Robot Programming with Lisp

7. Coordinate Transformations, TF, ActionLib

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Outline

Theory
- Coordinate Transformations
- TF
- ActionLib

Organizational

Outline

Poses in 3D Space

Point in 3D: *{x, y, z}*

3D-Vector

```
CL-TRANSFORMS> (make-3d-vector 1 2 3)
#<3D-VECTOR (1.0d0 2.0d0 3.0d0)>
CL-TRANSFORMS> (describe *)
#<3D-VECTOR (1.0d0 2.0d0 3.0d0)>
  [standard-object]
Slots with :INSTANCE allocation:
  X   = 1.0d0
  Y   = 2.0d0
  Z   = 3.0d0
CL-TRANSFORMS> (y **)
2.0d0
```

Object in 3D: *{position, orientation}*

- Position: *{x, y, z}*
- Orientation: axis-angle / rotation matrix / quaternions / ...

Theory Organizational

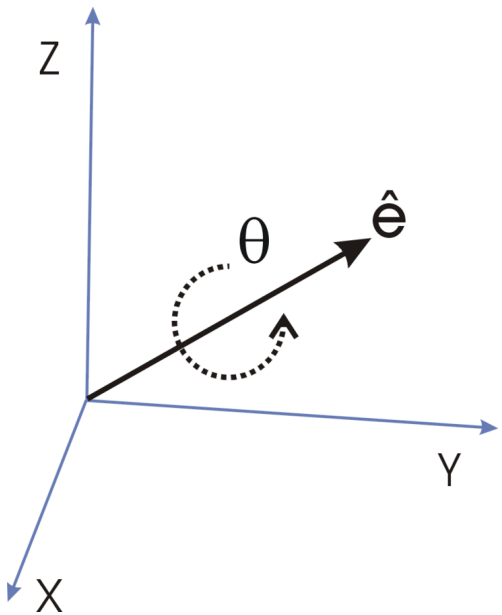
Representing Rotations

Axis-Angle representation:

$$< axis, angle >= \left\langle \begin{bmatrix} a_x \\ a_y \\ a_z \end{bmatrix}, \theta \right\rangle$$

Axis-Angle $\rightarrow$ Quaternion:

$$Q = \begin{pmatrix} q_x \\ q_y \\ q_z \\ q_w \end{pmatrix} = \begin{pmatrix} a_x \sin(\theta/2) \\ a_y \sin(\theta/2) \\ a_z \sin(\theta/2) \\ \cos(\theta/2) \end{pmatrix}$$



3D-Vector

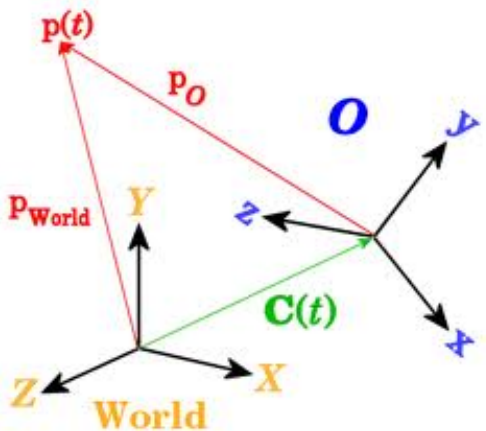
```
CL-TRANSFORMS> (make-quaternion 0 0 0 1)
CL-TRANSFORMS> (describe *)
#<QUATERNION (0.0d0 0.0d0 0.0d0 1.0d0)>
  [standard-object]
Slots with :INSTANCE allocation:
  X   = 0.0d0
  Y   = 0.0d0
  Z   = 0.0d0
  W   = 1.0d0
CL-TRANSFORMS> (axis-angle->quaternion
                (make-3d-vector 0 0 1) pi)
```

Poses in Lisp

cl-transforms:pose

```
CL-TRANSFORMS> (setf p (make-pose
                        (make-3d-vector 1 2 0)
                        (make-quaternion 0 0 0 1)))
#<POSE
   #<3D-VECTOR (1.0d0 2.0d0 0.0d0)>
   #<QUATERNION (0.0d0 0.0d0 0.0d0 1.0d0)>>
CL-TRANSFORMS> (origin p)
#<3D-VECTOR (1.0d0 2.0d0 0.0d0)>
CL-TRANSFORMS> (orientation p)
#<QUATERNION (0.0d0 0.0d0 0.0d0 1.0d0)>
```

Coordinate Systems



Transformations

```
CL-TRANSFORMS> (setf W (make-identity-pose))
#<POSE
   #<3D-VECTOR (0.0d0 0.0d0 0.0d0)>
   #<QUATERNION (0.0d0 0.0d0 0.0d0 1.0d0)>>
CL-TRANSFORMS> (setf O (make-pose
                        (make-3d-vector 2 0 0)
                        (make-quaternion 0 0 0 1)))
#<POSE
   #<3D-VECTOR (2.0d0 0.0d0 0.0d0)>
   #<QUATERNION (0.0d0 0.0d0 0.0d0 1.0d0)>>
CL-TRANSFORMS> (transform
                (transform-inv (pose->transform O))
                p)
#<POSE
   #<3D-VECTOR (-1.0d0 2.0d0 0.0d0)>
   #<QUATERNION (0.0d0 0.0d0 0.0d0 1.0d0)>>
```

TurtleBot Coordinate Frames

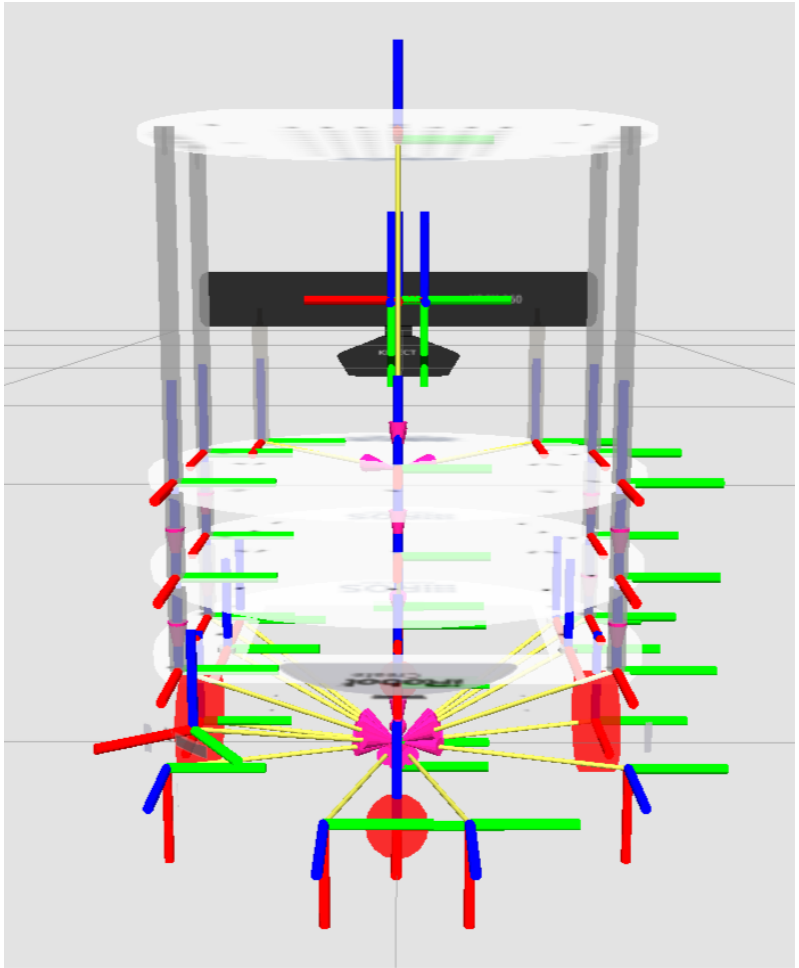
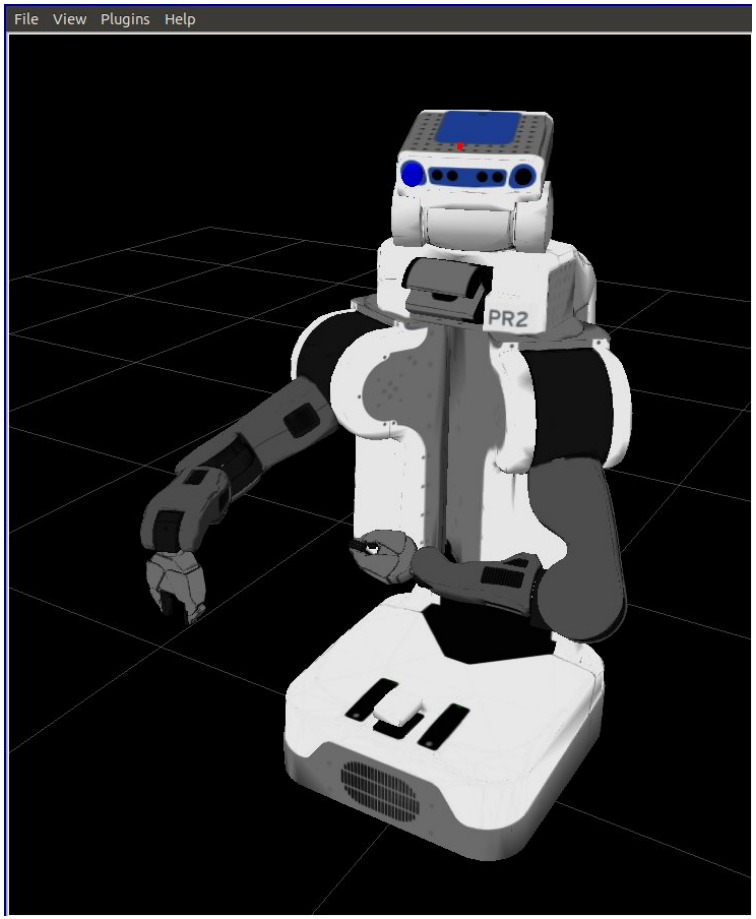


Image courtesy: Yujin Robot

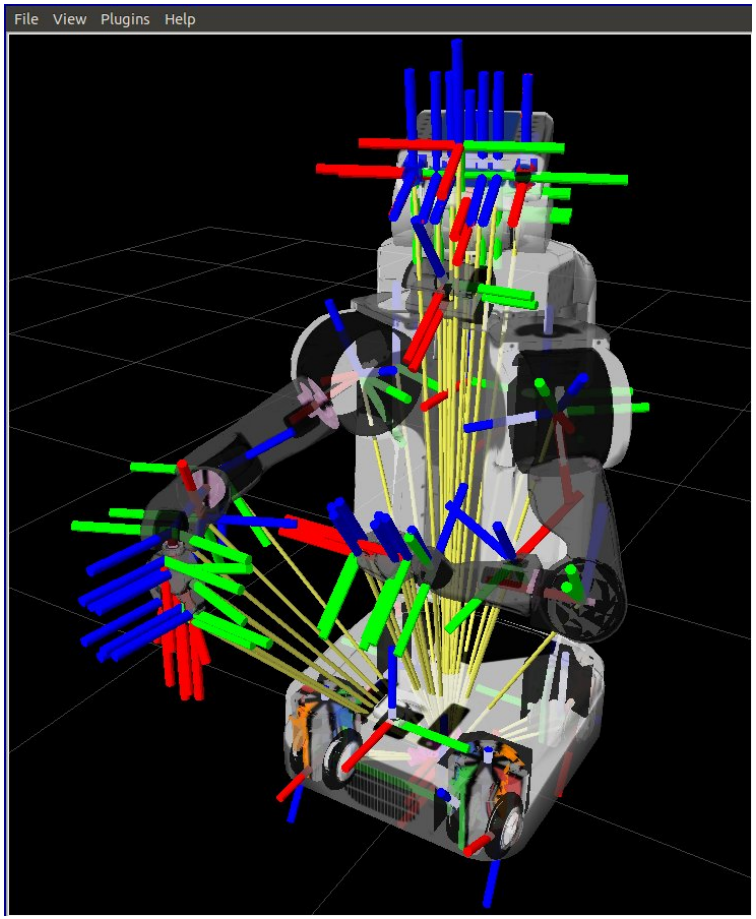
Outline

Motivation



- Robots consist of many *links*
- Every link describes its own *coordinate system*
- Sensor measurements are local to the corresponding link
- Links change their position over time (including the robot base)

Motivation



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- Every link describes its own *coordinate system*
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Implementation

- Transforms are produced by different nodes:
  - Localization in map (AMCL, gmapping)
  - Odometry (base controller)
  - Joint positions (robot controllers and robot_state_publisher)
- Many publishers, many consumers
- Distributed system, redundancy issues, ...

- **TF**: a coordinate frame tracking system
  - Publishing transforms to tf listeners
  - Looking up and calculating transforms by asking tf listeners
- Transformation data is cached over time
- All the transforms together build a TF tree

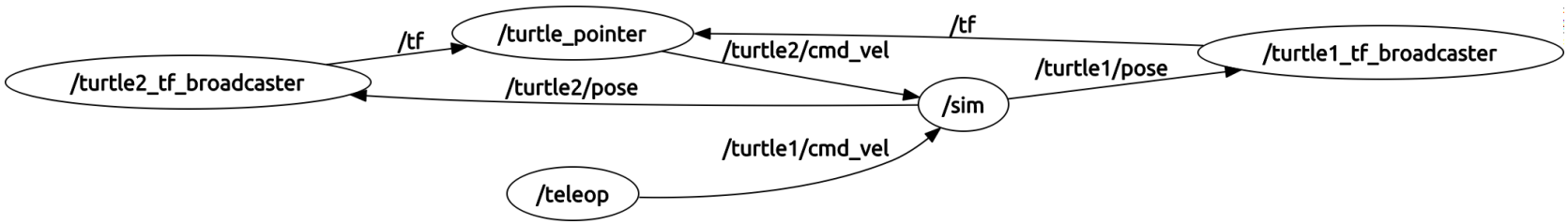
TurtleSim TF

- Start the core:

```
$ roscore
```

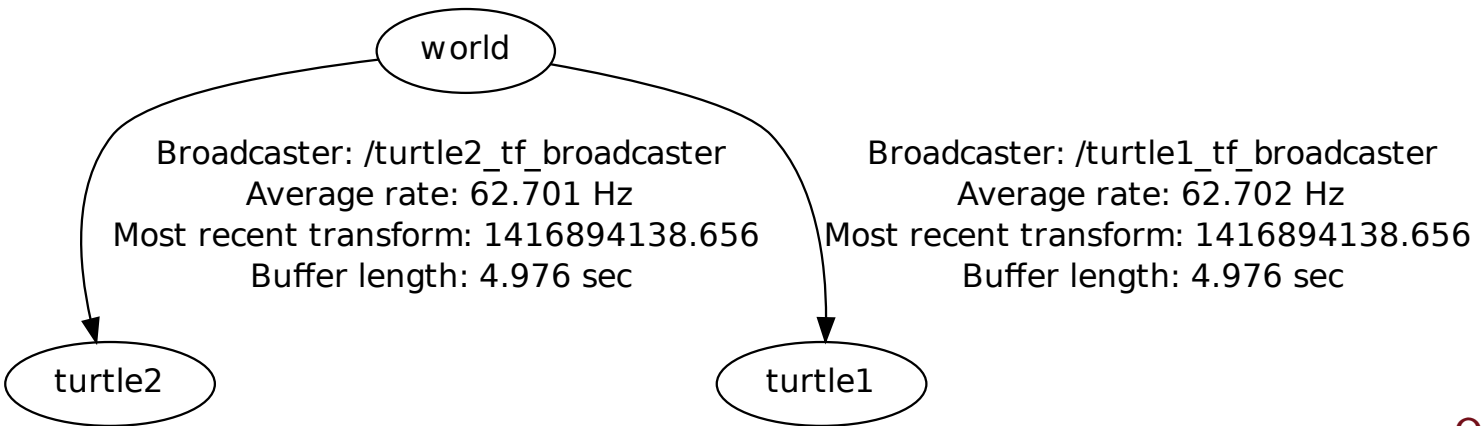
- Launch the demo:

```
$ roslaunch turtle_tf turtle_tf_demo.launch
```



- Generate a TF tree graph:

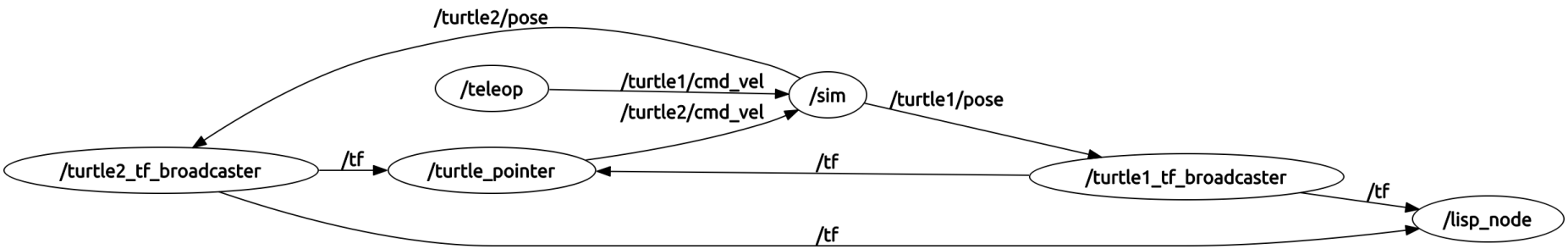
```
$ rosrun tf view_frames
```



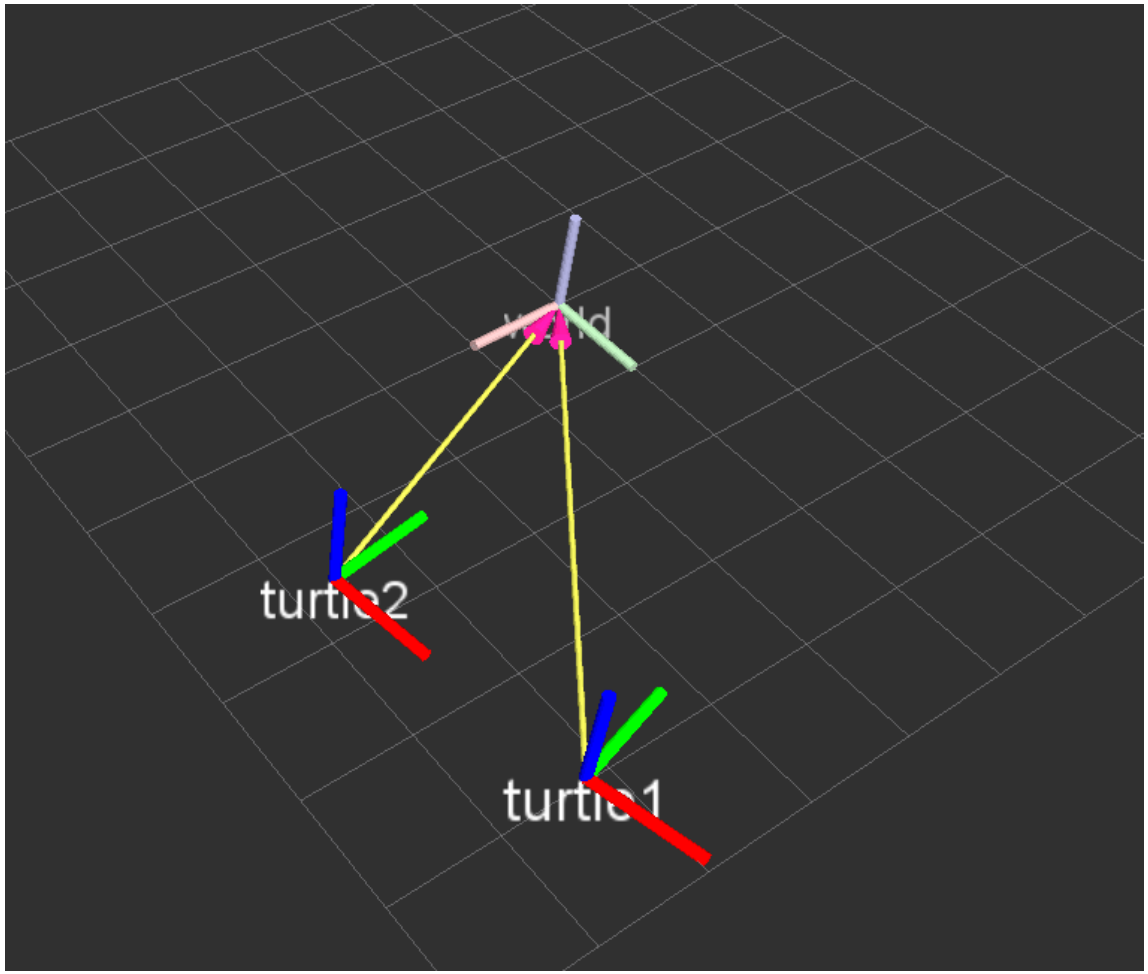
Lisp TF

cl_tf

```
TF> (roslisp:start-ros-node "lisp_node")
TF> (defparameter *transform-listener*
      (make-instance 'cl-tf:transform-listener))
TF> (lookup-transform *transform-listener*
                      :source-frame "/turtle1"
                      :target-frame "/turtle2")
#<STAMPED-TRANSFORM
   FRAME-ID: "/turtle2", CHILD-FRAME-ID: "/turtle1", STAMP: 1.4169d9
   #<3D-VECTOR (0.0d0 0.0d0 0.0d0)>
   #<QUATERNION (0.0d0 0.0d0 -0.5401331068059835d0 0.8415796022552d0)>>
```



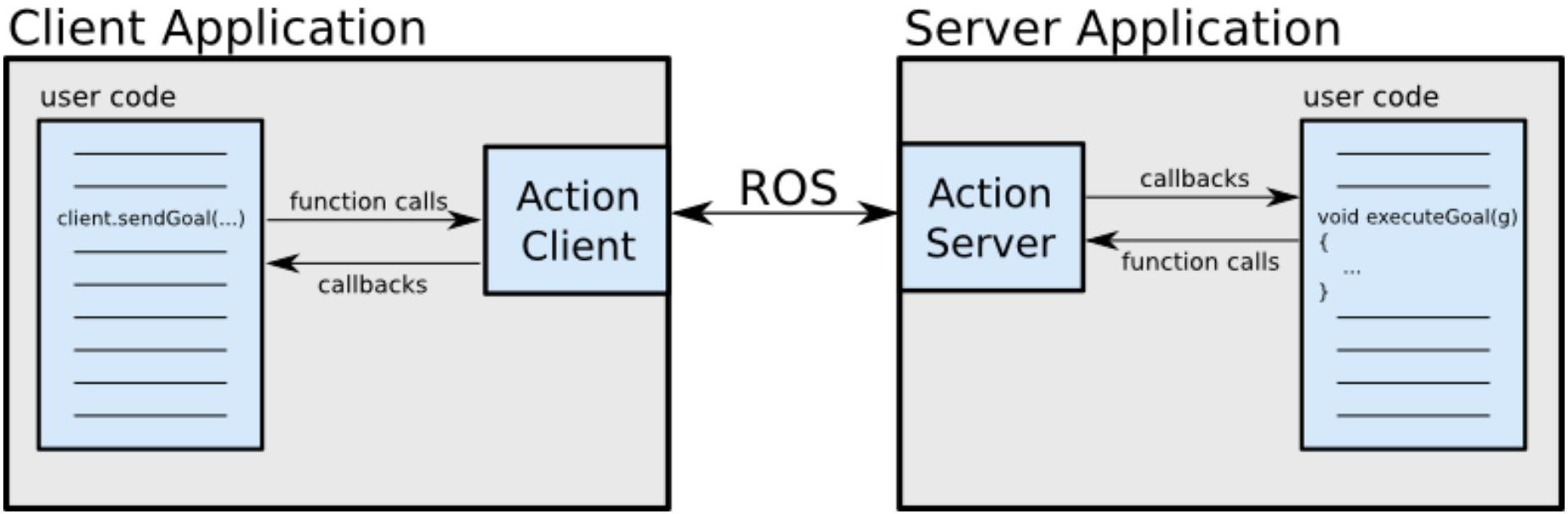
$ rosrun rviz rviz



Outline

ROS Actions

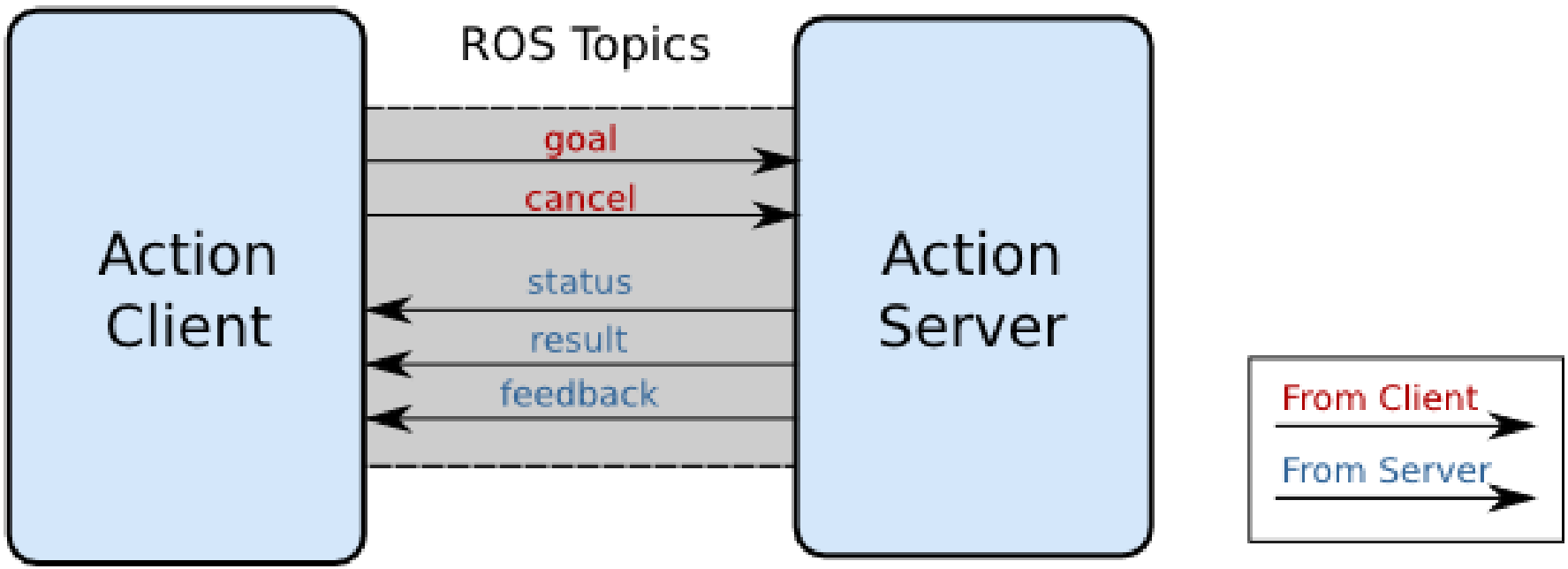
Interface to define and execute goals:



Action Protocol

Relies on ROS topics to transport messages.

Action Interface



Action Definitions

- Similar to messages and services.
- Definition: request + result + feedback
- Defined in *your_package/action/*.action*
- Example: *actionlib_tutorials/Fibonacci.action*

```
# goal definition
int32 order
---
# result definition
int32[] sequence
---
# feedback
int32[] sequence
```

Outline

Links

- roslisp_common repo:
  `https://github.com/ros/roslisp_common`
- ActionLib Lisp tutorials:
  `http://wiki.ros.org/actionlib_lisp/Tutorials`
- ROS best practices slides:
  `http://robohow.eu/_media/meetings/first-integration-workshop/ros-best-practices.pdf`

Info

- Last assignment this week
- Assignment code: `REPO/assignment_7_README.txt`
- Next class: 02.12, 14:15, TAB 1.58, bring your laptops!

Q & A

Thanks for your attention!