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Path 3: Artificial Intelligence in Robotics

Task 3 Part 1

Create 2 nodes shared a string message in a  
custom package

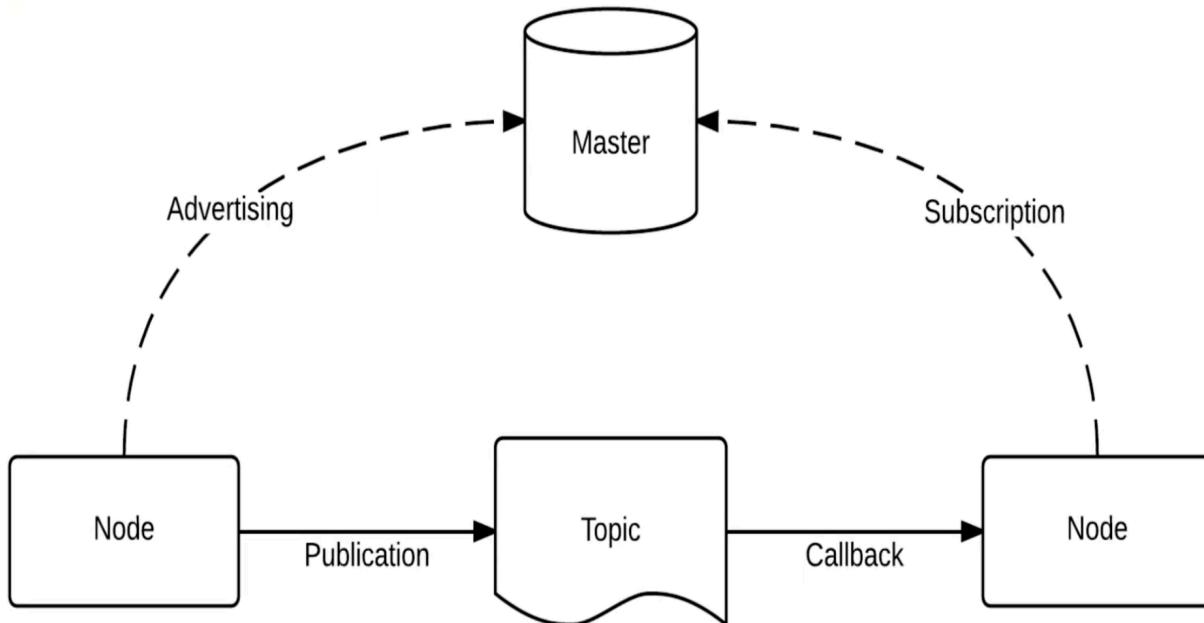
# Robot Operating System

Robot Operating System is robotics middleware. Although ROS is not an operating system, it provides services designed for a heterogeneous computer cluster such as hardware abstraction, low-level device control, implementation of commonly used functionality, message-passing between processes, and package management.

**Nodes:** A **node** is an executable that uses **ROS** to communicate with other **nodes**.

**Messages:** **ROS** data type used when subscribing or publishing to a topic.

**Topics:** **Nodes** can publish messages to a topic as well as subscribe to a topic to receive messages.



## What is Catkin?

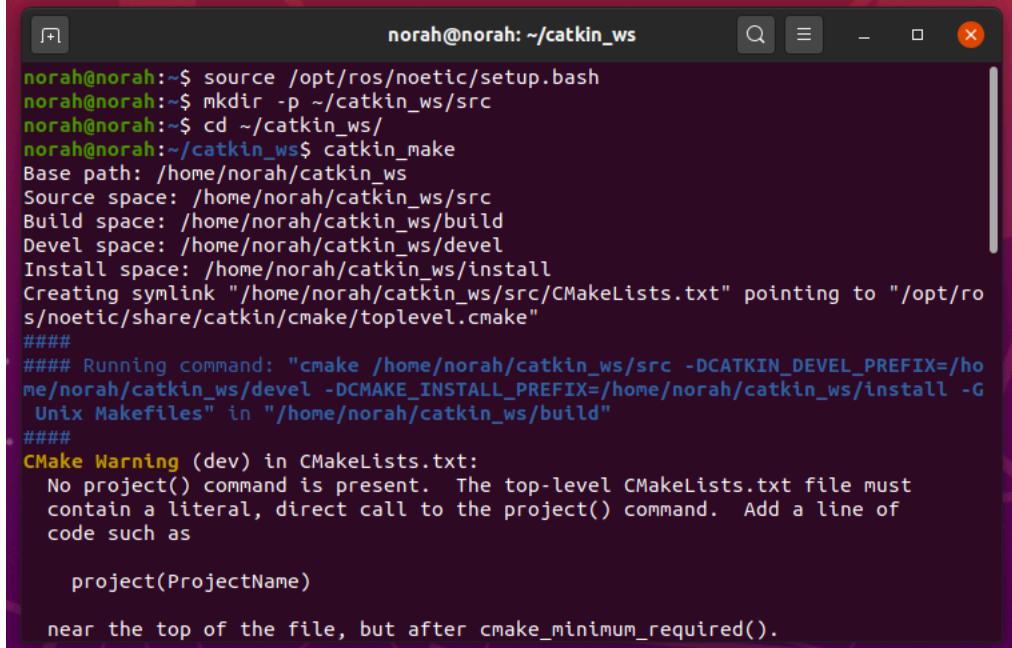
**Catkin.** **Catkin** is a collection of CMake macros and associated code used to build packages used in **ROS**. It was initially introduced as part of the **ROS Fuerte** release where it was used for a small set of base packages.

## What is catkin workspace?

A **catkin workspace** is a directory (folder) in which you can create or modify existing **catkin** packages. The **catkin** structure simplifies the build and installation process for your ROS packages.

## Steps to solve task 3 part 1 Create publisher node:

1. Create catkin workspace



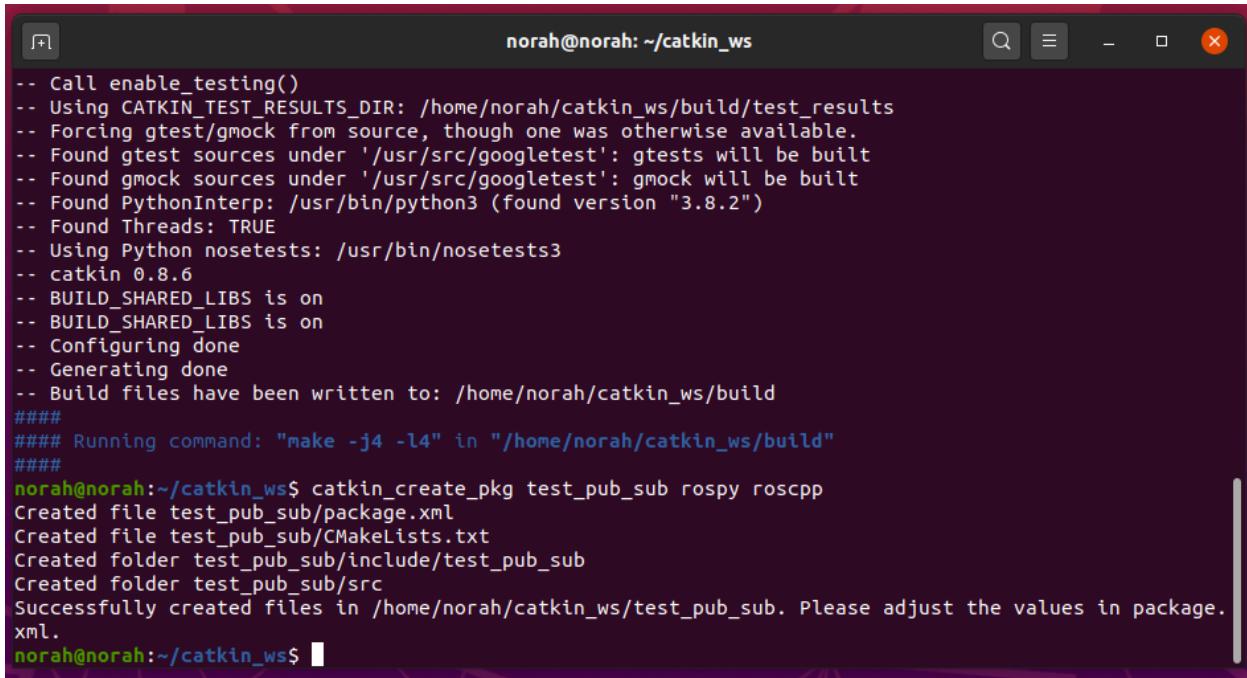
The screenshot shows a terminal window titled "norah@norah: ~/catkin\_ws". The terminal displays the following command sequence and output:

```
norah@norah:~$ source /opt/ros/noetic/setup.bash
norah@norah:~$ mkdir -p ~/catkin_ws/src
norah@norah:~$ cd ~/catkin_ws/
norah@norah:~/catkin_ws$ catkin_make
Base path: /home/norah/catkin_ws
Source space: /home/norah/catkin_ws/src
Build space: /home/norah/catkin_ws/build
Devel space: /home/norah/catkin_ws/devel
Install space: /home/norah/catkin_ws/install
Creating symlink "/home/norah/catkin_ws/src/CMakeLists.txt" pointing to "/opt/ros/noetic/share/catkin/cmake/toplevel.cmake"
#####
##### Running command: "cmake /home/norah/catkin_ws/src -DCATKIN_DEVEL_PREFIX=/home/norah/catkin_ws/devel -DCMAKE_INSTALL_PREFIX=/home/norah/catkin_ws/install -G Unix Makefiles" in "/home/norah/catkin_ws/build"
#####
CMake Warning (dev) in CMakeLists.txt:
  No project() command is present.  The top-level CMakeLists.txt file must
  contain a literal, direct call to the project() command.  Add a line of
  code such as

    project(ProjectName)

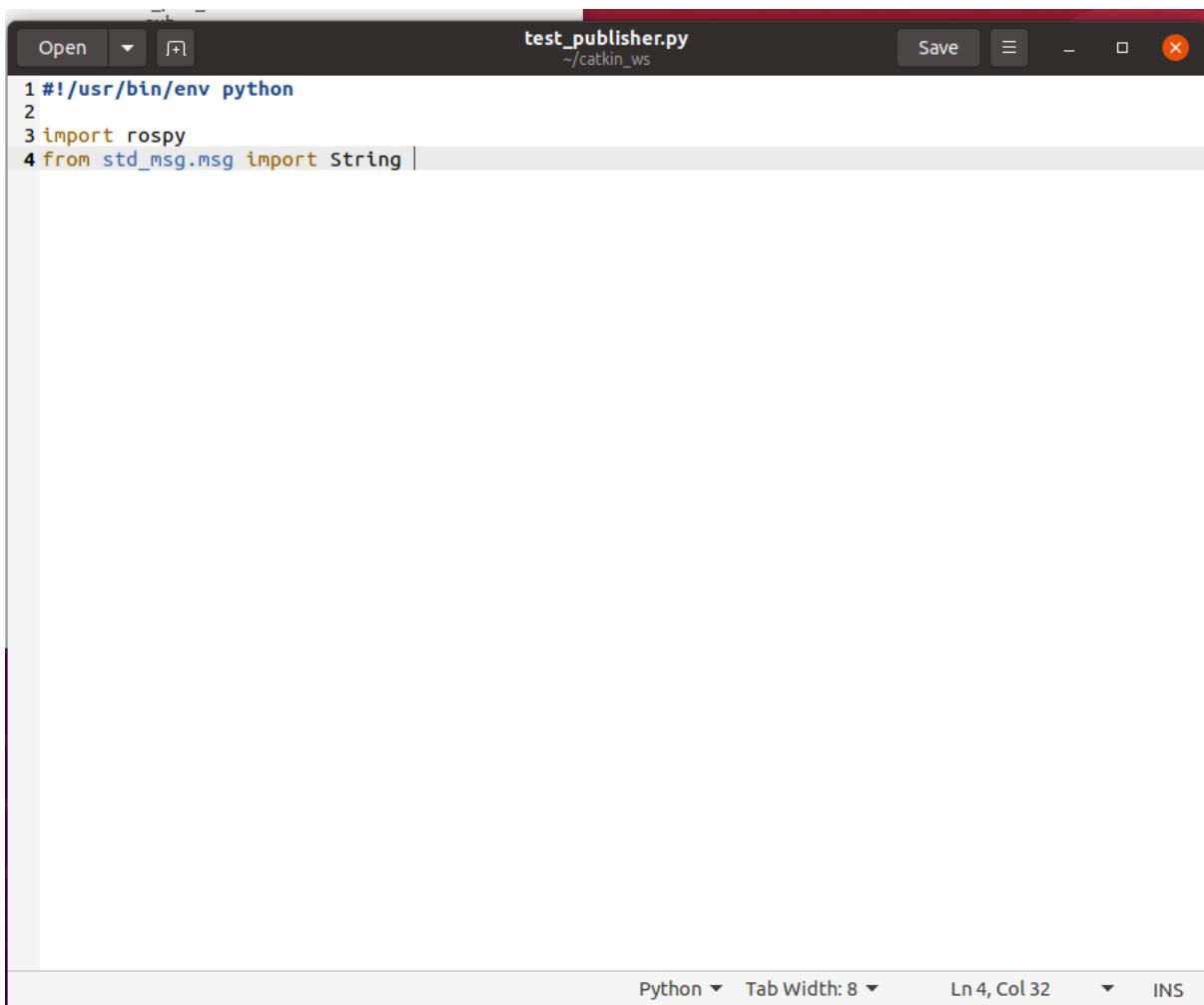
  near the top of the file, but after cmake_minimum_required().
```

## 2. Create a package:



```
-- Call enable_testing()
-- Using CATKIN_TEST_RESULTS_DIR: /home/norah/catkin_ws/build/test_results
-- Forcing gtest/gmock from source, though one was otherwise available.
-- Found gtest sources under '/usr/src/googletest': gtests will be built
-- Found gmock sources under '/usr/src/googletest': gmock will be built
-- Found PythonInterp: /usr/bin/python3 (found version "3.8.2")
-- Found Threads: TRUE
-- Using Python nosetests: /usr/bin/nosetests3
-- catkin 0.8.6
-- BUILD_SHARED_LIBS is on
-- BUILD_SHARED_LIBS is on
-- Configuring done
-- Generating done
-- Build files have been written to: /home/norah/catkin_ws/build
#####
##### Running command: "make -j4 -l4" in "/home/norah/catkin_ws/build"
#####
norah@norah:~/catkin_ws$ catkin_create_pkg test_pub_sub rospy roscpp
Created file test_pub_sub/package.xml
Created file test_pub_sub/CMakeLists.txt
Created folder test_pub_sub/include/test_pub_sub
Created folder test_pub_sub/src
Successfully created files in /home/norah/catkin_ws/test_pub_sub. Please adjust the values in package.xml.
norah@norah:~/catkin_ws$
```

## 3. Open the editor and write the commands:



```
test_publisher.py
~/catkin_ws
Open Save
1 #!/usr/bin/env python
2
3 import rospy
4 from std_msgs.msg import String
```

Python ▾ Tab Width: 8 ▾ Ln 4, Col 32 ▾ INS

#### 4. Go back to the terminal to install the package to standard messages

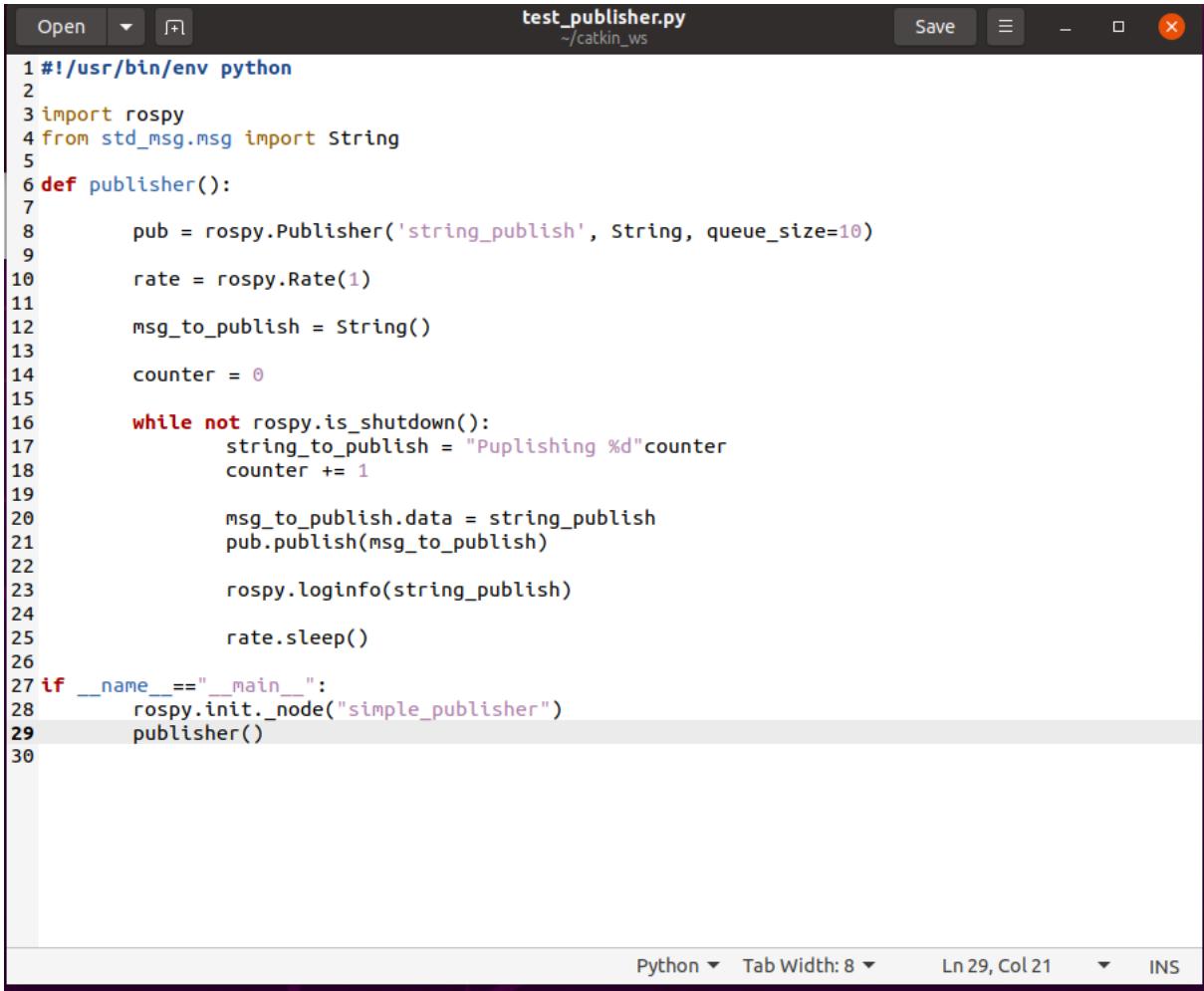
```
norah@norah: /opt/ros/noetic/share/std_msgs/msg
CMakeLists.txt test_publisher.py
norah@norah:~/catkin_ws/src$ cd test_publisher.py
bash: cd: test_publisher.py: Not a directory
norah@norah:~/catkin_ws/src$ cd test_publisher.py
bash: cd: test_publisher.py: Not a directory
norah@norah:~/catkin_ws/src$ ls
CMakeLists.txt test_publisher.py
norah@norah:~/catkin_ws/src$ cd ..
norah@norah:~/catkin_ws$ ls
build devel src test_pub_sub
norah@norah:~/catkin_ws$ cd test_pub_sub
norah@norah:~/catkin_ws/test_pub_sub$ roscd std_msgs/
norah@norah:/opt/ros/noetic/share/std_msgs$ ls
cmake msg package.xml
norah@norah:/opt/ros/noetic/share/std_msgs$ cd msg
norah@norah:/opt/ros/noetic/share/std_msgs/msg$ ls
Bool.msg          Float32MultiArray.msg   Int64.msg        UInt16.msg
Byte.msg          Float64.msg           Int64MultiArray.msg UInt16MultiArray.msg
ByteMultiArray.msg Float64MultiArray.msg Int8.msg        UInt32.msg
Char.msg          Header.msg           Int8MultiArray.msg UInt32MultiArray.msg
ColorRGBA.msg     Int16.msg            MultiArrayDimension.msg UInt64.msg
Duration.msg      Int16MultiArray.msg  MultiArrayLayout.msg UInt64MultiArray.msg
Empty.msg          Int32.msg            String.msg       UInt8.msg
Float32.msg       Int32MultiArray.msg Time.msg        UInt8MultiArray.msg
norah@norah:/opt/ros/noetic/share/std_msgs/msg$ nano String.msg
```

#### 5. The message in this example is composed on String data

```
norah@norah: /opt/ros/noetic/share/std_msgs/msg
String.msg
GNU nano 4.8
string data

[ File 'String.msg' is unwritable ]
^G Get Help  ^O Write Out  ^W Where Is  ^K Cut Text  ^J Justify  ^C Cur Pos  M-U Undo
^X Exit      ^R Read File  ^V Replace  ^U Paste Text ^T To Spell  ^A Go To Line M-E Redo
```

## 6. Go back to editor

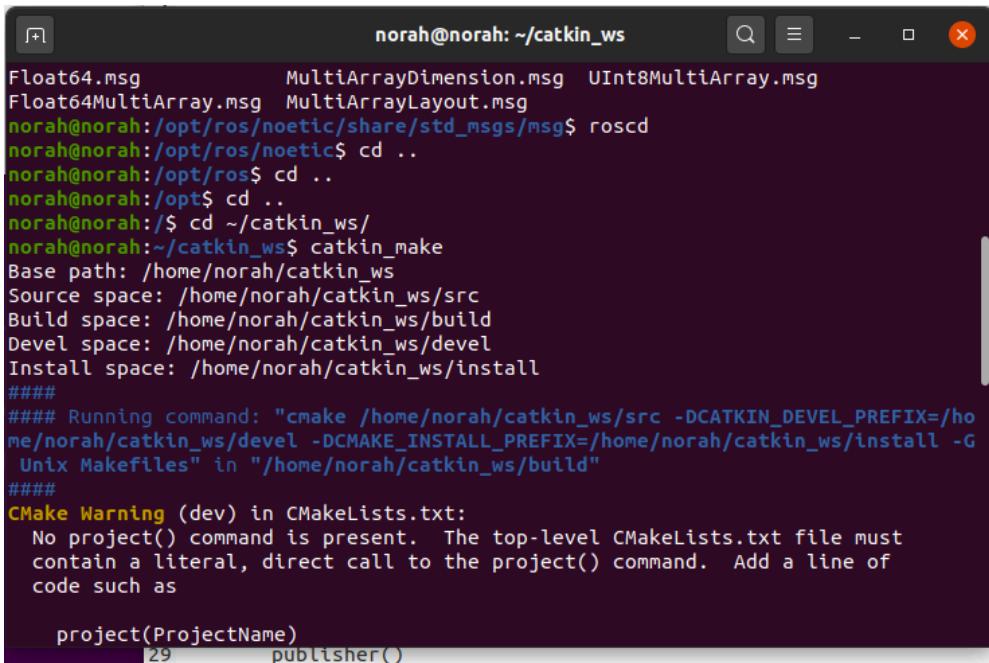


A screenshot of a code editor window titled "test\_publisher.py" located in a directory named "catkin\_ws". The code is a Python script for a ROS node. It imports rospy and std\_msgs.msg.String, defines a publisher function, and runs a while loop to publish messages at a rate of 1 Hz. The script ends with an if \_\_name\_\_ == "\_\_main\_\_": block that initializes the node and calls the publisher function.

```
1 #!/usr/bin/env python
2
3 import rospy
4 from std_msgs.msg import String
5
6 def publisher():
7
8     pub = rospy.Publisher('string_publish', String, queue_size=10)
9
10    rate = rospy.Rate(1)
11
12    msg_to_publish = String()
13
14    counter = 0
15
16    while not rospy.is_shutdown():
17        string_to_publish = "Publishing %d" % counter
18        counter += 1
19
20        msg_to_publish.data = string_to_publish
21        pub.publish(msg_to_publish)
22
23        rospy.loginfo(string_to_publish)
24
25        rate.sleep()
26
27 if __name__=="__main__":
28     rospy.init_node("simple_publisher")
29     publisher()
30
```

Python ▾ Tab Width: 8 ▾ Ln 29, Col 21 ▾ INS

## 7. Compile the catkin workspace



A screenshot of a terminal window showing the compilation of a Catkin workspace. The user is in a directory named "catkin\_ws". They run "roscd" to switch to the ROS workspace, then "cd .." to move up one level. They then run "catkin\_make" which outputs the base path, source space, build space, devel space, and install space. The process then runs "cmake" with specific arguments. A warning message is displayed about the CMakeLists.txt file not having a project() command. The terminal shows the last few lines of the CMakeLists.txt file, which includes a "project" call.

```
Float64.msg           MultiArrayDimension.msg   UInt8MultiArray.msg
Float64MultiArray.msg  MultiArrayLayout.msg
norah@norah:/opt/ros/noetic/share/std_msgs/msg$ roscd
norah@norah:/opt/ros/noetic$ cd ..
norah@norah:/opt/ros$ cd ..
norah@norah:/opt$ cd ..
norah@norah:$ cd ~/catkin_ws/
norah@norah:~/catkin_ws$ catkin_make
Base path: /home/norah/catkin_ws
Source space: /home/norah/catkin_ws/src
Build space: /home/norah/catkin_ws/build
Devel space: /home/norah/catkin_ws/devel
Install space: /home/norah/catkin_ws/install
#####
##### Running command: "cmake /home/norah/catkin_ws/src -DCATKIN_DEVEL_PREFIX=/home/norah/catkin_ws/devel -DCMAKE_INSTALL_PREFIX=/home/norah/catkin_ws/install -G Unix Makefiles" in "/home/norah/catkin_ws/build"
#####
CMake Warning (dev) in CMakeLists.txt:
No project() command is present. The top-level CMakeLists.txt file must
contain a literal, direct call to the project() command. Add a line of
code such as

  project(ProjectName)
[29]         publisher()
```

## 8. Source the environment

```
norah@norah: ~/catkin_ws/src/test_pub_sub/src
```

```
-- catkin 0.8.6
-- BUILD_SHARED_LIBS is on
-- BUILD_SHARED_LIBS is on
-- 
-- ~~ traversing 1 packages in topological order:
--   - test_pub_sub
-- 
-- +++ processing catkin package: 'test_pub_sub'
-- ==> add_subdirectory(test_pub_sub)
-- Configuring done
-- Generating done
-- Build files have been written to: /home/norah/catkin_ws/build
#####
##### Running command: "make -j4 -l4" in "/home/norah/catkin_ws/build"
#####
norah@norah:~/catkin_ws$ source devel/setup.bash
norah@norah:~/catkin_ws$ roscd test_pub_sub/src/
norah@norah:~/catkin_ws/src/test_pub_sub/src$ ls
norah@norah:~/catkin_ws/src/test_pub_sub/src$ ls
test_publisher.py
norah@norah:~/catkin_ws/src/test_pub_sub/src$ chmod +x test_publisher.py
norah@norah:~/catkin_ws/src/test_pub_sub/src$ ls
test_publisher.py
norah@norah:~/catkin_ws/src/test_pub_sub/src$
```

## 9. Run the publisher: create new windows and write roscore to launch and run the publisher in the other window

```
roscore http://norah:11311/
```

```
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://norah:44405/
ros_comm version 1.15.7

SUMMARY
========
PARAMETERS
  * /rostdistro: noetic
  * /rosversion: 1.15.7

NODES
auto-starting new master
process[master]: started with pid [59040]
ROS_MASTER_URI=http://norah:11311/

setting /run_id to 7bb26dfc-bcbc-11ea-9f22-d9eb5277eef9
process[rosout-1]: started with pid [59050]
started core service [/rosout]
```

```
norah@norah: ~/catkin_ws/src/test_pub_sub/src
```

```
publisher()
  File "/home/norah/catkin_ws/src/test_pub_sub/src/test_publisher.py", line 19, in publisher
    msg_to_publish.data = string_publish
NameError: name 'string_publish' is not defined
norah@norah:~/catkin_ws/src/test_pub_sub$ ls
CMakeLists.txt  include  package.xml  src
norah@norah:~/catkin_ws/src/test_pub_sub$ cd src
norah@norah:~/catkin_ws/src/test_pub_sub/src$ rosrun test_pub_sub test_publisher.py
[INFO] [1593801462.987463]: Publishing 0
[INFO] [1593801463.988579]: Publishing 1
[INFO] [1593801464.988648]: Publishing 2
[INFO] [1593801465.988357]: Publishing 3
[INFO] [1593801466.988028]: Publishing 4
[INFO] [1593801467.988940]: Publishing 5
[INFO] [1593801468.989016]: Publishing 6
[INFO] [1593801469.988479]: Publishing 7
[INFO] [1593801470.988831]: Publishing 8
[INFO] [1593801471.992674]: Publishing 9
[INFO] [1593801472.997960]: Publishing 10
[INFO] [1593801473.987999]: Publishing 11
[INFO] [1593801474.989492]: Publishing 12
[INFO] [1593801475.992652]: Publishing 13
```

```
norah@norah: ~/catkin_ws/src/test_pub_sub/src$
```

## 10. Verify the topic

```
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started rosrun server http://norah:4405/
ros_comm version 1.15.7

SUMMARY
=====

PARAMETERS
 * /rosdistro: noetic
 * /rosversion: 1.15.7

NODES

auto-starting new master
process[master]: started with pid [59040]
ROS_MASTER_URI=http://norah:11311

setting /run_id to 78b26dfc-bcbc-11ea-9f22-d9eb5277eef9
process[rosout-1]: started with pid [59050]
started core service [/rosout]
```

```
[INFO] [1593801697.993028]: Publishing 235
[INFO] [1593801699.988855]: Publishing 236
[INFO] [1593801699.992693]: Publishing 237
[INFO] [1593801700.989075]: Publishing 238
[INFO] [1593801701.987632]: Publishing 239
[INFO] [1593801702.988058]: Publishing 240
[INFO] [1593801703.998936]: Publishing 241
[INFO] [1593801704.992438]: Publishing 242
[INFO] [1593801705.996326]: Publishing 243
[INFO] [1593801706.988587]: Publishing 244
[INFO] [1593801707.988797]: Publishing 245
[INFO] [1593801708.989563]: Publishing 246
[INFO] [1593801709.987873]: Publishing 247
[INFO] [1593801710.988932]: Publishing 248
[INFO] [1593801711.994709]: Publishing 249
[INFO] [1593801712.988668]: Publishing 250
[INFO] [1593801713.989171]: Publishing 251
[INFO] [1593801714.988599]: Publishing 252
[INFO] [1593801715.988999]: Publishing 253
[INFO] [1593801716.988003]: Publishing 254
[INFO] [1593801717.988737]: Publishing 255
[INFO] [1593801718.988835]: Publishing 256
[INFO] [1593801719.992175]: Publishing 257
```

```
norah@norah:~/catkin_ws/src/test_pub_sub/src$ rostopic list
/rosout
/rosout_agg
/string_publish
norah@norah:~/catkin_ws/src/test_pub_sub/src$
```

## 11. Print the topic message

```
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started rosrun server http://norah:4405/
ros_comm version 1.15.7

SUMMARY
=====

PARAMETERS
 * /rosdistro: noetic
 * /rosversion: 1.15.7

NODES

auto-starting new master
process[master]: started with pid [59040]
ROS_MASTER_URI=http://norah:11311

setting /run_id to 78b26dfc-bcbc-11ea-9f22-d9eb5277eef9
process[rosout-1]: started with pid [59050]
started core service [/rosout]
```

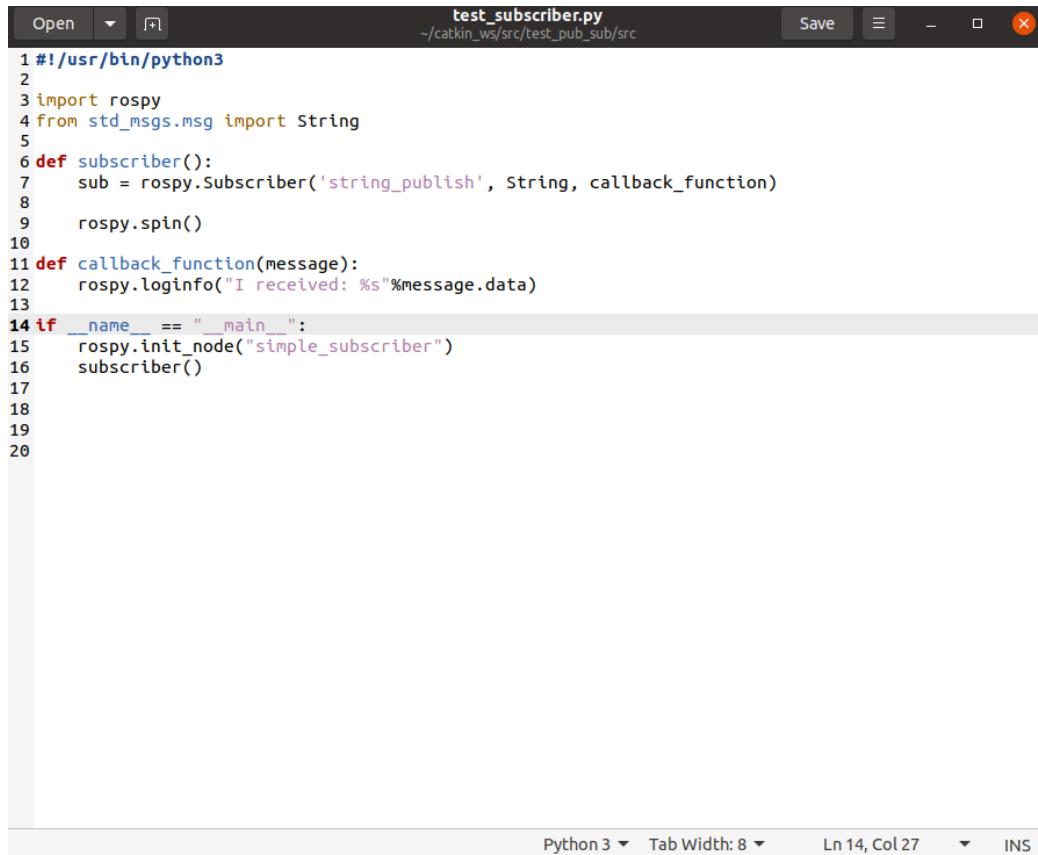
```
[INFO] [1593801896.988689]: Publishing 434
[INFO] [1593801897.988718]: Publishing 435
[INFO] [1593801898.993277]: Publishing 436
[INFO] [1593801899.988188]: Publishing 437
[INFO] [1593801900.988601]: Publishing 438
[INFO] [1593801902.008098]: Publishing 439
[INFO] [1593801902.992801]: Publishing 440
[INFO] [1593801903.993025]: Publishing 441
[INFO] [1593801904.988793]: Publishing 442
[INFO] [1593801905.989653]: Publishing 443
[INFO] [1593801906.992872]: Publishing 444
[INFO] [1593801907.992954]: Publishing 445
[INFO] [1593801908.993521]: Publishing 446
[INFO] [1593801910.009888]: Publishing 447
[INFO] [1593801910.990925]: Publishing 448
[INFO] [1593801911.993085]: Publishing 449
[INFO] [1593801912.988756]: Publishing 450
[INFO] [1593801913.988468]: Publishing 451
[INFO] [1593801914.991648]: Publishing 452
[INFO] [1593801915.989213]: Publishing 453
[INFO] [1593801916.992861]: Publishing 454
[INFO] [1593801917.988800]: Publishing 455
[INFO] [1593801918.996047]: Publishing 456
```

```
norah@norah:~/catkin_ws/src/test_pub_sub/src$ rostopic list
/rosout
/rosout_agg
/string_publish
norah@norah:~/catkin_ws/src/test_pub_sub/src$ rostopic echo /string_publish
data: "Publishing 430"
...
data: "Publishing 431"
...
data: "Publishing 432"
...
data: "Publishing 433"
...
data: "Publishing 434"
...
data: "Publishing 435"
...
data: "Publishing 436"
...
data: "Publishing 437"
...
data: "Publishing 438"
...
data: "Publishing 439"
```

## Steps to solve task 3 part 1 Create subscriber node:

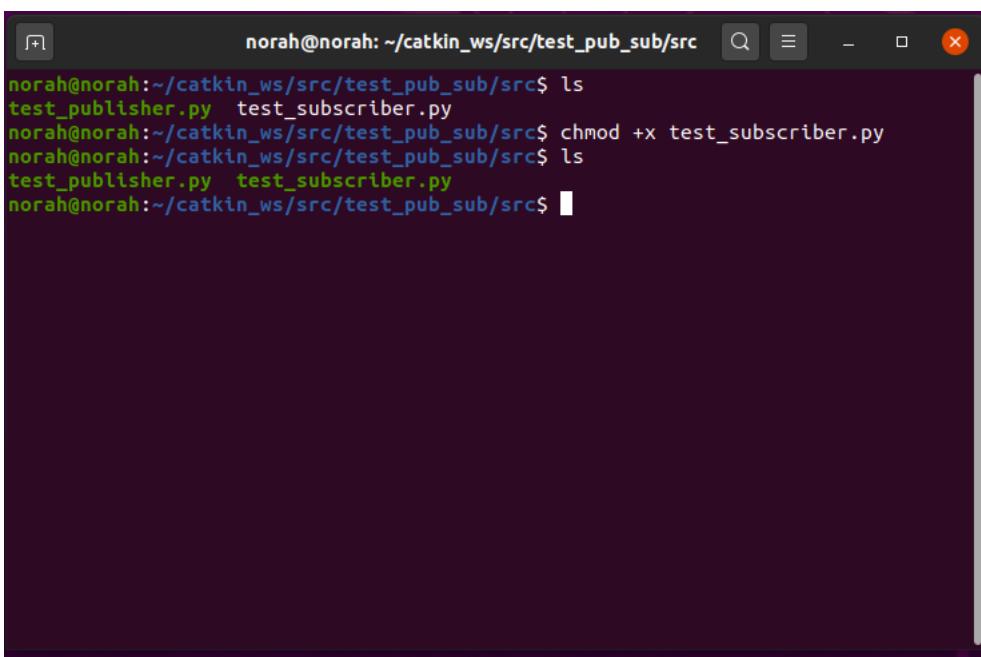
### 1. Write the subscriber node



A screenshot of a code editor window titled "test\_subscriber.py". The file path is shown as "/catkin\_ws/src/test\_pub\_sub/src". The code is a Python script using the rospy library to create a subscriber node. It includes imports for rospy and std\_msgs.msg.String, defines a subscriber function, and contains a main block with an if \_\_name\_\_ == "\_\_main\_\_": condition. The code editor has a status bar at the bottom indicating "Python 3", "Tab Width: 8", "Ln 14, Col 27", and "INS".

```
1 #!/usr/bin/python3
2
3 import rospy
4 from std_msgs.msg import String
5
6 def subscriber():
7     sub = rospy.Subscriber('string_publish', String, callback_function)
8
9     rospy.spin()
10
11 def callback_function(message):
12     rospy.loginfo("I received: %s" % message.data)
13
14 if __name__ == "__main__":
15     rospy.init_node("simple_subscriber")
16     subscriber()
17
18
19
20
```

### 2. Make the test subscriber file executable



A screenshot of a terminal window showing a user named "norah" performing file operations. The user runs "ls" to list files, then uses "chmod +x" to make the "test\_subscriber.py" file executable. Finally, they run "ls" again to show the updated list of files.

```
norah@norah:~/catkin_ws/src/test_pub_sub/src$ ls
test_publisher.py  test_subscriber.py
norah@norah:~/catkin_ws/src/test_pub_sub/src$ chmod +x test_subscriber.py
norah@norah:~/catkin_ws/src/test_pub_sub/src$ ls
test_publisher.py  test_subscriber.py
norah@norah:~/catkin_ws/src/test_pub_sub/src$
```

### 3. Run the subscriber

```

roscore http://norah:11311/
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://norah:39933/
ros_comm version 1.15.7

SUMMARY
=====
PARAMETERS
  * /rostdistro: noetic
  * /rosversion: 1.15.7

NODES

auto-starting new master
process[master]: started with pid [60758]
ROS_MASTER_URI=http://norah:11311/

setting /run_id to bbd64964-bd5f-11ea-9f22-d9eb5277eef9
process[rosout-1]: started with pid [60768]
started core service [/rosout]

```

```

norah@norah: ~/catkin_ws/src/test_pub_sub/src$ rosrun test_pub_sub test_subscriber.py
[INFO] [1593803809.376607]: I received: Publishing 649
[INFO] [1593803810.381657]: I received: Publishing 650
[INFO] [1593803811.378322]: I received: Publishing 651
[INFO] [1593803812.373297]: I received: Publishing 652
[INFO] [1593803813.373417]: I received: Publishing 653
[INFO] [1593803814.373744]: I received: Publishing 654
[INFO] [1593803815.373783]: I received: Publishing 655
[INFO] [1593803816.374249]: I received: Publishing 656
[INFO] [1593803817.375954]: I received: Publishing 657
[INFO] [1593803818.374701]: I received: Publishing 658
[INFO] [1593803819.381125]: I received: Publishing 659
[INFO] [1593803820.373988]: I received: Publishing 660
[INFO] [1593803821.373967]: I received: Publishing 661
[INFO] [1593803822.380768]: I received: Publishing 662
[INFO] [1593803823.377659]: I received: Publishing 663
[INFO] [1593803824.376854]: I received: Publishing 664
[INFO] [1593803825.374152]: I received: Publishing 665
[INFO] [1593803826.373614]: I received: Publishing 666

```

### 4. Graphical view between the subscriber and publisher

```

roscore http://norah:11311/
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://norah:39933/
ros_comm version 1.15.7

SUMMARY
=====
PARAMETERS
  * /rostdistro: noetic
  * /rosversion: 1.15.7

NODES

auto-starting new master
process[master]: started with pid [60758]
ROS_MASTER_URI=http://norah:11311/

setting /run_id to bbd64964-bd5f-11ea-9f22-d9eb5277eef9
process[rosout-1]: started with pid [60768]
started core service [/rosout]

```

```

norah@norah: ~/catkin_ws/src/test_pub_sub/src$ rosrun rqt_graph rqt_graph
norah@norah: ~/catkin_ws/src/test_pub_sub/src$ rqt_graph

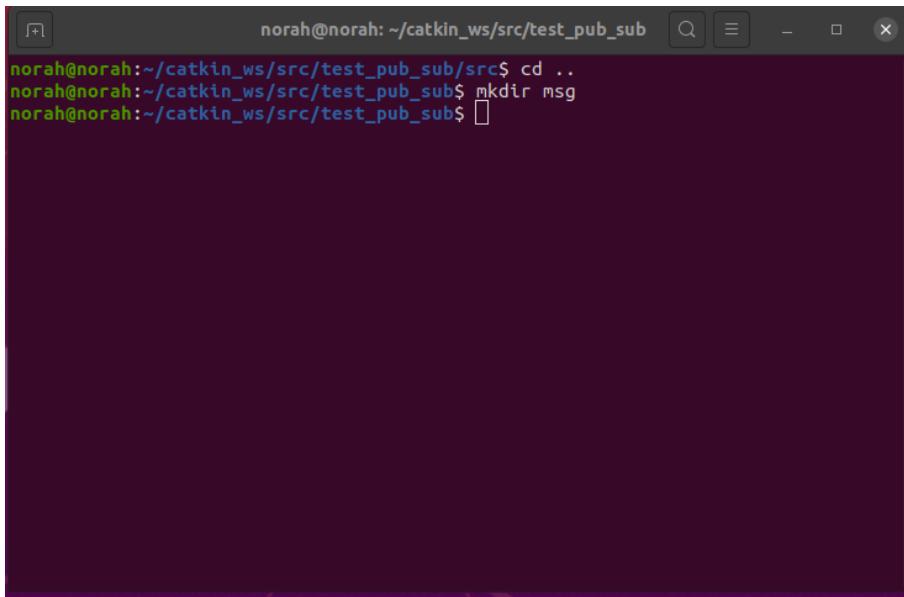
```

The rqt\_graph window displays a node graph with two nodes: `/simple_publisher` and `/simple_subscriber`. They are connected by a directed edge labeled `/string_publish`.

**Rqt\_graphs** are helpful in debugging the code to understand what is happening between the two nodes.

## Steps to solve task 3 create a custom message:

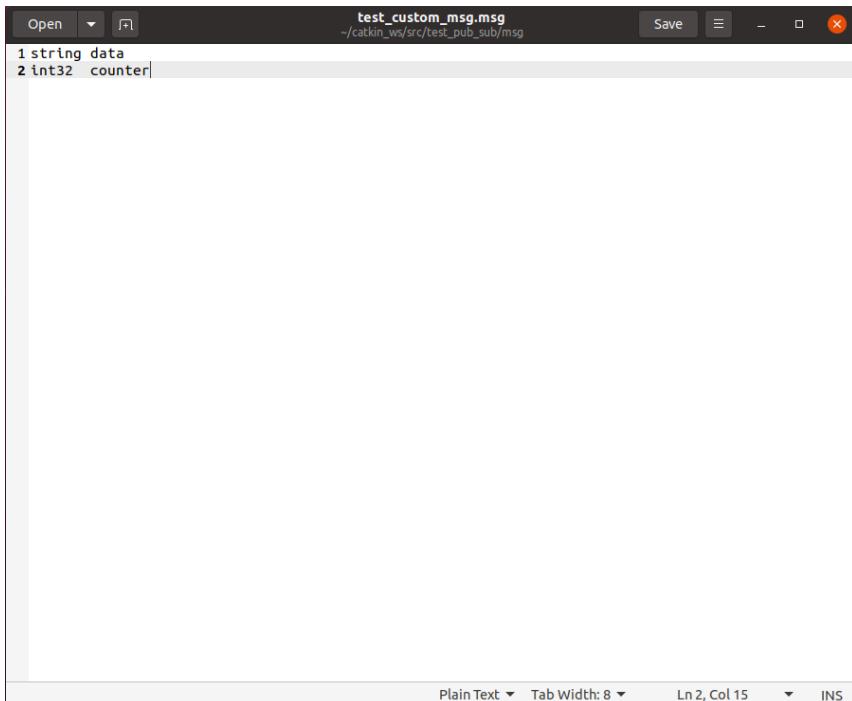
1. Create a msg folder inside the package



```
norah@norah:~/catkin_ws/src/test_pub_sub$ cd ..
norah@norah:~/catkin_ws/src/test_pub_sub$ mkdir msg
norah@norah:~/catkin_ws/src/test_pub_sub$
```

A terminal window titled "norah@norah: ~/catkin\_ws/src/test\_pub\_sub". It shows three commands being run sequentially: "cd ..", "mkdir msg", and then a final empty line. The background of the terminal is dark purple.

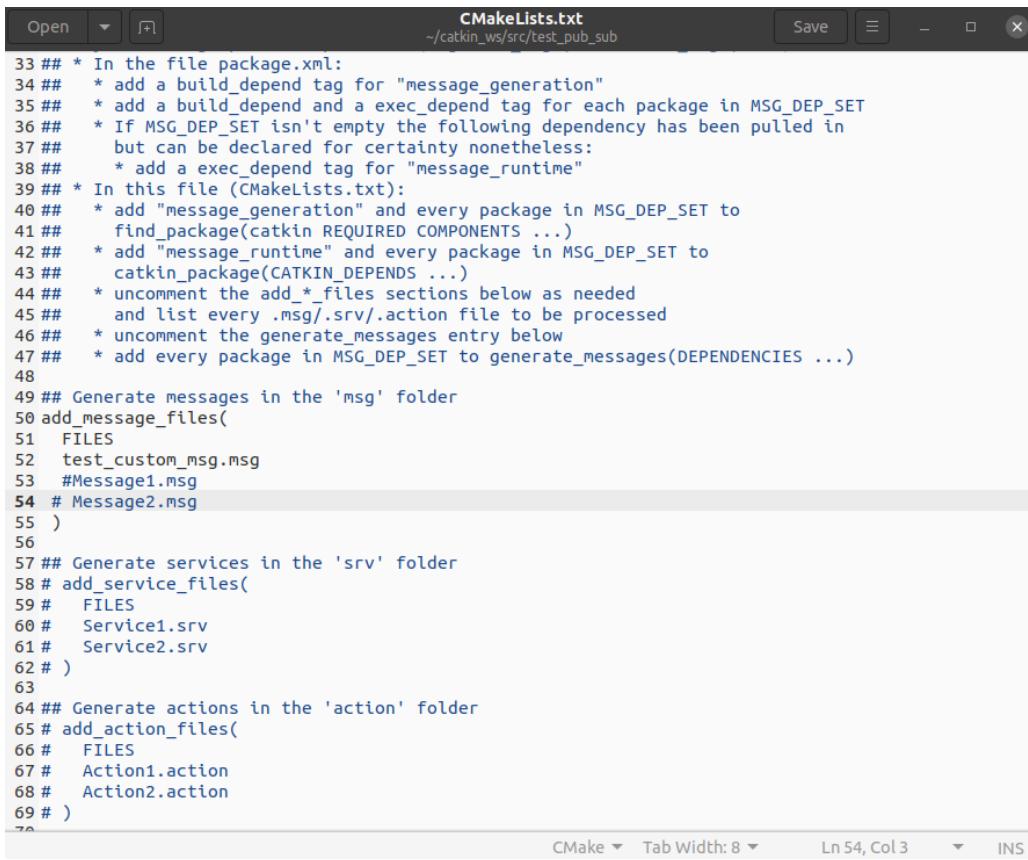
2. Create a custom message file and save it in the msg folder



```
test_custom_msg.msg
~/catkin_ws/src/test_pub_sub/msg
1 string data
2 int32 counter
```

A screenshot of a text editor window titled "test\_custom\_msg.msg" located at "~/catkin\_ws/src/test\_pub\_sub/msg". The editor shows two lines of code: "1 string data" and "2 int32 counter". The status bar at the bottom indicates "Plain Text", "Tab Width: 8", "Ln 2, Col 15", and "INS".

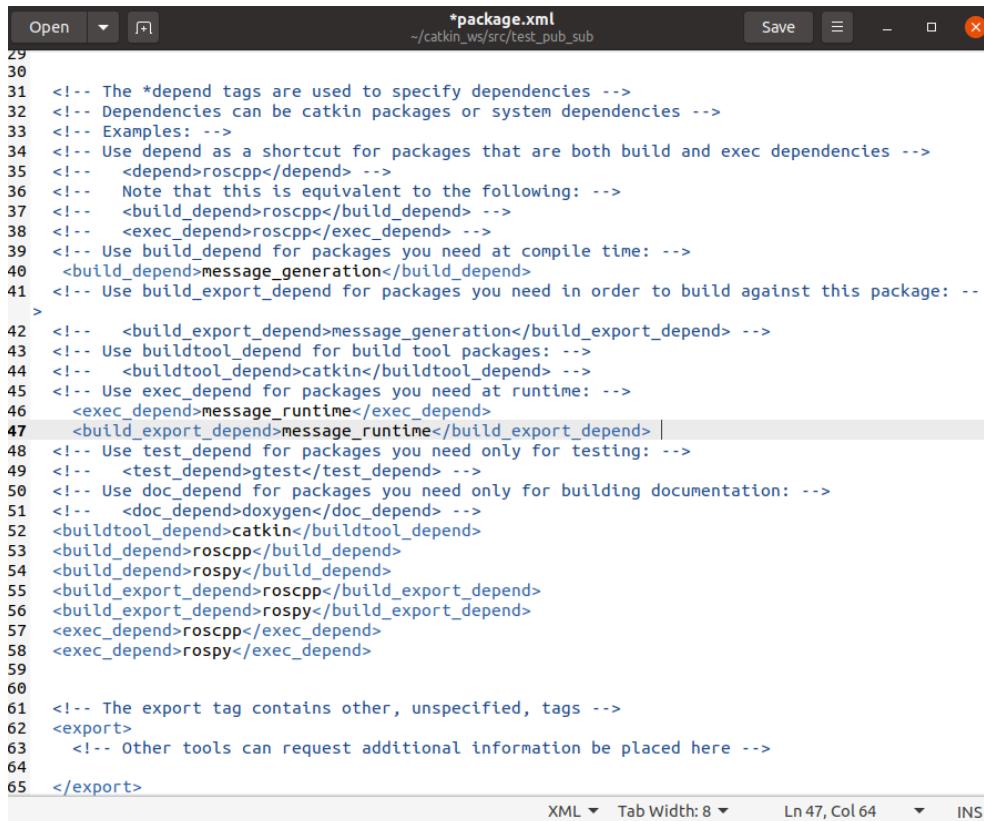
### 3. Modify package.xml and Cmakelist file inside the package



```
CMakeLists.txt
~/catkin_ws/src/test_pub_sub
Save
33 ## * In the file package.xml:
34 ##   * add a build_depend tag for "message_generation"
35 ##   * add a build_depend and a exec_depend tag for each package in MSG_DEP_SET
36 ##   * If MSG_DEP_SET isn't empty the following dependency has been pulled in
37 ##     but can be declared for certainty nonetheless:
38 ##       * add a exec_depend tag for "message_runtime"
39 ## * In this file (CMakeLists.txt):
40 ##   * add "message_generation" and every package in MSG_DEP_SET to
41 ##     find_package(catkin REQUIRED COMPONENTS ...)
42 ##   * add "message_runtime" and every package in MSG_DEP_SET to
43 ##     catkin_package(CATKIN_DEPENDS ...)
44 ##   * uncomment the add_*_files sections below as needed
45 ##     and list every .msg/.srv/.action file to be processed
46 ##   * uncomment the generate_messages entry below
47 ##   * add every package in MSG_DEP_SET to generate_messages(DEPENDENCIES ...)
48
49 ## Generate messages in the 'msg' folder
50 add_message_files(
51   FILES
52   test_custom_msg.msg
53   #Message1.msg
54   # Message2.msg
55 )
56
57 ## Generate services in the 'srv' folder
58 # add_service_files(
59 #   FILES
60 #   Service1.srv
61 #   Service2.srv
62 # )
63
64 ## Generate actions in the 'action' folder
65 # add_action_files(
66 #   FILES
67 #   Action1.action
68 #   Action2.action
69 # )
70
71 ## Generate added messages and services with any dependencies listed here
72 generate_messages(
73   DEPENDENCIES
74   std_msgs # Or other packages containing msgs
75 )
76
```

```
106 catkin_package(
107   INCLUDE_DIRS include
108   LIBRARIES test_pub_sub
109   CATKIN_DEPENDS roscpp rospy message_runtime
110   DEPENDS system_lib
111 )
```

#### 4. Open the package.xml and modify it

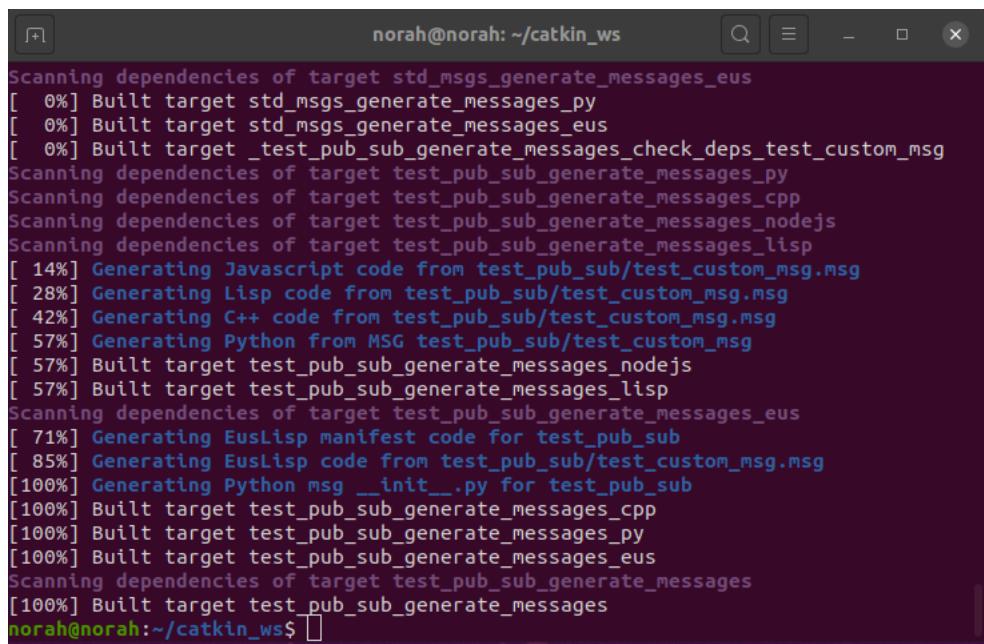


The screenshot shows a code editor window with the title bar "package.xml" and the path "/catkin\_ws/src/test\_pub\_sub". The code is XML-based and defines dependencies for the package. Lines 47 and 48 are highlighted, showing the addition of a new dependency:

```
29
30
31 <!-- The *depend tags are used to specify dependencies -->
32 <!-- Dependencies can be catkin packages or system dependencies -->
33 <!-- Examples: -->
34 <!-- Use depend as a shortcut for packages that are both build and exec dependencies -->
35 <!-- <depend>roscpp</depend> -->
36 <!-- Note that this is equivalent to the following: -->
37 <!-- <build_depend>roscpp</build_depend> -->
38 <!-- <exec_depend>roscpp</exec_depend> -->
39 <!-- Use build_depend for packages you need at compile time: -->
40 <!-- <build_depend>message_generation</build_depend>
41 <!-- Use build_export_depend for packages you need in order to build against this package: -->
42 <!-- <build_export_depend>message_generation</build_export_depend> -->
43 <!-- Use buildtool_depend for build tool packages: -->
44 <!-- <buildtool_depend>catkin</buildtool_depend> -->
45 <!-- Use exec_depend for packages you need at runtime: -->
46 <!-- <exec_depend>message_runtime</exec_depend>
47 <!-- <build_export_depend>message_runtime</build_export_depend> |
48 <!-- Use test_depend for packages you need only for testing: -->
49 <!-- <test_depend>gtest</test_depend> -->
50 <!-- Use doc_depend for packages you need only for building documentation: -->
51 <!-- <doc_depend>doxygen</doc_depend> -->
52 <!-- <buildtool_depend>catkin</buildtool_depend>
53 <!-- <build_depend>roscpp</build_depend>
54 <!-- <build_depend>rospy</build_depend>
55 <!-- <build_export_depend>roscpp</build_export_depend>
56 <!-- <build_export_depend>rospy</build_export_depend>
57 <!-- <exec_depend>roscpp</exec_depend>
58 <!-- <exec_depend>rospy</exec_depend>
59
60
61 <!-- The export tag contains other, unspecified, tags -->
62 <exports>
63 <!-- Other tools can request additional information be placed here -->
64
65 </exports>
```

XML Tab Width: 8 INS Ln 47, Col 64

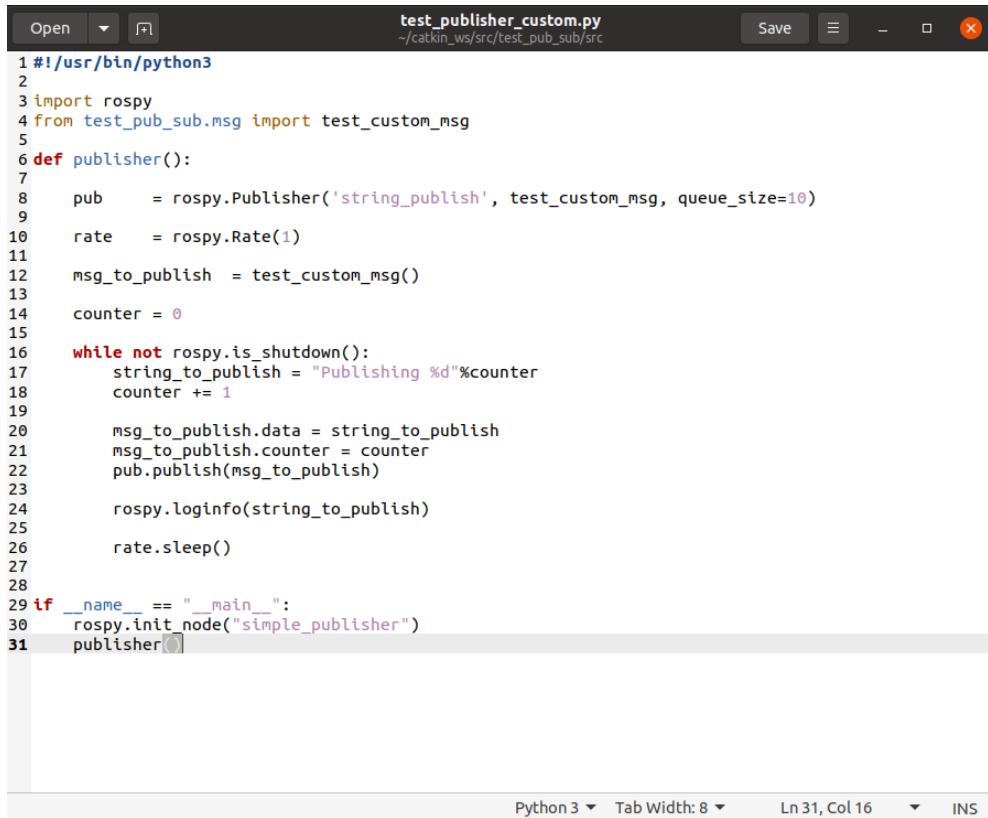
#### 5. Run catkin\_make and observe the changes



The screenshot shows a terminal window titled "norah@norah: ~/catkin\_ws". The output shows the process of generating messages for the "test\_pub\_sub" package. It lists various targets being built, including Python, C++, and EusLisp code generation, along with dependency scanning and manifest code generation.

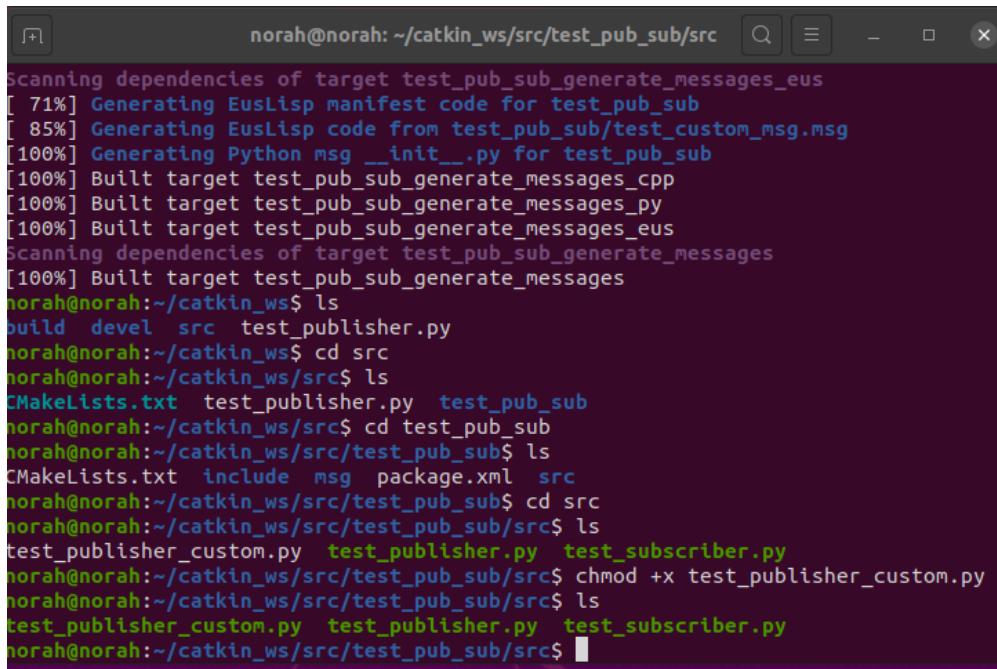
```
Scanning dependencies of target std_msgs_generate_messages_eus
[  0%] Built target std_msgs_generate_messages_py
[  0%] Built target std_msgs_generate_messages_eus
[  0%] Built target _test_pub_sub_generate_messages_check_deps_test_custom_msg
Scanning dependencies of target test_pub_sub_generate_messages_py
Scanning dependencies of target test_pub_sub_generate_messages_cpp
Scanning dependencies of target test_pub_sub_generate_messages_nodejs
Scanning dependencies of target test_pub_sub_generate_messages_lisp
[ 14%] Generating Javascript code from test_pub_sub/test_custom_msg.msg
[ 28%] Generating Lisp code from test_pub_sub/test_custom_msg.msg
[ 42%] Generating C++ code from test_pub_sub/test_custom_msg.msg
[ 57%] Generating Python from MSG test_pub_sub/test_custom_msg
[ 57%] Built target test_pub_sub_generate_messages_nodejs
[ 57%] Built target test_pub_sub_generate_messages_lisp
Scanning dependencies of target test_pub_sub_generate_messages_eus
[ 71%] Generating EusLisp manifest code for test_pub_sub
[ 85%] Generating EusLisp code from test_pub_sub/test_custom_msg.msg
[100%] Generating Python msg __init__.py for test_pub_sub
[100%] Built target test_pub_sub_generate_messages_cpp
[100%] Built target test_pub_sub_generate_messages_py
[100%] Built target test_pub_sub_generate_messages_eus
Scanning dependencies of target test_pub_sub_generate_messages
[100%] Built target test_pub_sub_generate_messages
norah@norah:~/catkin_ws$
```

## 5. Modify the publisher and subscriber code



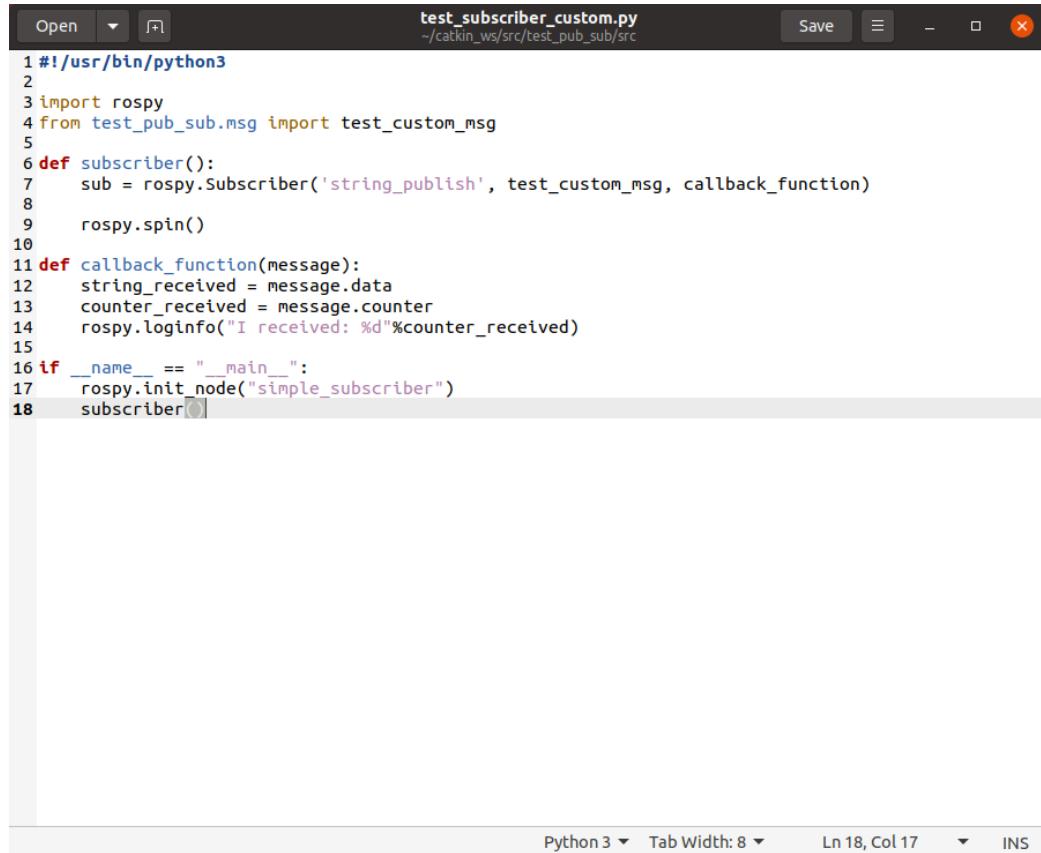
```
1 #!/usr/bin/python3
2
3 import rospy
4 from test_pub_sub.msg import test_custom_msg
5
6 def publisher():
7
8     pub      = rospy.Publisher('string_publish', test_custom_msg, queue_size=10)
9
10    rate     = rospy.Rate(1)
11
12    msg_to_publish  = test_custom_msg()
13
14    counter = 0
15
16    while not rospy.is_shutdown():
17        string_to_publish = "Publishing %d"%counter
18        counter += 1
19
20        msg_to_publish.data = string_to_publish
21        msg_to_publish.counter = counter
22        pub.publish(msg_to_publish)
23
24        rospy.loginfo(string_to_publish)
25
26        rate.sleep()
27
28
29 if __name__ == "__main__":
30     rospy.init_node("simple_publisher")
31     publisher()
```

## 6. Make the file executable



```
Scanning dependencies of target test_pub_sub_generate_messages_eus
[ 71%] Generating EusLisp manifest code for test_pub_sub
[ 85%] Generating EusLisp code from test_pub_sub/test_custom_msg.msg
[100%] Generating Python msg __init__.py for test_pub_sub
[100%] Built target test_pub_sub_generate_messages_cpp
[100%] Built target test_pub_sub_generate_messages_py
[100%] Built target test_pub_sub_generate_messages_eus
Scanning dependencies of target test_pub_sub_generate_messages
[100%] Built target test_pub_sub_generate_messages
norah@norah:~/catkin_ws$ ls
build  devel  src  test_publisher.py
norah@norah:~/catkin_ws$ cd src
norah@norah:~/catkin_ws/src$ ls
CMakeLists.txt  test_publisher.py  test_pub_sub
norah@norah:~/catkin_ws/src$ cd test_pub_sub
norah@norah:~/catkin_ws/src/test_pub_sub$ ls
CMakeLists.txt  include  msg  package.xml  src
norah@norah:~/catkin_ws/src/test_pub_sub$ cd src
norah@norah:~/catkin_ws/src/test_pub_sub/src$ ls
test_publisher_custom.py  test_publisher.py  test_subscriber.py
norah@norah:~/catkin_ws/src/test_pub_sub/src$ chmod +x test_publisher_custom.py
norah@norah:~/catkin_ws/src/test_pub_sub/src$ ls
test_publisher_custom.py  test_publisher.py  test_subscriber.py
norah@norah:~/catkin_ws/src/test_pub_sub/src$
```

## 7. Modify the subscriber node



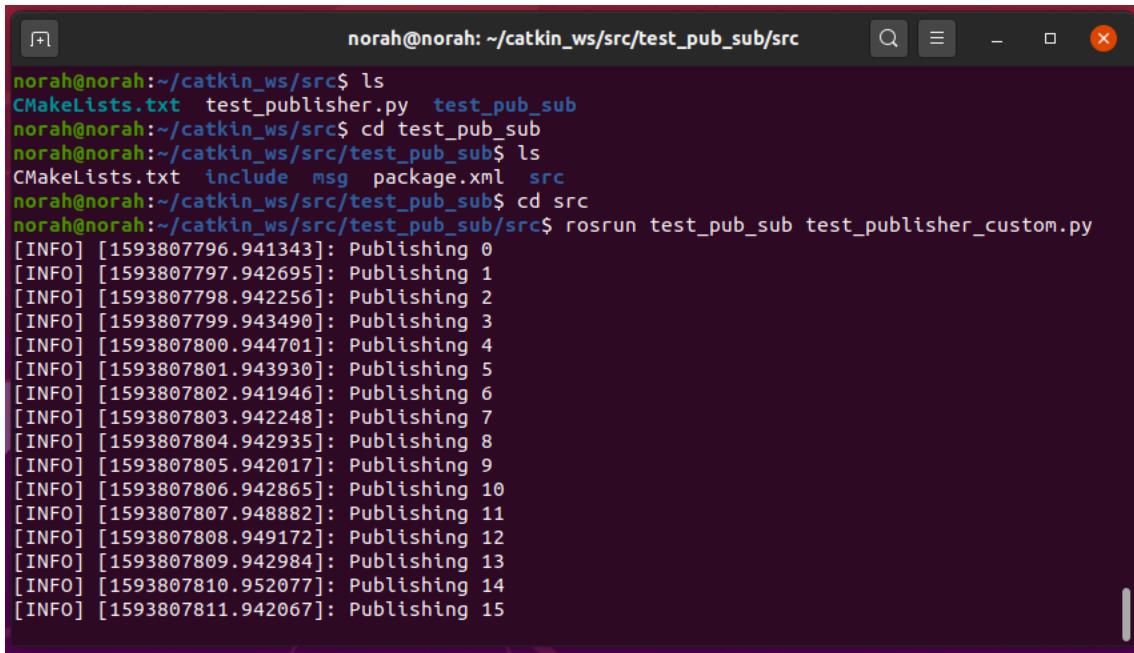
A screenshot of a code editor window titled "test\_subscriber\_custom.py" located at "/catkin\_ws/src/test\_pub\_sub/src". The code is written in Python and defines a subscriber node. It imports rospy and test\_custom\_msg, defines a subscriber function, and a callback function that prints the received message and counter. It also includes a main block to initialize the node. The code is syntax-highlighted with colors for different language elements.

```
1 #!/usr/bin/python3
2
3 import rospy
4 from test_pub_sub.msg import test_custom_msg
5
6 def subscriber():
7     sub = rospy.Subscriber('string_publish', test_custom_msg, callback_function)
8
9     rospy.spin()
10
11 def callback_function(message):
12     string_received = message.data
13     counter_received = message.counter
14     rospy.loginfo("I received: %d" % counter_received)
15
16 if __name__ == "__main__":
17     rospy.init_node("simple_subscriber")
18     subscriber()
```

## 8. Make the file executable

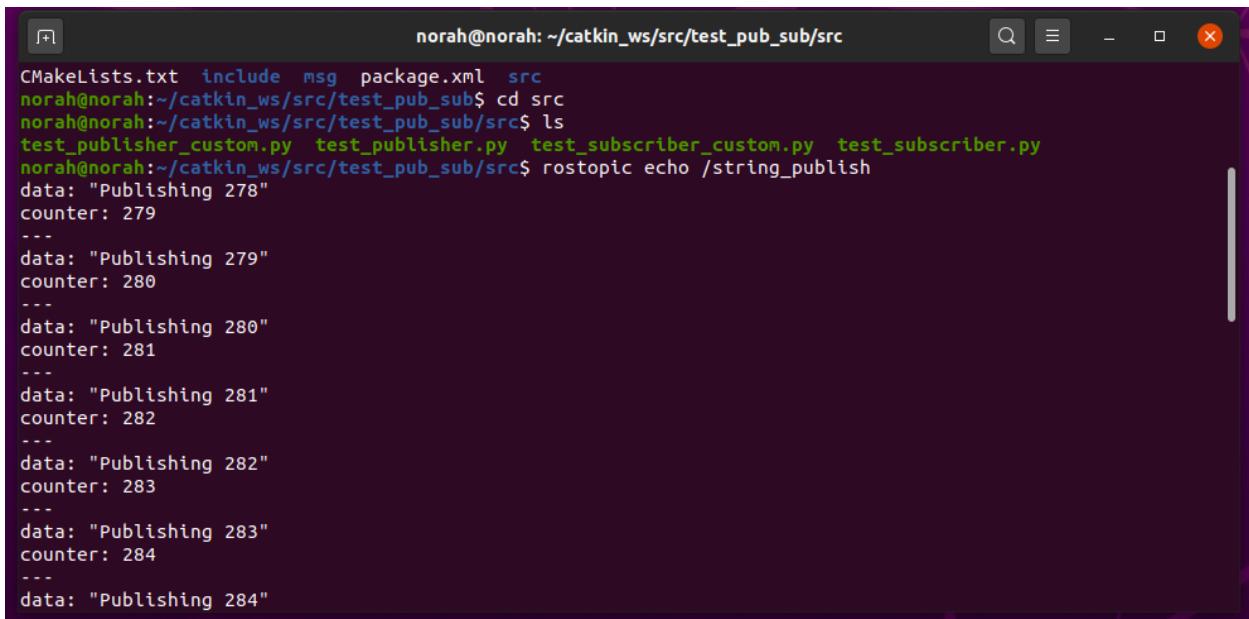
```
norah@norah:~/catkin_ws/src/test_pub_sub/src$ chmod +x test_subscriber_custom.py
norah@norah:~/catkin_ws/src/test_pub_sub/src$ ls
test_publisher_custom.py  test_subscriber_custom.py
test_publisher.py        test_subscriber.py
norah@norah:~/catkin_ws/src/test_pub_sub/src$
```

## 9. Run the publisher node



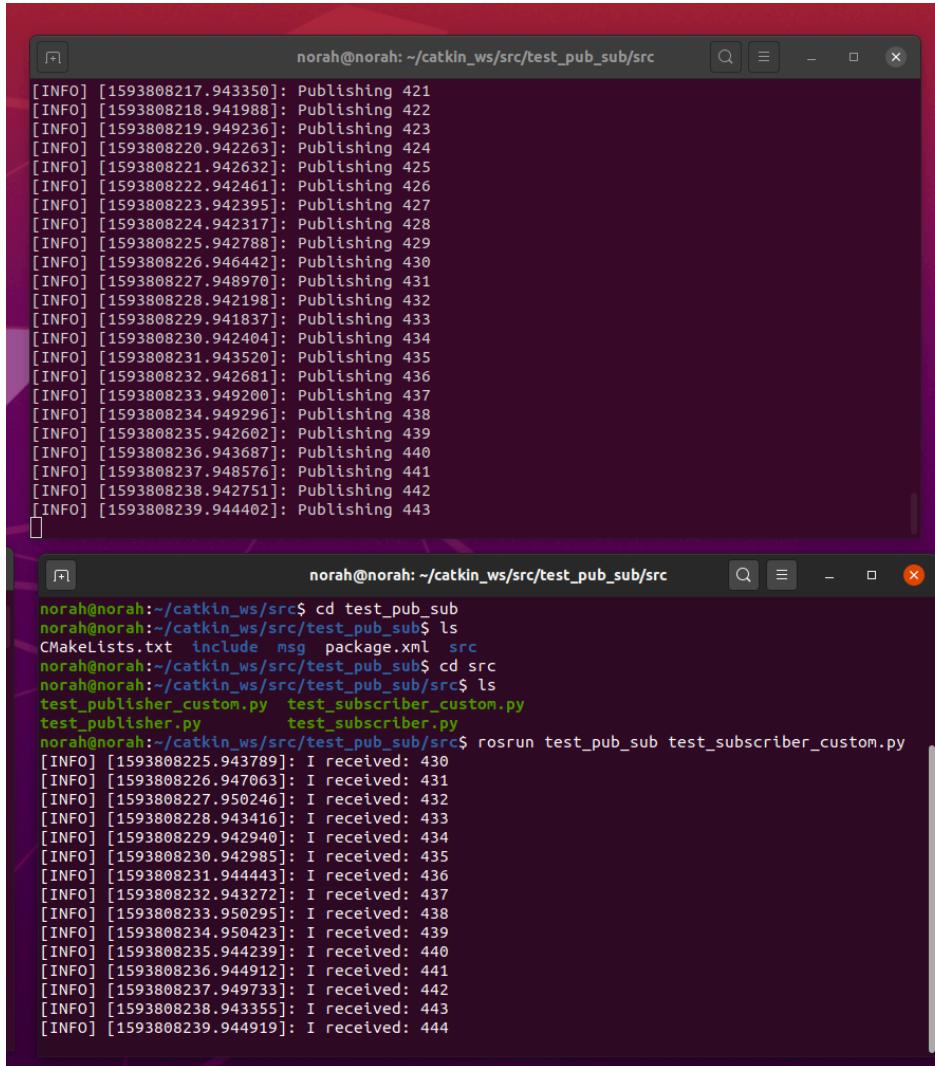
```
norah@norah:~/catkin_ws/src/test_pub_sub/src$ ls
CMakeLists.txt  test_publisher.py  test_pub_sub
norah@norah:~/catkin_ws/src$ cd test_pub_sub
norah@norah:~/catkin_ws/src/test_pub_sub$ ls
CMakeLists.txt  include  msg  package.xml  src
norah@norah:~/catkin_ws/src/test_pub_sub$ cd src
norah@norah:~/catkin_ws/src/test_pub_sub/src$ rosrun test_pub_sub test_publisher_custom.py
[INFO] [1593807796.941343]: Publishing 0
[INFO] [1593807797.942695]: Publishing 1
[INFO] [1593807798.942256]: Publishing 2
[INFO] [1593807799.943490]: Publishing 3
[INFO] [1593807800.944701]: Publishing 4
[INFO] [1593807801.943930]: Publishing 5
[INFO] [1593807802.941946]: Publishing 6
[INFO] [1593807803.942248]: Publishing 7
[INFO] [1593807804.942935]: Publishing 8
[INFO] [1593807805.942017]: Publishing 9
[INFO] [1593807806.942865]: Publishing 10
[INFO] [1593807807.948882]: Publishing 11
[INFO] [1593807808.949172]: Publishing 12
[INFO] [1593807809.942984]: Publishing 13
[INFO] [1593807810.952077]: Publishing 14
[INFO] [1593807811.942067]: Publishing 15
```

## 10. Check the topic to make sure publisher is working correctly



```
norah@norah:~/catkin_ws/src/test_pub_sub/src$ ls
CMakeLists.txt  include  msg  package.xml  src
norah@norah:~/catkin_ws/src/test_pub_sub$ cd src
norah@norah:~/catkin_ws/src/test_pub_sub/src$ ls
test_publisher_custom.py  test_publisher.py  test_subscriber_custom.py  test_subscriber.py
norah@norah:~/catkin_ws/src/test_pub_sub/src$ rostopic echo /string_publish
data: "Publishing 278"
counter: 279
---
data: "Publishing 279"
counter: 280
---
data: "Publishing 280"
counter: 281
---
data: "Publishing 281"
counter: 282
---
data: "Publishing 282"
counter: 283
---
data: "Publishing 283"
counter: 284
---
data: "Publishing 284"
```

## 11. Run the subscriber



The image shows two terminal windows side-by-side. The top window displays a continuous stream of INFO-level log messages from a publisher node, showing it publishing messages at regular intervals. The bottom window shows the terminal command to run the subscriber node, followed by its output where it receives messages from the publisher.

```
[INFO] [1593808217.943350]: Publishing 421
[INFO] [1593808218.941988]: Publishing 422
[INFO] [1593808219.949236]: Publishing 423
[INFO] [1593808220.942263]: Publishing 424
[INFO] [1593808221.942632]: Publishing 425
[INFO] [1593808222.942461]: Publishing 426
[INFO] [1593808223.942395]: Publishing 427
[INFO] [1593808224.942317]: Publishing 428
[INFO] [1593808225.942788]: Publishing 429
[INFO] [1593808226.946442]: Publishing 430
[INFO] [1593808227.948970]: Publishing 431
[INFO] [1593808228.942198]: Publishing 432
[INFO] [1593808229.941837]: Publishing 433
[INFO] [1593808230.942404]: Publishing 434
[INFO] [1593808231.943520]: Publishing 435
[INFO] [1593808232.942681]: Publishing 436
[INFO] [1593808233.949200]: Publishing 437
[INFO] [1593808234.949296]: Publishing 438
[INFO] [1593808235.942602]: Publishing 439
[INFO] [1593808236.943687]: Publishing 440
[INFO] [1593808237.948576]: Publishing 441
[INFO] [1593808238.942751]: Publishing 442
[INFO] [1593808239.944402]: Publishing 443
```

```
norah@norah:~/catkin_ws/src/test_pub_sub$ cd test_pub_sub
norah@norah:~/catkin_ws/src/test_pub_sub$ ls
CMakeLists.txt  include  msg  package.xml  src
norah@norah:~/catkin_ws/src/test_pub_sub$ cd src
norah@norah:~/catkin_ws/src/test_pub_sub/src$ ls
test_publisher_custom.py  test_subscriber_custom.py
test_publisher.py  test_subscriber.py
norah@norah:~/catkin_ws/src/test_pub_sub/src$ rosrun test_pub_sub test_subscriber_custom.py
[INFO] [1593808225.943789]: I received: 430
[INFO] [1593808226.947063]: I received: 431
[INFO] [1593808227.950246]: I received: 432
[INFO] [1593808228.943416]: I received: 433
[INFO] [1593808229.942940]: I received: 434
[INFO] [1593808230.942985]: I received: 435
[INFO] [1593808231.944443]: I received: 436
[INFO] [1593808232.943272]: I received: 437
[INFO] [1593808233.950295]: I received: 438
[INFO] [1593808234.950423]: I received: 439
[INFO] [1593808235.944239]: I received: 440
[INFO] [1593808236.944912]: I received: 441
[INFO] [1593808237.949733]: I received: 442
[INFO] [1593808238.943355]: I received: 443
[INFO] [1593808239.944919]: I received: 444
```

## 12. Create rqt\_graph

