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You can download the sources of this presentation here:
<https://github.com/severin-lemaignan/ros-presentation/>

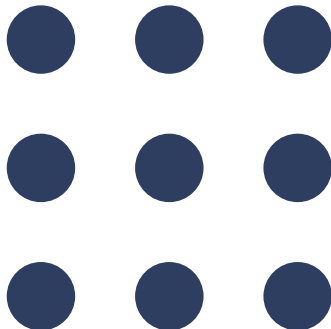
The Robot Operating System

High-Altitude Overview of ROS

February 15, 2016

Séverin Lemaignan

Centre for Robotics and Neural Systems
Plymouth University



ROS IS NOT AN OPERATING SYSTEM

INSTEAD, ROS IS...

- A fairly simple peer-to-peer message passing system designed with robotics in mind



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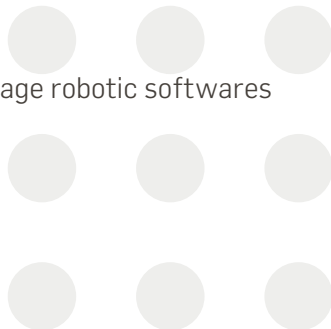
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- **A middleware?**



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- Deep integration of a few key open-source libraries (OpenCV, PCL, tf)

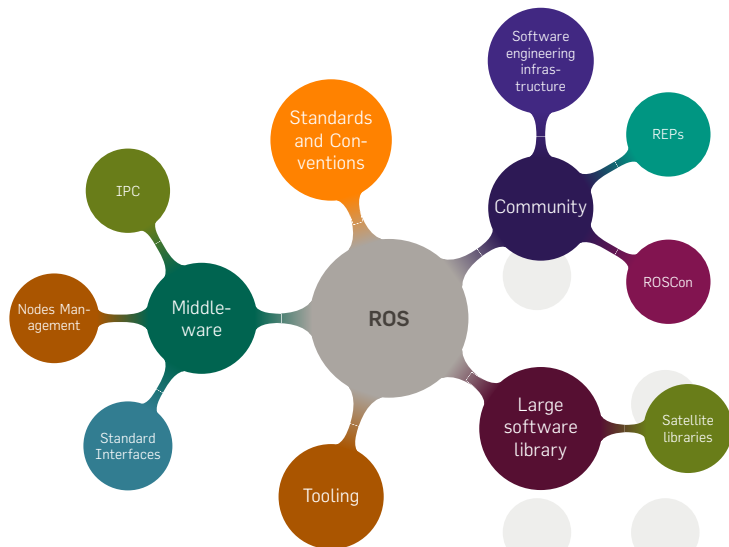
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- A set of conventions to write and package robotic softwares
- Deep integration of a few key open-source libraries (OpenCV, PCL, tf)
- A set of tools to run and monitor the nodes
- Engagement of a large academic community, leading to a library of thousands of nodes

ROS ECOSYSTEM

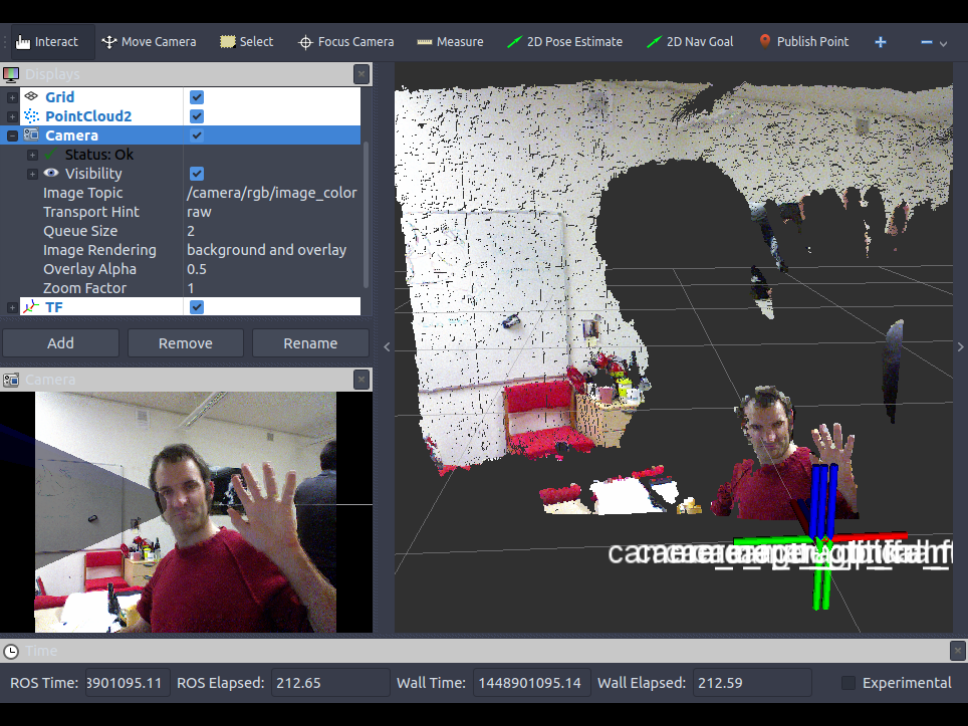


This being clarified...



HOW DOES IT LOOK LIKE?

```
$ roscore  
$ rosrun rviz rviz  
$ roslaunch oppenni_launch oppenni.launch
```

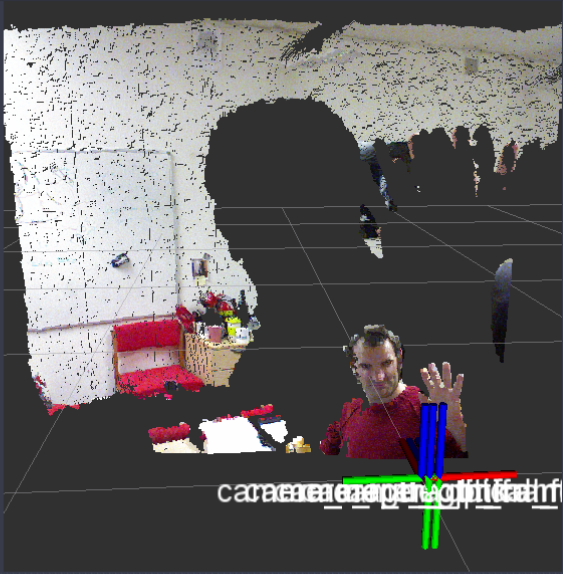


Interact Move Camera Select Focus Camera Measure 2D Pose Estimate 2D Nav Goal Publish Point + -

Displays

Grid	<input checked="" type="checkbox"/>
PointCloud2	<input checked="" type="checkbox"/>
Camera	<input checked="" type="checkbox"/>
Status: Ok	<input checked="" type="checkbox"/>
Visibility	<input checked="" type="checkbox"/>
Image Topic	/camera/rgb/image_color
Transport Hint	raw
Queue Size	2
Image Rendering	background and overlay
Overlay Alpha	0.5
Zoom Factor	1
TF	<input checked="" type="checkbox"/>

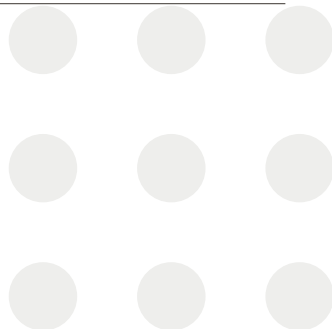
Add Remove Rename

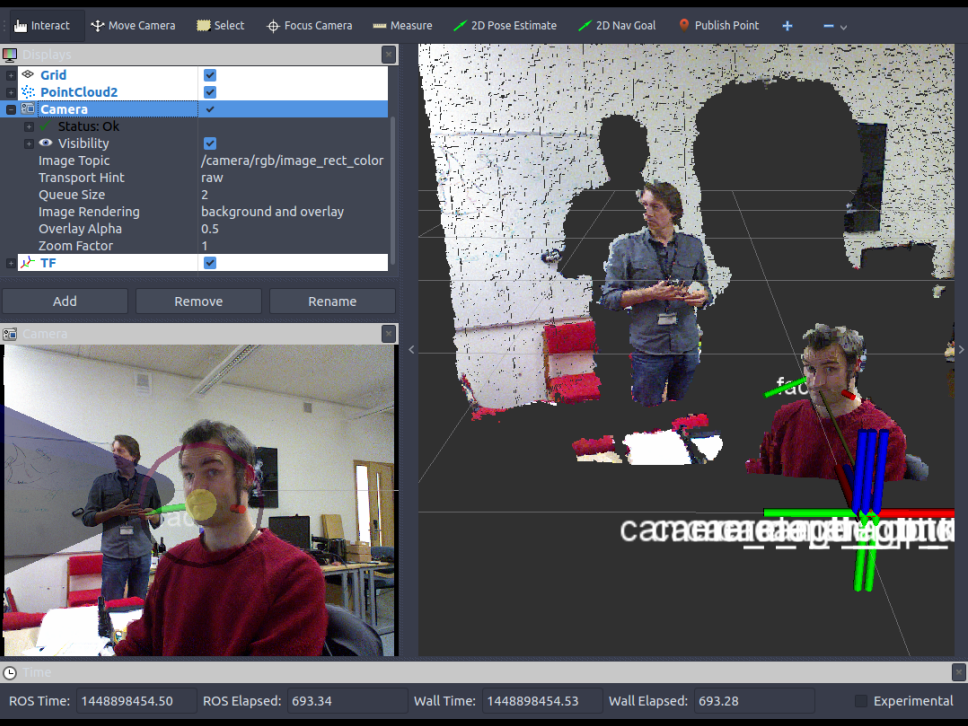


Time

ROS Time: 3901095.11 ROS Elapsed: 212.65 Wall Time: 1448901095.14 Wall Elapsed: 212.59 Experimental

```
$ rosrun attention_tracker estimate  
image:=/camera/rgb/image_color
```





```
$ rostopic list
/camera_base_link
/camera_base_link1
/camera_base_link2
/camera_base_link3
/ros_attention_tracker
/rosout
/camera/camera_nodelet_manager
/camera/debayer
/camera/depth_metric
/camera/depth_metric_rect
/camera/depth_points
/camera/depth_rectify_depth
/camera/depth_registered_hw_metric_rect
/camera/depth_registered_metric
/camera/depth_registered_rectify_depth
/camera/depth_registered_sw_metric_rect
/camera/disparity_depth
/camera/disparity_registered_hw
/camera/disparity_registered_sw
/camera/driver
```

```
$ rostopic list
/camera_info
/image
/nb_detected_faces
/rosout
/rosout_agg
/tf
/camera/depth/image_rect_raw
/camera/depth/image_rect_raw/compressed
/camera/depth/image_rect_raw/compressed/parameter_descriptions
/camera/depth/image_rect_raw/compressed/parameter_updates
/camera/depth/image_rect_raw/compressedDepth
/camera/depth/image_rect_raw/compressedDepth/parameter_descriptions
/camera/depth/image_rect_raw/compressedDepth/parameter_updates
/camera/depth/image_rect_raw/theora
/camera/depth/image_rect_raw/theora/parameter_descriptions
/camera/depth/image_rect_raw/theora/parameter_updates
/camera/depth_rectify_depth/parameter_descriptions
/camera/depth_rectify_depth/parameter_updates
```

```
$ rostopic echo tf
```

```
transforms:
```

```
-
```

```
  header:
```

```
    seq: 0
```

```
    stamp:
```

```
      secs: 1449222890
```

```
      nsecs: 396561780
```

```
    frame_id: /camera_link
```

```
  child_frame_id: /camera_rgb_frame
```

```
  transform:
```

```
    translation:
```

```
      x: 0.0
```

```
      y: -0.045
```

```
      z: 0.0
```

```
    rotation:
```

```
      x: 0.0
```

```
      y: 0.0
```

```
      z: 0.0
```

```
      w: 1.0
```



```
$ rosrun rqt_reconfigure rqt_reconfigure
```



rqt_reconfigure__Param - rqt

Dynamic Reconfigure

D ? - O

Filter key:

Collapse all

Expand all

- + attention_tracker
- camera
 - debayer
 - + depth
 - depth_rectify_depth
 - + depth_registered
 - depth_registered_rectify_depth
 - driver
 - + ir
 - rectify_color
 - rectify_ir
 - rectify_mono
 - + rgb

Refresh

/camera/driver

image_mode SXGA_15Hz (1)

depth_mode VGA_30Hz (2)

depth_registration ☒

data_skip 0 1000 0

depth_time_offset -1.0 1.0 0.0

image_time_offset -1.0 1.0 0.0

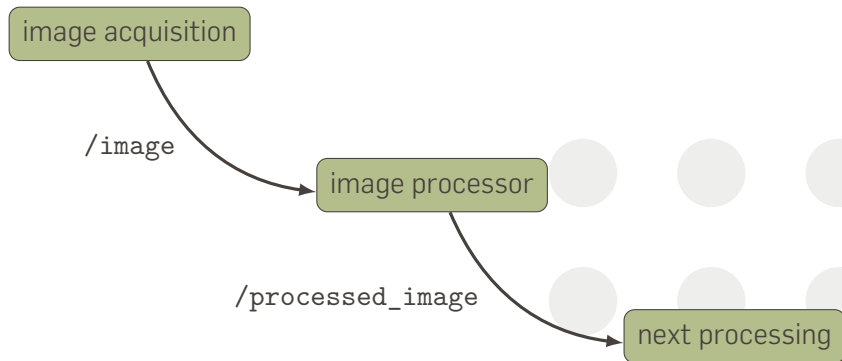
depth_ir_offset_x -10.0 10.0 5.0

depth_ir_offset_y -10.0 10.0 4.0

z_offset_mm -200 200 0

z_scaling 0.5 1.5 1.0

EXAMPLE: A SIMPLE IMAGE PROCESSING PIPELINE



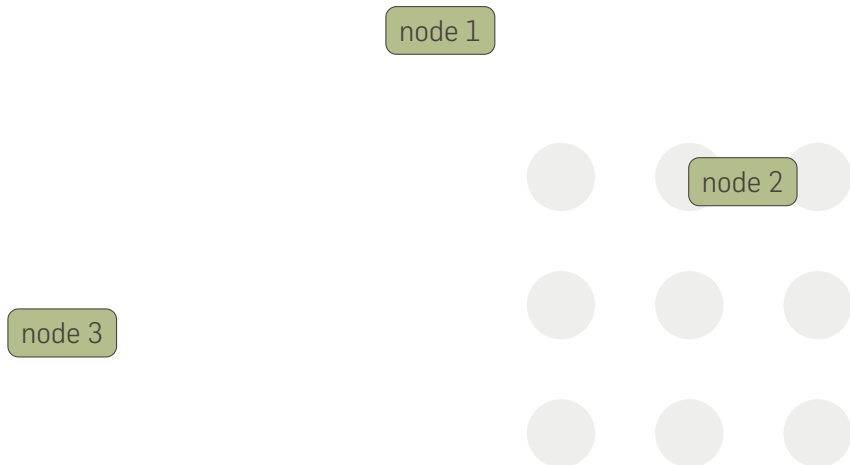

```
1  import sys, cv2, rospy
2  from sensor_msgs.msg import Image
3  from cv_bridge import CvBridge
4
5  def on_image(image):
6      cv_image = bridge.imgmsg_to_cv2(image, "bgr8")
7      (rows,cols,channels) = cv_image.shape
8      cv2.circle(cv_image, (cols/2,rows/2), 50,(0,0,255), -1)
9      cv2.imshow("Image window", cv_image)
10     cv2.waitKey(3)
11     image_pub.publish(bridge.cv2_to_imgmsg(cv_image, "bgr8"))
12
13  rospy.init_node('image_processor')
14  bridge = CvBridge()
15  image_sub = rospy.Subscriber("image",Image, on_image)
16  image_pub = rospy.Publisher("processed_image",Image)
17
18  while not rospy.is_shutdown():
19      rospy.spin()
```

```
$ roslaunch gscam v4l.launch  
$ python image_processor.py image:=/v4l/camera/image_raw  
$ rosrun image_view image_view image:=/processed_image
```

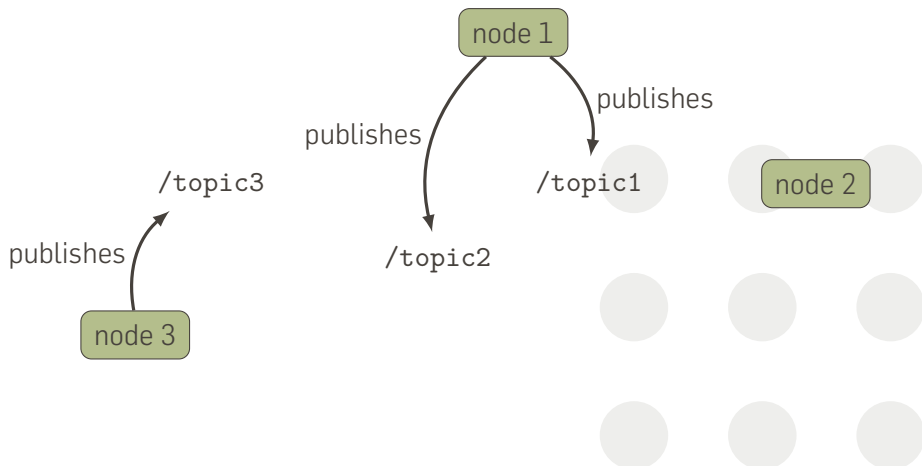


THE KEY CONCEPTS

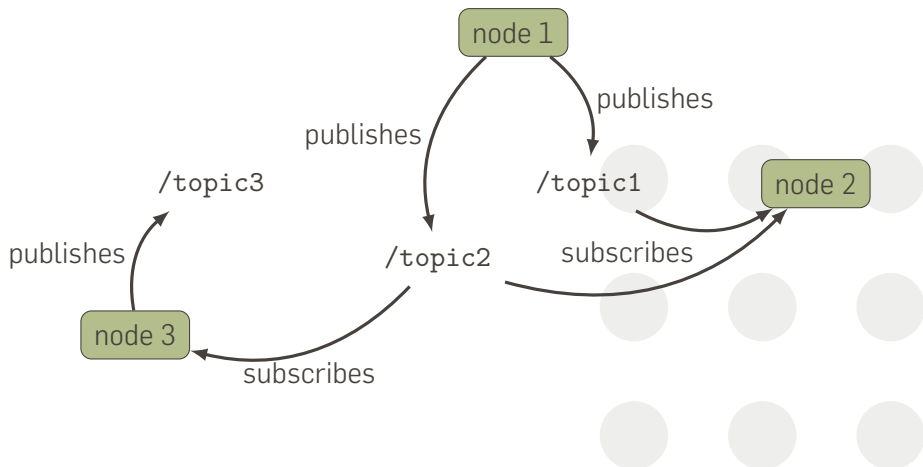
TALKING NODES



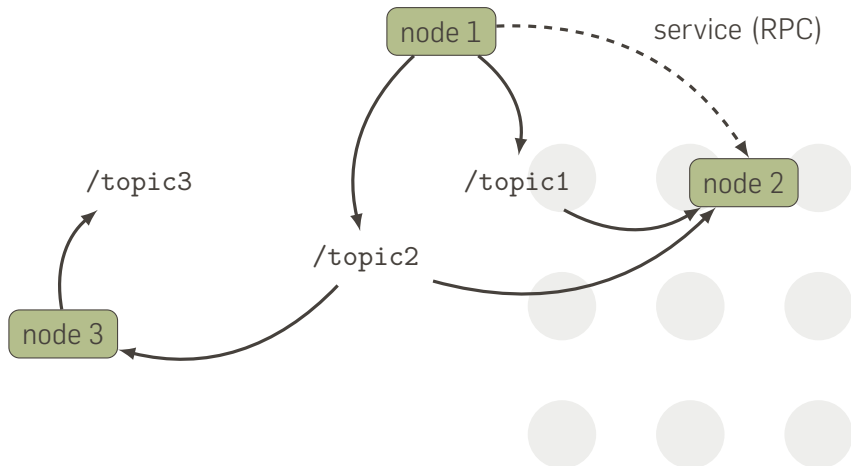
TALKING NODES



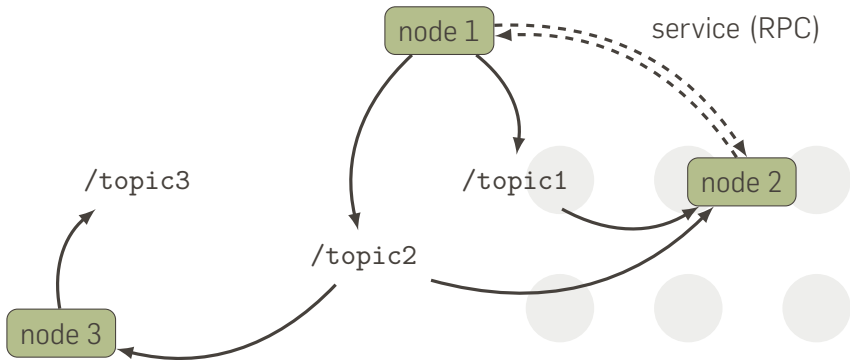
TALKING NODES



TALKING NODES

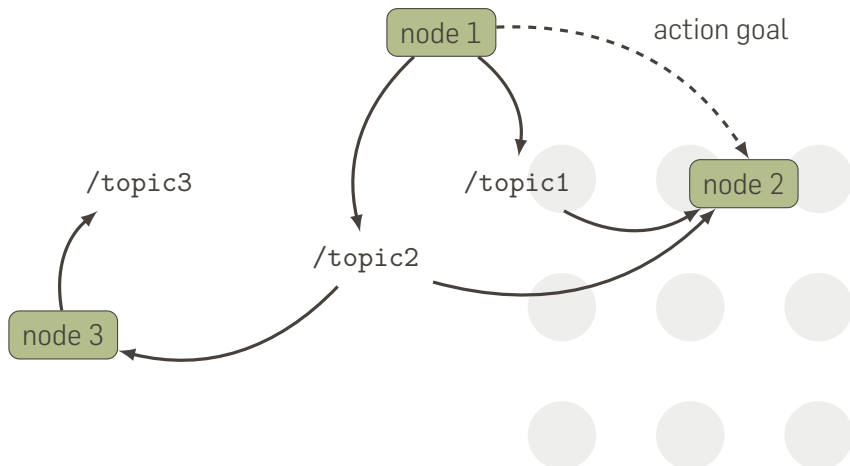


TALKING NODES

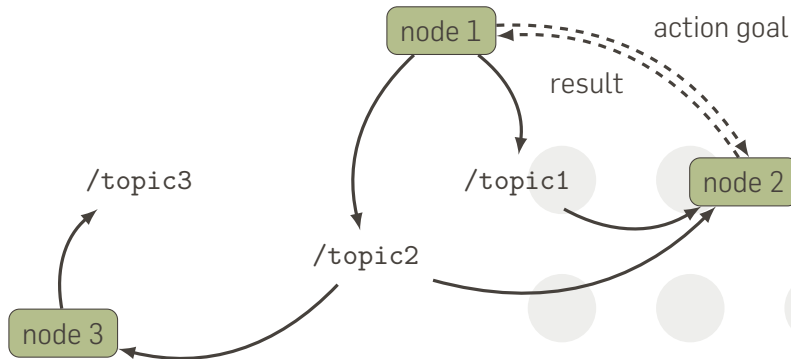


Services: **synchronous**

TALKING NODES

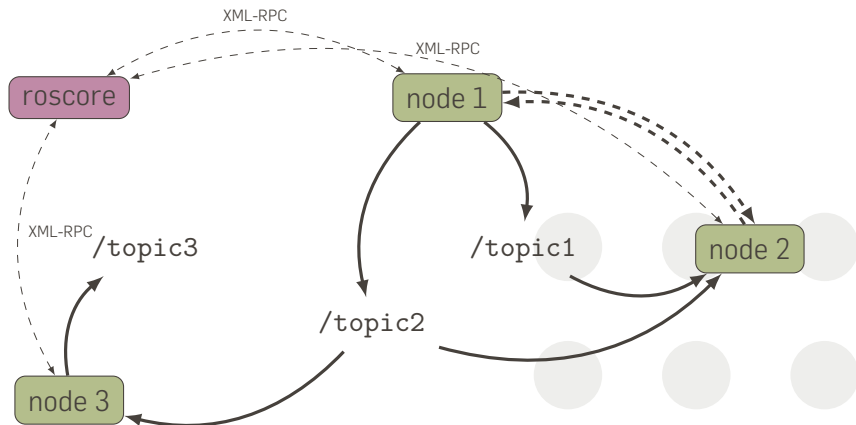


TALKING NODES



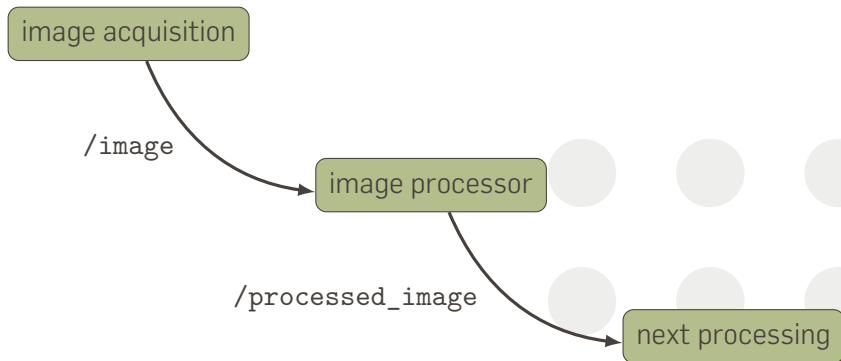
Actions: **asynchronous**

TALKING NODES



```
ROS_MASTER_URI=http://<host>:<port>
```

NODELETS



PACKAGES, NODES AND LAUNCH FILES

```
$ cd my_package
$ ls
CMakeLists.txt
cfg/
include/
launch/
msgs/
nodes/
package.xml
src/
$ rosrun my_package my_node
```



PACKAGES, NODES AND LAUNCH FILES

```
<launch>
```

```
<arg name="head_frame" default="head_camera"/>
```

```
<arg name="image" default="/camera/rgb/image_raw"/>
```

```
<node pkg="attention_tracker" type="focus" />
```

```
<node pkg="attention_tracker" type="estimate">
```

```
  <param name="face_model"
```

```
    value="$(find attention_tracker)/model.dat" />
```

```
  <remap from="/image" to="$(arg image)"/>
```

```
</node>
```

```
</launch>
```

```
$ roslaunch my_package my_system.launch
```

MESSAGES

```
$ rosmmsg show geometry_msgs/Pose
```

```
geometry_msgs/Point position
```

```
float64 x
```

```
float64 y
```

```
float64 z
```

```
geometry_msgs/Quaternion orientation
```

```
float64 x
```

```
float64 y
```

```
float64 z
```

```
float64 w
```

MESSAGES

```
$ rosmmsg show sensor_msgs/Image
std_msgs/Header header
  uint32 seq
  time stamp
  string frame_id
uint32 height
uint32 width
string encoding
uint8 is_bigendian
uint32 step
uint8[] data
```



MESSAGES

```
$ rostopic echo /camera/image_raw
```

```
header:
```

```
  seq: 56
```

```
  stamp:
```

```
    secs: 1449243166
```

```
    nsecs: 415330019
```

```
  frame_id: /camera_frame
```

```
height: 720
```

```
width: 1280
```

```
encoding: rgb8
```

```
is_bigendian: 0
```

```
step: 3840
```

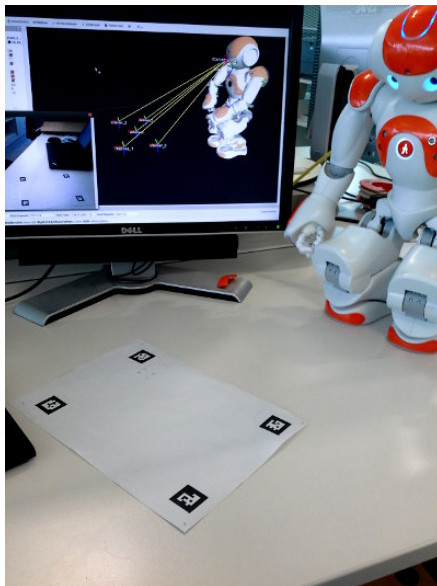
```
data: [32, 57, 51, 36, 61, 55, 41, 63, 60,...]
```

ROS VS YARP TERMINOLOGY

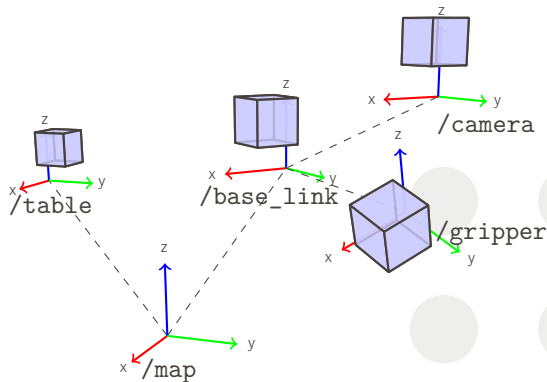
YARP	ROS
Port	topic
RpcClient/RpcServer	action (async) or service (sync)
Bottle	message
yarpserver	roscore

Connections of ports: explicit with YARP, implicit with ROS

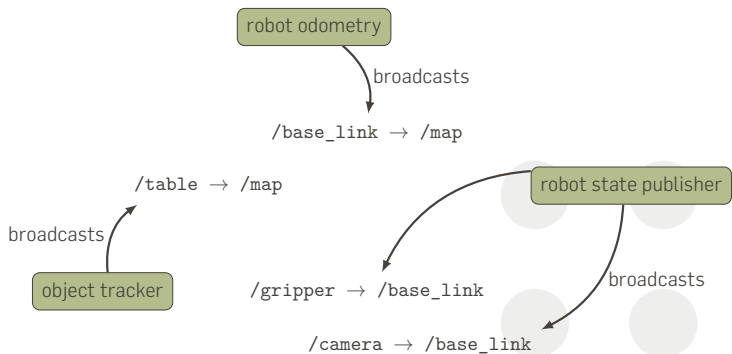
TRANSFORMATIONS



TRANSFORMATIONS



FRAMES



```
1 $ g++ tf.cpp -o tf -lroscpp -lrostime -lboost_system -ltf
2 $ ./tf
```



```
$ rostopic echo tf
transforms:
-
  header:
    seq: 0
    stamp:
      secs: 1449488936
      nsecs: 480597909
    frame_id: map
  child_frame_id: my_robot
  transform:
    translation:
      x: 239.0
      y: 0.0
      z: 0.0
    rotation:
      x: 0.0
      y: 0.0
      z: 0.0
      w: 1.0
```




```
$ rostopic echo tf
transforms:
-
  header:
    seq: 0
    stamp:
      secs: 1449488936
      nsecs: 480597909
    frame_id: map
  child_frame_id: my_robot
  transform:
    translation:
      x: 239.0
      y: 0.0
      z: 0.0
    rotation:
      x: 0.0
      y: 0.0
      z: 0.0
      w: 1.0
```



TO SUMMARIZE: KEY CONCEPTS

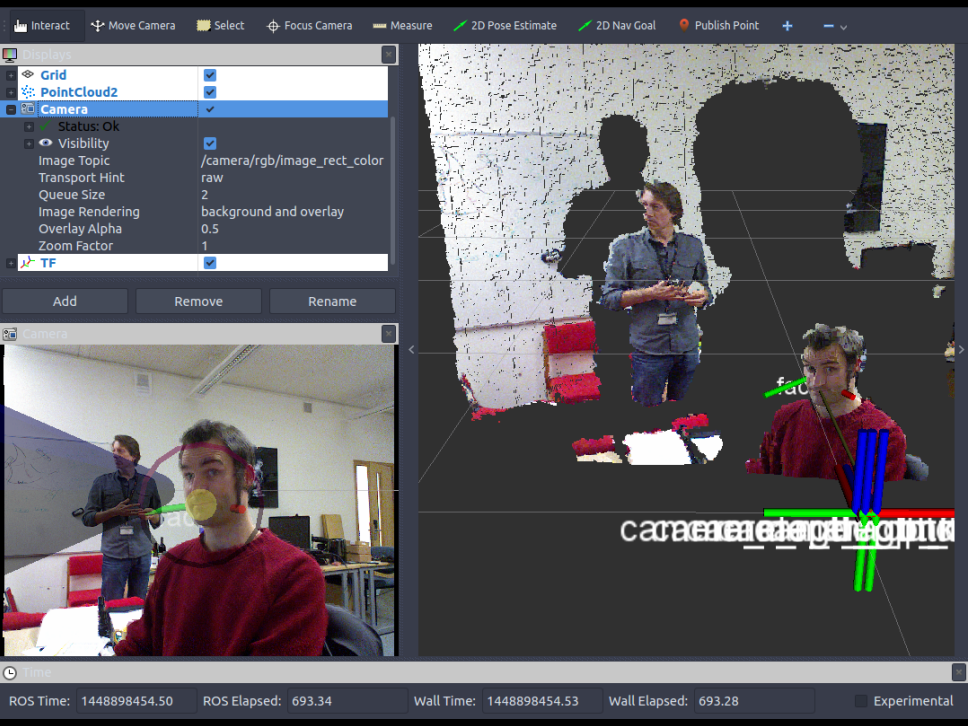
- Package, Node, Nodelet, Launch files
- Master
- Messages
- Topics
- Services
- Actions
- Transformations/frames



TOOLING

TOOLS

<code>rviz</code>	versatile 2D/3D visualization
<code>roscconsole</code>	Centralized logging
<code>rosbag</code>	Record and replay messages
<code>rqt_reconfigure</code>	Live configuration of nodes
<code>rqt_diagnostics</code>	Standardized diagnostics
<code>rosgaph</code>	plots the node network
+ tons of introspection tools	Print out/publish/call messages, services, nodes



rqt_console__Console - rqt

Console

D ? - O



Displaying 10 messages



Fit Columns

#	Message	Severity	Node	Stamp	Topics	Location
#8	Connection::drop(0)	Debug	/ros_attention_tracker	16:17:21.98...	/attention_...	/home/sl...
#7	TCP socket [18] closed	Debug	/ros_attention_tracker	16:17:21.98...	/attention_...	/home/sl...
#6	Connection::drop(2)	Debug	/ros_attention_tracker	16:17:21.98...	/attention_...	/home/sl...
#5	head_pose_estimator is r...	Info	/ros_attention_tracker	16:17:02.54...	/attention_...	/home/sl...
#4	Initializing the face detec...	Info	/ros_attention_tracker	16:17:01.48...	/rosout	/home/sl...
#3	Started stream.	Info	/v4l/gscam_driver_v4l	16:16:46.65...	/rosout, /v4...	/home/sl...
#2	Publishing stream...	Info	/v4l/gscam_driver_v4l	16:16:46.65...	/rosout, /v4...	/home/sl...
#1	Time offset: 1448897724....	Info	/v4l/gscam_driver_v4l	16:16:45.45...	/rosout	/home/sl...

Exclude Messages...

☒ ...with severities: Debug Info Warn Error Fatal

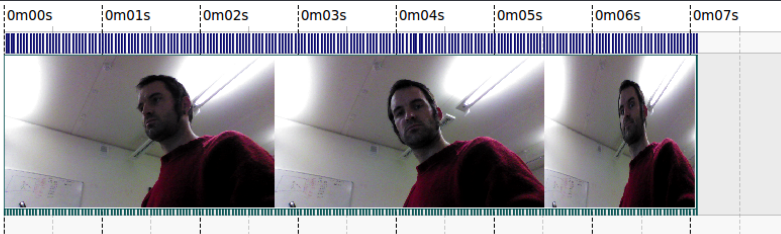
Highlight Messages...

☐ ...containing: face☐ Regex

rqt_bag_Bag - rqt

Bag

D ? - O



1449246342.413s Dec 04 2015 16:25:42.413 0.000s

rqt_reconfigure__Param - rqt

Dynamic Reconfigure

D ? - O

Filter key:

Collapse all

Expand all

- + attention_tracker
- camera
 - debayer
 - + depth
 - depth_rectify_depth
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 - depth_registered_rectify_depth
 - driver
 - + ir
 - rectify_color
 - rectify_ir
 - rectify_mono
 - + rgb

Refresh

/camera/driver

image_mode SXGA_15Hz (1)

depth_mode VGA_30Hz (2)

depth_registration ☒

data_skip 0 1000 0

depth_time_offset -1.0 1.0 0.0

image_time_offset -1.0 1.0 0.0

depth_ir_offset_x -10.0 10.0 5.0

depth_ir_offset_y -10.0 10.0 4.0

z_offset_mm -200 200 0

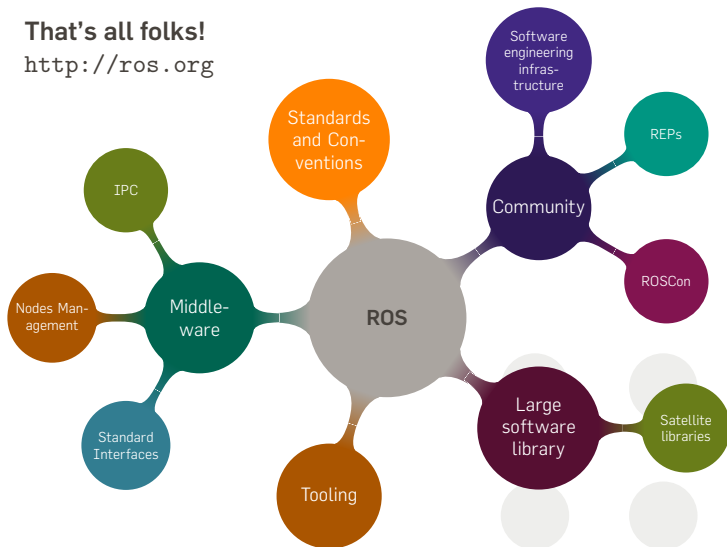
z_scaling 0.5 1.5 1.0

ROS VS YARP TOOLS

YARP	ROS		
yarpscope/yarpview	rviz		
yarpdatadumper/yarpdataplayer	rosbag		
yarpmanager	roslaunch		

That's all folks!

<http://ros.org>



Slides available online:

www.github.com/severin-lemaignan/ros-presentation