INFO 802

Master Advanced Mechatronics

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ROS

UNIVERSITÉ SAVOIE MONT BLANC

POLYTECH ANNECY-CHAMBÉRY

ROS message, ROS Service
Lecture 3

ROS Command Tools

See message definition information:

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

See active topics:

```
> rostopic list
```

See node information:

```
> rosnode info [message_type]
```

ROS System File

Commands

Get information on packages

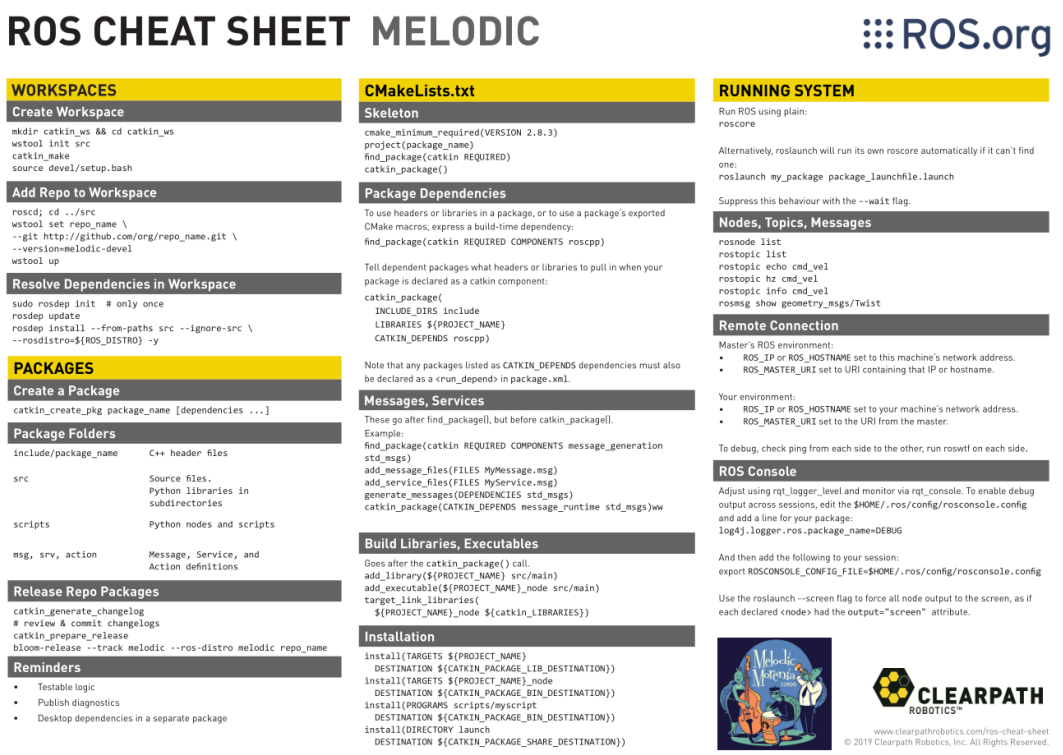
```
> rospack find [package_name]
```

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

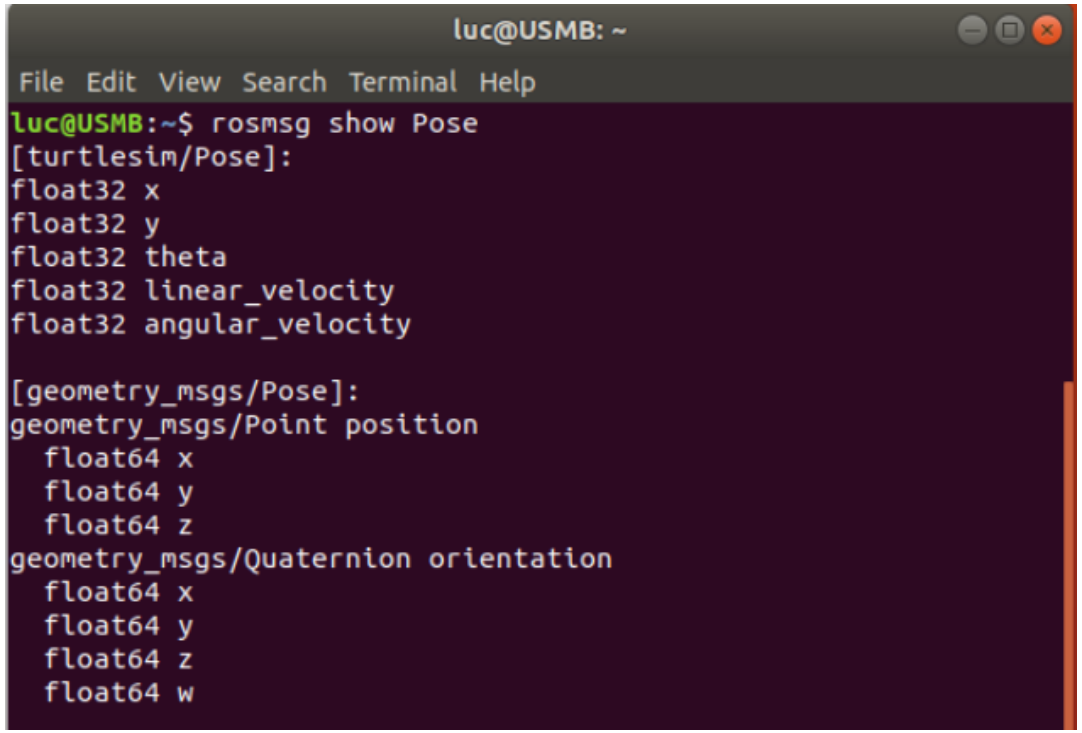
More info

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

ROS Command Tools

See message definition information:

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



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 computation graph *rqt*

Visualize running topics and nodes

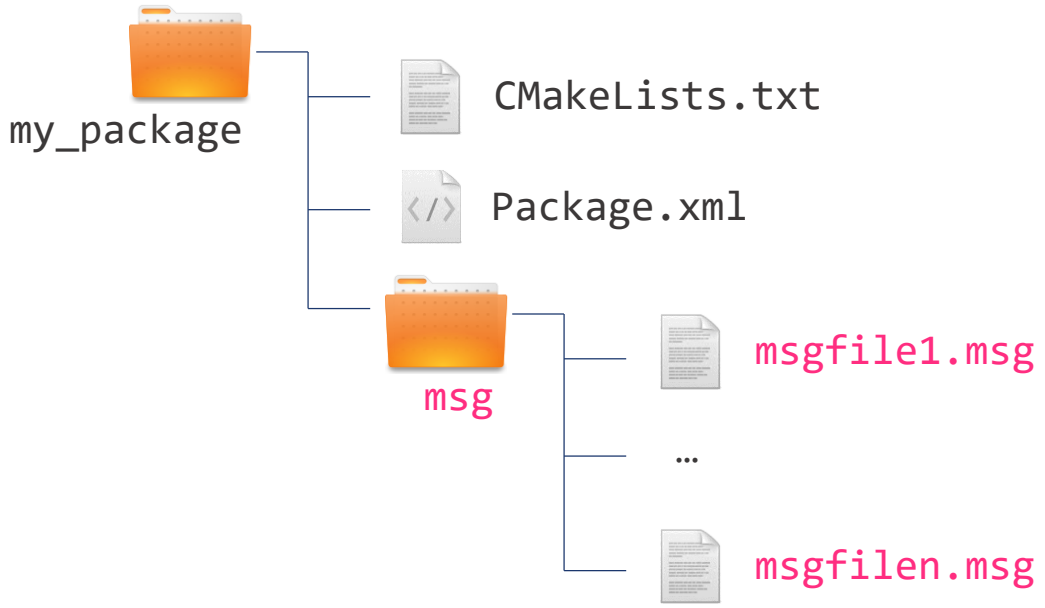
```
> rosrun rqt_graph rqt_graph
```

Visualize running topics and nodes

```
> rosrun rqt_plot rqt_plot
```

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]
```

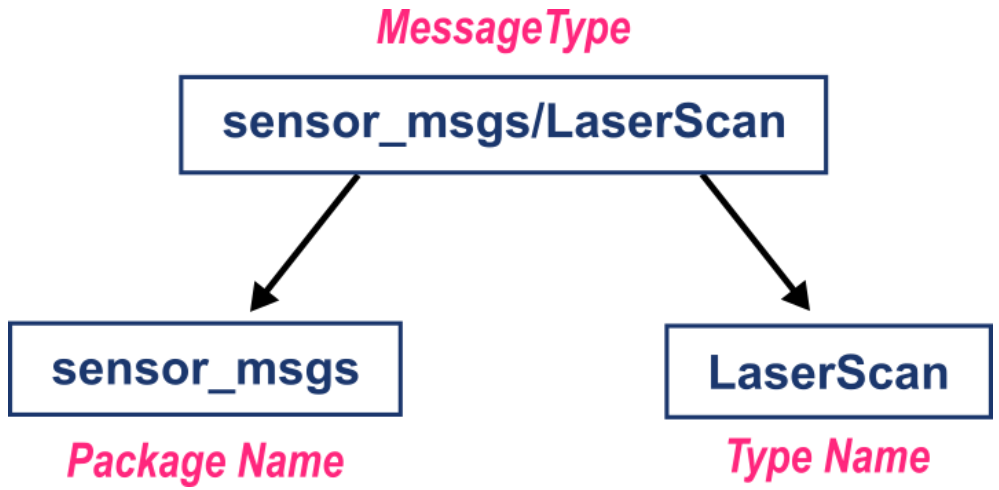
ROS Messages

- 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

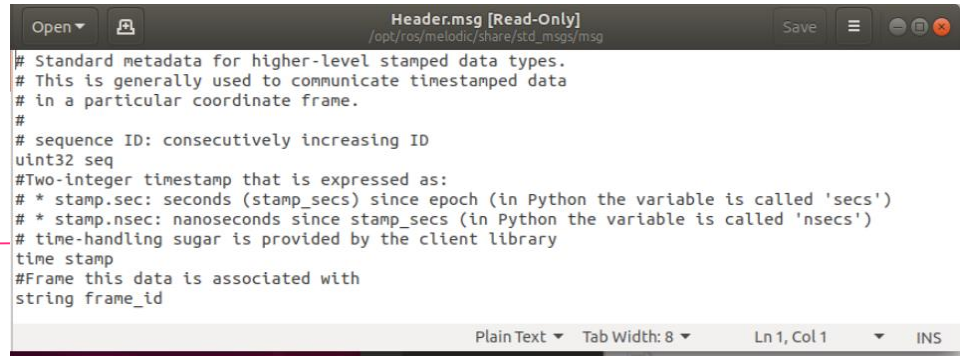
- msgs are just simple text files with a field type and field name per line. The field types you can use are:

```
•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

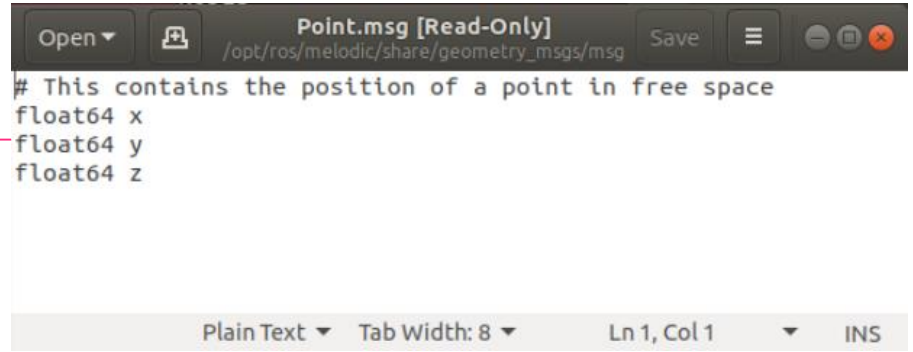
Primitive type	Serialization	C++	Python
bool	Unsigned 8-bit int	uint8_t	bool
int8	Signed 8-bit int	int8_t	int
uint8	Unsigned 8-bit int	uint8_t	int
int16	Signed 16-bit int	int16_t	int
uint16	Unsigned 16-bit int	uint16_t	int
int32	Signed 32-bit int	int32_t	int
uint32	Unsigned 32-bit int	uint32_t	int
int64	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/Points.msg

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

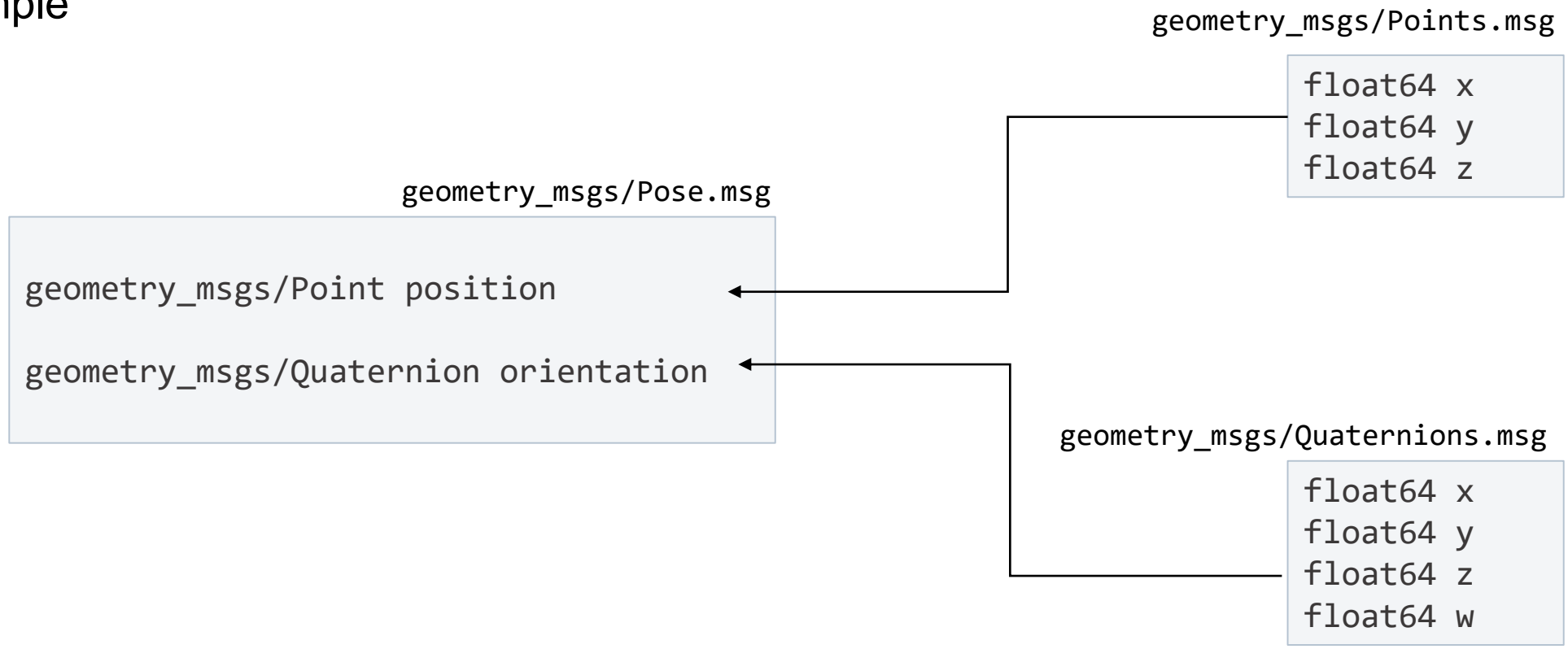


geometry_msgs/Quaternions.msg

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

ROS Messages

- Example



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
```

```
[geometry_msgs/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).

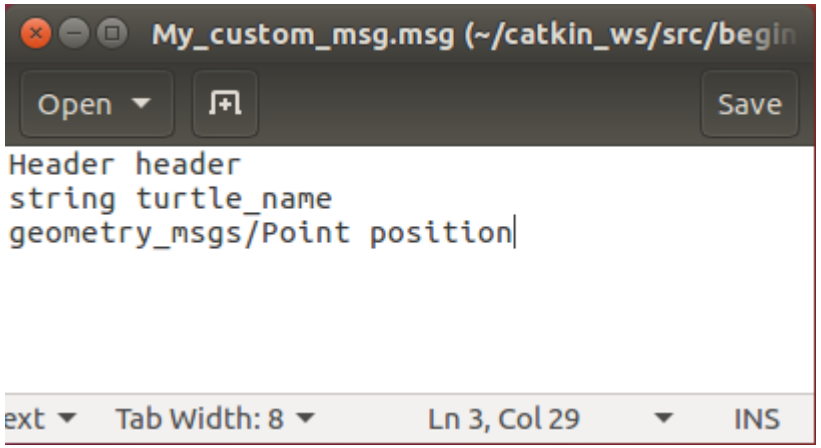
However, there are times when the built-in message types are not enough, and we have to define our own messages

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:

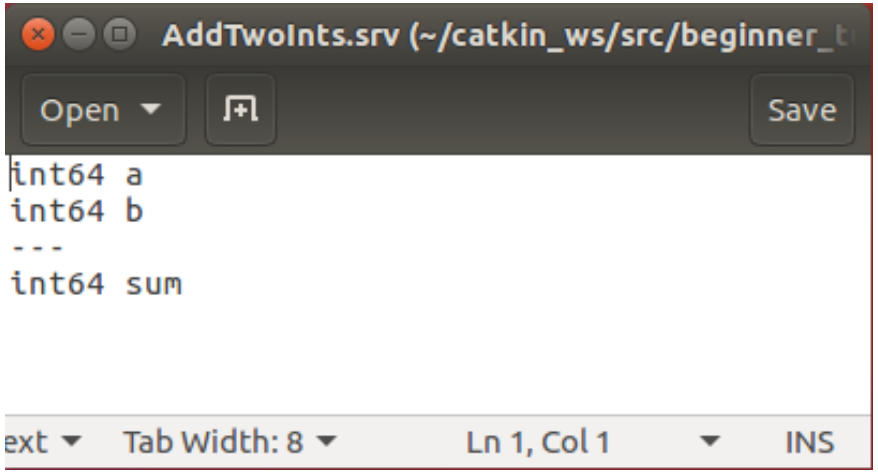
```
generate_messages(
  DEPENDENCIES
  std_msgs
)
```

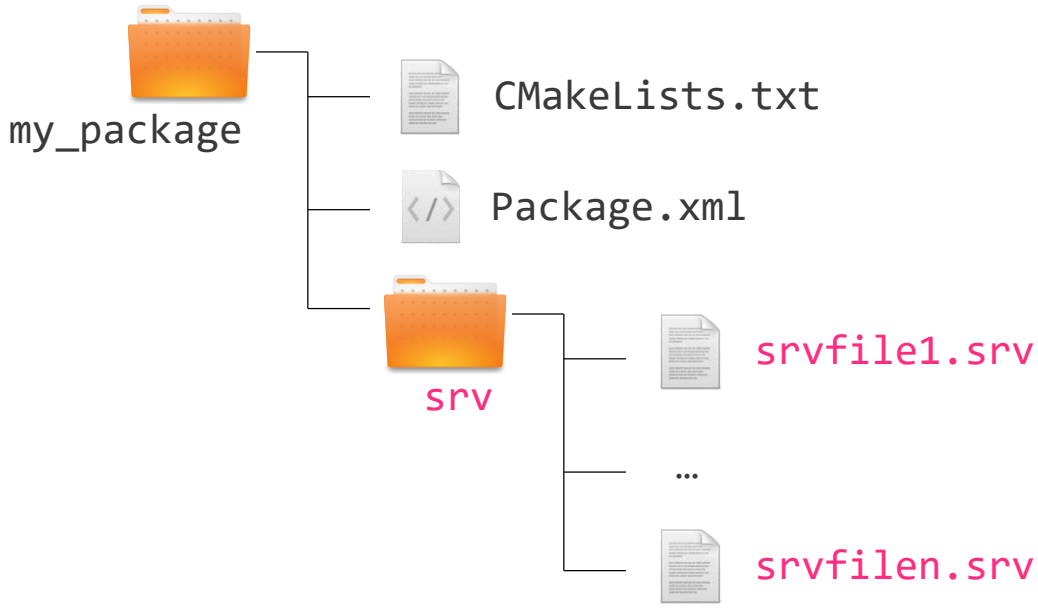
cmake will then know that the project needs to be reconfigurated with the addition of msg files

Creating a ROS srv

- Defined in **.srv* files stored in the srv subdirectory of a package

- srv files are just like msg files, except they contain two parts: a request and a response. The two parts are separated by a '---' line.





Creating a ROS srv

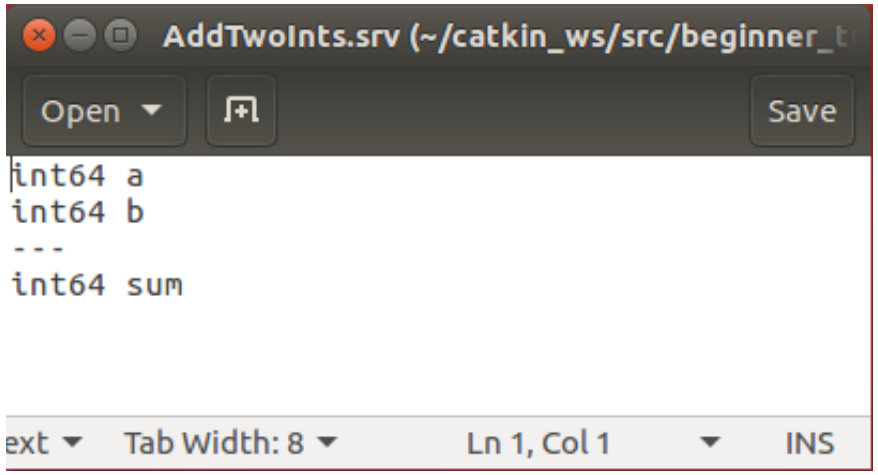
Modifify package.xml file

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

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

Example: create `AddTwoInts.srv` file and add the following lines

```
> subl srv/AddTwoInts.srv
```



Creating a ROS srv

Modify package.xml file

- We need to make sure that the srv 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 ROS srv

Modify CMakefile.txt file

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

  (Despite its name, message_generation works for both msg and srv.)

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

Creating a ROS srv

Modify CMakefile.txt file

- Find the following block

```
## Generate messages in the 'msg' folder
# add_service_files(
#   FILES
#   Service1.msg
#   Service2.msg
# )
```

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

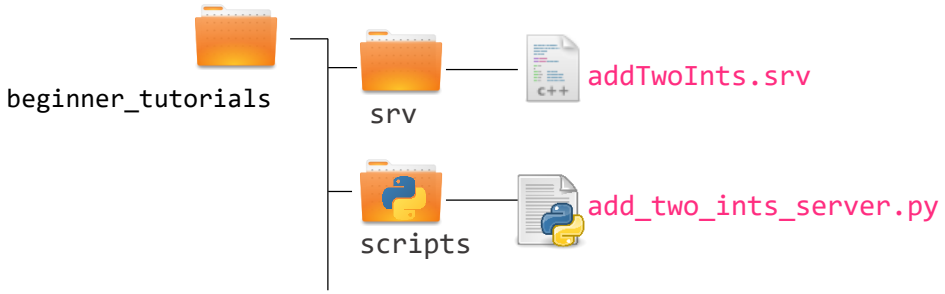
```
add_service_files(
   FILES
   AddTwoInts.srv
)
```

Creating a Service and Client Node (Python)

Writing the Service Node

Edit a py file in scripts folder

```
> cd ~/catkin_ws/beginner_tutorials/scripts
> sudo subl Add_two_ints_server.py
```



… and make it executable

```
> sudo chmod +x add_two_ints_server.py
```

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

from beginner_tutorials.srv import *
import rospy

def handle_add_two_ints(req):
    print "Returning [%s + %s = %s]"%(req.a, req.b, (req.a + req.b))
    return AddTwoIntsResponse(req.a + req.b)

def add_two_ints_server():
    rospy.init_node('add_two_ints_server')
    s = rospy.Service('add_two_ints', AddTwoInts,
handle_add_two_ints)
    print "Ready to add two ints."
    rospy.spin()

if __name__ == "__main__":
    add_two_ints_server()
```

Creating a Service and Client Node (Python)

Examining the Service Node

The *service* file has been defined and is located in the *srv* folder

init_node(): declare the node

This declares a new service named *add_two_ints* with the *AddTwoInts service* type. All requests are passed to *handle_add_two_ints* function. *handle_add_two_ints* is called with instances of AddTwoIntsRequest and returns instances of AddTwoIntsResponse.

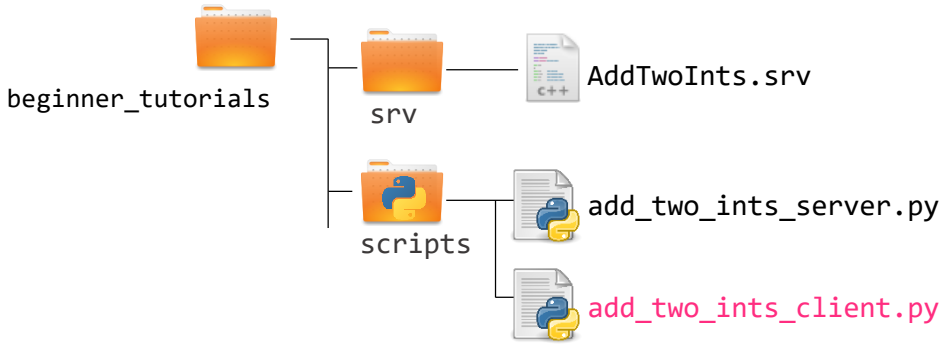
```
#!/usr/bin/env python

from beginner_tutorials.srv import *
import rospy

def handle_add_two_ints(req):
    print "Returning [%s + %s = %s]"%(req.a, req.b, (req.a + req.b))
    return AddTwoIntsResponse(req.a + req.b)

def add_two_ints_server():
    rospy.init_node('add_two_ints_server')
    s = rospy.Service('add_two_ints', AddTwoInts, handle_add_two_ints)
    print "Ready to add two ints."
    rospy.spin()

if __name__ == "__main__":
    add_two_ints_server()
```

Creating a Service and Client Node (Python)

Writing the Client Node

Edit a py file in scripts folder

```
> cd ~/catkin_ws/beginner_tutorials/scripts
> sudo subl Add_two_ints_client.py
```



… and make it executable

```
> sudo chmod +x Add_two_ints_client.py
```

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

import sys
import rospy
from beginner_tutorials.srv import *

def add_two_ints_client(x, y):
    rospy.wait_for_service('add_two_ints')
    try:
        add_two_ints = rospy.ServiceProxy('add_two_ints', AddTwoInts)
        resp1 = add_two_ints(x, y)
        return resp1.sum
    except rospy.ServiceException, e:
        print "Service call failed: %s"%e

def usage():
    return "%s [x y]"%sys.argv[0]

if __name__ == "__main__":
    if len(sys.argv) == 3:
        x = int(sys.argv[1])
        y = int(sys.argv[2])
    else:
        print usage()
        sys.exit(1)
    print "Requesting %s+%s"%(x, y)
    print "%s + %s = %s"%(x, y, add_two_ints_client(x, y))
```

Creating a Service and Client Node (Python)

Examining the Client Node

Wait for the service named *add_two_ints* to be advertised by the server

Once the service is advertised, we can set up a local proxy for it

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

import sys
import rospy
from beginner_tutorials.srv import *

def add_two_ints_client(x, y):
    rospy.wait_for_service('add_two_ints')
    try:
        add_two_ints = rospy.ServiceProxy('add_two_ints', AddTwoInts)
        resp1 = add_two_ints(x, y)
        return resp1.sum
    except rospy.ServiceException, e:
        print "Service call failed: %s"%e

def usage():
    return "%s [x y]"%sys.argv[0]

if __name__ == "__main__":
    if len(sys.argv) == 3:
        x = int(sys.argv[1])
        y = int(sys.argv[2])
    else:
        print usage()
        sys.exit(1)
    print "Requesting %s+%s"%(x, y)
    print "%s + %s = %s"%(x, y, add_two_ints_client(x, y))
```

Creating a Publisher and a Subscriber Node (Python)

Building the nodes

If not done yet: make the node executable (for Python only)

```
> subl chmod +x scripts/add_two_ints_server.py
> subl chmod +x scripts/add_two_ints_client.py
```

Build package
(we use Cmake as the build system even for Python nodes)

```
> cd ~/catkin_ws
> catkin_make beginner_tutorials
```

Make sure you have sourced your workspace's setup.bash file

```
> source ~/catkin_ws/devel/setup.bash
```

ROS Bags

- **rosbag:** set of tools for recording messages and playing back later to ROS topics offline.
- Can be used to mimic real sensor streams for offline debugging.
- Useful for debugging algorithm.
- The file a name is in the format: *file_name_ YYYY-MM-DD-HH-mm-ss.bag*

Record topics with

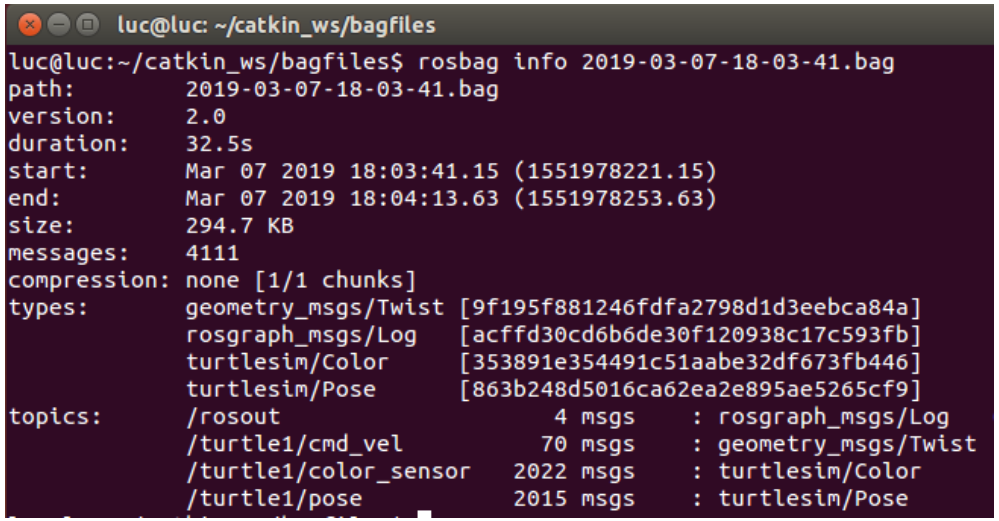
```
> rosbag record [topic_1] [topic_2] -o [bag_name]
```

Playback messages with

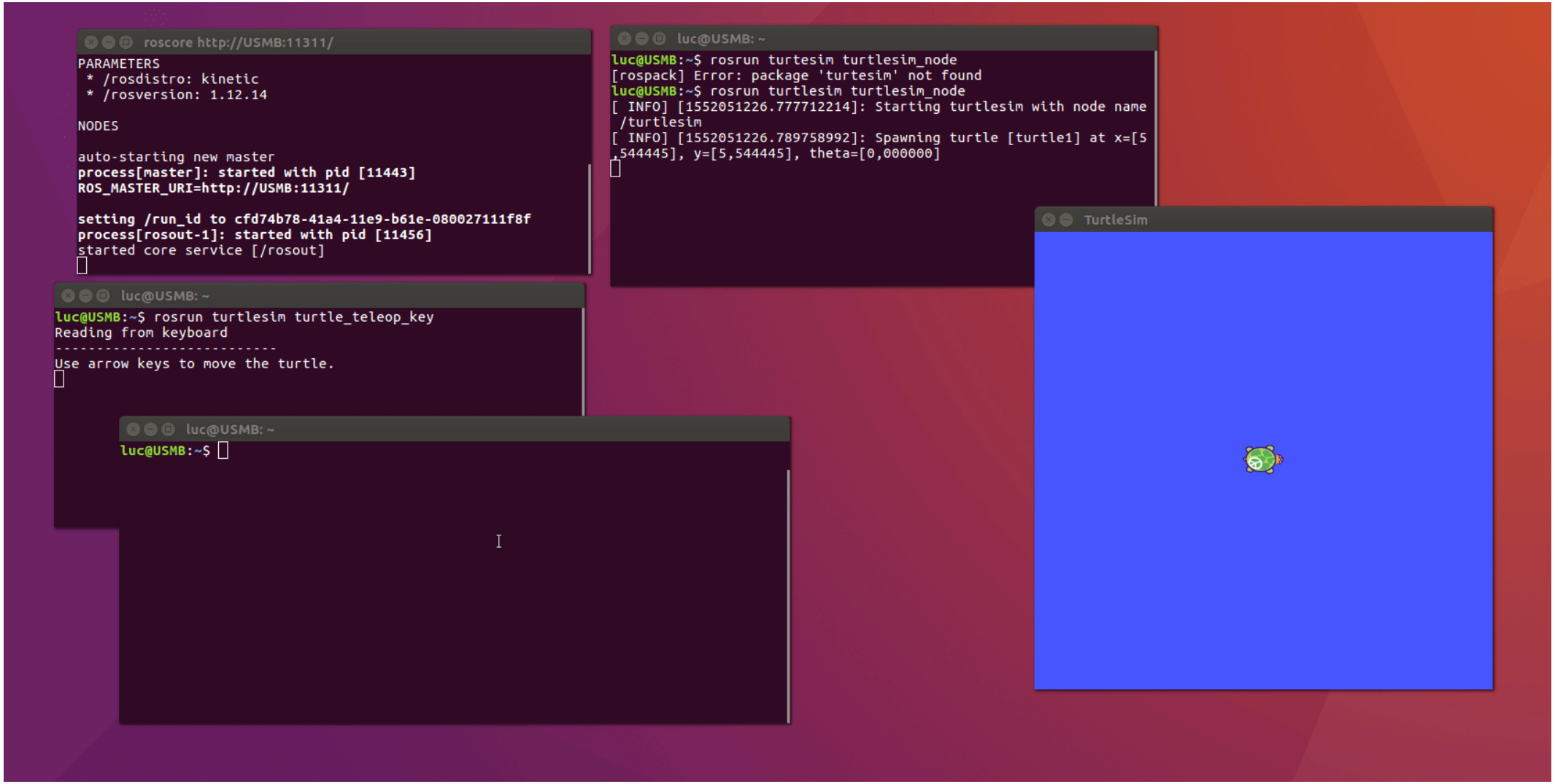
```
> rosbag play [bag_name]
```

Examples

```
> rosbag record –a

> rosbag play --clock mybag.bag
```



Example logging *turtlesim*



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
```

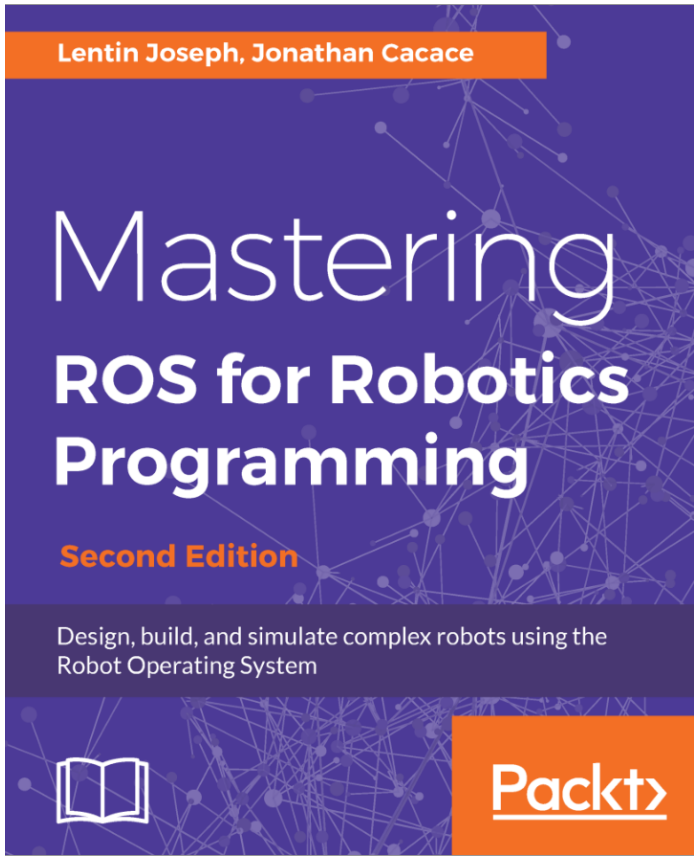
Launch rosrun rqt_logger_level rqt_logger_level (in an other terminal)

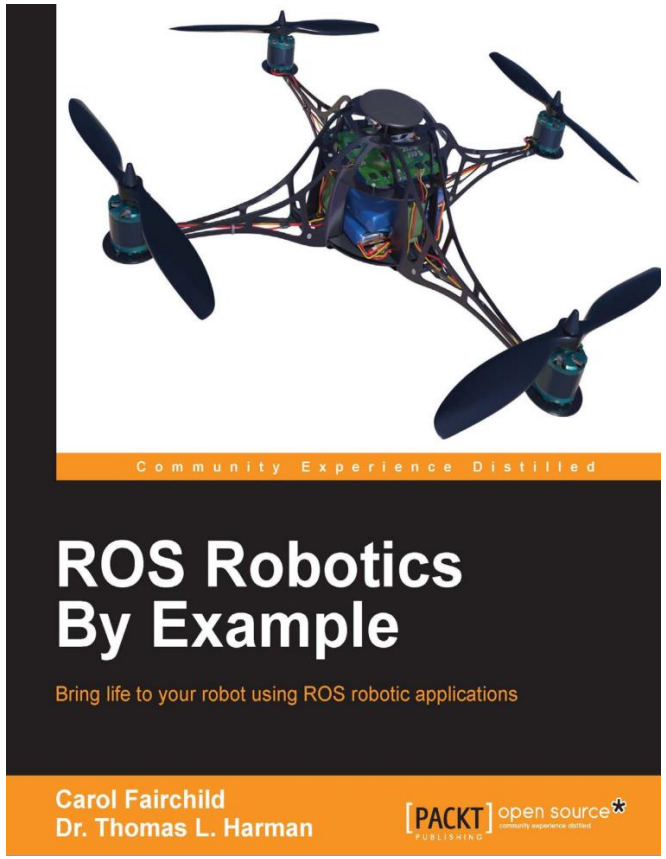
```
> rosrun rqt_logger_level rqt_logger_level
```

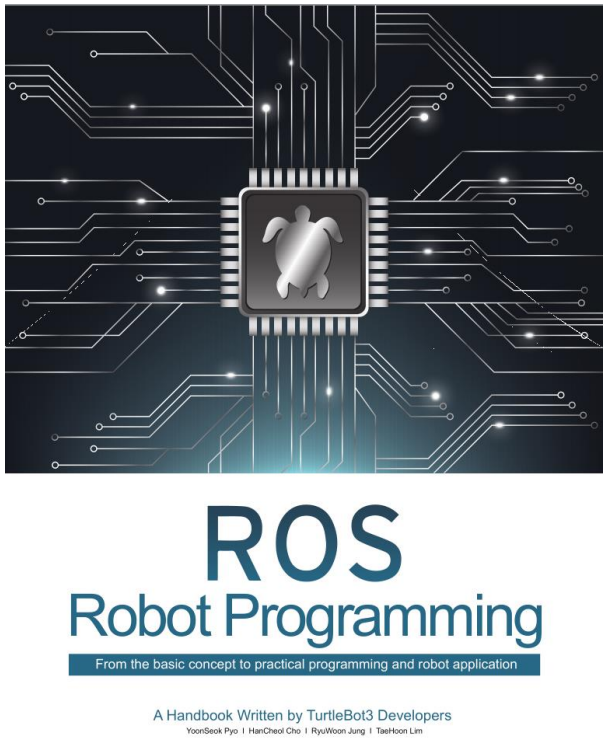
Further References

- 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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