SCHUNK Modular Robotics

ROS Drivers for LWA 4.P und LWA 4.D

Superior Clamping and Gripping

SCHUNK®

Contents

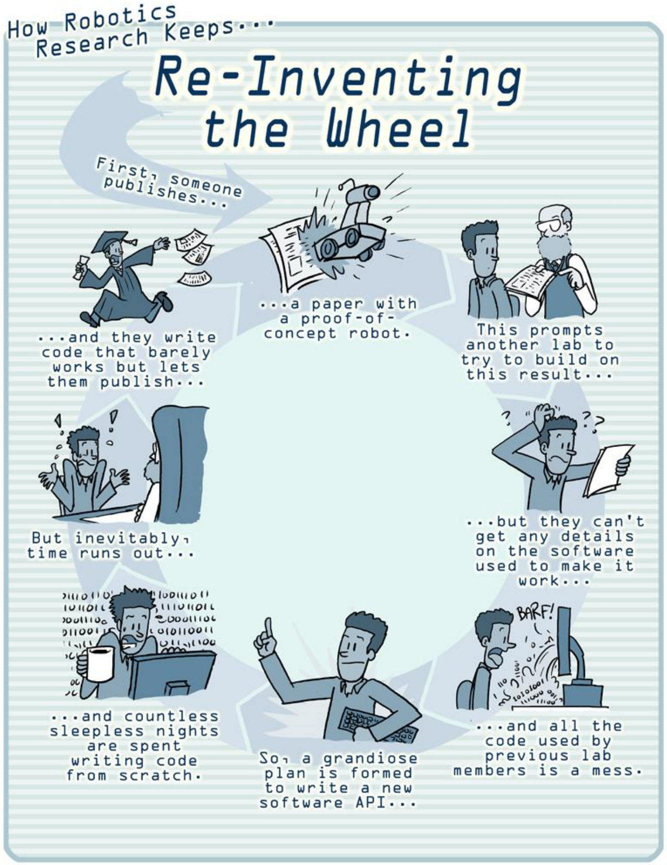
- Introduction to ROS
  - ROS – Technical Details
- ROS Support of SCHUNK components
  - Installation and Operation Instructions
  - Technical Details CANOpen-Driver
  - LWA 4.P (6-DOF Powerball Arm)
  - LWA 4.D (7-DOF Dextrous Arm)

Introduction to ROS

Research in robotics

- Reinvention of the Wheel
- Little Commonality
- Short Lifespan
- Inability to Compare Results

→ ROS addresses these

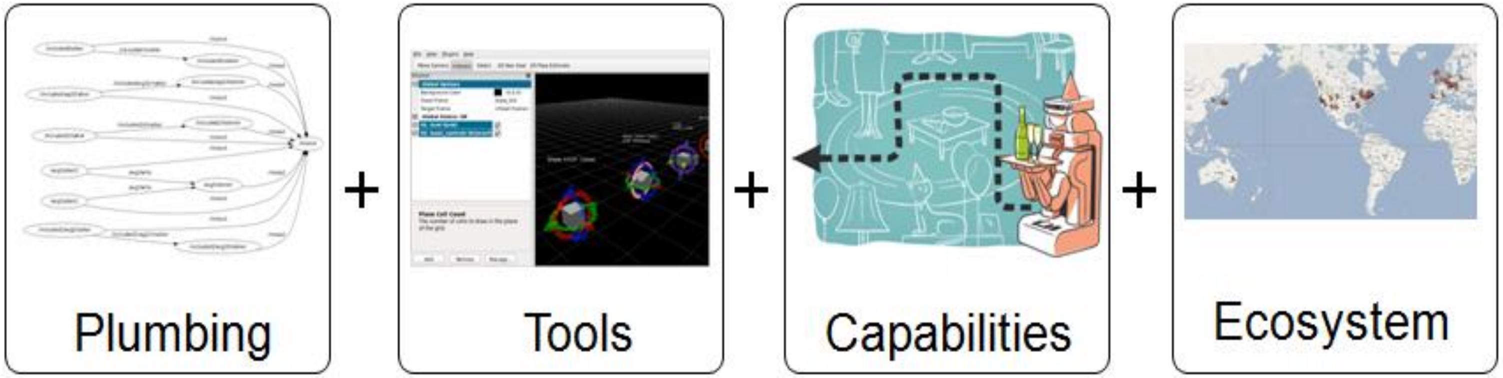

How Robotics Research Keeps...
Re-Inventing the Wheel
First, someone publishes...
...a paper with a proof-of-concept robot.
This prompts another lab to try to build on this result...
...but they can't get any details on the software used to make it work...
BARF!
...and all the code used by previous lab members is a mess.
So, a grandiose plan is formed to write a new software API...
...and countless sleepless nights are spent writing code from scratch.
But inevitably, time runs out...
...and they write code that barely works but lets them publish...

ROS – Robot Operating Syster

- ROS = **R**obot **O**perating **S**ystem

- „ROS is an open-source, meta-operating system for your robot.“ [ROS-wiki]

- ROS is a “robot framework” [ROS-wiki]



www.ros.org/wiki/ROS/Introduction

ROS – Video

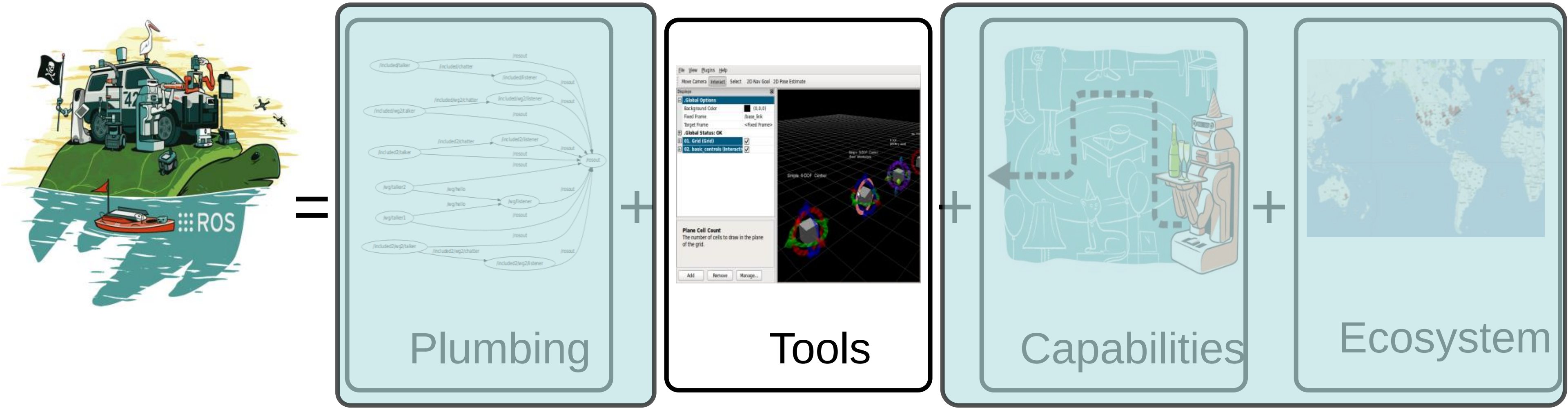
- 5 years of ROS

http://youtu.be/PGaXiLZD2KQ

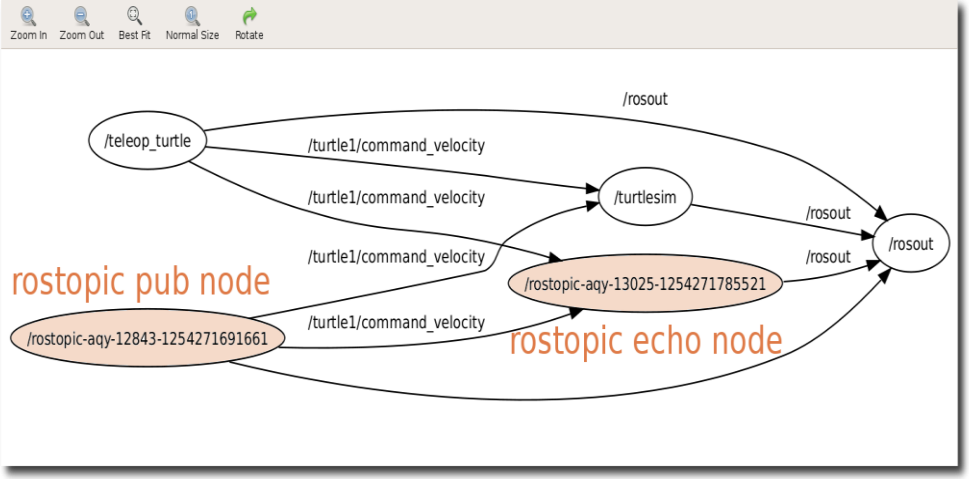
ROS – Robot Operating System

- What is ROS?
  - Provides
    - Hardware abstraction
    - Low-level device control
    - Communication layer with message-passing between processes
    - Recursive package management and build system
    - Runs primarily on Linux but is intended to be cross-platform compatible to MAC OS X and Windows
  - Content
    - ROS core build and runtime system
    - ROS packages, a collection of robotic algorithms

ROS – Tools

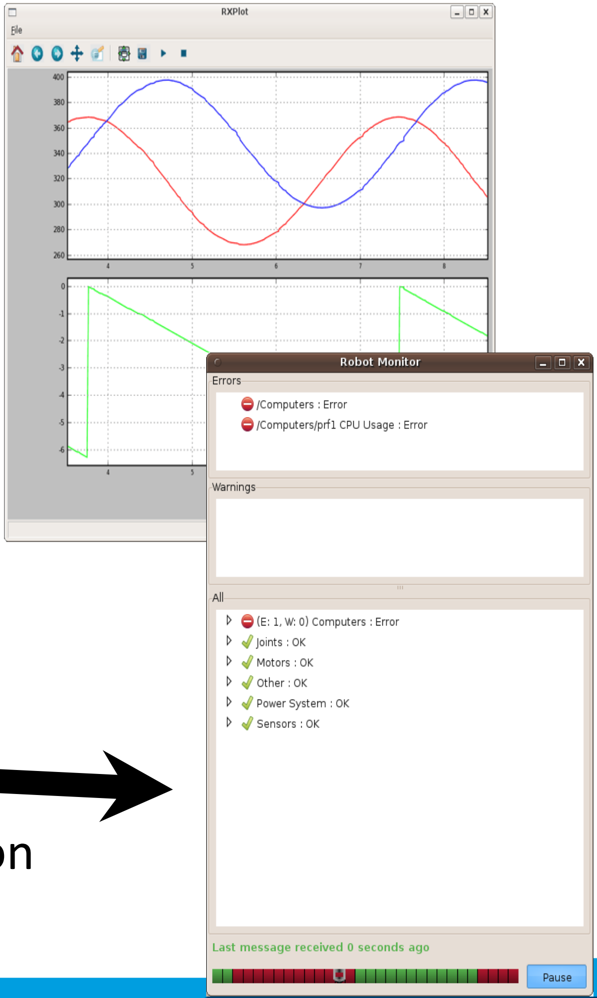

ROS
=
Plumbing
+
File View Plugins Help
Move Camera Interact Select 2D Nav Goal 2D Pose Estimate
Displays
Global Options
Background Color (0,0,0)
Fixed Frame /base_link
Target Frame <Fixed Frame>
Global Status: OK
01. Grid (Grid)
02. basic_controls (Interacti
Plane Cell Count
The number of cells to draw in the plane of the grid.
Add
Remove
Manage...
Simple 6-DOF Control
Tools
+
Capabilities
+
Ecosystem

ROS – Tools


Zoom In
Zoom Out
Best Fit
Normal Size
Rotate
/teleop_turtle
/rosout
/turtle1/command_velocity
/turtle1/command_velocity
/turtlesim
/turtle1/command_velocity
/rosout
/rosout
/rosout
/rostopic-aqy-13025-1254271785521
/turtle1/command_velocity
/rostopic-aqy-12843-1254271691661

rostopic pub node

rostopic echo node



Errors

/Computers : Error

/Computers/prf1 CPU Usage : Error

Warnings

All

(E: 1, W: 0) Computers : Error

Joints : OK

Motors : OK

Other : OK

Power System : OK

Sensors : OK

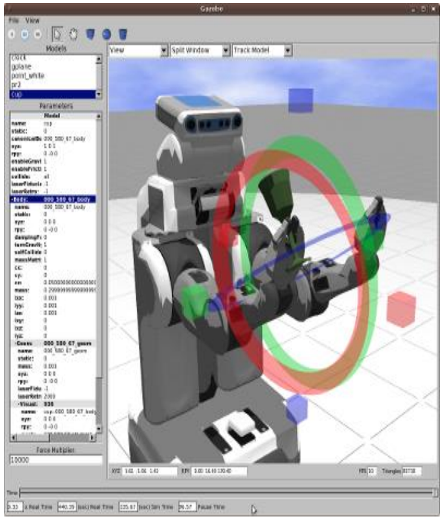
Last message received 0 seconds ago

plotting

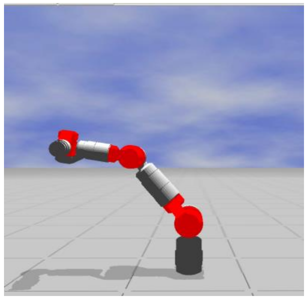
graph visualization

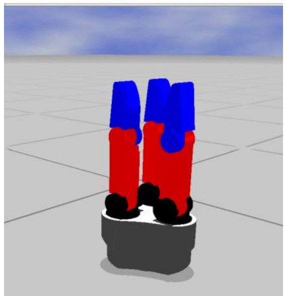
diagnostics

Simulation/visualization

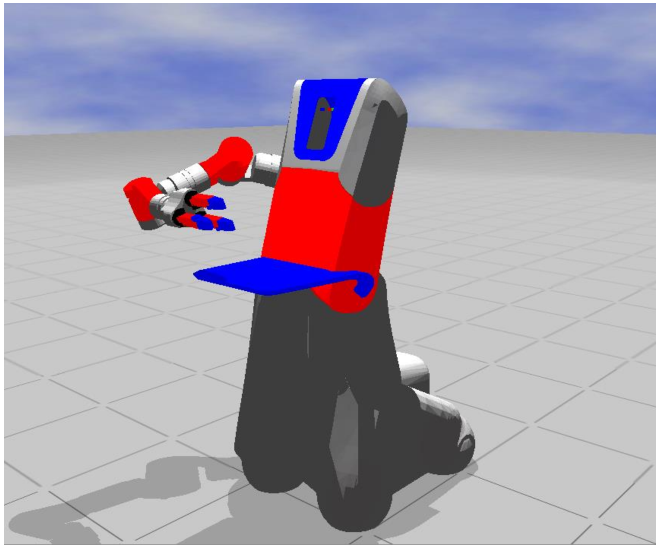


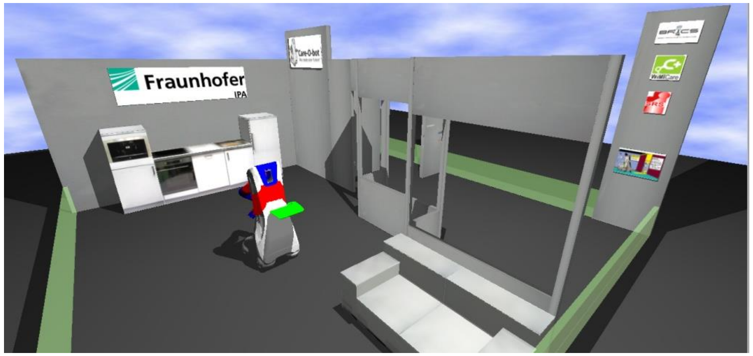
ROS – Tools Simulation





- Single simulated components
- Simulated sensors and actors, e.g.
  - Arm joints, hand
  - Cameras, laser scanners
- Model of the whole robot
- Kinematic and dynamic models of hardware components
- Environment model

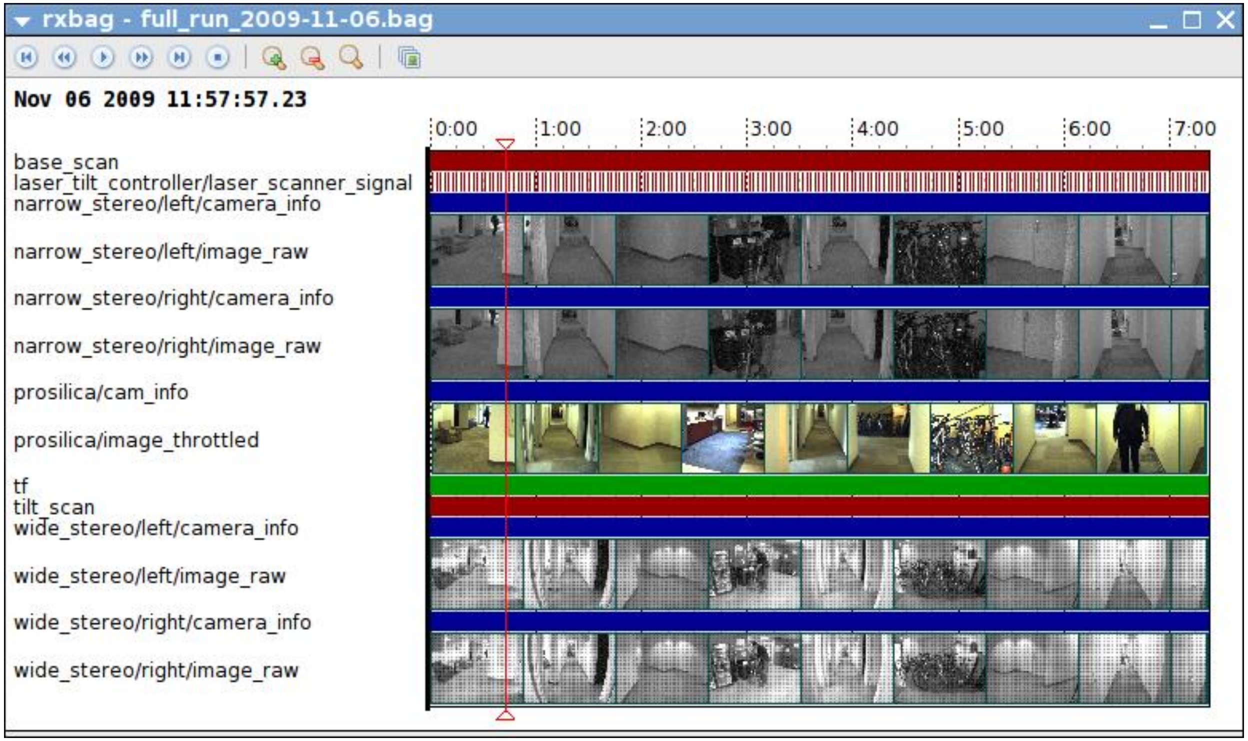




→ http://www.ros.org/wiki/simulator_gazebo

ROS – Tools Bag files

- Format for saving and playing back ROS message data
- Record and replay sensor data for developing and testing algorithms



rxbag - full_run_2009-11-06.bag

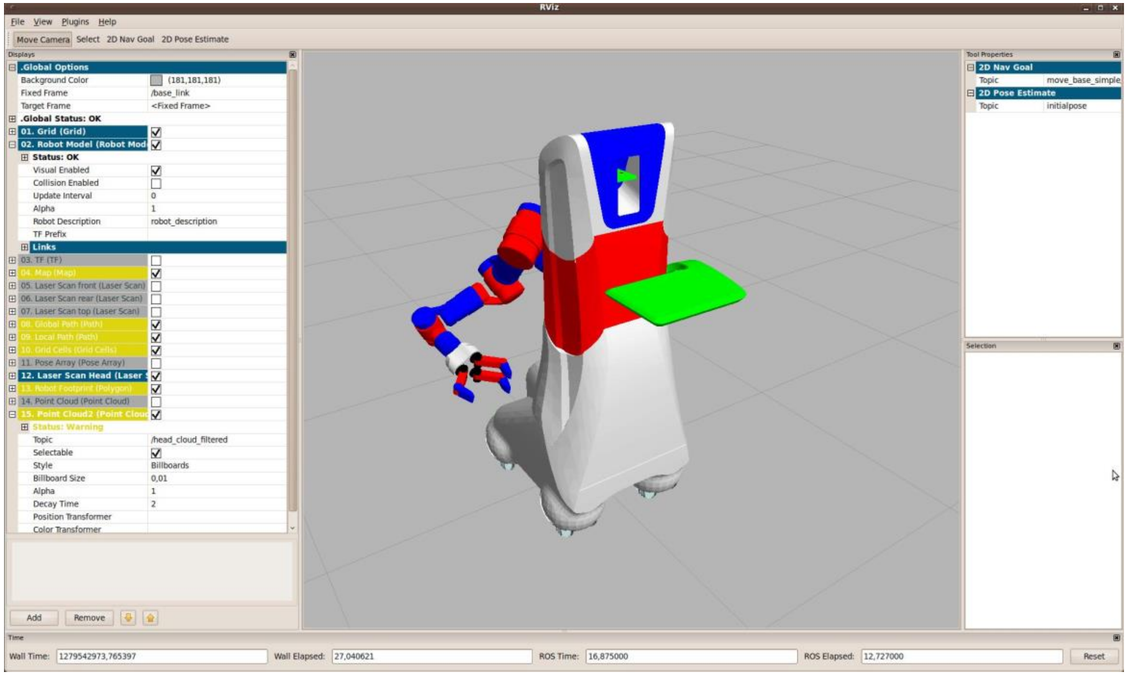
Nov 06 2009 11:57:57.23

0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
base_scan
laser_tilt_controller/laser_scanner_signal
narrow_stereo/left/camera_info
narrow_stereo/left/image_raw
narrow_stereo/right/camera_info
narrow_stereo/right/image_raw
prosilica/cam_info
prosilica/image_throttled
tf
tilt_scan
wide_stereo/left/camera_info
wide_stereo/left/image_raw
wide_stereo/right/camera_info
wide_stereo/right/image_raw

http://www.ros.org/wiki/rosbag

ROS – Tools Visualization

- Robot Model
- Sensor data (laser scanner, point cloud)
- 2D and 3D maps
- Markers



⊟ .Global Options	
Background Color	(181,181,181)
Fixed Frame	/base_link
Target Frame	<Fixed Frame>
⊞ .Global Status: OK	
⊞ 01. Grid (Grid)	☑
⊟ 02. Robot Model (Robot Mod	☑
⊞ Status: OK	
Visual Enabled	☑
Collision Enabled	□
Update Interval	0
Alpha	1
Robot Description	robot_description
TF Prefix	
⊞ Links	
⊞ 03. TF (TF)	□
⊞ 04. Map (Map)	☑
⊞ 05. Laser Scan front (Laser Scan)	□
⊞ 06. Laser Scan rear (Laser Scan)	□
⊞ 07. Laser Scan top (Laser Scan)	□
⊞ 08. Global Path (Path)	☑
⊞ 09. Local Path (Path)	☑
⊞ 10. Grid Cells (Grid Cells)	☑
⊞ 11. Pose Array (Pose Array)	□
⊞ 12. Laser Scan Head (Laser S	☑
⊞ 13. Robot Footprint (Polygon)	☑
⊞ 14. Point Cloud (Point Cloud)	□
⊟ 15. Point Cloud2 (Point Clouc	☑
⊞ Status: Warning	
Topic	/head_cloud_filtered
Selectable	☑
Style	Billboards
Billboard Size	0,01
Alpha	1
Decay Time	2
Position Transformer	
Color Transformer	

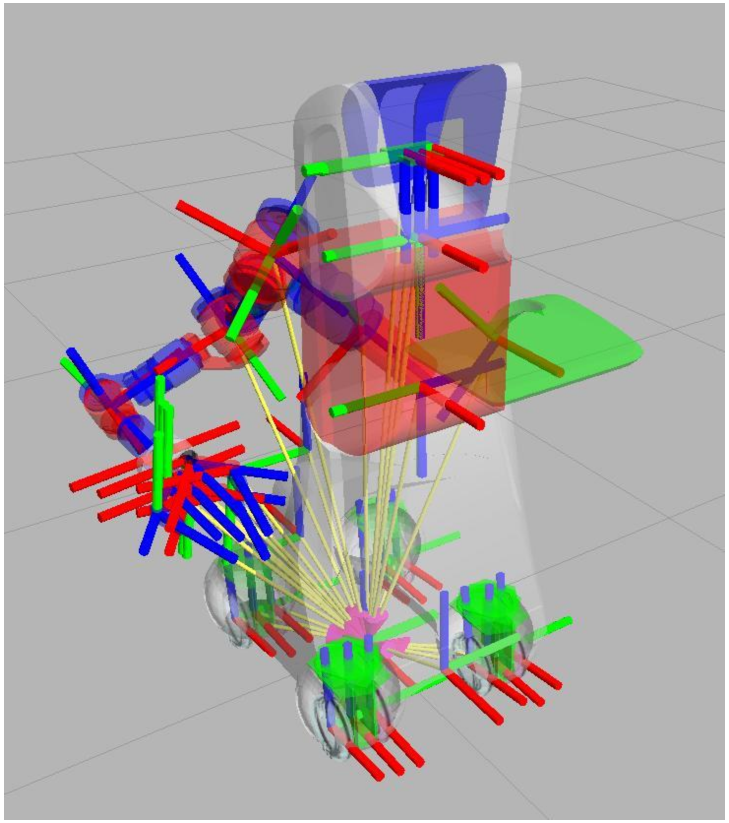
⊟ 2D Nav Goal	
Topic	move_base_simple
⊟ 2D Pose Estimate	
Topic	initialpose

Wall Time: 1279542973,765397 Wall Elapsed: 27,040621 ROS Time: 16,875000 ROS Elapsed: 12,727000

http://www.ros.org/wiki/rviz

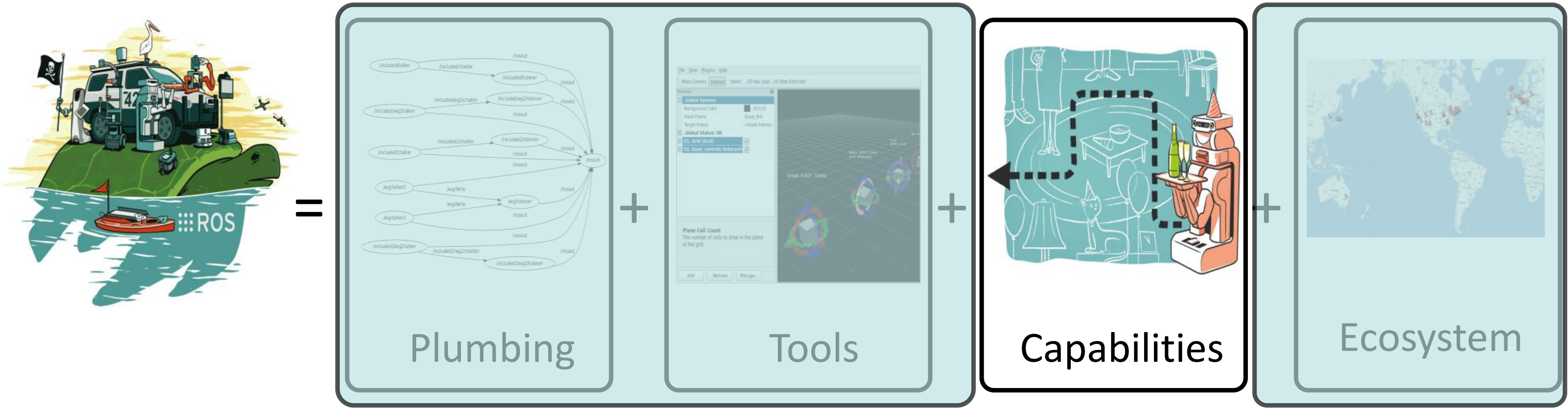
ROS – Tools transformations library (tf)

- Tree of coordinate systems
- Defined by urdf (Robot Description Language)
- Transformations between all coordinate systems available
- Generated automatically out of /joint_states topic



http://www.ros.org/wiki/tf

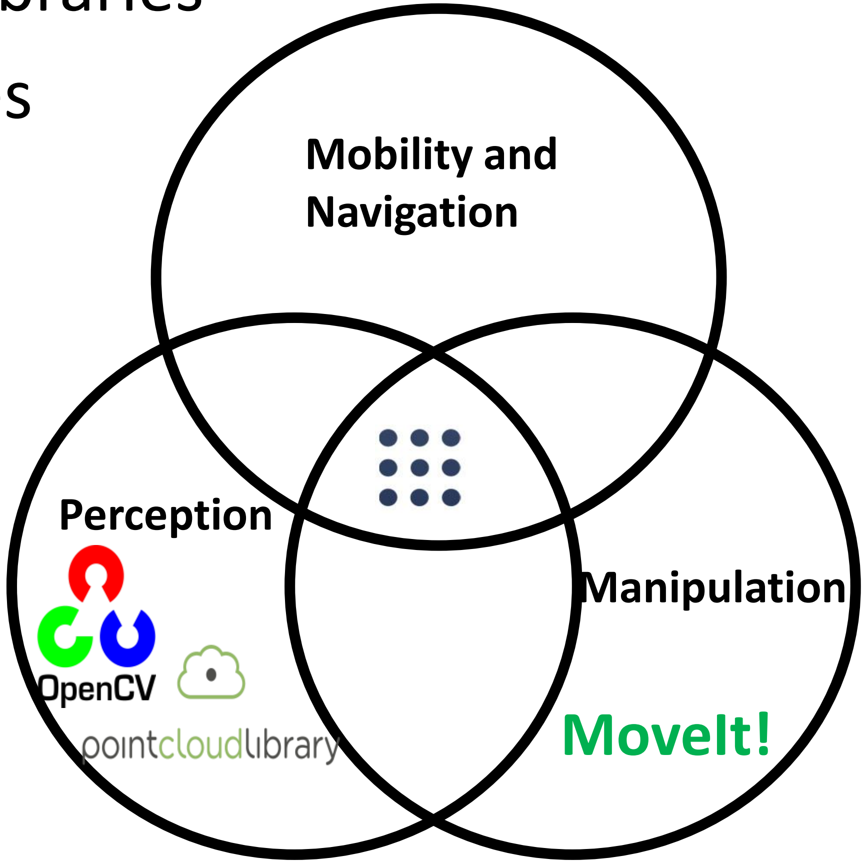
ROS – Capabilities



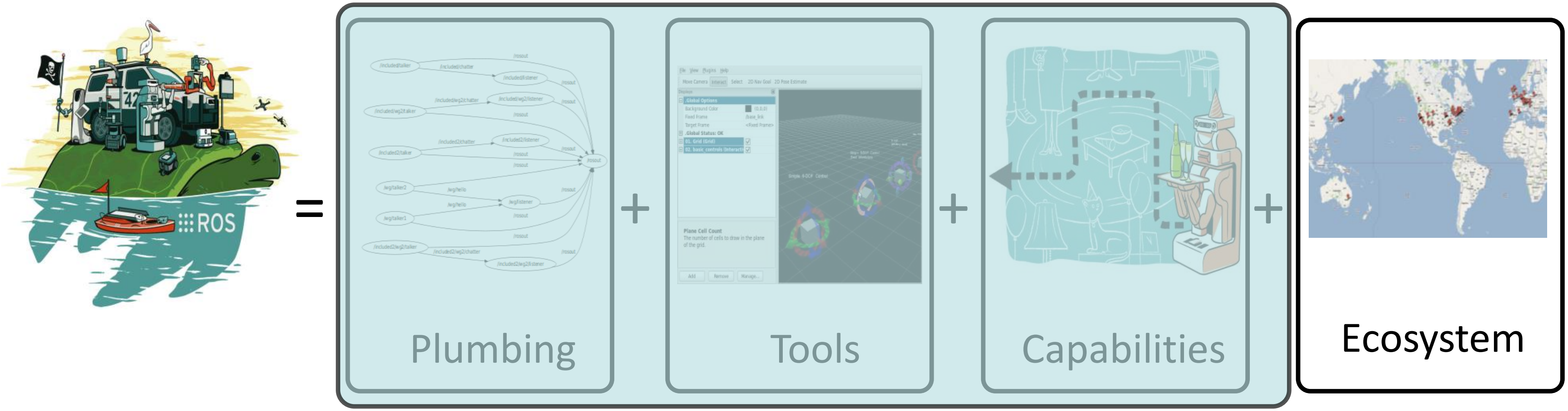
= Plumbing + Tools + Capabilities + Ecosystem

ROS – Capabilities

- State of the art algorithms
- Integration of available libraries
- Wide range of capabilities
  - ■ Navigation
  - ■ Perception
  - ■ manipulation



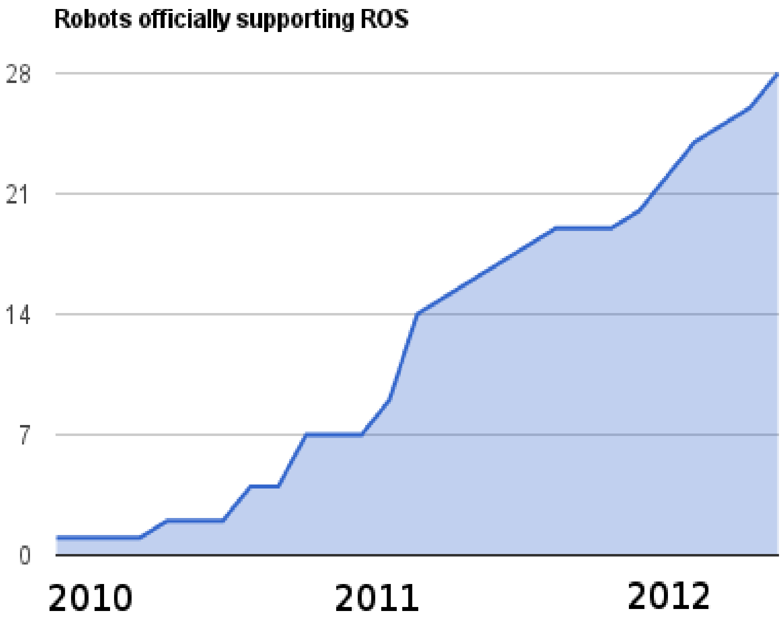
ROS – Community/Ecosysten

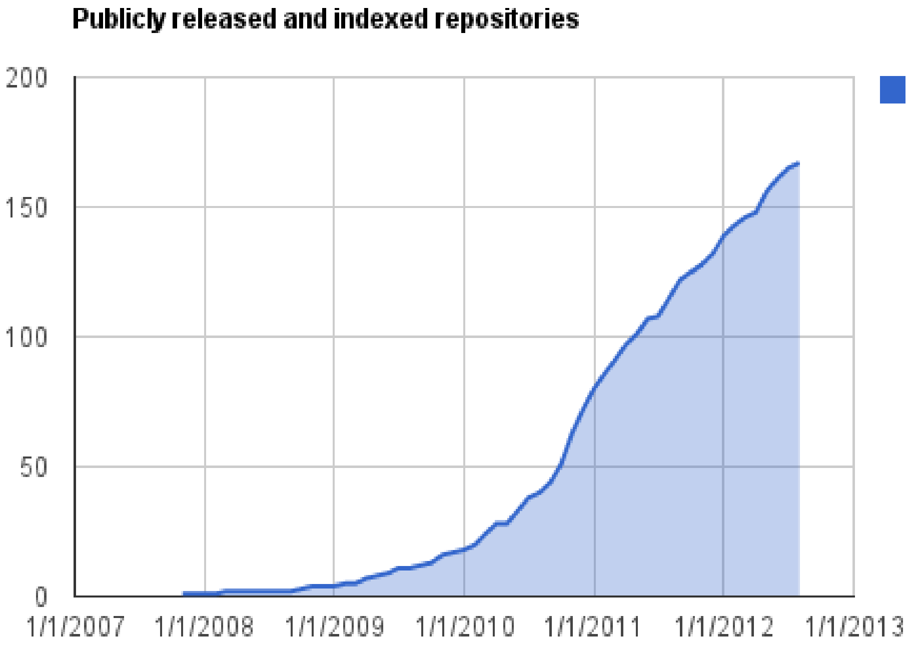


= Plumbing + Tools + Capabilities + Ecosystem

ROS – Community/Ecosysten

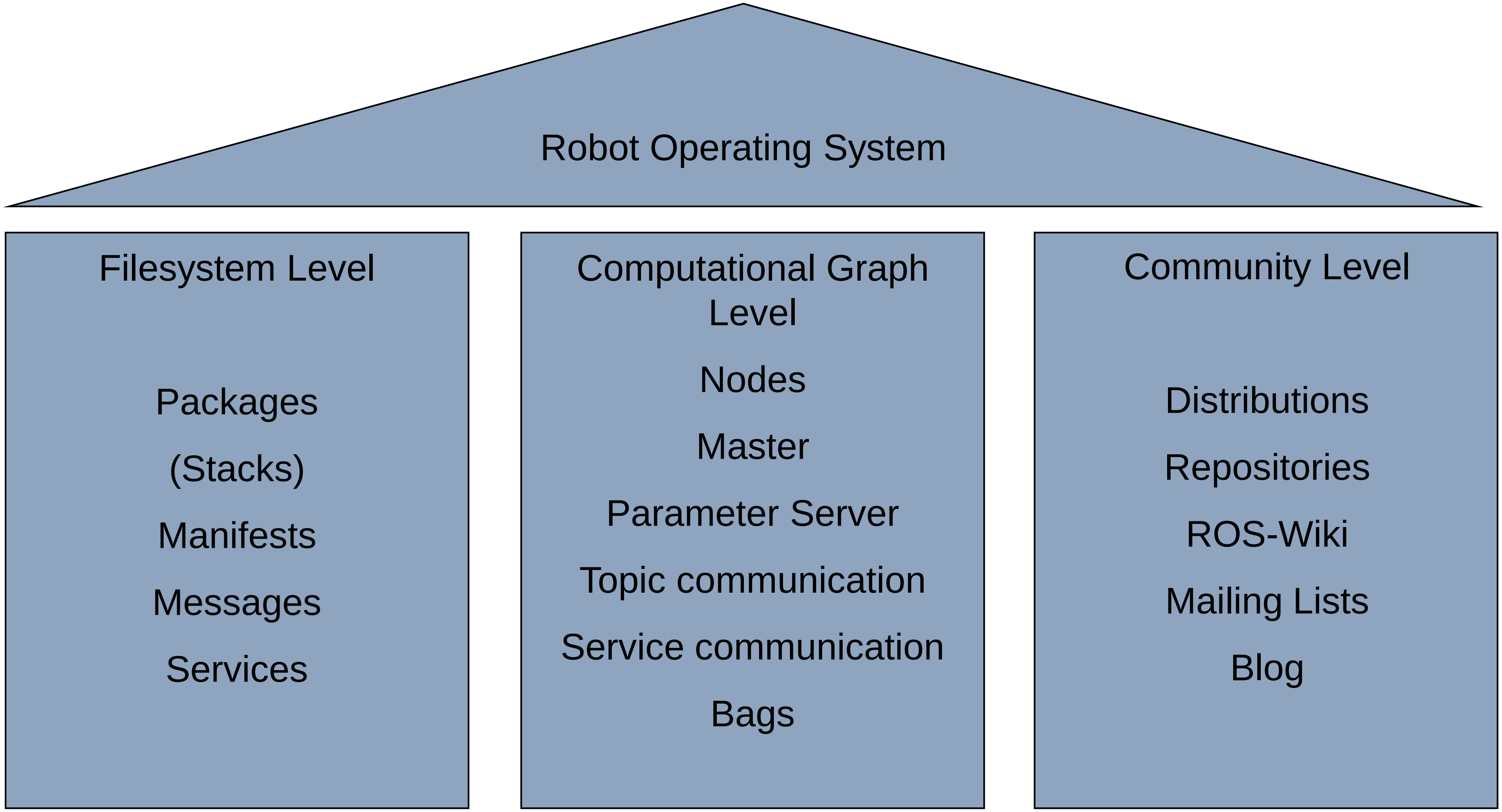
- Fast growing community
- De facto standard for service robotics





ROS – Technical details

Three levels of ROS concepts



Robot Operating System

Filesystem Level

Packages

(Stacks)

Manifests

Messages

Services

Computational Graph Level

Nodes

Master

Parameter Server

Topic communication

Service communication

Bags

Community Level

Distributions

Repositories

ROS-Wiki

Mailing Lists

Blog

http://ros.org/wiki/ROS/Concepts

ROS – Filesystem Level

- Packages
  - Main unit for organizing software
  - Typically one functionality, e.g. localisation or path planning
  - Contains: runtime processes (nodes), libraries, datasets, configuration files, …
- Stacks
  - Collection of packages
  - Aggregate functionality, e.g. navigation stack
  - Releases and versioning
- Stack- and Package- Manifests (*.xml)
  - Provide Metadata about a package/stack, e.g. license information and dependencies to other packages/stacks

→ http://ros.org/wiki/ROS/Concepts

ROS – Filesystem Level

- Messages types (*.msg)
  - Message descriptions, define data structures used for message communication
  - Language independent

TargetPoses.msg

```
Header header
Std_msgs/String name
Geometry_msgs/Pose2D[] poses
```

Pose2D.msg

```
Float64 x
Float64 y
Float64 theta
```

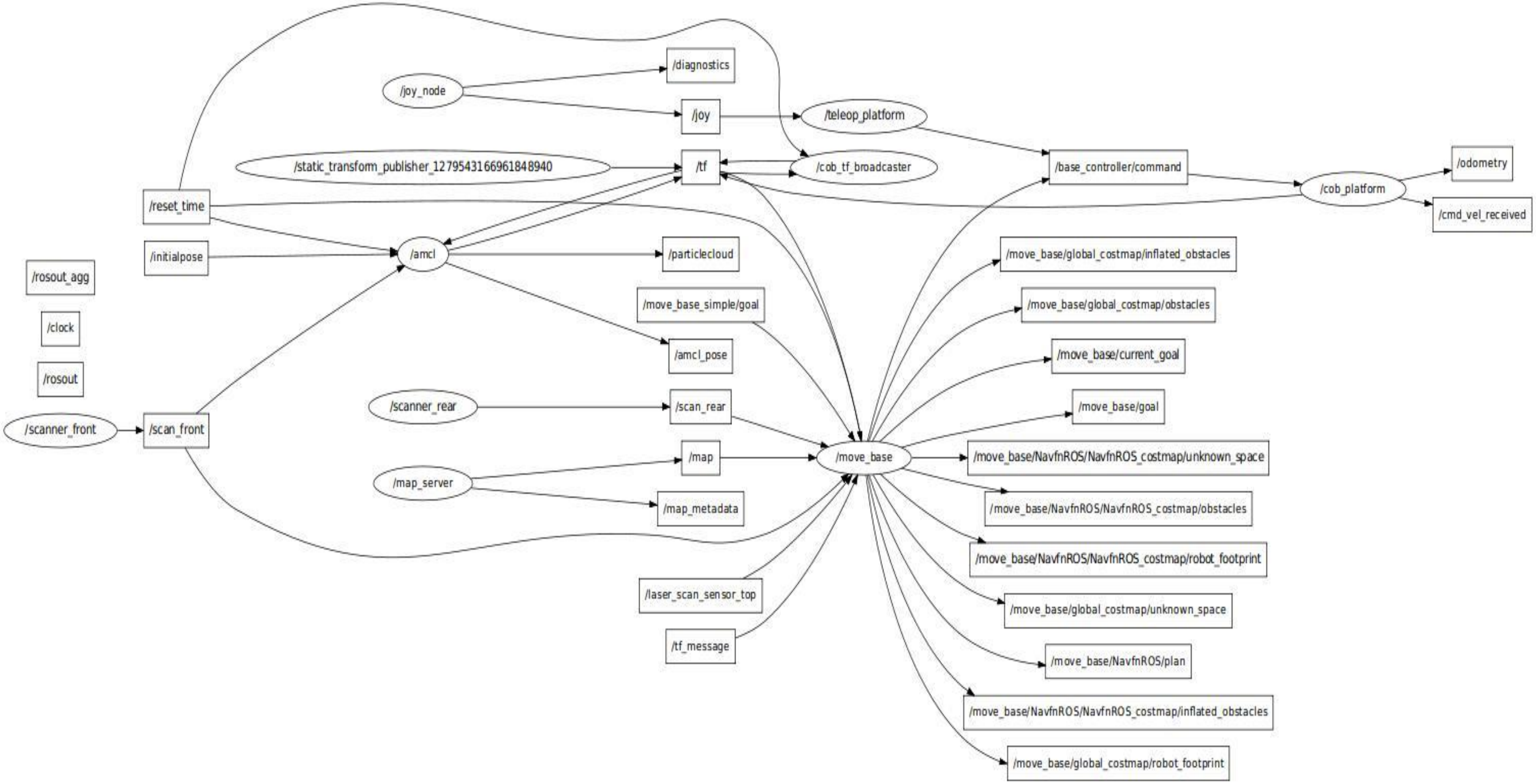
- Services types (*.srv)
  - Service descriptions, define request and response data structures used for service communication
  - Language independent

GetPose.srv

```
std_msgs/String name
--
Geometry_msgs/Pose2D pose
```

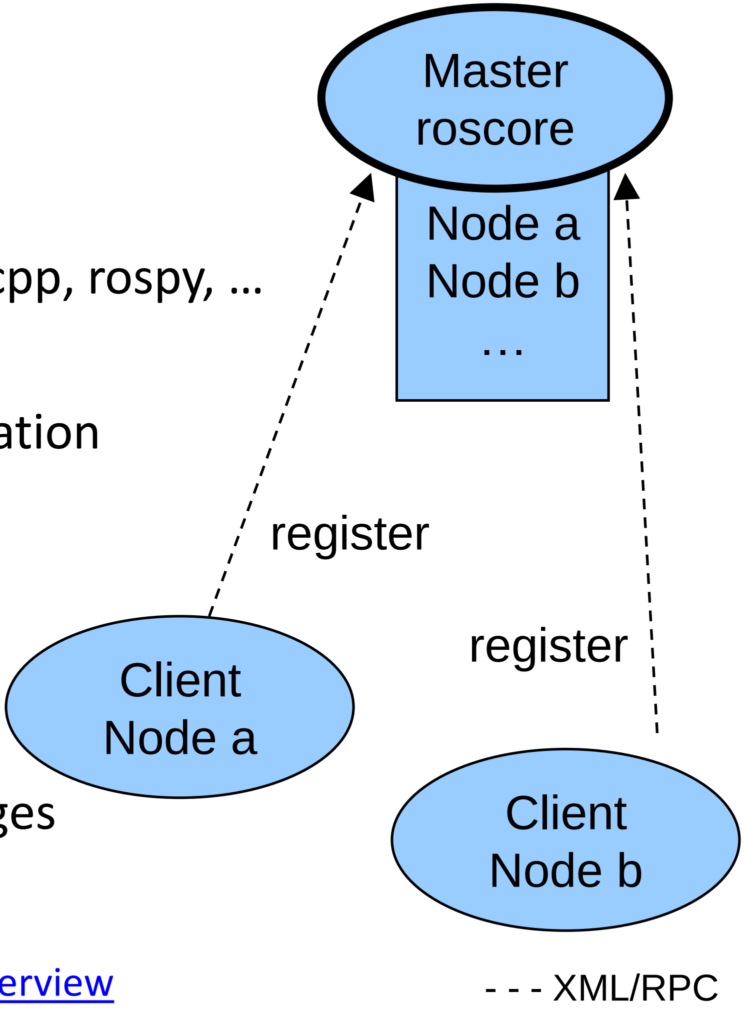
http://ros.org/wiki/msg, http://ros.org/wiki/srv

ROS – Computational Graph Level


/diagnostics
/joy_node
/joy
/teleop_platform
/static_transfom_publisher_1279543166961848940
/tf
/cob_tf_broadcaster
/base_controller/command
/odometry
/cob_platform
/cmd_vel_received
/reset_time
/initialpose
/amcl
/particlecloud
/rosout_agg
/clock
/rosout
/move_base_simple/goal
/amcl_pose
/move_base/global_costmap/inflated_obstacles
/move_base/global_costmap/obstacles
/move_base/current_goal
/move_base/goal
/scanner_rear
/scan_rear
/scanner_front
/scan_front
/map
/move_base
/map_server
/map_metadata
/move_base/NavfnROS/NavfnROS_costmap/unknown_space
/move_base/NavfnROS/NavfnROS_costmap/obstacles
/move_base/NavfnROS/NavfnROS_costmap/robot_footprint
/move_base/global_costmap/unknown_space
/laser_scan_sensor_top
/tf_message
/move_base/NavfnROS/plan
/move_base/NavfnROS/NavfnROS_costmap/inflated_obstacles
/move_base/global_costmap/robot_footprint

ROS – Computational Graph Level

- Nodes
  - Processes to perform computation
  - Usually many nodes at runtime
  - Written by a ROS client library, e.g. roscpp, rospy, …
- Master
  - Coordinating processes and communication
  - Name registration and lockup
- Parameter Server
  - Central location for storing data
- Messages
  - Nodes communicate by passing messages

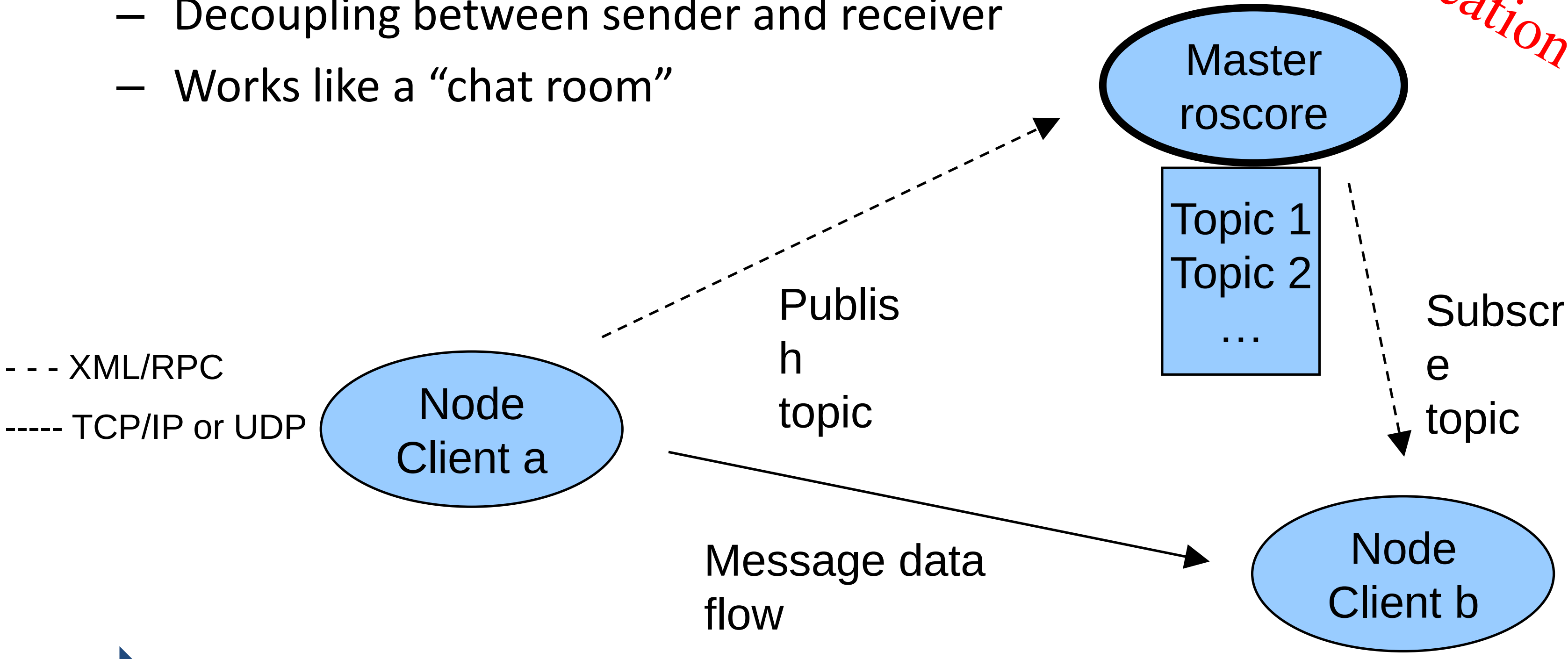


http://www.ros.org/wiki/ROS/Technical%20Overview

ROS – Communication concepts – topics

- Topics (asynchronous streaming)
  - Nodes can publish and subscribe to topics
  - Multiple publisher and subscriber to one topic
  - Decoupling between sender and receiver
  - Works like a “chat room”

Many-to-many, one-way communication



- - - XML/RPC

----- TCP/IP or UDP

Master roscore

Topic 1
Topic 2
…

Node Client a

Publish topic

Subscribe topic

Message data flow

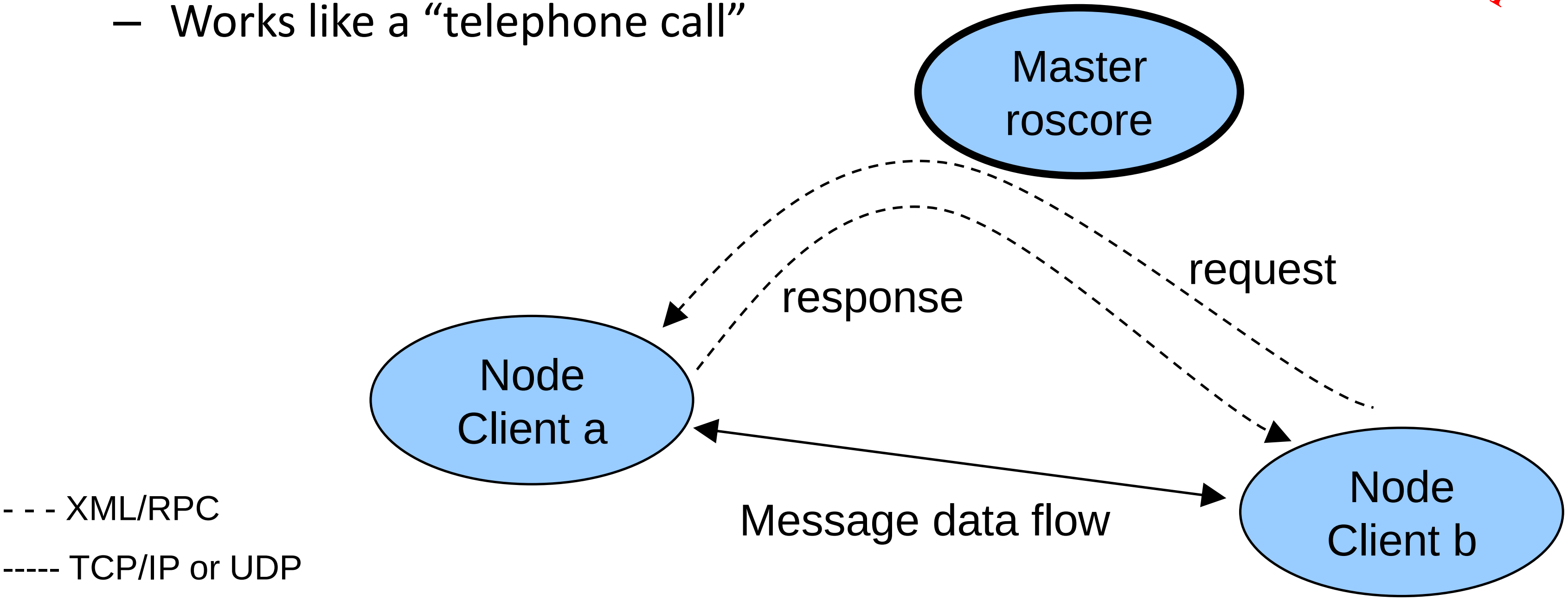
Node Client b

http://www.ros.org/wiki/Topics

ROS – Communication concepts – services

One-to-one, two-way communication

- Services (synchronous communication)
  - Request and reply interaction
  - Dedicated connection between two nodes
  - Works like a “telephone call”



http://www.ros.org/wiki/Services

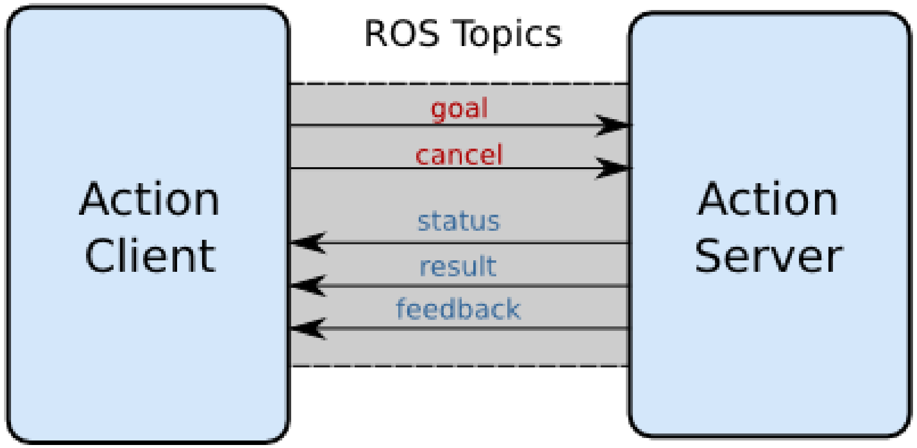
ROS – Communication concepts – actionlib

- Goal description similar to message and service definitions
- State-machine running on server and client

DetectBottle.action

```
#goal
std_msgs/String drink_name
---
#result
Geometry_msgs/Pose3D pose
---
#feedback
Int16 status
```

Action Interface



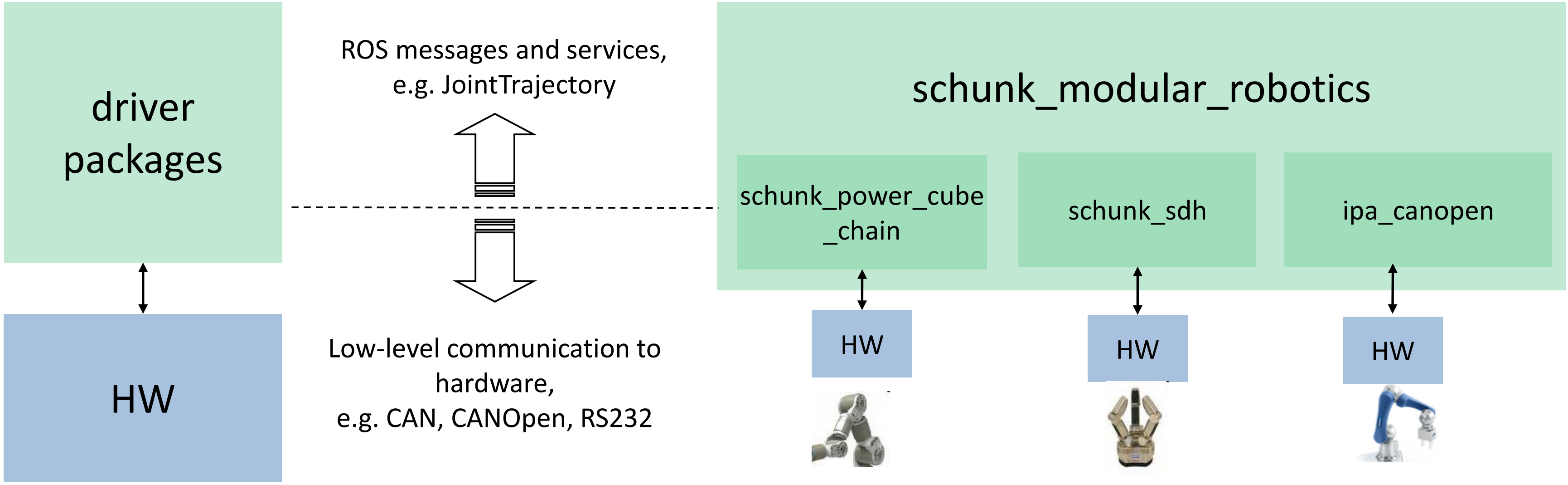
From Client
From Server

http://www.ros.org/wiki/actionlib

ROS support of Schunk components

ROS for Schunk components

- Devices supported in ROS
  - SDH (Schunk Dextrous Hand, SDH library)
  - LWA (Lightweight Arm, M5API)
  - Powerball (Powerball arm, CanOpen)



driver packages

HW

ROS messages and services, e.g. JointTrajectory

Low-level communication to hardware, e.g. CAN, CANOpen, RS232

schunk_modular_robotics

schunk_power_cube_chain

schunk_sdh

ipa_canopen

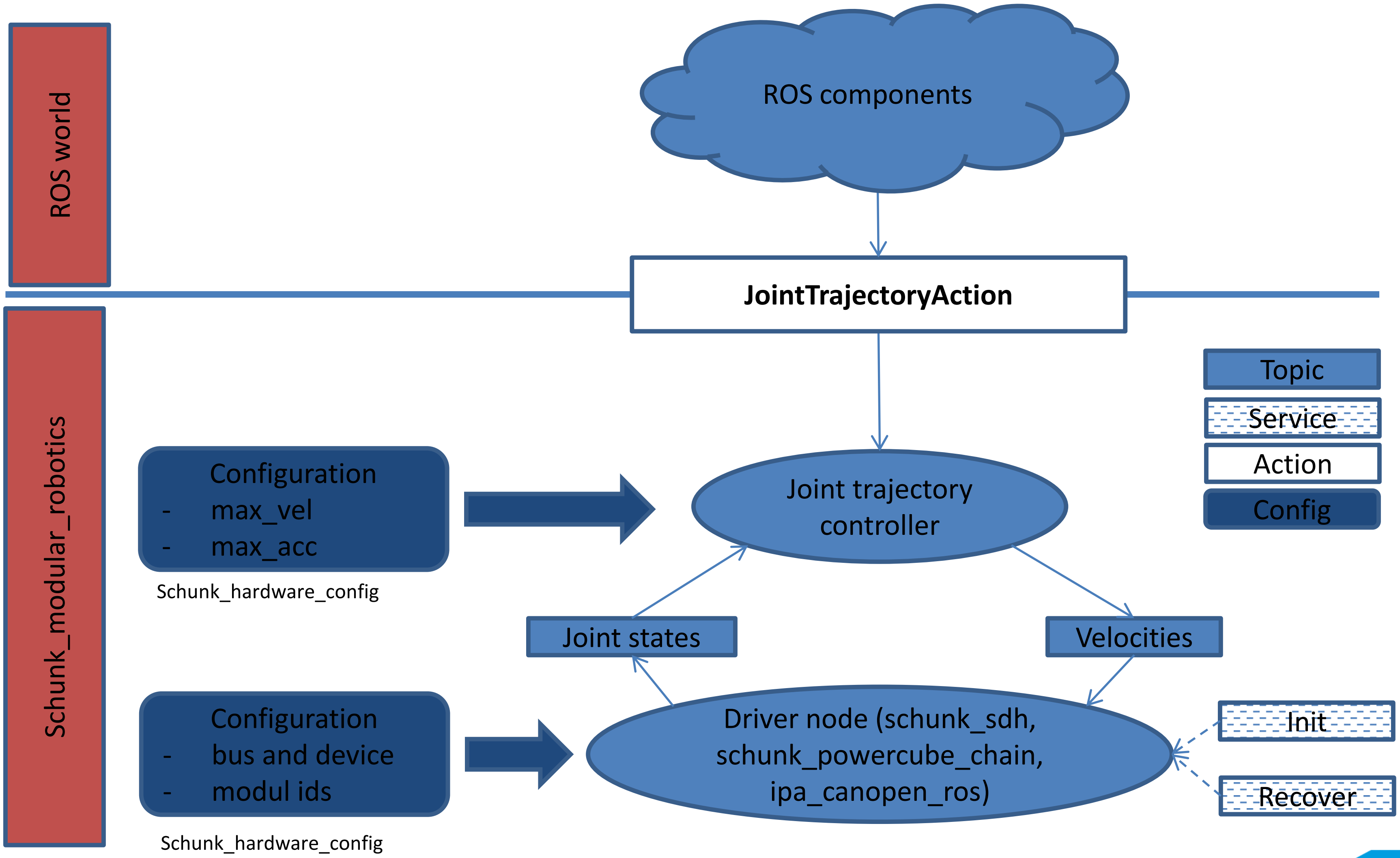
HW

HW

HW

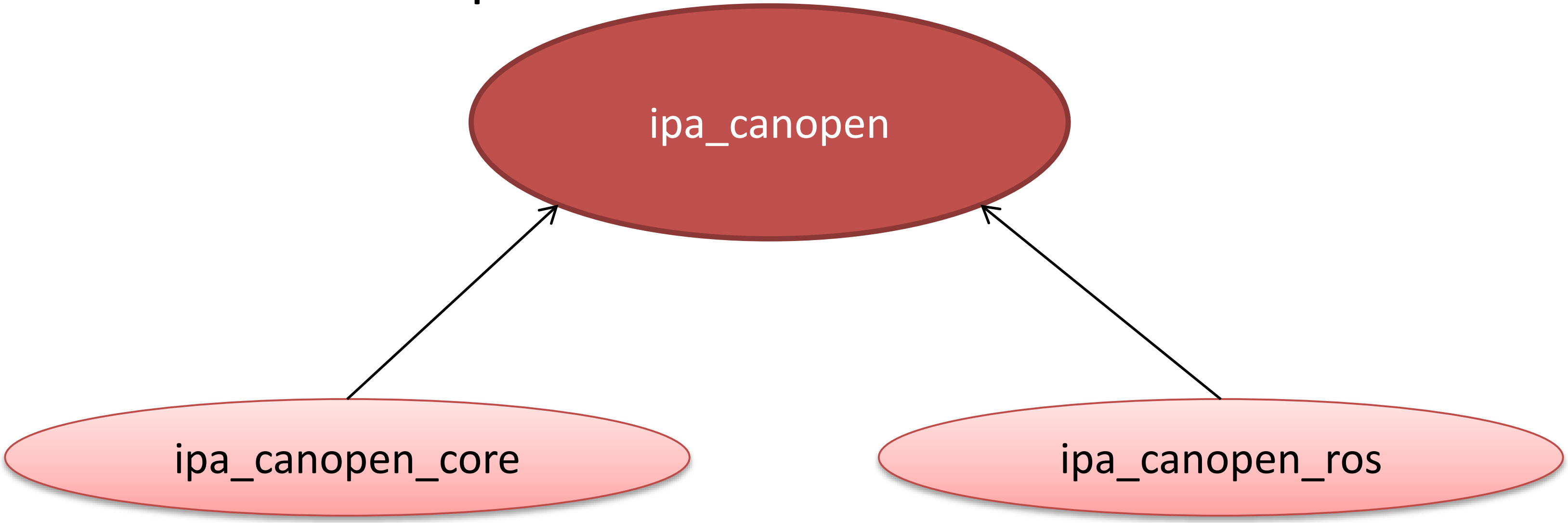
http://www.ros.org/wiki/schunk_modular_robotics

SW Architecture



CanOpen Architecture

- C++ framework
- Enables communication with CANopen motor devices
- Uses the pcan device driver
- Consists of two parts



http://www.ros.org/wiki/ipa_canopen

Installation and Operation Instructions

Installation and Operation Instructions

- 3 options of usage:
  1. Use low-level drivers independent of ROS: ipa_canopen_core
  2. Use low-level ROS-drivers: ipa_canopen_ros
  3. Use full ROS package with trajectory controllers: schunk_robots

Installing ROS for Schunk components for Groovy

- Install Ubuntu 12.04
- Install ROS Groovy
  http://www.ros.org/wiki/groovy/Installation/Ubuntu
- Download Schunk repositories to your ROS_PACKAGE_PATH
    - *mkdir <<YOUR ROS_PACKAGE_PATH>>, e.g. ~/git/schunk_robots*
    - *cd <<YOUR ROS_PACKAGE_PATH>>*
    - *rosinstall . https://raw.github.com/ipa320/schunk_robots/groovy_dev/groovy.rosinstall*
    - *echo “export ROS_PACKAGE_PATH=<<YOUR ROS_PACKAGE_PATH>>:$ROS_PACKAGE_PATH” >>~/.bashrc*
    - *Source ~/.bashrc*
  - Install additional dependencies
    - *sudo apt-get install ros-groovy-pr2-controllers ros-groovy-arm_navigation ros-groovy-arm-navigation-experimental ros-groovy-audio-common ros-groovy-pr2-power-drivers ros-groovy-pr2-gui*
  - Build Schunk packages
    - *rosdep install schunk_robots*
    - *rosmake schunk_robots*
  - Configure your hardware (Example for powerball)
    - *roscd schunk_hardware_config/powerball/config*
    - Modify canopenmaster.yaml, see slide 49

Installing ROS for Schunk components for Groovy

- Run driver (Example for lwa with M5API)
  - *roslaunch schunk_bringup powerball_solo.launch*
- Move with dashboard (Example for lwa with M5API)
  - *roslaunch schunk_bringup dashboard_powerball.launch*

Installation and Operation Instructions

IPA CANopen Installation – ROS package

- To install the IPA CANopen ROS package

```
-   git clone git://gitub.com/ipa320/ipa_canopen.git
-   rosmake ipa_canopen_ros
```

IPA CANopen Installation (without ROS)

- CMake (to manage the build process), in Ubuntu use the command

```
sudo apt-get install cmake
```

- Git (to download the sources from github) in Ubuntu use the command

```
sudo apt-get install git
```

- A C++ compiler with good support for the C++11 Standard

IPA CANopen Installation (without ROS)

- To install the C++ library independently from ROS

```
-   git clone git://github.com/ipa320/ipa_canopen.git
-   cd ipa_canopen/ipa_canopen_core
-   mkdir build
-   cd build
-   cmake ..
-   make
```

- To use the two command line tools, change the directory

```
cd ipa_canopen/ipa_canopen_core/bin
```

Technical details CANOpen

ipa_canopen_core

- ROS independent library
- Provides three command line tools (in ipa_canopen/ipa_canopen_core/bin)
  - Homing (takes two arguments)
    - Name of the devicefile
    - CANdevice ID of the module
    - E.g.
      ```
      ./homing /dev/pcan32 12
      ```
  - Move device (takes five argumtents)
    - Name of the devicefile
    - CAN device ID of the module
    - Synchronization time
    - Target velocity in rad/msec
    - Target acceleration in rad/msec^2
    - E.g.
      ```
      ./move_device /dev/pcan32 12 10 0.05 0.01
      ```
  - Get Errors(takes two arguments)
    - Name of the devicefile
    - CANdevice ID of the module
    - E.g.
      ```
      ./get_error /dev/pcan32 12
      ```

➡ http://www.ros.org/wiki/ipa_canopen_core

ipa_canopen_ros

- Wrapper to control CANopen motor devices in ROS
- Two ways to launch the node
    - Direct

```
rosrun ipa_canopen_ros ipa_canopen
```

    - Via a launchfile, e.g.

```
roslaunch schunk_bringup powerball_solo.launch
```

- In order to use the node you need
    - A trajectory controller
    - A rudimentary robot model (urdf)
  - For a list of services, subcribed and published topics and necessary parameters on the parameter server follow the link below

→ http://www.ros.org/wiki/ipa_canopen_ros

Moving the Schunk LWA 4.P (Powerball) arm with schunk_robots

Driving the Schunk LWA 4.P (Powerball) arm

- Make sure you have the following two repositories on your pc
    - ipa320/schunk_robots.git
    - ipa320/schunk_modular_robotics.git
  - If not

```
-   git clone git://github.com/ipa320/schunk_robots.git
-   git clone git://github.com/ipa320/schunk_modular_robotics.git
```

  - To launch the CANopen driver together with a trajectory controller

```
roslaunch schunk_bringup powerball_solo.launch
```

  - To launch the Powerball-arm in Gazebo

```
roslaunch schunk_bringup_sim powerball.launch
```

  - To move the arm with a graphical command GUI

```
roslaunch schunk_bringup dashboard_powerball.launch
```

  - To configure the necessary yaml-files: check the next slides

Configuring the Schunk LWA 4.P (Powerball) arm I

- Change directory

```
roscd schunk_hardware_config/powerball/config
```

- Modify canopenmaster.yaml e.g.

```
devices:
    - name: /dev/pcan32
      baudrate: 500K
      sync_interval: 10
chains: [“arm_controller“]
```

Configuring the Schunk LWA 4.6 (Powerball) arm II

- Change directory

```
roscd schunk_hardware_config/powerball/config
```

- Modify powerball.yaml e.g.

```
# canopen parameters
can_module: PCAN
can_baudrate: 1000
max_accelerations: [0.8, 0.8, 0.8, 0.8, 0.8, 0.8]
OperationMode: position

joint_names: [“arm_1_joint”, “arm_2_joint”, “arm_3_joint”, “arm_4_joint”, “arm_5_joint”,
“arm_6_joint”]
module_ids: [3, 4, 5, 6, 7, 8]
devices: [“/dev/pcan32”, “/dev/pcan32”, “/dev/pcan32”, “/dev/pcan32”, “/dev/pcan32”,
“/dev/pcan32”]

# trajectory controll parameters
ptp_vel: 0.4 # rad/sec
ptp_acc: 0.1 # rad/sec²
max_error: 0.2 # rad
frequency: 100
```

Configuring the Schunk LWA 4.6 (Powerball) arm III

- Change directory

```
roscd schunk_default_config/config
```

- Modify powerball_joint_configurations.yaml e.g.

```
joint_names:
["arm_1_joint","arm_2_joint","arm_3_joint","arm_4_joint","arm_5_joint","arm_6_joint"]

# back side positions
home: [[0,0,0,0,0,0]]
folded: [[0.32108866388214263, 0.6484189832579226, 2.06286710514828, -
1.2376313006847157, 5.658013215042093, -7.150174321779446e-05]]
wave_left: [[0.321033880484058, 0.49950722659008573, -0.4061025056033145, -
0.2370251233291425, 5.300248440143207e-06, 9.462633828505318e-06]]
wave_right: [[0.4741062629069983, -0.7912476227793528, 0.0041526706870680385, -
2.4662076334003302e-05, 2.4489075676648042e-05, 8.393716051102729e-06]]

# trajectories
wave_left-wave_right-home: [wave_left,wave_right,home]
```

Moving the Schunk LWA 4.D (Dextrous) arm schunk_robots

Driving the Schunk LWA 4.P (Powerball) arm

- Make sure you have the following two repositories on your pc
    - ipa320/schunk_robots.git
    - ipa320/schunk_modular_robotics.git
  - If not

```
-   git clone git://github.com/ipa320/schunk_robots.git
-   git clone git://github.com/ipa320/schunk_modular_robotics.git
```

  - To launch the CANopen driver together with a trajectory controller

```
roslaunch schunk_bringup powerball_solo.launch
```

  - To launch the Powerball-arm in Gazebo

```
roslaunch schunk_bringup_sim powerball.launch
```

  - To move the arm with a graphical command GUI

```
roslaunch schunk_bringup dashboard_powerball.launch
```

  - To configure the necessary yaml-files: check the next slides

Configuring the Schunk LWA 4.P (Powerball) arm I

- Change directory

```
roscd schunk_hardware_config/powerball/config
```

- Modify canopenmaster.yaml e.g.

```
devices:
        - name: /dev/pcan32
          baudrate: 500K
          sync_interval: 10
chains: [“arm_controller“]
```

Configuring the Schunk LWA 4.6 (Powerball) arm II

- Change directory

```
roscd schunk_hardware_config/powerball/config
```

- Modify powerball.yaml e.g.

```
# canopen parameters
can_module: PCAN
can_baudrate: 1000
max_accelerations: [0.8, 0.8, 0.8, 0.8, 0.8, 0.8]
OperationMode: position

joint_names: [“arm_1_joint”, “arm_2_joint”, “arm_3_joint”, “arm_4_joint”, “arm_5_joint”,
“arm_6_joint”]
module_ids: [3, 4, 5, 6, 7, 8]
devices: [“/dev/pcan32”, “/dev/pcan32”, “/dev/pcan32”, “/dev/pcan32”, “/dev/pcan32”,
“/dev/pcan32”]

# trajectory controll parameters
ptp_vel: 0.4 # rad/sec
ptp_acc: 0.1 # rad/sec²
max_error: 0.2 # rad
frequency: 100
```

Configuring the Schunk LWA 4.6 (Powerball) arm III

- Change directory

```
roscd schunk_default_config/config
```

- Modify powerball_joint_configurations.yaml e.g.

```
joint_names:
["arm_1_joint","arm_2_joint","arm_3_joint","arm_4_joint","arm_5_joint","arm_6_joint"]

# back side positions
home: [[0,0,0,0,0,0]]
folded: [[0.32108866388214263, 0.6484189832579226, 2.06286710514828, -
1.2376313006847157, 5.658013215042093, -7.150174321779446e-05]]
wave_left: [[0.321033880484058, 0.49950722659008573, -0.4061025056033145, -
0.2370251233291425, 5.300248440143207e-06, 9.462633828505318e-06]]
wave_right: [[0.4741062629069983, -0.7912476227793528, 0.0041526706870680385, -
2.4662076334003302e-05, 2.4489075676648042e-05, 8.393716051102729e-06]]

# trajectories
wave_left-wave_right-home: [wave_left,wave_right,home]
```

Schunk Demo

Save new positions for the ROS parameter server:

```
rosrun schunk_demo save_position.py -p <position>
```

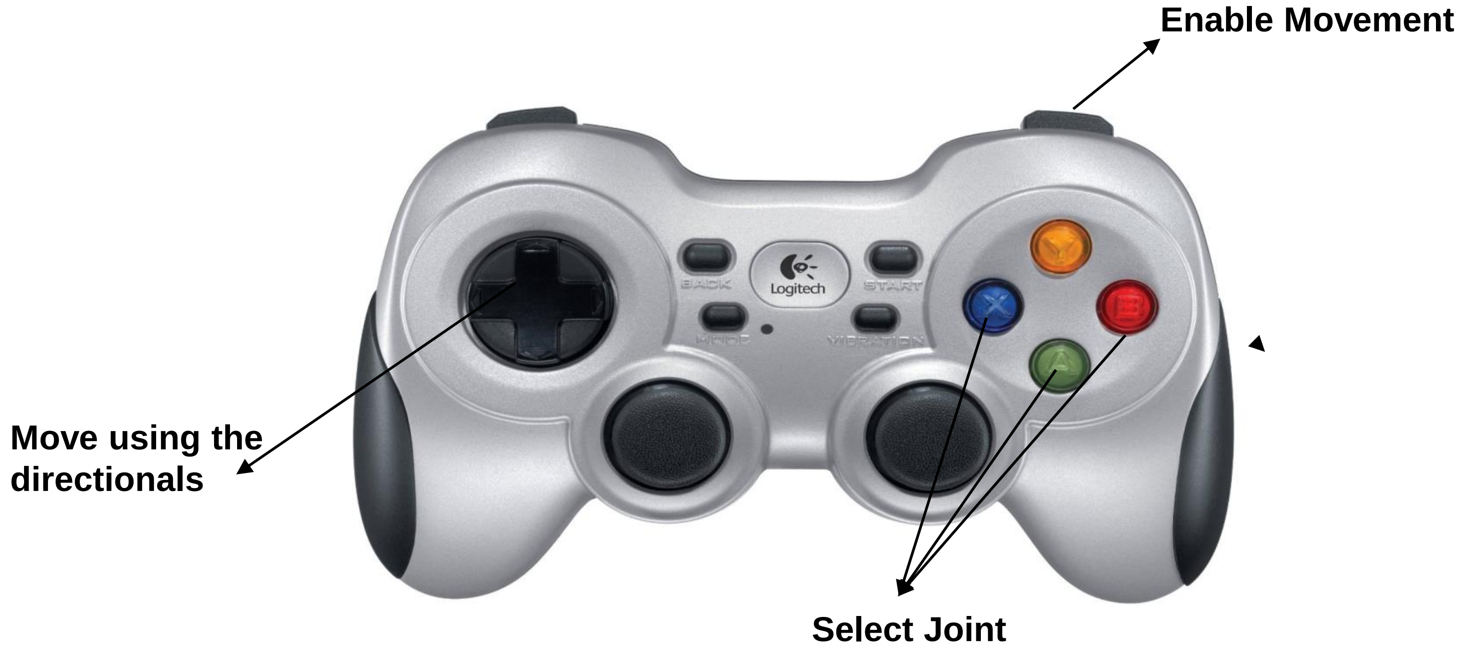
- home
- folded
- waveright
- waveleft

Moving through all the predefined positions:

```
rosrun schunk_demo demo_arm.py
```

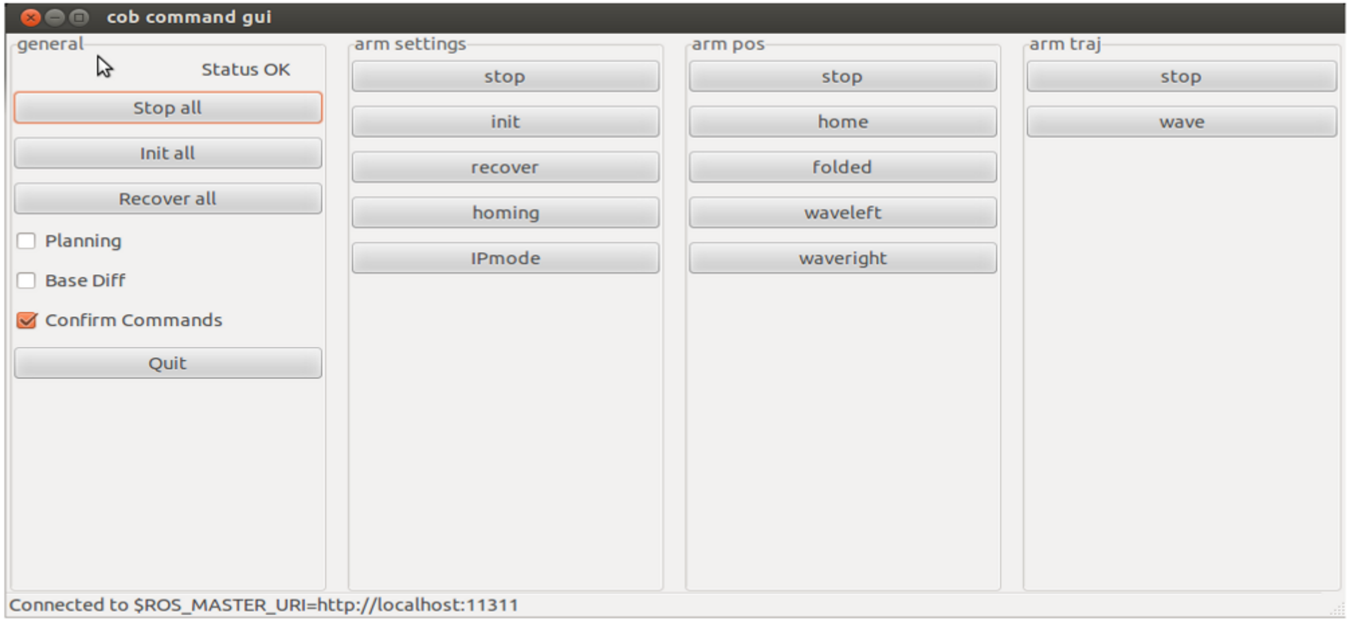
Moving with the joystick

The joystick node is automatically loaded from the schunk_bringup.



ROS for Schunk components – command gui

- Tool to easily move arm or hand
- Buttons for initializing and recover
- Buttons to move components in joint space
- *“roslaunch schunk_bringup dashboard_lwa.launch”*



Status OK

□ Planning

□ Base Diff

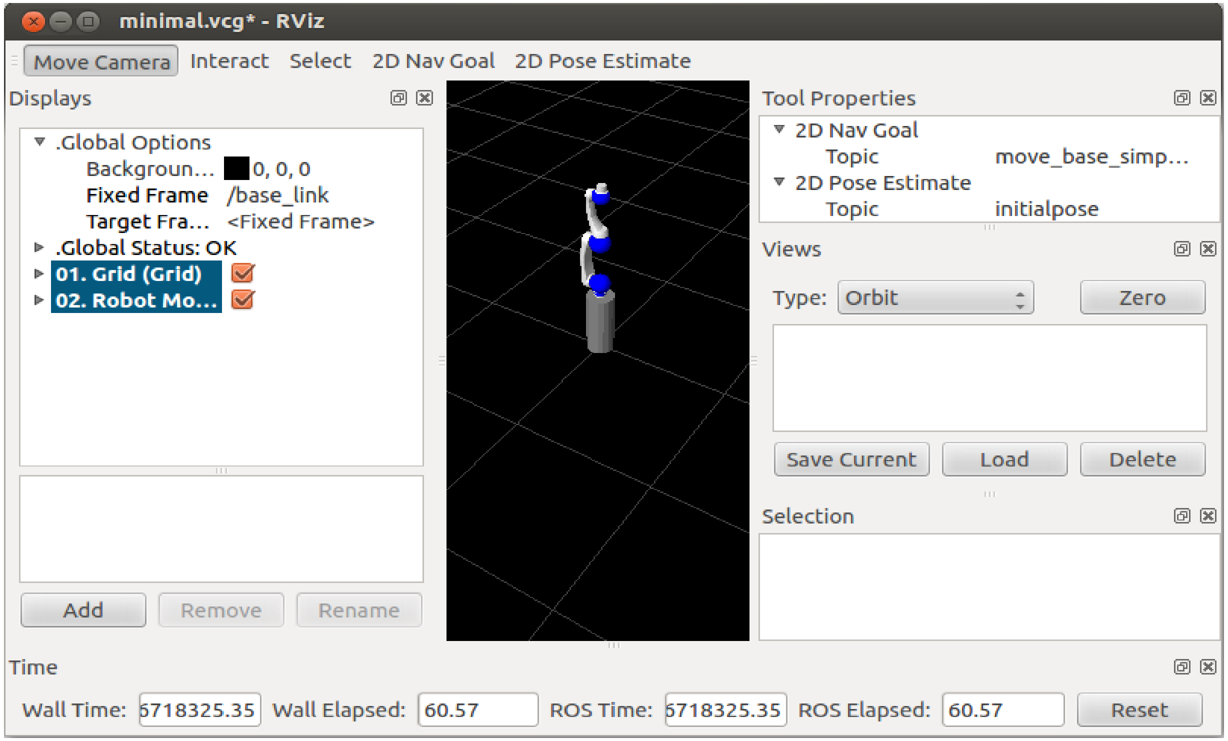
☑ Confirm Commands

Connected to $ROS_MASTER_URI=http://localhost:11311

http://www.ros.org/wiki/cob_command_gui

ROS for Schunk components – rviz

- Tool to visualize robot model
- *“roslaunch schunk_bringup rviz.launch”*



.Global Options
Backgroun… 0, 0, 0
Fixed Frame /base_link
Target Fra… <Fixed Frame>
.Global Status: OK
01. Grid (Grid) ☑
02. Robot Mo… ☑

2D Nav Goal
Topic move_base_simp…
2D Pose Estimate
Topic initialpose

Type: Orbit

Wall Time: 6718325.35 Wall Elapsed: 60.57 ROS Time: 6718325.35 ROS Elapsed: 60.57

http://www.ros.org/wiki/rviz

Thank you for your attention

ROS → SCHUNK®

Contact:

www.schunk-modular-robotics.com
www.ros.org/wiki/schunk_modular_robotics

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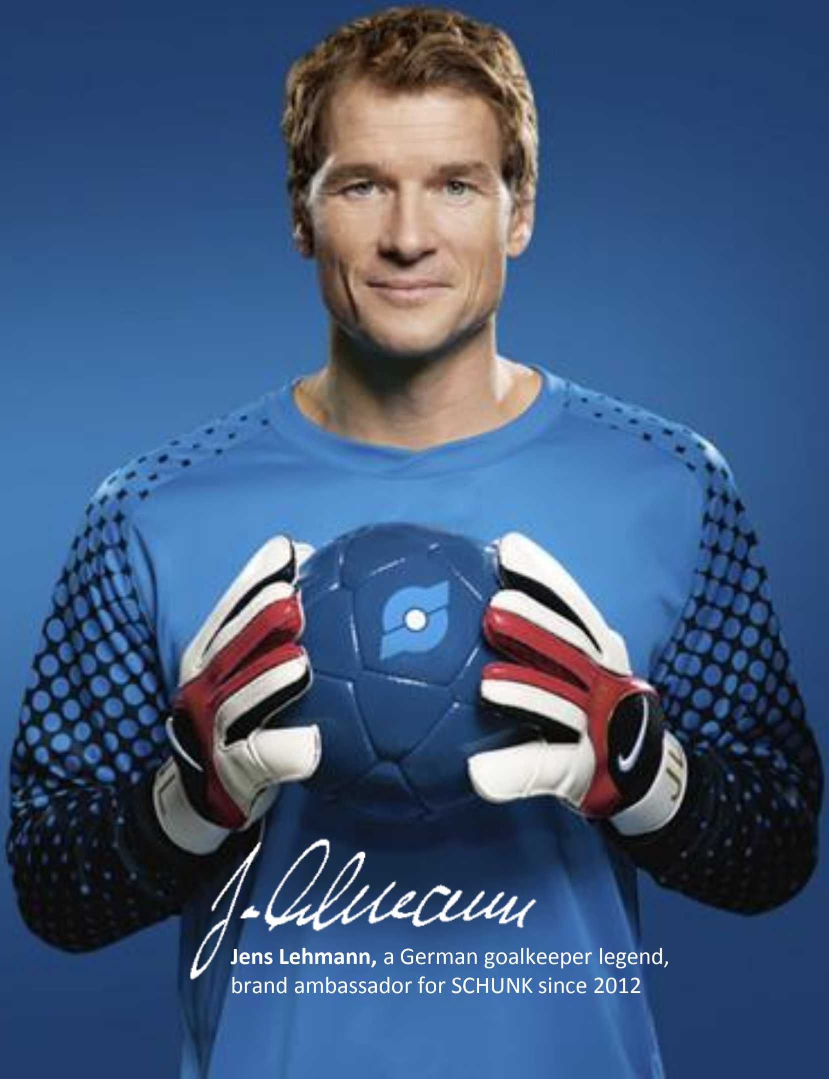
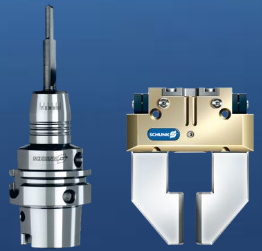


Jens Lehmann, a German goalkeeper legend,
brand ambassador for SCHUNK since 2012



www.schunk.com