

Robot Operating System (ROS)

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Outline

Introduction to ROS

Getting Started With ROS

Appendix

References

What is ROS? [1]

- Meta-operating system, providing low level services:
 - process communication over a network
 - device control
 - hardware abstraction
- Distributed framework of processes



Why use ROS?

- "Lightweight" framework that speeds up large-scale robotic development
- Many libraries developed on top of this framework that can be reused:
 - Physics simulation ([Gazebo](#))
 - Movement + Navigation ([ROS navigation](#))

ROS Concepts i

Computational Graph

- All computation is organized as a peer-to-peer network of communicating processes.

ROS Concepts ii

Nodes

- Processes that perform any form of computation.
- Nodes can communicate with one another.
- Example of nodes:
 - Publish sensor readings
 - Receiving teleop commands and running them
- Written with ROS client libraries ([rospy](#), [roscpp](#))

ROS Concepts iii

Master (Primary) Node

- Provides name registration, node lookup to all nodes in the computational graph.
- Enables communication between nodes.

Parameter Server

- "Distributed" key-value store: all nodes can access data stored in these keys.

ROS Concepts iv

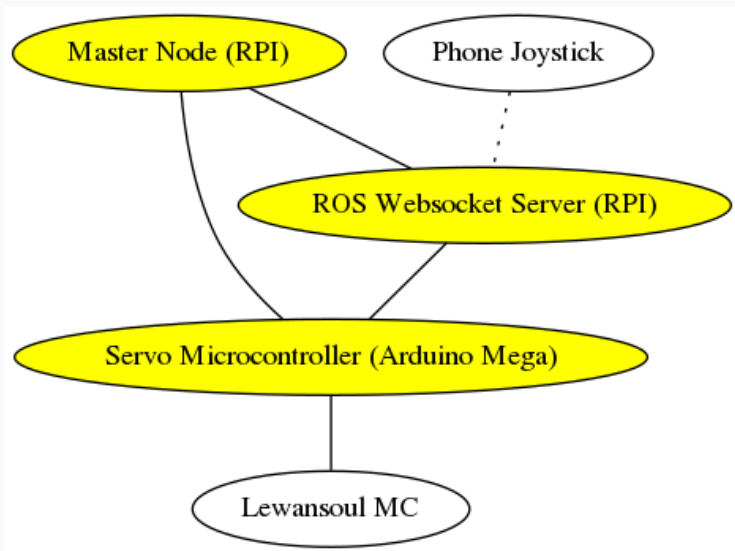
Topics

- Nodes communicating via the publish-subscribe semantics do so by publishing and subscribing to topics.
- Every topic has a name, e.g. `/sensors/temp1`
- No access permissions

Services

- Request-response semantics (think Web servers)
- Requests are blocking

Example Computational Graph



ROS Environment Setup

Here I assume you have the ROS environment set up. If not, see the appendix.

Creating a ROS Workspace

Catkin is ROS' package manager, built on top of CMake.

```
1  mkdir -p ~/catkin_ws/src           # Create the directories
2  cd ~/catkin_ws/                   # Change to the directory
3  catkin_make                        # Initial setup
```

Exploring ROS bash commands ¹

rospack

rospack find locates ROS packages.

```
1 rospack find roscpp # /opt/ros/melodic/share/roscpp
```

roscd

roscd changes you to the directory of the ros package.

```
1 roscd roscpp
2 pwd # /opt/ros/melodic/share/roscpp
```

¹Almost all bash commands have tab completion!

Creating a ROS package

We use the convenience script `catkin_create_pkg` to instantiate our package.

```
1  cd ~/catkin_ws/src
2  catkin_create_pkg workshop std_msgs rospy roscpp
3  # Created file workshop/CMakeLists.txt
4  # Created file workshop/package.xml
5  # Created folder workshop/include/workshop
6  # Created folder workshop/src
7  # Successfully created files in
   ↪ /home/jethro/catkin_ws/src/workshop. Please adjust the
   ↪ values in package.xml.
```

What's in a ROS package?

```
1  workshop
2      CMakeLists.txt          # Build instructions
3      include                 # For cpp deps, if any
4          workshop
5      package.xml             # Details about the package
6      src                     # Contains source code
```

Starting ROS

We initialize the ROS master node with `roscore`.

```
1  roscore
2
3  # ...
4  # process[master]: started with pid [16206]
5  # ROS_MASTER_URI=http://jethro:11311/
6
7  # setting /run_id to 05bf8c5e-efed-11e9-957b-382c4a4f3d31
8  # process[rosout-1]: started with pid [16217]
```

To kill it, press `Ctrl-C` in the same terminal.

ROS Nodes i

roscall

roscall let's us inspect available nodes:

- 1 `roscall list` *# /roscall*
- 2 `roscall info /roscall`

What happens if master is not running?

- 1 `roscall list` *# ERROR: Unable to communicate*
↳ *with master!*

ROS Nodes ii

Running a ROS node

A ROS package may contain many ROS nodes.

```
1 rosrun turtlesim <TAB>
2 # draw_square          mimic          turtlesim_node
  ↪ turtle_teleop_key
```

```
1 rosrun turtlesim turtlesim_node
2 # [ INFO] [1571214245.786246078]: Starting turtlesim with
  ↪ node name /turtlesim
3 # [ INFO] [1571214245.790986159]: Spawning turtle
  ↪ [turtle1] at x=[5.544445], y=[5.544445],
  ↪ theta=[0.000000]
```

Exercise: reinspect the node list.

ROS Installation

Ubuntu

Follow the instructions on ROS Wiki. [2]



nil.

Ros/introduction - ros wiki.

<http://wiki.ros.org/ROS/Introduction>, nil.

Online; accessed 15 October 2019.



nil.

melodic/installation/ubuntu - ros wiki.

<http://wiki.ros.org/melodic/Installation/Ubuntu>, nil.

Online; accessed 16 October 2019.