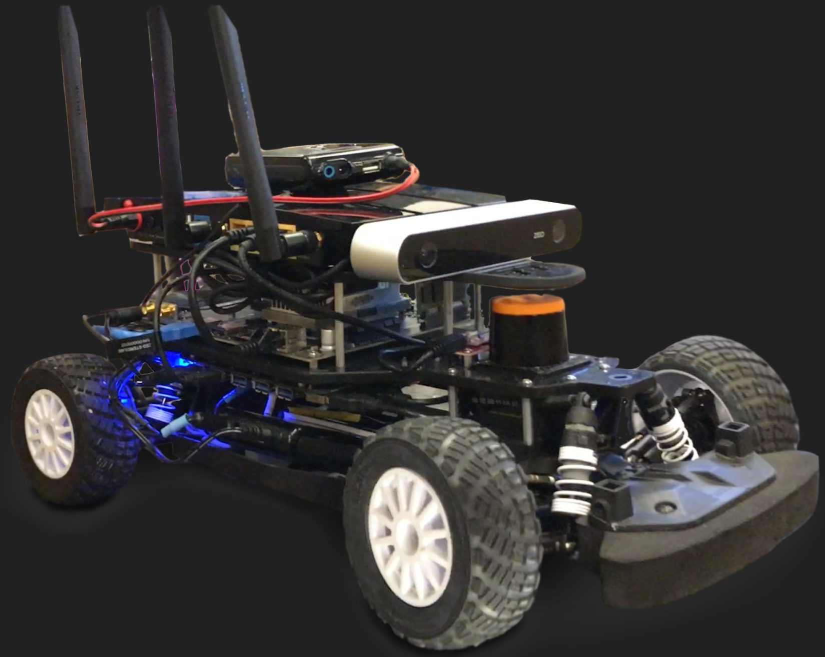


Link to Slides:
goo.gl/GfyunN

Autonomous RC Car

Downloads for Today

VirtualBox 6.0

https://www.virtualbox.org/wiki/Downloads

Shorter Link: https://bit.ly/1nlDA5d

Ubuntu/ROS Virtual Machine

https://drive.google.com/open?id=1FPbPAee3JatyO9YliNKLLHkS3Tr9VRHJ

Shorter Link: https://bit.ly/2WH1vFP

- These might take a while to download (especially the second one)
  so we’re getting them out of the way first

Before we start, administrative stuff

SRC Constitution Revision:

https://docs.google.com/document/d/1wQ1r7KBccbHzbuwlakexvvyDHXy30EZVCJSLZaTO6-M/edit?usp=sharing

Also, we need a new logo to replace our old one!

- We are accepting submission here: https://goo.gl/forms/tD94poDGbtR7TZoA2

What are we trying to achieve?

A Self-Driving Mobile R/C Car Platform

- Essentially to replicate **self-driving cars** on a **small scale**, while utilizing the same technologies
- Use **state-of-the-art sensors and computing hardware**, placed on top of a powerful **1/10-scale miniature race car**

NVIDIA

STEREOLABS

ROS

NVIDIA Self-Driving Car Demo

Different aspects of the project

Mechanical

- CAD Modeling & 3D Printing Structural Elements

Electronics (later on in the project)

- Speed Controller, 2D Lidar, ZED Stereo Camera, Battery

Software

- NVIDIA Jetson TX2 Dev Kit, Robot Operating System (ROS)

What does the car consist of

R/C Car Chassis: Exceed RC Infinitive EP Brushless Pro

On Board Computer: NVIDIA JETSON TX2 Dev Kit

2D Lidar: RPLIDAR A2M8 360° Laser Scanner

Stereo Camera: Zed Stereo Camera

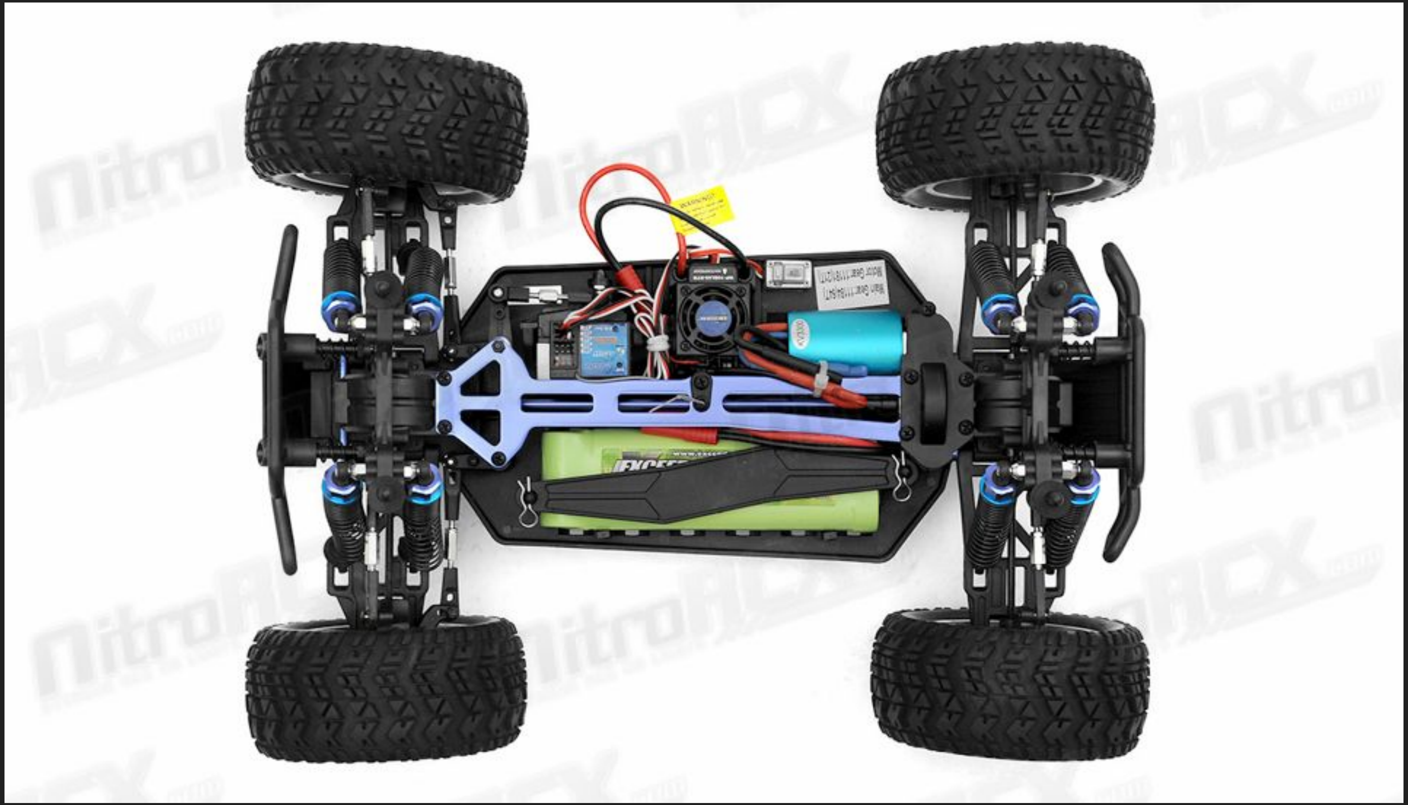
Battery for Electronics: TBA

R/C Car Platform

Exceed RC Infinitive EP Brushless Pro

https://www.nitrorcx.com/51c803-pro-ccblue-24ghz.html

Anatomy of an RC Car

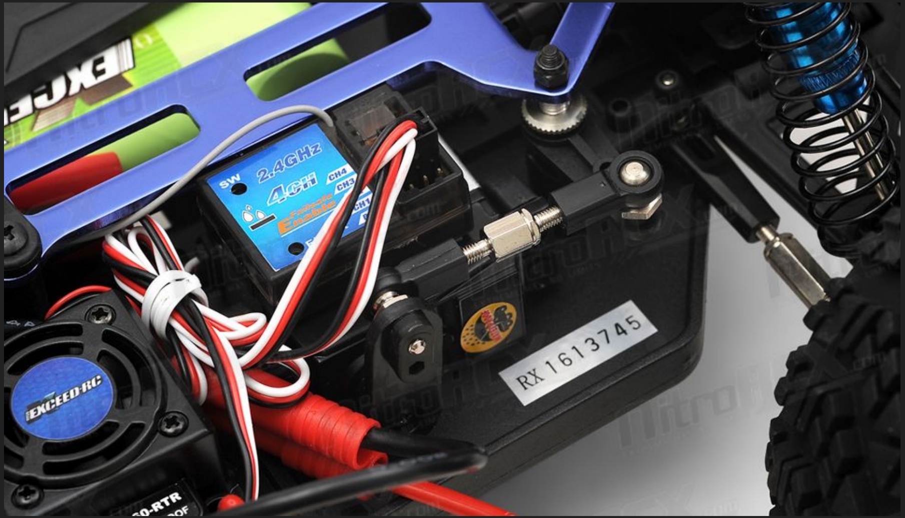


Electrical Components

- Battery connected to ESC
  - 8.4V - 3000 mAh
- ESC rated for 48A - 2s LiPo
- ESC controls power between the battery and motor

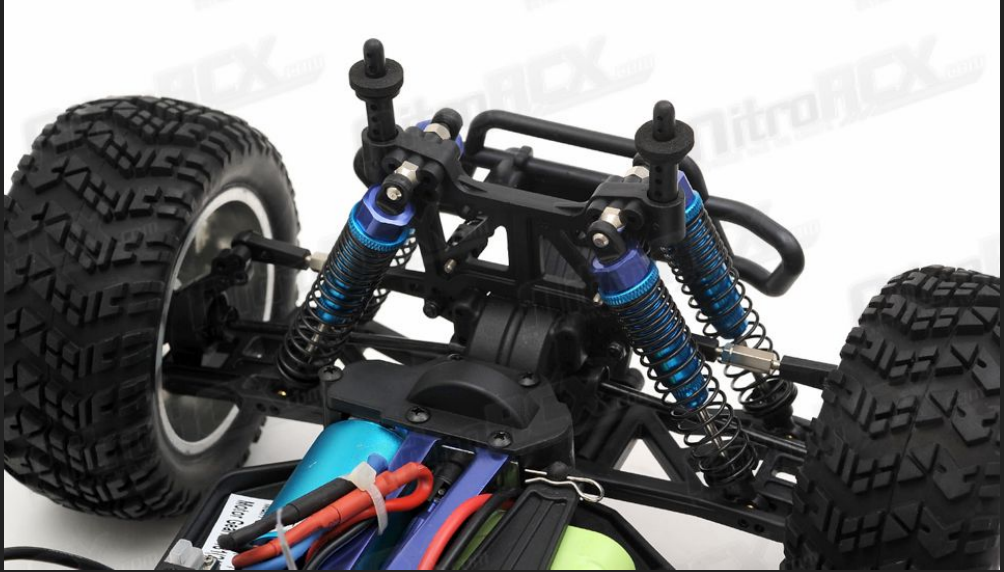
Control System

- ESC powers receiver
- Receiver controls servo for steering
- Also sends signals to ESC to control speed



Anatomy of an RC Car

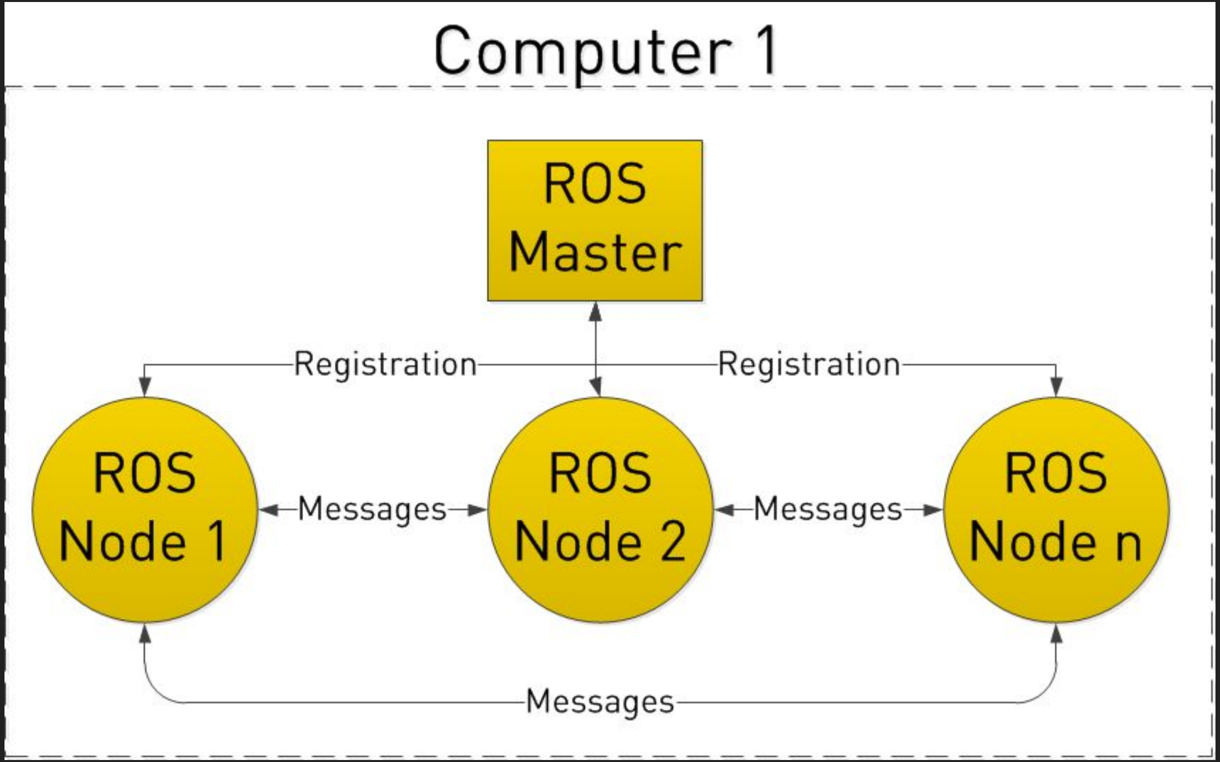
- All-Wheel drive
- Front and Rear Shocks
- All Terrain tires



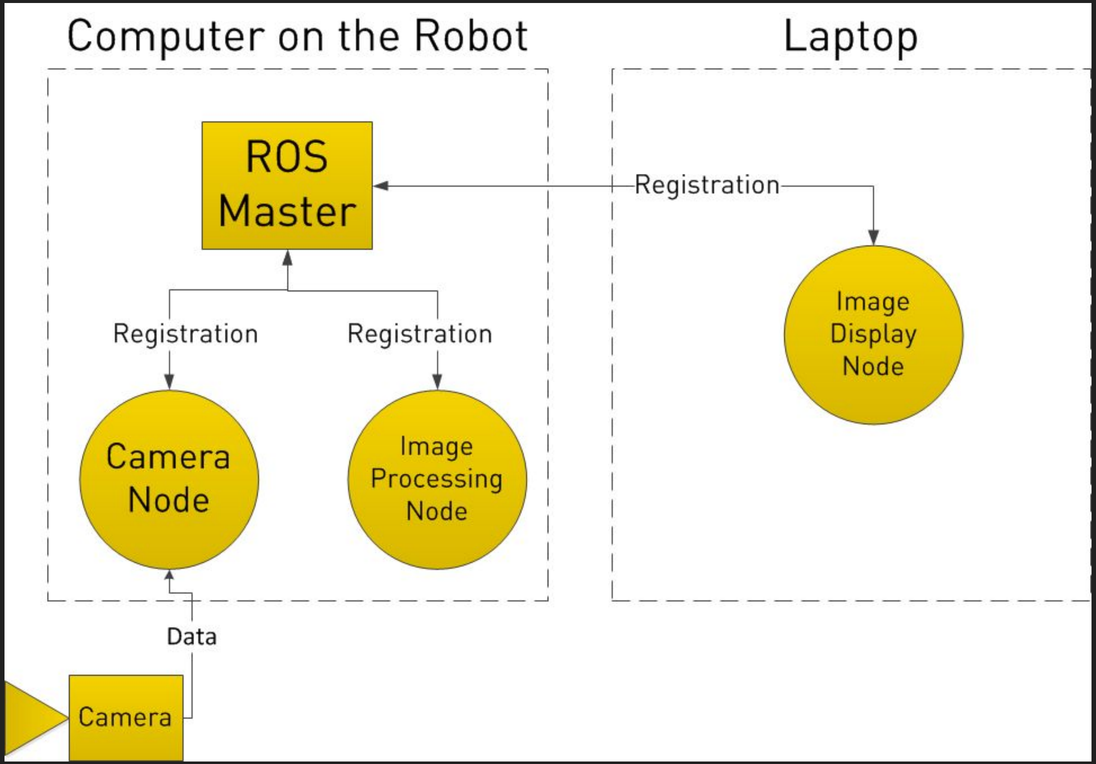
Link to Slides:
goo.gl/GfyunN

Intro to ROS

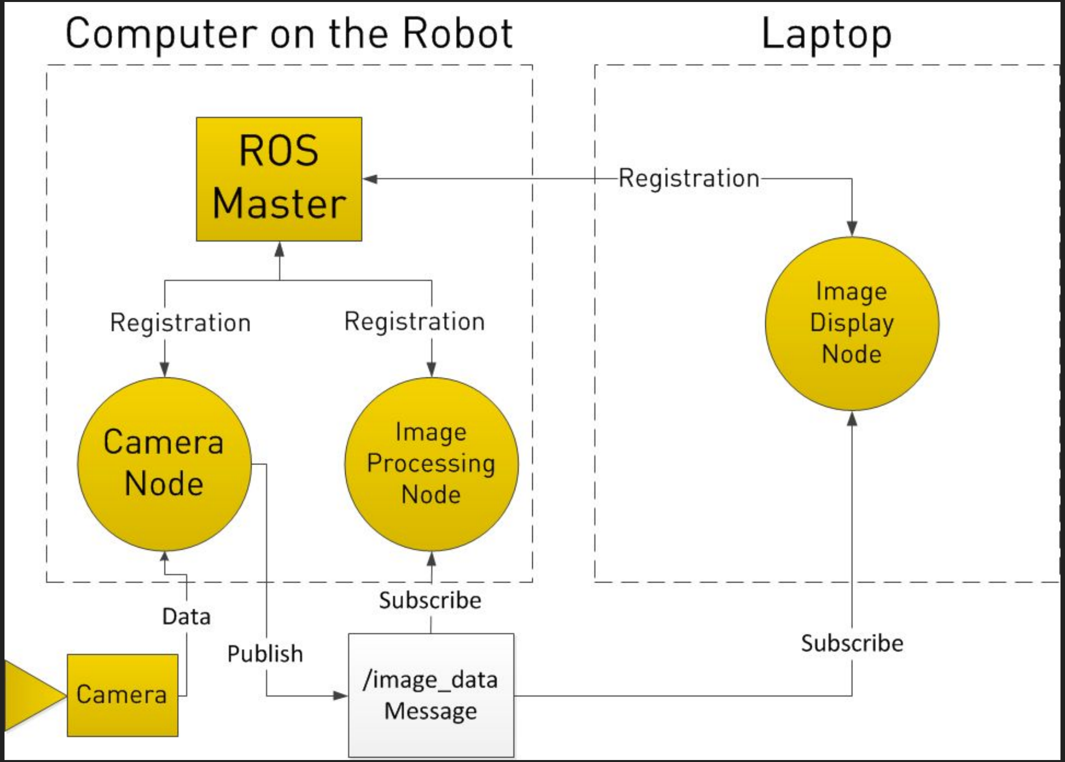
ROS Framework



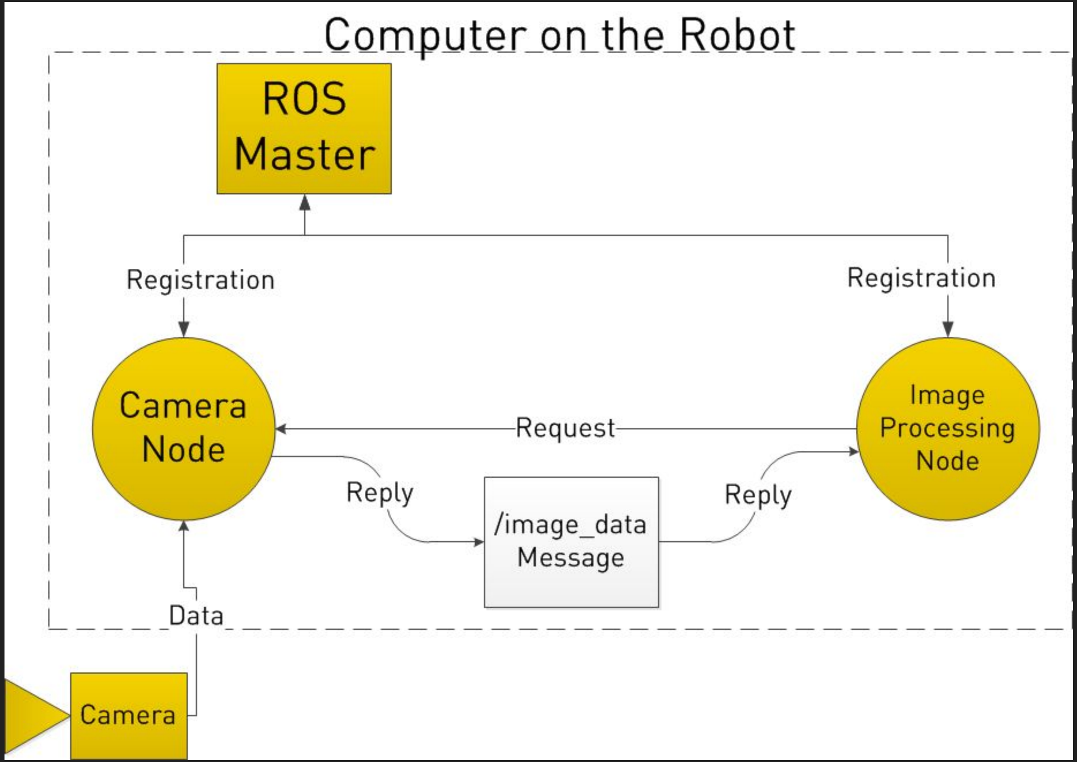
ROS Framework



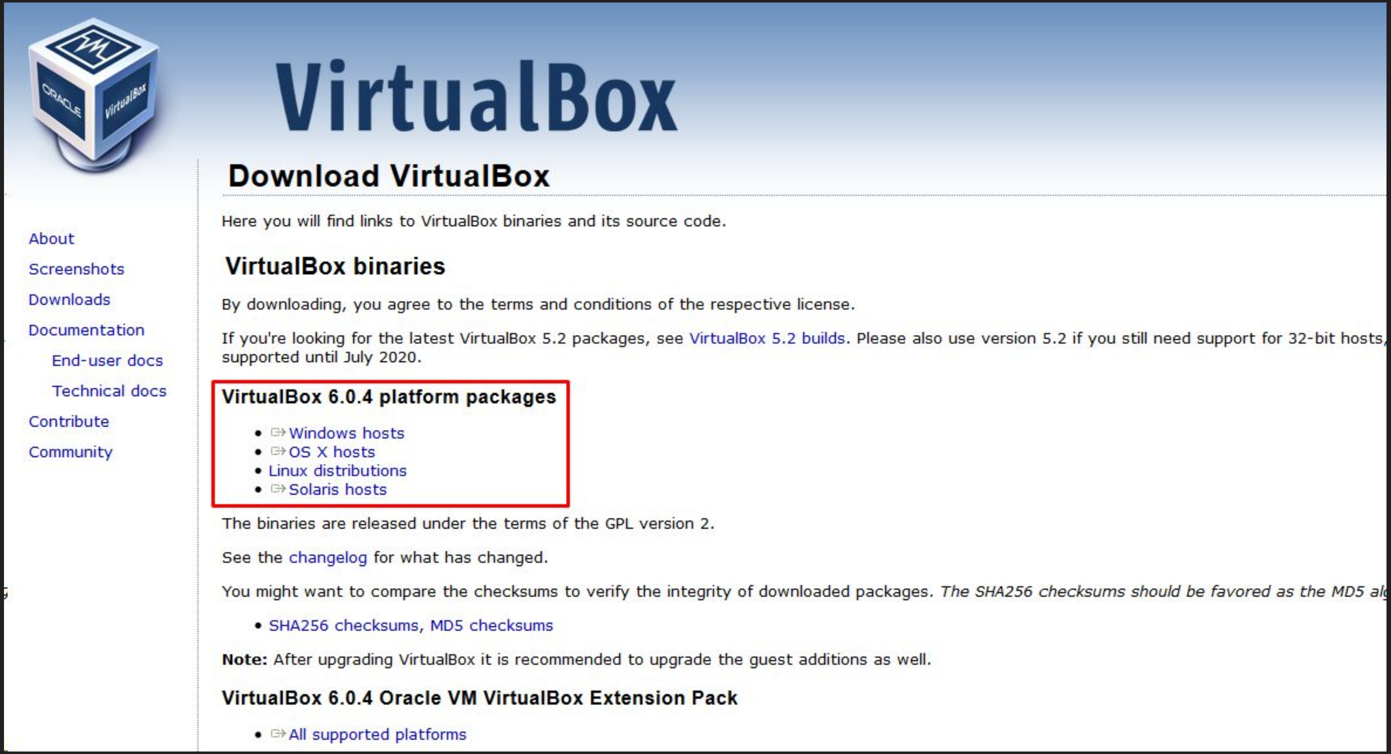
ROS Framework



ROS Framework



Download Oracle VM VirtualBox



Download VirtualBox

Here you will find links to VirtualBox binaries and its source code.

VirtualBox binaries

By downloading, you agree to the terms and conditions of the respective license.

If you're looking for the latest VirtualBox 5.2 packages, see VirtualBox 5.2 builds. Please also use version 5.2 if you still need support for 32-bit hosts, supported until July 2020.

VirtualBox 6.0.4 platform packages

- Windows hosts
- OS X hosts
- Linux distributions
- Solaris hosts

The binaries are released under the terms of the GPL version 2.

See the changelog for what has changed.

You might want to compare the checksums to verify the integrity of downloaded packages. *The SHA256 checksums should be favored as the MD5 al*

- SHA256 checksums, MD5 checksums

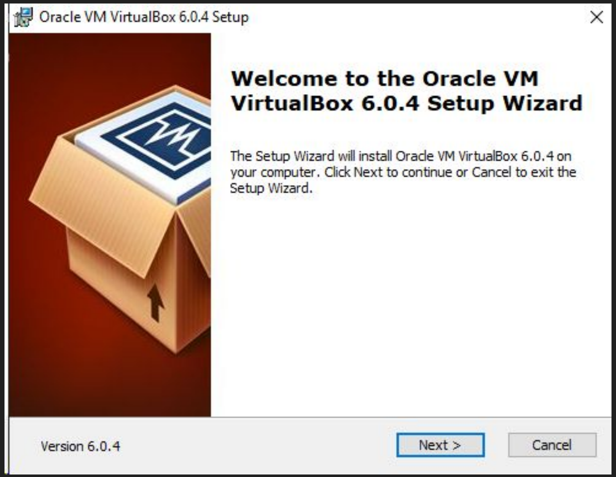
Note: After upgrading VirtualBox it is recommended to upgrade the guest additions as well.

VirtualBox 6.0.4 Oracle VM VirtualBox Extension Pack

- All supported platforms

Install Oracle VM VirtualBox

- Install using default options

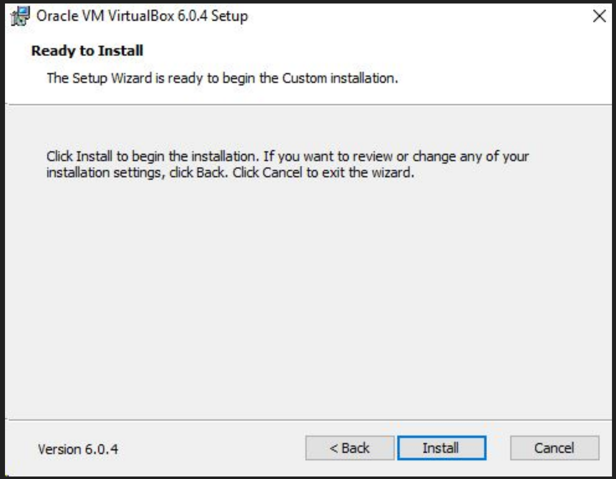


Oracle VM VirtualBox 6.0.4 Setup

Welcome to the Oracle VM VirtualBox 6.0.4 Setup Wizard

The Setup Wizard will install Oracle VM VirtualBox 6.0.4 on your computer. Click Next to continue or Cancel to exit the Setup Wizard.

Version 6.0.4



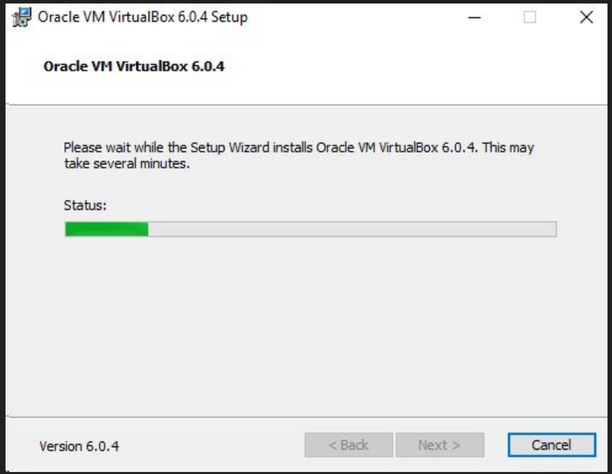
Oracle VM VirtualBox 6.0.4 Setup

Ready to Install

The Setup Wizard is ready to begin the Custom installation.

Click Install to begin the installation. If you want to review or change any of your installation settings, click Back. Click Cancel to exit the wizard.

Version 6.0.4



Oracle VM VirtualBox 6.0.4 Setup

Oracle VM VirtualBox 6.0.4

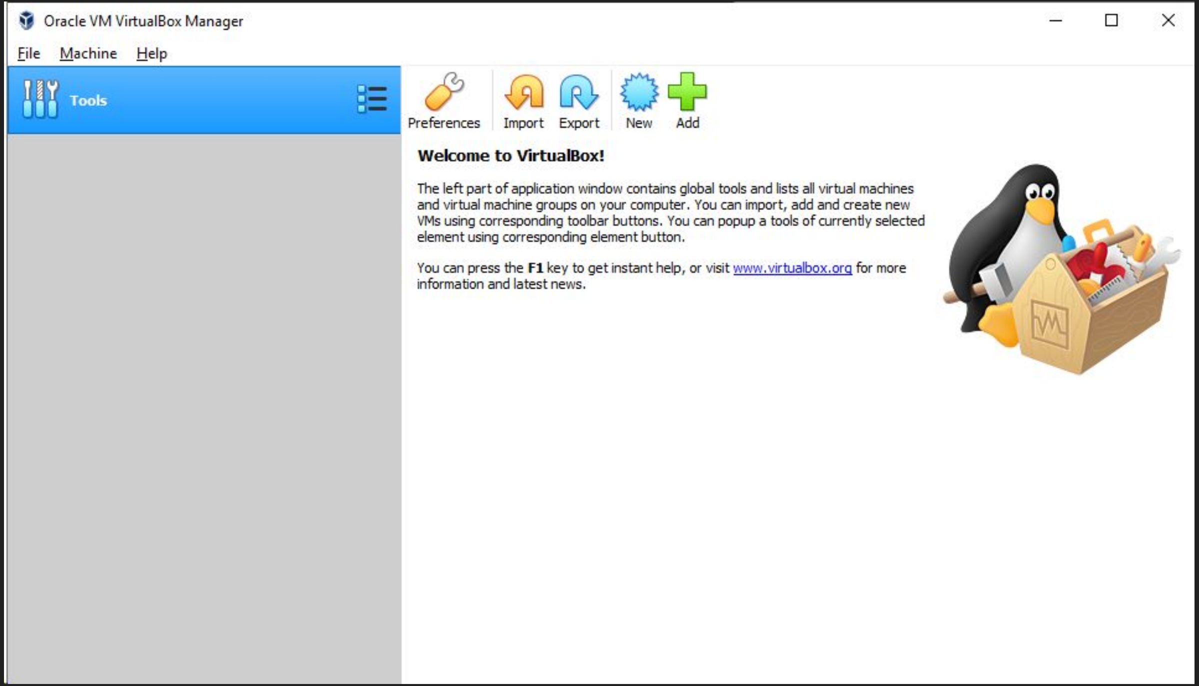
Please wait while the Setup Wizard installs Oracle VM VirtualBox 6.0.4. This may take several minutes.

Status:

Version 6.0.4

Install Oracle VM VirtualBox

- When finished it should look like:



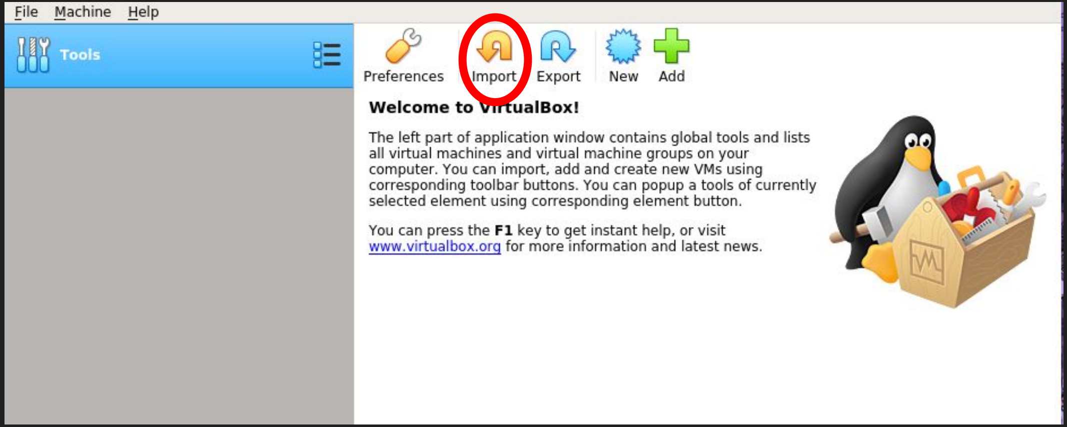
Welcome to VirtualBox!

The left part of application window contains global tools and lists all virtual machines and virtual machine groups on your computer. You can import, add and create new VMs using corresponding toolbar buttons. You can popup a tools of currently selected element using corresponding element button.

You can press the **F1** key to get instant help, or visit www.virtualbox.org for more information and latest news.

Setup Our ROS Install

- Hopefully the virtual machine and VirtualBox have downloaded by now
- Open virtualbox, hit the import button, or Ctrl+i
  - Import the .ova virtual machine you downloaded
  - Accept default settings
- Should end up with window on right ------------------>



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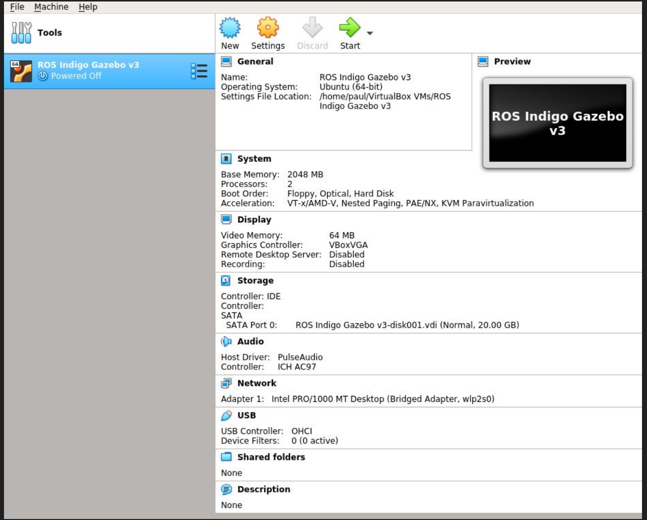


ROS Indigo Gazebo v3
Powered Off

General

Name: ROS Indigo Gazebo v3
Operating System: Ubuntu (64-bit)
Settings File Location: /home/paul/VirtualBox VMs/ROS Indigo Gazebo v3

System

Base Memory: 2048 MB
Processors: 2
Boot Order: Floppy, Optical, Hard Disk
Acceleration: VT-x/AMD-V, Nested Paging, PAE/NX, KVM Paravirtualization

Display

Video Memory: 64 MB
Graphics Controller: VBoxVGA
Remote Desktop Server: Disabled
Recording: Disabled

Storage

Controller: IDE
Controller: SATA
SATA Port 0: ROS Indigo Gazebo v3-disk001.vdi (Normal, 20.00 GB)

Audio

Host Driver: PulseAudio
Controller: ICH AC97

Network

Adapter 1: Intel PRO/1000 MT Desktop (Bridged Adapter, wlp2s0)

USB

USB Controller: OHCI
Device Filters: 0 (0 active)

Shared folders

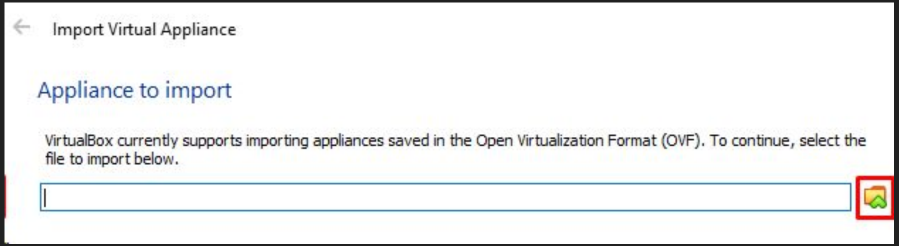
None

Description

None

ROS Install (details)

1

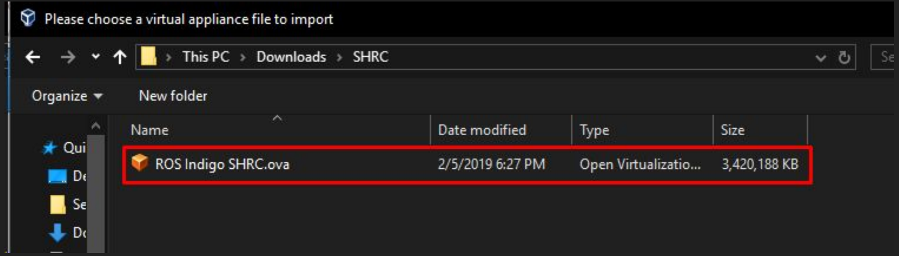


Import Virtual Appliance

Appliance to import

VirtualBox currently supports importing appliances saved in the Open Virtualization Format (OVF). To continue, select the file to import below.

2

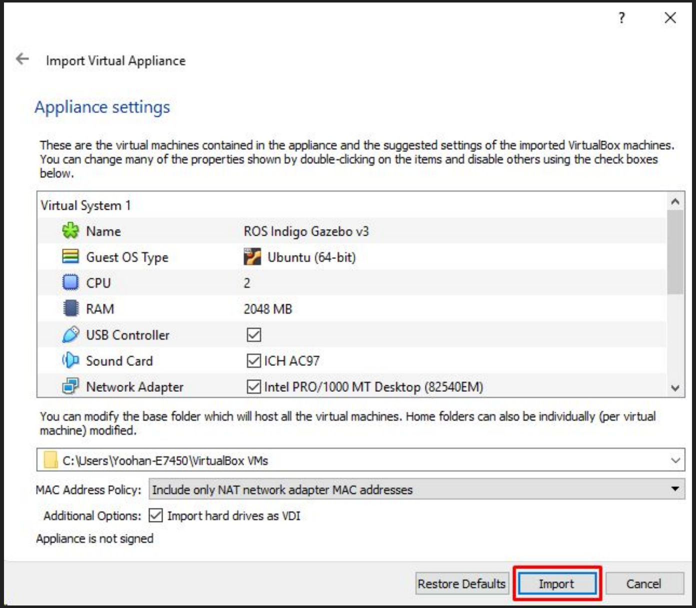


Please choose a virtual appliance file to import

This PC › Downloads › SHRC

Name	Date modified	Type	Size
ROS Indigo SHRC.ova	2/5/2019 6:27 PM	Open Virtualizatio...	3,420,188 KB

3



Import Virtual Appliance

Appliance settings

These are the virtual machines contained in the appliance and the suggested settings of the imported VirtualBox machines. You can change many of the properties shown by double-clicking on the items and disable others using the check boxes below.

Virtual System 1	
Name	ROS Indigo Gazebo v3
Guest OS Type	Ubuntu (64-bit)
CPU	2
RAM	2048 MB
USB Controller	☑
Sound Card	☑ ICH AC97
Network Adapter	☑ Intel PRO/1000 MT Desktop (82540EM)

You can modify the base folder which will host all the virtual machines. Home folders can also be individually (per virtual machine) modified.

C:\Users\Yoohan-E7450\VirtualBox VMs

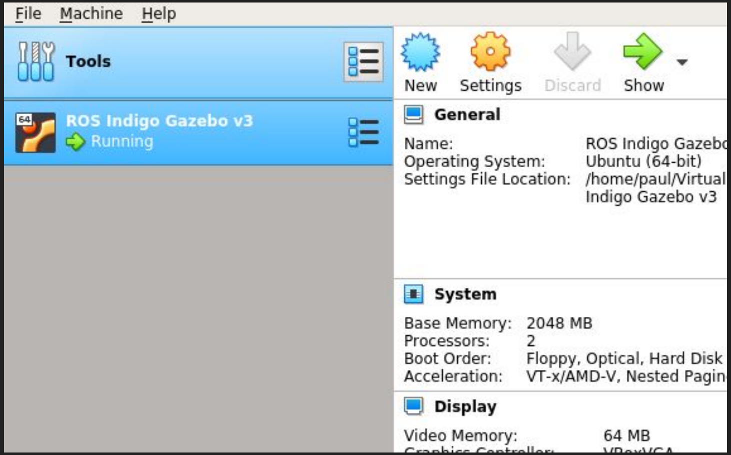
MAC Address Policy: Include only NAT network adapter MAC addresses

Additional Options: ☑ Import hard drives as VDI

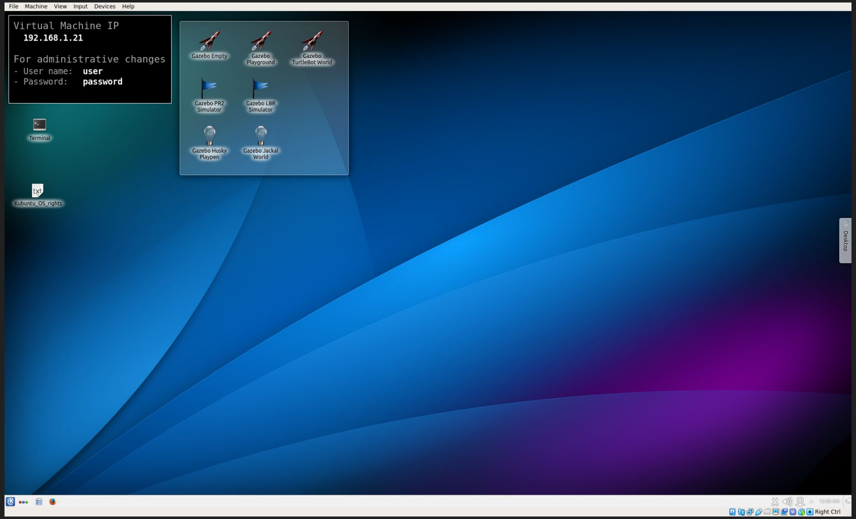
Appliance is not signed

Start the Virtual Machine

- Press start on the newly imported virtual machine
- **NOTE:** Just accept popup error about network interface, it will be configured automatically
- Should be seeing two windows below



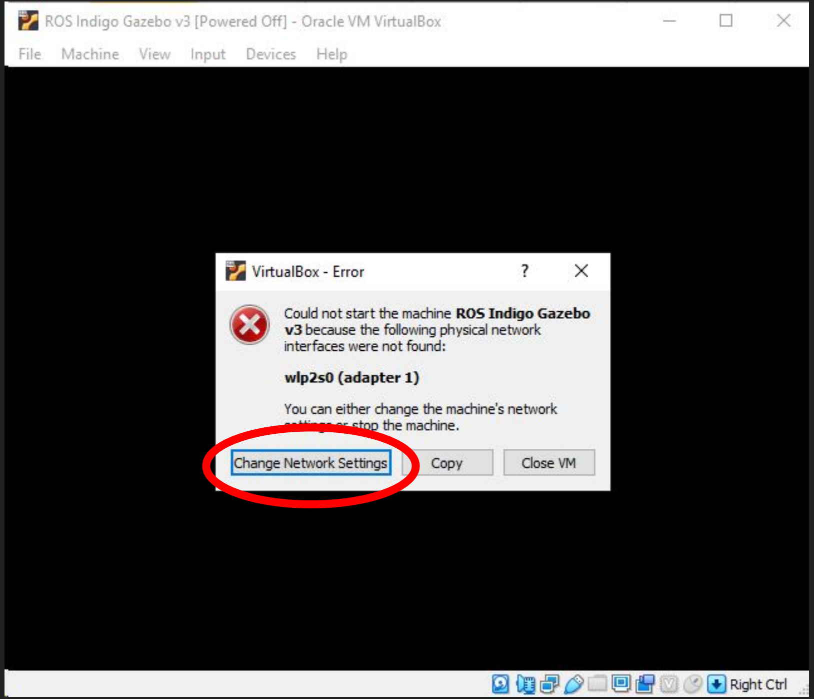
```
Name:                   ROS Indigo Gazebo
Operating System:       Ubuntu (64-bit)
Settings File Location: /home/paul/Virtual
                        Indigo Gazebo v3

Base Memory:   2048 MB
Processors:    2
Boot Order:    Floppy, Optical, Hard Disk
Acceleration:  VT-x/AMD-V, Nested Pagin

Video Memory:          64 MB
Graphics Controller:   VBoxVGA
```



```
Virtual Machine IP
  192.168.1.21

For administrative changes
- User name:  user
- Password:   password
```

First Boot-up (network error)

1



ROS Indigo Gazebo v3 [Powered Off] - Oracle VM VirtualBox

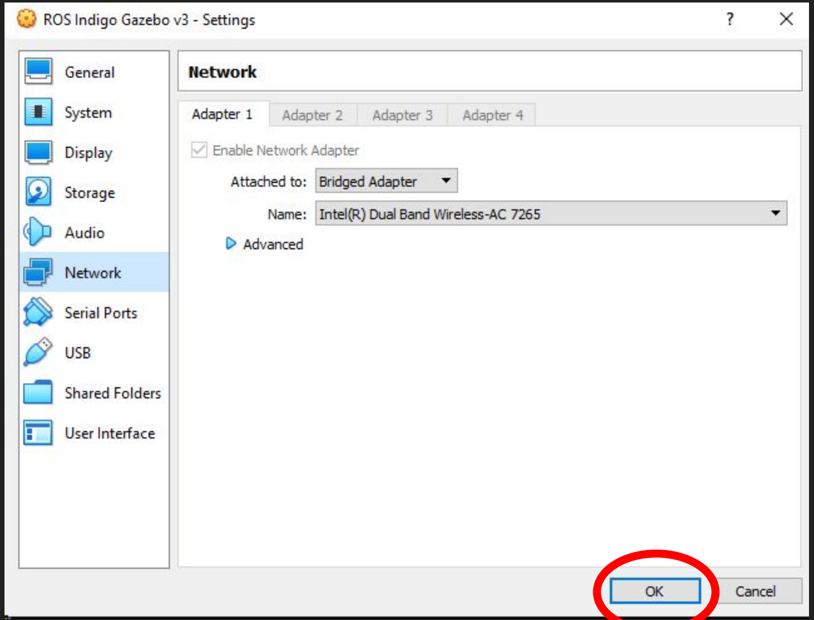
VirtualBox - Error

Could not start the machine **ROS Indigo Gazebo v3** because the following physical network interfaces were not found:

wlp2s0 (adapter 1)

You can either change the machine's network settings or stop the machine.

2. Leave everything as is



ROS Indigo Gazebo v3 - Settings

Network

Adapter 1

☑ Enable Network Adapter

Attached to: Bridged Adapter

Name: Intel(R) Dual Band Wireless-AC 7265

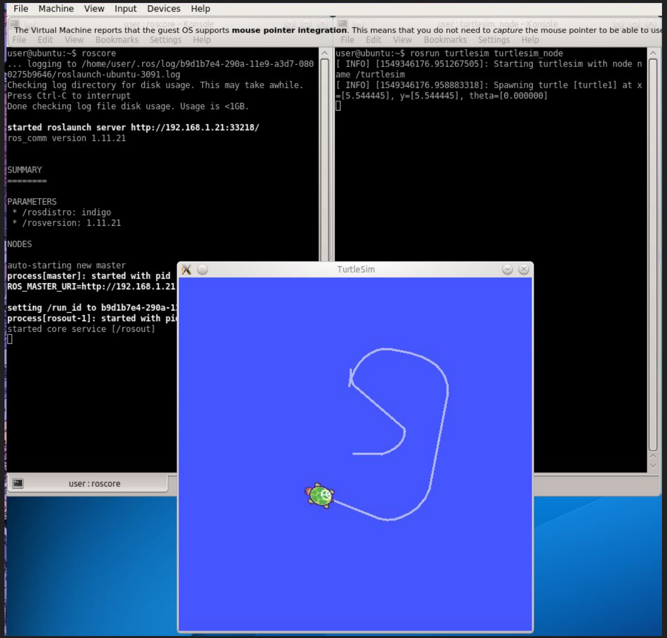
Simple Turtlesim Example

- We can use a package that comes preinstalled with ROS, **Turtlesim**, to show off some of what ROS can do

We're going to do the following:

1. Spawn a roscore
2. Run a turtlesim node
3. Run a turtle_teleop node

This will let us spawn a simulated 2d turtle and control it using the keyboard.


File Machine View Input Devices Help
File Edit View Bookmarks Settings Help
TurtleSim
user : roscore

The Virtual Machine reports that the guest OS supports **mouse pointer integration**. This means that you do not need to *capture* the mouse pointer to be able to use

```
user@ubuntu:~$ roscore
... logging to /home/user/.ros/log/b9d1b7e4-290a-11e9-a3d7-080
0275b9646/roslaunch-ubuntu-3091.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://192.168.1.21:33218/
ros_comm version 1.11.21


SUMMARY
========

PARAMETERS
 * /rosdistro: indigo
 * /rosversion: 1.11.21

NODES

auto-starting new master
process[master]: started with pid
ROS_MASTER_URI=http://192.168.1.21

setting /run_id to b9d1b7e4-290a-1
process[rosout-1]: started with pi
started core service [/rosout]
```

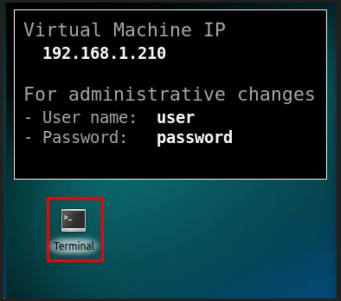
```
user@ubuntu:~$ rosrun turtlesim turtlesim_node
[ INFO] [1549346176.951267505]: Starting turtlesim with node n
ame /turtlesim
[ INFO] [1549346176.958883318]: Spawning turtle [turtle1] at x
=[5.544445], y=[5.544445], theta=[0.000000]
```

Simple Turtlesim Example

- Create 3 terminal windows
  - Can click on terminal icon, or type **Ctrl-Alt-T**

The dollar sign ($) means you type whatever is after it into the terminal

(Don't type the $, type whatever comes after it)



```
Virtual Machine IP
  192.168.1.210

For administrative changes
- User name:   user
- Password:    password
```

In 1st terminal, type:

$ roscore

and hit enter

In 2nd terminal, type:

$ rosrun turtlesim turtlesim_node

and hit enter

In 3rd terminal, type

$ rosrun turtlesim turtle_teleop_key

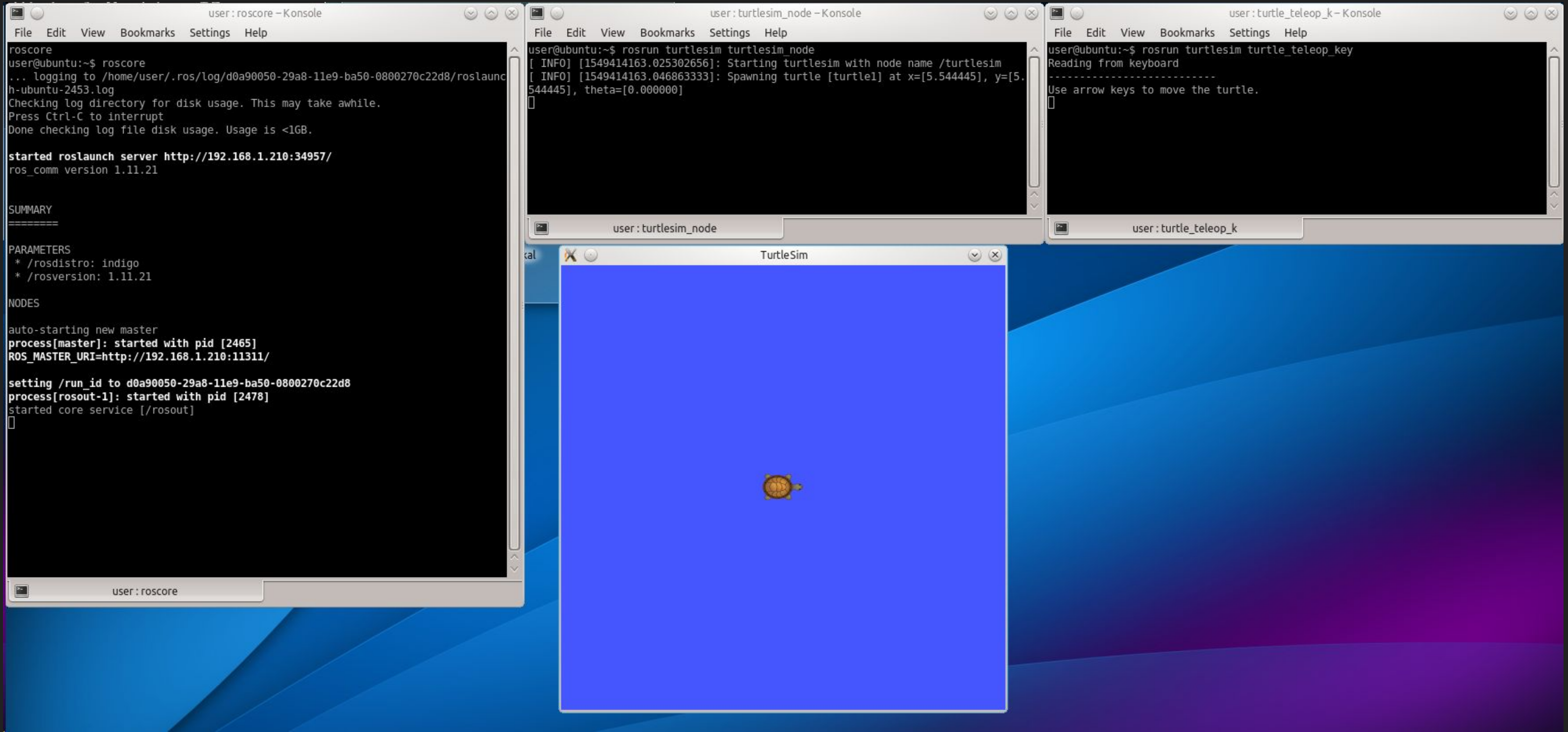
and hit enter

Turtlesim Startup Commands

$ roscore

$ rosrun turtlesim turtlesim_node

$ rosrun turtlesim turtle_teleop_key



```
roscore
user@ubuntu:~$ roscore
... logging to /home/user/.ros/log/d0a90050-29a8-11e9-ba50-0800270c22d8/roslaunc
h-ubuntu-2453.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://192.168.1.210:34957/
ros_comm version 1.11.21


SUMMARY
========

PARAMETERS
 * /rosdistro: indigo
 * /rosversion: 1.11.21

NODES

auto-starting new master
process[master]: started with pid [2465]
ROS_MASTER_URI=http://192.168.1.210:11311/

setting /run_id to d0a90050-29a8-11e9-ba50-0800270c22d8
process[rosout-1]: started with pid [2478]
started core service [/rosout]
```

user : turtlesim_node – Konsole
File Edit View Bookmarks Settings Help
user : turtlesim_node

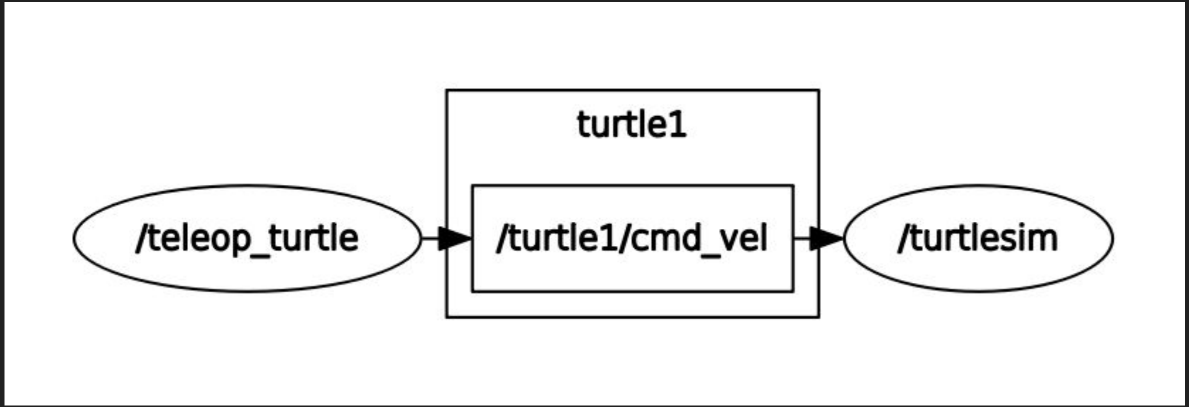
```
user@ubuntu:~$ rosrun turtlesim turtlesim_node
[ INFO] [1549414163.025302656]: Starting turtlesim with node name /turtlesim
[ INFO] [1549414163.046863333]: Spawning turtle [turtle1] at x=[5.544445], y=[5.
544445], theta=[0.000000]
```

user : turtle_teleop_k – Konsole
File Edit View Bookmarks Settings Help
user : turtle_teleop_k

```
user@ubuntu:~$ rosrun turtlesim turtle_teleop_key
Reading from keyboard
---------------------------
Use arrow keys to move the turtle.
```

How Does it Work?

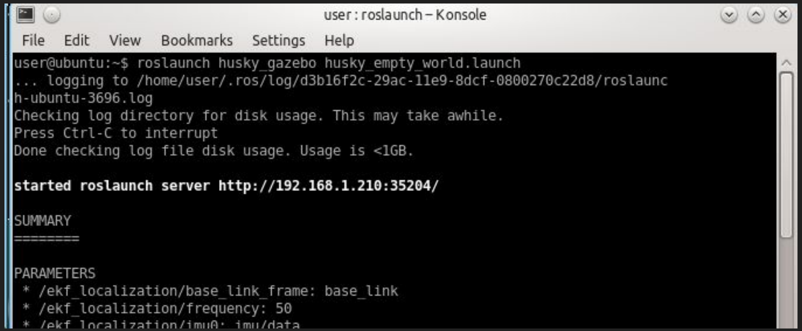
- Now, lets see how some of these messages are being passed between the ros nodes
  - Open a new terminal and run $ rqt_graph
  - This will show a representation of the nodes and how they connect



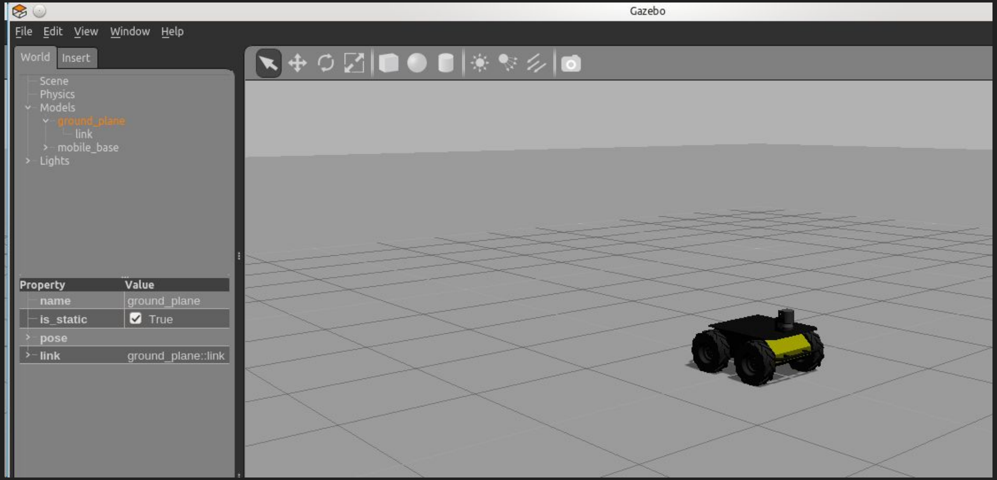
Husky - Gazebo

```
$ roslaunch husky_gazebo husky_empty_world.launch
```

- The ‘roslaunch’ command automatically creates a roscore node


user : roslaunch – Konsole
File Edit View Bookmarks Settings Help

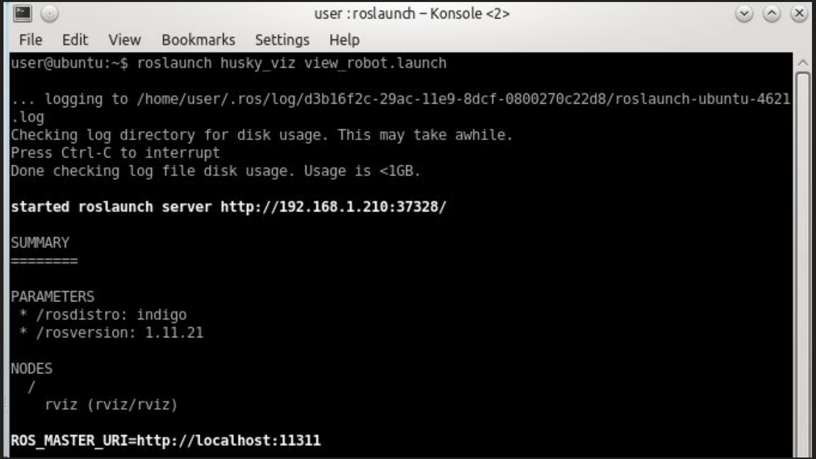
```
user@ubuntu:~$ roslaunch husky_gazebo husky_empty_world.launch
... logging to /home/user/.ros/log/d3b16f2c-29ac-11e9-8dcf-0800270c22d8/roslaunc
h-ubuntu-3696.log
Checking log directory for disk usage. This may take awhile.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://192.168.1.210:35204/

SUMMARY
========

PARAMETERS
 * /ekf_localization/base_link_frame: base_link
 * /ekf_localization/frequency: 50
 * /ekf_localization/imu0: imu/data
```



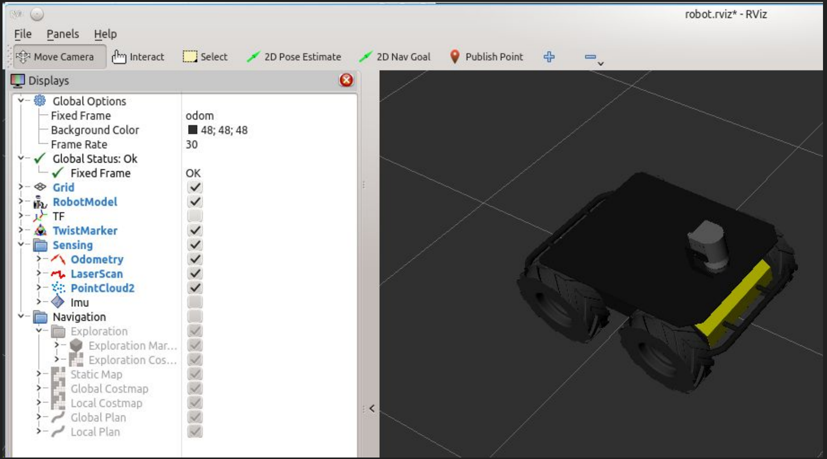
Property	Value
name	ground_plane
is_static	☑ True
pose	
link	ground_plane::link

Husky - RViz

```
$ roslaunch husky_viz view_robot.launch
```

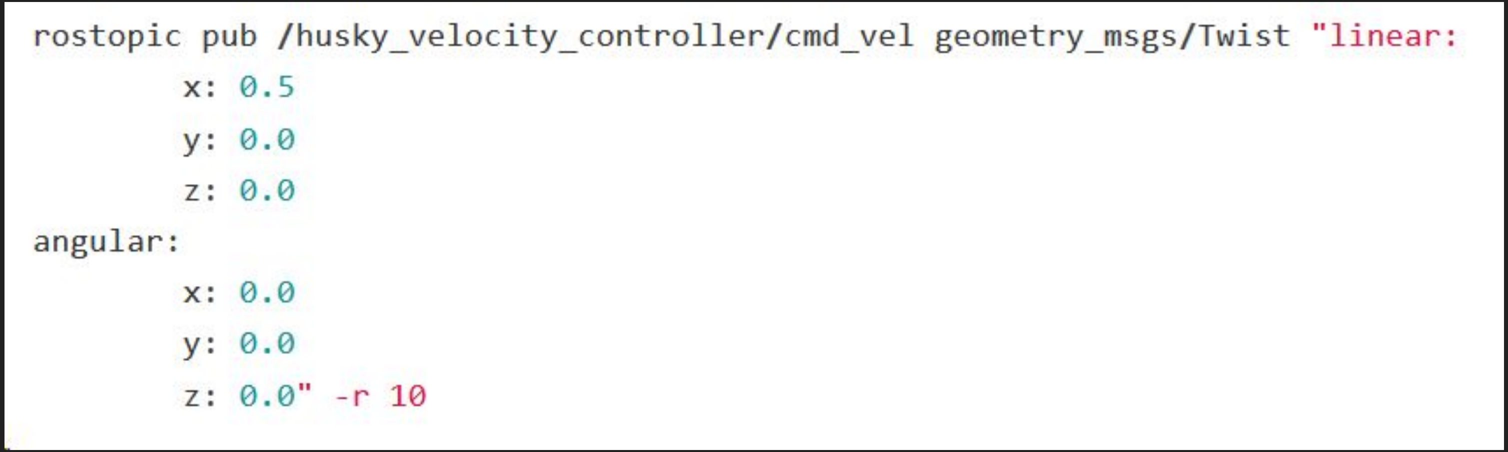


```
user@ubuntu:~$ roslaunch husky_viz view_robot.launch

... logging to /home/user/.ros/log/d3b16f2c-29ac-11e9-8dcf-0800270c22d8/roslaunch-ubuntu-4621
.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://192.168.1.210:37328/

SUMMARY
========

PARAMETERS
 * /rosdistro: indigo
 * /rosversion: 1.11.21

NODES
  /
    rviz (rviz/rviz)

ROS_MASTER_URI=http://localhost:11311
```



Global Options	
Fixed Frame	odom
Background Color	■ 48; 48; 48
Frame Rate	30
✓ Global Status: Ok	
✓ Fixed Frame	OK
Grid	☑
RobotModel	☑
TF	☐
TwistMarker	☑
Sensing	☑
Odometry	☑
LaserScan	☑
PointCloud2	☑
Imu	☐
Navigation	☐
Exploration	☑
Exploration Mar...	☑
Exploration Cos...	☑
Static Map	☑
Global Costmap	☑
Local Costmap	☑
Global Plan	☑
Local Plan	☑

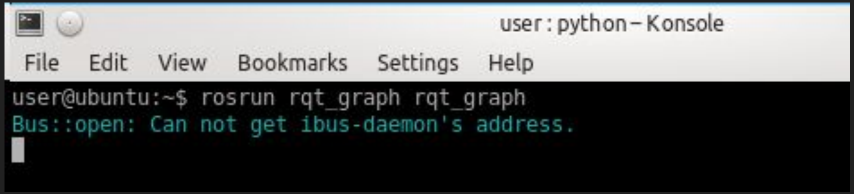
Husky



```
rostopic pub /husky_velocity_controller/cmd_vel geometry_msgs/Twist "linear:
        x: 0.5
        y: 0.0
        z: 0.0
angular:
        x: 0.0
        y: 0.0
        z: 0.0" -r 10
```

Husky - rqt_graph

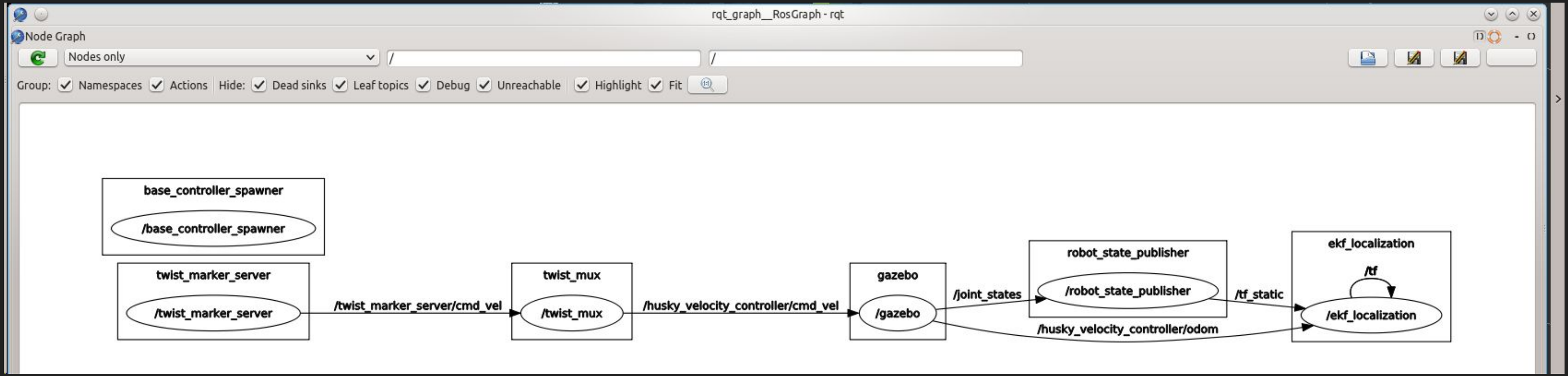
```
$ rosrun rqt_graph rqt_graph
```



user : python – Konsole

File Edit View Bookmarks Settings Help

```
user@ubuntu:~$ rosrun rqt_graph rqt_graph
Bus::open: Can not get ibus-daemon's address.
```



rqt_graph__RosGraph - rqt

Node Graph

Nodes only | / | /

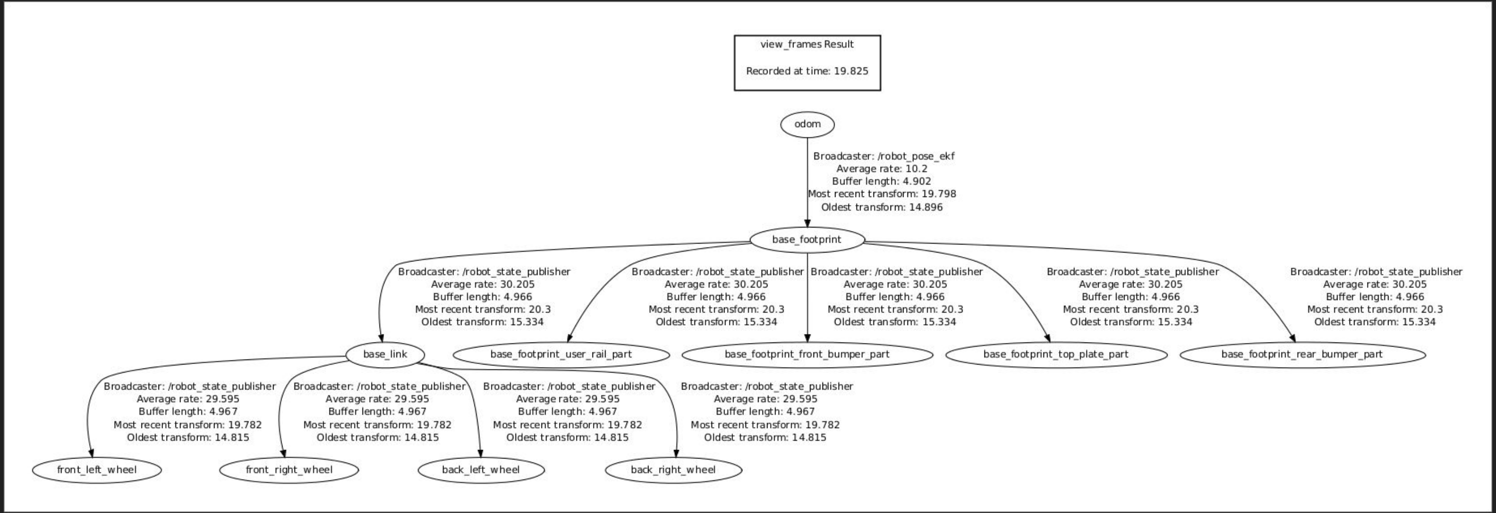
Group: ☑ Namespaces ☑ Actions Hide: ☑ Dead sinks ☑ Leaf topics ☑ Debug ☑ Unreachable ☑ Highlight ☑ Fit

Husky - rqt_graph

```
$ rosrun tf view_frames
```

(Wait for the command to finish running)

```
$ evince frames.pdf
```



Basic SLAM

- SLAM - Simultaneous Localization and Mapping
- Slam package preinstalled with ROS

- Run slam demo:
  a. $ rosrun gmapping slam_gmapping
  b. $ Add map topic to rviz

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Extra ROS Notes

- Tutorials to follow:
  - http://www.clearpathrobotics.com/assets/guides/ros/Intro%20to%20the%20Robot%20Operating%20System.html
  - https://www.cse.sc.edu/~jokane/agitr/
    - Gentle intro to ros, is a full book to understand ROS, only really useful for those interested in working at home
    - How Paul learned ROS (would recommend)
- Questions about basic linux commands?
  - http://www.clearpathrobotics.com/assets/guides/ros/Getting%20Started%20with%20Ubuntu.html