CSCE 574 ROBOTICS

History and ROS overview

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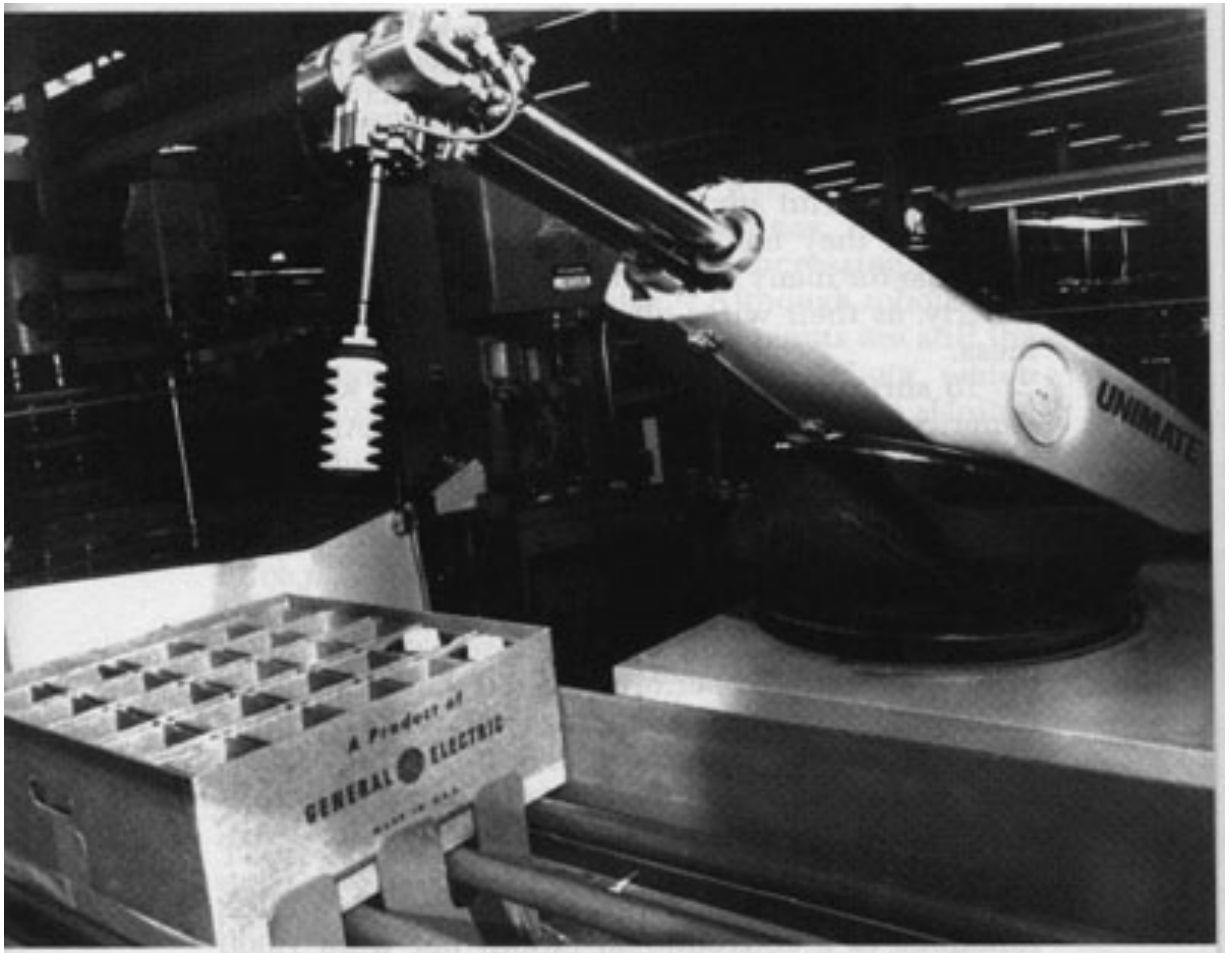
Outline

- Problems to solve in robotics
- Robot software architectures with some history
- ROS

Three Main Problems in Robotics

1. Where am I? (Localization)
2. What the world looks like? (Mapping)
   - Together 1 and 2 form the problem of *Simultaneous Localization and Mapping* (SLAM)
3. How do I go from **A** to **B**? (Path Planning)
   - More general: Which action should I pick next? (Planning)

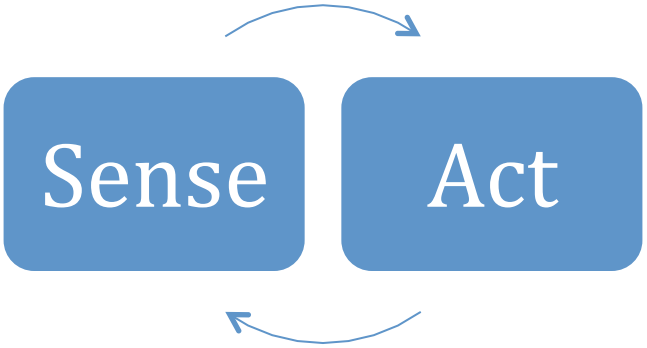
Preprogrammed Behaviors



Armed for duty. A Unimate robot—really, just an arm—picks up and puts down parts in a General Electric factory.

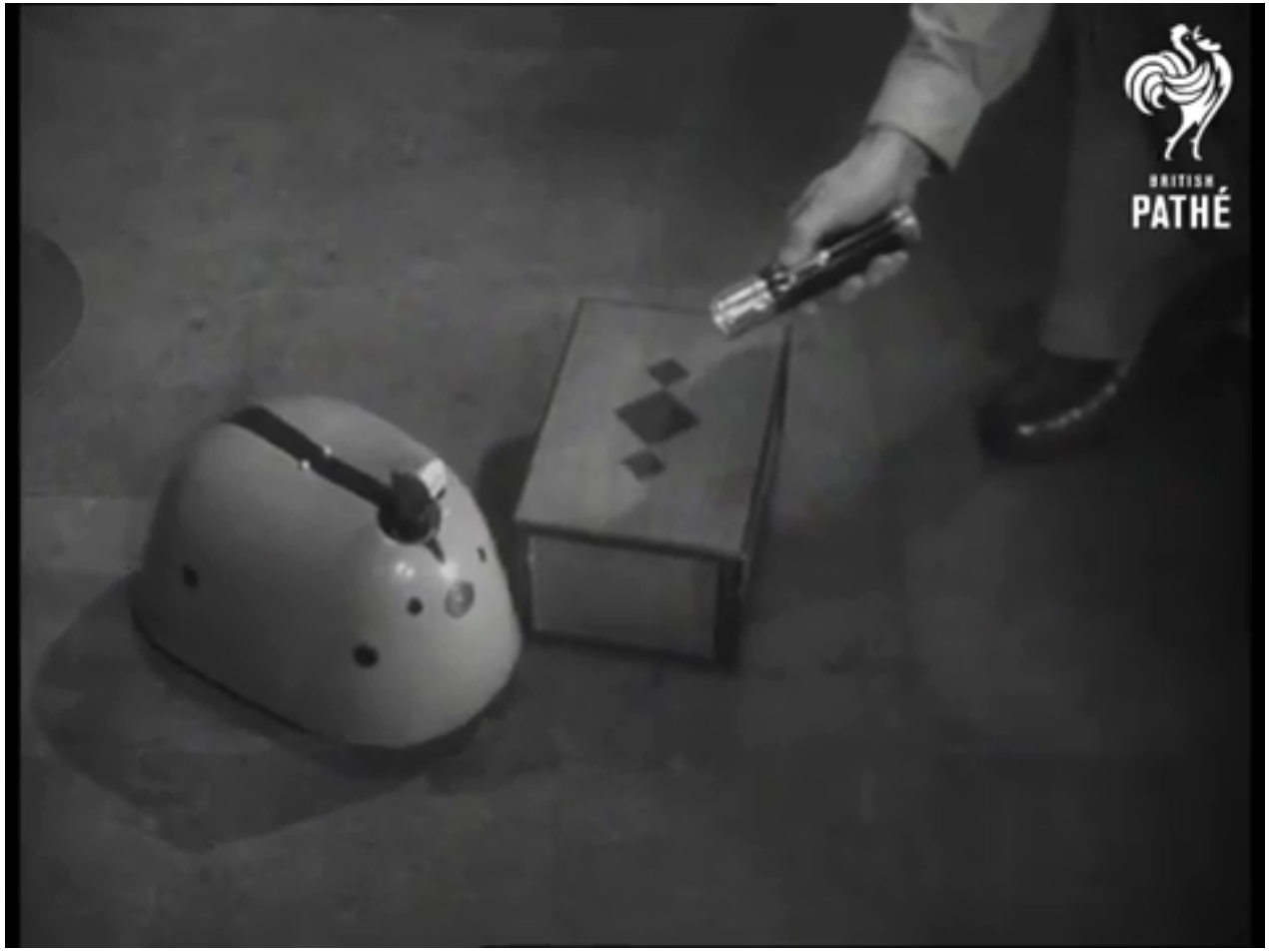
- The first industrial robot, UNIMATE, in 1954
  - Designed by George Devol, who coins the term Universal Automation
  - Name shortened to Unimation, which becomes the name of the first robot company (1962)

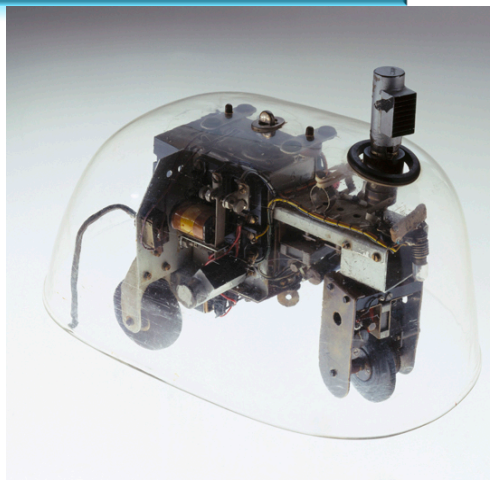
Reactive architecture



Mobile Robots: 1950

- Walter's *Tortoise*

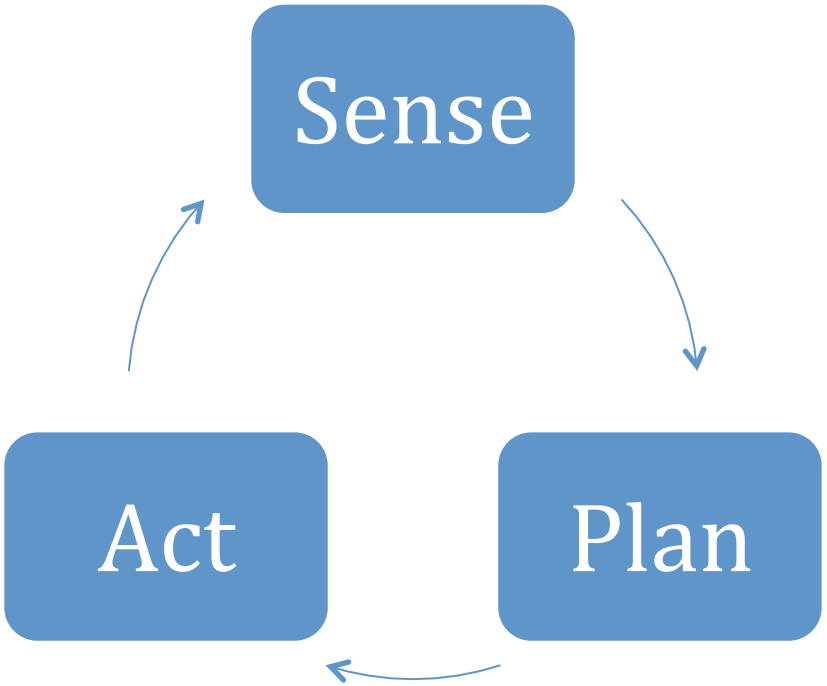




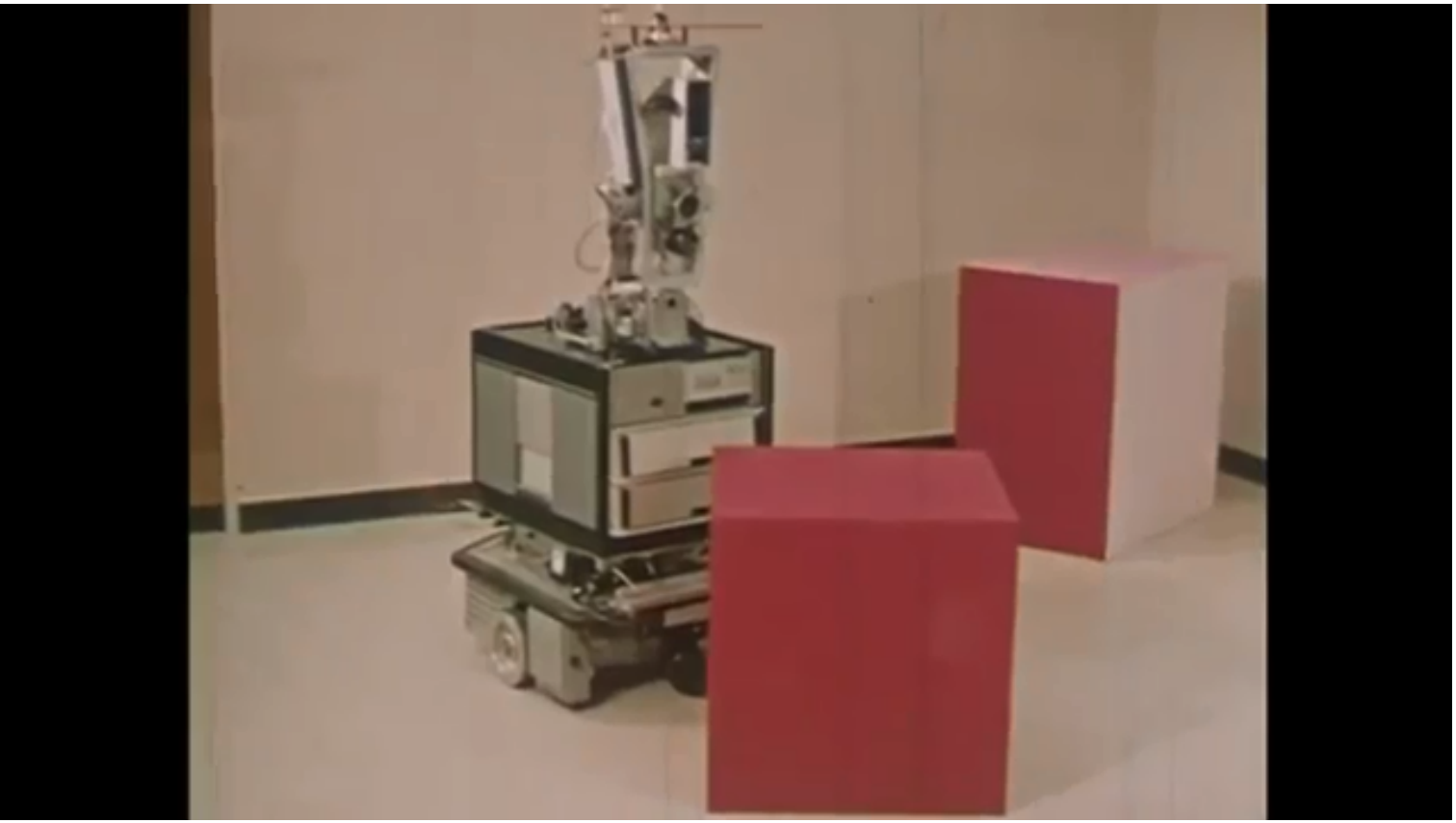
Source: sciencemuseum.org.uk

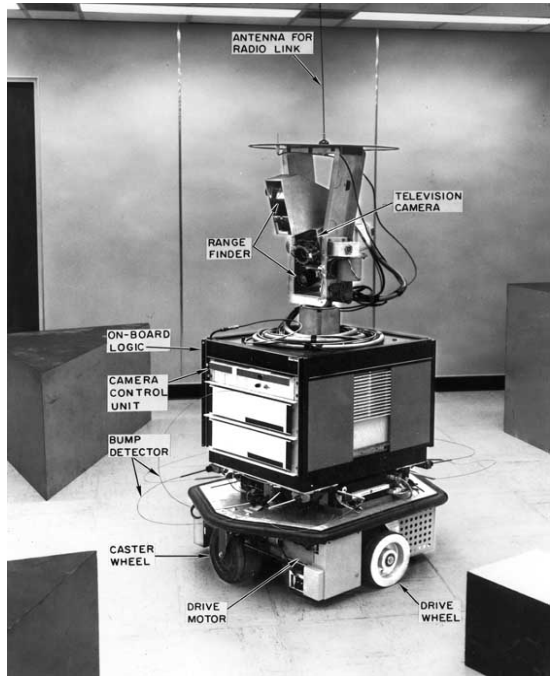
https://www.youtube.com/watch?v=wQE82derooc

Deliberative architecture



Shakey (1966 -1972)





Source: wikipedia.org

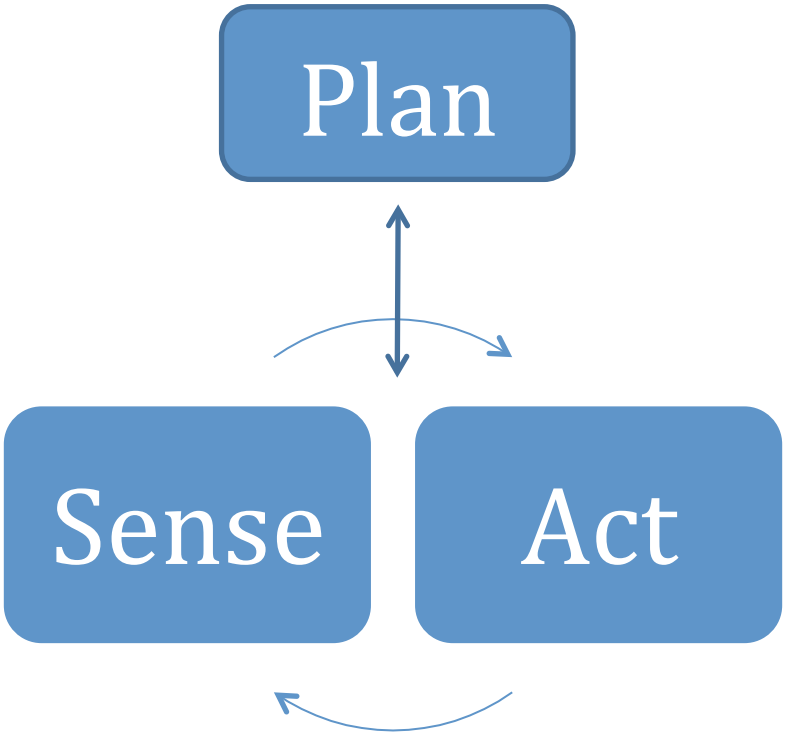
https://www.youtube.com/watch?v=7bsEN8mwUB8

Stanford Cart

Source: stanford.edu

- 1973-1979
  - Stanford Cart developed by Hans Moravec
  - Use of stereo vision.
  - Took pictures from several different angles
  - The computer gauged the distance between the cart and obstacles in its path to do basic collision avoidance
  - About **15 min** to think about each image, then drives 1 foot or so.

Hybrid architecture



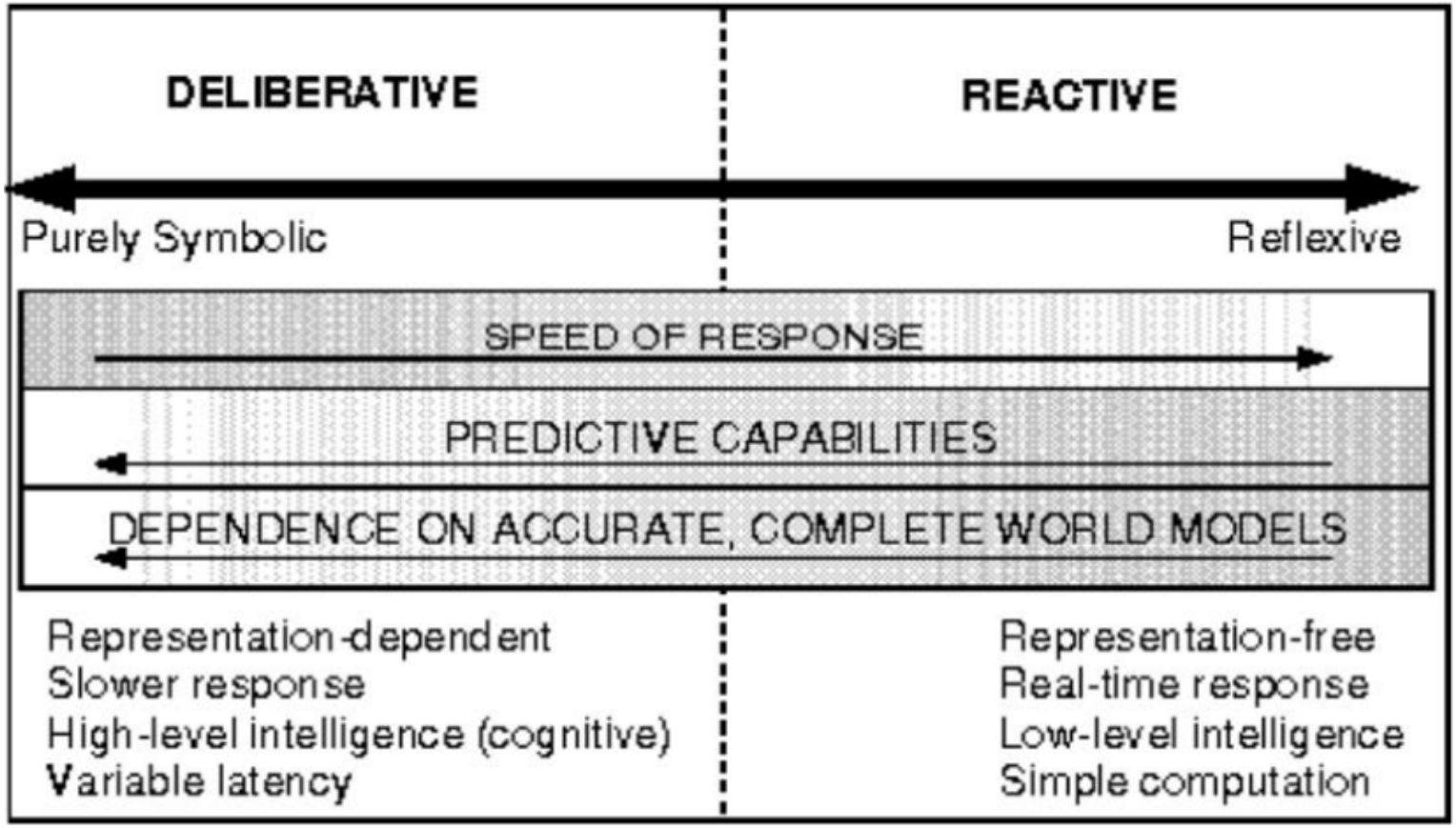
MIT Talos (2007)

Source: mit.edu

- Participated in the DARPA Grand Challenge

https://www.youtube.com/watch?v=F_tk6C9KGL4

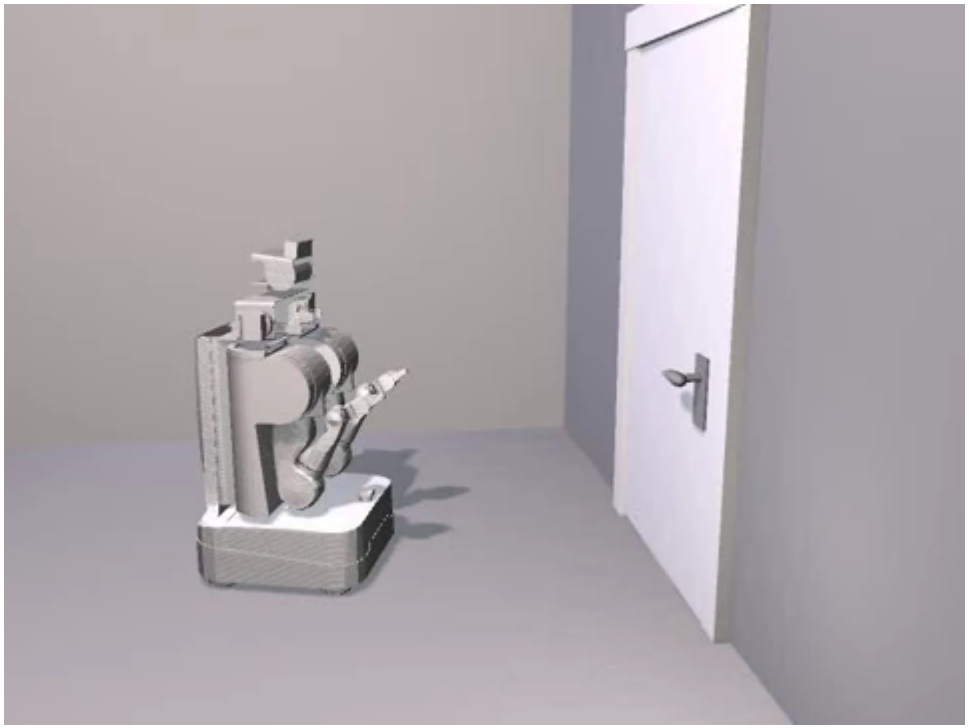
Spectrum of control

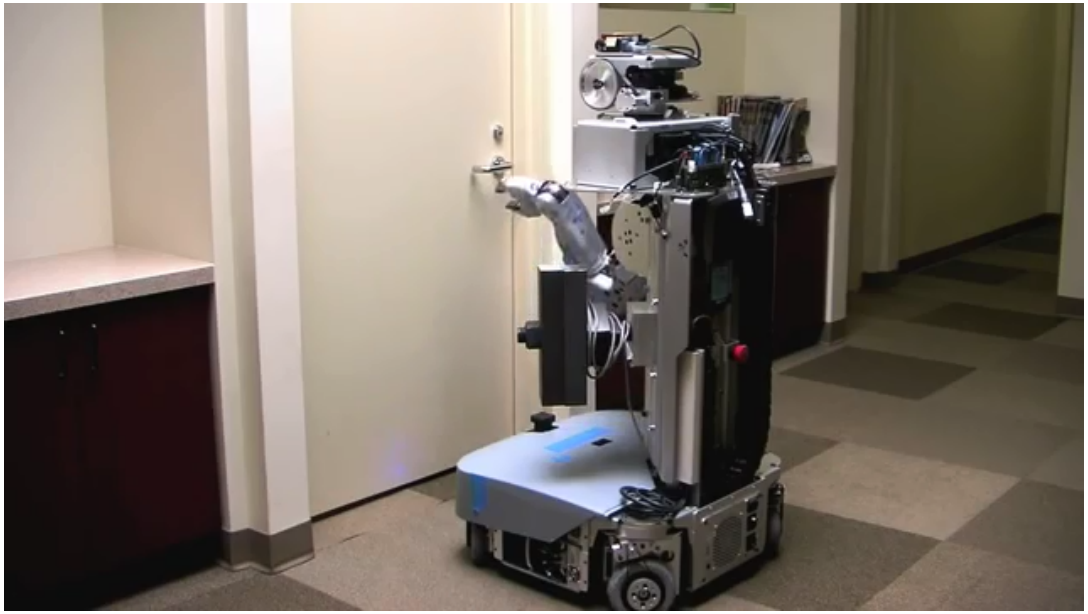


Source: [Arkin, 1998, MIT Press]

Middleware

WillowGarage PR2 (2007)





Source: WillowGarage

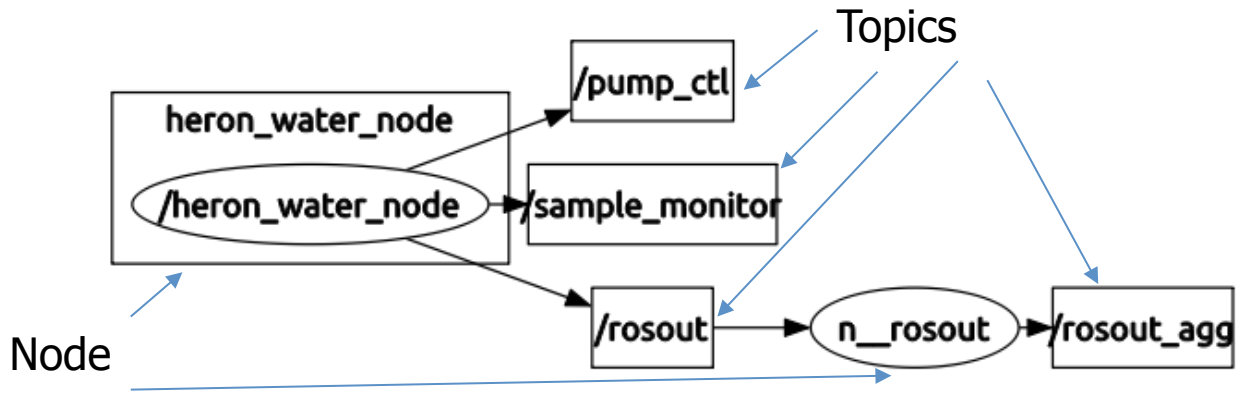
ROS

ROS

- The Robot Operating System (ROS) is a flexible framework for writing robot software
  - It is a collection of tools, libraries, and conventions that aim to simplify the task of creating complex and robust robot behavior across a wide variety of robotic platforms
- Developed and Maintained by the Open Source Robotics Foundation (OSRF)
- "The primary goal of ROS is to support *code reuse* in robotics research and development."

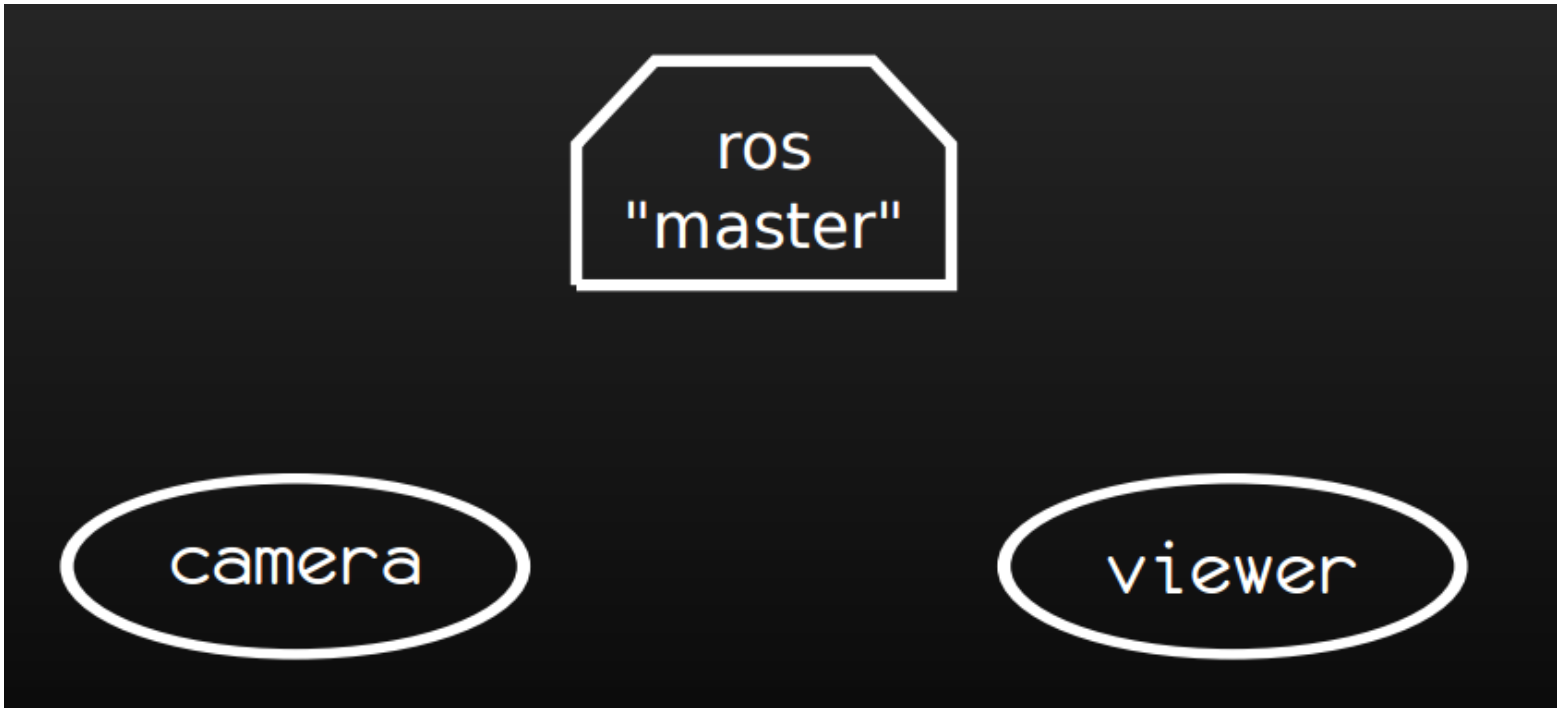
ROS

- ROS is based on publish/subscribe message passing approach
- The core elements are:
  - ROS master: process that provides naming and registration to the rest of the nodes
  - Nodes: processes implementing robotic components
  - Topics: named buses over which nodes exchange messages



ROS overview

- Process for making two nodes interact with each other



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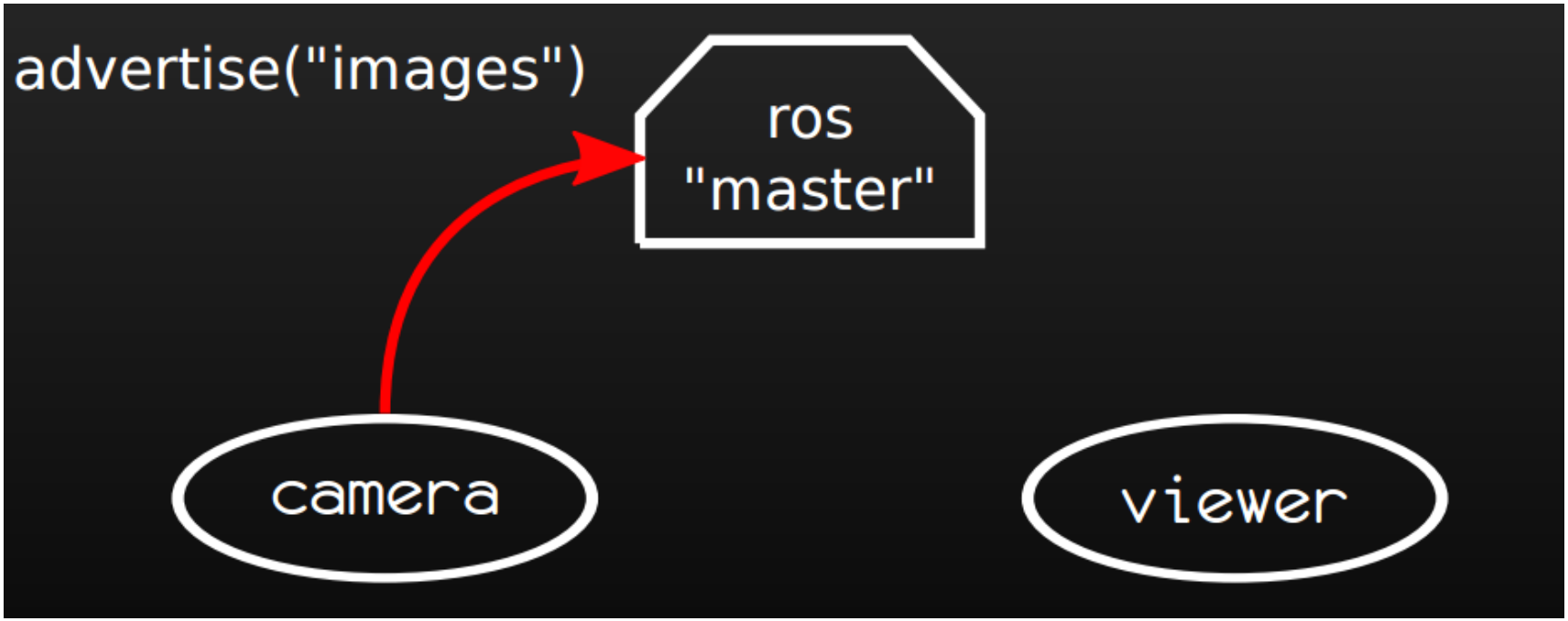

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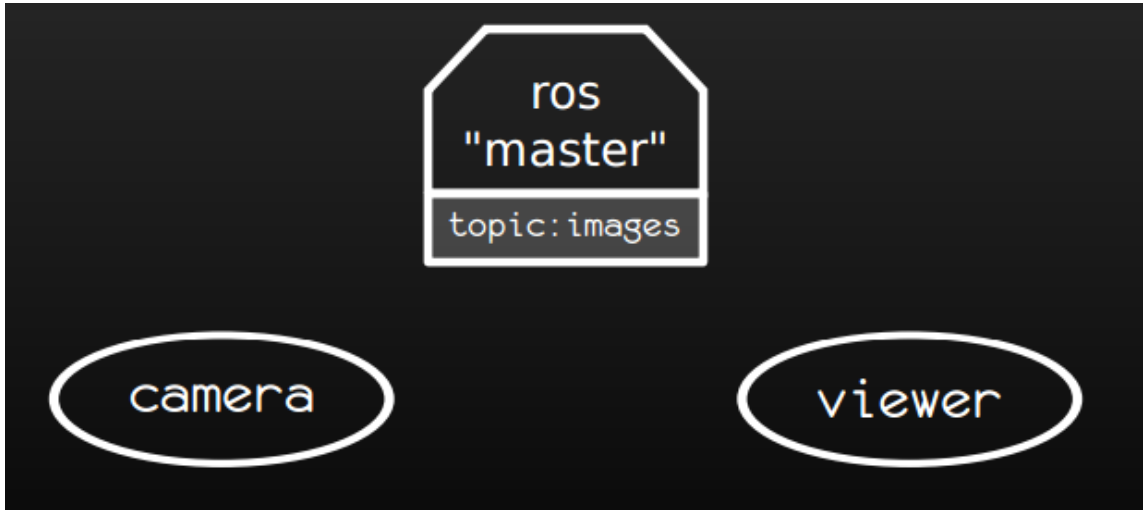

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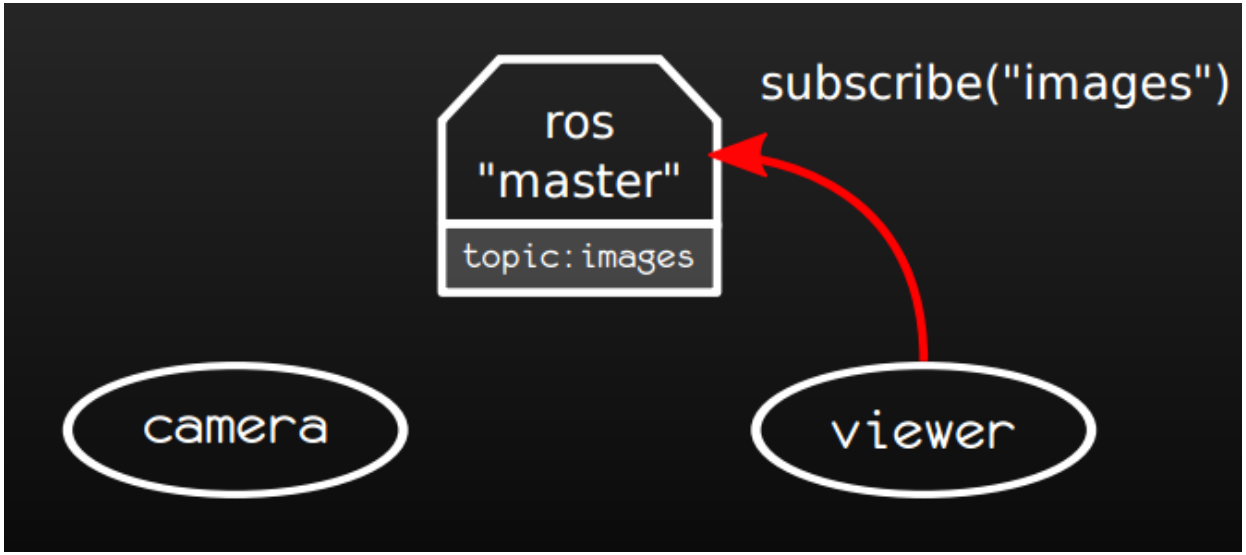

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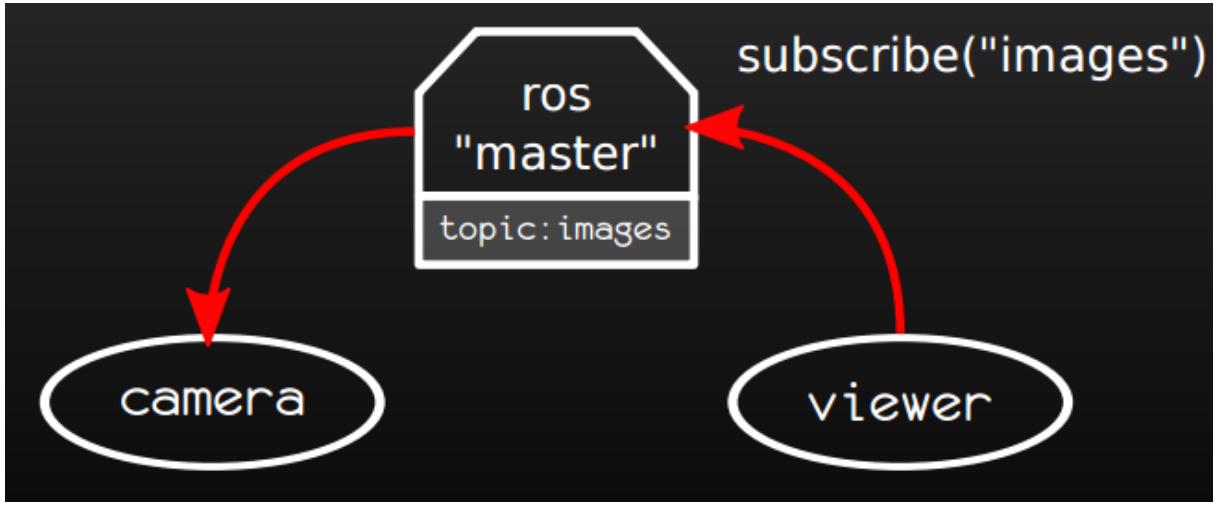

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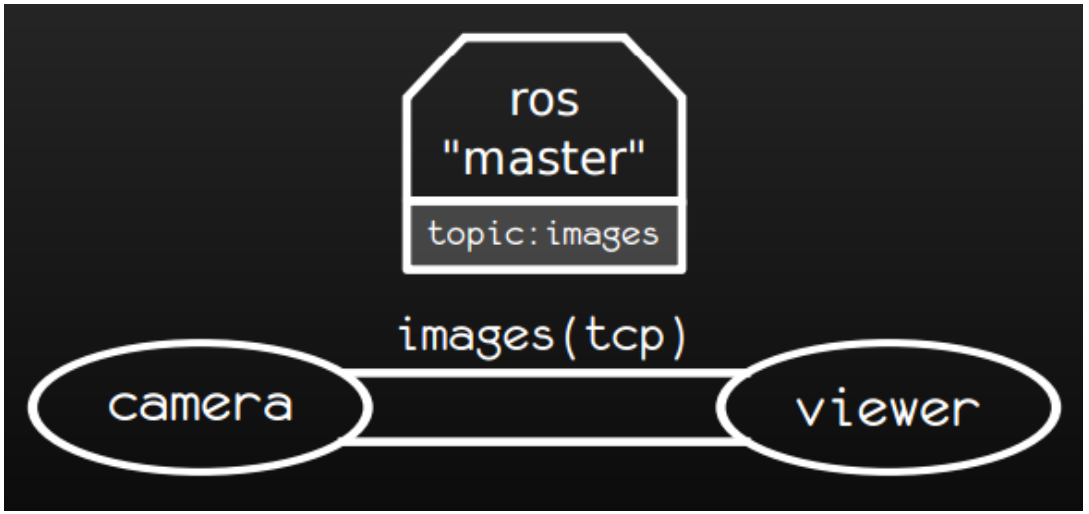

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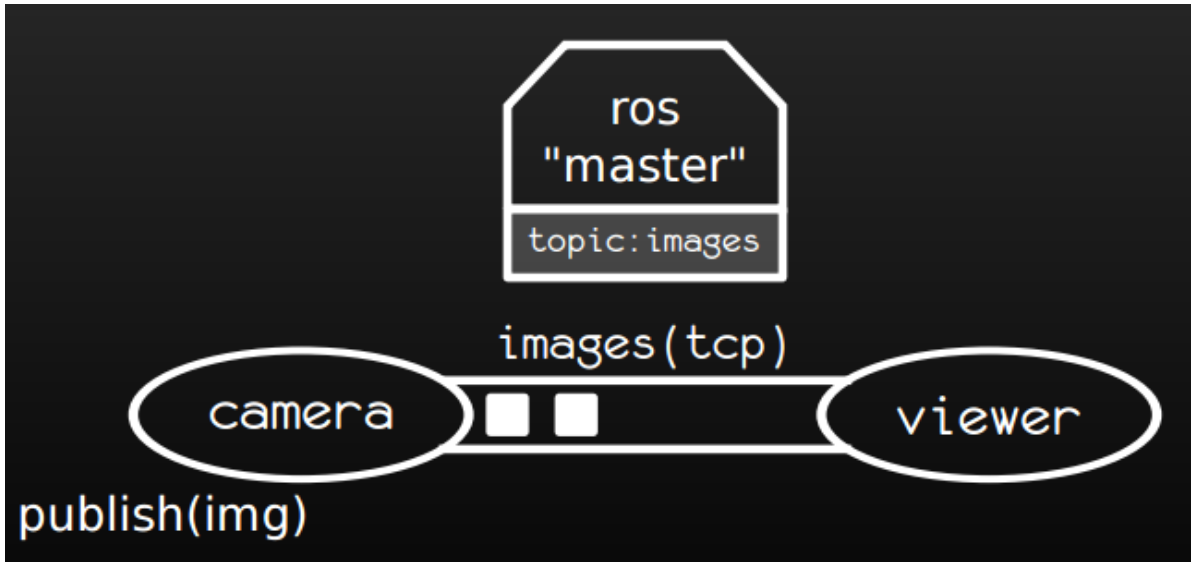

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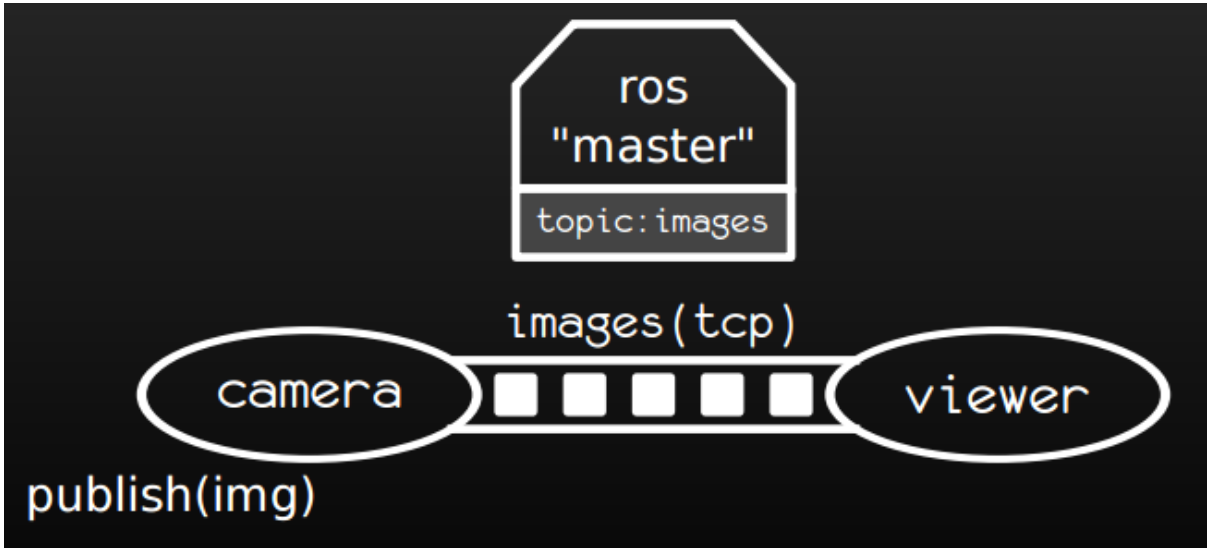

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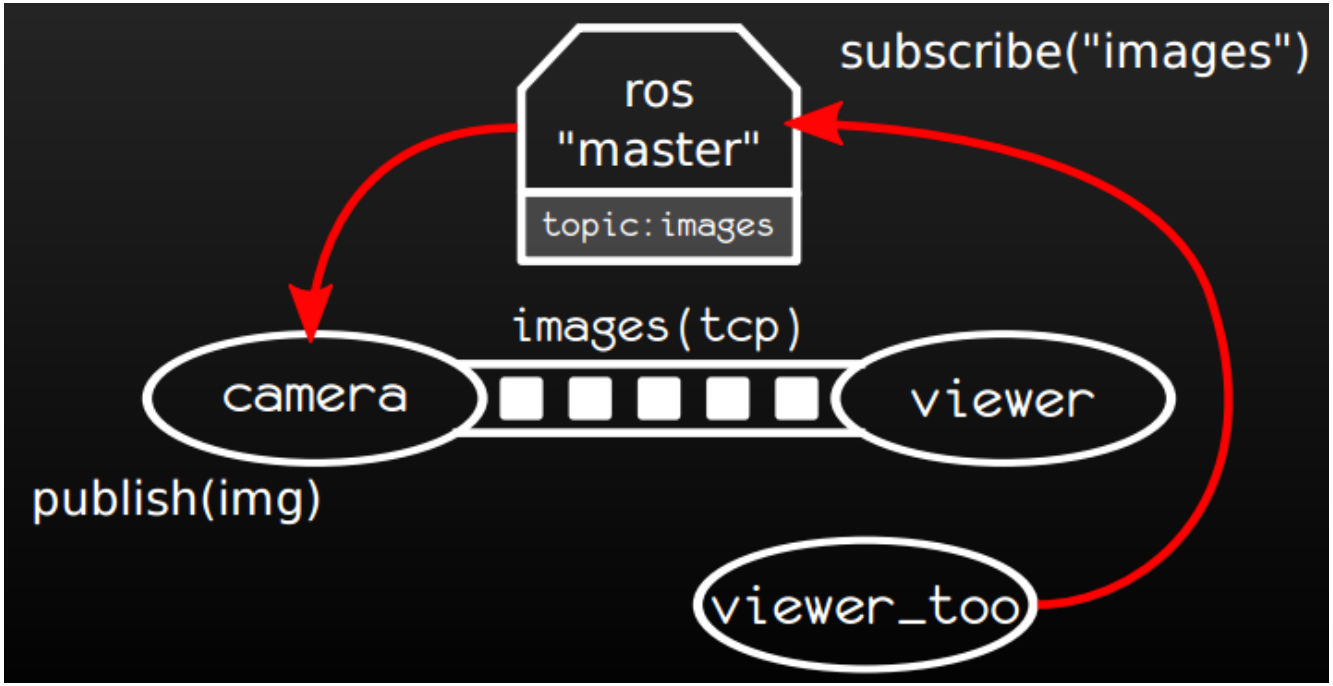

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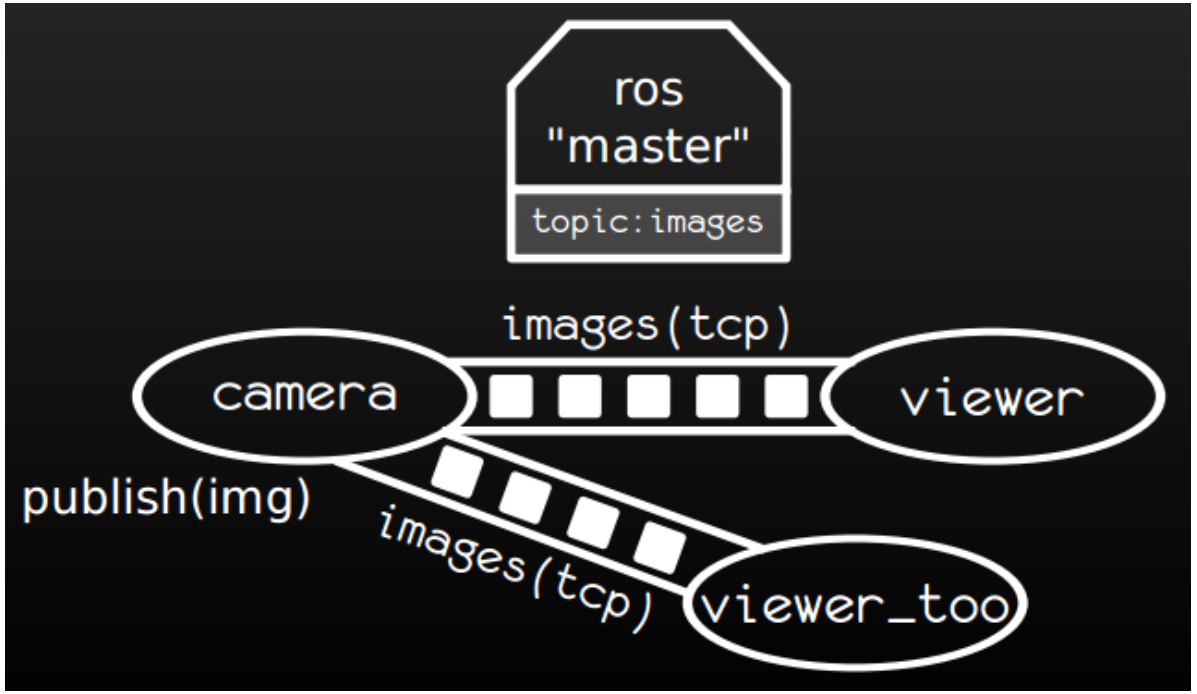
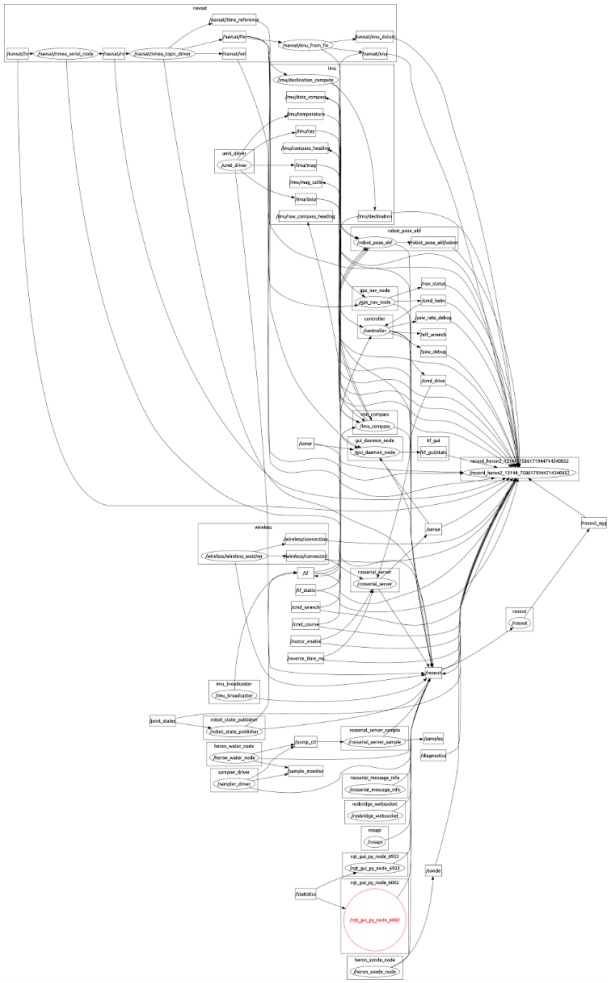
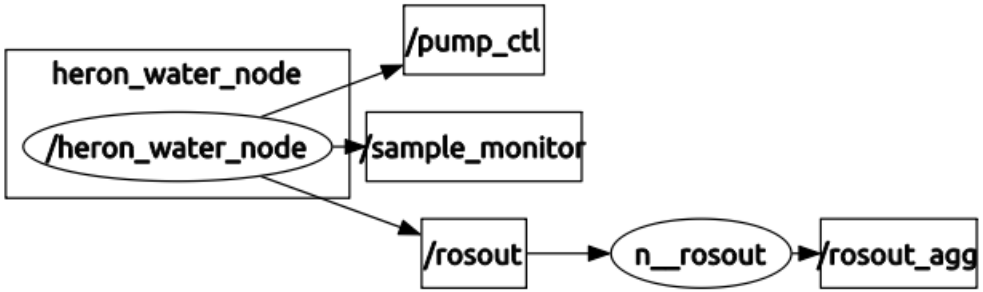


ROS overview

- Typically, a node represents one task (driver, localization, mapping, path planning, …)
- Nodes run in parallel
- To debug problems, use rqt_graph





ROS overview

- The main mean of communication in ROS are topics and messages

- However, there are other ways for nodes to communicate with each other
  - Services: similar to Remote Procedure Calls
  - Actionlib: preemptable tasks

ROS overview

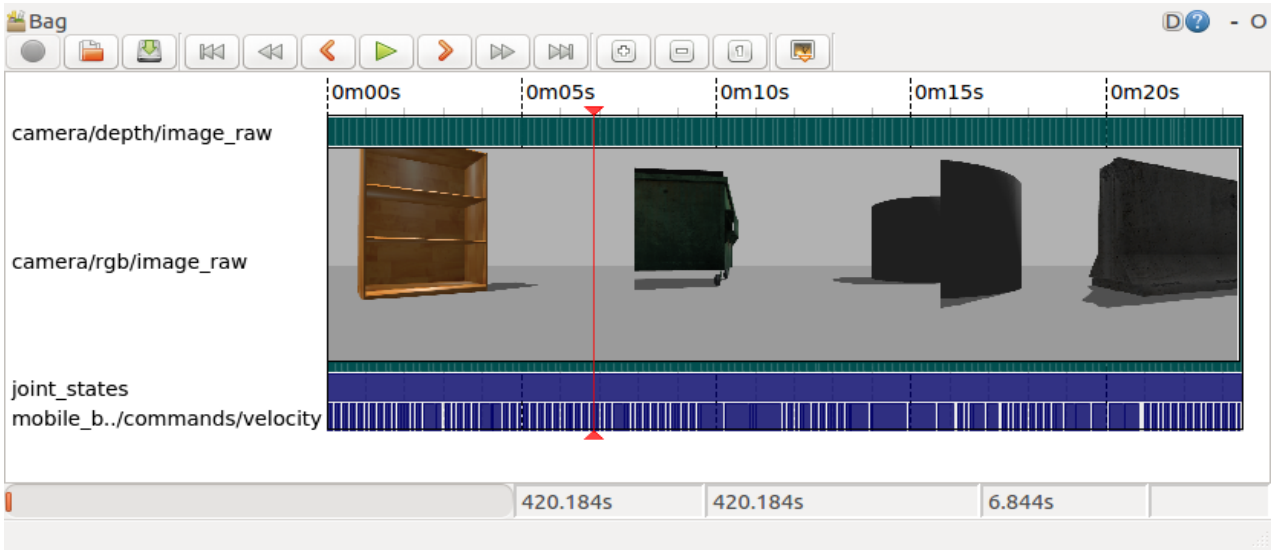
- How to decide what to use:
  - Topics: especially for stream of data
  - Services: execution of fast tasks
  - Actions: execution of tasks that need to be tracked and should be preempted in some cases

ROS overview

- Parameters can be easily set
  - Statically: rosparam
  - Dynamically: rqt_reconfigure
- Be careful in which namespace the parameters are defined: global or private

ROS overview

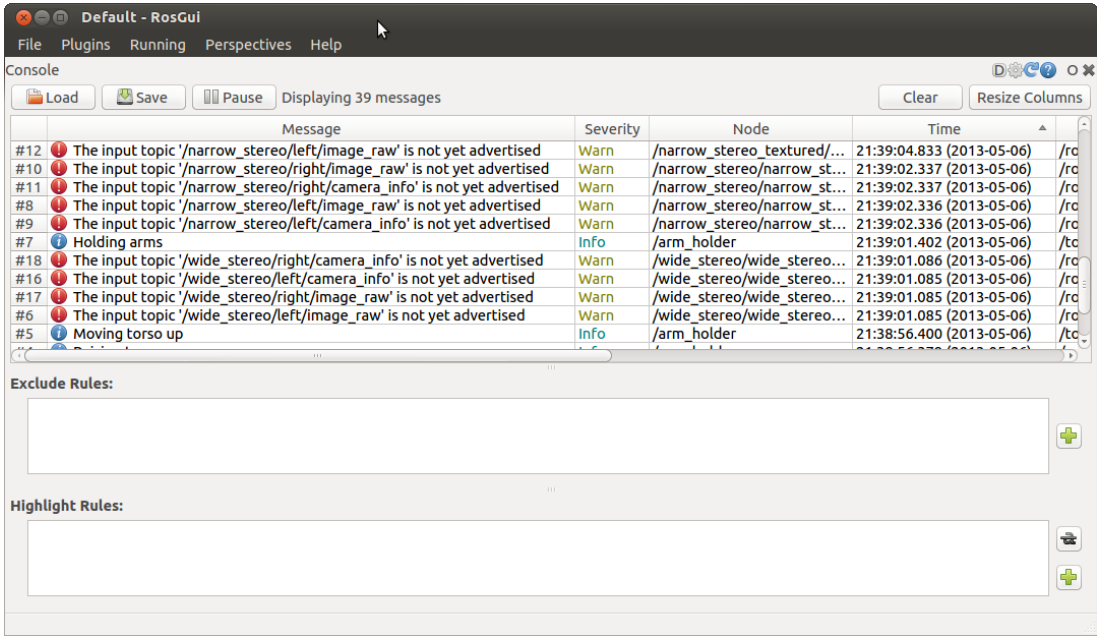
- Logging data streams can be achieved by using rosbag
- Remember the ROS parameter sim_time especially to run algorithms on bag files



Source: ros.org

ROS overview

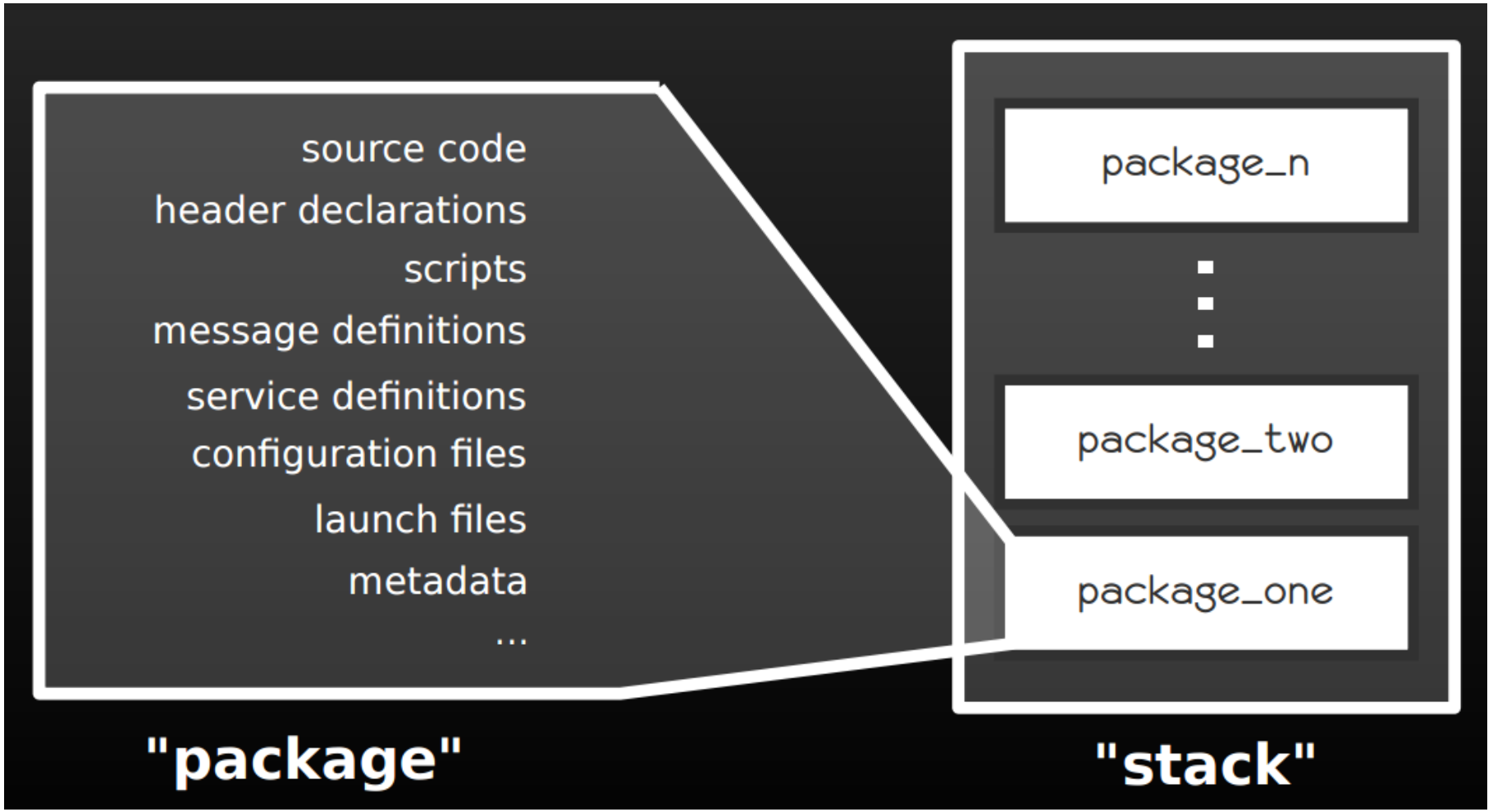
- Logging messages are published in rosout topic
  - Different log levels should be used according to the severity of the message
- rqt_console can be used to visualize them



ROS tools

- **Navigate**: roscd, rosls
- **Setup**: catkin_init_workspace, catkin_create_pkg
- **Configure**: package.xml, CmakeLists.txt
- **Build**: catkin_make
- **Execute**: roscore, rosrun, roslaunch, rosparam, rqt_reconfigure
- **Inspect**: rosnode, rostopic, rosservice
- **Debug**: rqt_graph, rostest, rqt_plot
- **Log & Analyze**: rosbag, rqt_bag, rqt_console

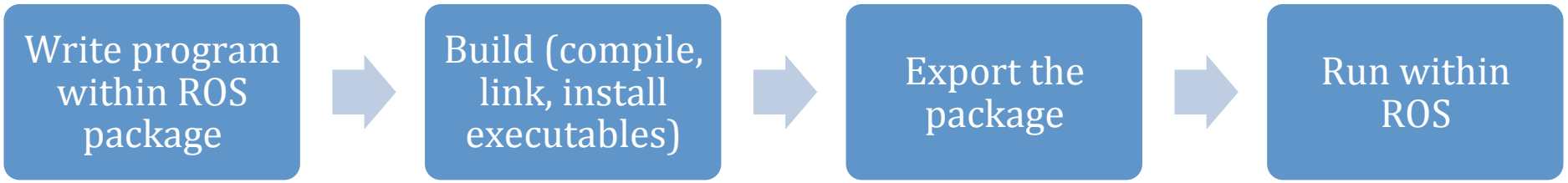
ROS packages



ROS distribution

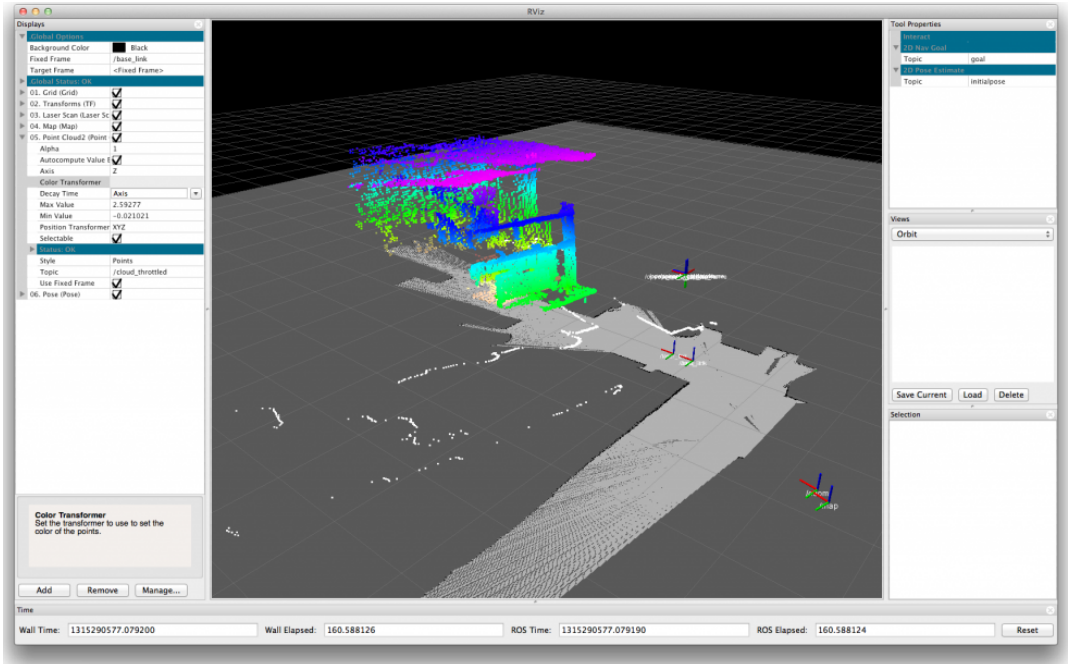
- Note that in Ubuntu, there are many packages ready just to be installed with sudo apt-get install

From source code to executable



ROS tools

- rviz can be used to visualize data



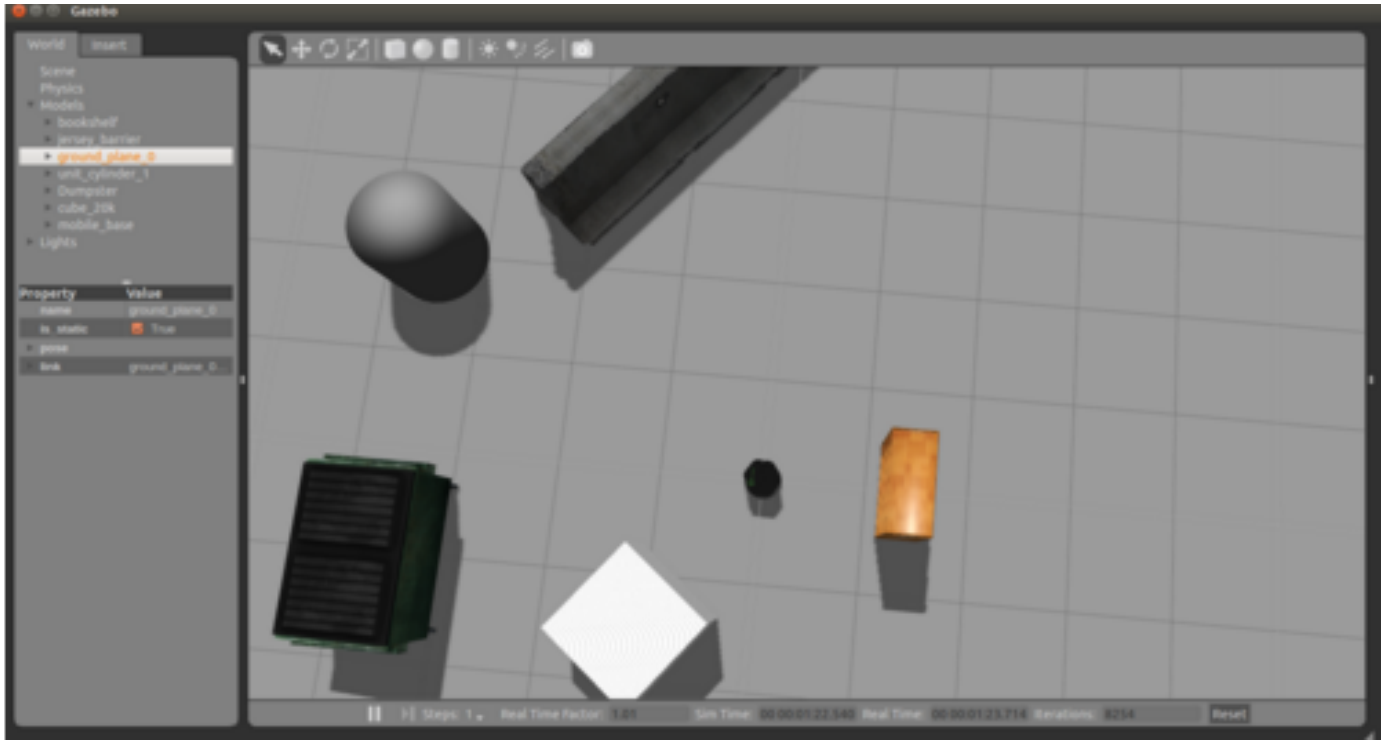
Source: iheartrobotics.com

ROS tools

- Stage, 2D simulator

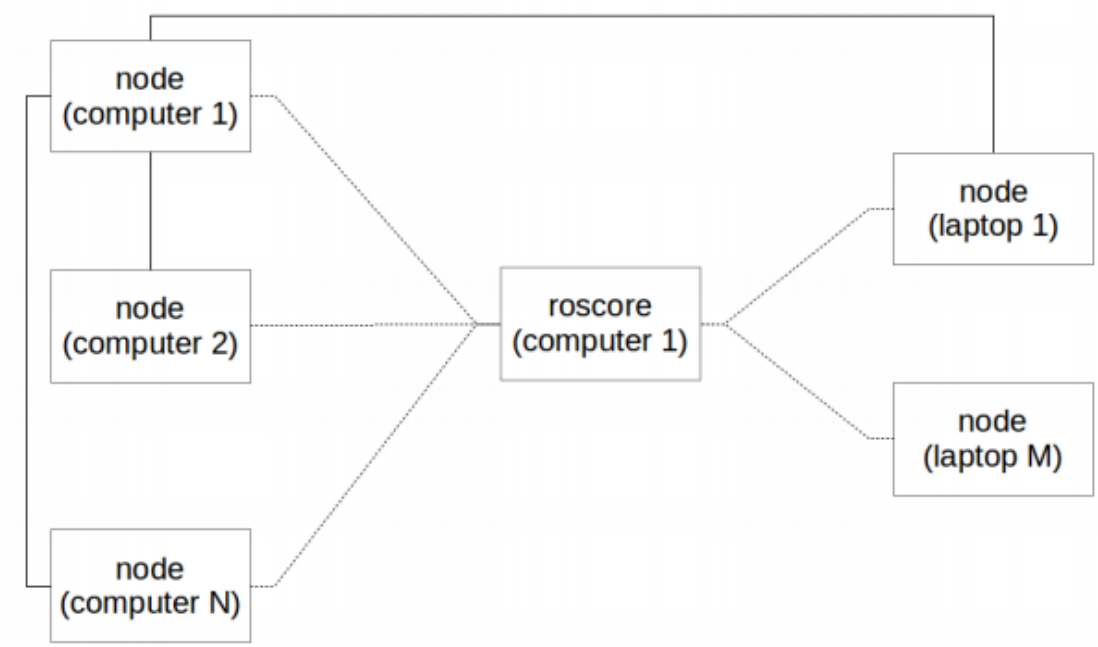
ROS tools

- Gazebo, 3D simulator



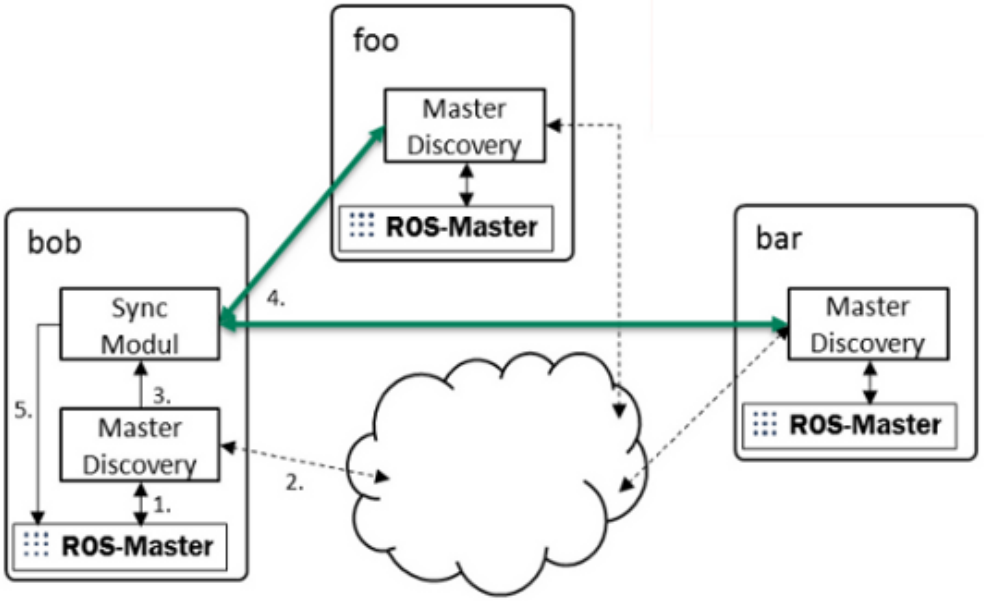
ROS overview

- In a multirobot settings, a possibility is to share the ROS master over all of the computers



ROS overview

- However, to have the system more robust, *multi-master-fkie* can be used to allow robots to see other ROS masters



Summary

- Problems to solve in robotics
  - Localization, Mapping, Planning
- Robot software architectures with some history
  - Deliberative
  - Reactive
  - Hybrid
- Middleware
  - ROS
    - Core elements
    - Packages
    - Tools

Questions?