



IRIS Lab

Intelligent RobotIcs and Systems Laboratory

ROS Introduction

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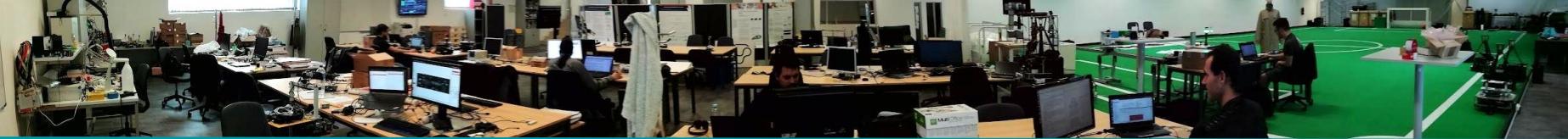
24 of November 2023 @RMI



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theoria poiesis praxis

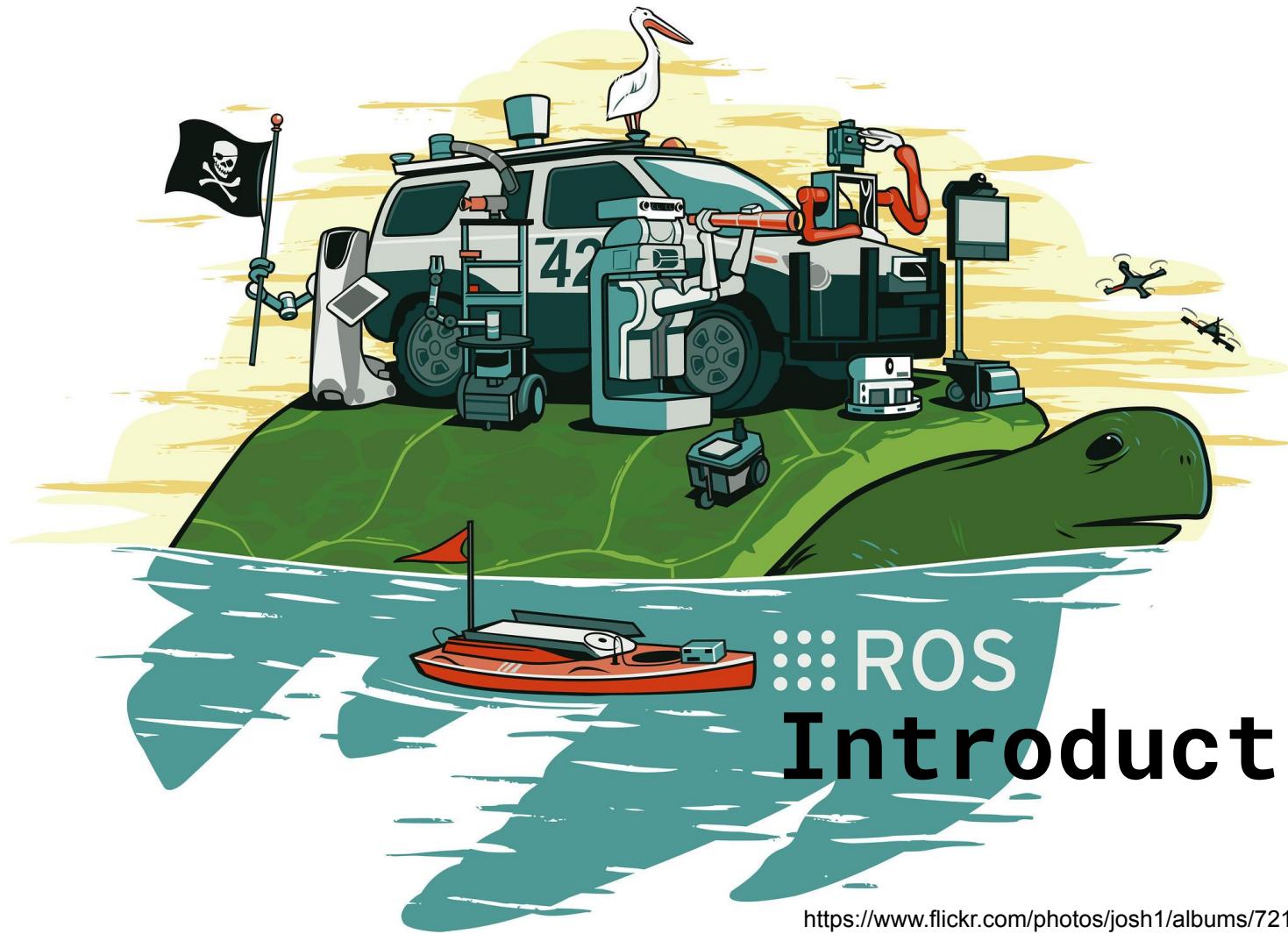
deti departamento de electrónica,
telecomunicações e informática





Outline

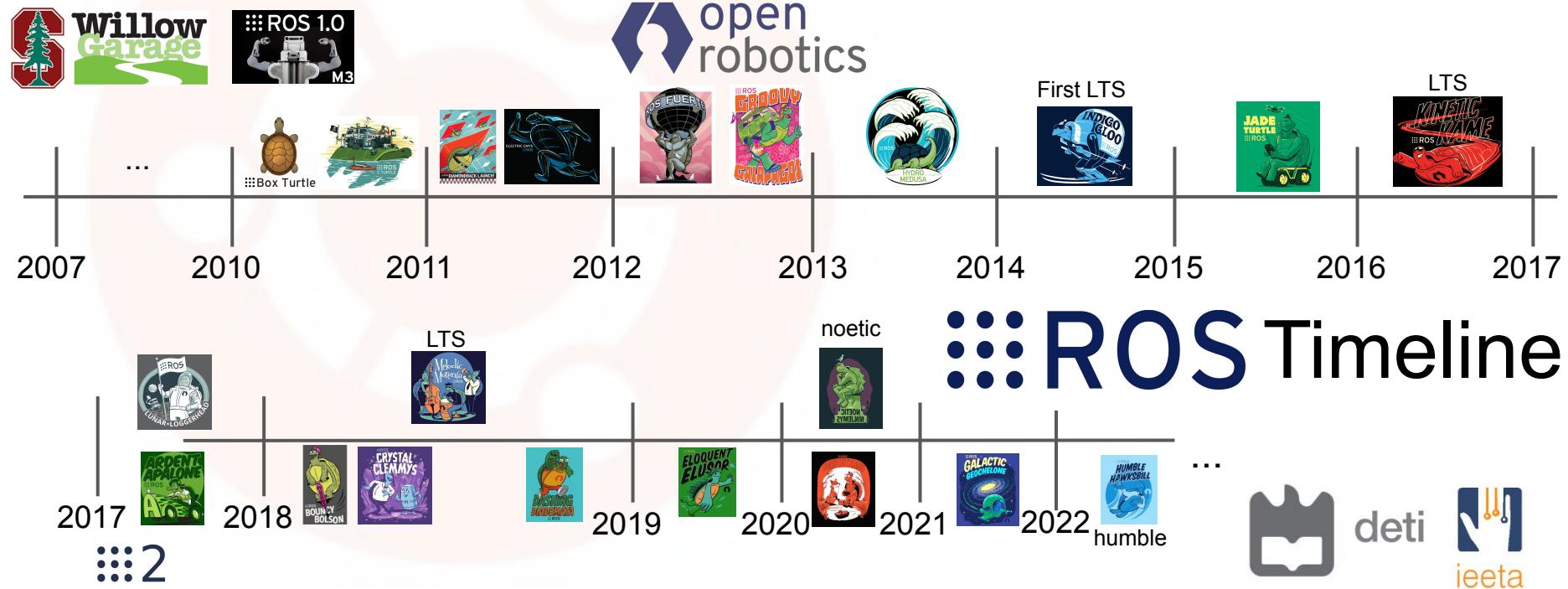
- The Robot Operating System (ROS)
- ROS Concepts
- ROS Components
- Ecosystem



ROS Introduction



The Robot Operating System <https://www.ros.org>





ROS presence in the industry

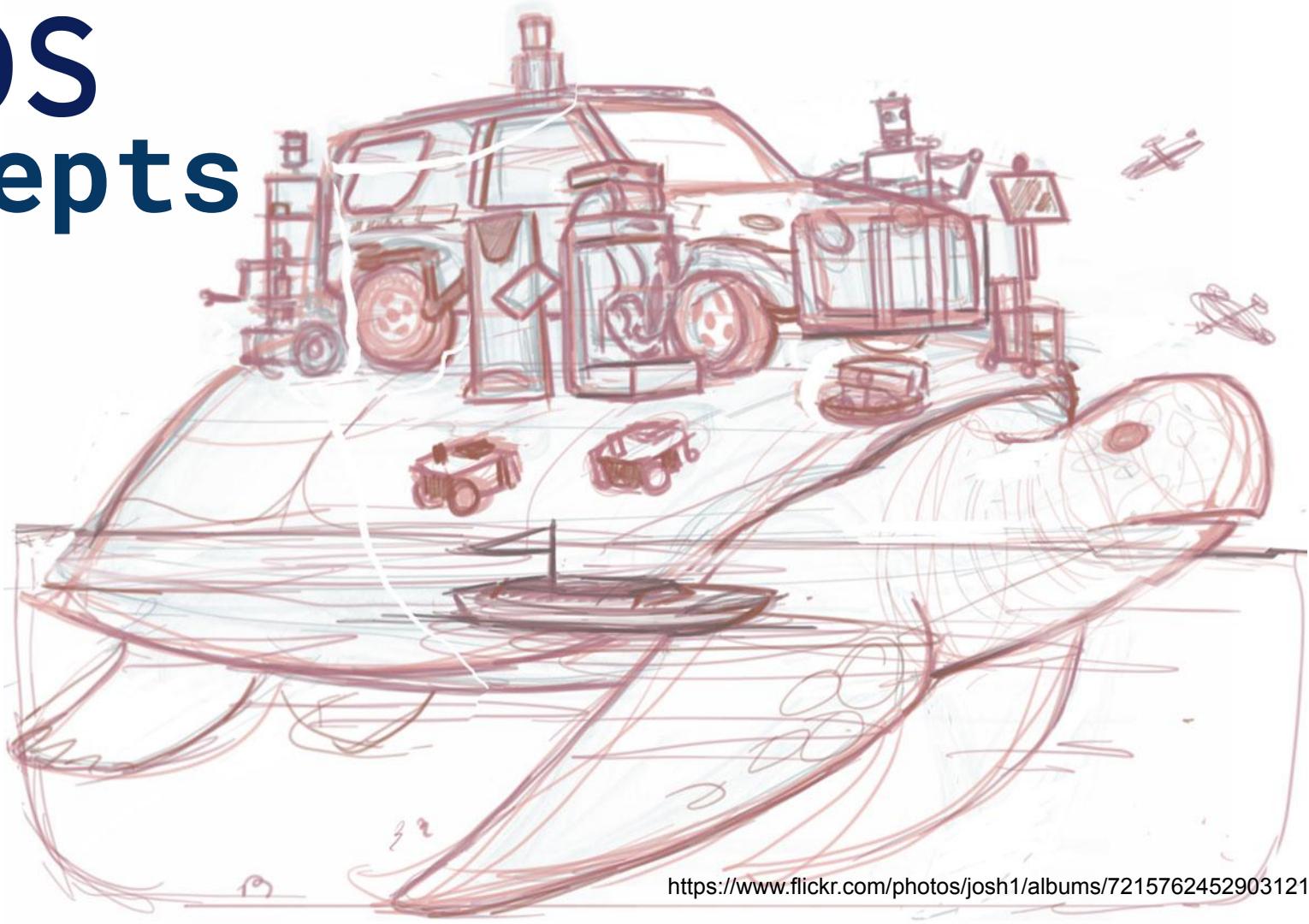
Bring robotics R&D to the Factory Floor
<https://rosindustrial.org/>



Quality-Assured Robot Software Components
<https://rosin-project.eu/>



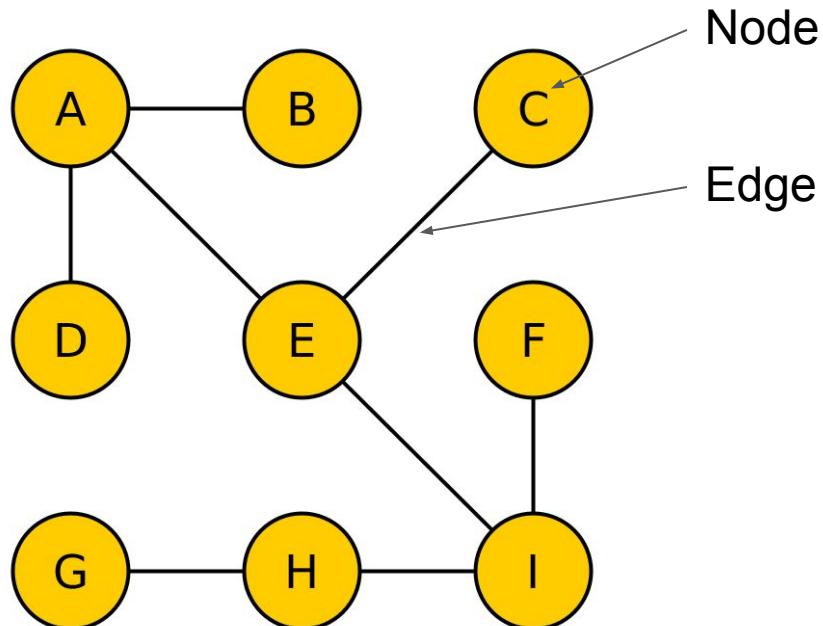
ROS Concepts



<https://www.flickr.com/photos/josh1/albums/72157624529031217>

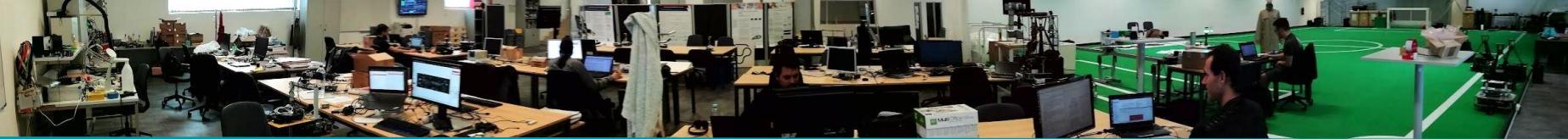


Let us start with a graph.

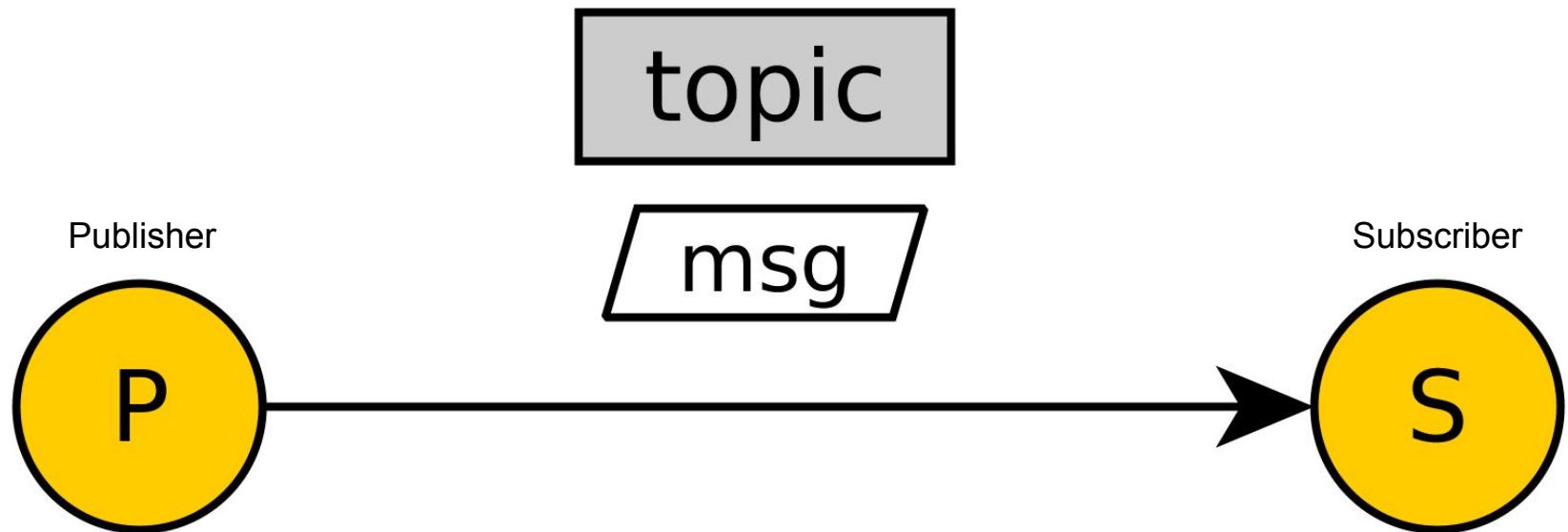


A *graph* is a structure that defines “relations” between pair of objects.

In ROS, a *node* represents a **processing thread** and an *edge* a **communication channel**.



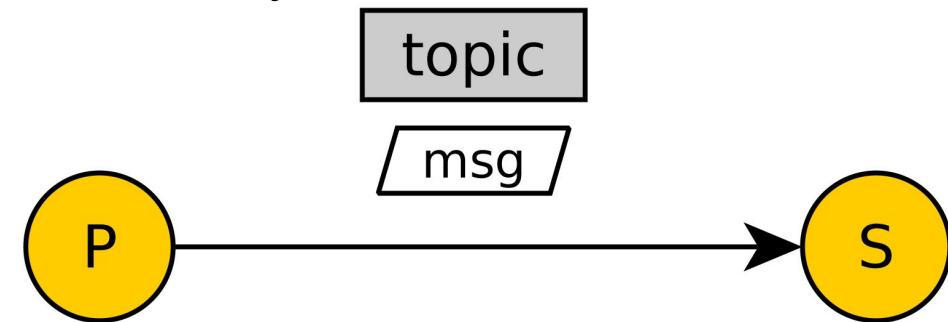
ROS Peer-to-Peer communication





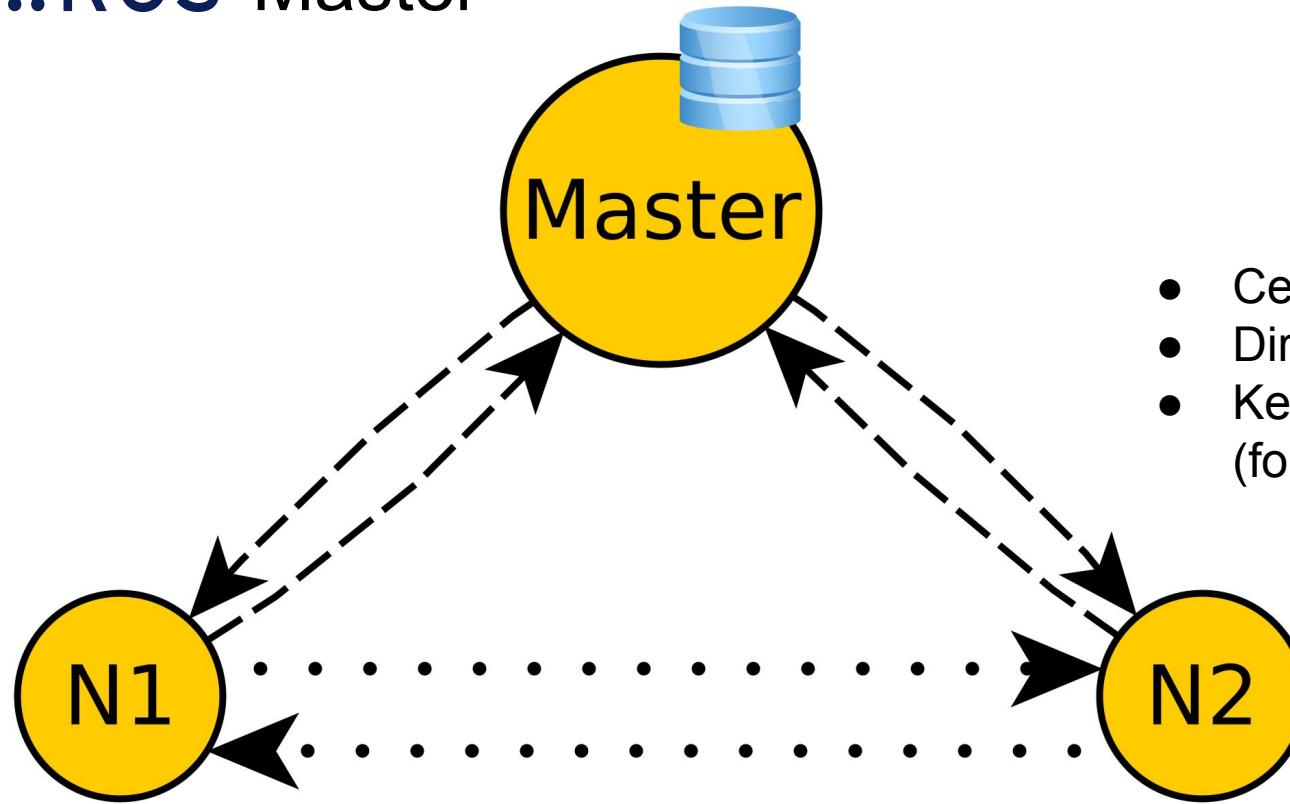
ROS Peer-to-Peer communication

- Publisher/Subscriber approach
- The **topic** has a **message type** and a **name**
- Message type defined using a Domain-Specific Language
- The **topic** is created when first referenced by a node
- **P** and **S** are independent
 - **P** can exist without an **S**
 - **S** can exist without a **P**





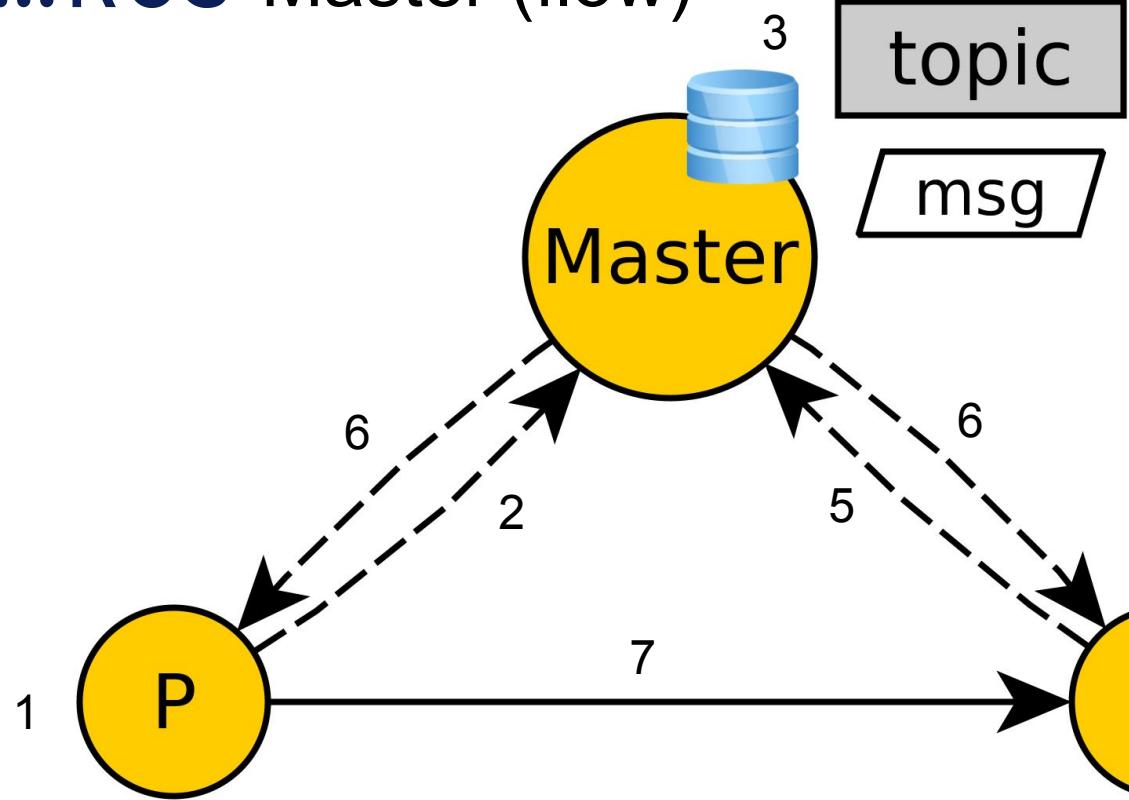
ROS Master



- Centralized
- Directory service for nodes
- Key-Value database (for parameters)



ROS Master (flow)



1. P is launched
2. P registers to master
3. The **topic** is created
4. S is launched
5. S registers to master
6. Master tells P/S about S/P
7. P connects to S



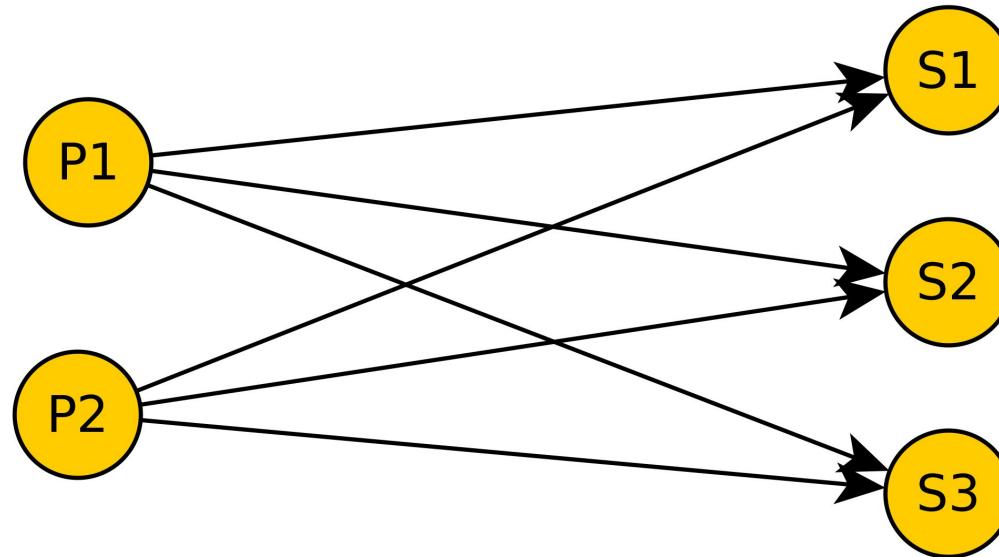
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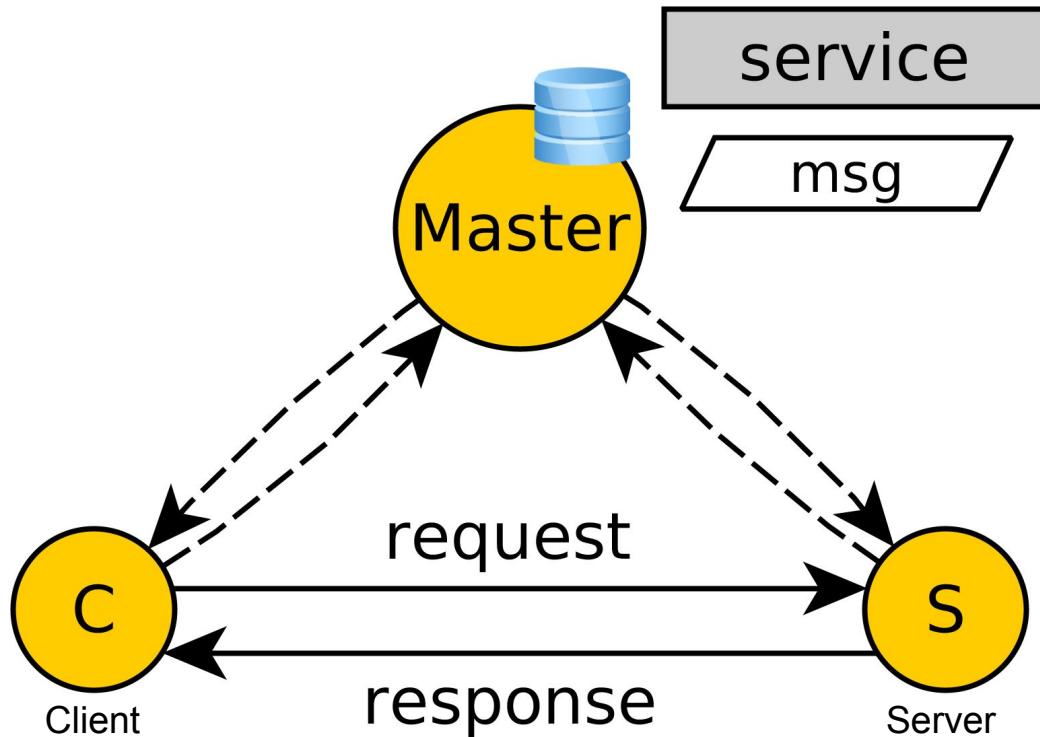


ROS Many-to-Many Pub/Sub





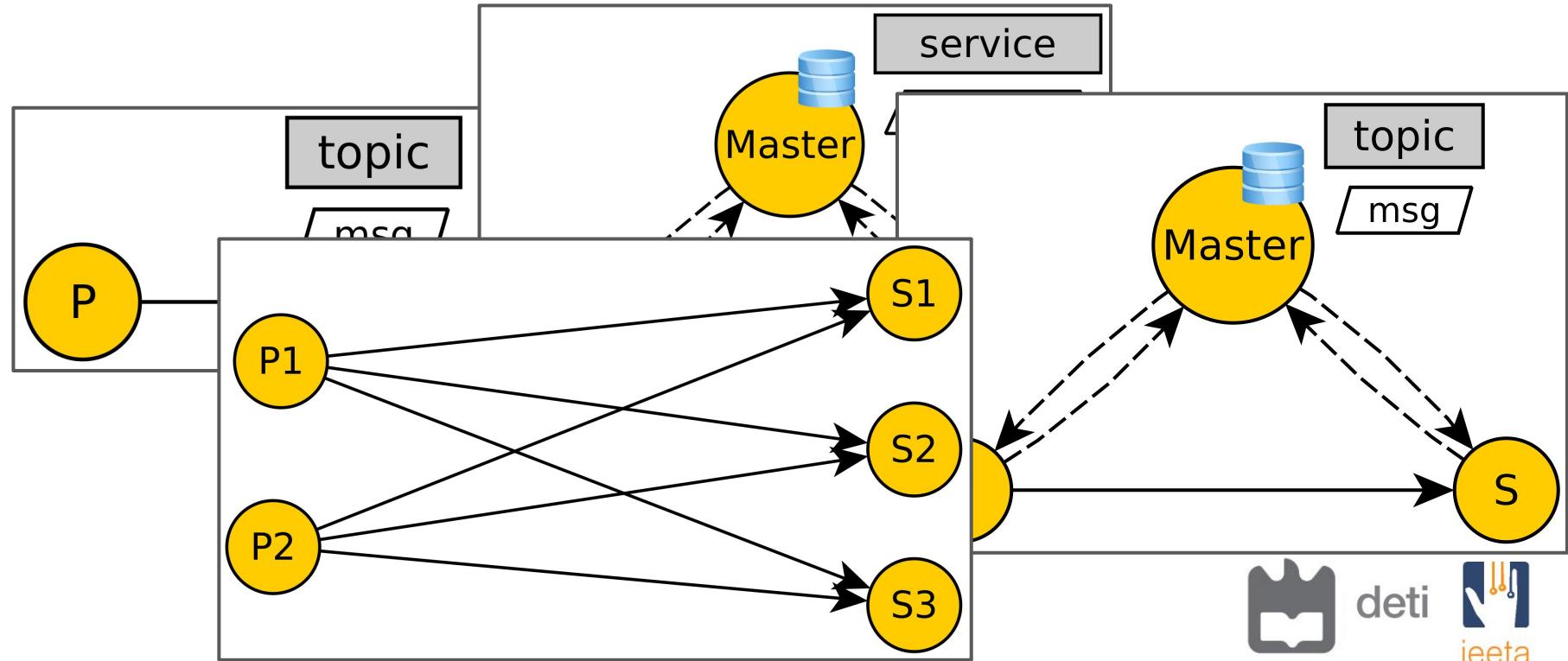
ROS Services



- **service name** over topic name
- **request / response** model
- synchronized call



But... is this robotics?





ROS
COMPONENTS!
COMPONENTS!
COMPONENTS!



ROS Messages for Robotics

- **Sensor Messages**
 - Image
 - Laser Scan
 - Point Cloud
 - Joint State
- **Geometry Messages**
 - Pose
 - Transformation
 - Twist
- **Navigation Messages**
 - Odometry
 - Occupancy Grid
 - Path
- **Trajectory Messages**
 - Joint Trajectory
 - Multi-DoF Joint Trajectory
- **Many others...**

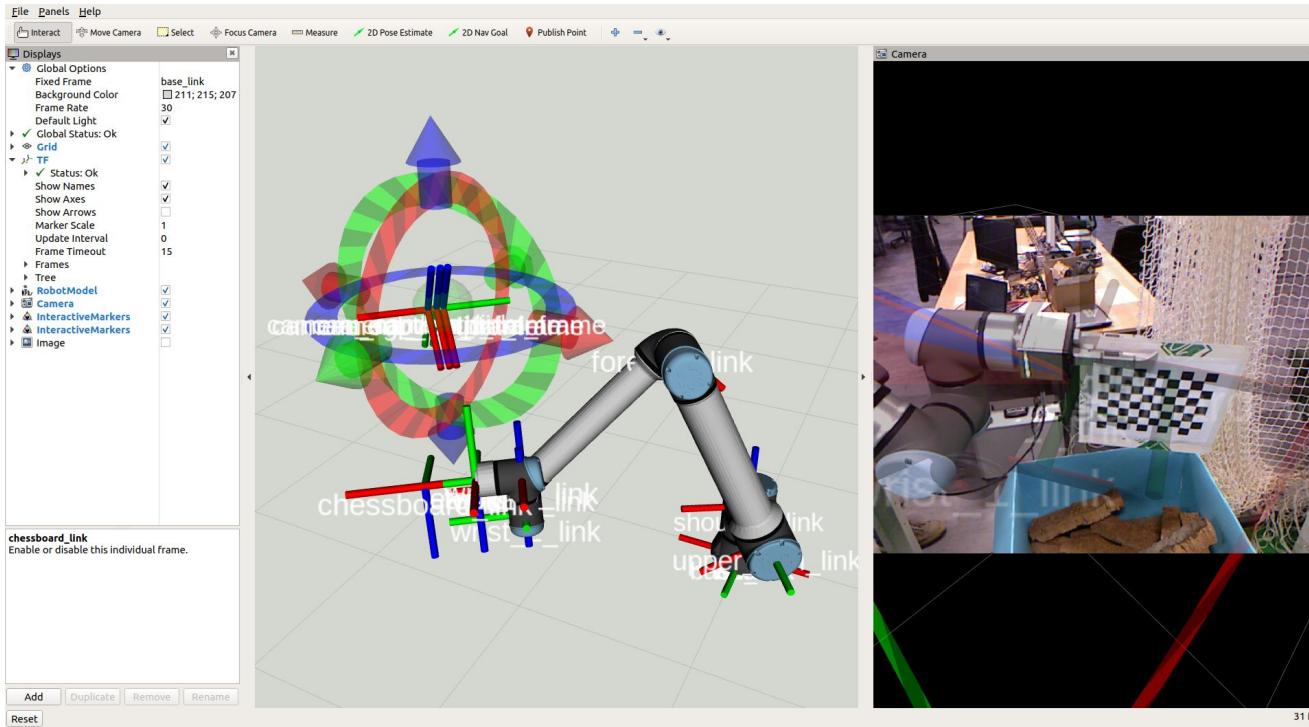


ROS Introspection Tools

- Command Line tools
 - **rostopic**, **rosmsg**
 - **rosnode**
 - **rosservice**,
rossrv
 - **rosbag**
 - **roslaunch**
- GUI tools
 - **rviz**
 - **rqt_***



ROS Introspection Tools - rviz



- Immediate feedback
- 2D/3D visualization
- Supports different sensors
- Allows interaction



ROS Introspection Tools - rqt_*

File Plugins Running Perspectives Help

Node Graph - O × Process Monitor - O × Topic Monitor - O ×

Nodes only / /

Group: 2 Namespaces Actions tf Images Highlight Fit

Hide: Dead sinks Leaf topics Debug tf Unreachable Params

Filter regex

Process Monitor

Node	PID	CPU %	Mem %	Num Threads
/sensors_first_guess	4687	4.10	1.93	15
/rqt_gui_py_node_5587	5587	9.10	2.08	12
/rosout	4267	1.00	0.24	5
/rosbag_play	4291	17.30	0.53	5
/robot_state_publisher	4279	11.20	0.31	6
/camera_base_link3	4273	2.00	0.24	5
/camera_base_link2	4272	3.00	0.24	5
/camera_base_link1	4271	3.00	0.24	5
/camera_base_link	4270	3.00	0.24	5

Kill Node

Topic Monitor

Topic	Type
/camera/rgb/camera_info	sensor_msgs/CameraInfo
/camera/rgb/image_rect_color	sensor_msgs/Image
/clock	rosgraph_msgs/Clock
/interactive_first_guess/update	visualization_msgs/InteractiveMarkerUpdate
/interactive_first_guess/update_full	visualization_msgs/InteractiveMarkerInit
/joint_states	sensor_msgs/JointState
/rosout	rosgraph_msgs/Log
/rosout_agg	rosgraph_msgs/Log
/tf	tf2_msgs/TFMessage
/tf_static	tf2_msgs/TFMessage

Diagram: A complex ROS node graph showing dependencies between nodes like /rosbag_play, /rqt_gui_py_node_5587, /rosout, /sensors_first_guess, and various camera and robot state publishers. Arrows indicate message flows and dependencies.

- Used to inspect ROS internals
- Node Graph
- Topic monitor
- Plot data graphs
- many more...
- Build YOUR OWN view
 - QT5



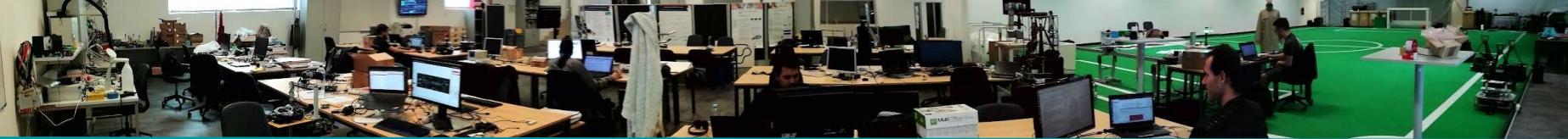
ROS bagging tool

- Allows data to be recorded and played back, respecting the production timeline
- **rosbag record**
 - Record a bag file with the contents of specified topics
- **rosbag play**
 - Play back the contents of one or more bag files in a time-synchronized fashion
- **rosbag info**
 - Summarize the contents of one or more bag files
- **rosbag ...**
 - a number of other options available

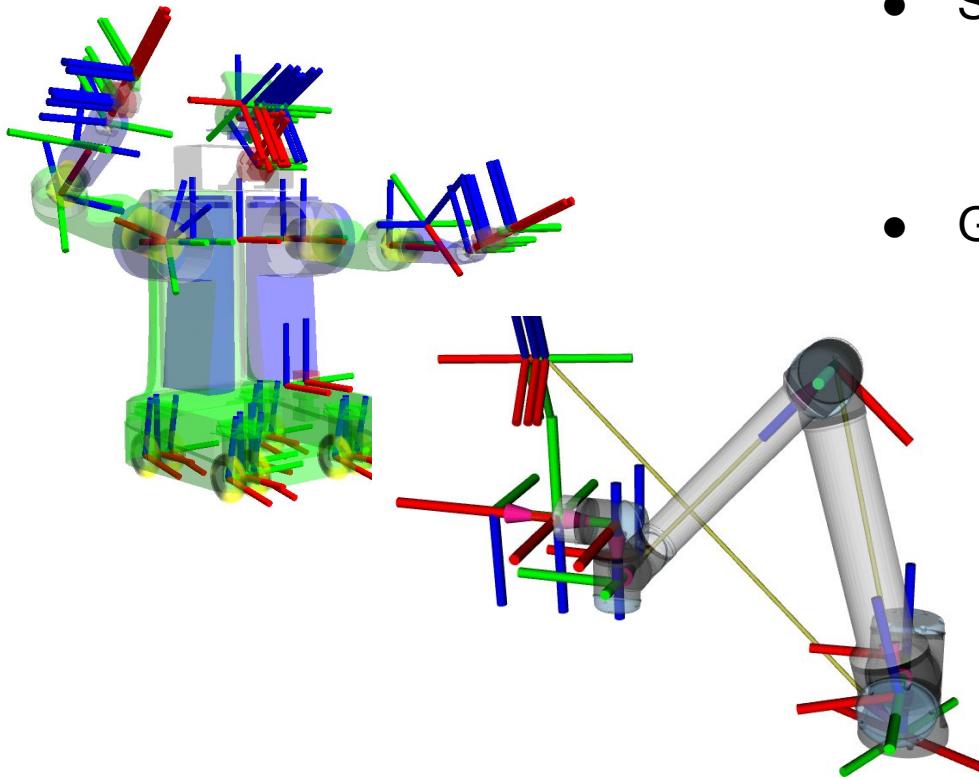


ROS Development

- Different languages support
 - mainly C++ and python
- Software organized in packages
- **catkin** build tool
 - based on **cmake**
 - handles build dependencies
- **rosdep** tool
 - Install dependencies



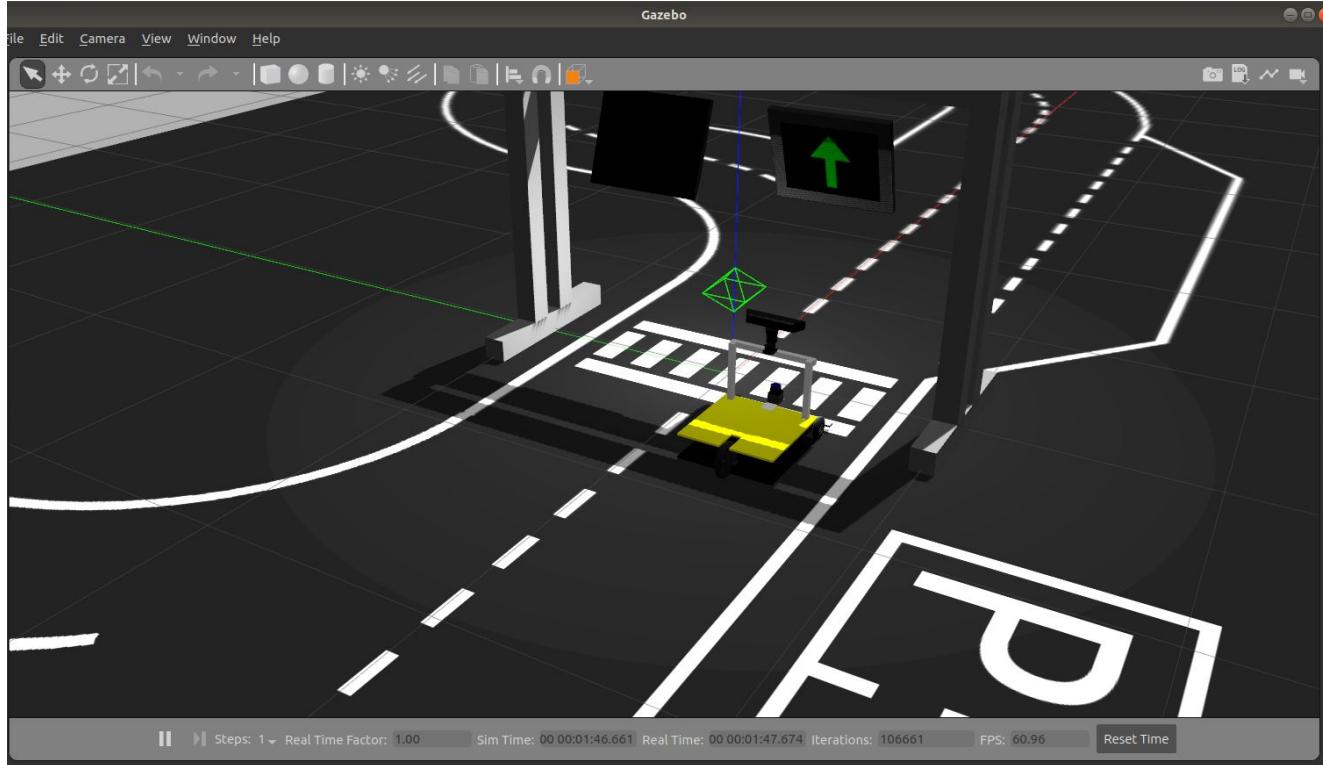
ROS TF



- Support for frame transformation
 - usually a quite complex and error prone problem
 - based on a transformation tree
 - time interpolation
- Generic
 - based on a description

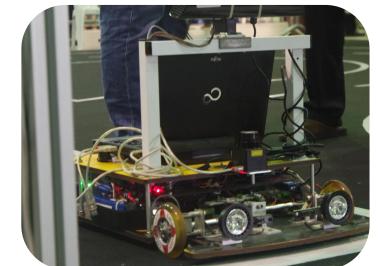


ROS Robotics Simulation



GAZEBO

<http://gazebosim.org/>



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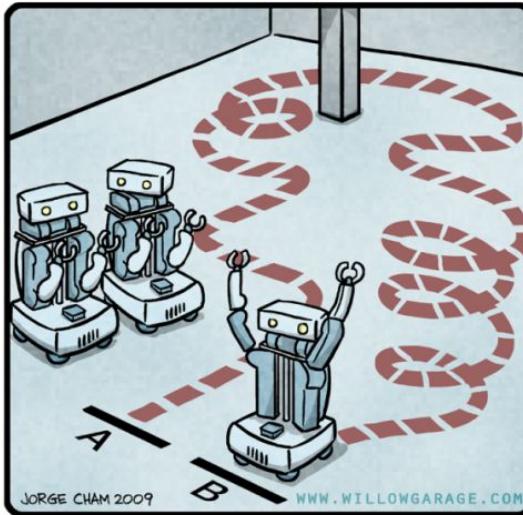
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ROS Off the shelf solutions

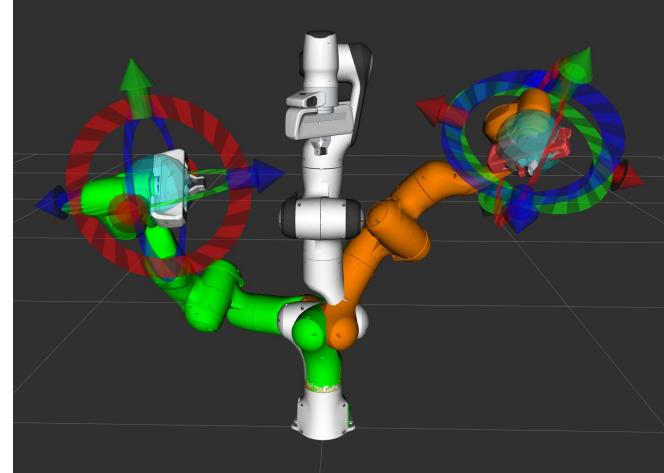
ROS Navigation

R.O.B.O.T. Comics



Arm Manipulation

> **MoveIt!**



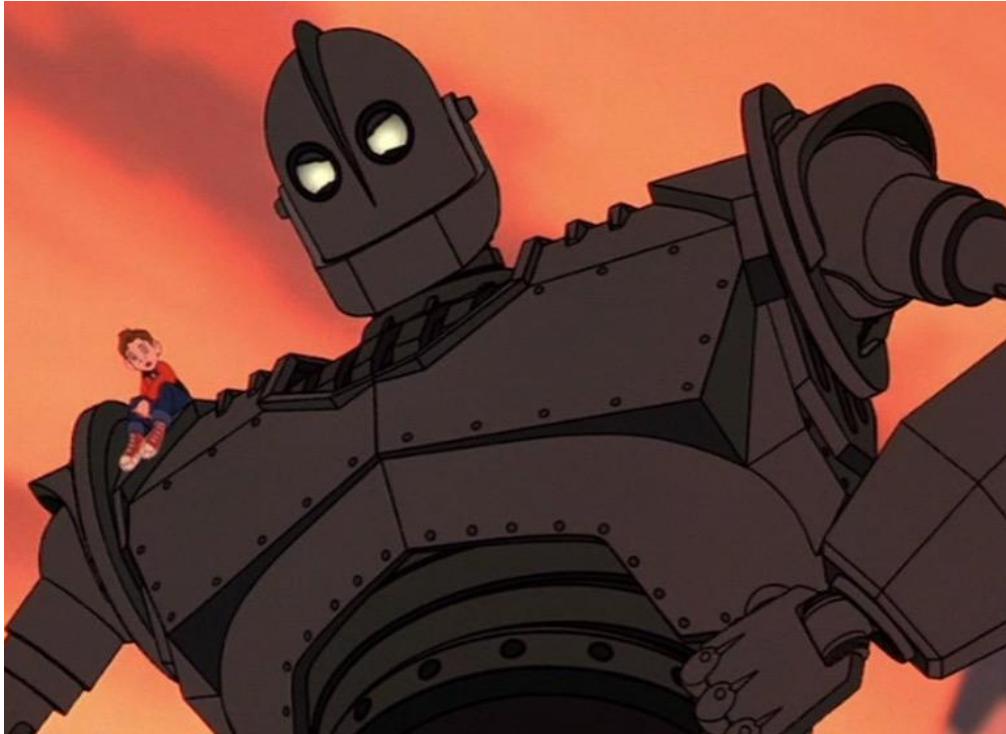
And many, many others...



ROS ECOSYSTEM



ROS Standing on the Shoulder of Giants



- Open Source
- Worldwide community of developers
- Even the industry is participating
- 2000+ available software packages
- Even more available at Github

Check our software at
<https://github.com/iris-ua>



ROS Learning

ROS.org

[Documentation](#)[Browse Software](#)[News](#)Search:

Documentation

ROS (Robot Operating System) provides libraries and tools to help software developers create robot applications. It provides hardware abstraction, device drivers, libraries, visualizers, message-passing, package management, and more. ROS is licensed under an open source, BSD license.

Available Translations: [German](#) | [Spanish](#) | [French](#) | [Italian](#) | [Japanese](#) | [Korean](#) | [Brazilian Portuguese](#) | [Portuguese](#) | [Русский \(Russian\)](#) | [Thai](#) | [Turkish](#) | [简体中文](#) | [Ukrainian](#) | [Vietnamese](#)

ROS:

[Install](#)

Install ROS on your machine.

[Getting Started](#)

Learn about various concepts, client libraries, and technical overview of ROS.

[Tutorials](#)

Step-by-step instructions for learning ROS hands-on

[Contribute](#)

How to get involved with the ROS community, such as submitting your own repository.

[Support](#)

What to do if something doesn't work as expected.

[Quality Assurance](#)

How to ensure that your ROS-based systems and your contributions to ROS are of high quality.

Software:

[Distributions](#)

View the different release Distributions for ROS.

[Packages](#)

Search the 2000+ software libraries available for ROS.

[Core Libraries](#)

APIs by language and topic.

[Common Tools](#)

Common tools for developing and debugging ROS software.

Robots/Hardware:

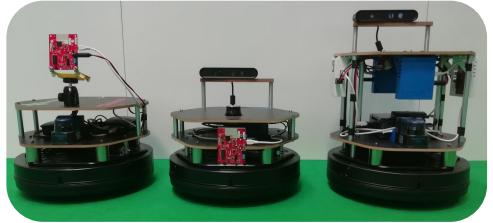
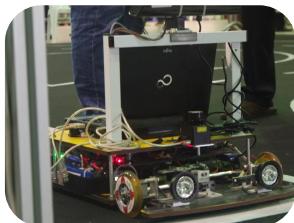
[Robots](#)

Robots that you can use with ROS.

- ROS wiki - <http://wiki.ros.org/>
 - the wiki is a good entry point
- ROS docs - <http://docs.ros.org/>
 - contains all API documentation
- ROS answers - <http://answers.ros.org/>
 - ask questions, get answers
- ROS forum - <https://discourse.ros.org/>
 - hear the latest discussions



Robotic Projects



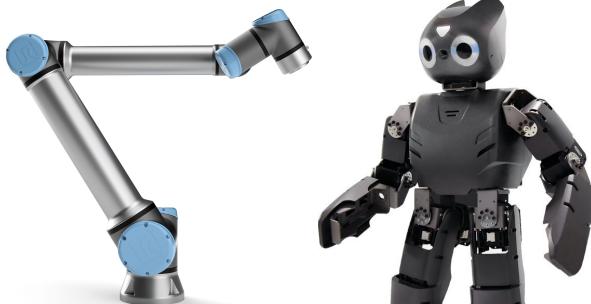
Multi-robot Agents
[Robotic Futebol]

Autonomous Driving

Intelligent Perception



Subaquatic Robotics



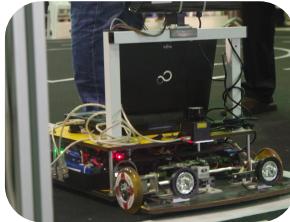
Anthropomorphic Robotics

etc ...



Robotic Projects

ROS



ROS



Multi-robot Agents
[Robotic Futebol]

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Subaquatic Robotics

ROS



Anthropomorphic Robotics

etc ...
ROS



That's all Folks!