Note: This tutorial assumes that you have completed the previous tutorials: building a ROS package (/ROS/Tutorials/BuildingPackages).

Please ask about problems and questions regarding this tutorial on answers.ros.org (http://answers.ros.org). Don't forget to include in your question the link to this page, the versions of your OS & ROS, and also add appropriate tags.

Understanding ROS Nodes

Description: This tutorial introduces ROS graph concepts and discusses the use of roscore (/roscore), rosnode (/rosnode), and rosrun (/rosrun) commandline tools.

Tutorial Level: BEGINNER

Next Tutorial: Understanding ROS topics (/ROS/Tutorials/UnderstandingTopics)

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1. Prerequisites

For this tutorial we'll use a lighweight simulator, to install it run the following command:

```
$ sudo apt-get install ros-<distro>-ros-tutorials
```

Replace '<distro>' with the name of your ROS distribution (e.g. indigo, jade, kinetic)

2. Quick Overview of Graph Concepts

- Nodes (/Nodes): A node is an executable that uses ROS to communicate with other nodes.
- Messages (/Messages): ROS data type used when subscribing or publishing to a topic.
- Topics (/Topics): Nodes can *publish* messages to a topic as well as *subscribe* to a topic to receive messages.
- Master (/Master): Name service for ROS (i.e. helps nodes find each other)
- rosout (/rosout): ROS equivalent of stdout/stderr
- roscore (/roscore): Master + rosout + parameter server (parameter server will be introduced later)

3. Nodes

A node really isn't much more than an executable file within a ROS package. ROS nodes use a ROS client library to communicate with other nodes. Nodes can publish or subscribe to a Topic. Nodes can also provide or use a Service.

4. Client Libraries

ROS client libraries allow nodes written in different programming languages to communicate:

- rospy = python client library
- roscpp = c++ client library

5. roscore

`roscore` is the first thing you should run when using ROS.

Please run:

```
$ roscore
```

You will see something similar to:

```
... logging to ~/.ros/log/9cf88ce4-b14d-11df-8a75-00251148e8cf/roslaunch-
machine_name-13039.log
Checking log directory for disk usage. This may take awhile.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://machine_name:33919/
ros_comm version 1.4.7

SUMMARY
======

PARAMETERS
 * /rosversion
 * /rosdistro

NODES

auto-starting new master
process[master]: started with pid [13054]
ROS_MASTER_URI=http://machine_name:11311/

setting /run_id to 9cf88ce4-b14d-11df-8a75-00251148e8cf
process[rosout-1]: started with pid [13067]
started core service [/rosout]
```

If `roscore` does not initialize, you probably have a network configuration issue. See Network Setup

- Single Machine Configuration (http://www.ros.org/wiki/ROS/NetworkSetup#Single_machine_configuration)

If `roscore` does not initialize and sends a message about lack of permissions, probably the `~/.ros` folder is owned by `root`, change recursively the ownership of that folder with:

```
$ sudo chown -R <your_username> ~/.ros
```

6. Using rosnode

Open up a **new terminal**, and let's use **rosnode** to see what running `roscore` did... Bear in mind to keep the previous terminal open either by opening a new tab or simply minimizing it.

Note: When opening a new terminal your environment is reset and your `~/.bashrc` file is sourced. If you have trouble running commands like `rosnode` then you might need to add some environment setup files to your `~/.bashrc` or manually re-source them.

`rosnode` displays information about the ROS nodes that are currently running. The `rosnode list` command lists these active nodes:

```
$ rosnode list
```

You will see:

```
/rosout
```

This showed us that there is only one node running: rosout (/rosout). This is always running as it collects and logs nodes' debugging output.

The `rosnode info` command returns information about a specific node.

```
$ rosnode info /rosout
```

This gave us some more information about `rosout`, such as the fact that it publishes `/rosout_agg`.

```
--------------------------------------------------------------------------------
Node [/rosout]
Publications:
 * /rosout_agg [rosgraph_msgs/Log]

Subscriptions:
 * /rosout [unknown type]

Services:
 * /rosout/get_loggers
 * /rosout/set_logger_level

contacting node http://machine_name:54614/ ...
Pid: 5092
```

Now, let's see some more nodes. For this, we're going to use `rosrun` to bring up another node.

7. Using rosrun

`rosrun` allows you to use the package name to directly run a node within a package (without having to know the package path).

Usage:

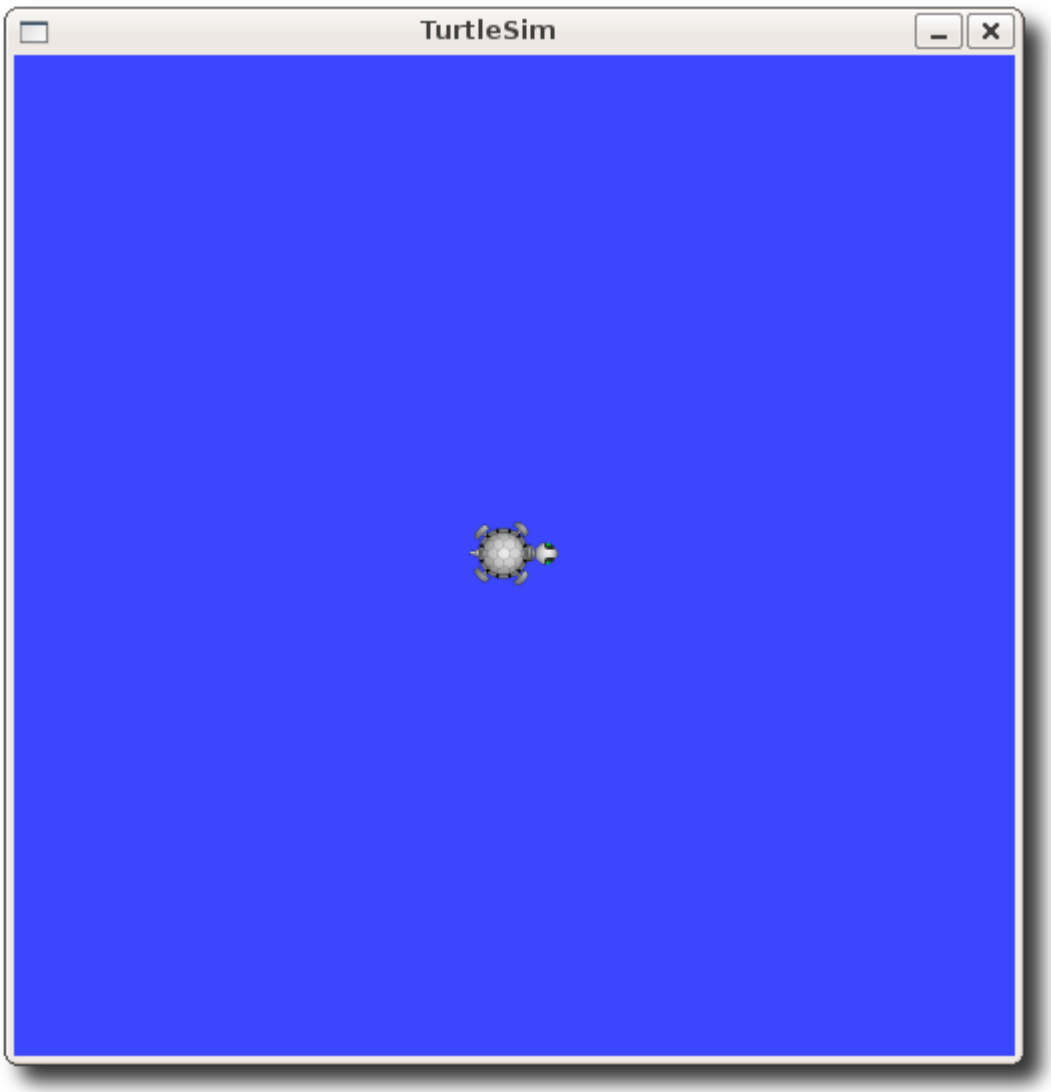
```
$ rosrun [package_name] [node_name]
```

So now we can run the turtlesim_node in the turtlesim package.

Then, in a **new terminal**:

```
$ rosrun turtlesim turtlesim_node
```

You will see the turtlesim window:



NOTE: The turtle may look different in your turtlesim window. Don't worry about it - there are many types of turtle (/Distributions#Current_Distribution_Releases) and yours is a surprise!

In a **new terminal**:

```
$ rosnode list
```

You will see something similar to:

```
/rosout
/turtlesim
```

One powerful feature of ROS is that you can reassign Names from the command-line.

Close the turtlesim window to stop the node (or go back to the `rosrun turtlesim` terminal and use `ctrl-C`). Now let's re-run it, but this time use a Remapping Argument (/Remapping%20Arguments) to change the node's name:

```
$ rosrun turtlesim turtlesim_node __name:=my_turtle
```

Now, if we go back and use `rosnode list`:

```
$ rosnode list
```

You will see something similar to:

```
/my_turtle
/rosout
```

Note: If you still see /turtlesim in the list, it might mean that you stopped the node in the terminal using `ctrl-C` instead of closing the window, or that you don't have the $ROS_HOSTNAME environment variable defined as described in Network Setup - Single Machine Configuration (http://www.ros.org/wiki/ROS/NetworkSetup#Single_machine_configuration). You can try cleaning the rosnode list with: $ rosnode cleanup

We see our new `/my_turtle` node. Let's use another `rosnode` command, `ping`, to test that it's up:

```
$ rosnode ping my_turtle
```

```
rosnode: node is [/my_turtle]
pinging /my_turtle with a timeout of 3.0s
xmlrpc reply from http://aqy:42235/     time=1.152992ms
xmlrpc reply from http://aqy:42235/     time=1.120090ms
xmlrpc reply from http://aqy:42235/     time=1.700878ms
xmlrpc reply from http://aqy:42235/     time=1.127958ms
```

8. Review

What was covered:

- roscore = ros+core : master (provides name service for ROS) + rosout (stdout/stderr) + parameter server (parameter server will be introduced later)
- rosnode = ros+node : ROS tool to get information about a node.
- rosrun = ros+run : runs a node from a given package.

Now that you understand how ROS nodes work, let's look at how ROS topics work (/ROS/Tutorials /UnderstandingTopics). Also, feel free to press `Ctrl-C` to stop turtlesim_node.

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(http://www.osrfoundation.org)