Robotics and Intelligent Systems Lab

Lecture 3

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WiSe 21/22

Recap

- `rostopic`
  - `list`, `info`, `echo`, `type`, `pub`, `hz`

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- rostopic
  - list, info, echo, type, pub, hz
- rosmsg
  - show(info), list, package

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- `rossrv`
  - `list, show(info), type, call`
- `rosparam`
  - `set, get, dump, load`

Launch files

Launchfiles

- For non-trivial programs, manually running nodes using rosrun becomes tedious and hard to reproduce.
- Launchfiles are used to start groups of nodes and pass parameters to them.
- Enables full configuration of running nodes
  - Which nodes are run
  - What parameters they use
  - What topics are named and more!
- XML-based .launch file
- Placed in `<package_folder>/launch`

Writing a Launchfile I

- The Launchfile format relies on XML, where some of the basic elements are
  - `<launch>`: the root element, every launchfile starts with this
  - `<node>`: Used to run a node.
  - `<include>`: Lets you include a launchfile in another launchfile
  - `<remap>`: Used for Remapping arguments
  - `<param>`: Sets an individual parameter on the parameter server
  - `<rosparam>`: Controls groups of parameters using .yaml files.
  - `<group>`: Groups nodes together and allows you to easily apply common settings
  - `<arg>`: Used to specify arguments which can be used to change the behavior of the launchfile from the command-line

Writing a Launchfile II

- `<launch>`: Root element of the launch file
  - every launchfile starts with `<launch>` and ends with `</launch>`
- `<node>`: Used to run a node.

```
<node name=".." pkg=".." type=".." output=".."/>
```

  - `name`: Name of the node
  - `pkg`: Package containing the node
  - `type`: Type oy the node, there must be a corresponding executable with the same name
  - `output`: where to output log messages (`screen`:console or `log`:log file)

Writing a Launchfile II

- `<param>`: Used to run a node.

```
<param name=".." value=".." type=".."/>
```

  - `name`: Name of the parameter
  - `value`: value of the parameter
  - `type`: Type of the parameter (int, str, etc.)

Writing a Launchfile III

- Write a launch file in the package beginner_tutorial to start the nodes `turtlesim_node` and `turtle_teleop_key`, and changes the value of parameter `/sim/background_r`

Writing a Launchfile III

- Write a launch file in the package beginner_tutorial to start the nodes `turtlesim_node` and `turtle_teleop_key`, and changes the value of parameter `/sim/background_r`

```
<launch>
  <!-- Turtlesim Node-->
  <node pkg="turtlesim" type="turtlesim_node" name="sim"/>

  <!-- Teleop node-->
  <node pkg="turtlesim" type="turtle_teleop_key" name="teleop" output="screen"/>

  <param name="/sim/background_r" value="255" type="int"/>
</launch>
```

Writing a Launchfile III

- Write a launch file in the package beginner_tutorial to start the nodes `turtlesim_node` and `turtle_teleop_key`, and changes the value of parameter `/sim/background_r`

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  <node pkg="turtlesim" type="turtlesim_node" name="sim"/>

  <!-- Teleop node-->
  <node pkg="turtlesim" type="turtle_teleop_key" name="teleop" output="screen"/>

  <param name="/sim/background_r" value="255" type="int"/>
</launch>
```

- launch it!

```
$ roslaunch <package_name> <launchfile>
```

Writing a Launchfile IV

- `<arg>`: creates a reusable launch file with a configurable tag

```
<arg name="arg_name" default="default_value"/>
```

  - Use argument within Launch file `$(arg arg_name)`
  - Set when launching file

```
$ roslaunch launch_file.launch arg_name:=value
```

Writing a Launchfile III

- Modify the launch file to set the value `/sim/background_r` as an argument

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```
<launch>
  <arg name="red_color" default="255"/>
  <!-- Turtlesim Node-->
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  <!-- Teleop node-->
  <node pkg="turtlesim" type="turtle_teleop_key" name="teleop" output="screen"/>

  <param name="/sim/background_r" value="$(arg red_color)" type="int"/>
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- launch it!

Writing a Launchfile III

- Modify the launch file to set the value /sim/background_r as an argument

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  <arg name="red_color" default="255"/>
  <!-- Turtlesim Node-->
  <node pkg="turtlesim" type="turtlesim_node" name="sim"/>

  <!-- Teleop node-->
  <node pkg="turtlesim" type="turtle_teleop_key" name="teleop" output="screen"/>

  <param name="/sim/background_r" value="$(arg red_color)" type="int"/>
</launch>
```

- launch it!

```
$roslaunch beginner_tutorials start_turtlesim_arg.launch red_color:=100
```

Writing a Launchfile IV

- `<group>`: Groups nodes in one namespace

```
<group ns=".."> ... </group>
```

  - `ns`: Namespace for a group

- `<remap>`: remapping names of arguments

```
<remap from=".." to="..">
```

  - `from`: original name of an argument
  - `to`: remapped name

Writing a Launchfile V

- run the node `mimic` from the `trurtlesim` package and inspect the topics it publishes and subscribes to.

Writing a Launchfile V

- run the node `mimic` from the `trurtlesim` package and inspect the topics it publishes and subscribes to.
- Write a launch file that
  - starts two instances of turtlesim each in a separate group.
  - starts the node `mimic`
  - remaps the output of turtle1 to input of mimic
  - remaps the output of mimic to input of turtle2

```
<launch>

  <group ns="turtlesim1">
    <node pkg="turtlesim" name="sim" type="turtlesim_node"/>
  </group>

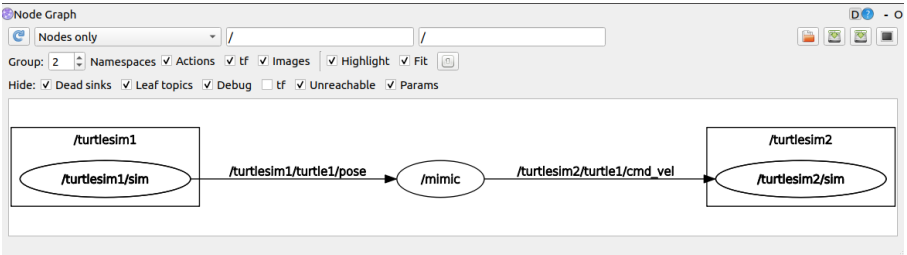
  <group ns="turtlesim2">
    <node pkg="turtlesim" name="sim" type="turtlesim_node"/>
  </group>

  <node pkg="turtlesim" name="mimic" type="mimic">
    <remap from="input" to="turtlesim1/turtle1"/>
    <remap from="output" to="turtlesim2/turtle1"/>
  </node>

</launch>
```

Writing a Launchfile V

- launch it then run rqt_graph



Writing a Launchfile V

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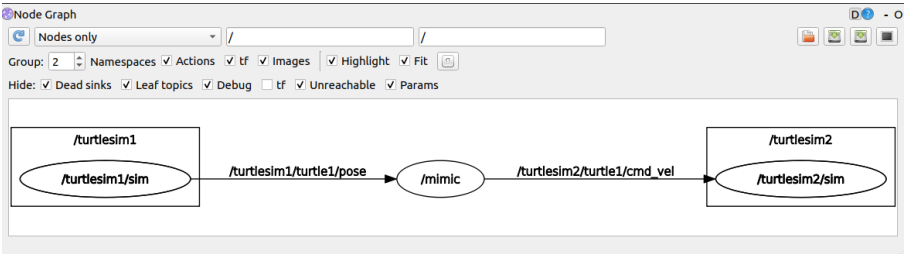
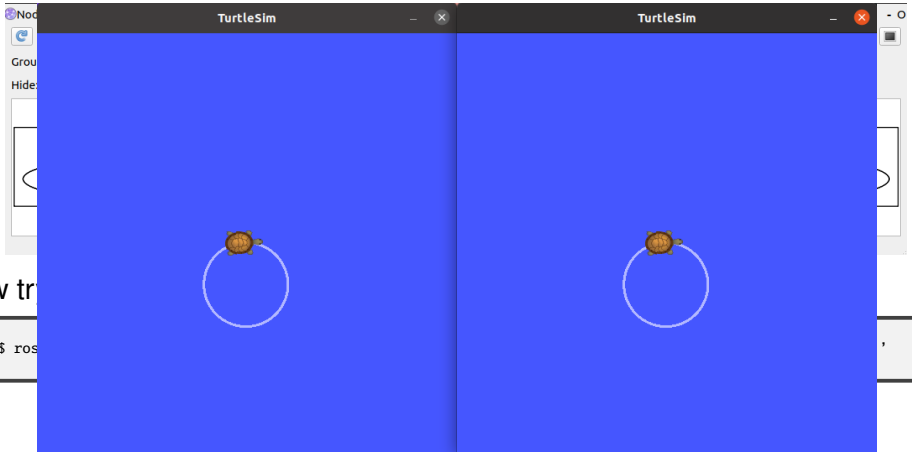


- now try publishing to turtlesim1

```
$ rostopic pub /turtlesim1/turtle1/cmd_vel geometry_msgs/Twist -r 1 -- '[2.0, 0.0, 0.0]' '[0.0, 0.0, -1.8]'
```

Writing a Launchfile V

- launch it then run rqt_graph



- now tr

```
$ ros
```

Names in ROS

- Every item in the ROS Computation Graph has a Graph Resource Name
- You manipulate names in ROS using Remapping, which enables you to re-wire the computation graph and connect otherwise unrelated components
- ROS's name system is the source of much of its flexibility, and you will use it in every ROS program you write.
- More info:
  - https://wiki.ros.org/Names
  - https://wiki.ros.org/Remapping%20Arguments

Creating Messages and Services

msg and srv

msg

- msg files are simple text files that describe the fields of a ROS message.
- They are used to generate source code for messages in different languages

srv

- an srv file describes a service. It is composed of two parts: a request and a response.

ROS msg I

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- 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]

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  - string
  - time, duration
  - other msg files
  - variable-length array[] and fixed-length array[C]
- There is also a special type in ROS: Header, the header contains a timestamp and coordinate frame information that are commonly used in ROS.

ROS msg II

- Inspect the `Header` msg using

```
rosmsg show Header
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```
▶ rosmsg show Header
[std_msgs/Header]:
uint32 seq
time stamp
string frame_id
```

ROS msg II

- Inspect the `Header` msg using

```
rosmsg show Header
```

```
▶ rosmsg show Header
[std_msgs/Header]:
uint32 seq
time stamp
string frame_id
```

- Here is an example of a msg that uses a Header, a string primitive, and two other msgs

```
Header header
string child_frame_id
geometry_msgs/PoseWithCovariance pose
geometry_msgs/TwistWithCovariance twist
```

ROS msg III

- Define a new msg in the package `beginner_tutorials` that was created previously

```
$ roscd beginner_tutorials
$ mkdir msg
$ touch msg/Student.msg
```

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```
$ roscd beginner_tutorials
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$ touch msg/Student.msg
```

- Now open the created msg file and add elements in (one per line)

```
string first_name
string last_name
uint8 age
uint32 score
```

ROS msg IV

- To make sure that the text file we created is turned into source code for C++ or Python, we need to do the following:
- Open `package.xml`, and make sure these two lines are in it and uncommented:

```
<build_depend>message_generation</build_depend>
<exec_depend>message_runtime</exec_depend>
```

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- Now open the `CMakeLists.txt` and add the `message_generation` dependency to the `find_package` so that you can generate messages

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```

- Now open the `CMakeLists.txt` and add the `message_generation` dependency to the `find_package` so that you can generate messages

```
## 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
  roscpp
  rospy
  std_msgs
  message_generation
)
```

ROS msg V

- Make sure you export the message runtime dependency.

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

ROS msg V

- Make sure you export the message runtime dependency.

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

- Next add the msg files you created under `add_message_files`

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

ROS msg V

- Make sure you export the message runtime dependency.

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

- Next add the msg files you created under `add_message_files`

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

- Finally ensure the `generate_messages()` function is called

```
## Generate added messages and services with any dependencies listed here
generate_messages(
  DEPENDENCIES
  std_msgs
)
```

ROS msg VI

- To use the msg you created, build the package using `catkin build`

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- You can now inspect the generated msg using

```
$ rosmsg show beginner_tutorials/Student
string first_name
string last_name
uint8 age
uint32 score
```

ROS msg VI

- To use the msg you created, build the package using `catkin build`
- You can now inspect the generated msg using

```
$ rosmsg show beginner_tutorials/Student
string first_name
string last_name
uint8 age
uint32 score
```

- If you forgot which package defines a certain message

```
$ rosmsg show Student
[beginner_tutorials/Student]:
string first_name
...
```

ROS srv I

- 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.
- srv files are stored in a directory called *srv/*
- Here is an example of a srv file:

```
int64 A
int64 B
---
int64 Sum
```

- A and B are the request, and Sum is the response

ROS srv I

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```

- A and B are the request, and Sum is the response
- Create a srv form the example shown above and store in in a file called `AddTwoInts.srv`

ROS srv II

- Create the srv files using

```
$ roscd beginner_tutorials
$ mkdir srv $ touch srv/AddTwoInts.msg
```

- Populate your srv file with the desired elements
- You need the same changes to package.xml for services as for messages
- Same changes as in messages need to be done in CMakelists.txt except for `add_message_files`
- Modify the lines at `add_service_files` as

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

ROS msg VI

- Run `catkin build` to generate the created srv
- You can now inspect the generated srv using

```
$ rossrv show beginner_tutorials/AddTwoInts
int64 a int64 b --- int64 sum
```

ROS msg VI

- Run `catkin build` to generate the created srv
- You can now inspect the generated srv using

```
$ rossrv show beginner_tutorials/AddTwoInts
int64 a int64 b --- int64 sum
```

- Similar to rosmsg, you can find service without specifying package name

```
$ rosmsg show AddTwoInts
[beginner_tutorials/AddTwoInts]:
int64 a
...

[rospy_tutorials/AddTwoInts]:
int64 a
...
```

ROS msg VI

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$ rossrv show beginner_tutorials/AddTwoInts
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[beginner_tutorials/AddTwoInts]:
int64 a
...

[rospy_tutorials/AddTwoInts]:
int64 a
...
```

- Notice that a second one exists from the rospy_tutorials package

rospy

rospy Introduction

- rospy is the ROS python client library which allows your python programs to interact with other ROS processes running on your system.
- rospy is written in pure python
- The rospy client API enables Python programmers to quickly interface with ROS Topics, Services, and Parameters
- rospy favors implementation speed (i.e. developer time) over runtime performance so that algorithms can be quickly prototyped and tested within ROS
- Many of the ROS tools, such as rostopic and rosservice, are built on top of rospy

Writing the Publisher Node using rospy I

- let's create a ROS node in the pakcage `beginner_tutorials` which will continuously publish a message

```
$ roscd beginner_tutorials
$ mkdir scripts
$ touch scripts/talker.py
```

- Make the created file an executable

```
$ beginner_tutorials
$ cd scripts
$ chmod +x talker.py
```

Writing the Publisher Node using rospy II

- The first line in a ROS node using rospy should start with

```
1 #!/usr/bin/env python
2
```

- This line makes sure your script is executed as a Python script.

Writing the Publisher Node using rospy II

- The first line in a ROS node using rospy should start with

```
1 #!/usr/bin/env python
2
```

- This line makes sure your script is executed as a Python script.
- Next we need to import rospy, as well as the String message from std_msgs

```
3 import rospy
4 from std_msgs.msg import String
5
```

- This will allow us to use `std_msgs/String` message type for publishing

Writing the Publisher Node using rospy III

create a publisher with the topic 'chatter' and msg type String

```
6 def talker():
7     pub = rospy.Publisher('chatter', String, queue_size=10)
8     rospy.init_node('talker', anonymous=True)
9     rate = rospy.Rate(10) # 10hz
10    while not rospy.is_shutdown():
11        hello_str = "hello world %s" % rospy.get_time()
12        rospy.loginfo(hello_str)
13        pub.publish(hello_str)
14        rate.sleep()
```

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create a publisher with the topic 'chatter' and msg type String

create a node called 'talker' and create a Rate object with a value of 10 Hz

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create a publisher with the topic 'chatter' and msg type String

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start a loop by checking the tag is_shutdown and define a string

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create a publisher with the topic 'chatter' and msg type String

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start a loop by checking the tag is_shutdown and define a string

print message to screen, and write it Node's log file. Publish the msg onto the topic

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```

create a publisher with the topic 'chatter' and msg type String

create a node called 'talker' and create a Rate object with a value of 10 Hz

start a loop by checking the tag is_shutdown and define a string

print message to screen, and write it Node's log file. Publish the msg onto the topic

sleep long enough to maintain the desired rate through the loop

Writing the Publisher Node using rospy IV

```
1 #!/usr/bin/env python
2
3 import rospy
4 from std_msgs.msg import String
5
6 def talker():
7     pub = rospy.Publisher('chatter', String, queue_size=10)
8     rospy.init_node('talker', anonymous=True)
9     rate = rospy.Rate(10) # 10hz
10    while not rospy.is_shutdown():
11        hello_str = "hello world %s" % rospy.get_time()
12        rospy.loginfo(hello_str)
13        pub.publish(hello_str)
14        rate.sleep()
15
16 if __name__ == '__main__':
17    try:
18        talker()
19    except rospy.ROSInterruptException:
20        pass
```

Writing the Subscriber Node using rospy I

- let's create a ROS node in the pakcage `beginner_tutorials` which will continuously listens to a message

```
$ roscd beginner_tutorials
$ mkdir scripts
$ touch scripts/listener.py
```

- Make the created file an executable

```
$ beginner_tutorials
$ cd scripts
$ chmod +x listener.py
```

Writing the Subscriber Node using rospy II

```
1 #!/usr/bin/env python
2 import rospy
3 from std_msgs.msg import String
4
5 def callback(data):
6     rospy.loginfo(rospy.get_caller_id() + "I heard %s", data.data)
7
8 def listener():
9
10    # In ROS, nodes are uniquely named. If two nodes with the same
11    # name are launched, the previous one is kicked off. The
12    # anonymous=True flag means that rospy will choose a unique
13    # name for our 'listener' node so that multiple listeners can
14    # run simultaneously.
15    rospy.init_node('listener', anonymous=True)
16
17    rospy.Subscriber("chatter", String, callback)
18
19    # spin() simply keeps python from exiting until this node is stopped
20    rospy.spin()
21
22 if __name__ == '__main__':
23    listener()
```

Writing the Subscriber Node using rospy II

```
1 #!/usr/bin/env python
2 import rospy
3 from std_msgs.msg import String
4
5 def callback(data):
6     rospy.loginfo(rospy.get_caller_id() + "I heard %s", data.data)
7
8 def listener():
9
10    # In ROS, nodes are uniquely named. If two nodes with the same
11    # name are launched, the previous one is kicked off. The
12    # anonymous=True flag means that rospy will choose a unique
13    # name for our 'listener' node so that multiple listeners can
14    # run simultaneously.
15    rospy.init_node('listener', anonymous=True)
16
17    rospy.Subscriber("chatter", String, callback)
18
19    # spin() simply keeps python from exiting until this node is stopped
20    rospy.spin()
21
22 if __name__ == '__main__':
23    listener()
```

The standard declartion of a node name

Writing the Subscriber Node using rospy II

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2 import rospy
3 from std_msgs.msg import String
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The standard declartion of a node name

Subscribes to the chatter topic which is of type std_msgs.msgs.String. When new messages are received, callback is invoked with the message as the first argument

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Callback function that takes a message as input. Here we only print message to screen, and write it Node's log file

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Building Python Nodes

- open your CMakeLists.txt file and add your files under

```
catkin_install_python(PROGRAMS scripts/talker.py scripts/listener.py
   DESTINATION $CATKIN_PACKAGE_BIN_DESTINATION
)
```

- Finally go to your catkin workspace and build your pakcage

```
$ cd ~/catkin_ws
$ catkin build
```

Inspecting Publisher & Subscriber

- Let's run both node to inspect what they are doing
- Make sure roscore is up and running
- Source your workspace environment and run the talker

```
$ rosrun beginner_tutorials talker.py
```

```
> rosrun beginner_tutorials talker.py
[INFO] [1632142191.934912]: hello world 1632142191.9346843
[INFO] [1632142192.035425]: hello world 1632142192.035042
[INFO] [1632142192.135123]: hello world 1632142192.1349468
[INFO] [1632142192.235051]: hello world 1632142192.2348762
[INFO] [1632142192.335307]: hello world 1632142192.3349996
[INFO] [1632142192.435291]: hello world 1632142192.434974
[INFO] [1632142192.535462]: hello world 1632142192.535004
[INFO] [1632142192.635211]: hello world 1632142192.6349683
[INFO] [1632142192.735102]: hello world 1632142192.734927
[INFO] [1632142192.835207]: hello world 1632142192.8349004
```

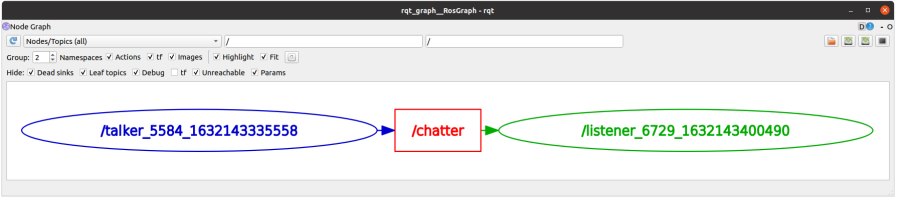
Inspecting Publisher & Subscriber

- Now run the listener node using

```
$ rosrun beginner_tutorials listener.py
```

```
rosrun beginner_tutorials listener.py
[INFO] [1632143352.117635]: /listener_5734_16321433518361 heard hello world 1632143352.1152816
[INFO] [1632143352.217623]: /listener_5734_16321433518361 heard hello world 1632143352.2151952
[INFO] [1632143352.320448]: /listener_5734_16321433518361 heard hello world 1632143352.3155568
[INFO] [1632143352.420459]: /listener_5734_16321433518361 heard hello world 1632143352.4155786
[INFO] [1632143352.520290]: /listener_5734_16321433518361 heard hello world 1632143352.515331
[INFO] [1632143352.617620]: /listener_5734_16321433518361 heard hello world 1632143352.615304
[INFO] [1632143352.717577]: /listener_5734_16321433518361 heard hello world 1632143352.7151933
```

- Inspect the computation graph using rqt_graph



Exercise

- Create a message WaveParams.msg that contains 3 elements:
  - period
  - magnitude
  - phase
- create a node that imports the created type and publishes a topic with the same message type created
- create another node that subscribes to the published topic and generates a sinusoidal signal and prints it on the screen.