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Robot Operating System – ROS

Introduction

Manchester Robotics

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Robot Operating System – ROS

Namespaces

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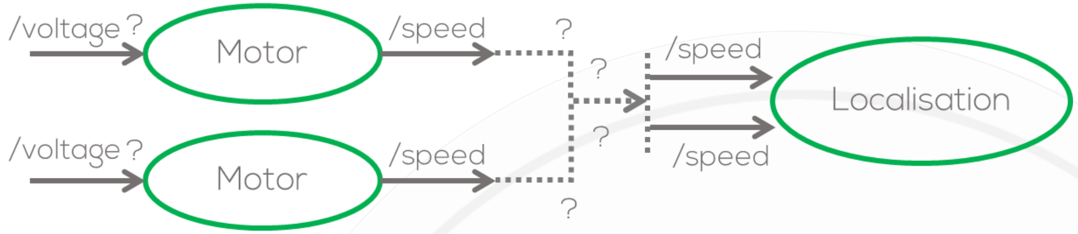
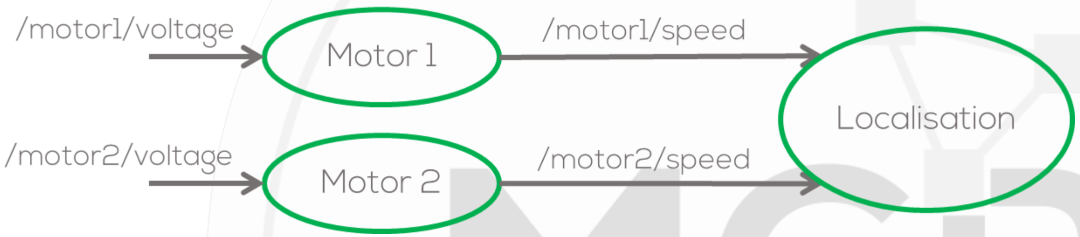
ROS Namespaces

- Imagine the following problem: you have a node that simulates a motor, and you require to simulate two (or more) motors using the same code.
- The problem in ROS will be the naming convention for the nodes and the topics to which the motor node subscribes, and where it publishes; since they will both be the same.
  - One simple solution will be to change the name of the nodes and topics manually by generating multiple .py files. For complex system this is not a good option. (What would happen if I require 10 motors?)
- Namespaces then become the best option to deal with name collisions, when systems become more complex.





ROS Namespaces

- A namespace in ROS can be viewed as a directory that contains items with different names.
- The items can be nodes, topics or other namespaces (hierarchy)
- There are several way to define the namespaces. The easiest way is via command line, which is very easy but for larger projects is not recommended.
- In this presentation, the file roslaunch will be used to define the namespaces.

Namespaces in ROS Example

For this example two talker nodes and two listener nodes will be generated using namespaces.

1. Open the launch file of the previous Talker and Listener Example (activity1.launch).
2. Modify it as follows

```
<?xml version="1.0" ?>
<launch>
   <group ns = "Group1">
      <node name="talker" pkg="basic_comms" type="talker.py" output="screen"    launch-
      prefix="gnome-terminal --command" />

      <node name="listener" pkg="basic_comms" type="listener.py" output="screen" launch-
      prefix="gnome-terminal --command" />
   </group>

   <group ns = "Group2">
      node name="talker" pkg="basic_comms" type="talker.py" output="screen" launch-
      prefix="gnome-terminal --command" />

      <node name="listener" pkg="basic_comms" type="listener.py" output="screen" launch-
      prefix="gnome-terminal --command" />
   </group>

</launch>
```

ROS Namespaces

ROS Launch

```
<?xml version="1.0" ?>
<launch>
  <group ns = "Group1">
    <node name="talker" pkg="basic_comms" type="talker.py"
    output="screen"    launch-prefix="gnome-terminal --command" />

    <node name="listener" pkg="basic_comms" type="listener.py"
    output="screen" launch-prefix="gnome-terminal --command" />
  </group>

  <group ns = "Group2">
    node name="talker" pkg="basic_comms" type="talker.py"
    output="screen" launch-prefix="gnome-terminal --command" />

    <node name="listener" pkg="basic_comms" type="listener.py"
    output="screen" launch-prefix="gnome-terminal --command" />
  </group>

</launch>
```

Group Namespace

Group Namespace

1. Execute the Launch file

```
$ roslaunch basic_comms activity1.launch
```

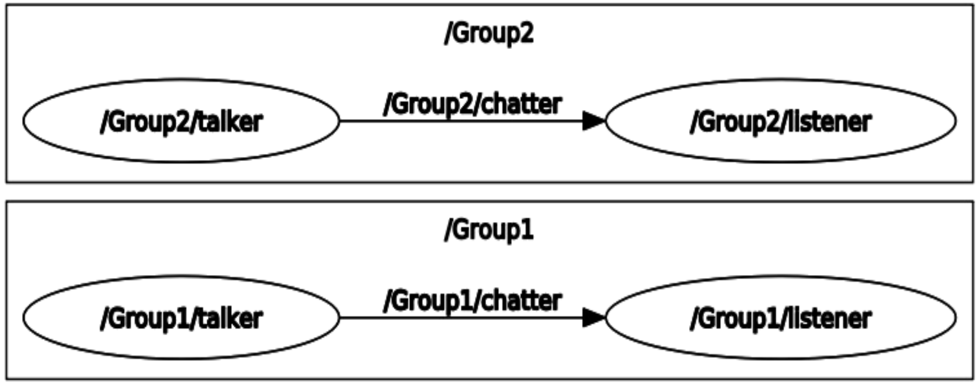
2. Execute the following command in a new terminal

```
$ rostopic list
```

3. In a new terminal, execute the rqt_graph to visualize the nodes

```
$ rosrun rqt_graph rqt_graph
```

```
student@ubuntu:~$ rostopic list
/Group1/chatter
/Group2/chatter
/rosout
/rosout_agg
student@ubuntu:~$
```



Robot Operating System – ROS

Parameter Files

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ROS Parameters

- Any software application, specially in robotics requires parameters.
- Parameters are variables with some predefined values that are stored in a separate file or hardcoded in a program such that the user has easy access to change their value.
- At the same time parameters can be shared amongst different programs to avoid rewriting them or recompiling the nodes (C++)
- In robotics, parameters are used to store values requiring tunning, robot names, sampling times or flags.
- ROS encourage the usage of parameters to avoid making dependencies or rewriting nodes.
- To this end, ROS uses a “dictionary” to store and share the parameters to be used by its nodes. This dictionary is called Parameter Server.

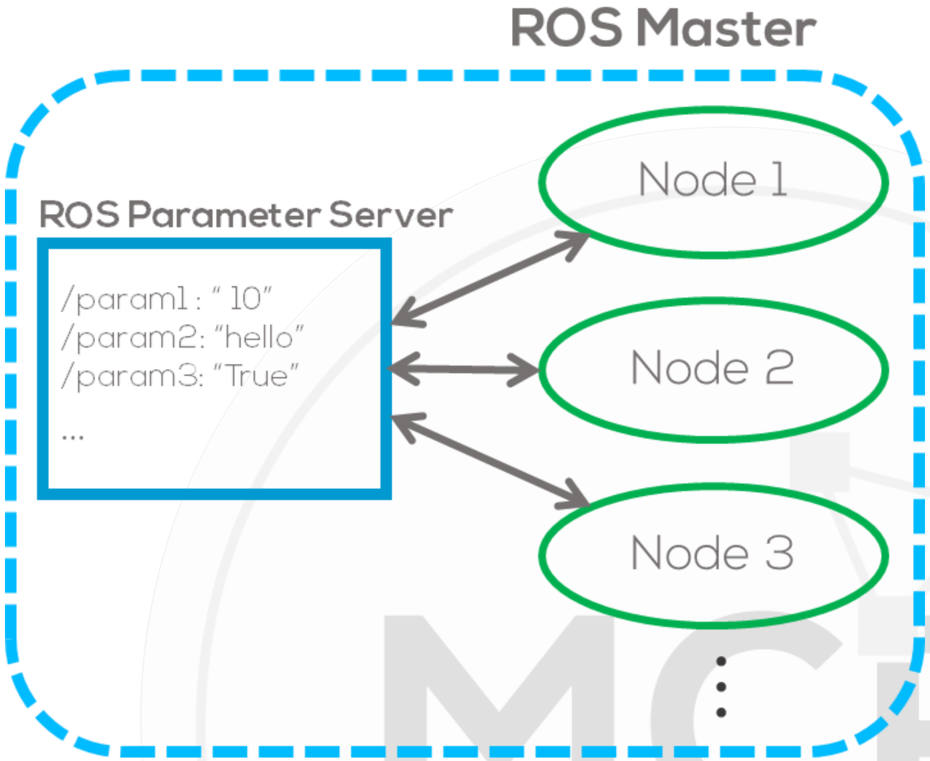
ROS Parameters

ROS Parameter Server

- As stated before, ROS allows to load variables into a server, run by the master which is accessible by all the nodes of the system.
- Nodes use this server to store and retrieve parameters at runtime.
- These parameters, are used to load settings, robot constants, or other data that may be used in different scenarios where the same code is applied.
- This is a globally viewed static library.
- Parameters are composed of a name and a datatype.

  ROS can use the following types of parameters. More information here.

- 32-bit integers
- Booleans
- strings
- doubles
- base64-encoded binary data



ROS Parameters

ROS Parameter Server

- In ROS parameters can be set in different ways.
- By the user in the launch files to be used by the nodes.
- They can also be taken from the command line and passed directly into the nodes.
- Set by nodes themselves.
- Parameters can be global (global namespace), within a local namespace (to a group of nodes only) or private i.e., specific to a node.
- It useful to point out that the parameter server depends on the execution of the ROS master not to the node execution time. Therefore, if you kill a node but not the master, the parameter will keep the value if it was modified.

ROS Parameter command line tools

- **rosparam**
  - *rosparam set [param]:* set a parameter
  - *rosparam get [param]:* get a parameter
  - *rosparam delete [param]:* delete parameter
  - *rosparam list:* list parameter names

** This is only a list with the most basic and used command line parameter tools. Other parameter command line tools can be seen here.

Parameters example

ROS Parameter Example (Setting the parameters)

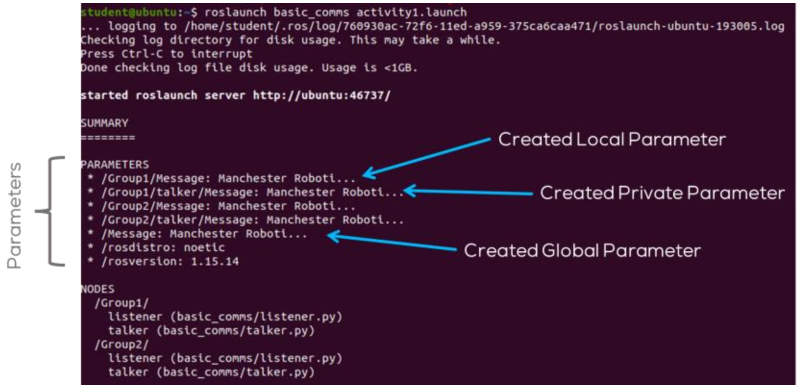
For this example, a global, a local, and a private parameters will be declared in the launch file.

1. Open the previous example Launch file "activity1.launch", and overwrite it as follows

```
<?xml version="1.0" ?>
<launch>

<param name = "Message" value = "Manchester Robotics Global!" />

   <group ns = "Group1">
            <param name = "Message" value = "Manchester Robotics Local!" />

            <node name="talker" pkg="basic_comms" type="talker.py" output="screen" launch-prefix="gnome-terminal --command" >
                   <param name = "Message" value = "Manchester Robotics Private!" />
            </node>
            <node name="listener" pkg="basic_comms" type="listener.py" output="screen" launch-prefix="gnome-terminal --command" />
   </group>

   <group ns = "Group2">
            <param name = "Message" value = "Manchester Robotics Local!" />
            <node name="talker" pkg="basic_comms" type="talker.py" output="screen" launch-prefix="gnome-terminal --command" >
                          <param name = "Message" value = "Manchester Robotics Private!" />
            </node>
            <node name="listener" pkg="basic_comms" type="listener.py" output="screen" launch-prefix="gnome-terminal --command" />
   </group>

</launch>
```

Parameters example

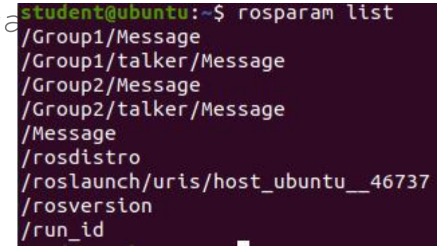
- Save the launch file and execute it as defined previously.
- You will see the parameters being displayed when ROS initializes



```
student@ubuntu:~$ roslaunch basic_comms activity1.launch
... logging to /home/student/.ros/log/760930ac-72f6-11ed-a959-375ca6caa471/roslaunch-ubuntu-193005.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://ubuntu:46737/

SUMMARY
========

PARAMETERS
 * /Group1/Message: Manchester Roboti...
 * /Group1/talker/Message: Manchester Roboti...
 * /Group2/Message: Manchester Roboti...
 * /Group2/talker/Message: Manchester Roboti...
 * /Message: Manchester Roboti...
 * /rosdistro: noetic
 * /rosversion: 1.15.14

NODES
  /Group1/
    listener (basic_comms/listener.py)
    talker (basic_comms/talker.py)
  /Group2/
    listener (basic_comms/listener.py)
    talker (basic_comms/talker.py)
```


- Open a terminal and type the following command to view the parameters

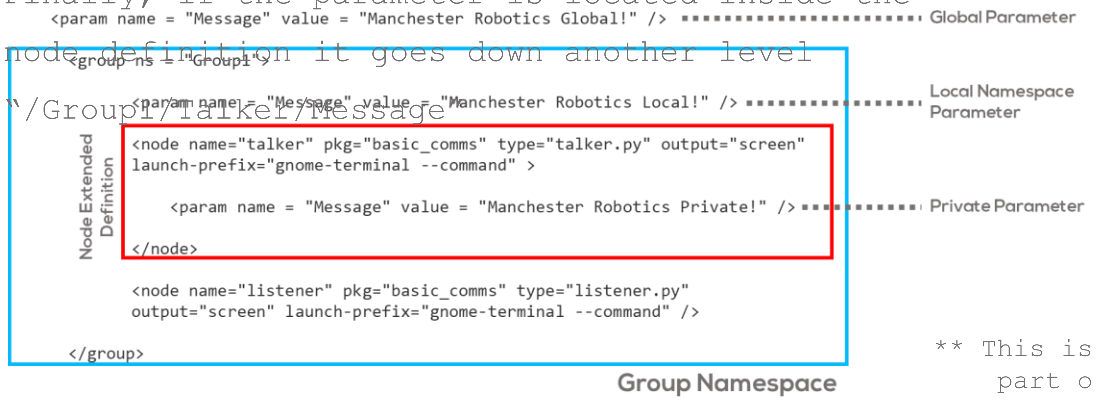
```
$ rosparam list
```



```
student@ubuntu:~$ rosparam list
/Group1/Message
/Group1/talker/Message
/Group2/Message
/Group2/talker/Message
/Message
/rosdistro
/roslaunch/uris/host_ubuntu__46737
/rosversion
/run_id
```

Launch file parameters

- The parameters declared outside the group's namespace are classified as global parameters. They are in the "root" of the directory therefore they only start with the forward slash "/". For this case, the parameter is depicted as "/Message"
- If the parameter is in the namespace of the group, the address decreases one level in this case "/Group1/Message".
- Finally, if the parameter is located inside the node definition it goes down another level "/Group1/talker/Message"



```
<param name = "Message" value = "Manchester Robotics Global!" />
<group ns = "Group1">
  <param name = "Message" value = "Manchester Robotics Local!" />
  <node name="talker" pkg="basic_comms" type="talker.py" output="screen"
  launch-prefix="gnome-terminal --command" >
     <param name = "Message" value = "Manchester Robotics Private!" />
  </node>
  <node name="listener" pkg="basic_comms" type="listener.py"
  output="screen" launch-prefix="gnome-terminal --command" />
</group>
```


** This is just part of the launch file

Parameters example

ROS Parameter Example (Getting the parameters)

This example will show hot to use the parameters inside the nodes.

The command t retrieve parameters in python is the following

```
rospy.get_param(<parameter_name>, <default_value>)
```

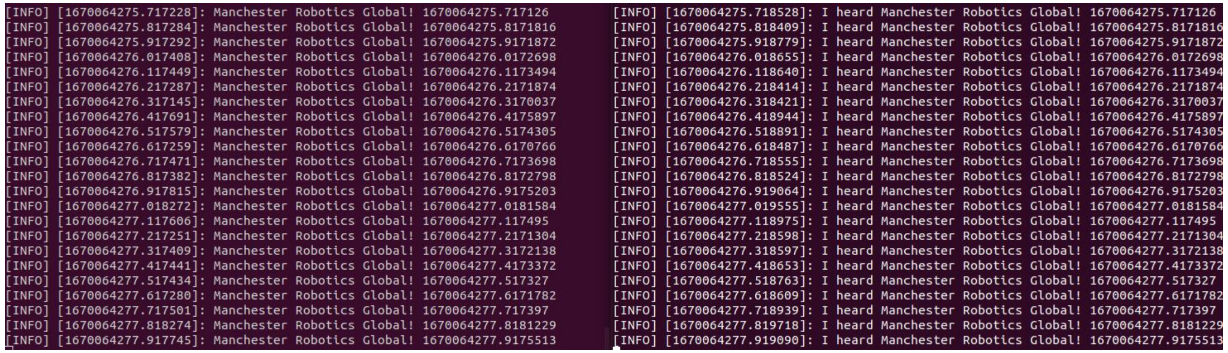
- Open the file “talker.py”

```
hello_str = “hello world %s” % rospy.get_time()
```

```
hello_str = rospy.get_param("/Message", "No Parameter Found")  + " " 
  + str(rospy.get_time())
```

- Save the file and execute it using the roslaunch file.

- The following results must be shown.



- For accessing the local namespace parameters and the private parameters modify the previous code accordingly. Run the code as before, and you should see the other parameters being printed.

More information here.

Local Parameter

```
hello_str = rospy.get_param("Message", "No Parameter Found")  + " " +
  str(rospy.get_time())
```

Private Parameter

```
hello_str = rospy.get_param(“~Message", "No Parameter Found")  + " " 
  + str(rospy.get_time())
```

**As in ubuntu use the tilde ~ for private addresses.

Parameter files

Parameter Files

- The previous way of defining parameters is very useful, but for the case when having to define many different parameters this can become very inefficient.
- ROS offers the capability to define parameters using a parameter file.
- These types of files are configuration files, written in YAML. These files are commonly used in other languages to set up parameters or variables.
- The following example will be used to show how to create config files and interact with them.

- **The parameters set up in the config files (YAML Files) can be declared as before global, local to a parent namespace or private.**
- **The way to define the hierarchy of a parameter, like in python depends on spacing.**

```
Message: "Parameter YAML File Global“

Group1:
   Message: "Parameter YAML File local G1"
   talker:
          Message: "Parameter YAML File private G1“
```

- **For this case, “Message” is a global parameter which will be named “/Message” since its located in the root directory.**
- **The same applies for the following “Message” Parameters, since they will be located a namespace level and a private level for the node “talker”.**

Parameter files

Parameter files example

For this example, we will use the previous example.

1. **Inside the "basic_comms" package, create a folder named "config".**
2. **Inside the config folder create a file named "params.yaml" (the file can have any name just make sure follow a convention properly).**

```
catkin_workspace
  ├ build
  ├ devel
  └ src
      └ basic_comms
          ├ CMakeLists.txt
          ├ package.xml
          ├ src
          ├ launch
          └ config
              └ params.yaml
```

Parameter files

3. Open the newly created parameter file (params.yaml) and edit it as follows

```yaml
Message: "Parameter YAML File Global“

Group1:
   Message: "Parameter YAML File local G1"
   talker:
          Message: "Parameter YAML File private G1“

Group2:
   Message: "Parameter YAML File G2"
   talker:
          Message: "Parameter YAML File private G2"
```

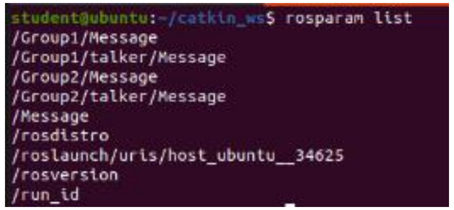
4. Save it and close the file.
5. Open the roslaunch file (activity1.launch)
6. Modify the launch file as follows, save it and close it.

```xml
<?xml version="1.0" ?>
<launch>

    <rosparam file = "$(find basic_comms)/config/params.yaml" command = "load" />

    <group ns = "Group1">
        <node name="talkerG1" pkg="basic_comms" type="talker.py" output="screen"
    launch-prefix="gnome-terminal --command" />
        <node name="listenerG1" pkg="basic_comms" type="listener.py" output="screen"
    launch-prefix="gnome-terminal --command" />
    </group>

    <group ns = "Group2">
        <node name="talkerG2" pkg="basic_comms" type="talker.py" output="screen"
    launch-prefix="gnome-terminal --command" />
        <node name="listenerG2" pkg="basic_comms" type="listener.py" output="screen"
    launch-prefix="gnome-terminal --command" />
    </group>

</launch>
```

- The first line is where the address of the params.yaml file is located. The label “$(find basic_comms)” allows to the launch file to determine that the path to the config file is inside the package “basic_coms”.

Parameter files

6. Run the modified launch file.
7. Open a new terminal and type **rosparam list**



8. To access each parameter as before, the **get_parameter** function must be modified as follows.

Global Parameter

```
hello_str = rospy.get_param("/Message", "No Parameter Found")  + " "
   + str(rospy.get_time())
```

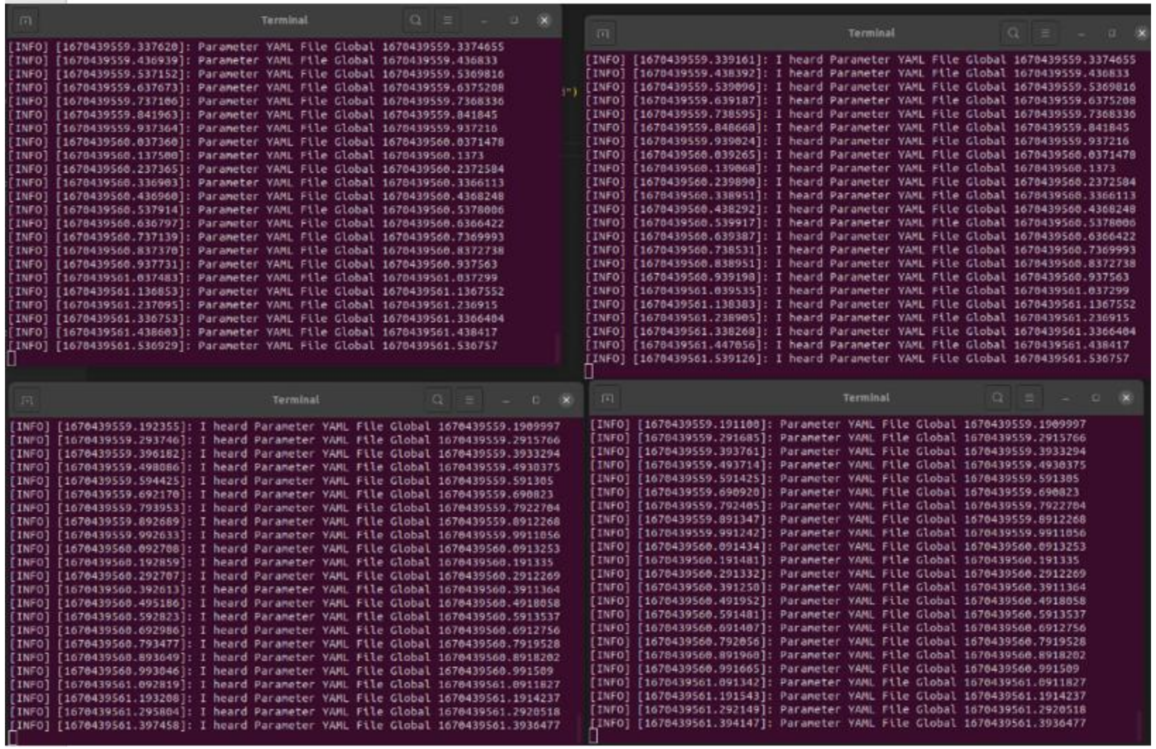
Local Namespace Parameter

```
hello_str = rospy.get_param("Message", "No Parameter Found")  + " " +
   str(rospy.get_time())
```

Private Parameter

```
hello_str = rospy.get_param("~Message", "No Parameter Found")  + " "
   + str(rospy.get_time())
```

- The Following image, shows the result when using the global parameter.



Robot Operating System – ROS

Custom Messages

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ROS Packages

Configuration Files

- As seen before, packages are the “buildable and redistributable units” of ROS code. Therefore, to build a package it is necessary to build the entire package as one piece.
- In most projects, the user would require to build multiple packages to group nodes, libraries and other resources for different purposes/functionalities.
- ROS has the package tool called Catkin to help build multiple packages at once.
  - Catkin, lets us group the packages into a workspace, and allows us to build all the packages inside the workspace.
- To do this, Catkin require different configuration files to properly define the dependencies and properties (meta information) for the different

ROS Packages

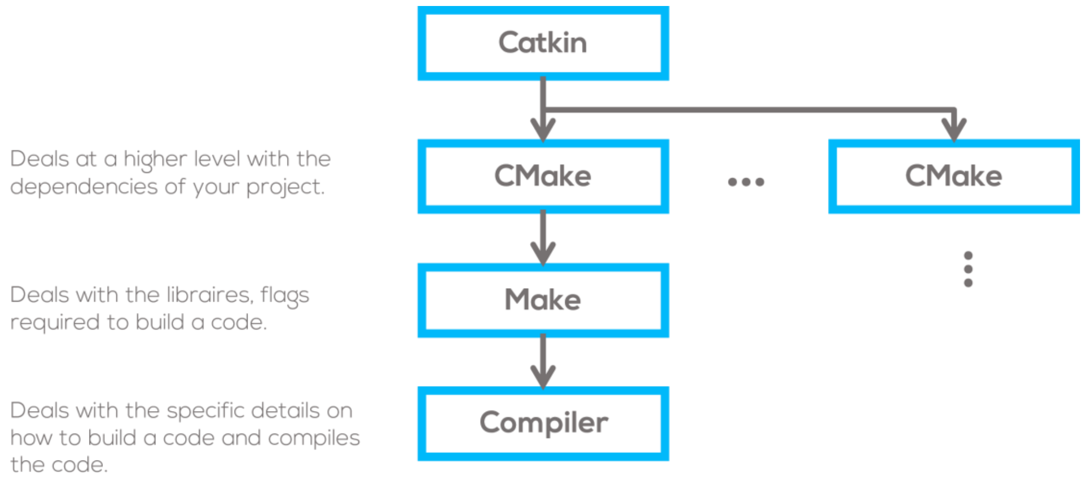
Catkin and CMakeLists Files

- Compilers and executables usually require libraries, external files or flags to be able to compile and run a program.
- **Build tools**, describe the setup of the project (set of rules and commands) at a user level to generate the specific flags and paths required by the program to run.
- In Linux these build tools are commonly known as **Make files**.
- Make files sometimes require information from the system, like paths to libraries, dependencies, targets to be built, locations, etc.
- When sharing a project, the paths to those libraries may change.
- CMake is a tool (build system generator) that allows the user to deal with the issue by searching for the library paths and generating the flags in other machines to generate the make file.
  - CMake tool only works with one project at a time.
- CMake uses CMakeLists files to work.

ROS Packages

Catkin and CMake Files

- ROS is a very large collection of packages. That means lots of independent packages which depend on each other, utilize various programming languages, tools, and code organization conventions.
- The build process for a target in some package may be completely different from the way another target is built.
- To coordinate all the CMake files across projects the Catkin tool was created. Catkin is the official build system of ROS
- Catkin specifically tries to improve development on large sets of related packages in a consistent and conventional way.



ROS Packages

```
# Declare the version of the CMake API for forward-compatibility
cmake_minimum_required(VERSION 2.8)

# Declare the name of the CMake Project
project(hello_world_tutorial)

# Find Catkin
find_package(catkin REQUIRED)
# Declare this project as a catkin package
catkin_package()

# Find and get all the information about the roscpp package
find_package(roscpp REQUIRED)

# Add the headers from roscpp
include_directories(${roscpp_INCLUDE_DIRS})
# Define an execuable target called hello_world_node
add_executable(hello_world_node hello_world_node.cpp)
# Link the hello_world_node target against the libraries used by roscpp
target_link_libraries(hello_world_node ${roscpp_LIBRARIES})
```

CMakeLists.txt

Example

CMakeLists Structure

- **Required CMake Version** (cmake_minimum_required)
- **Package Name** (project())
- **Find other CMake/Catkin packages needed for build** (find_package())
- **Enable Python module support** (catkin_python_setup())
- **Message/Service/Action Generators** (add_message_files(), add_service_files(), add_action_files())
- **Invoke message/service/action generation** (generate_messages())
- **Specify package build info export** (catkin_package())
- **Libraries/Executables to build** (add_library()/add_executable()/target_link_libraries())

ROS Packages

CMake Files

- When using Python, compared with C++, CMakeLists files are used to define the list of dependencies or modules, create custom messages, installation rules or when using a client/server model.
- When using C++, CmakeLists can become more "complex" because you will need to declare more parameters, flags and libraries into the file.
- More information about CMakeLists when using C++ can be found here and here.
- Examples of CMakeLists files can be found here.

```
cmake_minimum_required(VERSION 3.0.2)
project(courseworks)
```

CMake Version and project name (same name as in package.xml)

```
## Find catkin macros and libraries
## if COMPONENTS list like find_package(catkin REQUIRED COMPONENTS xyz)
## is used, also find other catkin packages
find_package(catkin REQUIRED COMPONENTS
  rospy
  std_msgs
)
```

List of packages required by your package to be built (must be declared in the package.xml)

```
## Uncomment this if the package has a setup.py. This macro ensures
## modules and global scripts declared therein get installed
# catkin_python_setup()
```

Install python modules/scripts the current package or from other packages (requires a setup.py file)

```
catkin_package(
#  INCLUDE_DIRS
#  LIBRARIES
CATKIN_DEPENDS rospy std_msgs
#  DEPENDS
)
```

Specify Build Export Information:
INCLUDE_DIRS: Dirs. With header files.
LIBRARIES: Libraries created for this project.
CATKIN_DEPENDS: Packages dependent projects also require.
DEPENDS: System dependencies, dependent projects require (listed in package.xml)

```
## Specify additional locations of header files
## Your package locations should be listed before other locations
include_directories(
# include
  ${catkin_INCLUDE_DIRS}
)
```

Specify locations of header files (if required) not for python.

```
## Mark executable scripts (Python etc.) for installation
## in contrast to setup.py, you can choose the destination
 catkin_install_python(PROGRAMS
   scripts/signal_generator.py scripts/process.py
   DESTINATION ${CATKIN_PACKAGE_BIN_DESTINATION}
 )
```

Installation of the scripts

ROS Packages

Package.xml File

- Package manifest file.
- Contains the metadata of the package.
- XML File that must be included with any catkin-compliant package.
- Defines the properties about the package such as the package name, version numbers, authors, maintainers, and dependencies on other catkin packages.
- More information about Package.xml files can be found here, here and here.

```xml
<?xml version="1.0"?>
  <package format="2">
  <name>package_name</name>
  <version>1.0.0</version>
  <description>The example package</description>
  <maintainer email="me@todo.todo">linux</maintainer>
  <license>TODO</license>

  <buildtool_depend>catkin</buildtool_depend>

  <depend>rospy</depend>

</package>
```

package.xml File Example

ROS Packages

Package.xml File Dependencies

- **exec_depend:** Packages required at runtime. The most common dependency for a python-only package. If your package or launchfile imports/runs code from another package.
- **build_depend:** Package required at build time. Python packages usually do not require this. Some exceptions is when you depend upon messages, services or other packages.
- **build_export_depend:** Specify which packages are needed to build libraries against this package. This is the case when you transitively include their headers in public headers in this package

```xml
<?xml version="1.0"?>
<package format="2">
  <name>courseworks</name>
  <version>1.0.0</version>
  <description>The courseworks package </description>
  <maintainer email="mario.mtz@manchester-robotics.com" >Mario Martinez </maintainer>
  <license>BSD</license>
  <url type="website" >http://www.manchester-robotics.com </url>
  <author email="mario.mtz@manchester-robotics.com" >Mario Martinez </author>

  <buildtool_depend>catkin</buildtool_depend>

  <build_depend>rospy</build_depend>
  <build_depend>std_msgs</build_depend>
  <build_depend>numpy</build_depend>

  <build_export_depend>rospy</build_export_depend>
  <build_export_depend>std_msgs</build_export_depend>
  <build_export_depend>numpy</build_export_depend>

  <exec_depend>rospy</exec_depend>
  <exec_depend>std_msgs</exec_depend>
  <exec_depend>numpy</exec_depend>
</package>
```

Package Metadata

Specify build system tools required by the package.

Dependency tags:

- **build_depend:** Dependencies must be present when the code is built.
- **build_export_depend:** Specify which packages are needed to build libraries against this package.
- **exec_depend:** Packages needed to be installed along our package in order to run. Packages required at runtime.

ROS Custom messages

- ROS has some predefined messages like the *std_messages*, *geometric_messages*, etc.
- Sometimes, the message structures are required to be altered for a custom application.
- ROS allows the user to customise the messages and create new messages.
- Custom messages are a way to personalise your own messages for a specific purpose or application.
- Custom messages are created by the user, and must be linked to the package where they will be used.
- More information here, here and here

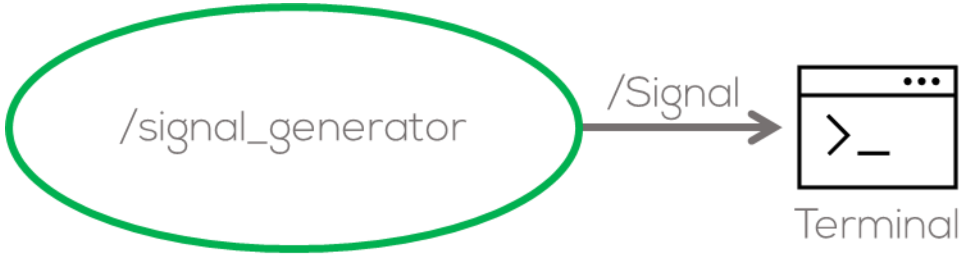
ROS Custom Message Example

This example will help the student to understand the concepts of custom messages, how to implement them and how to add them to the package.

- For this example, a simpler version of the previous activity (Signal Generator) code will be used.
  - It is encouraged for the students to use their coursework code and modify it to use a custom message.
- Since this is not a challenge, we will use the "basic_comms" package for this example. **The student can follow the same steps in any package.**

ROS Custom messages

- For this example, a new message will be generated to contain two different values of data.
- In comparison with the previous exercise where the user had to publish two different messages, each one in a different topic.
- For this example only one topic will be necessary, and the message will include all the information required in the previous exercise.



Custom msg signal_msg
Float32 time_x
Float32 signal_y

ROS Custom messages

ROS Custom Message Creation

To start let's create the custom message

1. In the “basic_comms” package (or the student's own package), create a folder named “msg”
2. Inside the folder “msg” create a file called “signal_msg.msg”
3. Open the file using a text editor and write

```
float32 time_x
float32 signal_y
```

4. Save the file. The custom message has been created!

ROS Custom Message Configuration

The following step is to tell ROS that a custom message will be used, where the message located and its dependencies.

To do this, the CmakeList.txt and the Package.xml will be modified (Follow each step carefully).

1. Open the CMakeLists.txt, of the “basic_comms” package (or the students’ package) and find the

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

- This line is telling ROS to add the message_generation component (to create new messages), when compiling the program.

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2. Find the following lines, uncomment it and modify them as follows.

```
add_message_files(
   FILES
  signal_msg.msg
)


generate_messages(
  DEPENDENCIES
  std_msgs
)
```

- These lines tells ROS the name of the message files contained in the msg folder, and the dependencies of such messages (for more complex message you must add the dependencies here).

3. Modify the *catkin_package* line as follows. This line tells the dependencies used by

```
 catkin_package(
#  INCLUDE_DIRS include
#  LIBRARIES basic_comms
  CATKIN_DEPENDS message_runtime
#  DEPENDS system_lib
)
```

4. Done! The configuration for using a custom message has been finished.

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ROS Custom Message Usage

The following code, as stated before, is just a simple example on how to use the newly created message. This code is based on the previous challenge.

- Firstly, the new message must be imported from the

```
from basic_comms.msg import signal_msg
```

- Define the new publisher and its attributes, to

```
signal_pub=rospy.Publisher("signal",signal_msg, queue_size=10)
```

- Finally, fill out the message with the data to be

```
msg.time_x = time
msg.signal_y = signal

signal_pub.publish(msg)
```

```
#!/usr/bin/env python
import rospy
import numpy as np
from basic_comms.msg import signal_msg  #Import the message to be used

if _name=='__main_’:

    ## Declare the new message to be used
    signal_pub=rospy.Publisher("signal",signal_msg, queue_size=10)

    rospy.init_node("signal_generator")
    rate = rospy.Rate(10)
    init_time = rospy.get_time()
    msg = signal_msg()

    while not rospy.is_shutdown():
        time = rospy.get_time()-init_time
        signal = np.sin(time)

        ## Fill the message with the required information
        msg.time_x = time
        msg.signal_y = signal

        ## Publish the message
        signal_pub.publish(msg)

        rospy.loginfo("The signal value is: %f at a time %f", signal, time)
        rate.sleep()
```

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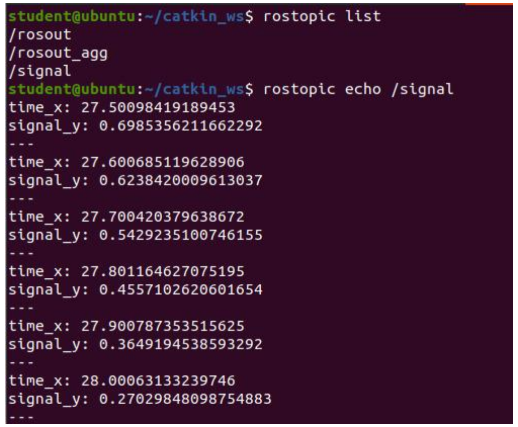
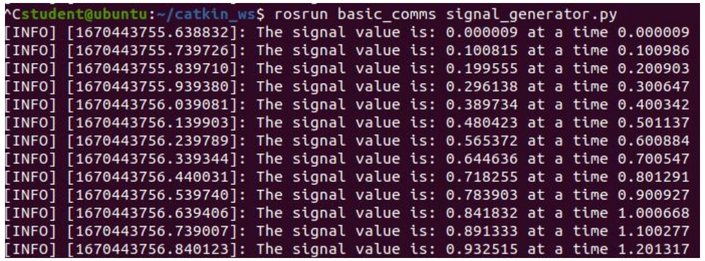
ROS Custom Message Usage

- Save the previous file and close it. (do not forget to make it executable *sudo chmod +x file.py*)
- Recompile the workspace using "*catkin_make*".
- Open a new terminal and start a *roscore*.
- Open another terminal and print the topics using *rostopic list*
- Echo the topic (*rostopic echo /signal*) to verify if the information is being sent.
- The following results are expected.





ROS Activity

Activity

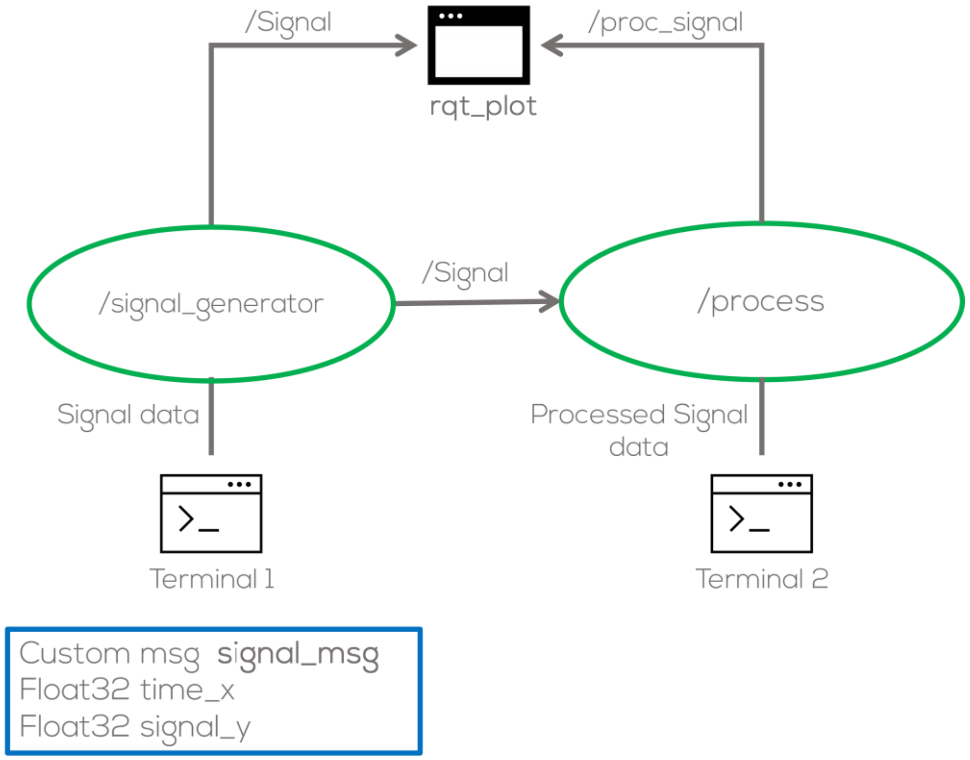
- Make the "Process" Node (created in the previous challenge) subscribe to the new topic and use the custom message.
- Make a roslaunch file for both nodes.

Hints: import the signal message and don't forget to declare the variable (to be global) appropriately inside the call-back function

```
from basic_comms.msg import signal_msg
```

```
signal_data = 0
time_data = 0

def callback(msg):
    global signal_data, time_data
    signal_data = msg.signal_y
    time_data = msg.time_x
```



Q&A

Questions?

{Learn, Create, Innovate};

Thank you

Mini Challenge Answer

```
#!/usr/bin/env python
import rospy
import numpy as np
from std_msgs.msg import Float32
from basic_comms.msg import signal_msg

signal_data = 0
time_data = 0
angle = np.pi/2.0
offset = 1.0
amplitude = 0.5

def callback(msg):
    global signal_data, time_data
    signal_data = msg.signal_y
    time_data = msg.time_x
```

```
if _name=='__main_':

   rospy.init_node("process")
    rospy.Subscriber("/signal", signal_msg, callback)
    pub=rospy.Publisher("proc_signal",Float32, queue_size=10)
    rate = rospy.Rate(10)

   while not rospy.is_shutdown():

            processed_signal = amplitude * (signal_data + offset)

            rospy.loginfo("The signal value is: %f at a time %f",
            processed_signal, time_data)

            pub.publish(processed_signal)
            rate.sleep()
```