TEAM IGVC
INDIAN INSTITUTE OF TECHNOLOGY KANPUR

ROS

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Kanpur

IIT

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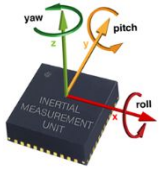
- What makes a Robotic System ?
- What is ROS ?
- ROS Architecture
- ROS workflow
- Add Ons

What Makes a Robotic System ?

Camera

IMU



Laser scanner

Motor & Encoder

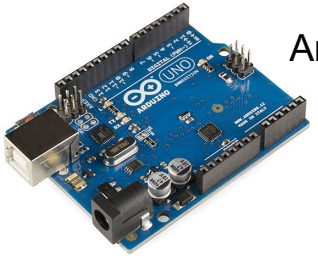
Robot

GPS

A cooperative system of sensors and actuators...

Intel NUC

Arduino



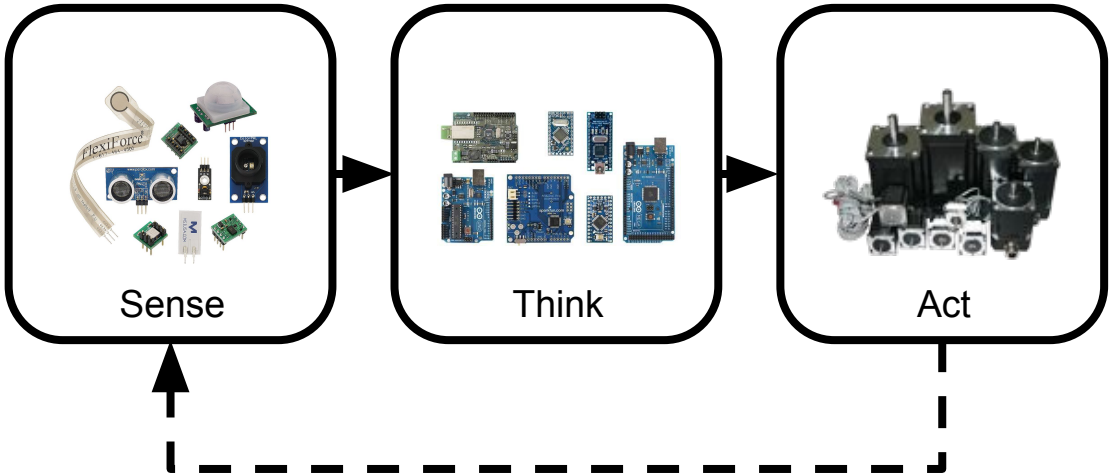
Robot

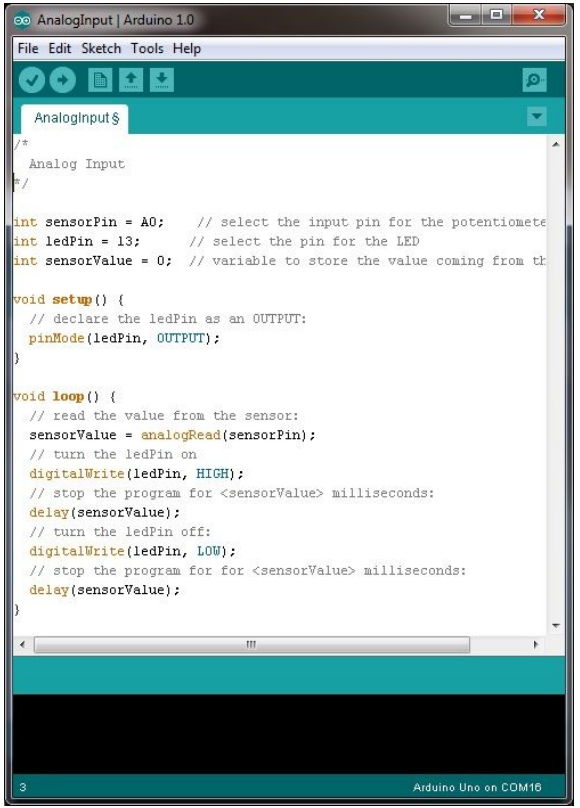
Raspberry Pi

ODROID

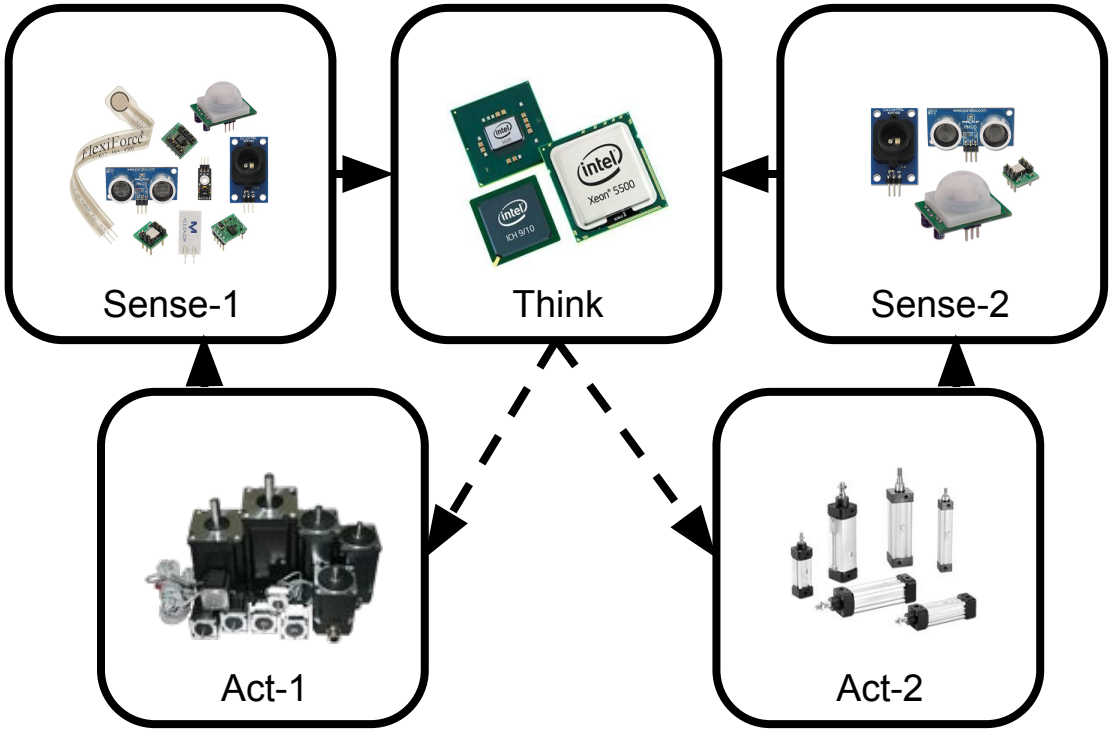
...and processors to help in this cooperation

Robotic System: Sequential workflow



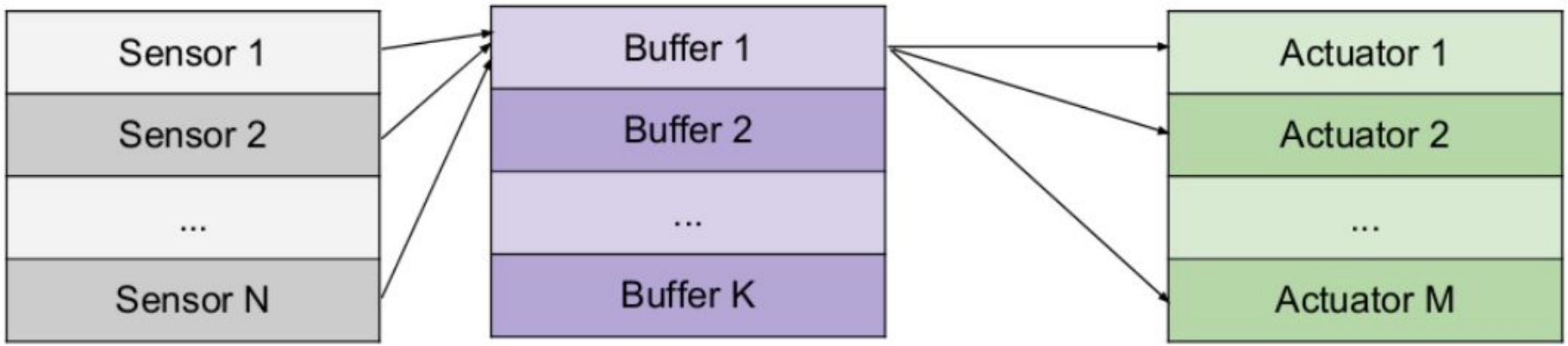


Robotic System: Parallel workflow




```
roscore http://ROSDEV:11311/
ibaranov@ROSDEV:~$ roscore
... logging to /home/ibaranov/.ros/log/115868b0-76fe-11e3
aunch-ROSDEV-4593.log
Checking log directory for disk usage. This may take awhi
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://ROSDEV:54414/
ros_comm version 1.9.50


SUMMARY
========

PARAMETERS
 * /rosdistro
 * /rosversion

NODES

auto-starting new master
process[master]: started with pid [4607]
ROS_MASTER_URI=http://ROSDEV:11311/

setting /run_id to 115868b0-76fe-11e3-a540-000c294d48a1
process[rosout-1]: started with pid [4620]
started core service [/rosout]
```

Implementing a Robotic System in Parallel Mode



So, How do we do this ? We all have the used a software that does all this.

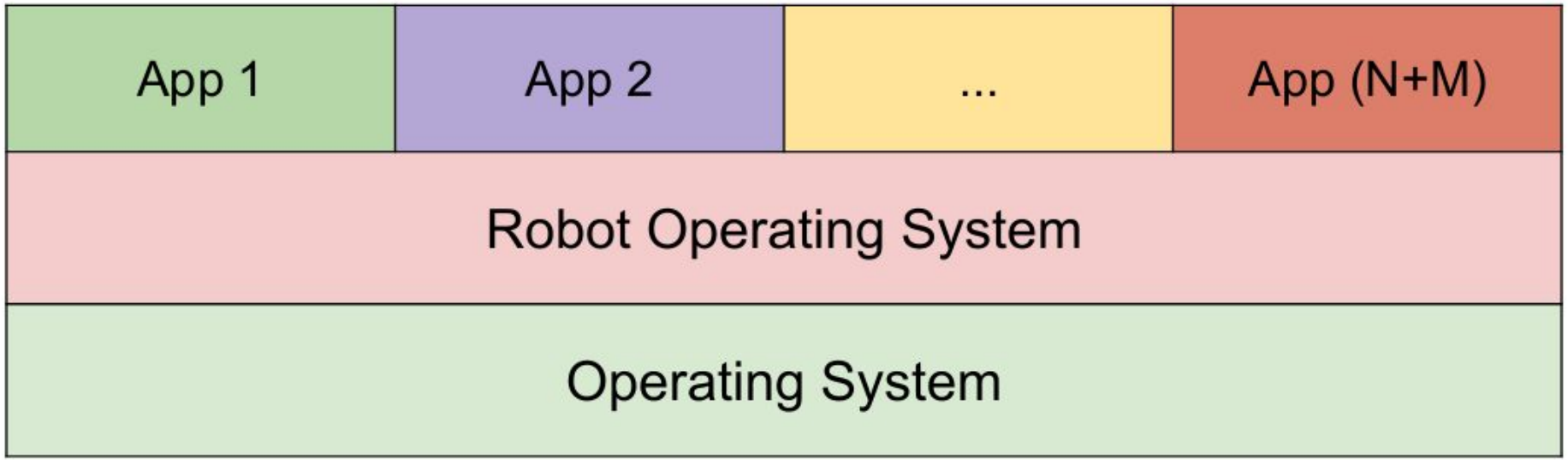
Source : Lakshay Garg

Think

The Operating System

ROS to the rescue

Why not let the OS handle the tedious task.



Source : Lakshay Garg

What is ROS ?

- **ROS** or **Robot Operating System**.
- **Framework** for **robotic software development** providing Operating System Like functionality, including **hardware abstraction**, **low-level-device control**, **message-passing** between processes, and **package management**.
- The origins lie in Stanford Artificial Intelligence Lab and was further developed at Willow Garage.

- Available for all major operating systems
- Massively growing user base.

ROS 10 years 11 Distros

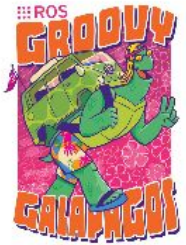
2010

2010

2011

2011

2012



2012

2013

2014

2015

2016

2017

open robotics

ROS is more than just a “middleware”.

Tools	Capabilities	Plumbing	Ecosystem
• Simulation • Visualization • GUI • Data Logging • Debugging • Testing	Libraries for • Mobility • Perception • Manipulation • Control	• Process Management • Message Passing Interface • Device Drivers	• Large community of Developers and organizations. • Documentation • Tutorials

Credit : ETHZ RSL

Philosophy of ROS

- **Peer to Peer**
  - Individual programs (nodes) communicate over ROS API (messages, etc)
- **Distributed**
  - Nodes can communicate over a network.
- **Multilingual**
  - Native support for C++, Python and Lisp, Experimental support exist for Java and Lua too. Client Libraries for Matlab etc.
- **Light Weight**
  - Doesn’t slow the programs or even hinder their ability to work with other frameworks.
- **Free and Open Source**

Credit : ETHZ RSL

What ROS isn’t ?

- An actual Operating System
- A programming Language
- A programming environment/IDE
- A hardware.

Credit : ETHZ RSL

ROS Architecture

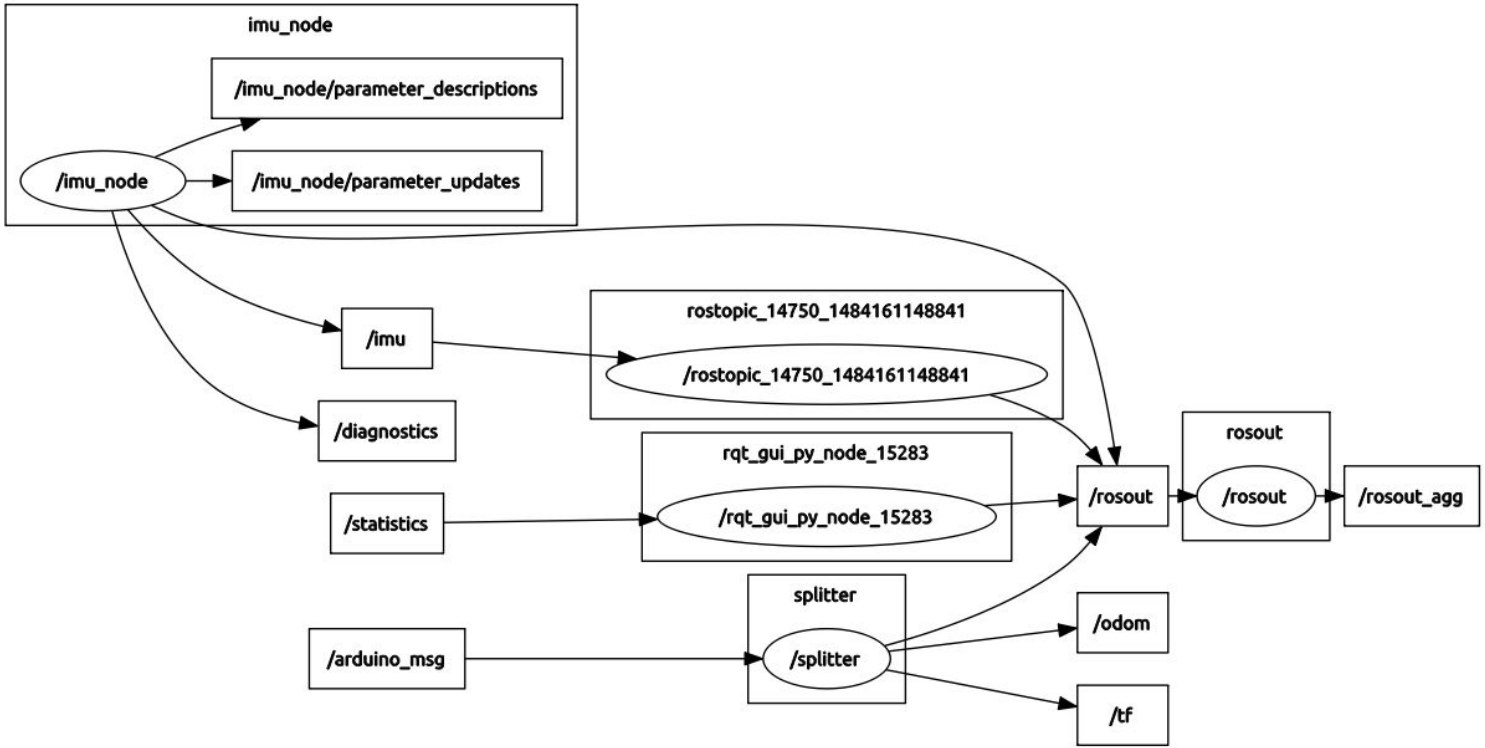
ROS Communication Layer : ROS Core

- **ROS Master**
  - Centralized Communication Server based on XML and RPC
  - Negotiates the communication connections
  - Registers and looks up names for ROS graph resources
- **Parameter Server**
  - Stores persistent configuration parameters and other arbitrary data.
- **`*rosout*`**
  - Network based `*stdout*` for human readable messages.

ROS Communication Layer : Graph Abstraction

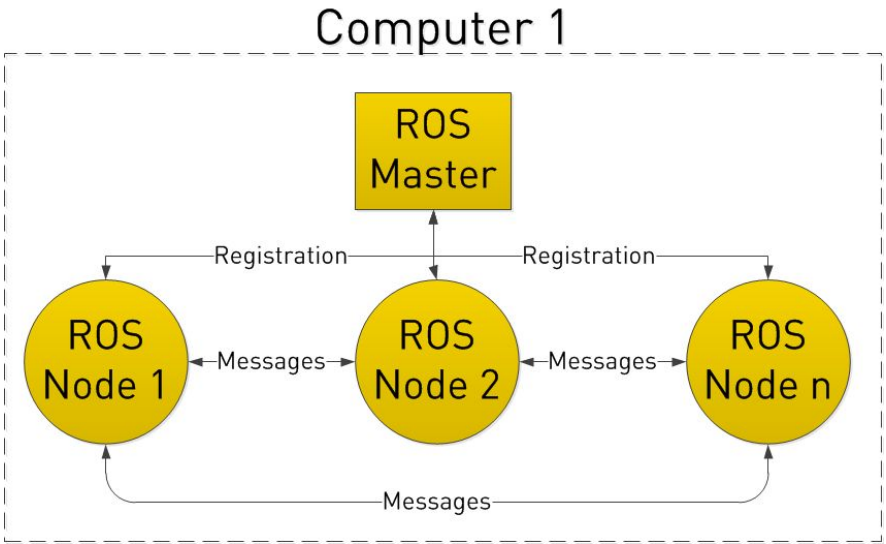
- **Nodes**
  - Processes distributed over the network.
  - Serves as source and sink for the data sent over the network
- **Parameters**
  - Persistent data such as configuration and initialization settings, i.e the data stored on the parameter server. e.g camera configuration
- **Topics**
  - Asynchronous many-to-many communication stream
- **Services**
  - Synchronous one-to-many network based functions

ROS Communication Layer : Graph Abstraction



#1: ros::roscore

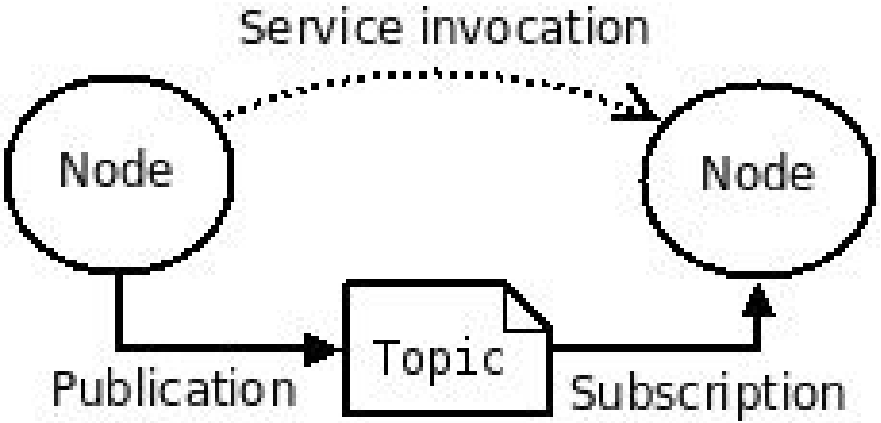
- ROS master process is called roscore
- Allows intercommunication between *nodes* (processes using ROS framework)
- *Syntax:* `$ roscore`



```
turtlebot@turtlebot-X200CA:~$ roscore
... logging to /home/turtlebot/.ros/log/6ef6185c-9127-11e4-83da-0c84dc11754b/ros
launch-turtlebot-X200CA-9168.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://192.168.0.8:45853/
ros_comm version 1.11.9


SUMMARY
========

PARAMETERS
 * /rosdistro: indigo
 * /rosversion: 1.11.9

NODES

auto-starting new master
process[master]: started with pid [9180]
ROS_MASTER_URI=http://192.168.0.8:11311/

setting /run_id to 6ef6185c-9127-11e4-83da-0c84dc11754b
process[rosout-1]: started with pid [9193]
started core service [/rosout]
```

#2: ros::Topic

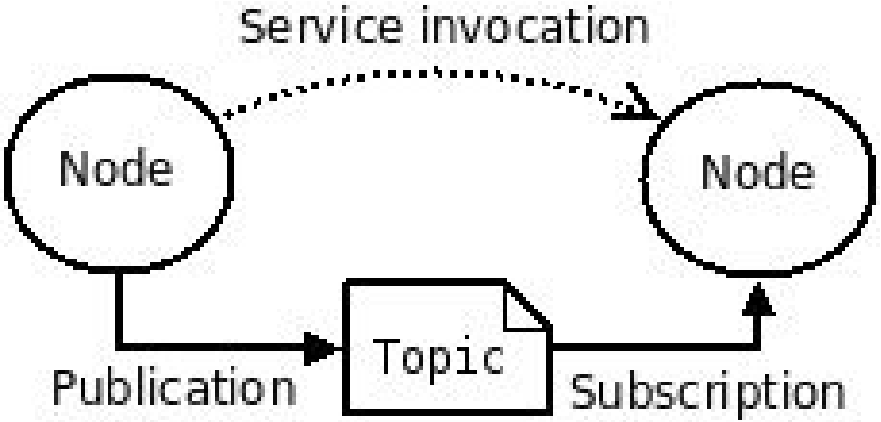
- *Topics* are used to send messages from a node to other nodes
- *Publish* = send message to a topic
- *Subscribe* = receive message from a topic



```
yahya@yahya-Compaq-Presario-CQ61-Notebook-PC:~$ rostopic list
/camera/depth/camera_info
/camera/depth/image_raw
/camera/depth/points
/camera/parameter_descriptions
/camera/parameter_updates
/camera/rgb/camera_info
/camera/rgb/image_raw
/camera/rgb/image_raw/compressed
/camera/rgb/image_raw/compressed/parameter_descriptions
/camera/rgb/image_raw/compressed/parameter_updates
/camera/rgb/image_raw/compressedDepth
/camera/rgb/image_raw/compressedDepth/parameter_descriptions
/camera/rgb/image_raw/compressedDepth/parameter_updates
/camera/rgb/image_raw/theora
/camera/rgb/image_raw/theora/parameter_descriptions
/camera/rgb/image_raw/theora/parameter_updates
/clock
```

#3: ros::Service

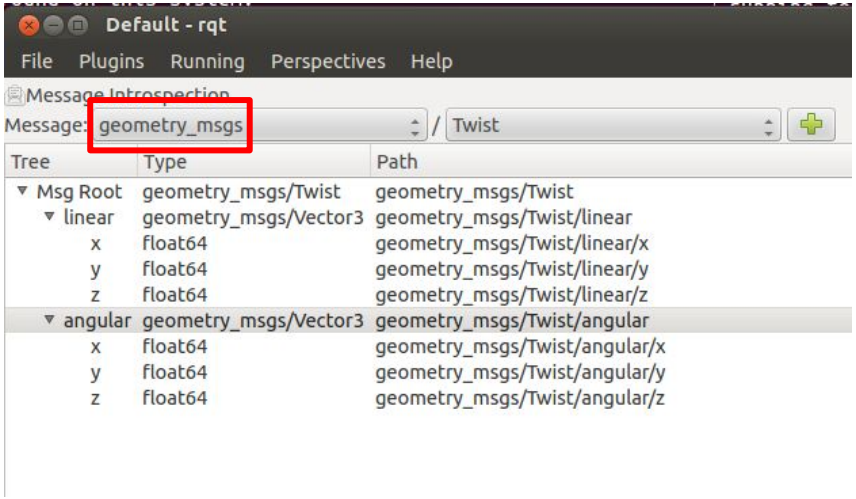
- *Services* are used to send a request to another node and receive a response
- A service is called with a *request* struct and *response* struct is returned
- These structs are different from *topic* messages



```
^Cosman@ubuntu:~/catkin_ws$ rosservice call /robot_pose_ekf/get_status
status: Input:
 * Odometry sensor
   - is NOT active
   - received 0 messages
   - listens to topic /odom
 * IMU sensor
   - is active
   - received 5907 messages
   - listens to topic /imu_data
 * Visual Odometry sensor
   - is NOT active
   - received 0 messages
   - listens to topic
Output:
 * Robot pose ekf filter
   - is NOT active
   - sent 0 messages
   - pulishes on topics /robot_pose_ekf/odom_combined and /tf

osman@ubuntu:~/catkin_ws$ ^C
osman@ubuntu:~/catkin_ws$ rosservice call /robot_pose_ekf/get_status
```

#4: ros::Message

- *Messages* in ROS are used for inter process interactions like topics or services
- Defined as text files with internal variable declarations
- Single file contains both request and response



ROS workflow

ROS workflow : Demo

Please Visit this link and clone the repository.

- https://github.com/harshsinh/ros-demo

- git clone https://github.com/harshsinh/ros-demo.git
- cp ros-demo/demo ~/catkin_ws/src -rf
- cd ~/catkin_ws/
- catkin_make

ROS workflow : workspace

The typical ROS workspace would look somewhat like this :

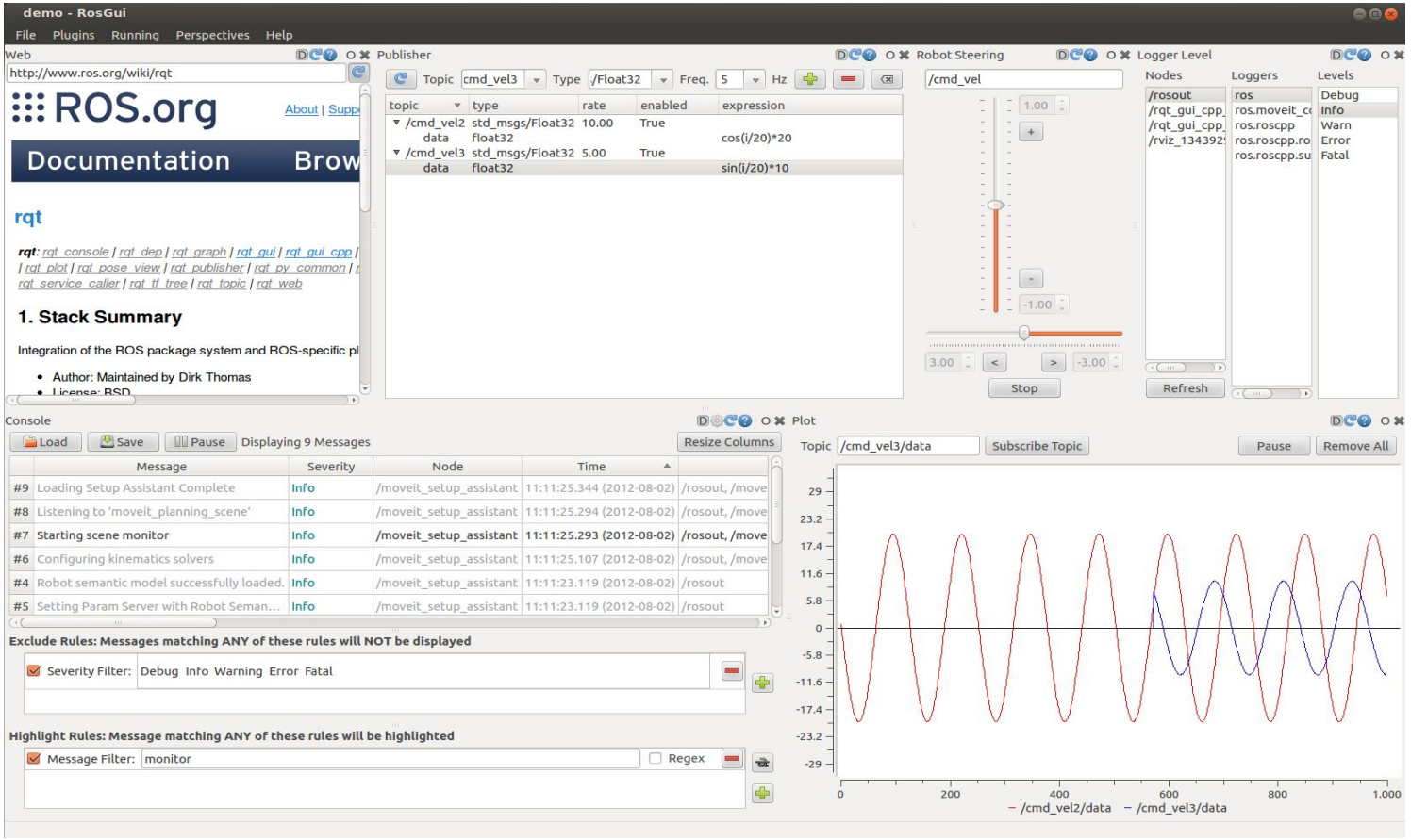
- catkin_ws/
  - build/
  - devel/
  - src/
    - CMakeLists.txt
    - Package_1/
    - Package_2/
      - CMakeLists.txt
      - package.xml
      - include/
      - launch/
      - src/

ROS Build System : catkin

- ROS uses a `catkin` build system.
  - `catkin_make` or `catkin build` would generate **executables**, **libraries** and **interfaces**.
  - Choose one of the above and stick to it.
  - Always `*source*` your workspace after you build.
- A cross platform build system which treats your entire workspace as a single CMake project where each project is a subproject then on.

Add Ons

rqt : A QT based GUI developed for ROS

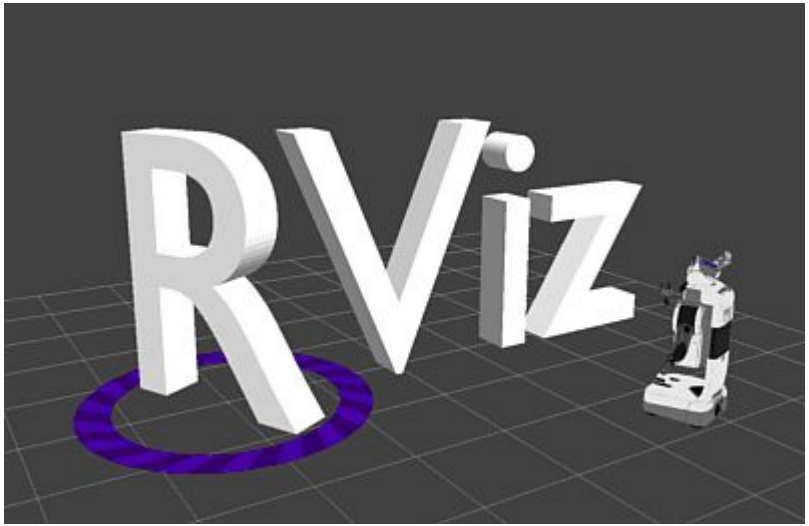


rqt : A QT based GUI developed for ROS

- Lots of different plugins.
  - `*rqt_graph*`, `*rqt_image_view*`, `*rqt_console*` to name a few.
  - `*rqt_graph*` can be used to view the graph structure of the system, i.e the nodes, and how are they related etc.
- Multiple plugins can be run simultaneously.
- Anyone can add more custom plugins written in C++ or Python.

RVIZ : ROS

- A Powerful tool for 3D Visualization in ROS
- Modular state and sensor visualization
- Excellent community support.



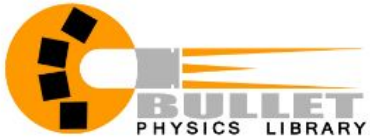
Gazebo Simulator

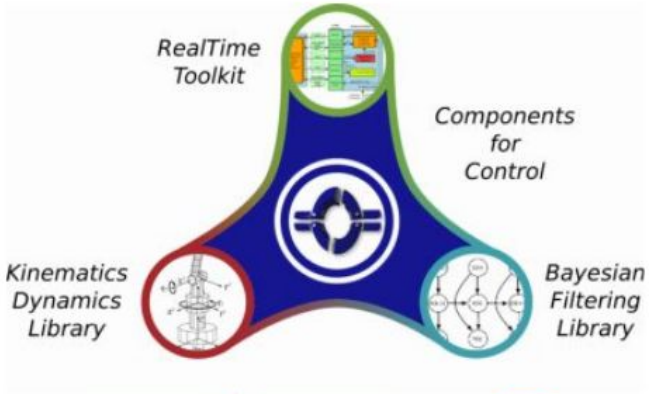
- Simulate 3D rigid body dynamics
- Simulate a variety of different sensors, many of them are available online ready to use.
- Has many environments and robots pre-implemented.
- With ROS interface, it can be used to directly to test the applications inside a simulation.
- Has even more plugins available.

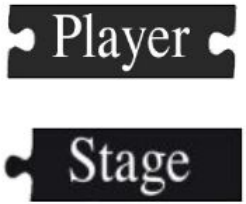
Further References

- ROS Wiki
  - http://wiki.ros.org/
- Tutorials
  - http://wiki.ros.org/ROS/Tutorials
- Available Packages
  - http://www.ros.org/browse/list.php
- ROS Style Guides
  - http://wiki.ros.org/StyleGuide
- ROS Cheat Sheet
  - https://www.clearpathrobotics.com/ros-robot-operating-system-cheat-sheet/
- ROS Answers
  - https://answers.ros.org/

ROS is not alone







Thank You