

# Robot Programming with Lisp

## 6. Lisp Packaging and Introduction to ROS

Gayane Kazhoyan

Institute for Artificial Intelligence  
Universität Bremen

24<sup>th</sup> November, 2015

# Outline

## Lisp Packages and ASDF Systems

Lisp Packages

ASDF Systems

## Robot Operating System

What is a Robot?

ROS Overview

ROS Communication Layer

ROS Build System

Programming with ROS

## Organizational

Lisp Packages and ASDF Systems

Robot Operating System

Organizational

# Outline

## Lisp Packages and ASDF Systems

Lisp Packages

ASDF Systems

## Robot Operating System

What is a Robot?

ROS Overview

ROS Communication Layer

ROS Build System

Programming with ROS

## Organizational

Lisp Packages and ASDF Systems

Robot Operating System

Organizational

# Lisp Packages

Lisp packages define namespaces.

They are used to avoid naming clashes and control access permissions.

## Lisp Packages

```
CL-USER> (defun lambda () #\L)
Lock on package COMMON-LISP violated when proclaiming LAMBDA as ...
CL-USER> (defpackage :i-want-my-own-lambda)
CL-USER> (in-package :i-want-my-own-lambda)
#<COMMON-LISP:PACKAGE "I-WANT-MY-OWN-LAMBDA">
I-WANT-MY-OWN-LAMBDA> (common-lisp:defun lambda () #\L)
LAMBDA
I-WANT-MY-OWN-LAMBDA> (common-lisp:in-package :cl-user)
#<PACKAGE "COMMON-LISP-USER">
CL-USER> (describe *)
#<PACKAGE "COMMON-LISP-USER">
Documentation:
  public: the default package for user code and data
Nicknames: CL-USER
Use-list: COMMON-LISP, SB-ALIEN, SB-DEBUG, SB-EXT, SB-GRAY, SB-PROFILE
  Lisp Packages and ASDF Systems      Robot Operating System      Organizational
```

# Lisp Packages [2]

## Defining a Package

`defpackage` *defined-package-name* *[[option]]* => *package*

option ::= ( :nicknames nickname\* )\* |  
          ( :documentation string ) |  
          ( :use package-name\* )\* |  
          ( :shadow symbol-name\* )\* |  
          ( :shadowing-import-from package-name symbol-name\* )\* |  
          ( :import-from package-name symbol-name\* )\* |  
          ( :export symbol-name\* )\* |  
          ( :intern symbol-name\* )\* |  
          ( :size integer )

# Lisp Packages [3]

## Example Package Definition

```
CL-USER> (defpackage :homework
           (:nicknames :hw)
           (:documentation "A namespace for my homework assignments")
           (:use :common-lisp))
#<PACKAGE "HOMEWORK">
CL-USER> (in-package :homework)
#<PACKAGE "HOMEWORK">
HW> (defun say-hello () (print "hello"))
HW> (say-hello)
"hello"
HW> (in-package :common-lisp-user)
#<PACKAGE "COMMON-LISP-USER">
CL-USER> (say-hello)
The function COMMON-LISP-USER::SAY-HELLO is undefined.
CL-USER> (hw:say-hello)
The symbol "SAY-HELLO" is not external in the HOMEWORK package.
CL-USER> (hw::say-hello)
"hello"
```

# Symbol Namespaces

## symbol-package

```
CL-USER> (in-package "HOMEWORK")
#<PACKAGE "HOMEWORK">
HW> (describe 'say-hello)
HOMEWORK::SAY-HELLO
HW> (describe 'defun)
COMMON-LISP:DEFUN
HW> (describe :hello)
:HELLO
HW> (symbol-package 'say-hello)
#<PACKAGE "HOMEWORK">
HW> (symbol-package :hello)
#<PACKAGE "KEYWORD">
HW> (eql ':hello :hello)
T
HW> keyword:hello
:HELLO
HW> (eql :hello keyword:hello)
T
```

## Symbol Namespaces [2]

Uninterned symbols, `find-package`, `intern`

```
HW> '#:hello
#:HELLO
HW> (symbol-package '#:hello)
NIL
HW> (eql '#:hello '#:hello)
NIL
HW> (gensym)
#:G1008
HW> (find-package :homework)
#<PACKAGE "HOMEWORK">
HW> (intern "HELLO" (find-package :homework))
HELLO
NIL
HW> (describe 'hello)
HOMEWORK::HELLO
HW> (loop for i from 1 to 5
      collect (intern (format nil "NAME-~a" i)))
(NAME-1 NAME-2 NAME-3 NAME-4 NAME-5)
```



# Outline

## Lisp Packages and ASDF Systems

Lisp Packages

ASDF Systems

## Robot Operating System

What is a Robot?

ROS Overview

ROS Communication Layer

ROS Build System

Programming with ROS

## Organizational

Lisp Packages and ASDF Systems

Robot Operating System

Organizational

# ASDF Systems

ASDF is Another System Definition Facility:

- It takes care of compiling and “linking” files together in correct order.
- It is also responsible for finding Lisp files across the file system.

## ASDF System Definition

```
(in-package :cl-user)
(asdf:defsystem my-system
  :name "My Super-Duper System"
  :description "My Super-Duper System is for doing cool stuff."
  :long-description "Here's how it does cool stuff: ..."
  :version "0.1"
  :author "First Last <email@bla.bla>"
  :licence "BSD"
  :depends-on (alexandria and-another-system)
  :components ((:file "package")))
```

## ASDF Systems [2]

ASDF keeps a *registry* of all the paths where it expects to find `.asd` files. A registry is a list of paths.

There are different types of registries: for users, for administrators, etc. But the simplest is to work with the `*central-registry*`.

### Managing the Registry

```
CL-USER> asdf:*central-registry*  
(#P"/some/path/"  
 #P"/some/other/path/")  
CL-USER> (push "~/path/to/dir/of/my-system/" asdf:*central-registry*)  
( "~/path/to/dir/of/my-system/"  
  #P"/some/path/"  
  #P"/some/other/path/")  
CL-USER> (asdf:load-system :my-system)  
T
```

The trailing slash is important ("`/some/path/`")!

# Outline

## Lisp Packages and ASDF Systems

Lisp Packages

ASDF Systems

## Robot Operating System

What is a Robot?

ROS Overview

ROS Communication Layer

ROS Build System

Programming with ROS

## Organizational

Lisp Packages and ASDF Systems

Robot Operating System

Organizational

# Outline

## Lisp Packages and ASDF Systems

Lisp Packages

ASDF Systems

## Robot Operating System

What is a Robot?

ROS Overview

ROS Communication Layer

ROS Build System

Programming with ROS

## Organizational

Lisp Packages and ASDF Systems

Robot Operating System

Organizational

# Industrial Robots

## Logistics



Image courtesy: BIBA

## Automotive

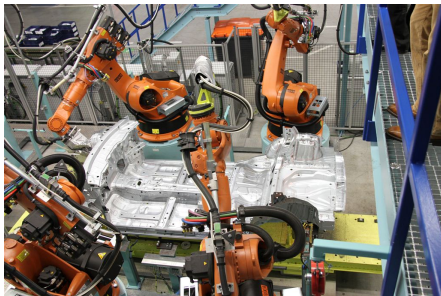


Image courtesy: Mercedes Benz Bremen

- 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)

Lisp Packages and ASDF Systems

Robot Operating System

Organizational

# Industrial Light-weight Robots

## Production:



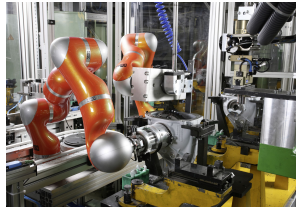
Copyright: Universal Robots

## 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



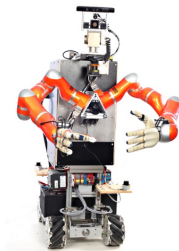
# Service Robots with Light-weight Arms

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

## Lisp Packages and ASDF Systems

Lisp Packages

ASDF Systems

## Robot Operating System

What is a Robot?

ROS Overview

ROS Communication Layer

ROS Build System

Programming with ROS

## Organizational

Lisp Packages and ASDF Systems

Robot Operating System

Organizational

# Motivation

- Numerous different robotics labs, each with their own robot platforms, different operating systems and programming languages but similar software and hardware modules for most of them.

# Motivation

- Numerous different robotics labs, each with their own robot platforms, different operating systems and programming languages but similar software and hardware modules for most of them.
- Each lab reinventing the wheel for their platforms.

# Motivation

- Numerous different robotics labs, each with their own robot platforms, different operating systems and programming languages but similar software and hardware modules for most of them.
- Each lab reinventing the wheel for their platforms.
- **Idea:** provide a unified software framework for everyone to work with.  
Requirements:

# Motivation

- Numerous different robotics labs, each with their own robot platforms, different operating systems and programming languages but similar software and hardware modules for most of them.
- Each lab reinventing the wheel for their platforms.
- **Idea:** provide a unified software framework for everyone to work with.  
Requirements:
  - Support for different programming languages

# Motivation

- Numerous different robotics labs, each with their own robot platforms, different operating systems and programming languages but similar software and hardware modules for most of them.
- Each lab reinventing the wheel for their platforms.
- **Idea:** provide a unified software framework for everyone to work with.  
Requirements:
  - Support for different programming languages
  - Different operating systems

# Motivation

- Numerous different robotics labs, each with their own robot platforms, different operating systems and programming languages but similar software and hardware modules for most of them.
- Each lab reinventing the wheel for their platforms.
- **Idea:** provide a unified software framework for everyone to work with.

Requirements:

- Support for different programming languages
- Different operating systems
- Distributed processing over multiple computers / robots



# Motivation

- Numerous different robotics labs, each with their own robot platforms, different operating systems and programming languages but similar software and hardware modules for most of them.
- Each lab reinventing the wheel for their platforms.
- **Idea:** provide a unified software framework for everyone to work with.

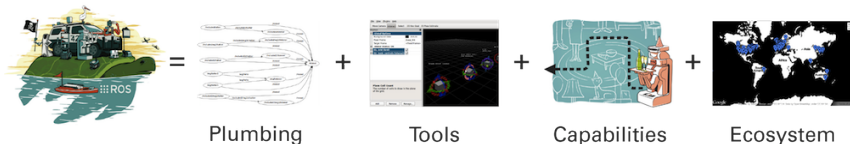
Requirements:

- Support for different programming languages
- Different operating systems
- Distributed processing over multiple computers / robots
- 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:

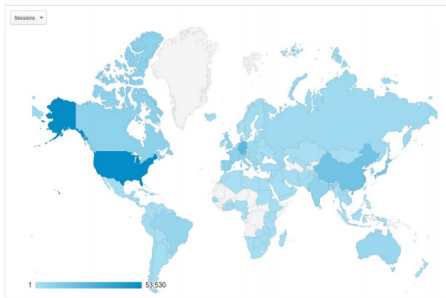
- hardware drivers
- libraries (PCL, OpenCV, TF, ...)
- capabilities (navigation, manipulation, control, ...)
- applications (fetching beer, making popcorn, ...)

# 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 (3.22%)
9.	 India	7,360 (3.22%)
10.	 Italy	6,623 (2.90%)
11.	 Brazil	5,837 (2.55%)
12.	 South Korea	4,980 (2.18%)
13.	 Australia	4,828 (2.11%)
14.	 Singapore	4,680 (2.02%)
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

Lisp Packages and ASDF Systems

Robot Operating System

Organizational

# ROS Community [2]

Some robots supporting ROS (data from November 2014):



Lisp Packages and ASDF Systems

Robot Operating System

Organizational

# Outline

## Lisp Packages and ASDF Systems

Lisp Packages

ASDF Systems

## Robot Operating System

What is a Robot?

ROS Overview

ROS Communication Layer

ROS Build System

Programming with ROS

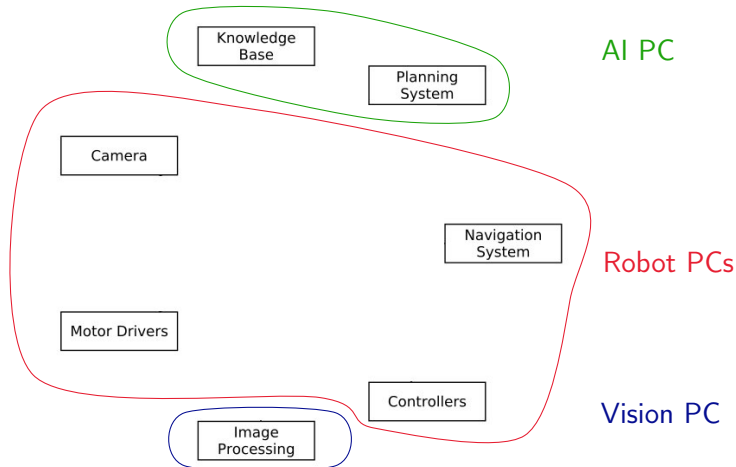
## Organizational

Lisp Packages and ASDF Systems

Robot Operating System

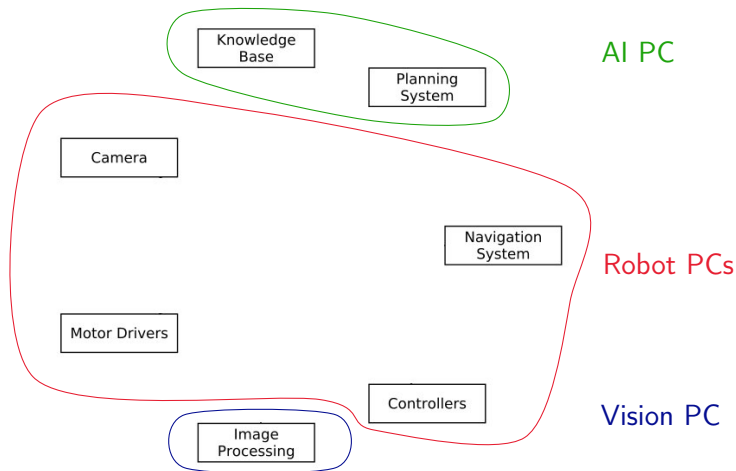
Organizational

# Robotic software components





# Robotic software components



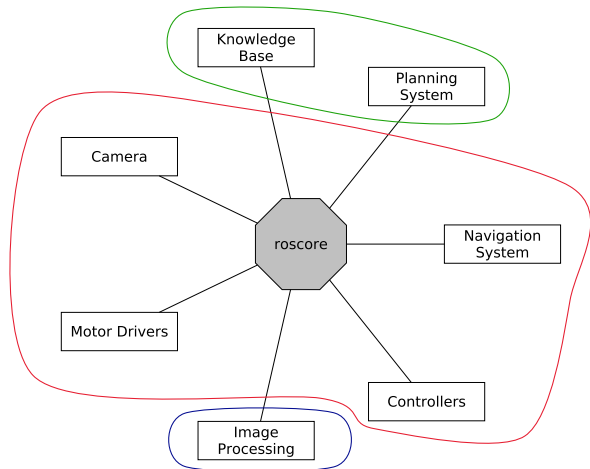
→ Processes distributed all over the place.

Lisp Packages and ASDF Systems

Robot Operating System

Organizational

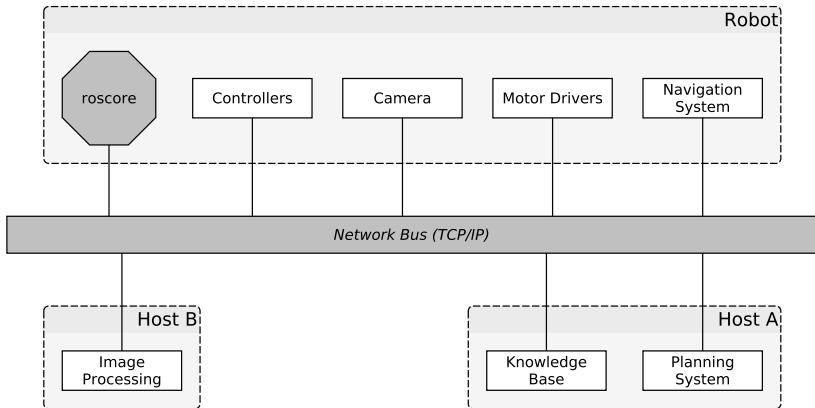
# Connecting Pieces Together



# 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



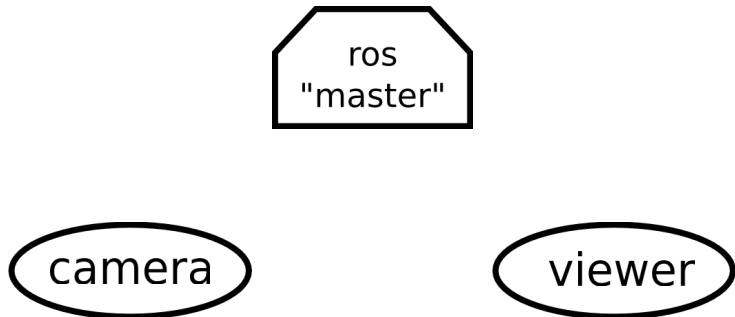
# Terminology

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

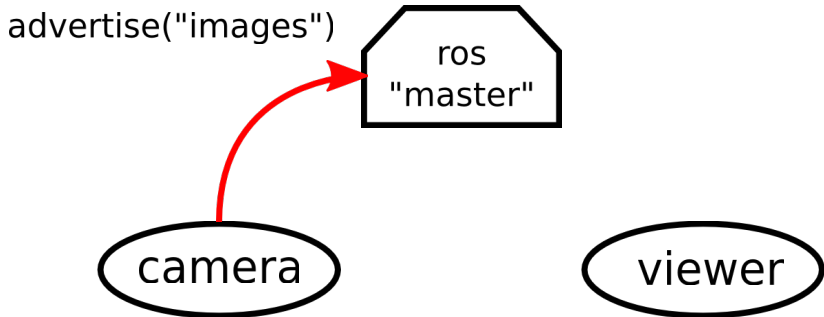
Node communication means:

- **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

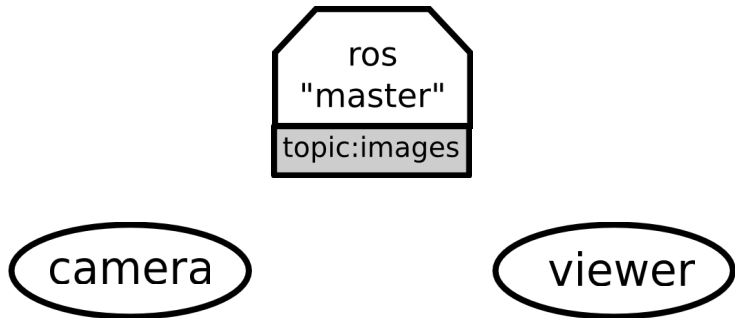
# Establishing Communication



# Establishing Communication

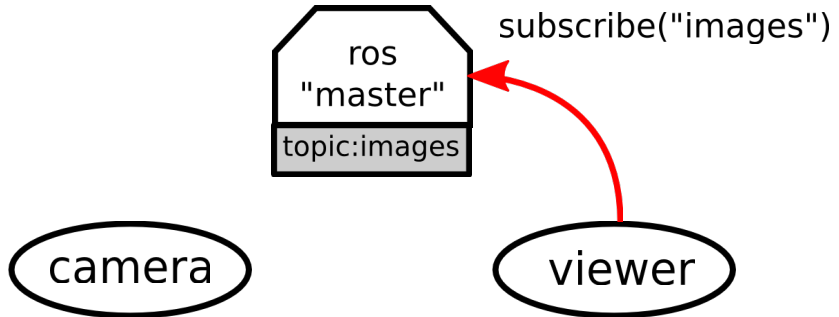


# Establishing Communication

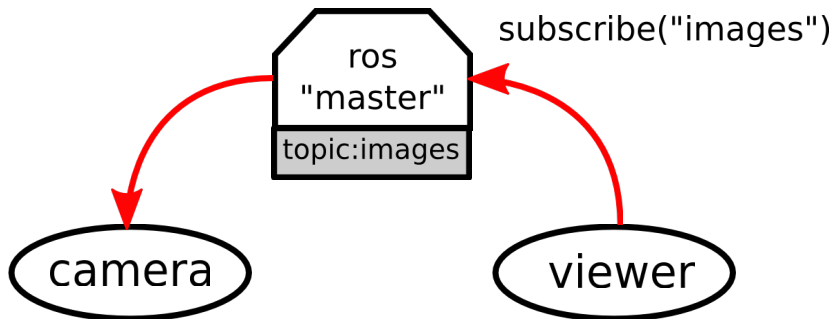




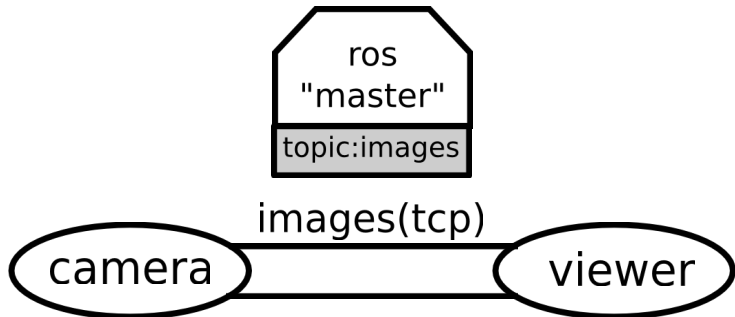
# Establishing Communication



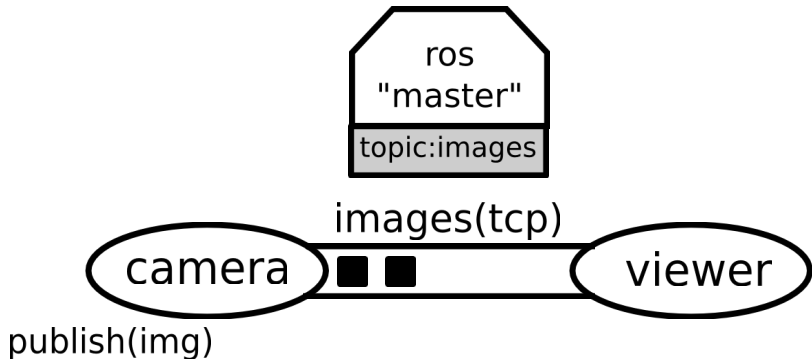
# Establishing Communication



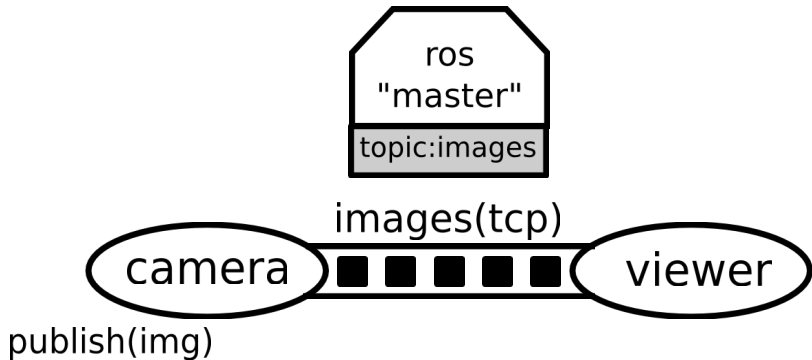
# Establishing Communication



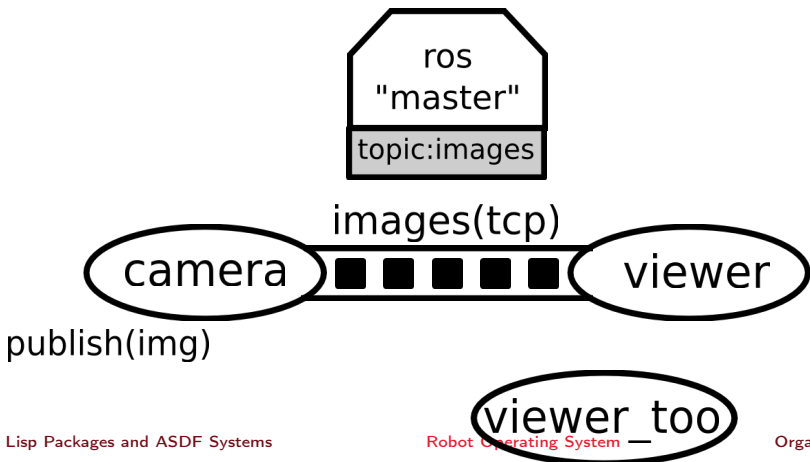
# Establishing Communication



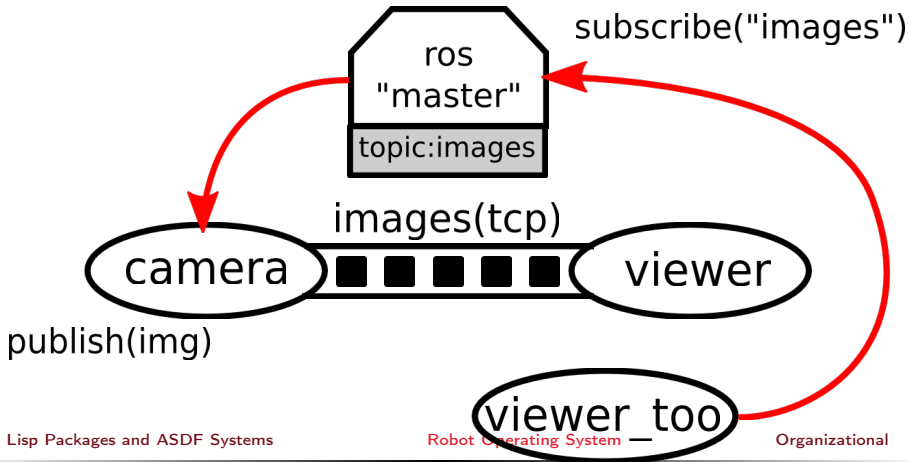
# Establishing Communication



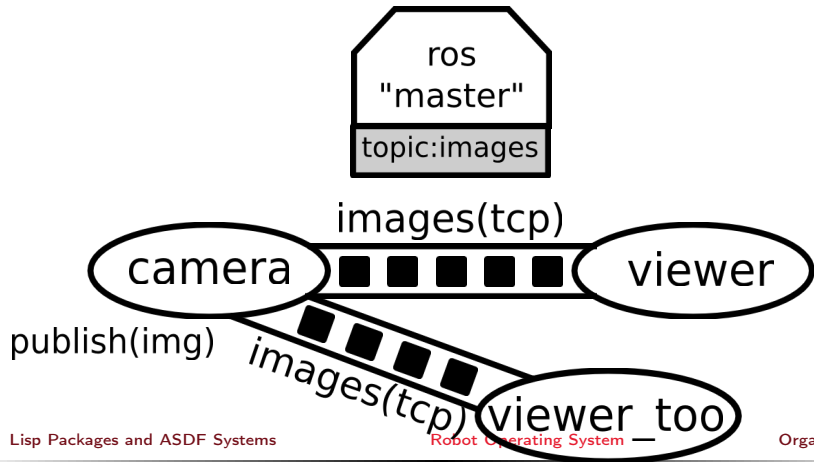
# Establishing Communication



# Establishing Communication

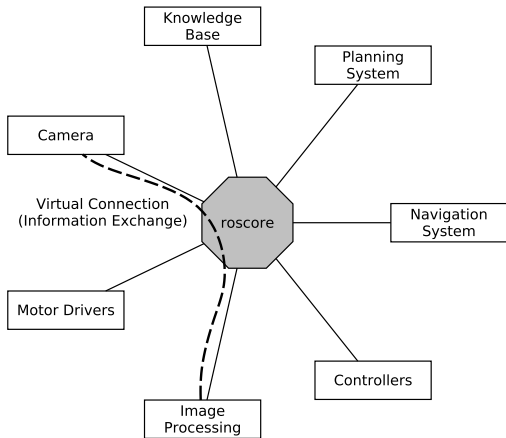


# Establishing Communication

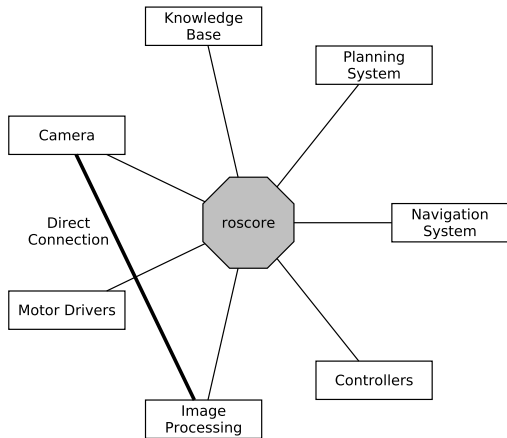




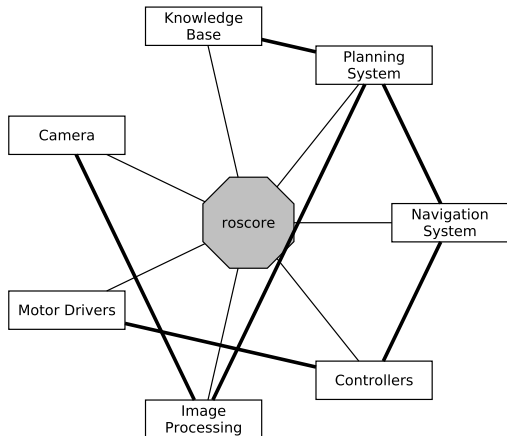
# Establishing Communication [2]



# Establishing Communication [2]



# Establishing Communication [2]



# ROS Graph

- Starting the core:

```
$ roscore
```

- Starting a node:

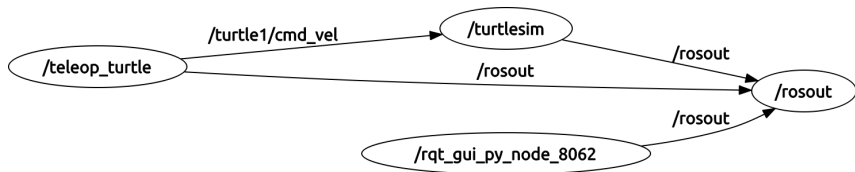
```
$ rosruntime turtlesim turtlesim_node
```

- Starting another node:

```
$ rosruntime turtlesim turtle_teleop_key
```

- Examining the ROS Graph:

```
$ rqt_graph
```



# Tools

- `roscall`: gives the user information about a node  
`$ roscall -h`  
`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`
- `rosmmsg`: 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

## Lisp Packages and ASDF Systems

Lisp Packages

ASDF Systems

## Robot Operating System

What is a Robot?

ROS Overview

ROS Communication Layer

ROS Build System

Programming with ROS

## Organizational

Lisp Packages and ASDF Systems

Robot Operating System

Organizational



# 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 or more related packages which are loosely grouped together

Similar to Debian packages.

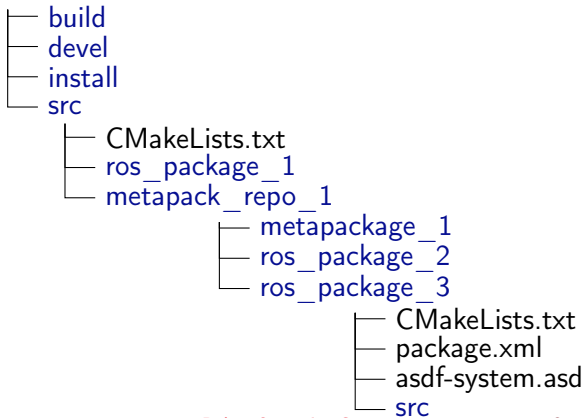
Actually released through the Debian packaging system.

# 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

## Lisp Packages and ASDF Systems

Lisp Packages

ASDF Systems

## Robot Operating System

What is a Robot?

ROS Overview

ROS Communication Layer

ROS Build System

Programming with ROS

## Organizational

Lisp Packages and ASDF Systems

Robot Operating System

Organizational

# 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

## Lisp Packages and ASDF Systems

Lisp Packages

ASDF Systems

## Robot Operating System

What is a Robot?

ROS Overview

ROS Communication Layer

ROS Build System

Programming with ROS

## Organizational

Lisp Packages and ASDF Systems

Robot Operating System

Organizational

# Organizational Info

- Assignment:

`lisp_course_material/assignment_6_README.md`

- Grades: 5 out of 50 points for this assignment

- Tutorial link:

`http://wiki.ros.org/roslisp/Tutorials/OverviewVersion`

- Next class: 01.12, 14:15, TAB 1.58

# Q & A

Thanks for your attention!

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