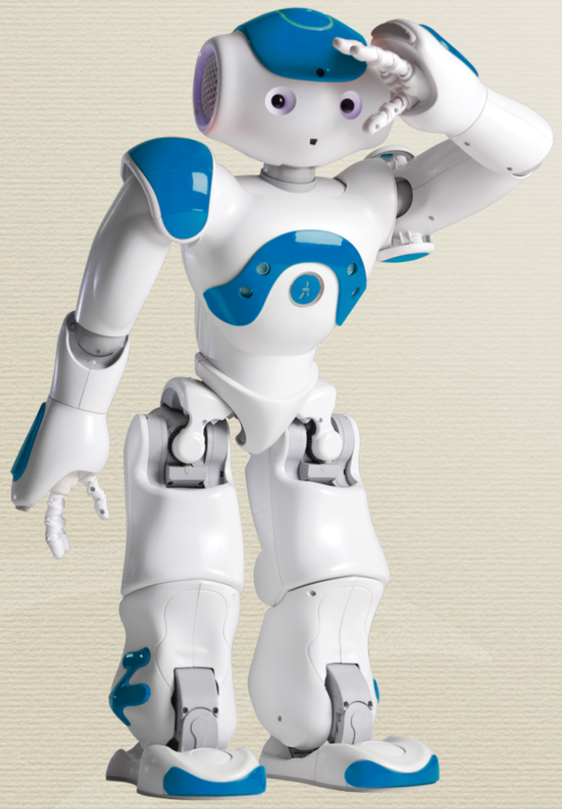
Imperial College London

PERSONAL ROBOTICS LABORATORY

imperial.ac.uk/**PersonalRobotics**

Intro to ROS

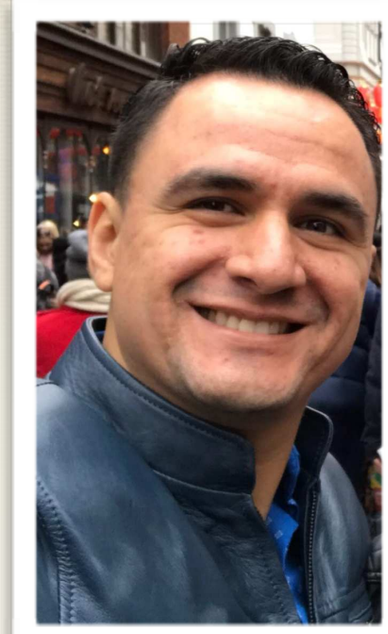
EE4-60 Human-Centred Robotics



ROS

Your Wonderful GTAs

Mark Zolotas



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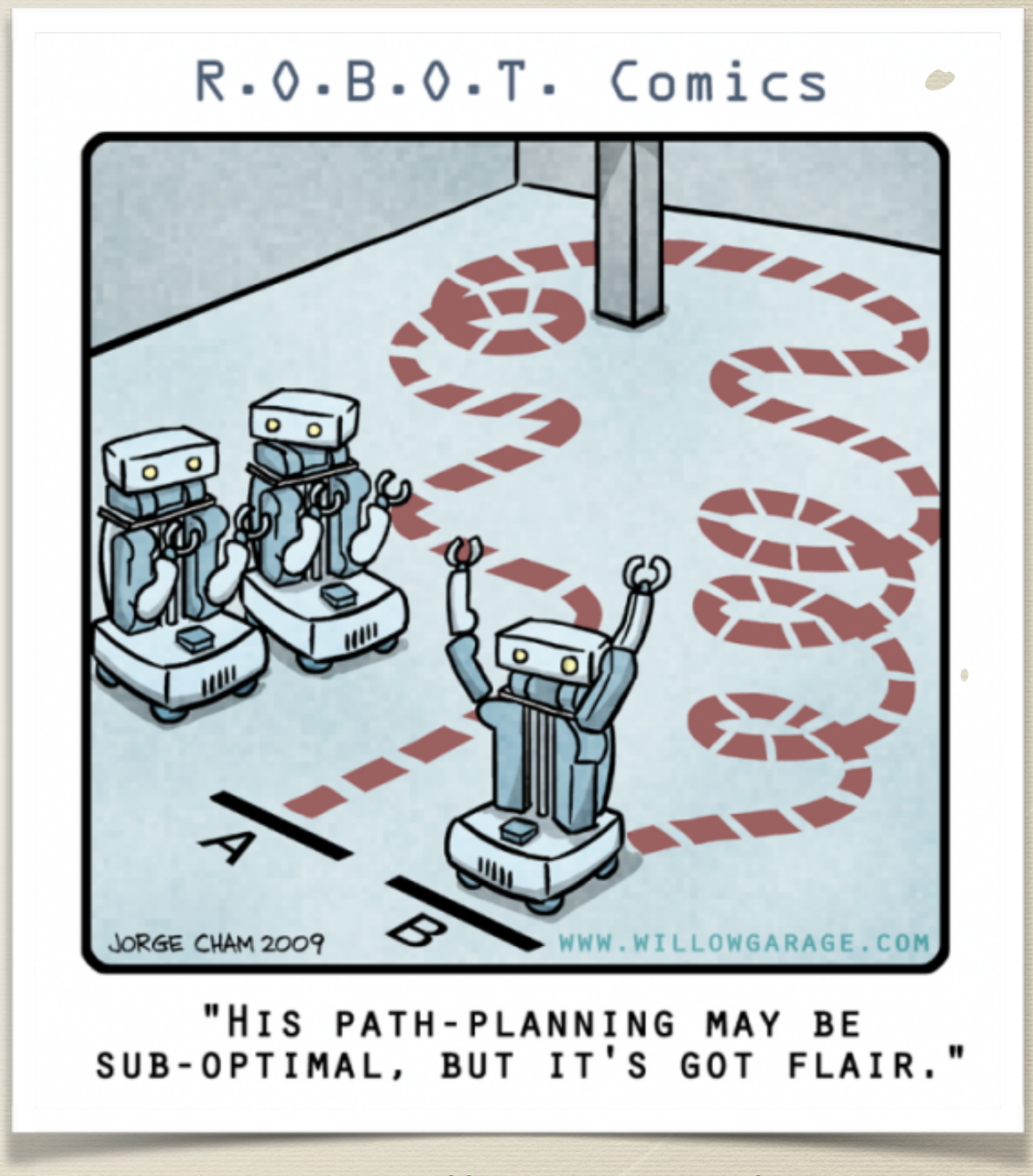
Outline

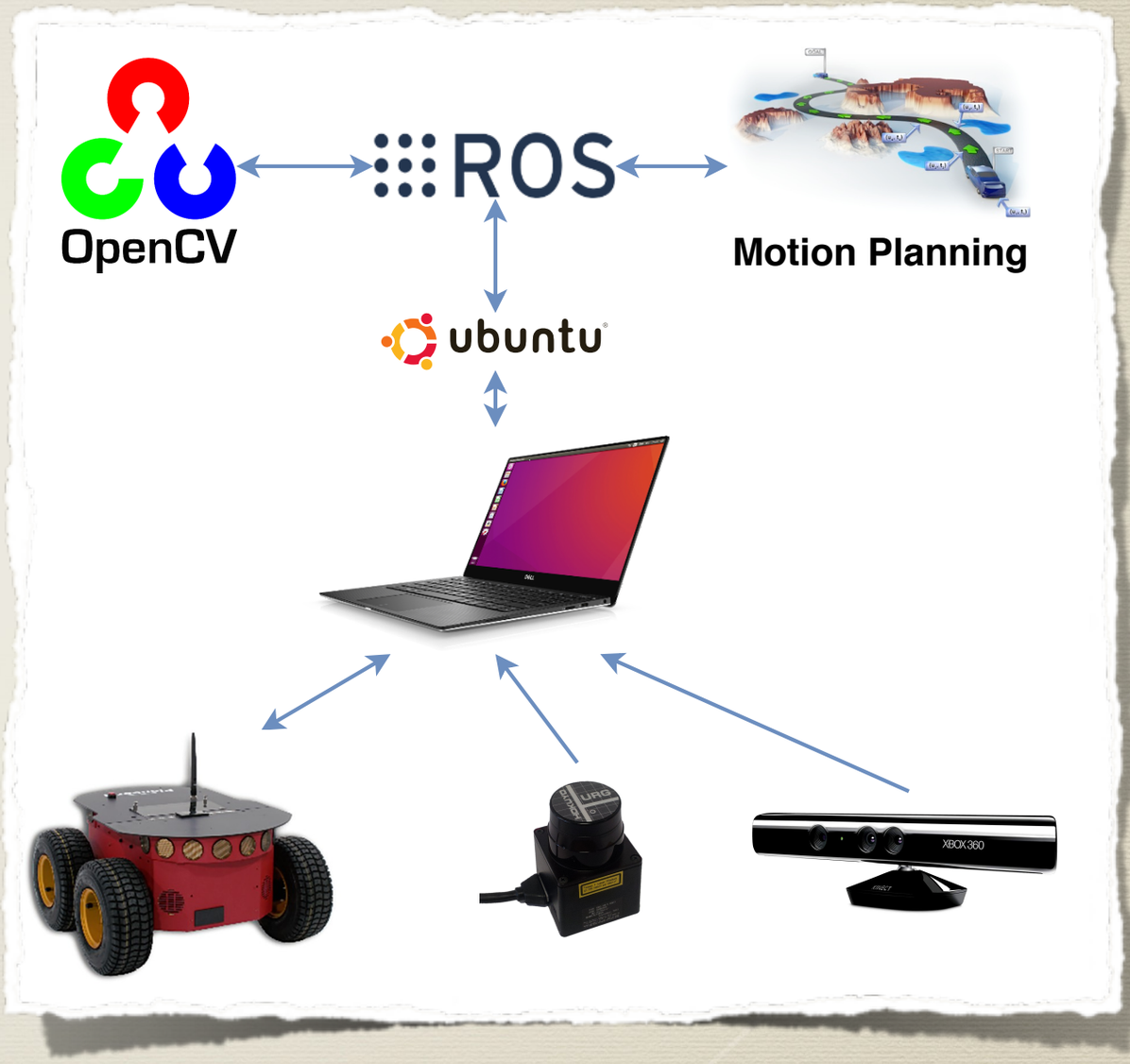
- What is ROS and why use it?
- Conceptual overview
- How do I use it? Sample code…
- Live demo + exercises
- Further resources



Taken from: http://wiki.ros.org/navigation

What is ROS?

- ROS is an open-source **Robot Operating System**
- **NOT** an actual operating system but instead a **software framework** that offers similar services:
  - Inter-process communication
  - Hardware abstraction
  - Low-level device control
- Collection of **libraries** & **tools** for common robot functionality



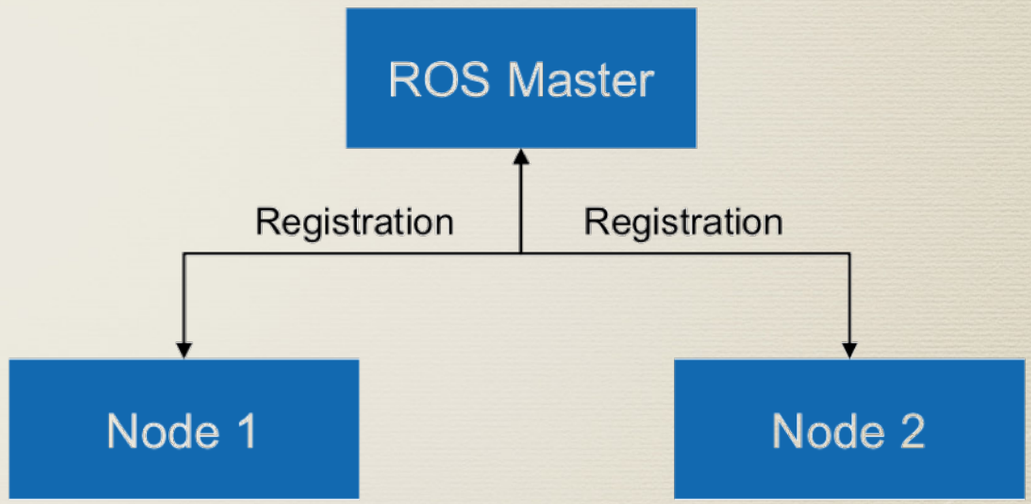
Why ROS?

- Widely used in the robotics community
- Works with C++, Python, Matlab etc.
- Sensors (http://wiki.ros.org/Sensors) and robots!

Taken from: https://robots.ros.org/

ROS Master and Nodes

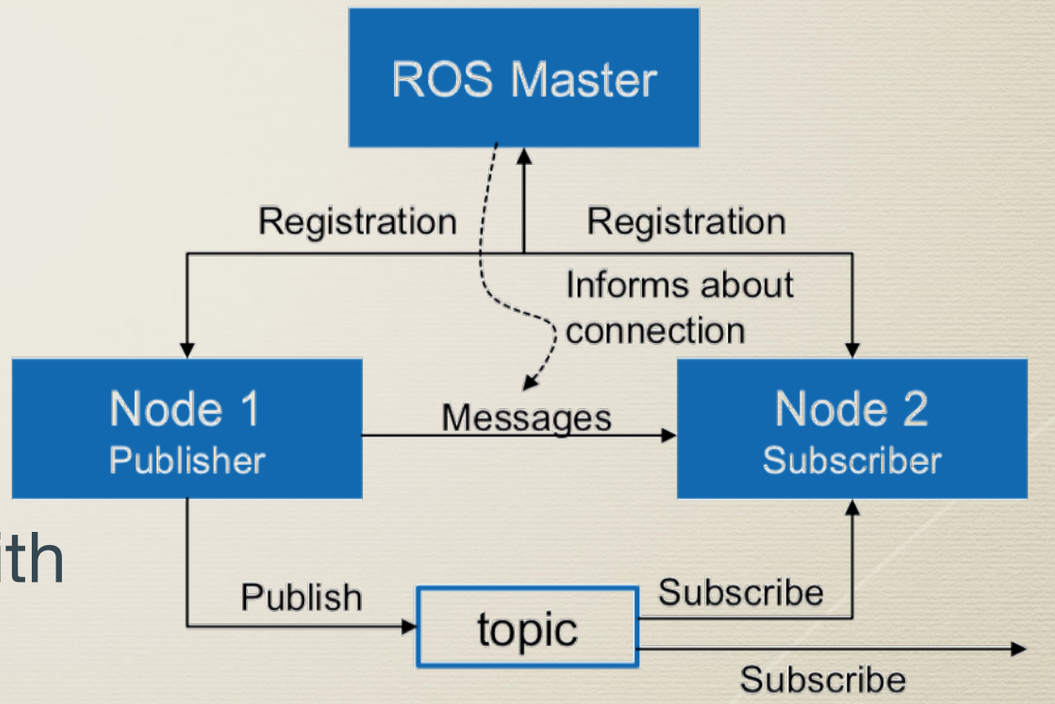
- **Nodes** are single-purpose, executable programs
- ROS **Master** manages the communication between nodes
- Every node registers a startup with the master



- Start a master with
  `roscore`
- Run a node with
  `rosrun package_name node_name`
- See active nodes with
  `rosnode list`
- Retrieve information about a node with
  `rosnode info node_name`

Topics

- Named bus for **one-to-many** communication
- Nodes exchange messages via topics
- Use **publish/subscribe** semantics for message transfer

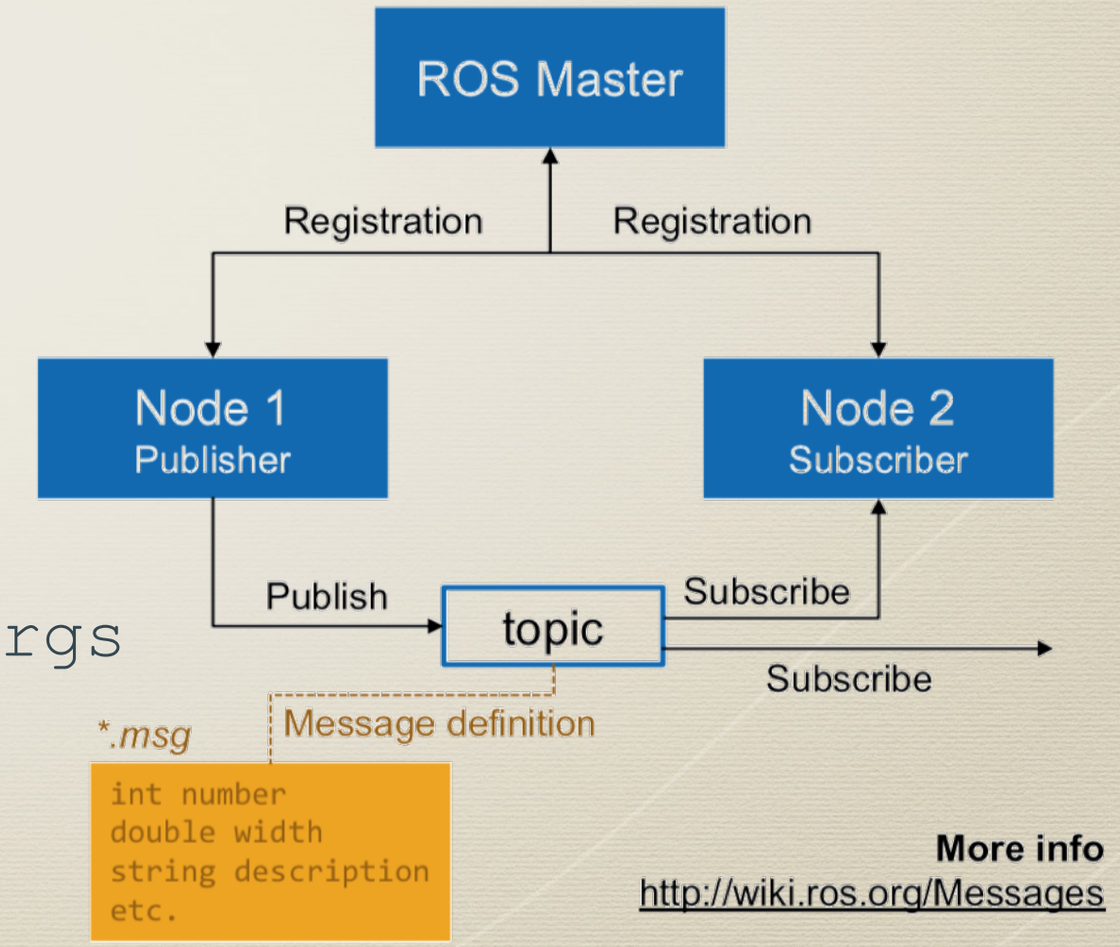


- List active topics with
  `rostopic list`
- Subscribe and print topic contents with
  `rostopic echo /topic`
- Show information about topic with
  `rostopic info /topic`

Messages

- Data structures defining the **type** of a topic
- Can be comprised of a nested structure of types e.g. integers, floats, arrays of objects etc.
- Defined in ***.msg** files

- Display the type of a topic with
  `rostopic type /topic`
- Publish a message to a topic with
  `rostopic pub /topic type args`

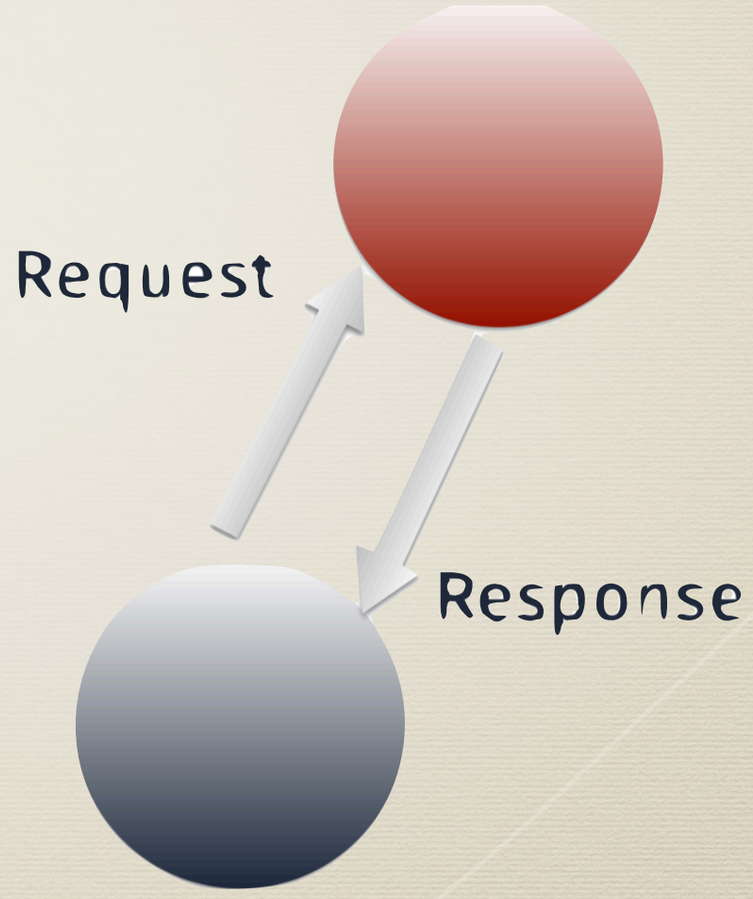


More info
http://wiki.ros.org/Messages

Services

- **Request/response** communication paradigm
- **One-to-one:** client sends a request and server responds
- Defined in ***.srv** files

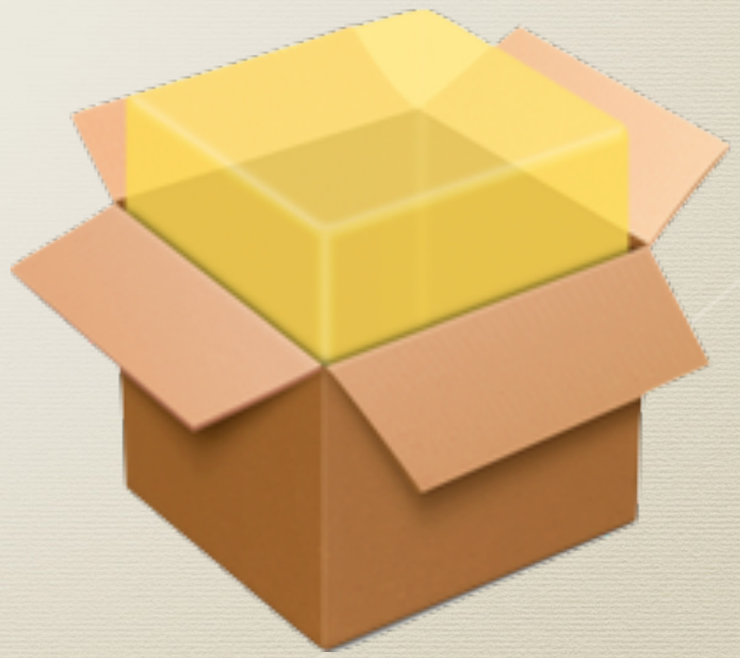
Use instead of topics for specific actions e.g. to rapidly query the state of the robot **once**



Packages

- Organise ROS-related resources into **packages**
- Contain nodes, libraries & associated files
- Every node *must* be inside a package
- Packages *must* be inside a **workspace**

"A ROS package is simply a directory which contains an XML file describing the package and stating any dependencies" —
http://www.willowgarage.com/sites/default/files/icraoss09-ROS.pdf



Remember how to execute nodes with

```
rosrun package_name node_name
```

Launch Files

* Use a tool `roslaunch` to recall loads of individual processing units i.e. nodes

* **Single command** to launch multiple processes at once

* Written as XML files describing the computation graph

So… How do I use it?

- Learn how to **install** ROS and setup a **workspace**
- Walkthrough of a complete C++ tutorial on how to create/write a **…**
  - **… workspace**
  - **… package**
  - **… node**
  - **… publisher**
  - **… subscriber**
  - **… roslaunch file**

- **GitHub URL:** https://github.com/mazrk7/tutorial_pub_sub.git
- Full instructions for installation found at: http://wiki.ros.org/kinetic/Installation/Ubuntu

Installation

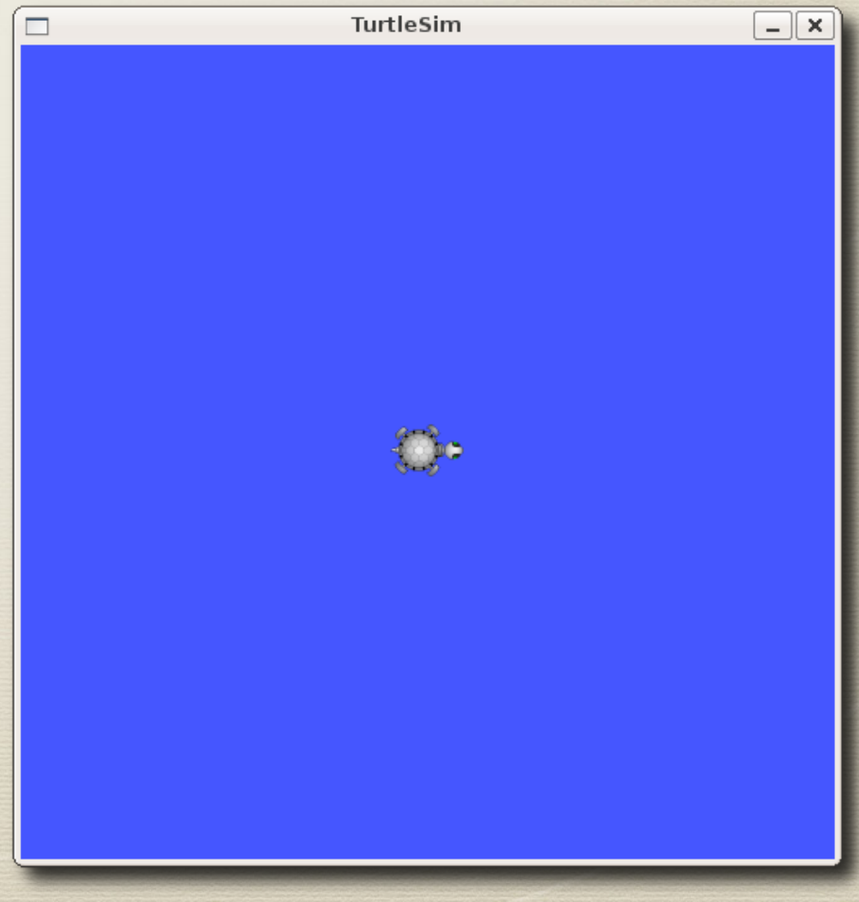
- **Configure** your Ubuntu repositories
  - `$ sudo sh -c 'echo "deb https://packages.ros.org/ros/ubuntu $ (lsb_release -sc) main" > /etc/apt/sources.list.d/ros-latest.list'`
  - `$ sudo apt-key adv –keyserver hip://ha.pool.sks-keyservers.net:80 –recv-key 421C365BD9FF1F717815A3895523BAEEB01FA116`
- **Update** package manager and run a **full install**
  - `$ sudo apt-get update`
  - `$ sudo apt-get install ros-kinetic-desktop-full`
- Initialise `rosdep` and **setup** environment
  - `$ sudo rosdep init`
  - `$ rosdep update`
  - `$ echo "source /opt/ros/kinetic/setup.bash" >> ~/.bashrc`
  - `$ source ~/.bashrc`
  - `$ sudo apt-get install python-rosinstall python-rosinstall-generator python-wstool build-essential`

Creating a Workspace

* Create the **workspace**
  * `$ mkdir -p ~/catkin_ws/src`
  * `$ cd ~/catkin_ws`
  * `$ catkin_make`
  * `$ echo "source ~/catkin_ws/devel/setup.bash" >> ~/.bashrc`
  * `$ source ~/.bashrc`
* When executed for the first time, `catkin make` will create two other folders: `build` and `devel`
* If you execute `ls` command, you should have the following folders
  * `build` - compilation files
  * `devel` - executables, libraries, messages
  * `src` - packages, source files (.cpp, .h, .xml), launch files (.launch)

Running ROS

* Download the ROS tutorial software
  * `$ sudo apt-get install ros-kinetic-ros-tutorials`
* Startup our **ROS core**
  * `$ roscore`
* `roscore` is the node responsible for operating the basic processes required for any ROS system
* In another terminal, run the turtle demo
  * `$ rosrun turtlesim turtlesim_node`



Creating a Package

* Create a **package** to control the turtle position
  * `$ cd ~/catkin_ws/src`
  * `$ catkin_create_pkg tutorial_pub_sub std_msgs roscpp`
  * `$ source ~/.bashrc`
* Several files/folders will be created
  * `include/tutorial_pub_sub` — folder containing header files .h or .hpp
  * `src` — folder containing source files .cpp (can do the same for .py scripts instead)
  * `package.xml` — package description and dependencies
  * `CMakeLists.txt` — build instructions
* You have been provided with the `tutorial_pub_sub` package

package.xml

- Contains package **meta-data** (description, dependencies, …)
- Important fields
  - <name> package name </name>
  - <description> brief description </description>
  - <buildtool_depend> build tools packages </buildtool_depend>
  - <build_depend> packages needed at compile time </build_depend>
  - <exec_depend> packages needed at runtime </exec_depend>

CMakeLists.txt

* Contains the package **build instructions**
* Important fields
  * `cmake_minimum_required` — cmake version required
  * `project` — package name
  * `find_packages` — find necessary packages
  * `catkin_package` — package build info export
  * `include_directories` — included files `.h`
  * `add_executables` — node executable
  * `add_dependencies` — add necessary dependencies to library/executable
  * `target_link_libraries` — link libraries to other libraries/executable

Creating a Node

- **`hello_node.cpp`** — a “Hello ROS” node
- Important lines
  - `#include <ros/ros.h>` — includes main ROS headers
  - `ros::init(argc, argv, pkgName);` — initialise ROS node
  - `ros::NodeHandle nh;` — node handle to create ROS objects
  - `ROS_INFO(info);` — printing function (`ROS_DEBUG`, `ROS_ERROR`, …)
  - `ros::spin();` — awaits for stopping signal
- Build and run the package
  - `$ cd ~/catkin_ws`
  - `$ catkin_make --pkg tutorial_pub_sub`
  - `$ rosrun tutorial_pub_sub hello`

ROS Publishers

- **`tutorial_pub_node.cpp`** — a simple publisher
- Important lines
  - #include <geometry_msgs/Twist.h> — velocity cmds messages
  - ros::Publisher pub=nh.advertise<msgType>(topic, bufferSize);
  - ros::Rate loop_rate(frequency); — handle for keeping periodicity
  - ros::ok() — check if node is running fine
  - pub.publish(msg); — publish a message on topic advertised
  - ros::spinOnce(); — check once for stopping signal
- Run the node
  - `$ rosrun tutorial_pub_sub tutorial_pub`

ROS Subscribers

- `tutorial_pub_sub_node.cpp` — a simple publisher/subscriber
- Important lines
  - #include <turtlesim/Pose.h> — pose messages
  - ros::Subscriber sub=nh.subscribe(topic, bufferSize, &callbackFunc);
  - void callbackFunc(msgType msg); — subscriber callback function
- Run the node with a remapping to subscribe to `/turtle1/pose`
  - `$ rosrun tutorial_pub_sub tutorial_pub_sub pose:=/turtle1/pose`

ROS Launch

- **`tutorial_pub_sub.launch`** — run everything with just one launch file
- Important lines
  - <node pkg="pkgName" name="uniqueROSNodeName" type="execName">
  - <remap from="topicFrom" to="topicTo"> — remaps topic's flow
  - <param name="paramName" value="paramValue"> — node initial parameters
- Launch!
  - `$ roslaunch tutorial_pub_sub tutorial_pub_sub.launch`

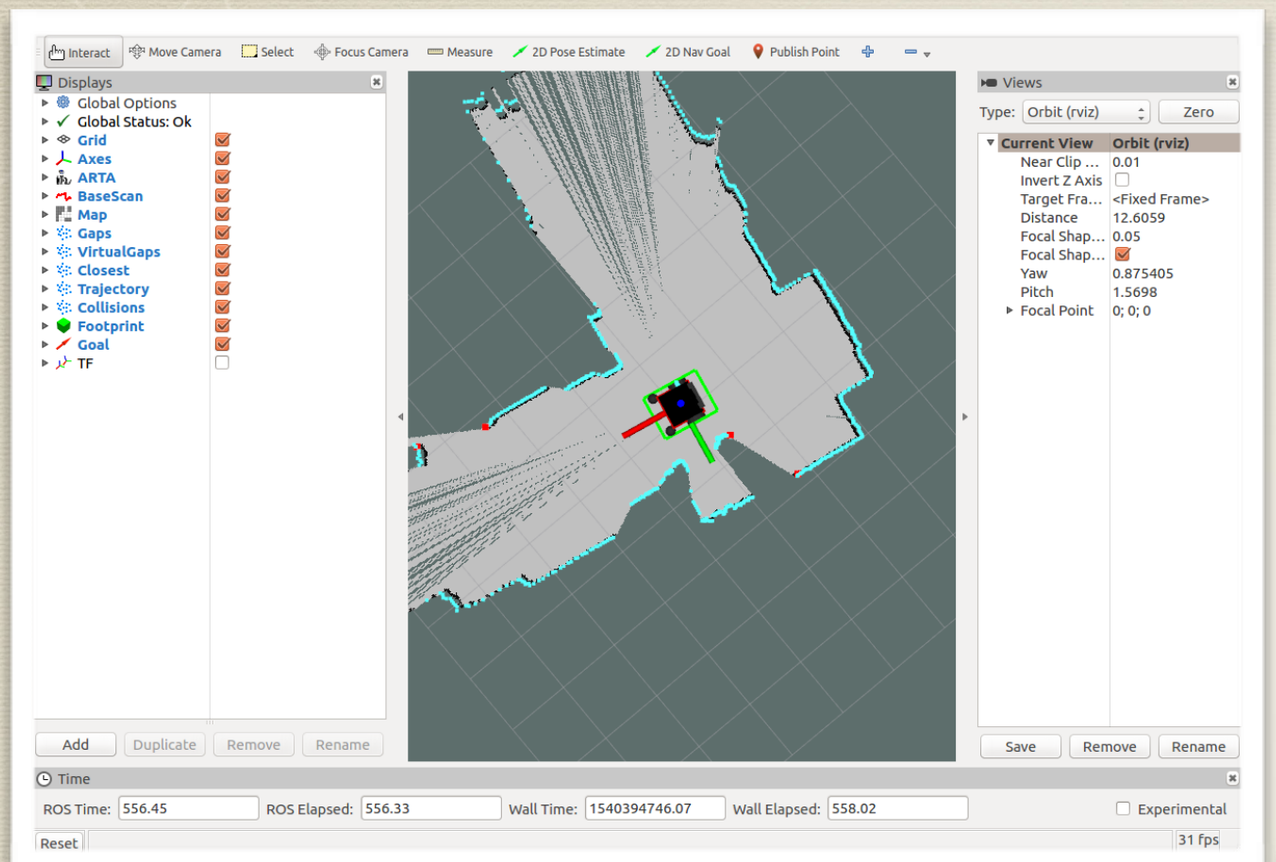
Live Demo!

joy

our node

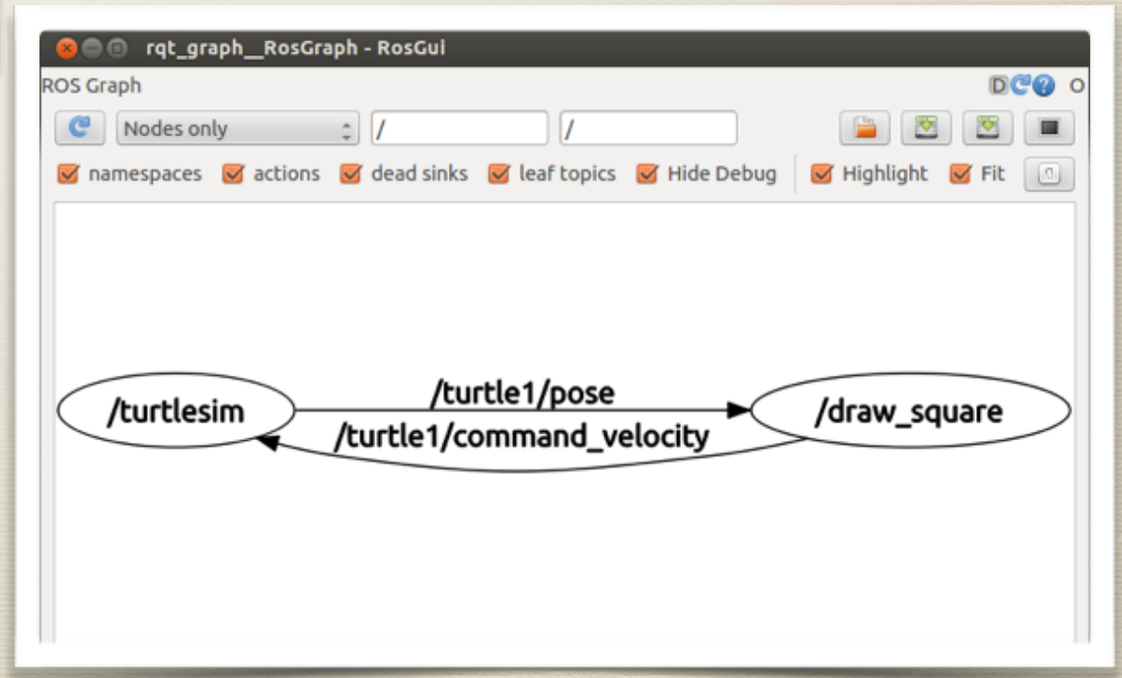
p2os_driver

rviz + rqt_graph



rviz: visualise many robotic-related datatypes

rqt_graph: view nodes & topics



Logging Data

* **Bags** used to store ROS message data
* Record **all** data (`-a`) passing through topics
  * `$ rosbag record -a`
* **Playback** the recorded data with
  * `$ rosbag play bag_file`
* Services are not logged!
* Be weary of large files and expensive I/O

Additional Resources

- **ROS tutorials**
  - http://wiki.ros.org/ROS/Tutorials
- **ROS answers**
  - https://answers.ros.org/questions/
- **ROS paper**
  - http://www.willowgarage.com/sites/default/files/icraoss09-ROS.pdf
- **Navigation stack**
  - http://wiki.ros.org/navigation
  - http://kaiyuzheng.me/documents/navguide.pdf
- **TF package**
  - http://wiki.ros.org/tf/Tutorials

Thanks for listening!