Robot Operating System

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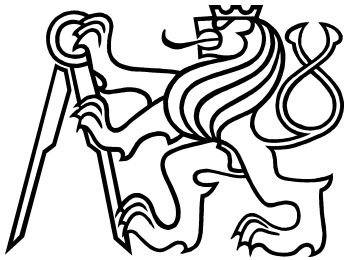

Czech Technical University
Cybernetics and Robotics

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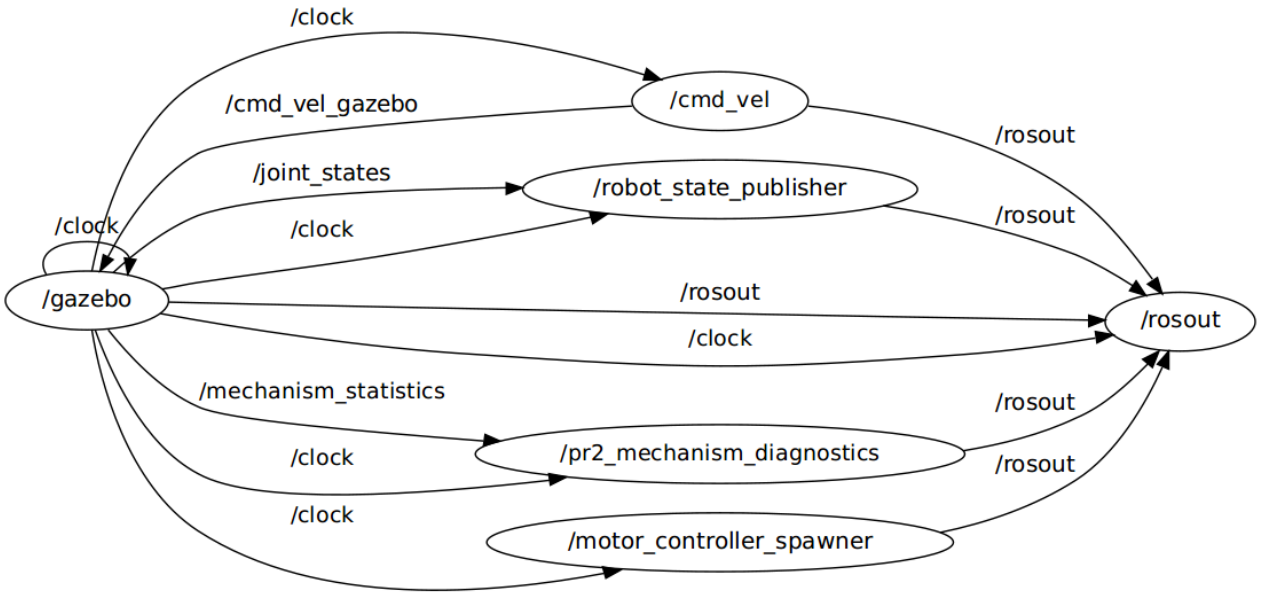
Motivation

Clopema video: Repet_grasp_garment_1
Alpaca video: tazibot

ROS

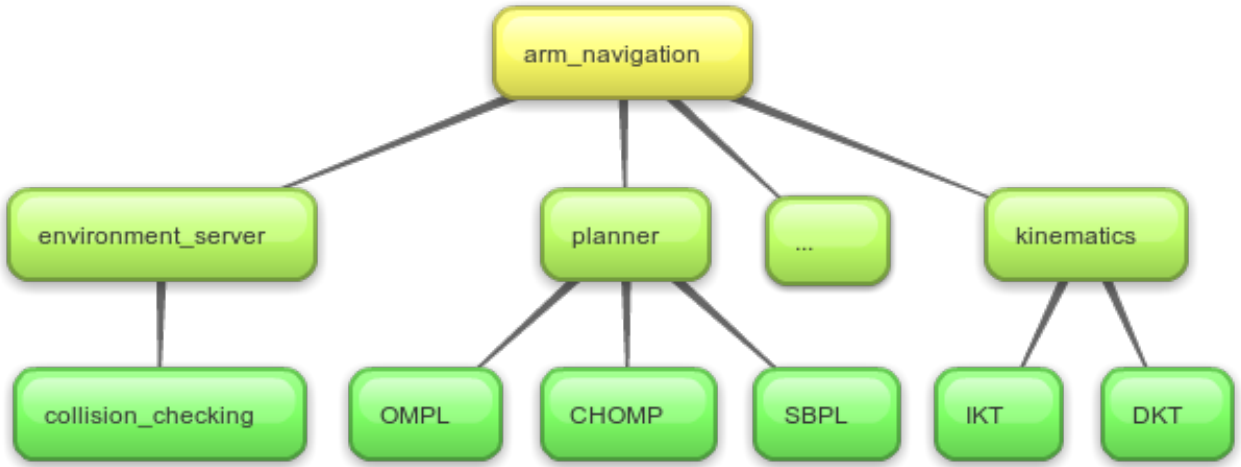
- 5 years old
- Willow Garage $\rightarrow$ OSRF
- Ubuntu
- Meta-operating system
  - Process communication
  - Package management
  - Hardware abstraction
  - Language independence (Python, C++, Lisp)

Simple application



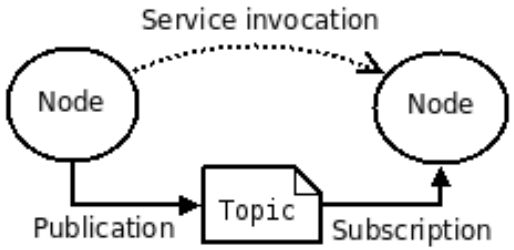
File System Level

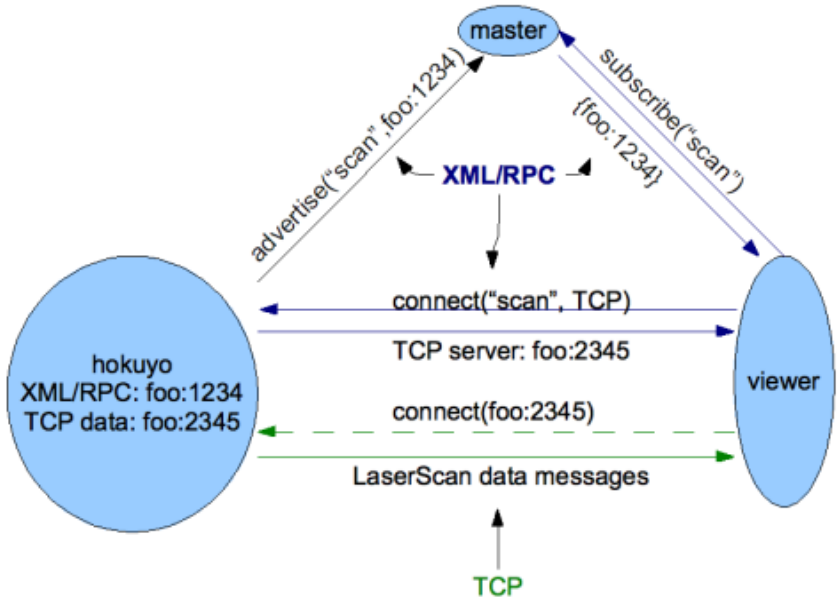
- Node
- Package
- Stack



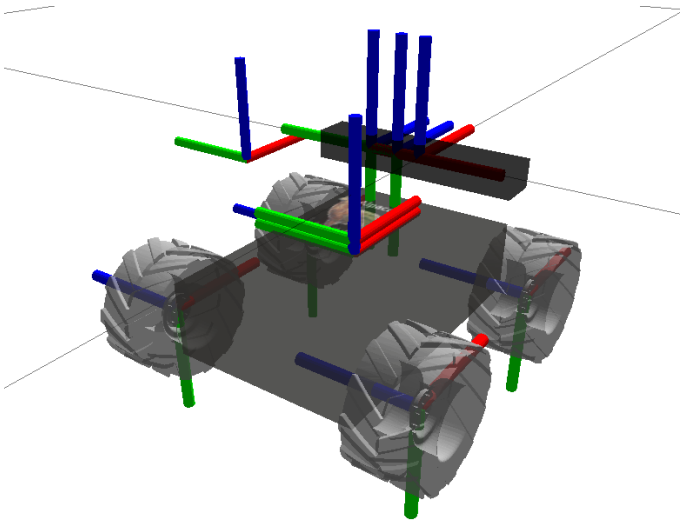
Concepts

- Master (roscore)
- Topics, publisher - subscriber architecture
- Services, client - server architecture
- Parameter Server
- Bagfiles





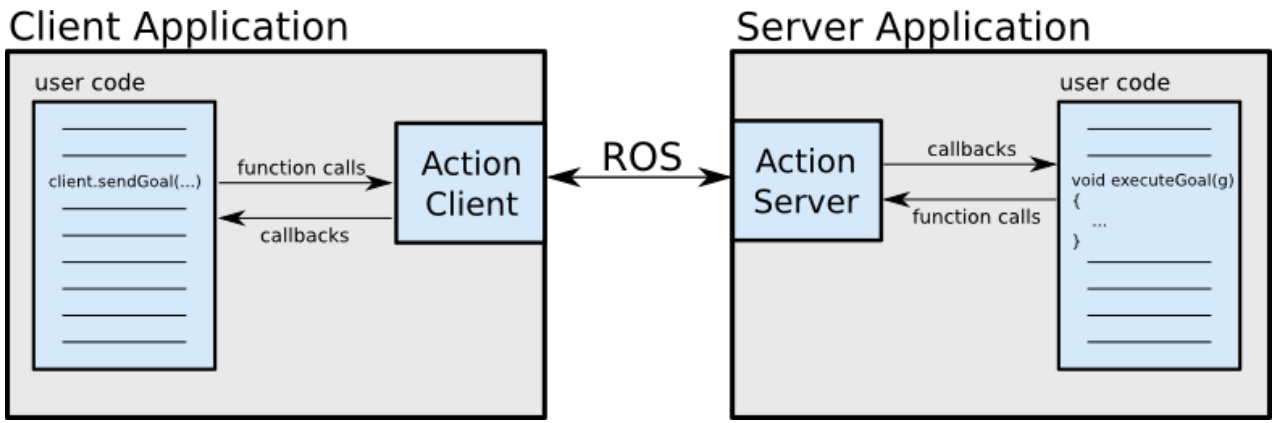
Transformation (tf)



- Transformation in tree structure
- Any transformation relative to any frame
- Buffered in time

Actions (actionlib)

- For preemptable tasks / Longtime running tasks
- For example *Goto*
  - Planning
  - Filtering
  - Trajectory execution



Practical Implementation

Contents

- Common packages, visualization, robot model, simulators
- Packages for mobile robots
- Packages for manipulators
- State Machine

RVIZ

3D visualization tool for ROS

- Marker, Markers Array
- Point cloud
- Images
- 2D Map

VIDEO: polyg_1_inv

URDF, Xacro

Unified Robot Description Format

- XML format
- links (origin, visual and collision model, color)
- joints (origin, type)

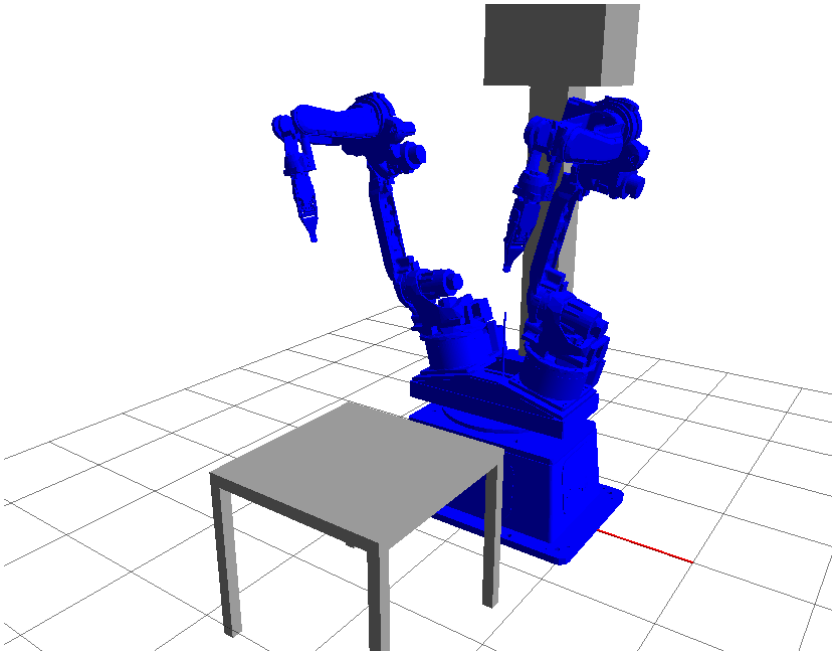
Xacro

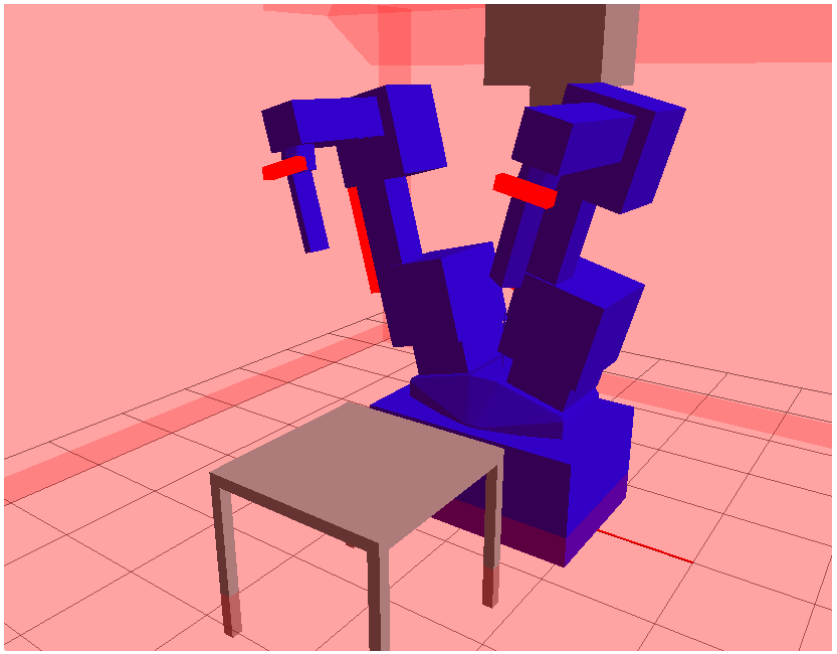
- XML macro language
- more readable XML
- macros, parameters, maths

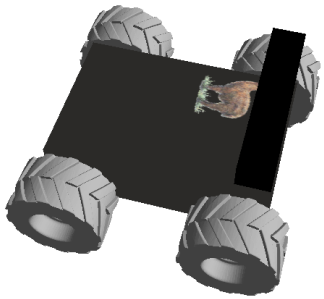
URDF, Xacro

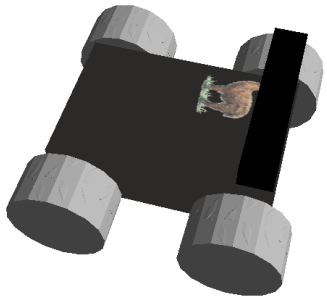
```
1  <xacro:macro name="table_leg" params="*origin parent suffix color height">
2      <link name="${suffix}">
3          <xacro:default_inertial/>
4          <visual>
5              <geometry>
6                  <box size="0.05 0.05 ${height-0.050}" />
7              </geometry>
8              <material name="${color}" />
9              <origin xyz="0 0 -${(height+0.05)/2}"/>
10         </visual>
11     </link>
12     <joint name="${suffix}joint_ftable_leg" type="fixed">
13         <insert_block name="origin" />
14         <parent link="${parent}"/>
15         <child link="${suffix}"/>
16     </joint>
17 </xacro:macro>
```

URDF, Xacro









Gazebo

Video: Alpaca in gazebo (alpaca_teleop)
Why not Clopema in gazebo?

- Started in 2002
- In 2009 interface to ROS was created
- In 2011 WG started providing financial support
- In 2013 OSRF started providing financial support

- Multi-robot simulator for outdoor environments
- Most users use it for indoor environments
- Plenty of sensors (laser, camera, kinect, *GPS*)

Mobile robot

Typical sensors

- Mechanical odometry
- Camera
- Laser range finder (kinect)
- IMU

Convention in ROS

- Control: topic *cmd_vel* [geometry_msgs/Twist]
- Feedback: topic *odom* [sensor_msgs/Odometry]

Mobile robot

Typical problems solved by move_base stack

- Mapping (2D, 3D)
- Localization
- SLAM (Simultaneous Localization and Mapping)
- Reactive (local) planner
- Global planner
- Actionlib interface

Videos: par12_final_slow

Manipulators

- Kinematics (DKT, IKT - numerical, OpenRave),
- Collision checking, geometrical constraints support
- Motion planners (OMPL, SBPL, CHOMP)
- Trajectory filters
- Actionlib interface

Videos: CAIK, simple_plan, plan_out_of_vision

SMACH

- State MACHine
- Higher-Level behaviours
- Hierarchical (every state machine is state)
- Concurrence containers (parallel)

- Outcomes
- Userdata
- Implemented interface to services and actions

Video: ICRA_MAP_BUILDING

ROS

Conclusion

- Nodes, Packages, Stacks
- Topics, Services, Parameters, Transformations, Actions

Implementation

- Node for hardware interface
- Node for controller
- Create robot model
- Generate configuration files using wizard
- Higher level tasks with SMACH

References

Questions?

References:

- www.ros.org
- www.gazebosim.org
- www.moveit.ros.org
- www.osrfoundation.org
- www.willowgarage.com