Quick Introduction to ROS

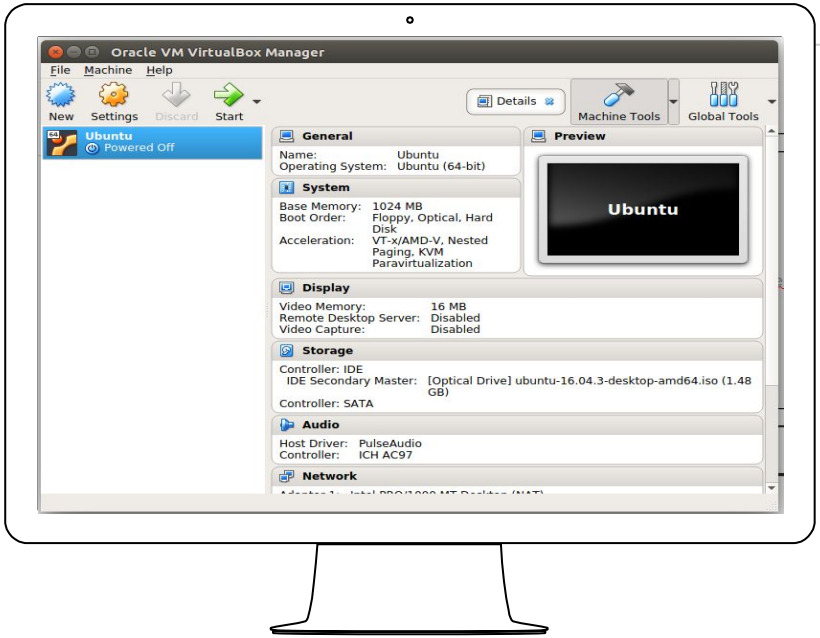
1

Installing Ubuntu 16.04

Quick and painless with Virtualbox

Open Virtualbox

- Install Virtualbox
- Download Ubuntu 16.04
- Install to a USB drive



Time for a demo!

Let’s install Ubuntu on a USB drive. I’ve uploaded a video of this to Youtube here: https://youtu.be/UGl0x2ZT_cI

2

What is ROS?

Getting started with the concepts

ROS is huge

ROS is an open-source, meta-operating system for humanoid robots

What can ROS do?

- Hardware abstraction
- Low-level device control
- Message passing between nodes
- Sophisticated build environment
- Libraries
- Debugging and Visualization Tools

What are the major concepts?

- ROS packages
- ROS messages
- ROS nodes
- ROS services
- ROS action servers
- ROS topics
- ...and many more!

What can ROS do?

- Both based on ROS
- Research development
  - Fast prototyping easier in a simulated world
- Transferring from simulated robot to real robot takes a bit of effort

3

ROS Concepts

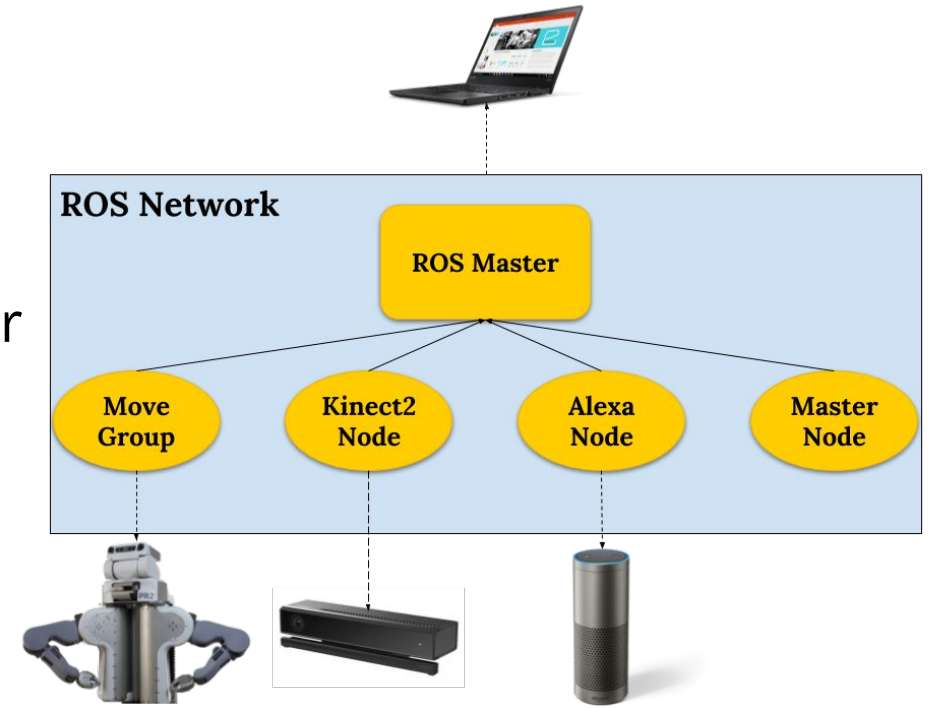
ROS is like HTTP but with extra steps

ROS Nodes

- The ROS framework is component oriented
- Each component is called a node
  - A node is a process
  - Nodes communicate through **topics**, **services**, and **actions**

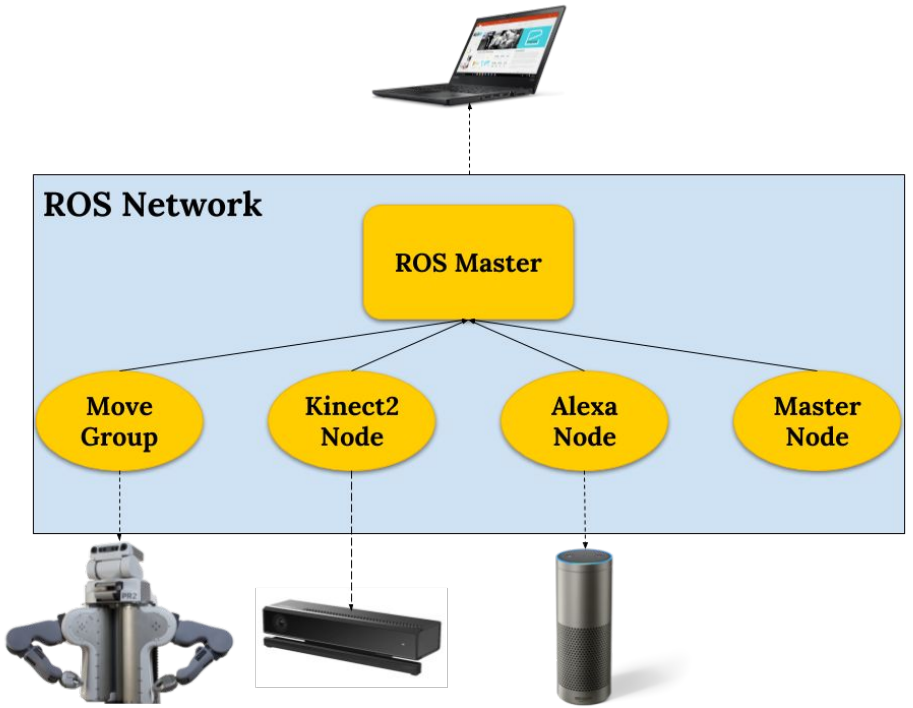
ROS as a framework

- ROS Master sends/receives
- Several nodes at once
- Whole network on your computer



ROS as a framework cont.

- Kinect2 → /kinect2/images
- Publishes image messages
- What are messages?



Interact | Move Camera | Select

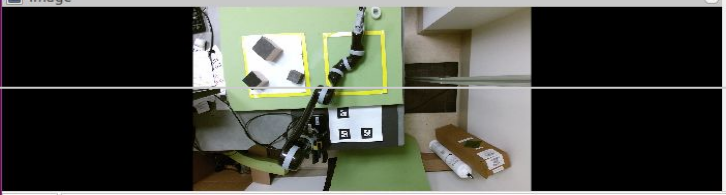
Displays

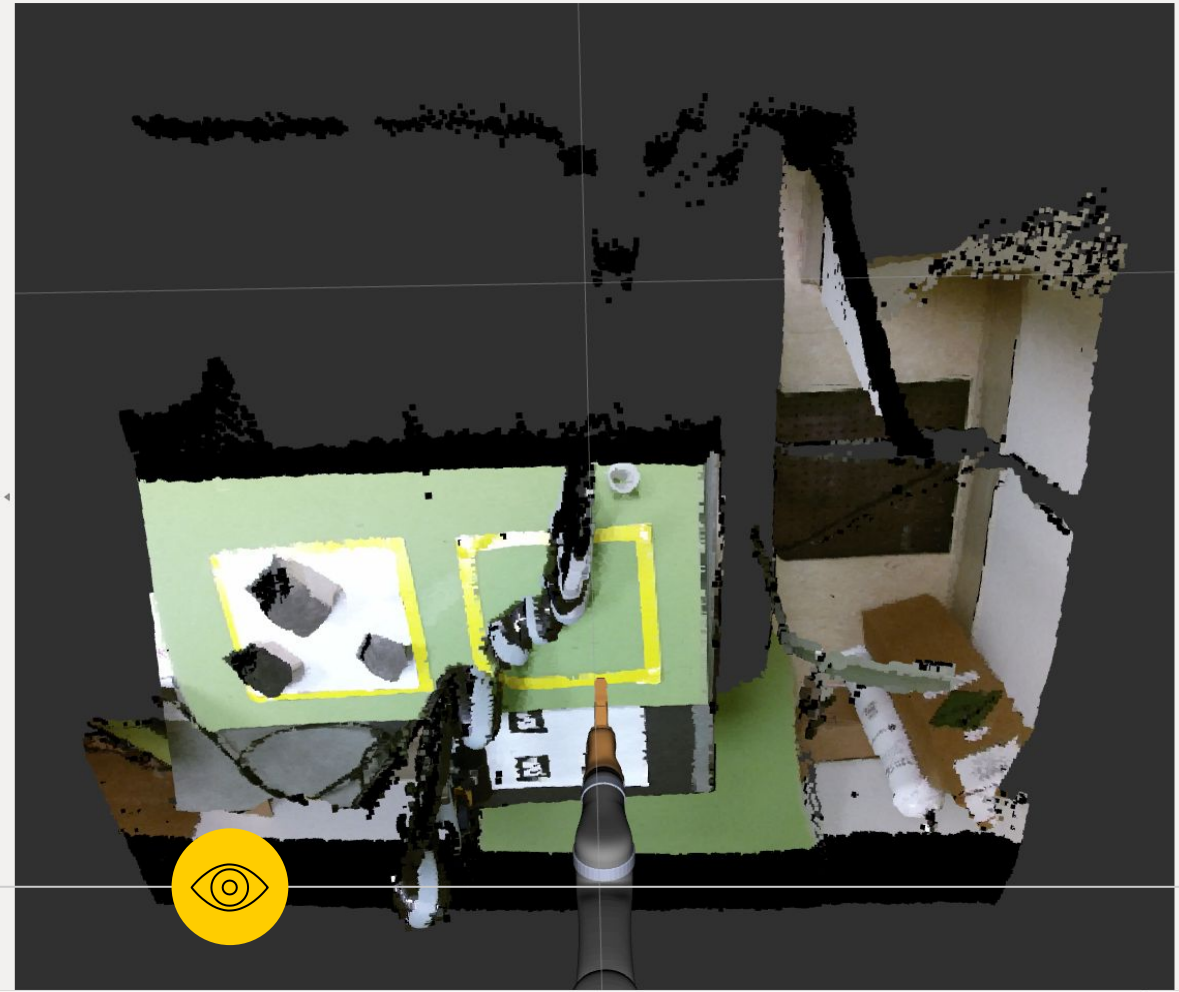
Global Options	
Fixed Frame	kinect2_link
Background Color	48; 48; 48
Frame Rate	30
Default Light	☑
Global Status: Ok	
Grid	☑
MotionPlanning	☑
PointCloud2	☑
Status: Ok	
Topic	/kinect2/sd/points
Unreliable	☐
Selectable	☑
Style	Flat Squares
Size (m)	0.01
Alpha	1
Decay Time	0
Position Transformer	XYZ
Color Transformer	RGB8
Queue Size	10
MarkerArray	☑
Marker	☑
MarkerArray	☑
TF	☐
Marker	☑
Image	☑
Status: Ok	
Image Topic	/kinect2/hd/image_color
Transport Hint	raw
Queue Size	2
Unreliable	☐

Image Topic
sensor_msgs::Image topic to subscribe to.

Add | Duplicate | Remove | Rename

Image





Reset | **Left-Click:** Rotate. **Middle-Click:** Move X/Y. **Right-Click:**: Move Z. **Shift:** More options. | 29 fps

So what does this mean?

- Hardware talks to drivers, which then talk to nodes, which then talks to ROS
- Nodes can run any software you want as long as it is a language ROS supports

Topics

- Each node can listen on or publish messages to topics
  - Built in message types (std_msgs)
  - User defined messages
  -

Complex.msg

float32 real
float32 imaginary

All ROS messages are viewable

```
david@kirintor:/opt/ros/kinetic/share/std_msgs/msg$ cat String.msg
string data
david@kirintor:/opt/ros/kinetic/share/std_msgs/msg$
```

Services

- A node can provide **services –** synchronous remote procedure calls
  - Request
  - Response
  -

Add.srv **#**Example Service

float32 x
float32 y
--- *#Three dashes separate the request and response*
Float32 result

Can view all ROS services

```
david@kirintor:/opt/ros/kinetic/share/std_srvs/srv$ ls
Empty.srv  SetBool.srv  Trigger.srv
david@kirintor:/opt/ros/kinetic/share/std_srvs/srv$ cat Trigger.srv
---
bool success   # indicate successful run of triggered service
string message # informational, e.g. for error messages
david@kirintor:/opt/ros/kinetic/share/std_srvs/srv$
```

Actions (actionlib)

- Actions (asynchronous) are for long-running processes.
- They have a Goal, Result, and Feedback

```
-Navigation.action                    #Example Action
    float32 dest_x
    float32 dest_y
    ---
    boolean success                   # Result
    ---
    uint32 percent_complete           # Feedback
```

Can view all ROS actions

```
david@kirintor:/opt/ros/kinetic/share/actionlib/action$ cat TestRequest.action
int32 TERMINATE_SUCCESS = 0
int32 TERMINATE_ABORTED = 1
int32 TERMINATE_REJECTED = 2
int32 TERMINATE_LOSE = 3
int32 TERMINATE_DROP = 4
int32 TERMINATE_EXCEPTION = 5
int32 terminate_status
bool ignore_cancel  # If true, ignores requests to cancel
string result_text
int32 the_result    # Desired value for the_result in the Result
bool is_simple_client
duration delay_accept  # Delays accepting the goal by this amount of time
duration delay_terminate  # Delays terminating for this amount of time
duration pause_status  # Pauses the status messages for this amount of time
---
int32 the_result
bool is_simple_server
---
```

Packages

- ROS software is organized into **packages**
  - Each package contains some combination of code, data, and documentation

package_name/

package.xml	← describes the package and it's dependencies
CMakeLists.txt	← Finds other required packages and messages/services/actions
src/	← C++ source code for your node (includes go in **include/** folder)
scripts/	← Python scripts for your node
msg/	← ROS messages defined for your node (for topics)
srv/	← ROS services defined for your node (for services)
launch/	← The folder that contains .launch files for this package

Building/Running

- **Catkin** is the official build system of ROS
  - Catkin combines Cmake macros and Python scripts to provide some functionality on top of Cmake's normal workflow
- Run ROS code
  -
  -

```
$ rosrun <package_name> <script>
$ roslaunch <package_name> <launch_file>
```

Launch Files

- Automate the launching of collections of ROS nodes via XML files and **roslaunch**

example.launch:

```
<launch>
  <node name="talker" pkg="rospy_tutorials"
        type="talker.py" output="screen" />
  <node name="listener" pkg="rospy_tutorials"
        type="listener.py" output="screen" />
</launch>

$ roslaunch rospy_tutorials example.launch
```

Launch Files

- You can also pass parameters via launch files
-

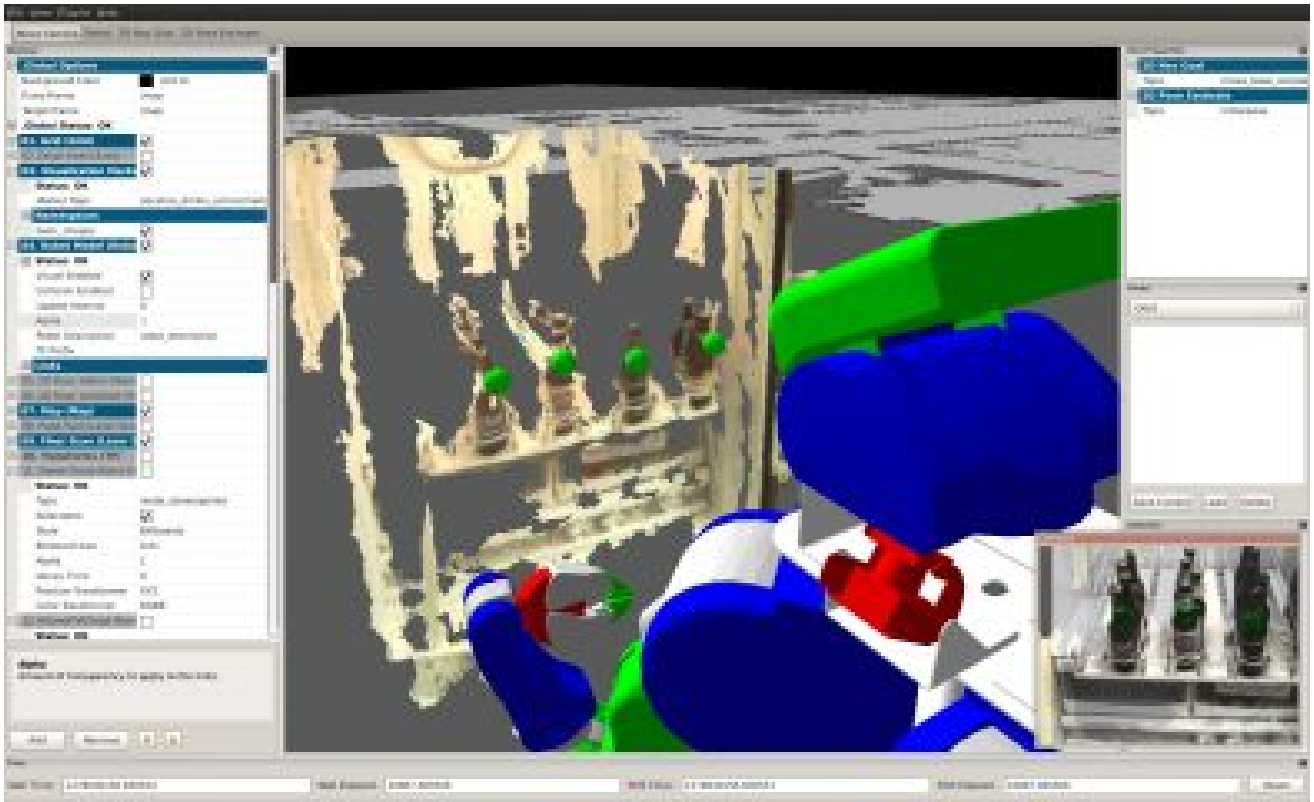
```
<launch>
  <arg name="gui" default="true"/>
  <param name="/use_sim_time" value="true" />
  <include file="$(find gazebo_ros)/launch/
  empty_world.launch">
    <arg name="world_name" value="worlds/willowgarage.world"
    />
    <arg name="gui" value="$(arg gui)" />
    </include>
<include file="$(find pr2_gazebo)/launch/pr2.launch"/>
  <node name="spawn_table" pkg="gazebo_ros" type="
  spawn_model"
   args="-urdf -file $(find humanoids_robots)/
   pr2_gazebo_pick_object/scenario/objects/table.urdf
   -model table -x 2.15 -y 0.5"
   respawn="false" output="screen" />
</launch>
```

Command Line Tools

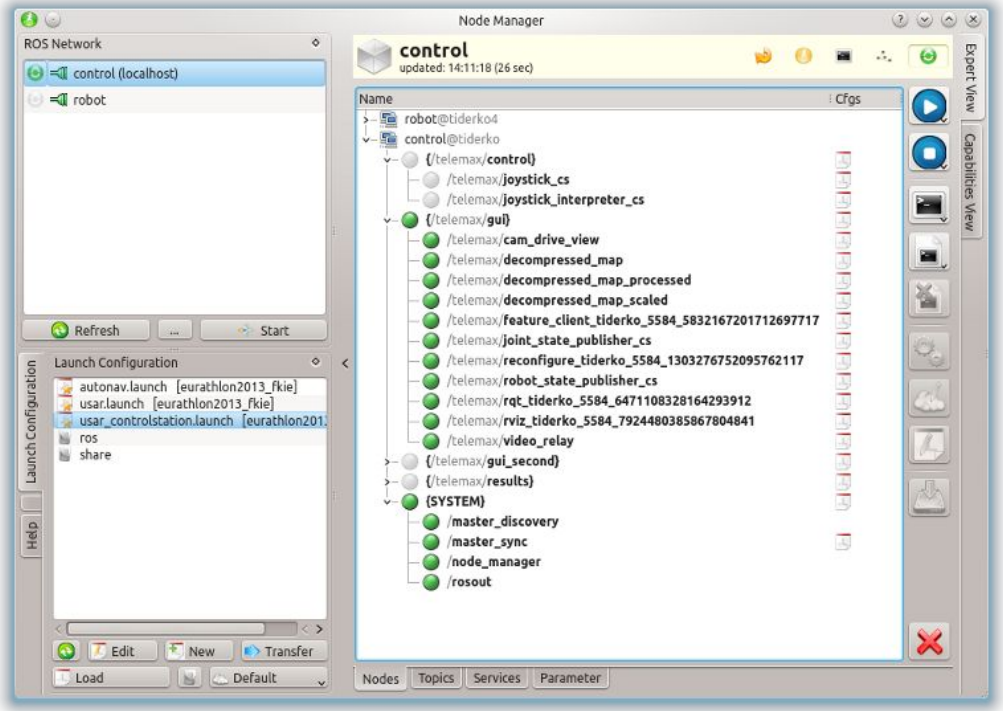
-

```
$ rosnode list
$ rostopic list
$ rostopic echo
$ rosmsg show
$ rosservice
$ tf viewframes
```

Rviz: Robot Visualization



Node Manager Fkie



Robots + ROS

Sensor Data

Joint Trajectories

Your **ROS** Code Here

Robots available - Fetch

Provides Data From (sensors):

- Depth camera
- Laser scanner
- Head camera
- Current Joint States

http://fetchrobotics.com/wp-content/uploads/2016/02/Fetch_spec_download_2016.pdf

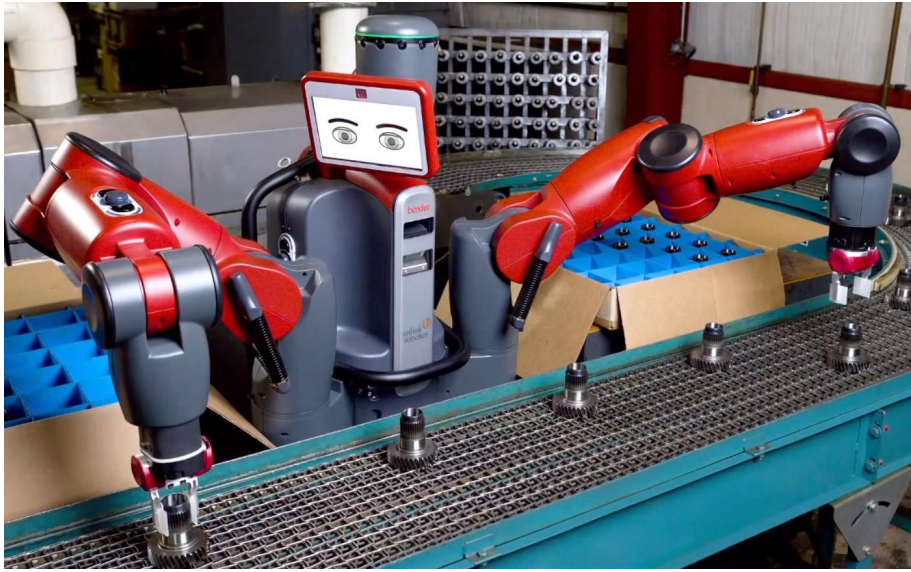
Robots available - PR2

Provides Data From (sensors):

- Kinect
- Two Laser Scanners
- Multiple Cameras (head and hand cameras)
- Fingertip pressure sensor arrays (gripper)
- Current Joint States

Robots available - Baxter

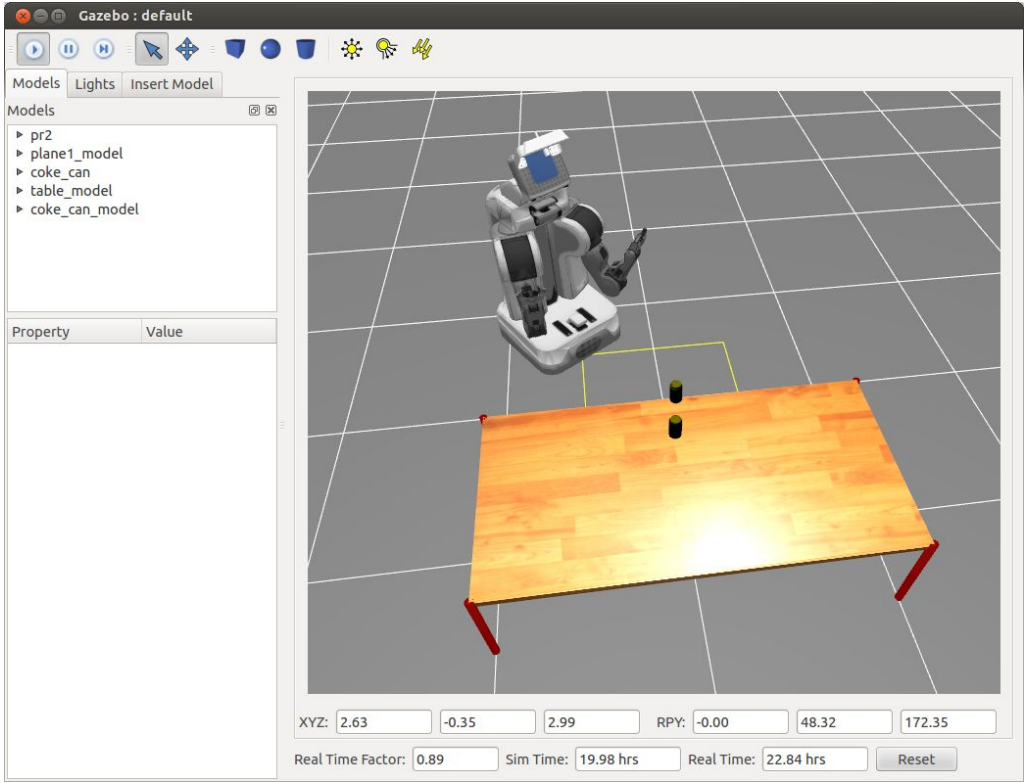
- More cost-effective
- Also has 2 arms
- Stationary base
- Sensors:
  - Sonar
  - Hand and head cameras
  - Hand rangefinders



Robots in the wild - Problems

- I don’t have a Robot in front of me
- I want to try something that may break my Robot
- Setting up the Robot takes too much time, I want to test changes to my code quickly

Gazebo Simulator



Gazebo Simulator

- Same interface as real Fetch, PR2 or Baxter
- Add/remove items in environment
- Physics engine to simulate effects of motor commands and provide updated sensor feedback

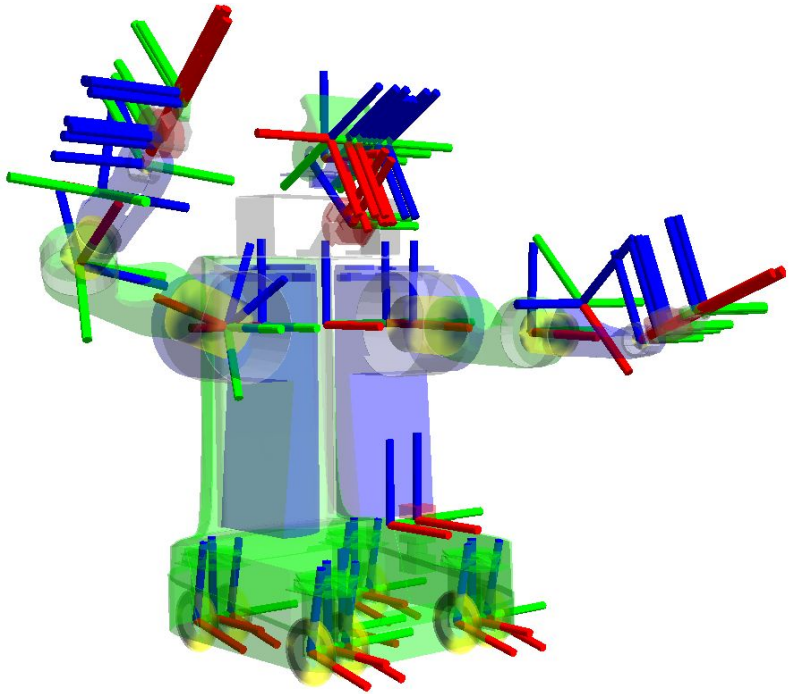
Gazebo Demo

- Add object to world
  - Physics
  - Simulated Sensor Output Topics

```
$ roslaunch fetch_gazebo playground.launch
```

Moving the robot - TF

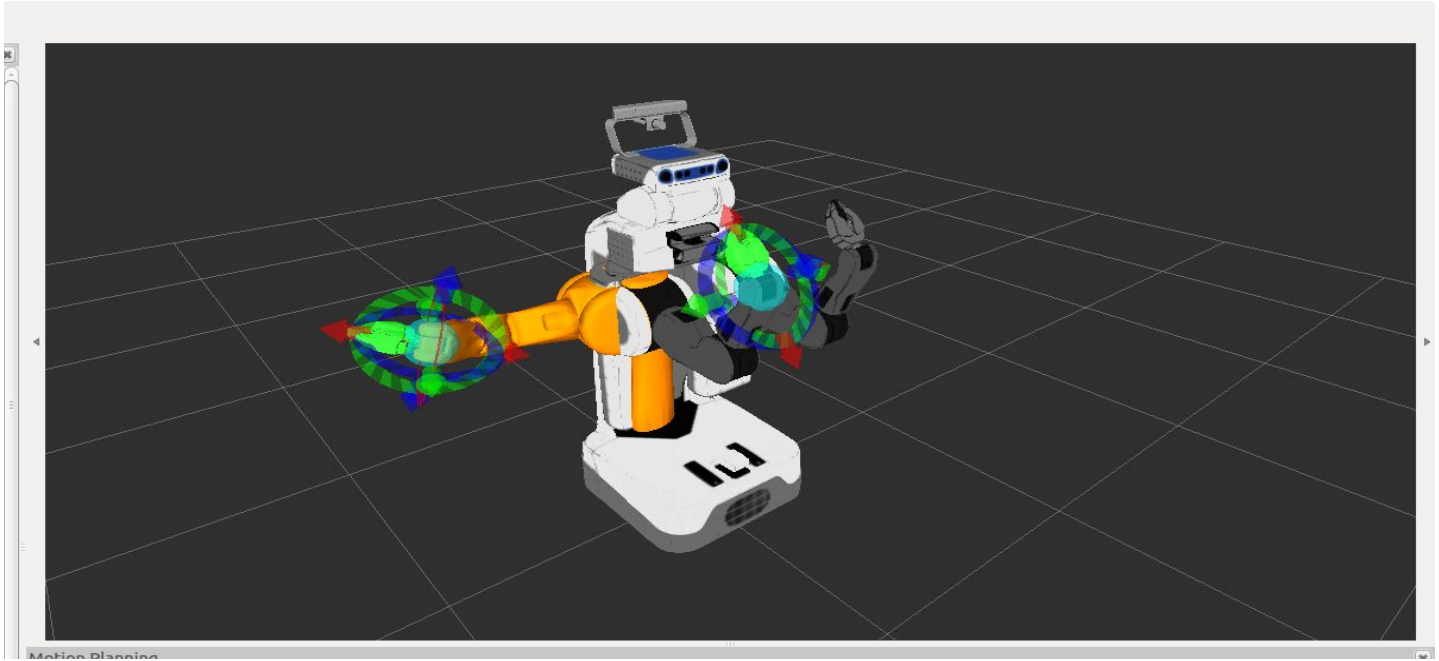
- A robotic system typically has many 3D coordinate frames that change over time.
- tf keeps track of all these frames over time.



Moveit!

- Given:
  - Current State of Arm
  - Desired End Effector Pose
  - Scene
- Returns:
  - Trajectory to Move End Effector to Desired Pose

Moveit! Demo



Moveit!

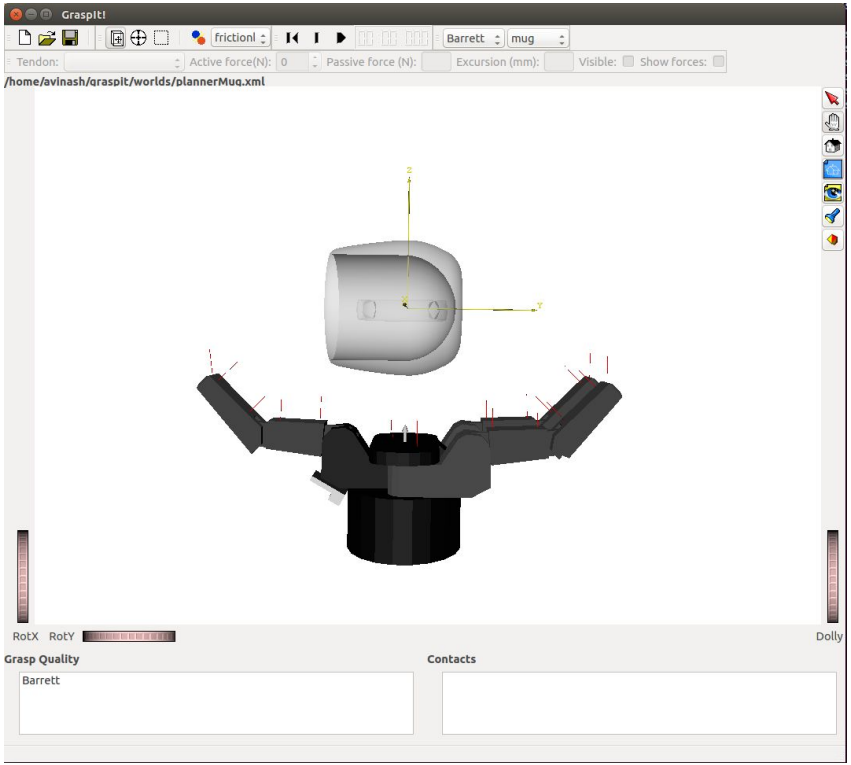
- Provides a common interface to several different planners (mostly OMPL)
- Probabilistic Planners: will not return the same path every time and may not even find a path reliably.

Moving the robot

- Several Interfaces:
  - Base Motion Commands
  - Gripper Commands
  - Head Commands
  - MoveIt! for arm trajectories generation

Graspit!

- Grasp planner
- Lots of robots and objects



Graspit! Demo

- PlannerMug.xml
- Show virtual contacts
- Show EGPlanner,
  - Energy functions
  - Simulated annealing
  - Contact quality, Potential quality
  - Semantics?

Debugging Tips

- Using Launch File
  - output = “screen”
  - Separate the specific node from launch and run it using roslaunch or rosrun
- Use node_manager
- Check RVIZ to see if anything is wrong
- Command line commands like rosnode etc can be very useful

If you have a question

- Look in Tutorials:
  - http://wiki.ros.org/ROS/Tutorials
- Reference class slides/codes provided
- Google it
- http://answers.ros.org/questions/
- Ask a TA

Some project tips

- Get going early.
- Start from a simple prototype.
- Seek help.
- Several robot platforms available (Fetch, PR2, and Baxter)

HW0, 1, and 2 are out

- Submissions details:
  - HW0 – February 6th
  - HW1 – February 6th
  - HW2 – February 13th
- Demo for HW2 February 14th