Robot Programming with Lisp

6. Introduction to ROS

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Outline

Outline

Industrial Robots

Logistics

Image courtesy: BIBA

Automotive

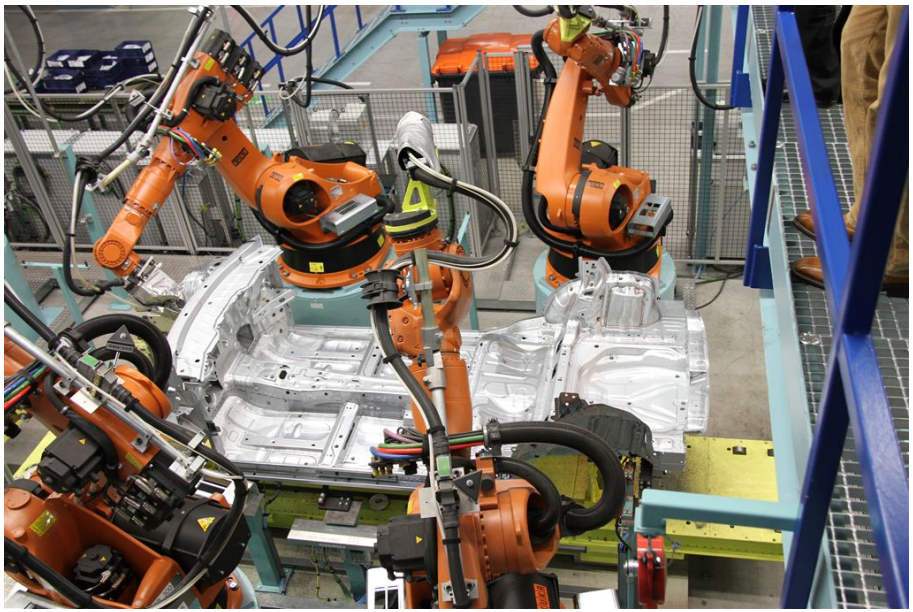


Image courtesy: Mercedes Benz Bremen

- Extremely heavy, precise and dangerous, not really smart
- Mostly no sensors, only high-precision motor encoders
- Programmable through PLCs (using block diagrams or Pascal / Basic like languages)

Industrial Light-weight Robots

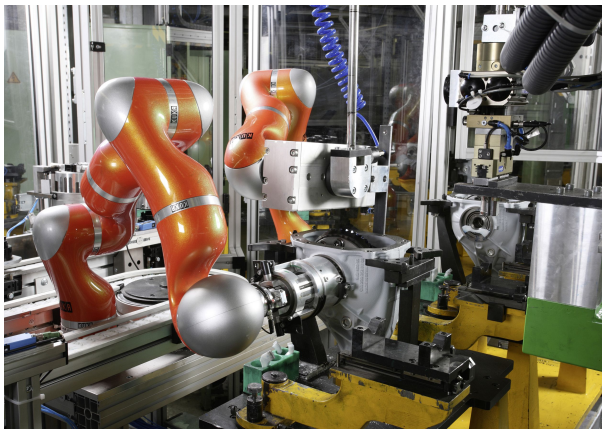
Production:

Copyright: Universal Robots

Medicine:

Copyright: Intuitive Surgical

Automotive:



Copyright: KUKA Roboter GmbH

- Very precise, moderately dangerous, somewhat smart
- High-precision motor encoders, sometimes force sensors, cameras
- Native programming and simulation tools (C++, Java, Python, GUIs)

Service Robots

Autonomous aircrafts

Courtesy DJI

Mobile platforms

Courtesy NASA/JPL-Caltech

Manipulation platforms

Humanoids

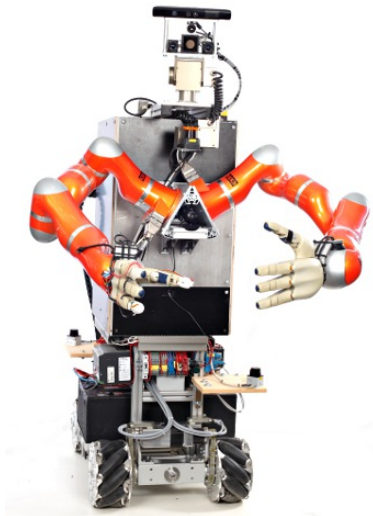
- Usually not very precise
- Not really dangerous
- Usually cognition-enabled
- Equipped with lots of sensors
- Usually running a Linux

Service Robots with Light-weight Arms

DLR Justin

Courtesy of DLR

TUM Rosie



- Moderately precise and dangerous
- Cognition-enabled
- Equipped with lots of sensors
- Usually running a combination of a real-time and non real-time OS.

Outline

Motivation

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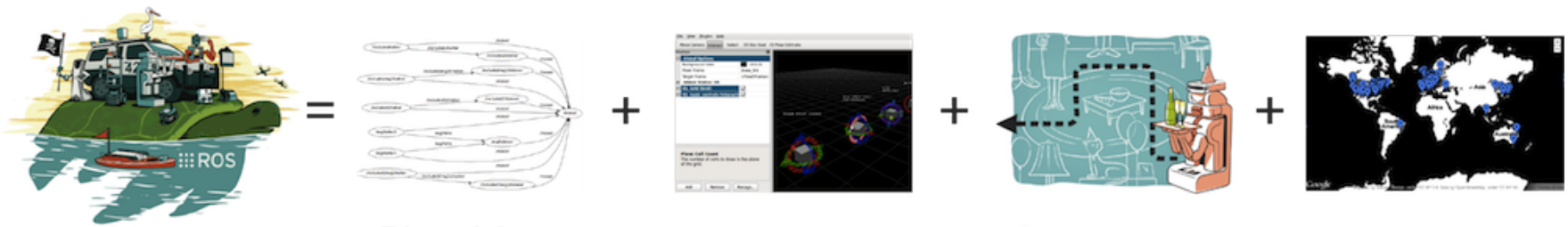
  - Easy software sharing mechanisms

Robot Operating System

At 2007 Willow Garage, a company founded by an early Google employee Scott Hassan at 2006 in the Silicon Valley, starts working on their Personal Robotics project and ROS.



Robot Operating System [2]

ROS core components:

- Meta-Operating System for programming robotics software (configuring, starting / stopping, logging etc. software components)
- Middleware for communication of the components of a robotic system (distributed inter-process / inter-machine communication)
- A collection of packaging / build system tools with a strong focus on integration and documentation
- Language-independent architecture (C++, Python, Lisp, Java, JavaScript, ...)

ROS core software developed and maintained by OSRF and some externals.

Robot Operating System [3]

In addition, developed by the ROS community:

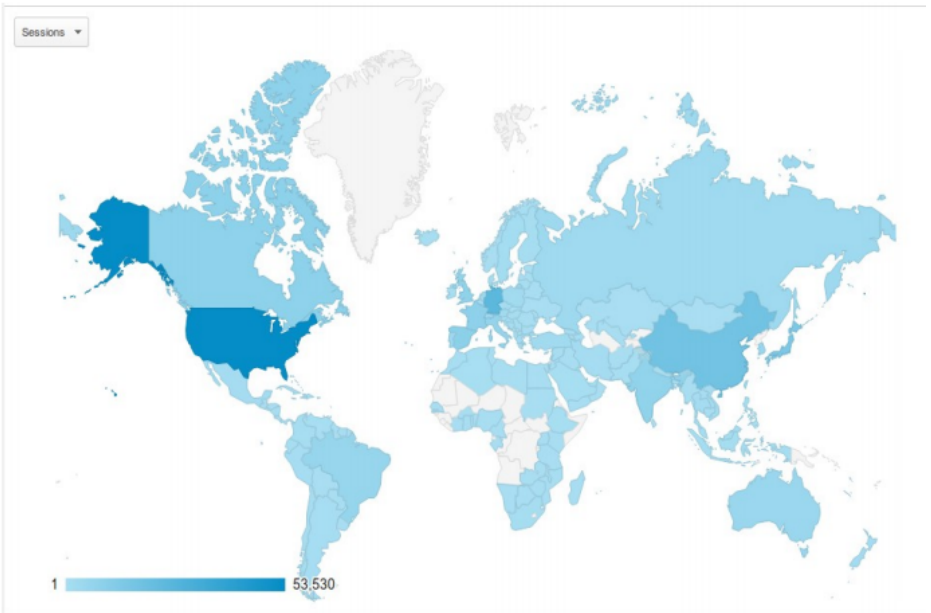
- hardware drivers
- libraries (PCL, OpenCV, TF, ...)
- capabilities (navigation, manipulation, control, ...)
- applications (fetching beer, making popcorn, ...)

ROS Community

From the community report July 2014:

wiki.ros.org visitor locations:

1.	United States	53,530 (23.40%)
2.	Germany	25,133 (10.99%)
3.	China	17,812 (7.79%)
4.	Japan	14,619 (6.39%)
5.	Spain	9,192 (4.02%)
6.	Canada	8,611 (3.76%)
7.	France	8,399 (3.67%)
8.	United Kingdom	7,434 (3.25%)
9.	India	7,360 (3.22%)
10.	Italy	6,623 (2.90%)
11.	Brazil	5,837 (2.55%)
12.	South Korea	4,988 (2.18%)
13.	Australia	4,828 (2.11%)
14.	Singapore	4,688 (2.05%)
15.	Russia	3,534 (1.54%)
16.	Portugal	3,194 (1.40%)
17.	Netherlands	2,556 (1.12%)
18.	Switzerland	2,454 (1.07%)
19.	Poland	2,279 (1.00%)
20.	Taiwan	2,252 (0.98%)



Source: Google Analytics
Site: wiki.ros.org in August

Theory

Organizational

ROS Community [2]

Some robots supporting ROS (data from November 2014):


Fraunhofer IPA Care-O-bot


Videre Erratic


TurtleBot


Robotnik SummitXL


AMIGO


TUlip


Aldebaran Nao


Lego NXT


Shadow Hand


Eddiebot


Allegro Hand SimLab


REEM


Willow Garage PR2


iRobot Roomba


Robotnik Guardian


Merlin miabotPro


AscTec Quadrotor


CoroWare Corobot


Kobuki


Komodo


Dr. Robot Jaguar


Clearpath Robotics Husky


Clearpath Robotics Kingfisher


Clearpath Robotics Grizzly


BipedRobin


WheeledRobin


Kawada Nextage / Hiro


Gostai Jazz


Neobotix mp-500


Neobotix mpo-500


Neobotix mpo-700


ROS-Industrial


Robotnik Modular Arm


Denso VS060


PAL Robotics REEM-C


Kinova JACO


Robotnik Summit


Cyton-Gamma


Robonaut 2

Otto Bock SensorHand Speed

Lizi

Adept MobileRobots Pioneer family (P3DX, P3AT, PeopleBot, PowerBot, AmigoBot, PatrolBot, GuiaBot)

Adept MobileRobots Seekur family (Seekur, Seekur Jr.)

Adept MobileRobots Pioneer LX

Festo Didactic Robotino

Robotnik Agvs

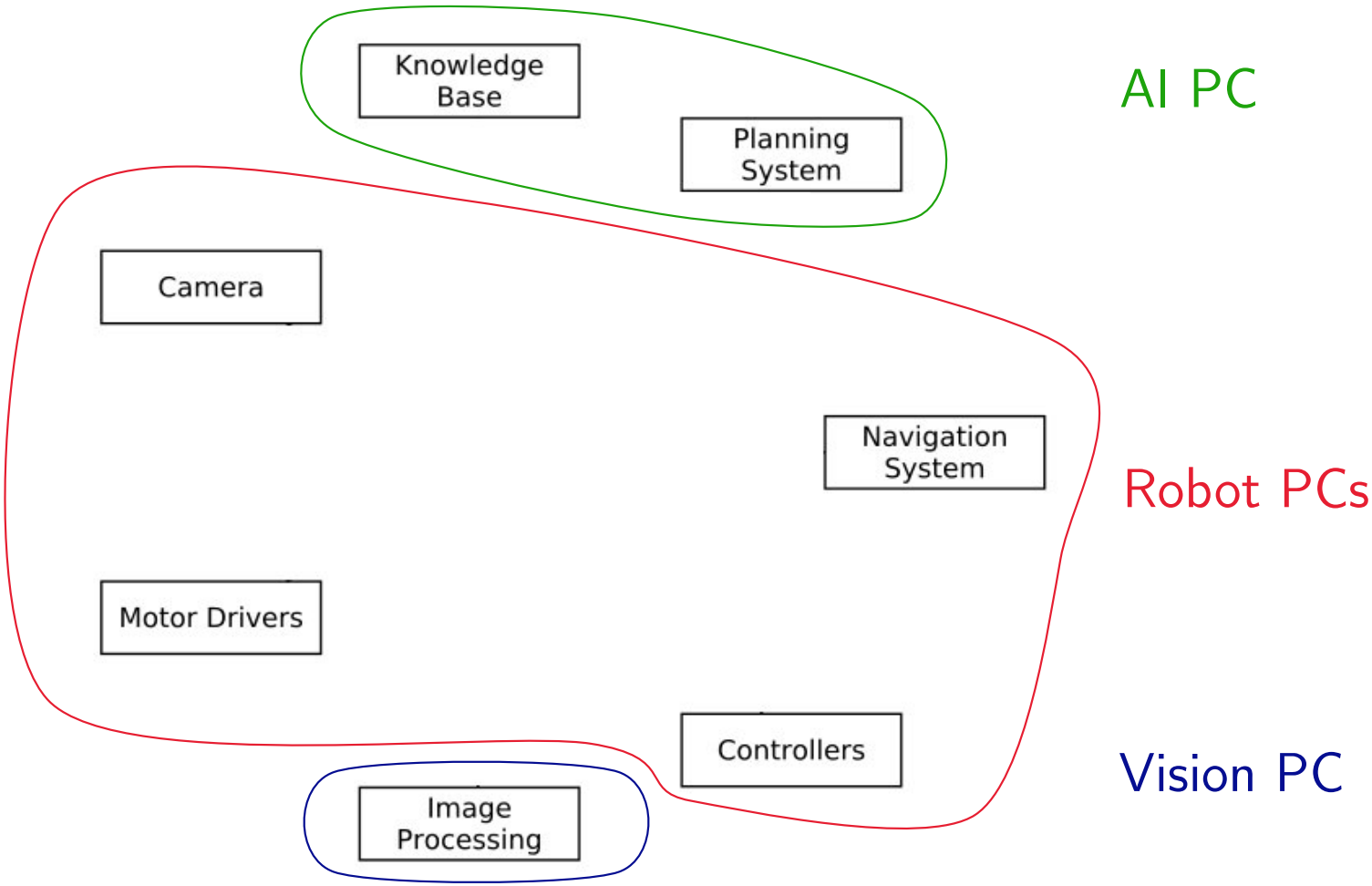
Kinova MICO

Theory

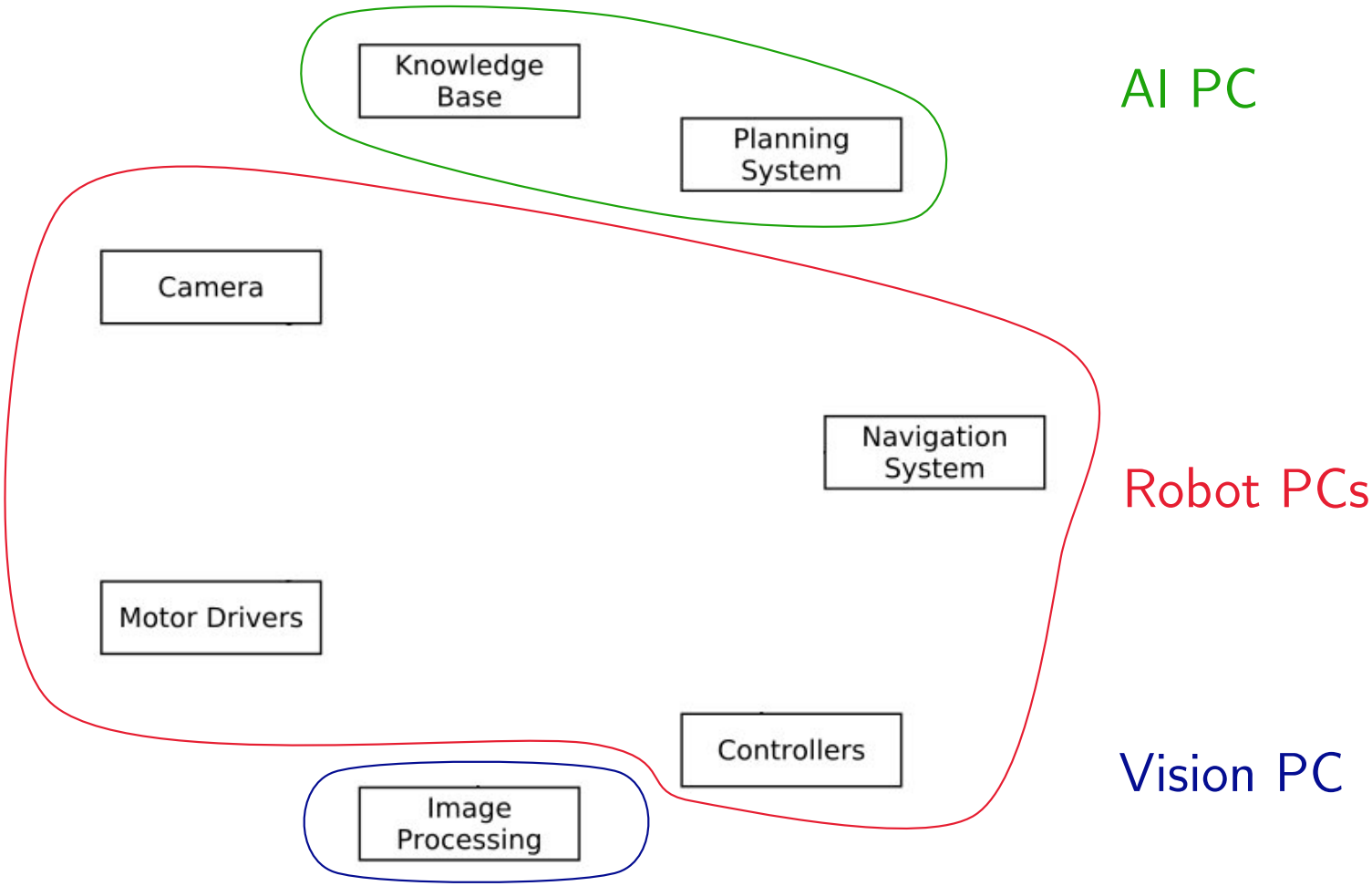
Organizational

Outline

Robotic software components

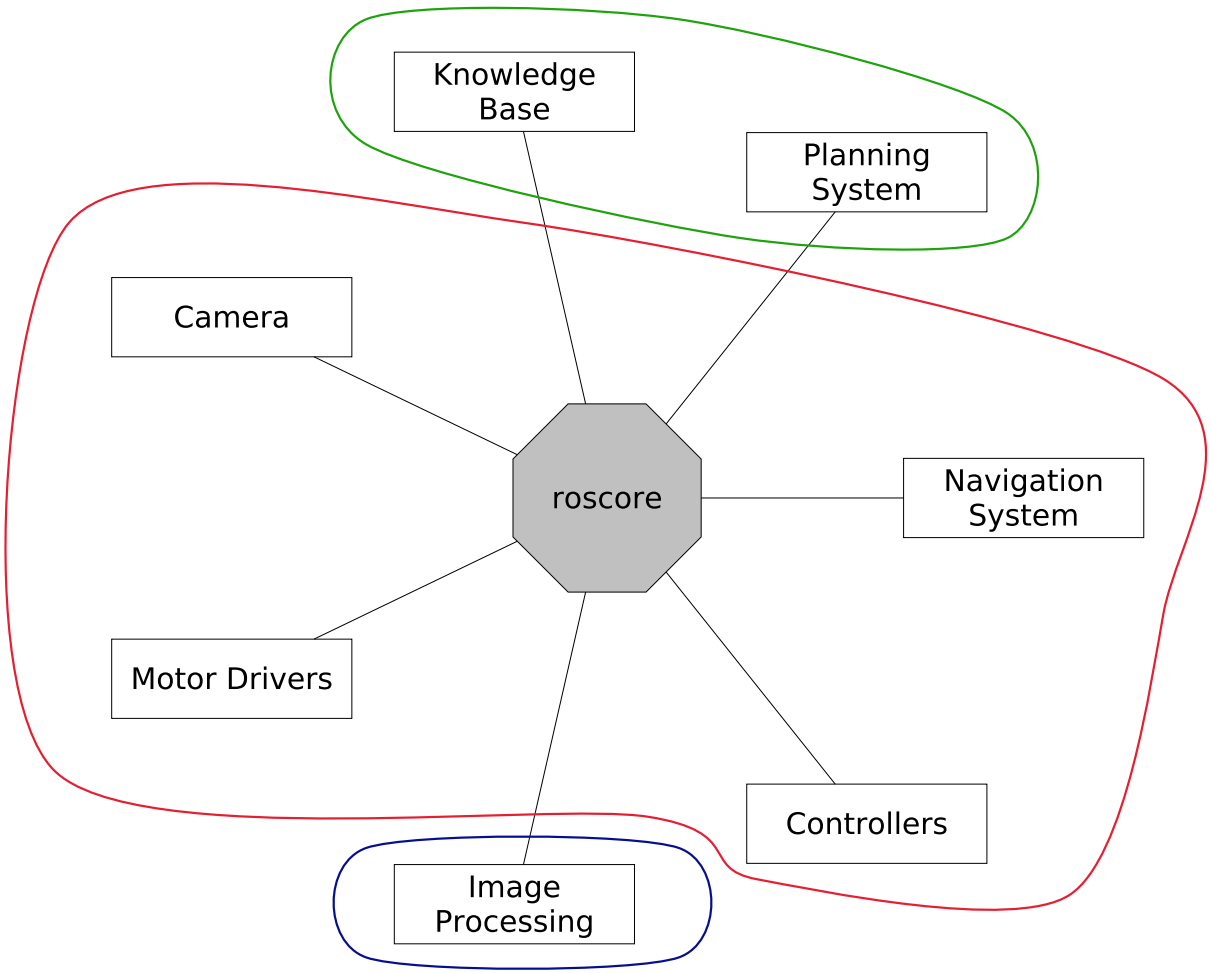


Robotic software components



→ Processes distributed all over the place.

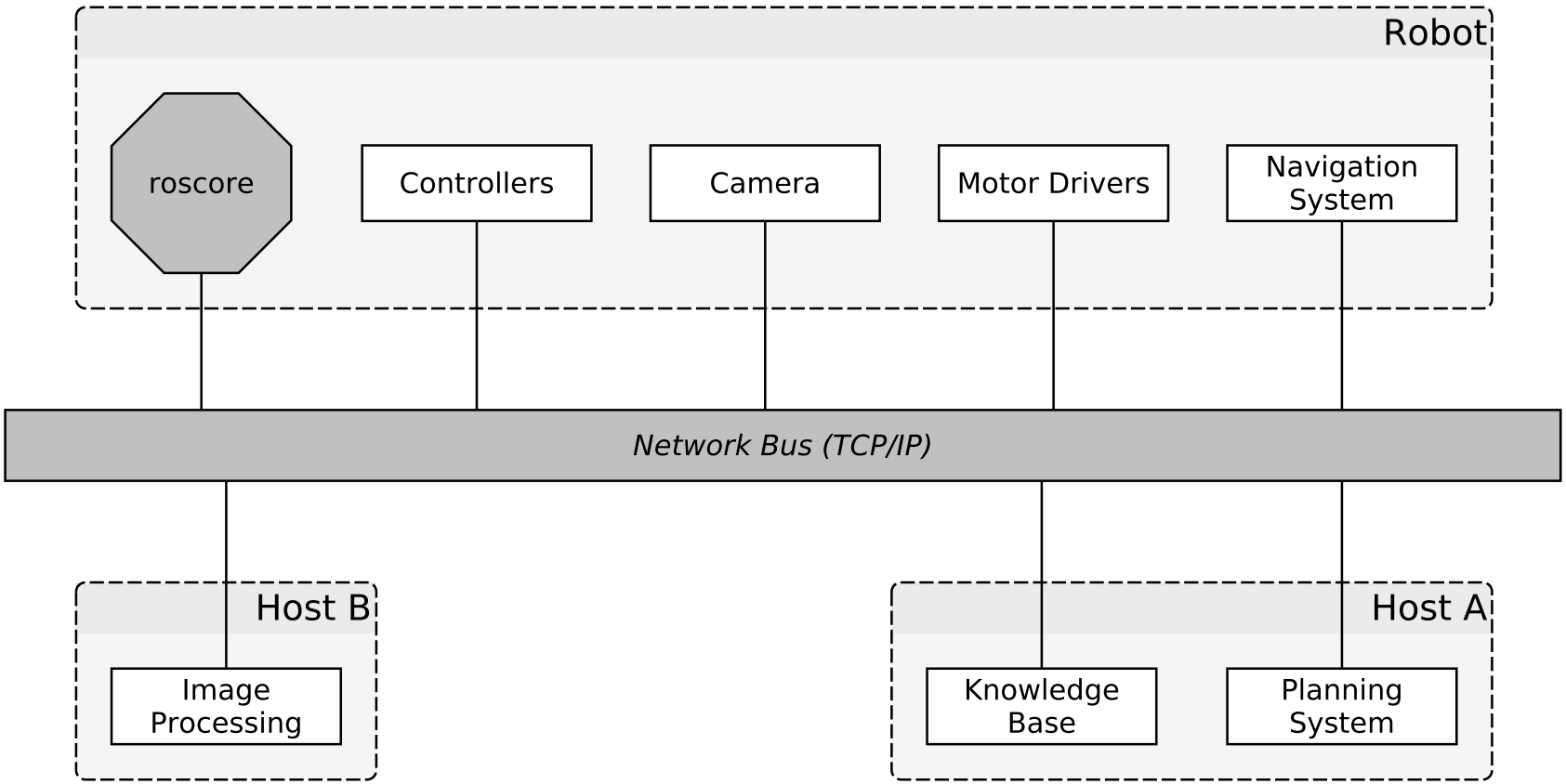
Connecting Pieces Together



roscore

- ROS master
  - A centralized XML-RPC server
  - Negotiates communication connections
  - Registers and looks up names of participant components
- Parameter Server
  - Stores persistent configuration parameters and other arbitrary data
- rosout
  - Distributed stdout

Distributed Hosts



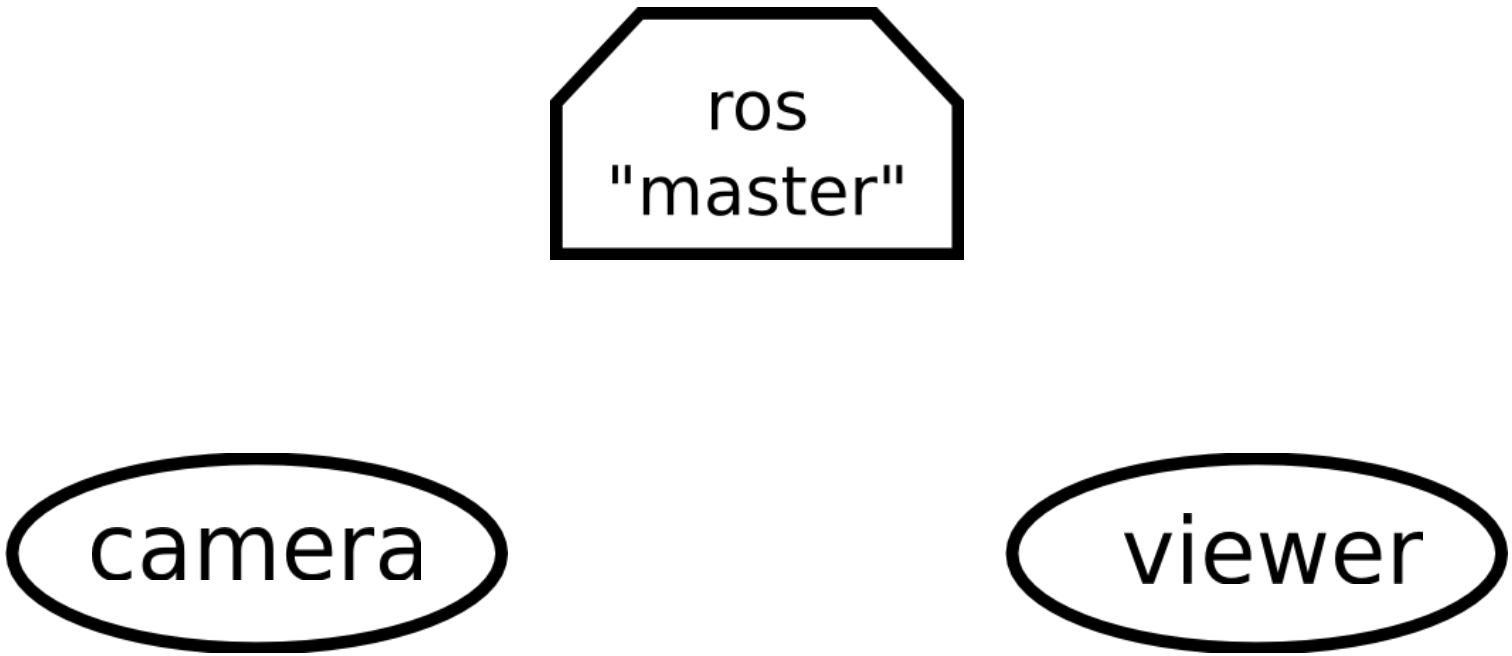
Terminology

- **Nodes** are processes that produce and consume data
- **Parameters** are persistent data stored on parameter server, e.g. configuration and initialization settings

Node communication means:

- **Topics**: asynchronous many-to-many "streams-like"
  - Strongly-typed (ROS .msg spec)
  - Can have one or more *publishers*
  - Can have one or more *subscribers*
- **Services**: synchronous blocking one-to-many "function-call-like"
  - Strongly-typed (ROS .srv spec)
  - Can have only one *server*
  - Can have one or more *clients*
- **Actions**: asynchronous non-blocking one-to-many "function-call-like"
  - Built on top of topics but can be canceled

Establishing Communication



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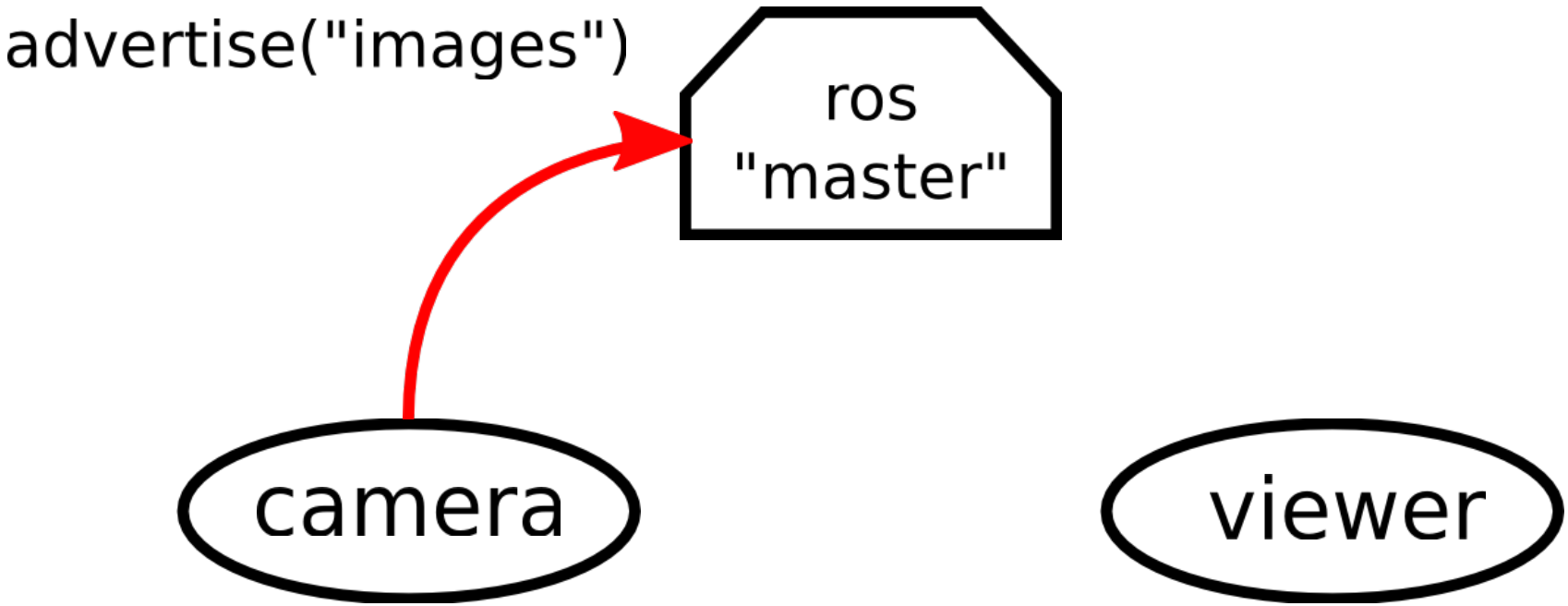

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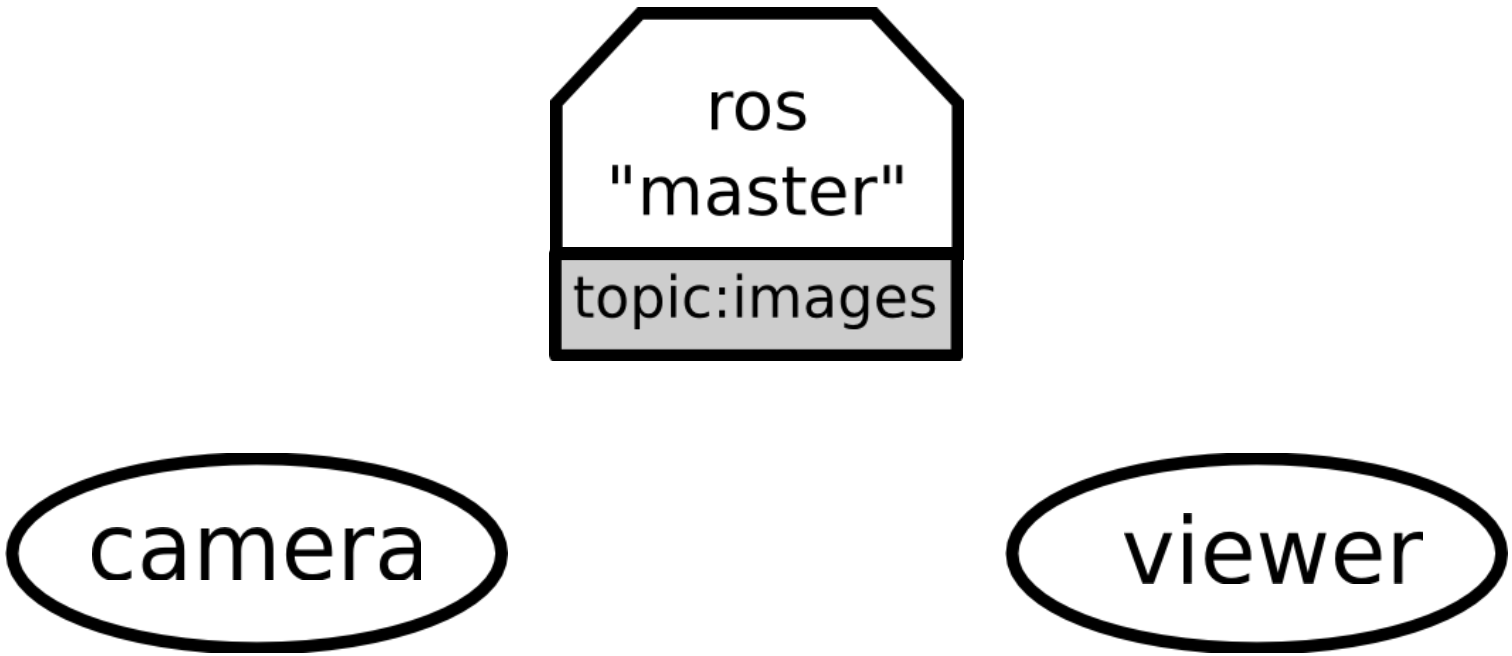

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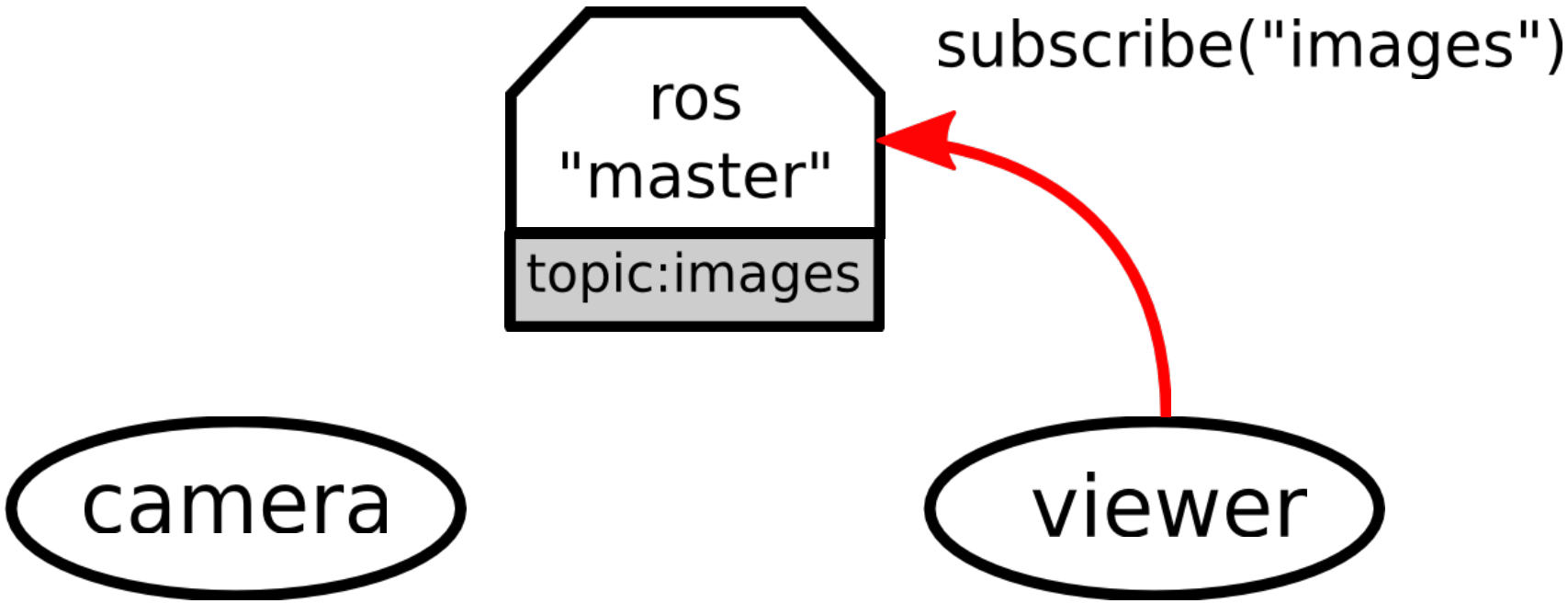

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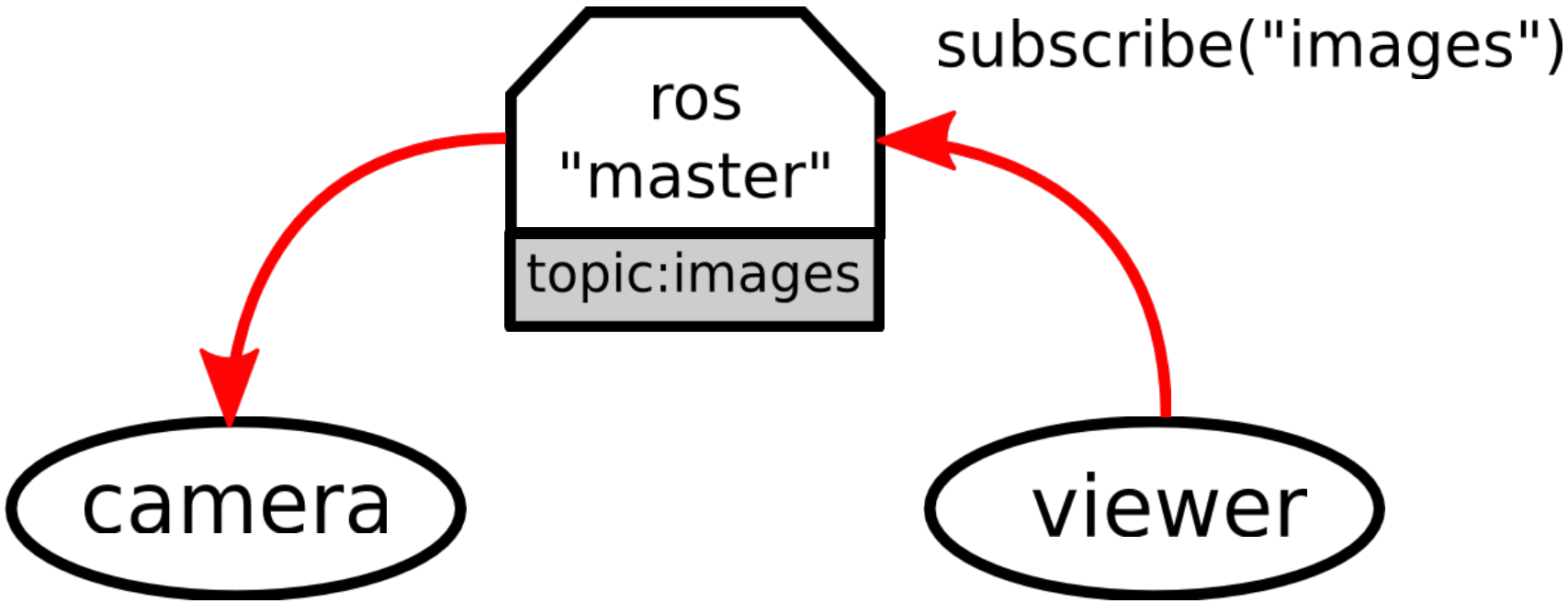

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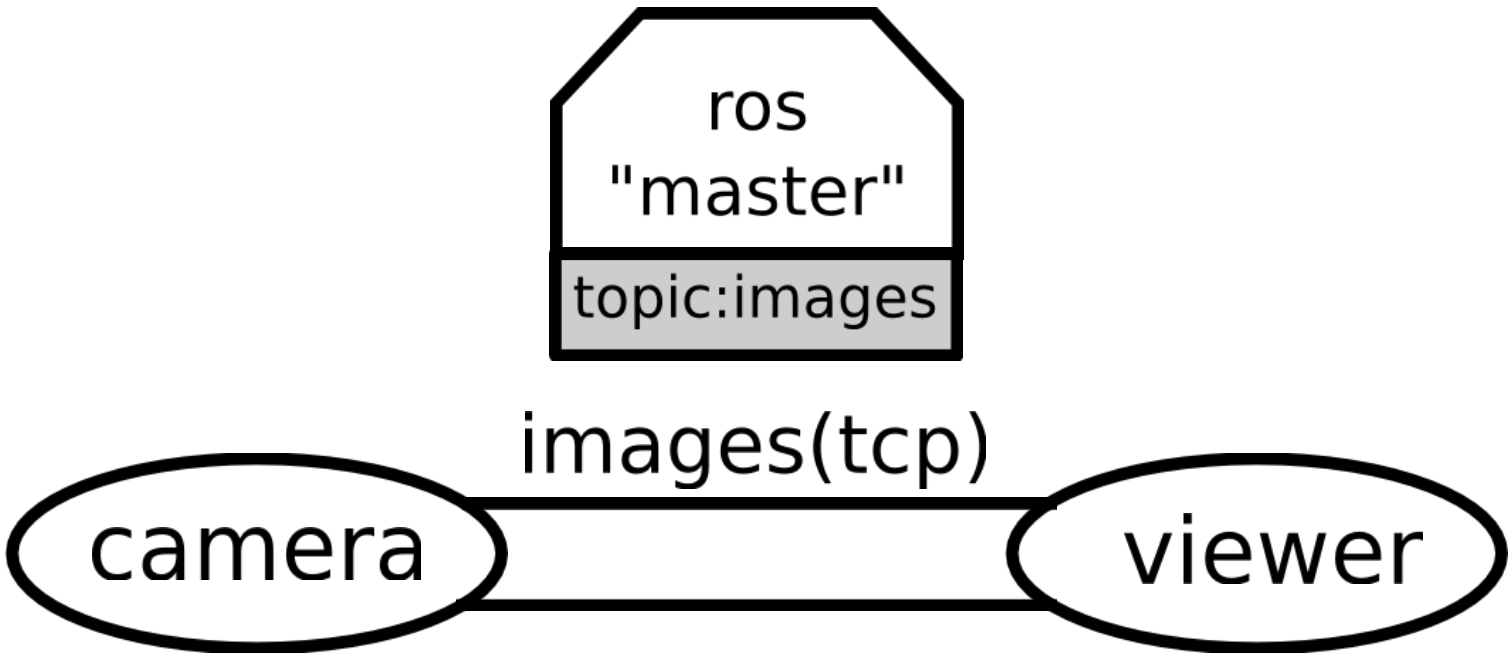

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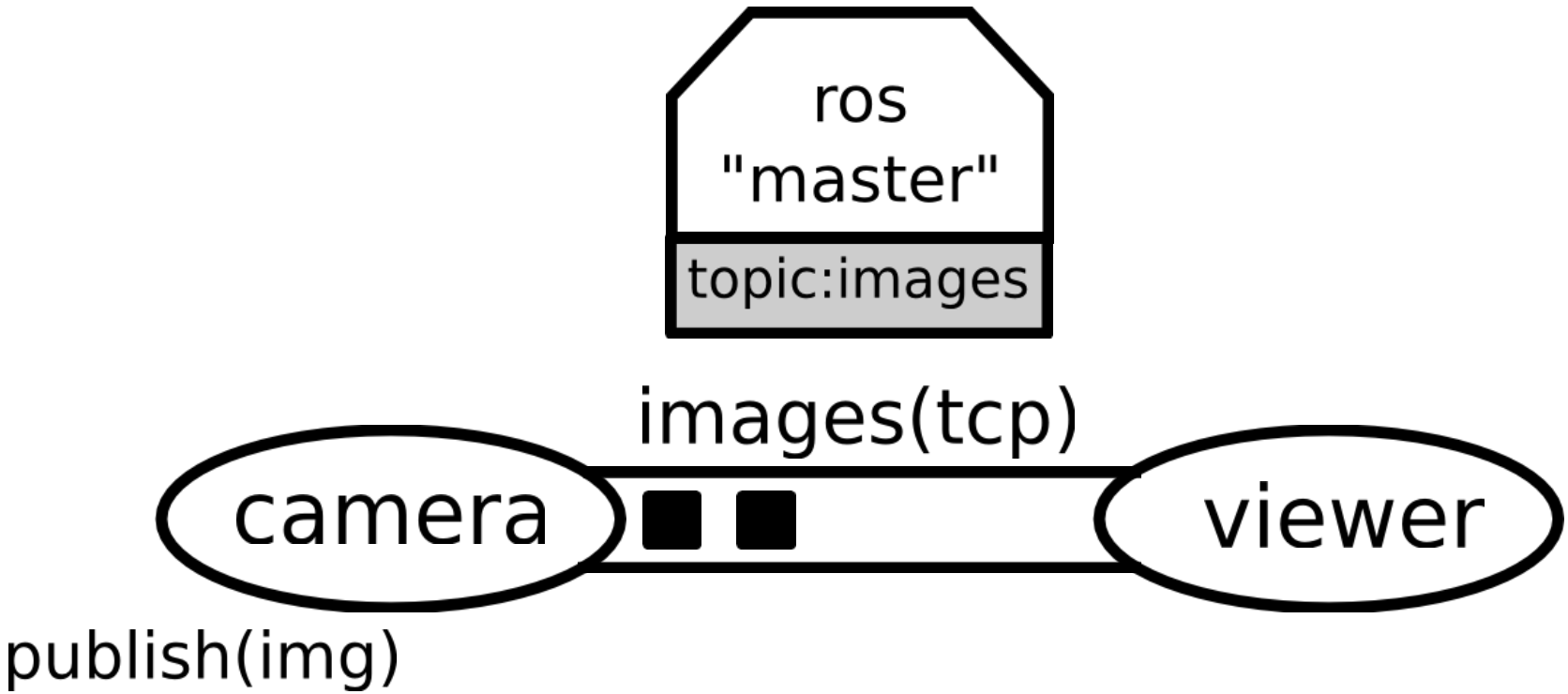

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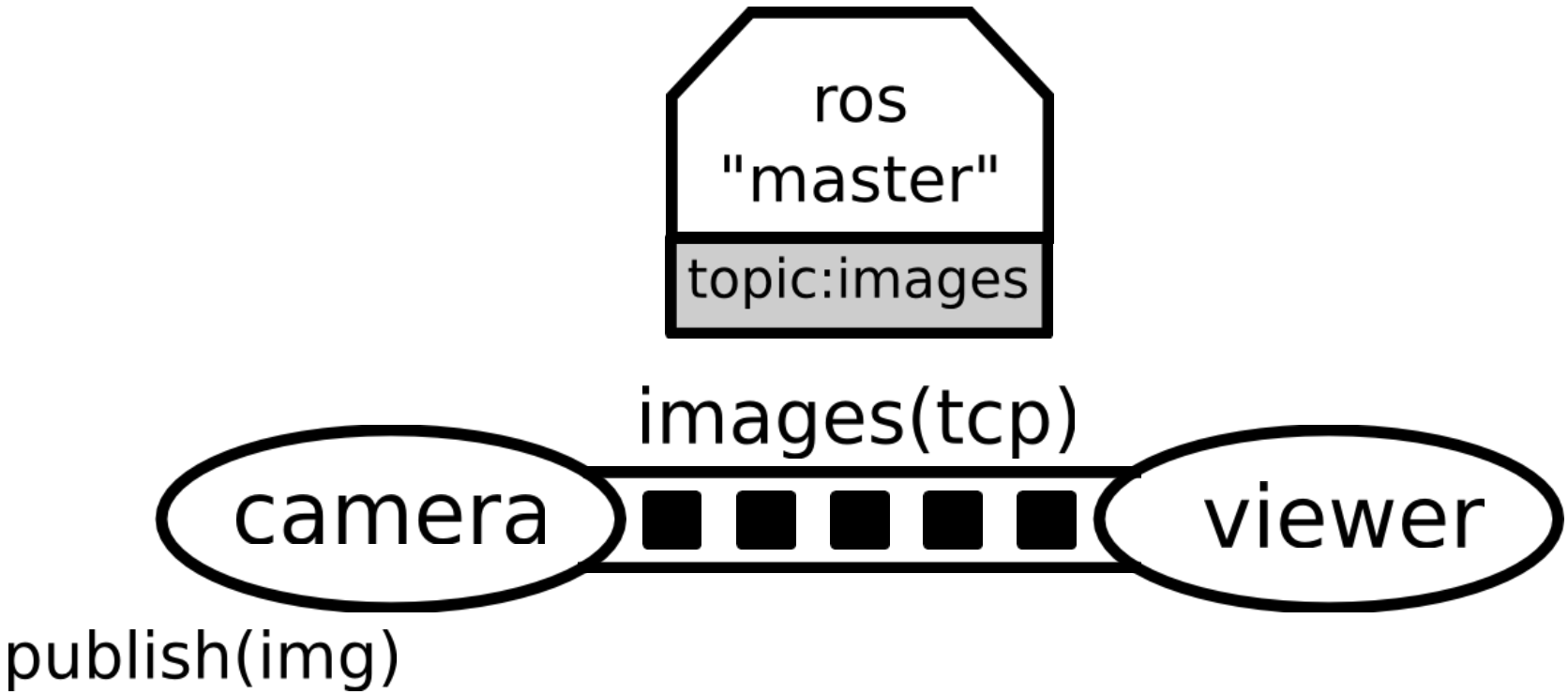

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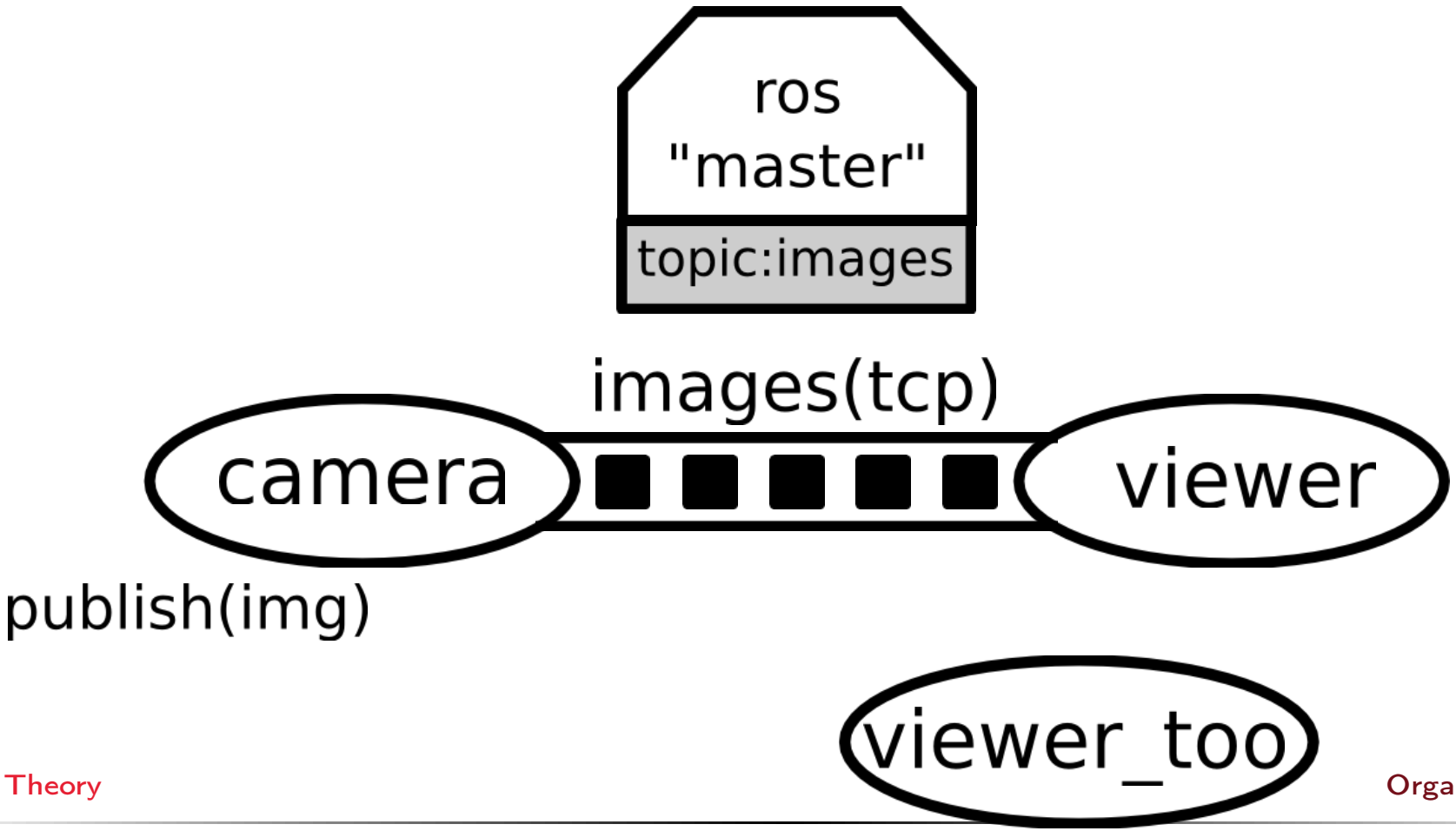

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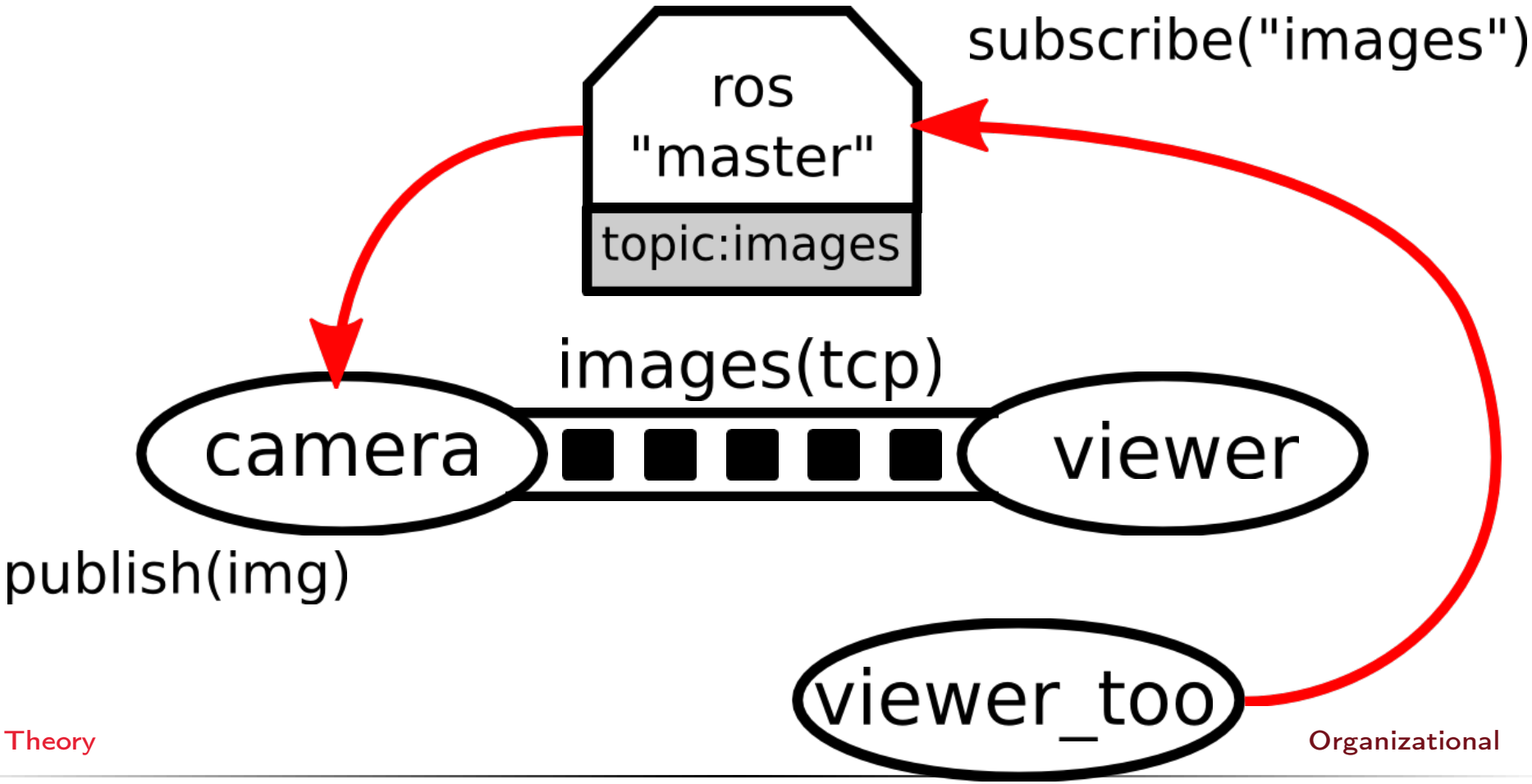

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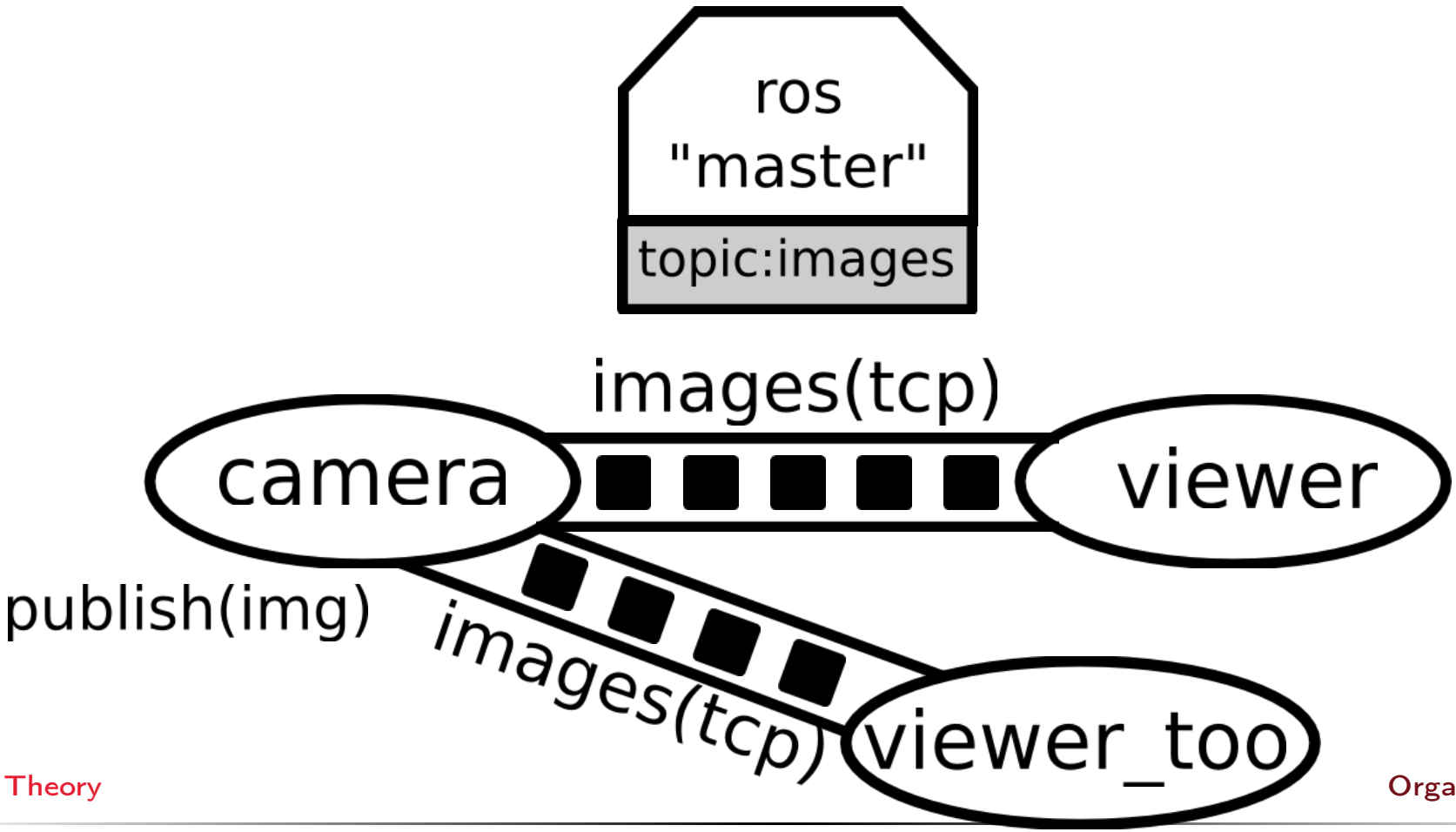

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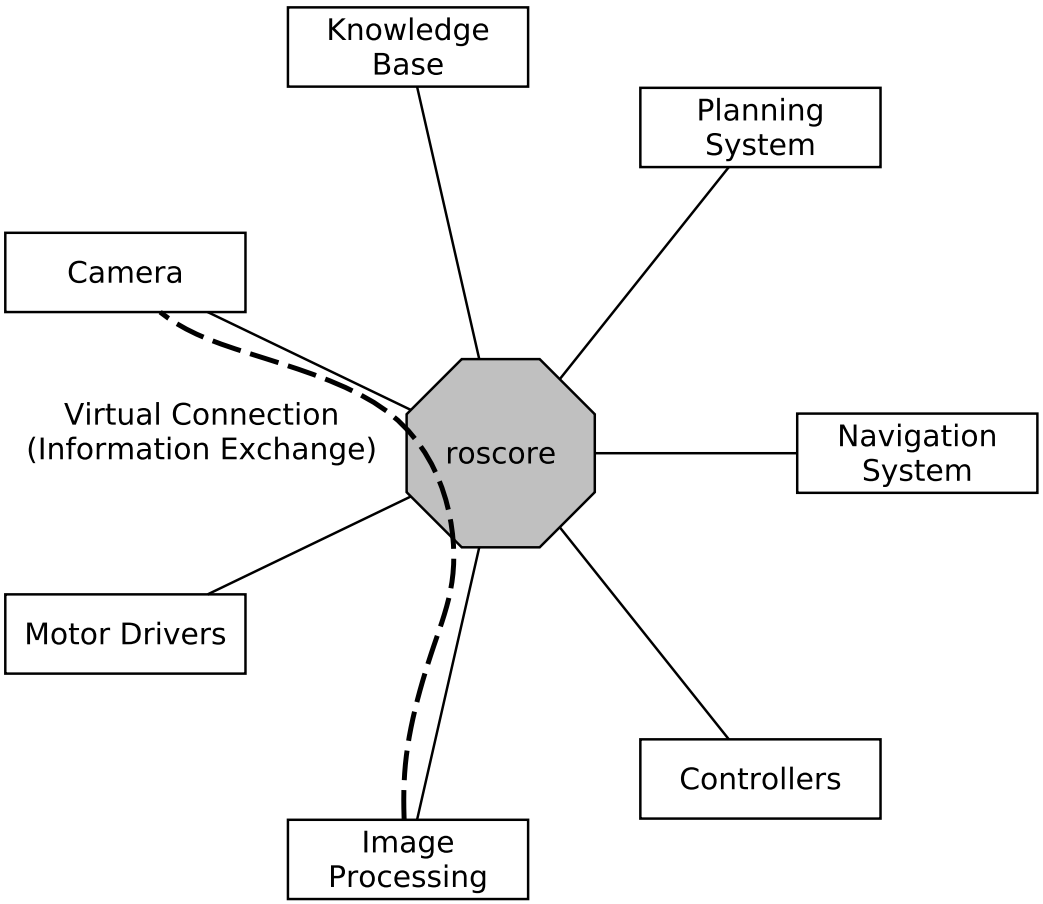

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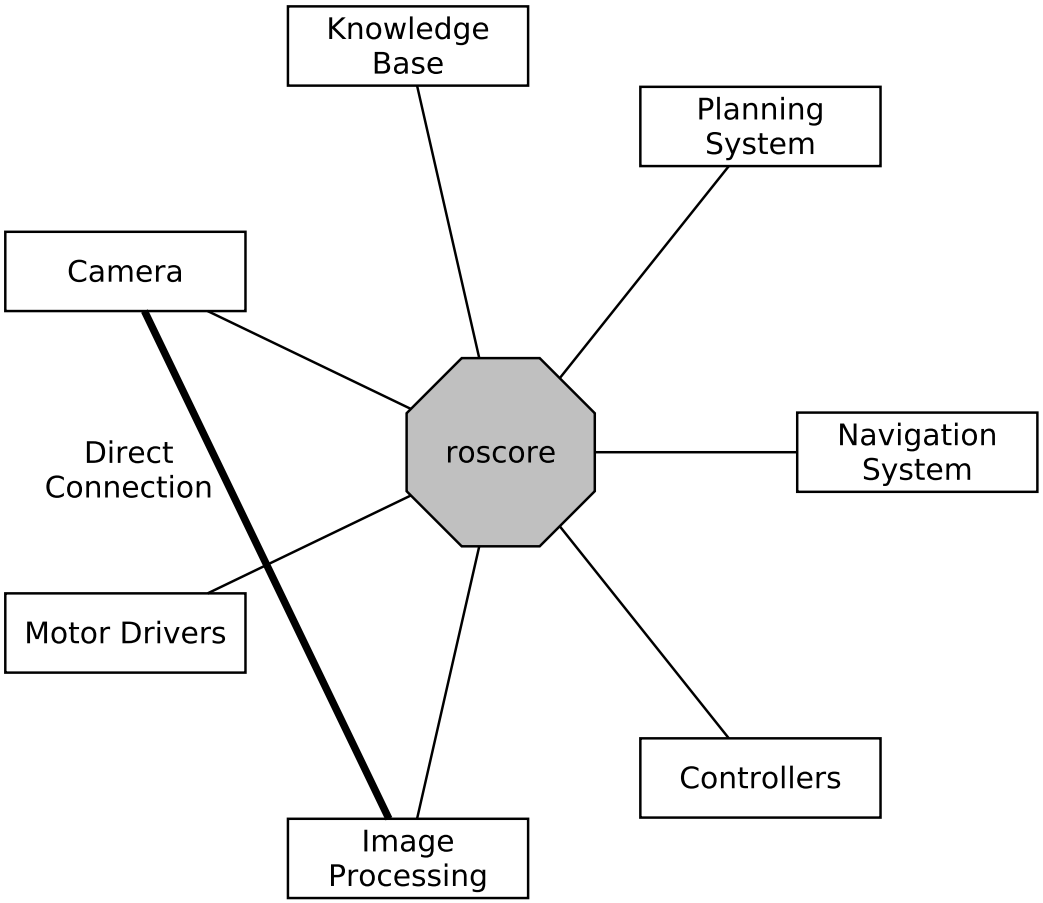

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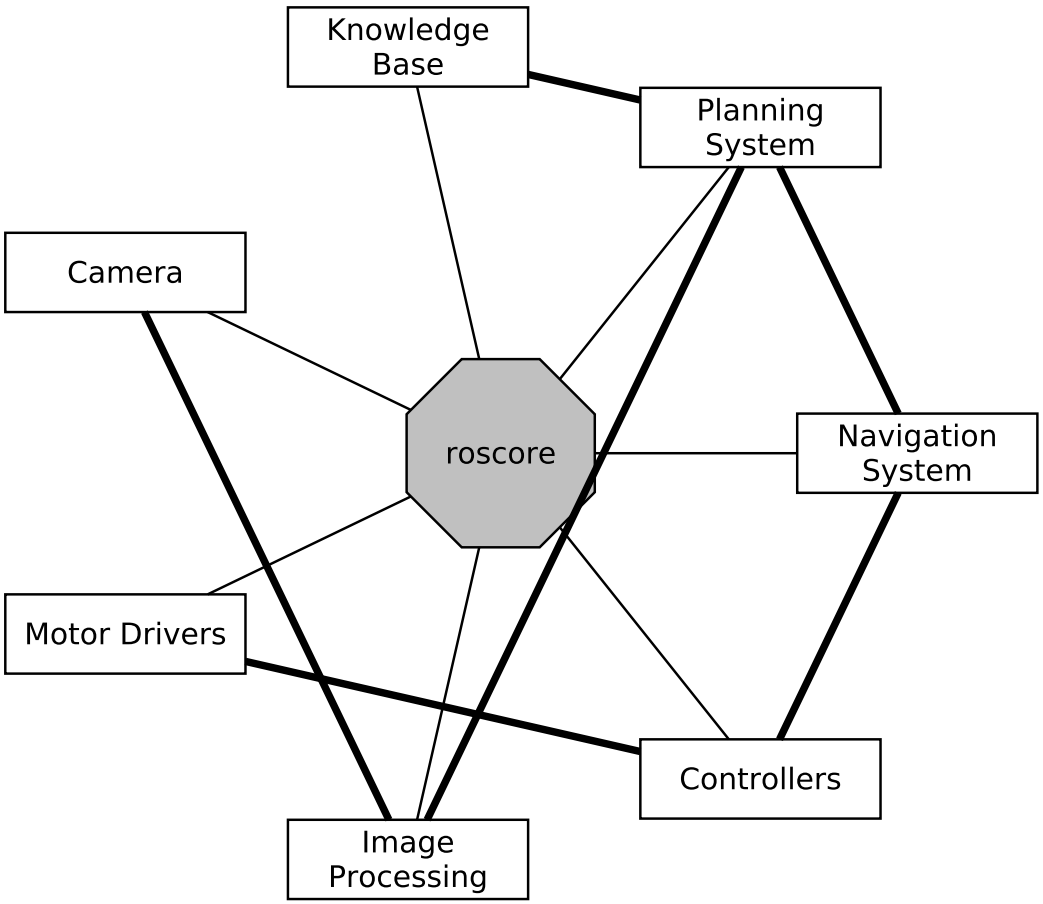


ROS Graph

- Starting the core:

```
$ roscore
```

- Starting a node:

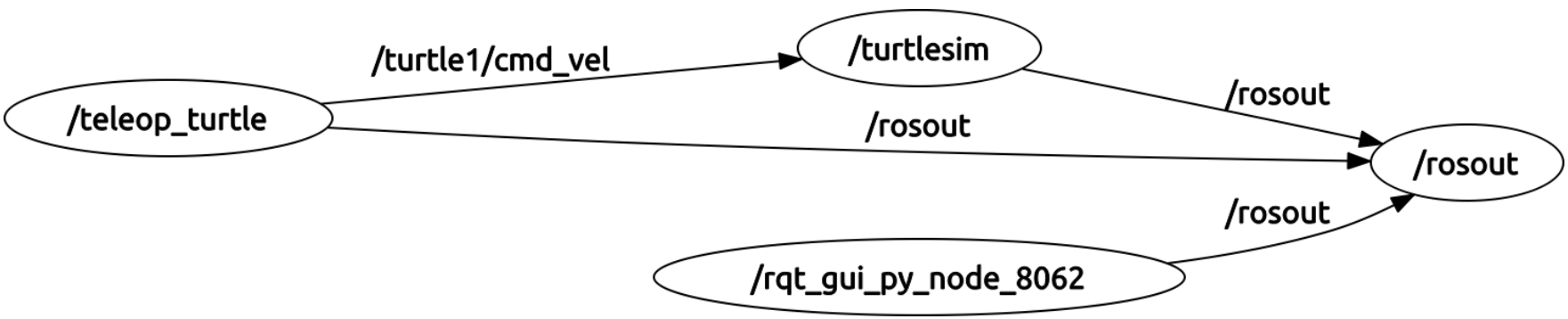
```
$ rosrun turtlesim turtlesim_node
```

- Starting another node:

```
$ rosrun turtlesim turtle_teleop_key
```

- Examining the ROS Graph:

```
$ rosrun turtlesim turtle_teleop_key
```



Tools

- `rosnode`: gives the user information about a node

```
$ rosnode -help

cleanup, info, kill, list, machine, ping
```

- `rostopic`: gives publishers, subscribes to the topic, datarate, the actual data

```
bw, echo, find, hz, info, list, pub, type
```

- `rosservice`: enables a user to call a ROS Service from the command line

```
call, find, list, type, uri
```

- `rosmsg`: gives information about message types

```
list, md5, package, packages, show
```

- `rossrv`: same as above for service types

```
list, md5, package, packages, show
```

- `roswtf`: diagnoses problems with a ROS network

Launch Files

Automated Starting, Stopping and Configuring the Nodes

XML files for launching nodes:

- automatically set parameters and start nodes with a single file
- hierarchically compose collections of launch files
- automatically re-spawn nodes if they crash
- change node names, namespaces, topics, and other resource names
- without recompiling
- easily distribute nodes across multiple machines

Launch Files [2]

Automated Starting, Stopping and Configuring the Nodes

Example

```
<launch>
  <!-- Starting nodes-->
  <node pkg="turtlesim" type="turtlesim_node" name="sim"/>
  <node pkg="turtlesim" type="turtle_teleop_key" name="teleop"
        output="screen"/>

  <!-- Setting parameters -->
  <param name="some_value" type="double" value="2.0"/>
</launch>
```

Using the launch file:

```
$ roslaunch package_name launch_file_name
```

Outline

Packages and Metapackages

- *Packages* are a named collection of software that is built and treated as an atomic dependency in the ROS build system.
- *Metapackages* are dummy "virtual" packages that reference one ofr more related packages which are loosely grouped together

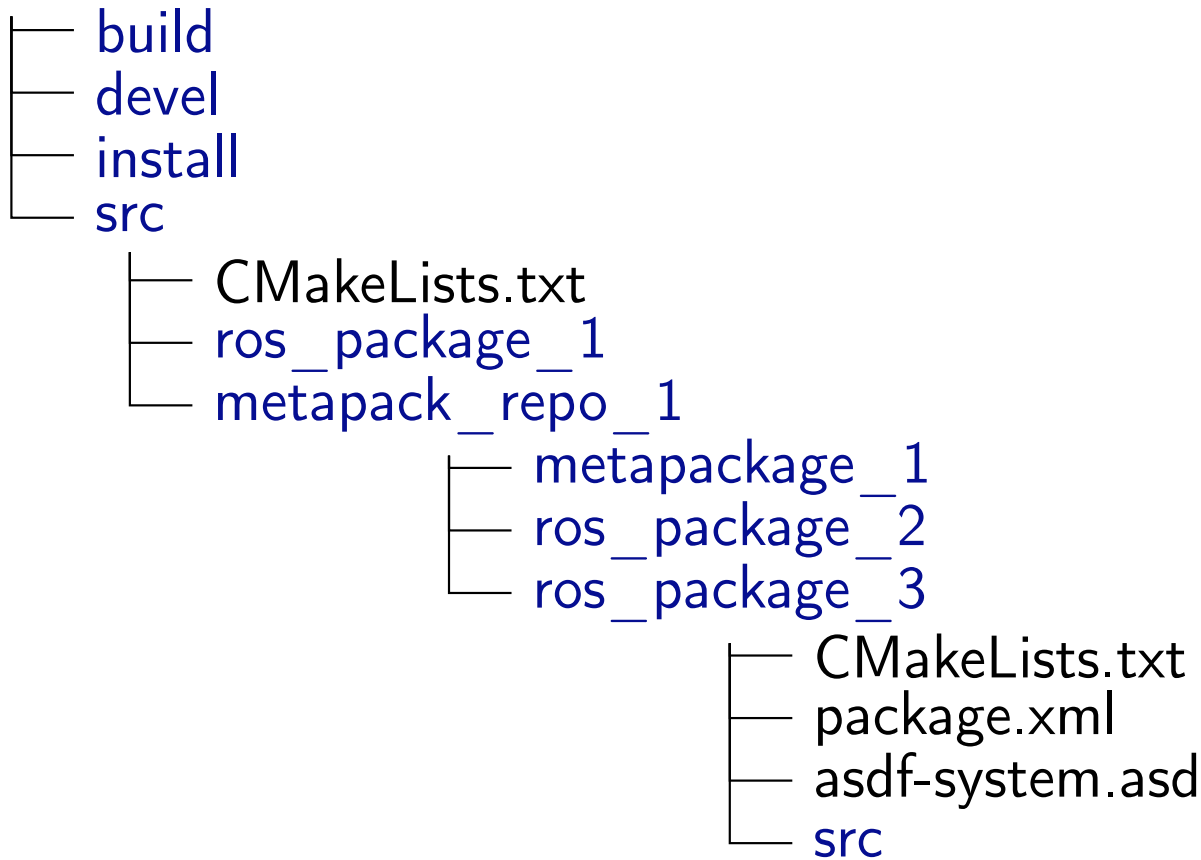
Similar to Debian packages.
Actually released through the Debian packaging system.

ROS Workspace

Packages are stored in ROS workspaces:

```
$ roscd
```

Workspaces have a specific structure



Managing Packages

- Creating a package:

```
$ roscd && cd src/lisp_course_material
$ catkin_create_pkg assignment_6 roslisp turtlesim geometry_msgs
```

- Compiling a package:

```
$ roscd && catkin_make
```

- Moving through ROS workspaces:

```
$ roscd assignment_6
```

Naming convention: underscores (no CamelCase, no-dashes)!

All the packages in your workspace are one huge CMake project.

→ Multiple workspaces chained together.

Package.xml

assignment_6/package.xml

```
<?xml version="1.0"?>
<package>
  <name>assignment_6</name>
  <version>0.0.0</version>
  <description>The assignment_6 package</description>
  <maintainer email="kazhoyan@cs.uni-bremen.de">Gaya</maintainer>
  <license>Public domain</license>
  <buildtool_depend>catkin</buildtool_depend>
  <build_depend>geometry_msgs</build_depend>
  <build_depend>roslisp</build_depend>
  <build_depend>turtlesim</build_depend>
  <run_depend>geometry_msgs</run_depend>
  <run_depend>roslisp</run_depend>
  <run_depend>turtlesim</run_depend>
</package>
```

CMakeLists

assignment_6/CMakeLists.txt

```
cmake_minimum_required(VERSION 2.8.3)
project(assignment_6)
find_package(catkin REQUIRED COMPONENTS
  roslisp
  geometry_msgs
)
catkin_package(
  CATKIN_DEPENDS roslisp geometry_msgs
)
```

Outline

ROS API

ROS API provides the programmer with means to

- start ROS node processes
- generate messages
- publish and subscribe to topics
- start service servers
- send service requests
- provide and query action services
- find ROS packages
- ...

ROS APIs: `roscpp`, `rospy`, `rosjava`, `rosjs`, **`roslisp`**

Links

- ROS documentation

  `http://wiki.ros.org/`

- ROS community support

  `http://answers.ros.org/questions/`

Outline

Organizational Info

- Assignment: `roslisp` tutorial not graded
- Assignment link:

  `http://wiki.ros.org/roslisp/Tutorials/OverviewVersion`
- Next class: 25.11, 14:15, TAB 1.58

Q & A

Thanks for your attention!

Special thanks to Lorenz Mösenlechner and Jan Winkler for providing illustrations!