



CASE STUDY REVIEW

Privacy Level

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REVISION HISTORY

Date	Revision No.	Definition	Author(s)
10/04/2023	1.0	Initial document	Buse Nur EMİR

1. INTRODUCTION

Robot Operating System (ROS) is a collection of tools, libraries, and rules aimed at simplifying the task of creating complex and robust robot behavior across a wide variety of robotic platforms. It provides a flexible framework for robot software. ROS is built on various conceptual structures, including nodes, topics, services, and parameters.

1. Nodes: They are functionally independent units, and a ROS application can include multiple nodes.
2. Topics: They are communication channels and enable data sharing between nodes.
3. Services: They allow one node to call another node to perform a task.
4. Parameters: They are used to change various features of the ROS application

The case study is built in that the talker unit shared the data of battery level and the listener unit takes this data to display it. By using ROS, the units are defined as nodes. The nodes communicate with each other via “/battery_topic” topic as shown in Figure 1.

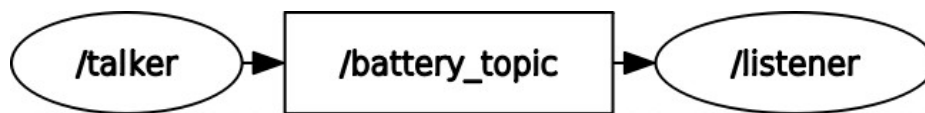


Figure 1. The structure of the project with rqt_graph

2. INSTALLATION

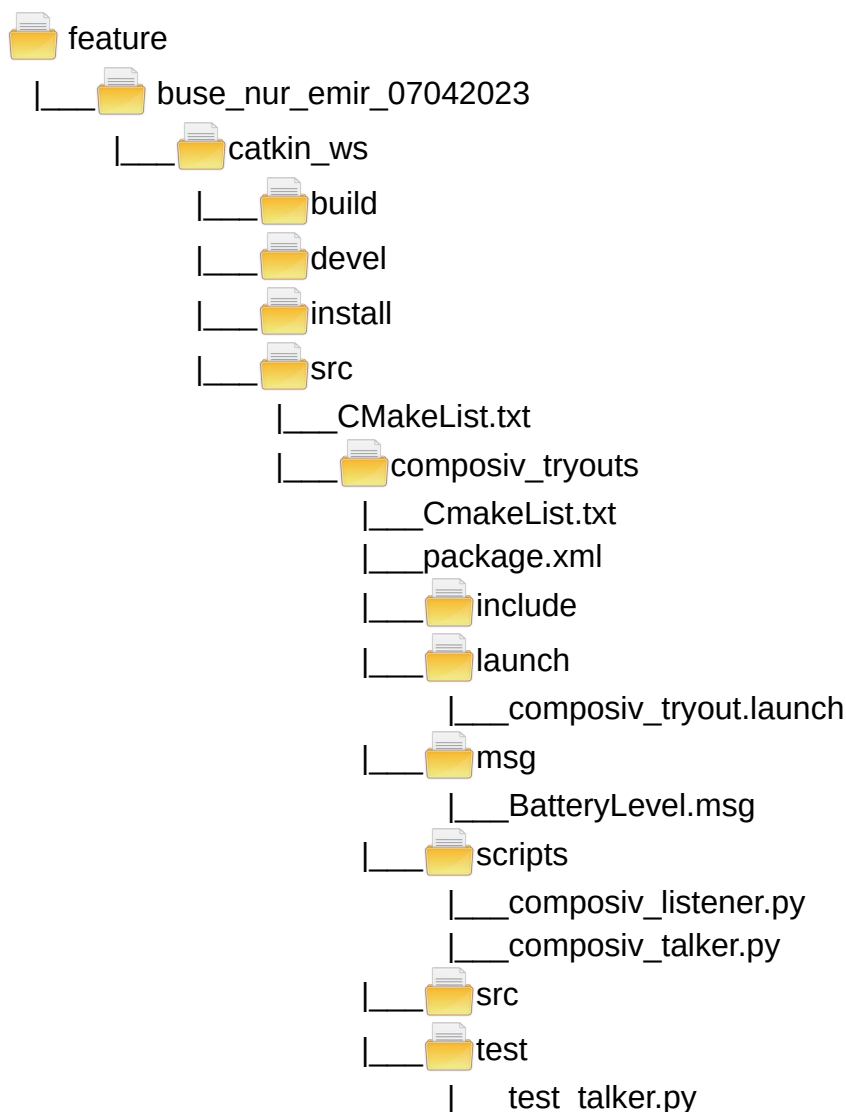
ROS is supported by many operating systems. However, the officially supported operating system is Ubuntu. ROS has different versions for different operating systems. This project is built on ROS Noetic Ninjemysm recommended for Ubuntu 20.04.

For installation, please visit [this page](#) and follow the steps.

3. STRUCTURE

The environment-based system in ROS provides modularize the code and dependencies, which makes it easier to develop, test, and deploy robotic applications. In ROS, the environment refers to a set of packages and their dependencies, which are installed and used together. Each package contains nodes, libraries, and configuration files that enable different functionalities. The ROS environment is structured as a hierarchical file system, where each package has its directory with subdirectories for different types of files. These files can include source code, configuration files, launch files, documentation, and more. Each package directory also contains a package.xml file, which defines the package name, version, dependencies, and other package-specific information.

The structure of the project is as below. The "catkin_ws" workspace under the feature/buse_nur_emir_07042023 directory is in the ROS environment. It includes the "composiv_tryouts" package. It was created that one test, one message, one launch, and two scripts file in this package.



4. IMPLEMENTATION

4.1 Creating Workspace and Package

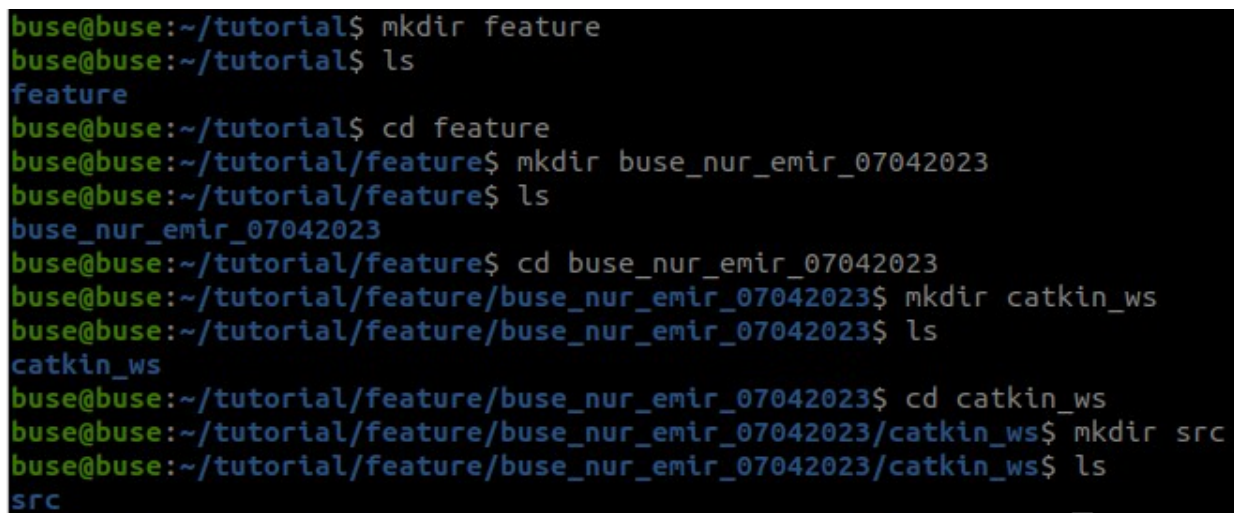
First of all, the necessary conditions must be created to work in the ROS environment. The first thing to do is to define the configuration settings. This definition is made in the `bashrc` file in order not to do the same thing every time the terminal is opened. The `bashrc` file is opened by typing the following command into the terminal:

➤ `gedit ~/.bashrc`

The text below is added to the bottom line of the file:

➤ `source /opt/ros/noetic/setup.bash`

Then the workspace `catkin_ws` is created under the `feature/buse_nur_emir_07042023` directory as mentioned under the Structure heading. New folders must be created for this. To perform this operation from the terminal, `mkdir`, `cd`, and `ls` commands are used. “`mkdir`” command is used to create a new directory or folder. “`cd`” command is used to change the current directory. “`ls`” command is used to list the files and directories in the current working directory. The steps followed to create `catkin_ws` and the `src` folder in it are shown in Figure 2.



```
buse@buse:~/tutorial$ mkdir feature
buse@buse:~/tutorial$ ls
feature
buse@buse:~/tutorial$ cd feature
buse@buse:~/tutorial/feature$ mkdir buse_nur_emir_07042023
buse@buse:~/tutorial/feature$ ls
buse_nur_emir_07042023
buse@buse:~/tutorial/feature$ cd buse_nur_emir_07042023
buse@buse:~/tutorial/feature/buse_nur_emir_07042023$ mkdir catkin_ws
buse@buse:~/tutorial/feature/buse_nur_emir_07042023$ ls
catkin_ws
buse@buse:~/tutorial/feature/buse_nur_emir_07042023$ cd catkin_ws
buse@buse:~/tutorial/feature/buse_nur_emir_07042023/catkin_ws$ mkdir src
buse@buse:~/tutorial/feature/buse_nur_emir_07042023/catkin_ws$ ls
src
```

Figure 2. Creating folders

The `catkin_make` command is run under `catkin_ws` to compile the workspace. As a result of the process, “`build`” and “`devel`” folders are created under the folder. The “`build`” folder is where temporary files generated during the compilation process of the project are stored, while the “`devel`” folder contains development materials used during the development process. The “`src`” folder is where the project's source code is stored. The following text is added to the last part of the `bashrc` file to declare the source of the working environment:

- `source`
`/home/buse/feature/buse_nur_emir_07042023/catkin_ws/devel/setup.bash`

Packages must be in the workspace under the `src` folder. After going to this directory, the following command is used to create the "composiv_tryouts" package. Since it is foreseen that `cpp` and `python` languages can be used for the developments to be made in the package, the package is created depending on `rospy` and `roscpp`.

- `catkin_create_pkg composiv_tryouts rospy roscpp`

"include" and "src" folders, "package.xml" and "CMakeLists.txt" files are created automatically in the package. Then, the package is compiled with the `catkin_make` command after going to the workspace folder.

4.2 Creating Message File

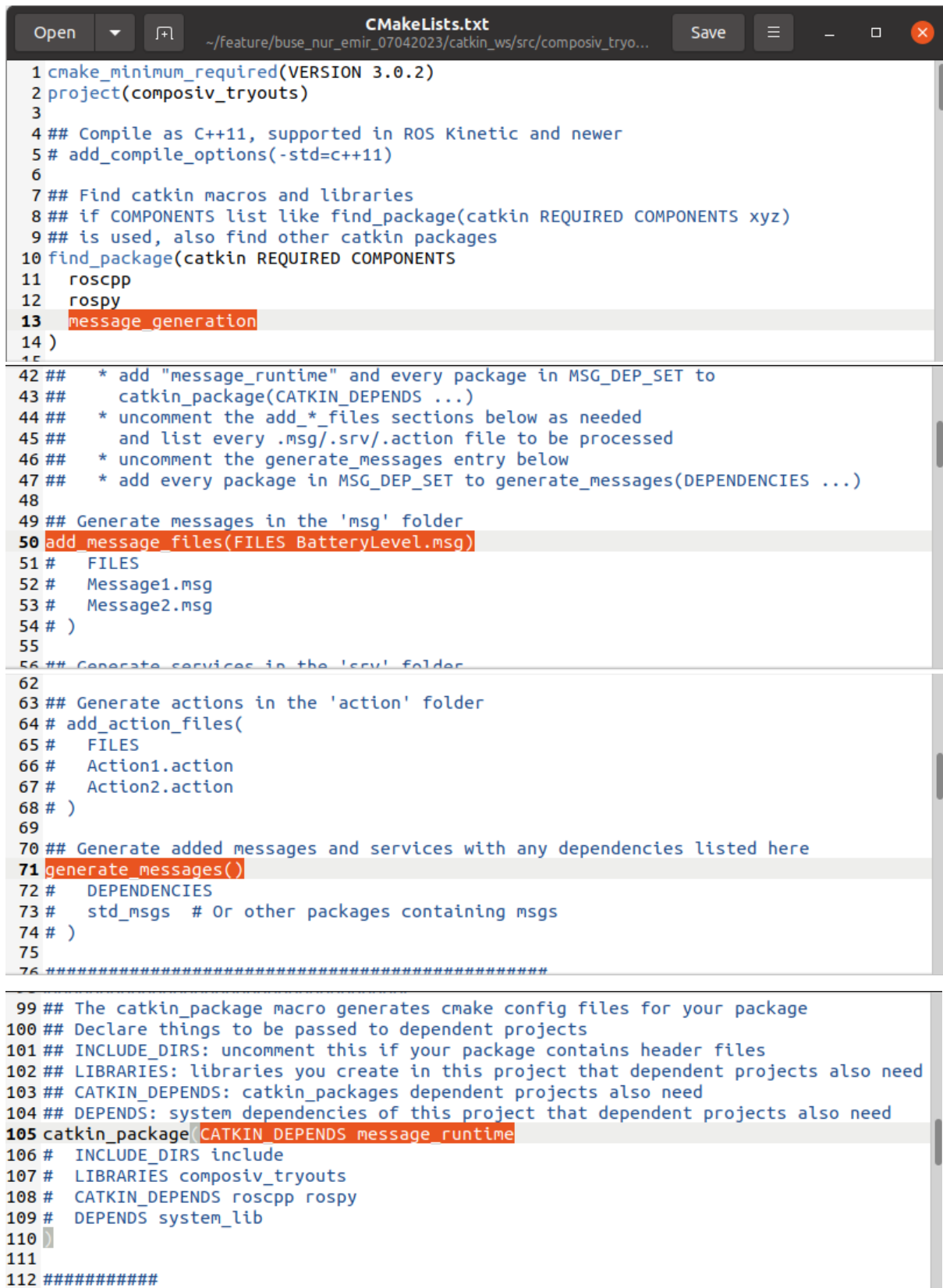
ROS msg (message) files define the structure of the data that can be exchanged between ROS nodes over a topic. They specify the name and data type of each field in a message. In this project, it is aimed to transfer battery level information over the "battery_topic" topic.

First, the `msg` folder is created in the `composiv_tryouts` folder. A message file named "BatteryLevel.msg" is created inside this folder. The contents of this file are as follows. It is stated that the value kept in the `battery` variable is of `string` type.

- `string battery`

Then edits are made in `package.xml` and `CMakeLists.txt` files of the package. The changes shown in Figure 3 have been made in the `CMakeLists.txt` file.

1. "message_generation" dependence is added because it works with messages.
2. The message file is determined
3. It is provided that generating message by uncomment the "generate_message()" function
4. The package is depended to `message_runtime`.



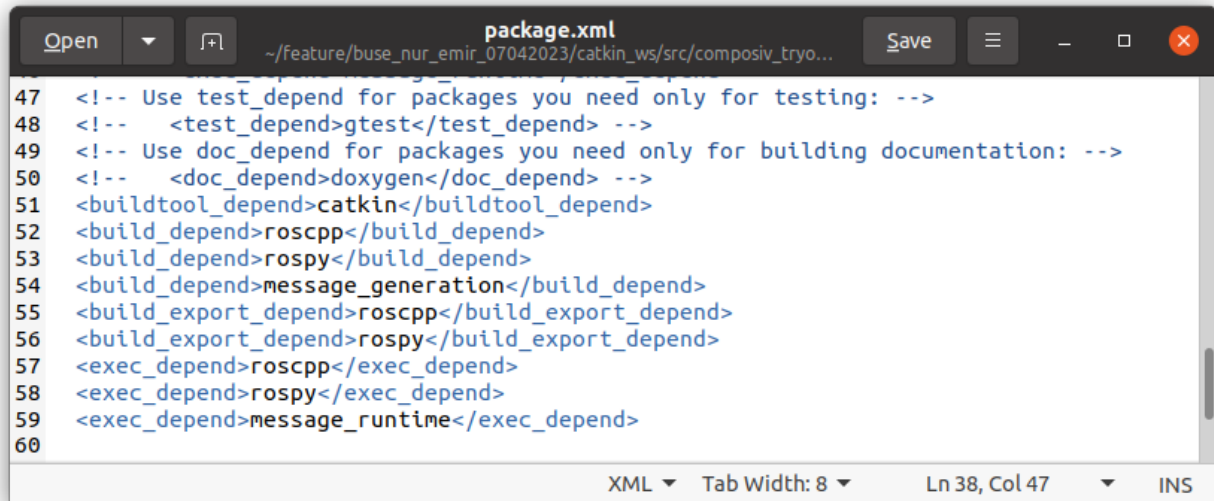
```

1 cmake_minimum_required(VERSION 3.0.2)
2 project(composiv_tryouts)
3
4 ## Compile as C++11, supported in ROS Kinetic and newer
5 # add_compile_options(-std=c++11)
6
7 ## Find catkin macros and libraries
8 ## if COMPONENTS list like find_package(catkin REQUIRED COMPONENTS xyz)
9 ## is used, also find other catkin packages
10 find_package(catkin REQUIRED COMPONENTS
11   roscpp
12   rospy
13   message_generation
14 )
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
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(FILES BatteryLevel.msg)
51 #   FILES
52 #   Message1.msg
53 #   Message2.msg
54 # )
55
56 ## Generate services in the 'srv' folder
57
58
59
60
61
62 ## Generate actions in the 'action' folder
63 # add_action_files(
64 #   FILES
65 #   Action1.action
66 #   Action2.action
67 # )
68 # )
69
70 ## Generate added messages and services with any dependencies listed here
71 generate_messages()
72 #   DEPENDENCIES
73 #   std_msgs  # Or other packages containing msgs
74 # )
75
76 #####
77
78
79
80
81
82
83
84
85
86
87
88
89 ## The catkin_package macro generates cmake config files for your package
90 ## Declare things to be passed to dependent projects
91 ## INCLUDE_DIRS: uncomment this if your package contains header files
92 ## LIBRARIES: libraries you create in this project that dependent projects also need
93 ## CATKIN_DEPENDS: catkin_packages dependent projects also need
94 ## DEPENDS: system dependencies of this project that dependent projects also need
95 catkin_package(CATKIN_DEPENDS message_runtime
96 #   INCLUDE_DIRS include
97 #   LIBRARIES composiv_tryouts
98 #   CATKIN_DEPENDS roscpp rospy
99 #   DEPENDS system_lib
100 )
101
102
103
104
105
106
107
108
109
110
111
112 #####

```

Figure 3.Changes in CMakeLists.txt

The changes have been made in the package.xml file is shown in Figure 4. Since message_generation is needed in compilation and message_runtime is needed in operation, they have been added to the file.



```
47 <!-- Use test_depend for packages you need only for testing: -->
48 <!--   <test_depend>gtest</test_depend> -->
49 <!-- Use doc_depend for packages you need only for building documentation: -->
50 <!--   <doc_depend>doxygen</doc_depend> -->
51 <buildtool_depend>catkin</buildtool_depend>
52 <build_depend>roscpp</build_depend>
53 <build_depend>rospy</build_depend>
54 <build_depend>message_generation</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 <exec_depend>message_runtime</exec_depend>
60
```

Figure 4.Changes in package.xml

4.3 Creating Publisher-Subscriber Nodes

Package source code is stored in the src folder. Source codes can be written in python and cpp languages. To separate these files, cpp files are in the src folder and python files are in the scripts folder. For this reason, the scripts folder is created in the same directory. Since the python language is preferred in the project, the codes are located in the scripts folder. The files must be made executable with the example command below, otherwise the files will not work.

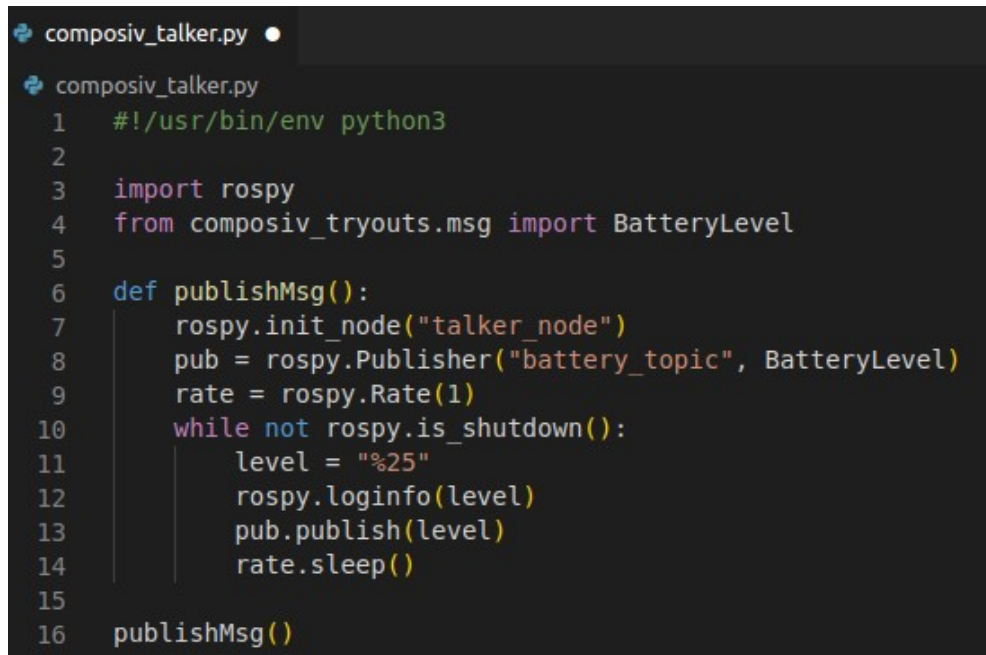
➤ `chmod +x composiv_talker.py`

4.3.1 Publisher Node

A python script file named “composiv_talker” is created for the publisher node. This script shown in Figure 5 uses the rospy library to publish messages to a ROS topic called "battery_topic" with the message type of "BatteryLevel". The script starts by initializing the ROS node with the name "talker_node" and creating a publisher object for the "battery_topic" topic.

The script then enters a while loop that will run until the node is shutdown. Within the loop, the variable "level" is assigned the value of "%25", which represents a battery level of 25%. The "rospy.loginfo()" function is used to print the current battery level to the console.

Finally, the "publish()" method of the publisher object is called with the "level" variable as the argument to publish the message to the "battery_topic" topic. The "rate.sleep()" function is used to pause the loop for 1 second between each iteration to control the publishing frequency. The script ends by calling the "publishMsg()" function.



```
composiv_talker.py
1  #!/usr/bin/env python3
2
3  import rospy
4  from composiv_tryouts.msg import BatteryLevel
5
6  def publishMsg():
7      rospy.init_node("talker_node")
8      pub = rospy.Publisher("battery_topic", BatteryLevel)
9      rate = rospy.Rate(1)
10     while not rospy.is_shutdown():
11         level = "%25"
12         rospy.loginfo(level)
13         pub.publish(level)
14         rate.sleep()
15
16     publishMsg()
```

Figure 5. Publisher node

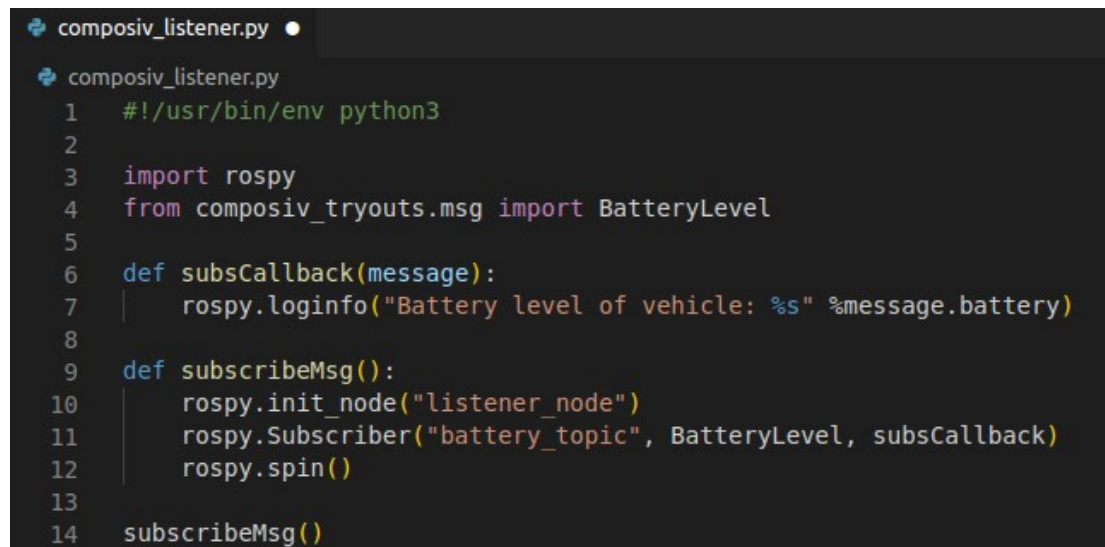
4.3.2 Subscriber Node

A python script file named "composiv_listener" is created for the subscriber node. This script shown in Figure 6 uses the rospy library to subscribe to a ROS topic called "battery_topic" with the message type of "BatteryLevel". The script starts by initializing the ROS node with the name "listener_node" and creating a subscriber object for the "battery_topic" topic, with a callback function "subsCallback" specified as the second argument.

The "subsCallback" function takes a single argument, which is the message received from the "battery_topic" topic. In this case, the function prints a log message to the console, which includes the battery level of the vehicle obtained from the received message.

The "subscribeMsg()" function is then called, which enters a loop that will run until the node is shutdown. Within the loop, the subscriber object listens for messages on the "battery_topic" topic and calls the "subsCallback" function whenever a message is received.

The "rospy.spin()" function is used to keep the script running and handle any incoming messages in the background. Finally, the script ends by calling the "subscribeMsg()" function.

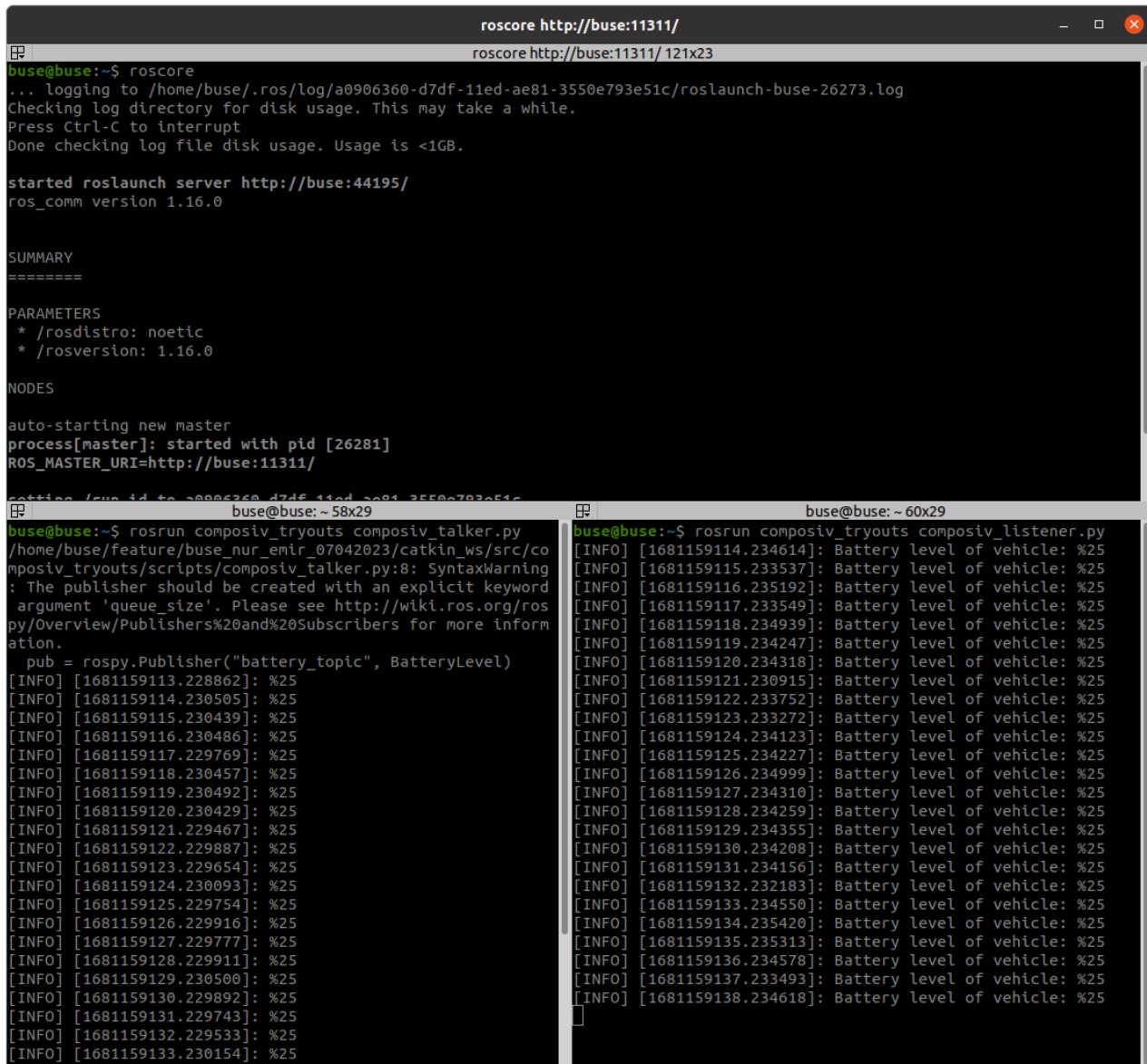
A screenshot of a code editor window titled 'composiv_listener.py'. The code is written in Python and defines a subscriber node for ROS. It includes a shebang line, imports for 'rospy' and 'BatteryLevel', a callback function 'subsCallback', and a 'subscribeMsg' function that initializes the node, subscribes to 'battery_topic', spins, and then calls itself recursively.

```
composiv_listener.py
1  #!/usr/bin/env python3
2
3  import rospy
4  from composiv_tryouts.msg import BatteryLevel
5
6  def subsCallback(message):
7      rospy.loginfo("Battery level of vehicle: %s" %message.battery)
8
9  def subscribeMsg():
10     rospy.init_node("listener_node")
11     rospy.Subscriber("battery_topic", BatteryLevel, subsCallback)
12     rospy.spin()
13
14     subscribeMsg()
```

Figure 6.Subscriber node

4.3.3 Test

At this stage, 3 different terminal screens are needed, Figure 7. First, the roscore command shown on the upper terminal is run to start ROS. Then the nodes are run by rosrund command. The outputs show that both nodes are working fine.



The image displays three terminal windows. The top window, titled 'roscore http://buse:11311/', shows the execution of 'roscore' which starts the ROS master. The middle window, titled 'buse@buse: ~ 58x29', shows the execution of 'roslaunch composiv_tryouts composiv_talker.py' which publishes battery level data. The bottom window, titled 'buse@buse: ~ 60x29', shows the execution of 'roslaunch composiv_tryouts composiv_listener.py' which receives the battery level data. Both nodes output a series of 'Battery level of vehicle: %25' messages.

```
roscore http://buse:11311/
roscore http://buse:11311/ 121x23
buse@buse:~$ roscore
... logging to /home/buse/.ros/log/a0906360-d7df-11ed-ae81-3550e793e51c/roslaunch-buse-26273.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://buse:44195/
ros_comm version 1.16.0

SUMMARY
=====

PARAMETERS
* /rostdistro: noetic
* /rosversion: 1.16.0

NODES

auto-starting new master
process[master]: started with pid [26281]
ROS_MASTER_URI=http://buse:11311/

buse@buse:~ 58x29
buse@buse:~$ roslaunch composiv_tryouts composiv_talker.py
/home/buse/feature/buse_nur_emir_07042023/catkin_ws/src/composiv_tryouts/scripts/composiv_talker.py:8: SyntaxWarning: The publisher should be created with an explicit keyword argument 'queue_size'. Please see http://wiki.ros.org/rospy/Overview/Publishers%20and%20Subscribers for more information.
  pub = rospy.Publisher("battery_topic", BatteryLevel)
[INFO] [1681159113.228862]: %25
[INFO] [1681159114.230505]: %25
[INFO] [1681159115.230439]: %25
[INFO] [1681159116.230486]: %25
[INFO] [1681159117.229769]: %25
[INFO] [1681159118.230457]: %25
[INFO] [1681159119.230492]: %25
[INFO] [1681159120.230429]: %25
[INFO] [1681159121.229467]: %25
[INFO] [1681159122.229887]: %25
[INFO] [1681159123.229654]: %25
[INFO] [1681159124.230093]: %25
[INFO] [1681159125.229754]: %25
[INFO] [1681159126.229916]: %25
[INFO] [1681159127.229777]: %25
[INFO] [1681159128.229911]: %25
[INFO] [1681159129.230500]: %25
[INFO] [1681159130.229892]: %25
[INFO] [1681159131.229743]: %25
[INFO] [1681159132.229533]: %25
[INFO] [1681159133.230154]: %25

buse@buse:~ 60x29
buse@buse:~$ roslaunch composiv_tryouts composiv_listener.py
[INFO] [1681159114.234614]: Battery level of vehicle: %25
[INFO] [1681159115.233537]: Battery level of vehicle: %25
[INFO] [1681159116.235192]: Battery level of vehicle: %25
[INFO] [1681159117.233549]: Battery level of vehicle: %25
[INFO] [1681159118.234939]: Battery level of vehicle: %25
[INFO] [1681159119.234247]: Battery level of vehicle: %25
[INFO] [1681159120.234318]: Battery level of vehicle: %25
[INFO] [1681159121.230915]: Battery level of vehicle: %25
[INFO] [1681159122.233752]: Battery level of vehicle: %25
[INFO] [1681159123.233272]: Battery level of vehicle: %25
[INFO] [1681159124.234123]: Battery level of vehicle: %25
[INFO] [1681159125.234227]: Battery level of vehicle: %25
[INFO] [1681159126.234999]: Battery level of vehicle: %25
[INFO] [1681159127.234310]: Battery level of vehicle: %25
[INFO] [1681159128.234259]: Battery level of vehicle: %25
[INFO] [1681159129.234355]: Battery level of vehicle: %25
[INFO] [1681159130.234208]: Battery level of vehicle: %25
[INFO] [1681159131.234156]: Battery level of vehicle: %25
[INFO] [1681159132.232183]: Battery level of vehicle: %25
[INFO] [1681159133.234550]: Battery level of vehicle: %25
[INFO] [1681159134.235420]: Battery level of vehicle: %25
[INFO] [1681159135.235313]: Battery level of vehicle: %25
[INFO] [1681159136.234578]: Battery level of vehicle: %25
[INFO] [1681159137.233493]: Battery level of vehicle: %25
[INFO] [1681159138.234618]: Battery level of vehicle: %25
```

Figure 7. Test screen

4.4 Creating Unit-Test

The "rotest" and "unittest" modules are Python modules that help test software units on ROS. The "unittest" module provides a framework for defining test cases. These states describe the behavior, errors, and success of the functions to be tested. These test cases are used to determine that a particular part of your program is working correctly. The "rotest" module provides a framework for testing ROS packages. This module enables automatic coordination of tests between ROS packages using the "roslaunch" command. With these tests, dependencies between ROS packages, messages are sent and received correctly, and functions are called correctly can be tested. The test folder is created in the `composiv_tryouts` folder for the test scripts.

A python script file named "test_talker" shown in Figure 8 defines a unit test case for a ROS (Robot Operating System) node that publishes messages to a topic named "battery_topic". The test case is defined using the "unittest" module, which provides a framework for writing and executing tests.

The "TalkerTestCase" class extends the "unittest.TestCase" class and defines a test method called "test_talker_publishing". This method initializes a ROS node with the name "test_talker" and creates a subscriber object for the "battery_topic" topic. It also defines a callback function called "callback" that will be called when messages are received on the topic.

The "test_talker_publishing" method then enters a loop that will run until the node is shutdown, a maximum of 5 seconds have elapsed, or a message has been received on the "battery_topic" topic. If a message is received, the "self.talker_ok" flag is set to True, indicating that the test has passed.

The "if name == 'main':" block at the end of the script uses the "rotest" module to run the "composiv_talker" node with the "TalkerTestCase" test case. This allows the test case to be executed as part of a larger test suite for the ROS package "composiv_tryouts".

It is benefitted from the [\[ROS Q&A\] 098 - How to see if my ROS Publisher works using ROS Unit Testing](#) video to write this script.

```

test_talker.py
run > user > 1000 > doc > af49d4e5 > test_talker.py
1  #!/usr/bin/env python3
2
3  import unittest
4  import rospy
5  from composiv_tryouts.msg import BatteryLevel
6  from time import sleep
7  import rostest
8
9  class TalkerTestCase(unittest.TestCase):
10     talker_ok = False
11
12     def callback(self,data):
13         self.talker_ok = True
14
15     def test_talker_publishing(self):
16         rospy.init_node('test_talker')
17         rospy.Subscriber("battery_topic", BatteryLevel, self.callback)
18         counter = 0
19         while not rospy.is_shutdown() and counter<5 and (not self.talker_ok):
20             sleep(1)
21             counter += 1
22
23         self.assertTrue(self.talker_ok)
24
25 if __name__ == '__main__':
26     rostest.rostest('composiv_tryouts','composiv_talker', TalkerTestCase)

```

Figure 8. Test script

The test can be performed with the rosrn command using three separate terminals, as shown in Figure 9. It can also be done with the rostest command by creating a launch file.

```

roscore http://buse:11311/
roscore http://buse:11311/ 121x13
buse@buse:~$ roscore
... logging to /home/buse/.ros/log/d761fc6a-d7e3-11ed-ae81-3550e793e51c/roslaunch-buse-28893.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://buse:34885/
ros_comm version 1.16.0

SUMMARY
=====
PARAMETERS
buse@buse: ~ 59x13
buse@buse:~$ rosrn composiv_tryouts composiv_talker.py
/home/buse/feature/buse_nur_emir_07042023/catkin_ws/src/composiv_tryouts/scripts/composiv_talker.py:8: SyntaxWarning: The publisher should be created with an explicit keyword argument 'queue_size'. Please see http://wiki.ros.org/rospy/0view/Publishers%20and%20Subscribers for more information
pub = rospy.Publisher("battery_topic", BatteryLevel)
[INFO] [1681160915.270384]: %25
[INFO] [1681160916.272508]: %25
[INFO] [1681160917.271559]: %25
[INFO] [1681160918.271832]: %25
[INFO] [1681160919.271782]: %25
[INFO] [1681160920.272045]: %25
buse@buse:~$ rosrn composiv_tryouts test_talker.py
[ROSUNIT] Outputting test results to /home/buse/.ros/test_results/composiv_tryouts/rosunit-composiv_talker.xml
[Testcase: test_talker_publishing] ... ok
-----
SUMMARY:
* RESULT: SUCCESS
* TESTS: 1
* ERRORS: 0 []
* FAILURES: 0 []
buse@buse:~$

```

Figure 9. Running test script

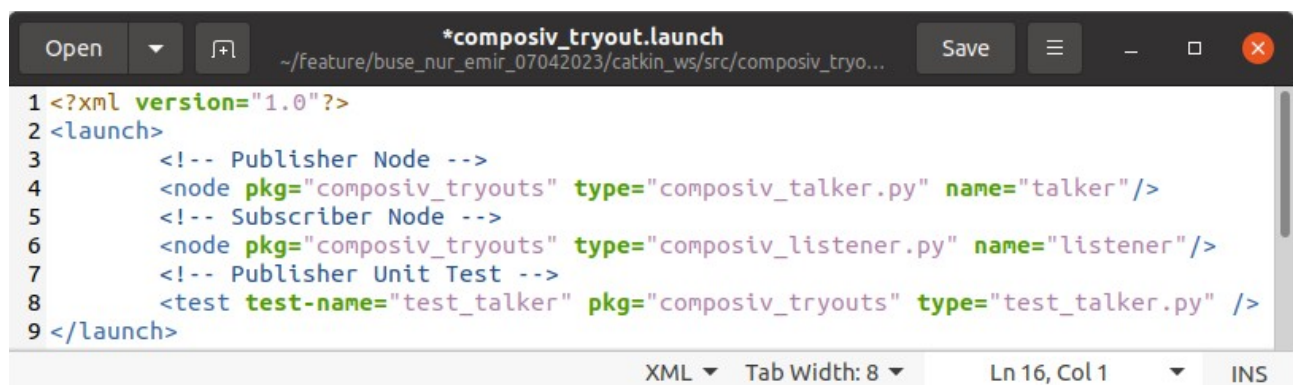
4.5 Creating Launch File

A launch file specifies the dependencies between ROS packages and starts the ROS nodes you want to run. The launch folder is created in the `composiv_tryouts` folder for the launch files. In the launch file named "`composiv_tryout`" shown in Figure 10, three nodes are started from the "`composiv_tryouts`" package.

The first node launches a ROS node named "`talker`" from the "`composiv_talker.py`" file. This node publishes messages to a ROS topic named "`battery_topic`" at certain intervals.

The second node launches a ROS node named "`listener`" from the "`composiv_listener.py`" file. This node listens to messages published on the "`battery_topic`" ROS topic and prints the messages it receives.

The third node launches a ROS test case named "`test_talker.py`". This test case checks whether the "`talker`" node in the "`composiv_talker.py`" file sends messages to the "`battery_topic`" topic correctly. This way, it tests whether the "`talker`" node is working properly.



```
1 <?xml version="1.0"?>
2 <launch>
3     <!-- Publisher Node -->
4     <node pkg="composiv_tryouts" type="composiv_talker.py" name="talker"/>
5     <!-- Subscriber Node -->
6     <node pkg="composiv_tryouts" type="composiv_listener.py" name="listener"/>
7     <!-- Publisher Unit Test -->
8     <test test-name="test_talker" pkg="composiv_tryouts" type="test_talker.py" />
9 </launch>
```

Figure 10.The launch file

This "`launch`" file can be run with the "`roslaunch`" command, which will automatically start all the nodes and test cases. In addition, testing can be performed by running the launch file with the `rotest` command, Figure 11.

```
buse@buse: ~  
buse@buse: ~ 80x22  
buse@buse:~$ rostest composiv_tryouts composiv_tryout.launch  
... logging to /home/buse/.ros/log/rostest-buse-29503.log  
[ROSUNIT] Outputting test results to /home/buse/.ros/test_results/composiv_tryouts/rostest-launch_composiv_tryout.xml  
/home/buse/feature/buse_nur_emir_07042023/catkin_ws/src/composiv_tryouts/scripts/composiv_talker.py:8: SyntaxWarning: The publisher should be created with an explicit keyword argument 'queue_size'. Please see http://wiki.ros.org/rospy/Overview/Publishers%20and%20Subscribers for more information.  
  pub = rospy.Publisher("battery_topic", BatteryLevel)  
[Testcase: testtest_talker] ... ok  
  
[ROSTEST]-----  
  
[composiv_tryouts.rosunit-test_talker/test_talker_publishing][passed]  
  
SUMMARY  
* RESULT: SUCCESS  
* TESTS: 1  
* ERRORS: 0  
* FAILURES: 0  
  
rostest log file is in /home/buse/.ros/log/rostest-buse-29503.log
```

Figure 11.Usage of rostest