Understanding ROS using Turtlesim

F1/10 Autonomous Racing
CS 4501

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[Compiled using the official ROS Turtlesim tutorials.]

Contents

Roscore

This starts ROS and creates the Master so that nodes can communicate.

$ **roscore** **[1]**

From the ROS tutorial http://wiki.ros.org/roscore

> roscore is a collection of nodes and programs that are pre-requisites of a ROS-based system. You **must** have a roscore running in order for ROS nodes to communicate. It is launched using the `roscore` command.
>
> NOTE: If you use roslaunch, it will automatically start `roscore` if it detects that it is not already running.
>
> `roscore` will start up:
>
> - a ROS Master
> - a ROS Parameter Server
> - a rosout logging node

Leave this window active but minimized so that the ROS Master is still available.

ROS Nodes, Topics, and Services using Turtlesim

 If you are new to ROS - don't be impatient. There is a great deal to learn but the Turtlesim example shown here should make things easier.

The ROS official tutorials are at these WEB sites: **http://wiki.ros.org/turtlesim/Tutorials**

ROS Tutorials Helpful for the Examples to Follow:

- ROS/Tutorials/UnderstandingNodes
- ROS/Tutorials/UnderstandingTopics
- ROS/Tutorials/UnderstandingServicesParams

Turtlesim Node

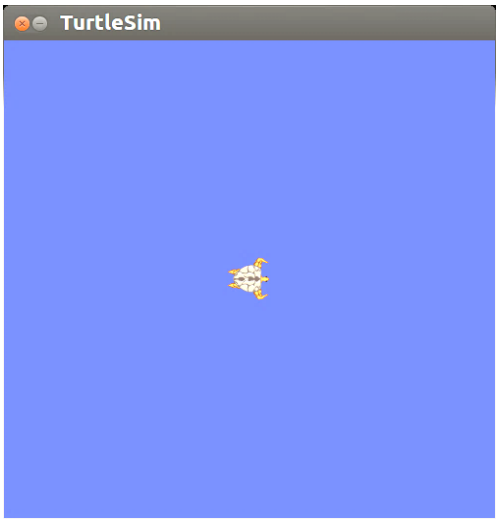
We will start the turtlesim node and explore its properties. Execute roscore and in a new terminal create the turtlesim node from the package turtlesim:

$ roscore

$ **rosrun turtlesim turtlesim_node** **[2]**

[INFO] [1516751529.792931813]: Starting turtlesim with node name /turtlesim
[INFO] [1516751529.797525686]: Spawning turtle [turtle1] at x=[5.544445], y=[5.544445], theta=[0.000000]

The rosrun command takes the arguments [package name] [node name]. The node creates the screen image and the turtle. Here the turtle is in the center in x=5.5, y=5.5 with no rotation.



Before moving the turtle, let us study the properties of the nodes, topics, service and messages available within turtlesim package in another window. (remember to use terminator)

ROS Nodes with Turtlesim

rosnode list **[3]**

$ **rosnode list**
/rosout
/turtlesim

Note the difference in notation between the node **/turtlesim** and the *package* **turtlesim**.

racing@racing-vm:~$ rosnode info /turtlesim [4]

Node [/turtlesim]
Publications: **(This information is sent to nodes listening to /turtlesim)**
* /turtle1/color_sensor [turtlesim/Color] **(Color message in turtlesim package)**

* /rosout [rosgraph_msgs/Log]
* /turtle1/pose [turtlesim/Pose] **(Pose message in turtlesim package for /turtle1)**

Subscriptions:
* /turtle1/cmd_vel [unknown type] **(This node will listen for command velocities)**

(We can use ROS services to manipulate the turtle and perform other operations.)

Services: (**The format is $rosservice call <service> <arguments>)**
* /turtle1/teleport_absolute
* /turtlesim/get_loggers
* /turtlesim/set_logger_level
* /reset
* /spawn
* /clear
* /turtle1/set_pen
* /turtle1/teleport_relative
* /kill

contacting node http://D104-45931:42032/ ...
Pid: 4911
Connections:
* topic: /rosout
  * to: /rosout
  * direction: outbound
  * transport: TCPROS

The node /**turtlesim** publishes three topics and subscribes to the **/turtle1/cmd_vel** topic**.** The services for the node are listed also.

ROS Services to Move the Turtle

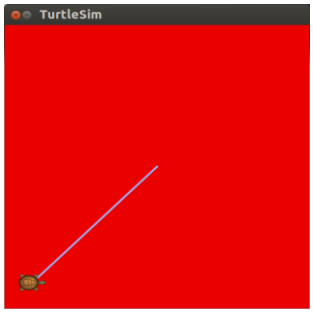
Services: **(We can use ROS services to manipulate the turtle and perform other operations - the format is $rosservice call <service> <arguments>)**
*** /turtle1/teleport_absolute**
* /turtlesim/get_loggers
* /turtlesim/set_logger_level
* /reset
* /spawn
* /clear

* /turtle1/set_pen
*** /turtle1/teleport_relative**
* /kill

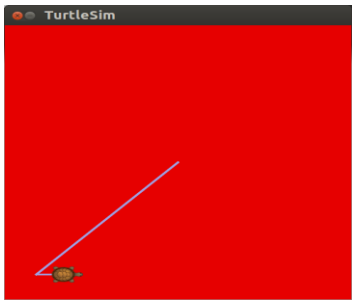
The turtle can be moved using the rosservice teleport option. The format of the position is [x y theta].

teleport_absolute

racing@racing-vm:/$ rosservice call /turtle1/teleport_absolute 1 1 0 **[5]**



Turtle After Absolute Move



Turtle After Relative Move

The relative teleport option moves the turtle with respect to its present position. The arguments are [linear, angle]

teleport_relative

rosservice call /turtle1/teleport_relative 1 0 **[6]**

Turtle now at x=2, y=1.

Turtlesim Node Topic Pose

Another topic for turtlesim node is the turtle's **pose.** This is the x, y position, angular direction, and the linear and angular velocity.

$ rostopic info /turtle1/pose **[7]**

```
Type: turtlesim/Pose
Publishers:
 * /turtlesim (http://D104-45931:42032/)
Subscribers: None
```

This displays the message type.

racing@racing-vm:~$ rostopic type /turtle1/pose **[8]**

```
turtlesim/Pose
```

Confirming the message type

tlharmanphd@D125-43873:~$ **rosmsg show turtlesim/Pose** **[9]**

```
float32 x
float32 y
float32 theta
float32 linear_velocity
float32 angular_velocity
```

Show/display the message fields.

tlharmanphd@D125-43873:/$ **rostopic echo /turtle1/pose** **[10]**

```
x: 2.0
y: 1.0
theta: 0.0
linear_velocity: 0.0
angular_velocity: 0.0
---
x: 2.0
y: 1.0
theta: 0.0
linear_velocity: 0.0
angular_velocity: 0.0
.
.
.
```

Echo the message to the terminal, i.e. display the message values.

Continuous output of the position, orientation, and velocities. Compare to the position on the turtle window. Ctrl+c to stop output.

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

Make the Turtle move in a circle rostopic pub <command>

racing@racing-vm:~$ rosnode info /turtlesim **[11]**

```
--------------------------------------------------------------------------------
Node [/turtlesim]
Publications:
 * /turtle1/color_sensor [turtlesim/Color]
 * /rosout [rosgraph_msgs/Log]
 * /turtle1/pose [turtlesim/Pose]

Subscriptions:
 * /turtle1/cmd_vel [unknown type]

Services:
 * /turtle1/teleport_absolute
 * /turtlesim/get_loggers
 * /turtlesim/set_logger_level
 * /reset
 * /spawn
 * /clear
 * /turtle1/set_pen
 * /turtle1/teleport_relative
 * /kill


contacting node http://D104-45931:42032/ ...
Pid: 4911
Connections:
 * topic: /rosout
    * to: /rosout
    * direction: outbound
    * transport: TCPROS
```

Type of message for cmd_vel

racing@racing-vm:~$ rostopic type /turtle1/cmd_vel **[12]**

```
geometry_msgs/Twist
```

Once again, rostopic type <topic name> displays the type of message in the topic

racing@racing-vm:~$ rosmsg show geometry_msgs/Twist **[13]**

```
geometry_msgs/Vector3 linear
  float64 x
  float64 y
  float64 z
geometry_msgs/Vector3 angular
  float64 x
  float64 y
  float64 z
```

Let us take a look at the geometry_msgs/Twist message type

Using the Linux shell we can combine two commands. The | operator is used to pipe commands into the shell.
A pipe is a form of redirection that is used in Linux systems to send the output of one program to another program.
The general syntax for pipes is: command_1 | command_2 | command_3 . . .

$ **rostopic type /turtle1/cmd_vel | rosmsg show** **[14]**

```
geometry_msgs/Vector3 linear
  float64 x
  float64 y
  float64 z
geometry_msgs/Vector3 angular
  float64 x
  float64 y
  float64 z
```

The requirement is for two vectors with 3 elements each. The message type is geometry_msgs/Twist .

To get a list of messages for ROS of **geometry_msgs**
http://wiki.ros.org/geometry_msgs

This displays a verbose list of topics to publish to and subscribe to and their type:
$ **rostopic list -v** **[15]**

```
Published topics:
 * /turtle1/color_sensor [turtlesim/Color] 1 publisher
 * /rosout [rosgraph_msgs/Log] 1 publisher
 * /rosout_agg [rosgraph_msgs/Log] 1 publisher
 * /turtle1/pose [turtlesim/Pose] 1 publisher

Subscribed topics:
 * /turtle1/cmd_vel [geometry_msgs/Twist] 1 subscriber
* /rosout [rosgraph_msgs/Log] 1 subscriber
```

Moving the Turtle Once

The following command will send a single message to turtlesim telling it to move with a linear velocity of 2.0, and an angular velocity of 1.8. It will move from its starting position along a circular trajectory for a distance and then stop.

$ **rostopic pub -1 /turtle1/cmd_vel geometry_msgs/Twist -- '[2.0, 0.0, 0.0]' '[0.0, 0.0, 1.8]'** **[16]**

```
-r RATE, --rate=RATE  publishing rate (hz).  For -f and stdin input, this
                      defaults to 10.  Otherwise it is not set.
 -1, --once           publish one message and exit
```

NOTE: Here is a place to use TAB completion to find data formats for this command:
Lets try it:

$ rosto (Tab) pub -1 /tur (Tab) cm (Tab) geo (Tab) (Tab) (Tab) ….. [17] With result:

racing@racing-vm:~$ rostopic pub -1 /turtle1/cmd_vel geometry_msgs/Twist "linear:

x: 0.0

y: 0.0

z: 0.0

angular:

x: 0.0

y: 0.0

z: 0.0"

Now back space to fill in the values z= 1.8 and x=0.0. (Not executed)

Where is the turtle? (After the Initial Command)

$ **rostopic echo /turtle1/pose [18]**

x: 3.0583717823

y: 2.39454507828

theta: 1.81439995766

linear_velocity: 0.0

angular_velocity: 0.0

Use CNTL+c to stop the output of position, orientation and velocity.

A geometry_msgs/Twist msg has two vectors of three floating point elements each: linear and angular. In this case, '[2.0, 0.0, 0.0]' becomes the linear value with x=2.0, y=0.0, and z=0.0, and '[0.0, 0.0, 1.8]' is the angular value with x=0.0, y=0.0, and z=1.8. These arguments are actually in YAML syntax, which is described more in the YAML command line documentation.

'[2.0, 0.0, 0.0]' '[0.0, 0.0, 1.8]'

You will have noticed that the turtle has stopped moving; this is because the turtle requires a steady stream of commands at 1 Hz to keep moving. We can publish a steady stream of commands using **rostopic pub -r** command:

Here we publish the topic **/turtle1/command_velocity** with the message to repeat the message at 1 second intervals with linear velocity 2 and angular velocity 1.8. The node turtlesim subscribes to the message as shown by the command $ **rosnode info /turtlesim** shown before with the subscription:

Subscribed topics:

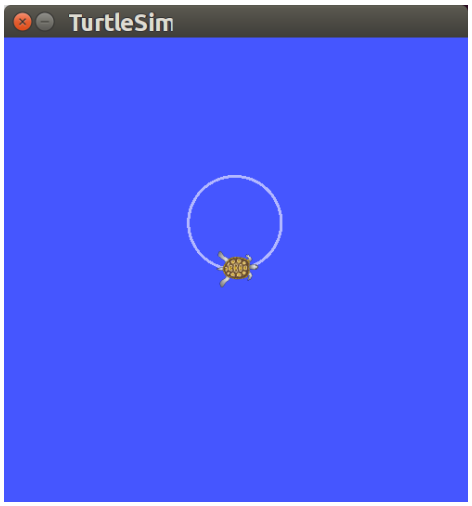
* /turtle1/cmd_vel [geometry_msgs/Twist] 1 subscriber **rostopic pub**

Make the turtle move in a circle

Let's reset Turtlesim

racing@racing-vm:~$ rosservice call /reset [19]

racing@racing-vm:~$ rostopic pub -r 1 /turtle1/cmd_vel geometry_msgs/Twist -- '[2.0, 0.0, 0.0]' '[0.0, 0.0, 1.8]' [20]



Turtle moving in a circle

rostopic hz

Show the rate in Hz for publication (Crtl-C to stop data):

rostopic hz /turtle1/pose [21]

subscribed to [/turtle1/pose]
average rate: 62.501
min: 0.016s max: 0.016s std dev: 0.00014s window: 62
average rate: 62.501
min: 0.016s max: 0.016s std dev: 0.00014s window: 124
average rate: 62.504
min: 0.016s max: 0.016s std dev: 0.00014s window: 187
average rate: 62.500
min: 0.016s max: 0.016s std dev: 0.00014s window: 249
average rate: 62.496
min: 0.015s max: 0.017s std dev: 0.00014s window: 300

Output at about a 60 Hz rate. Updated every 16 ms.

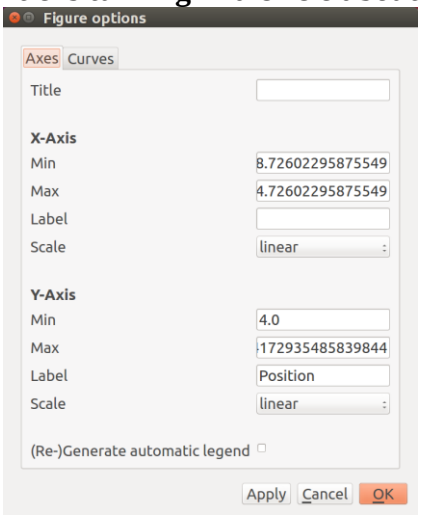
Using rqt plot with Turtlesim

http://wiki.ros.org/rqt_plot

rqt_plot
We can plot information about the nodes and topics.

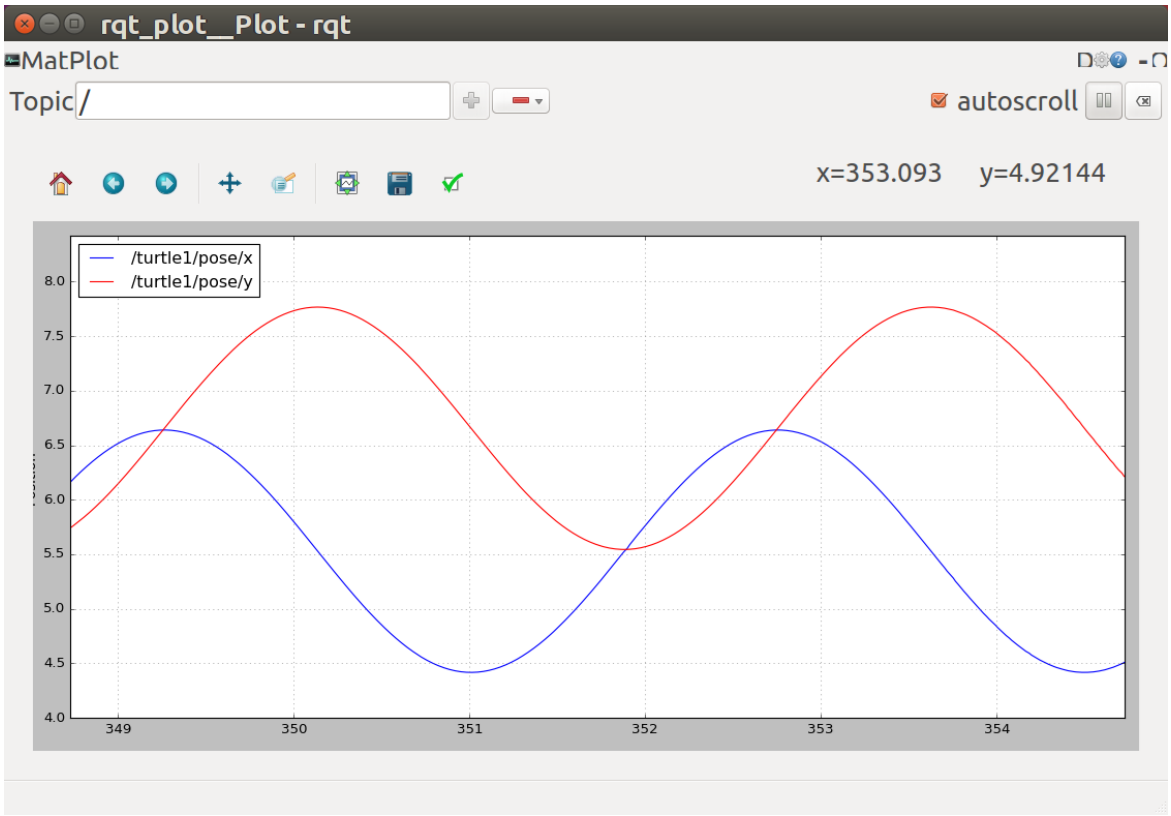
$ rqt_plot /turtle1/pose/x:y:z **[22]**

Turtle is turning in a circle about 5.5 Ymin x goes from about 4.5 to 6.5.



Selection of Axis for rqt_plot (Click on the check mark)

Experiment with different controls allowed for the plot such as changing the scales, etc.



Plot of /turtle1/pose/x and /pose/y

Period of just over 3 seconds for 360 degree rotation. Note the periodic motion in x and y. Right click to change values for axes, etc.

Choosing only x and y positions and experimenting with scales and autoscroll. See the tutorial for further help.

http://wiki.ros.org/rqt_plot

To plot from the command line, both of the following lines plot the same topics according to the wiki.

```
$ rqt_plot /turtle1/pose/x:y:z
$ rqt_plot /turtle1/pose/x /turtle1/pose/y /turtle1/pose/z
```

Obviously, if you want to change the topics to plot, you need to restart the program and give the new topic names.

Keyboard Control

In a third window, we execute a node that allows keyboard control of the turtle. Roscore is running in one window and turtlesim_node in another.

$ rosrun turtlesim turtle_teleop_key **[23]**

racing@racing-vm:~$ rosrun turtlesim turtle_teleop_key

Reading from keyboard

Use arrow keys to move the turtle.
Up arrow Turtle In Turtle's x direction
Down arrow Turtle In Turtles's -x direction
Right arrow Rotate CW
Left arrow Rotate CCW

racing@racing-vm:~$ rosnode list **[24]**

/rosout
/teleop_turtle
/turtlesim

Notice that now we have a new node in the list called /teleop_turtle

racing@racing-vm:~$ rosnode info /teleop_turtle **[25]**

Node [/teleop_turtle]
Publications:
*** /turtle1/cmd_vel [geometry_msgs/Twist]**
* /rosout [rosgraph_msgs/Log]

The /teleop_turtle node is publishing on topic /turtle1/cmd_vel
Can you tell the message type for this topic ?

Subscriptions: None

The /teleop_turtle node does not subscribe to any topic.

Services:
* /teleop_turtle/get_loggers
* /teleop_turtle/set_logger_level

contacting node http://D104-45931:43692/ ...
Pid: 8381
Connections:
* topic: /rosout
  * to: /rosout
  * direction: outbound
  * transport: TCPROS
* topic: /turtle1/cmd_vel
  * to: /turtlesim
  * direction: outbound
* transport: TCPROS

Notice publication of /turtle1/cmd_vel [geometry_msgs/Twist]

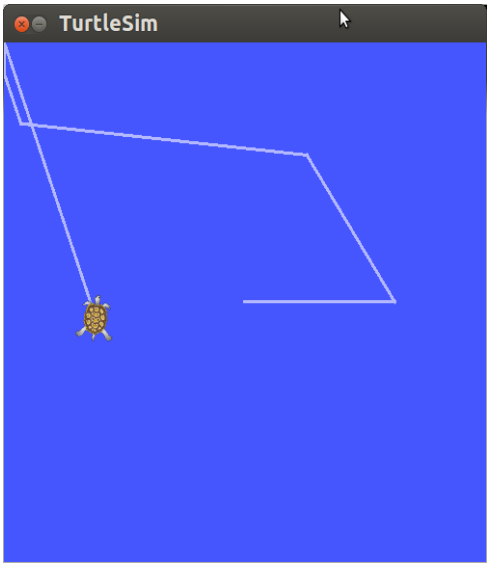
Let us look again at the node /turtlesim after we have started runing the /teleop_turtle node

racing@racing-vm:~$ rosnode info /turtlesim **[26]**

```
--------------------------------------------------------------------------------
Node [/turtlesim]
Publications:
 * /turtle1/color_sensor [turtlesim/Color]
 * /rosout [rosgraph_msgs/Log]
 * /turtle1/pose [turtlesim/Pose]

Subscriptions:
 * /turtle1/cmd_vel [geometry_msgs/Twist]

Services:
 * /turtle1/teleport_absolute
 * /reset
 * /clear
 * /turtle1/teleport_relative
 * /kill
 * /turtlesim/get_loggers
 * /turtlesim/set_logger_level
 * /spawn
 * /turtle1/set_pen

contacting node http://D104-45931:42252/ ...
Pid: 7956
Connections:
 * topic: /rosout
    * to: /rosout
    * direction: outbound
    * transport: TCPROS
 * topic: /turtle1/pose
    * to: /rqt_gui_py_node_22321
    * direction: outbound
    * transport: TCPROS
          * topic: /turtle1/cmd_vel
            * to: /teleop_turtle (http://D125-43873:44984/)
            * direction: inbound
* transport: TCPROS
```

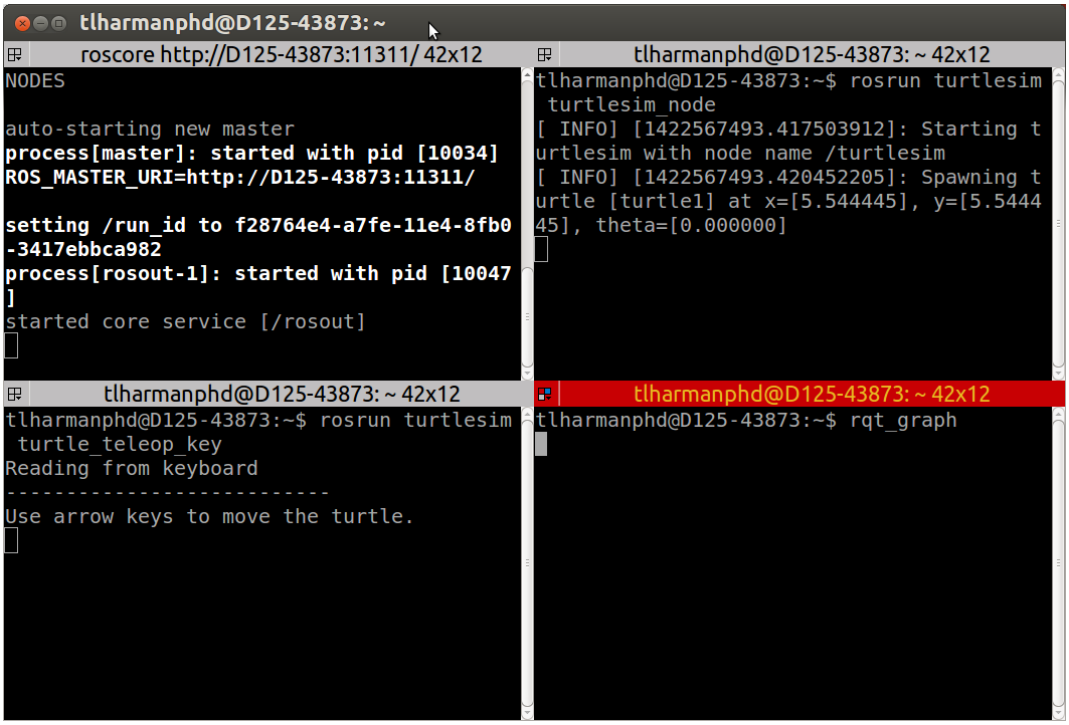
Note: New topic /turtle1/cmd_vel to /teleop_turtle

To move turtle with arrow keys, be sure the focus is on the terminal that is running turtle_teleop_key.



Turtlesim keyboard control

Now start a fourth terminal window to view the information that is available through ROS for the Turtlesim. The commands in that window elicit data while the other windows keep the turtle active. To move the turtle, use window three.



1. List the ROS parameters to get information about the ROS nodes. The nodes are generally the executable scripts in ROS.
2. Determine what information you can get for the node turtlesim.

(Publications and Subscriptions)

racing@racing-vm:~$ rostopic list **[27]**

```
/rosout
/rosout_agg
/turtle1/cmd_vel
/turtle1/color_sensor
/turtle1/pose
```

One important topic is /turtle1/cmd_vel which will be **published** using the keyboard or by publishing the topic with the rostopic pub command.

Determine data from Topic /turtle1/cmd_vel

The **rostopic echo** command shows the data sent by the node to control the turtle. As you move the turtle, the data are updated. As you press the arrow keys the displayed values will change: x velocity if linear motion, z velocity if rotation.

tlharmanphd@D125-43873:~$ **rostopic echo /turtle1/cmd_vel** **[28]**

```
linear:
  x: 2.0          (Velocity ahead)
  y: 0.0
  z: 0.0
angular:
  x: 0.0
  y: 0.0
  z: 0.0
---
linear:
  x: 2.0
  y: 0.0
  z: 0.0
angular:
  x: 0.0
  y: 0.0
  z: 0.0
---
linear:
  x: -2.0
  y: 0.0
```

```
  z: 0.0
angular:
  x: 0.0
  y: 0.0
  z: 0.0
---
linear:
  x: 0.0
  y: 0.0
  z: 0.0
angular:
  x: 0.0
  y: 0.0
  z: 2.0      (Counter Clockwise Rotational velocity about z axis – out of window)
---
.
.
```

These show the parameters for **cmd_vel** which are linear velocity and angular velocity. In this result, the turtle was moved linearly until the last output which shows a rotation.

To find the turtle's position in the ocean, use /turtle1/pose

tlharmanphd@D125-43873:~$ **rostopic echo /turtle1/pose** **[29]**

```
x: 5.544444561
y: 5.544444561
theta: 0.0
linear_velocity: 0.0
angular_velocity: 0.0
---
.
.
```

CNTL+c to stop output. Here the turtle is at rest in the center of the window.

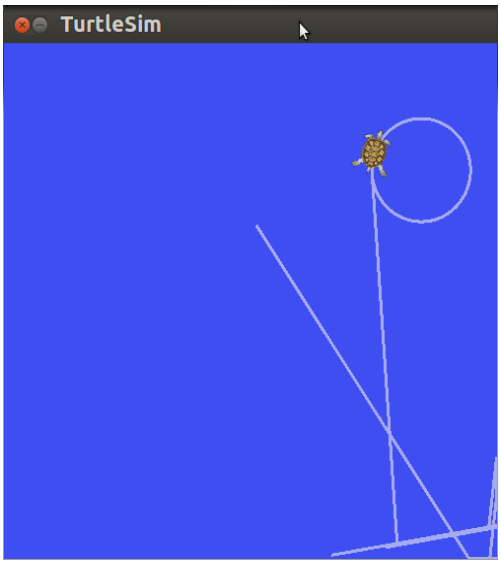
If you return to the teleop_key window and move the turtle with the arrow keys you can see the output of the pose message (turtlesim/Pose) change. Remember the format:

tlharmanphd@D125-43873:~$ **rosmsg show turtlesim/Pose**

```
float32 x
float32 y
float32 theta
float32 linear_velocity
float32 angular_velocity
```

We can make the turtle turn in a circle by publishing the topic turtle1/cmd_velocity

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



Turtle responds to published topic

The command will publish at a rate (-r) of once a second (1 Hz). The topic /turtle1/command_velocity is followed by the message type turtlesim/Velocity that commands the turtle to turn with linear velocity 2.0 and angular velocity 1.8 according to the ROS tutorial:

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

Try changing the rate to 0.5 or some value less than 1 to see the turtle stall in the circle.

As noted before, a turtlesim/Velocity message has two floating point elements : `linear` and `angular`. In this case, `2.0` becomes the linear value, and `1.8` is the `angular` value. These arguments are actually in YAML syntax, which is described more in the YAML command line documentation.

To clear the turtlesim screen use:

racing@racing-vm:~$ rosservice call /clear