pose.position.x = 1.0

# by creating an object
My_Object = Pose()
My_Object.position.x = 1.0

My_Object.orientation.y = My_Object.position.x  + 43.2
```

```
luc@USMB:~$ rosmsg show geometry_msgs/Pose
[geometry_msg/Pose]:
geometry_msgs/Point position
  float64 x
  float64 y
  float64 z
geometry_msgs/Quaternion orientation
  float64 x
  float64 y
  float64 z
  float64 w
```

Creating a custom ROS msg

Edit *.msg file

- When Should You Make a New Message Type?

Only when you absolutely have to (check before with *rosmsg* to see if there is already something there that you can use instead).

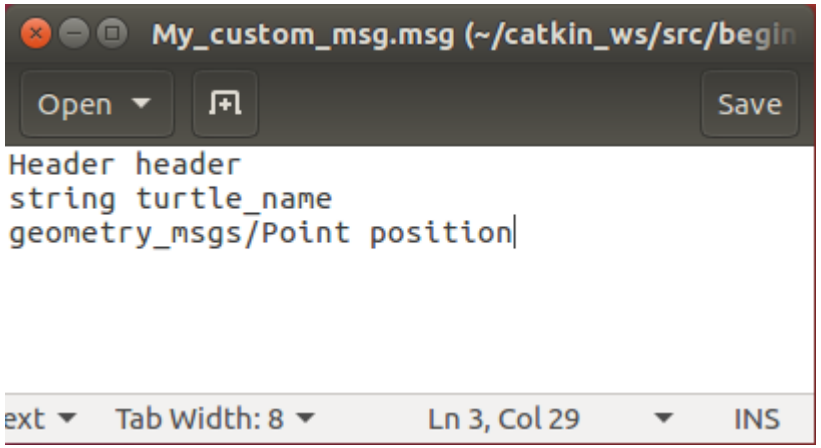
However, there are times when the built-in message types are not enough, and we have to define our own messages

Create a subfolder named **msg** in your package folder

```
> cd ~/catkin_ws/src/beginner_tutorials
> mkdir msg
```

Create a new my_custom_msg.msg file and add the following lines

```
> subl msg/my_custom_msg.msg
```



Creating a custom ROS msg

Modify package.xml file

- We need to make sure that the msg files are turned into source code for C++, Python, and other languages

uncomment those two lines in the package.xml file

```
<build_depend>message_generation</build_depend>
<run_depend>message_runtime</run_depend>
```

- Note that at build time, we need "message_generation", while at runtime, we need "message_runtime"

Creating a custom ROS msg

Modify CMakefile.txt file

- In CMakeLists.txt add the message_generation dependency to the find package call so that you can generate messages:

```
find_package(catkin REQUIRED COMPONENTS
  roscpp
  rospy
  std_msgs
  message_generation
)
```

- Also make sure you export the message runtime dependency:

```
catkin_package(
#  INCLUDE_DIRS include
#  LIBRARIES multi_sync
    CATKIN_DEPENDS roscpp rospy std_msgs message_runtime
#  DEPENDS system_lib
)
```

Creating a custom ROS msg

Modify CMakefile.txt file

- Find the following block

```
## Generate messages in the 'msg' folder
# add_message_files(
#   FILES
#   Message1.msg
#   Message2.msg
# )
```

- Uncomment it by removing the # symbols and then replace the stand in Message*.msg files with your .msg file, such that it looks like this:

```
add_message_files(
   FILES
   my_custom_msg.msg
)
```

Creating a custom ROS msg

Modifify CMakefile.txt file

- ensure the generate_messages() function is called: uncomment this lines

```
# generate_messages(
#   DEPENDENCIES
#   std_msgs
# )
```

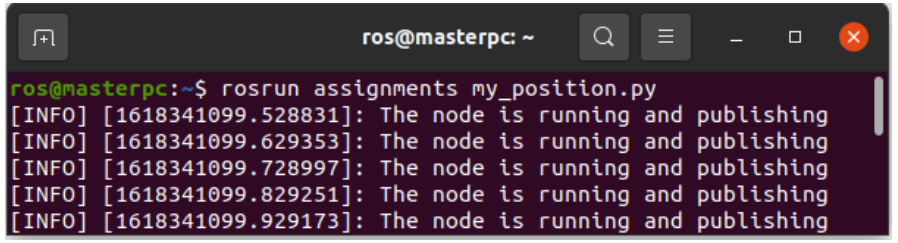
- So it looks like:

```
generate_messages(
  DEPENDENCIES
  std_msgs
)
```

cmake will then know that the project needs to be reconfigurated with the addition of msg files

Assignement

- Due to Wednesday April 8, 2020. (6pm max. deadline)
- Answer to question 1 to 5 and leave your responses on Moodle



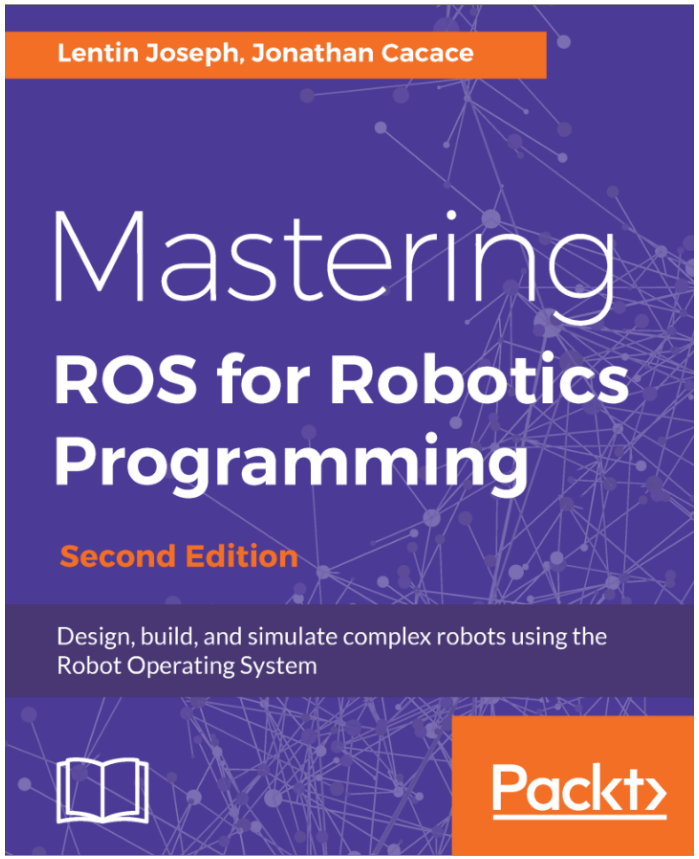
run the node *my_position.py* from the package *assignments*

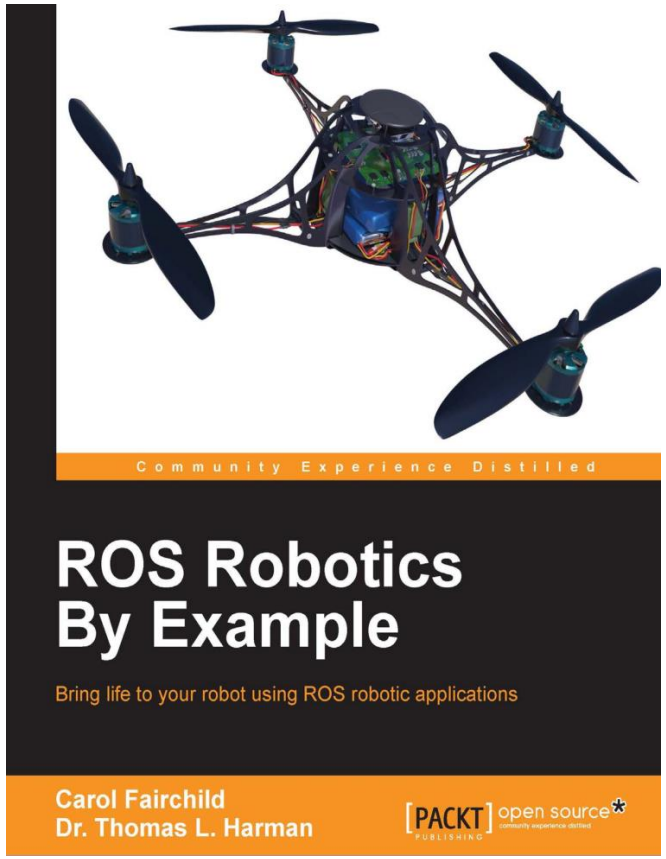
1. Find which topic the *my_position.py* publishes to
2. Find what message is used on this topic
3. Edit the node *get_position.py* in the package *assignments* so it subscribes to the topic …
4. … and prints in the Terminal only the y value of the coordinates.
5. run and validate the node *get_position.py*

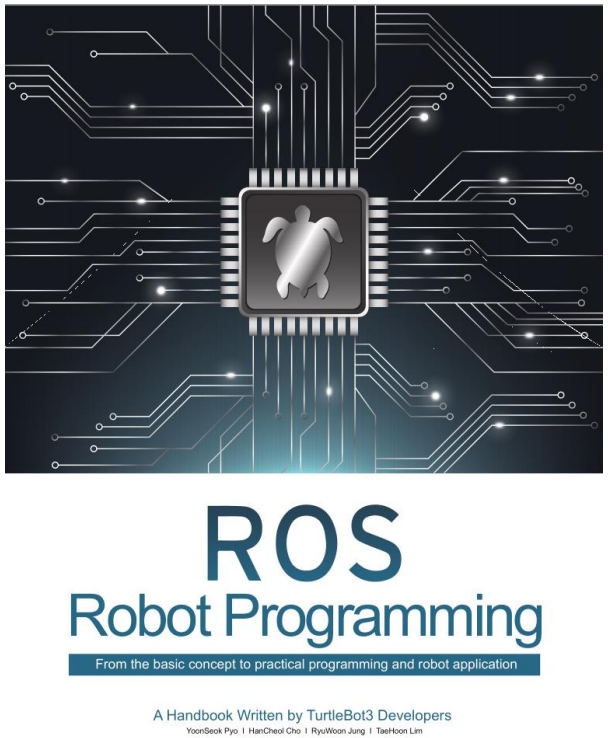
Further References

- ROS Wiki
  - http://wiki.ros.org/
- Installation
  - http://wiki.ros.org/ROS/Installation
- Tutorials
  - http://wiki.ros.org/ROS/Tutorials
- Available packages
  - http://www.ros.org/browse/
- ROS Cheat Sheet
  - https://www.clearpathrobotics.com/ros-robot-operating-system-cheat-sheet/
  - https://kapeli.com/cheat_sheets/ROS.docset/
- ROS Best Practices
  - https://github.com/leggedrobotics/ros_best_practices/wiki
- ROS Package Template
  - https://github.com/leggedrobotics/ros_best_practices/tree/master/ros_package_template

Relevant books







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SYMME

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