One day with a humanoid robot

a crash course on the iCub software tools

as part of
2014 IEEE-RAS International Conference
on Humanoid Robots

November, 18th 2014
Madrid, Spain

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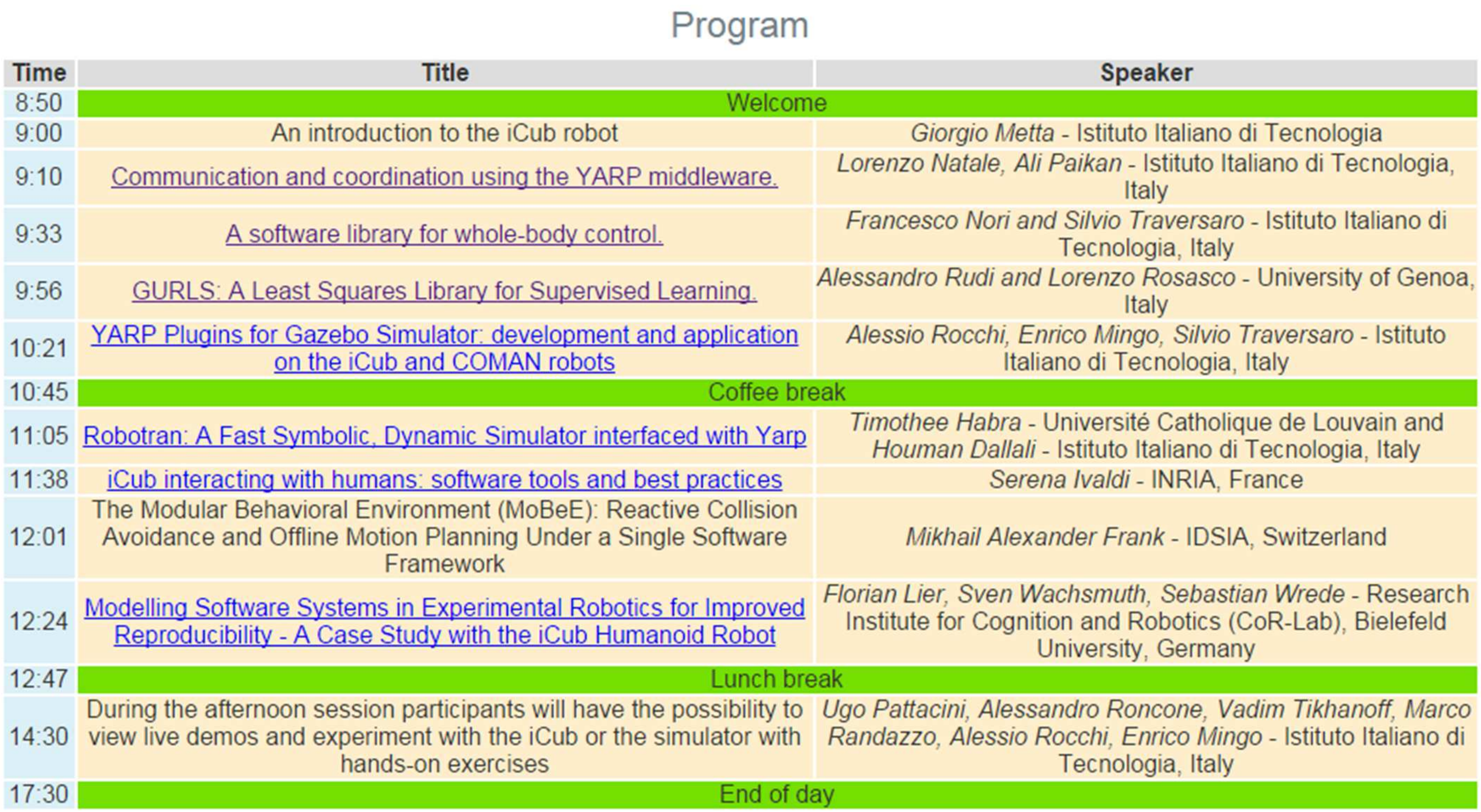
(2) Robotics, Brain and Cognitive Sciences
Istituto Italiano di Tecnologia (IIT)
Via Morego, 30 - 16163 Genoa, Italy



Program

Time	Title	Speaker
8:50	Welcome	
9:00	An introduction to the iCub robot	*Giorgio Metta* - Istituto Italiano di Tecnologia
9:10	Communication and coordination using the YARP middleware.	*Lorenzo Natale, Ali Paikan* - Istituto Italiano di Tecnologia, Italy
9:33	A software library for whole-body control.	*Francesco Nori and Silvio Traversaro* - Istituto Italiano di Tecnologia, Italy
9:56	GURLS: A Least Squares Library for Supervised Learning.	*Alessandro Rudi and Lorenzo Rosasco* - University of Genoa, Italy
10:21	YARP Plugins for Gazebo Simulator: development and application on the iCub and COMAN robots	*Alessio Rocchi, Enrico Mingo, Silvio Traversaro* - Istituto Italiano di Tecnologia, Italy
10:45	Coffee break	
11:05	Robotran: A Fast Symbolic, Dynamic Simulator interfaced with Yarp	*Timothee Habra* - Université Catholique de Louvain and *Houman Dallali* - Istituto Italiano di Tecnologia, Italy
11:38	iCub interacting with humans: software tools and best practices	*Serena Ivaldi* - INRIA, France
12:01	The Modular Behavioral Environment (MoBeE): Reactive Collision Avoidance and Offline Motion Planning Under a Single Software Framework	*Mikhail Alexander Frank* - IDSIA, Switzerland
12:24	Modelling Software Systems in Experimental Robotics for Improved Reproducibility - A Case Study with the iCub Humanoid Robot	*Florian Lier, Sven Wachsmuth, Sebastian Wrede* - Research Institute for Cognition and Robotics (CoR-Lab), Bielefeld University, Germany
12:47	Lunch break	
14:30	During the afternoon session participants will have the possibility to view live demos and experiment with the iCub or the simulator with hands-on exercises	*Ugo Pattacini, Alessandro Roncone, Vadim Tikhanoff, Marco Randazzo, Alessio Rocchi, Enrico Mingo* - Istituto Italiano di Tecnologia, Italy
17:30	End of day	

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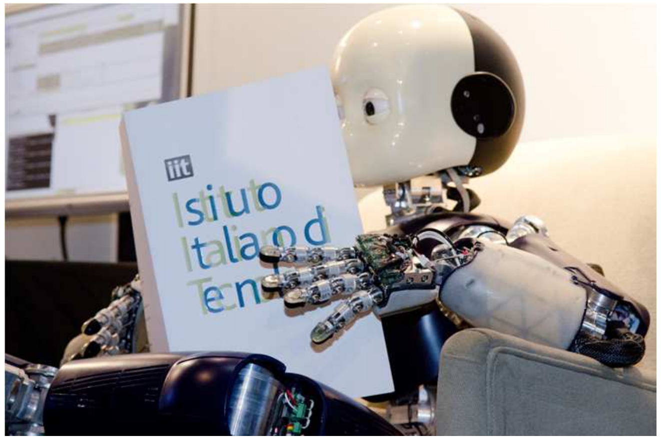
Lorenzo Natale

Coordination and Communication with the YARP middleware



Humanoids 2015 workshop: A day with a humanoid robot
November 18, Madrid Spain

why is the iCub special?

- hands: we started the design from the hands
  - 5 fingers, 9 degrees of freedom, 19 joints

- sensors: human-like, e.g. no lasers
  - cameras, microphones, gyros, encoders, force, tactile…

- electronics: flexibility for research
  - custom electronics, small, programmable (DSPs)

- reproducible platform: community designed
  - reproducible & maintainable yet evolvable platform
  - large software repository (~2M lines of code)

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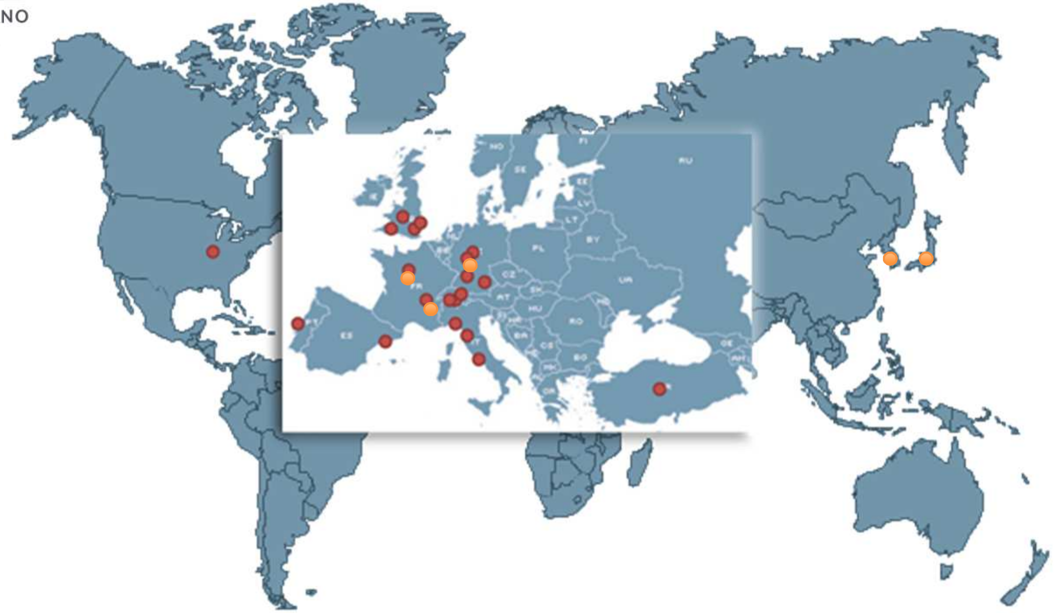
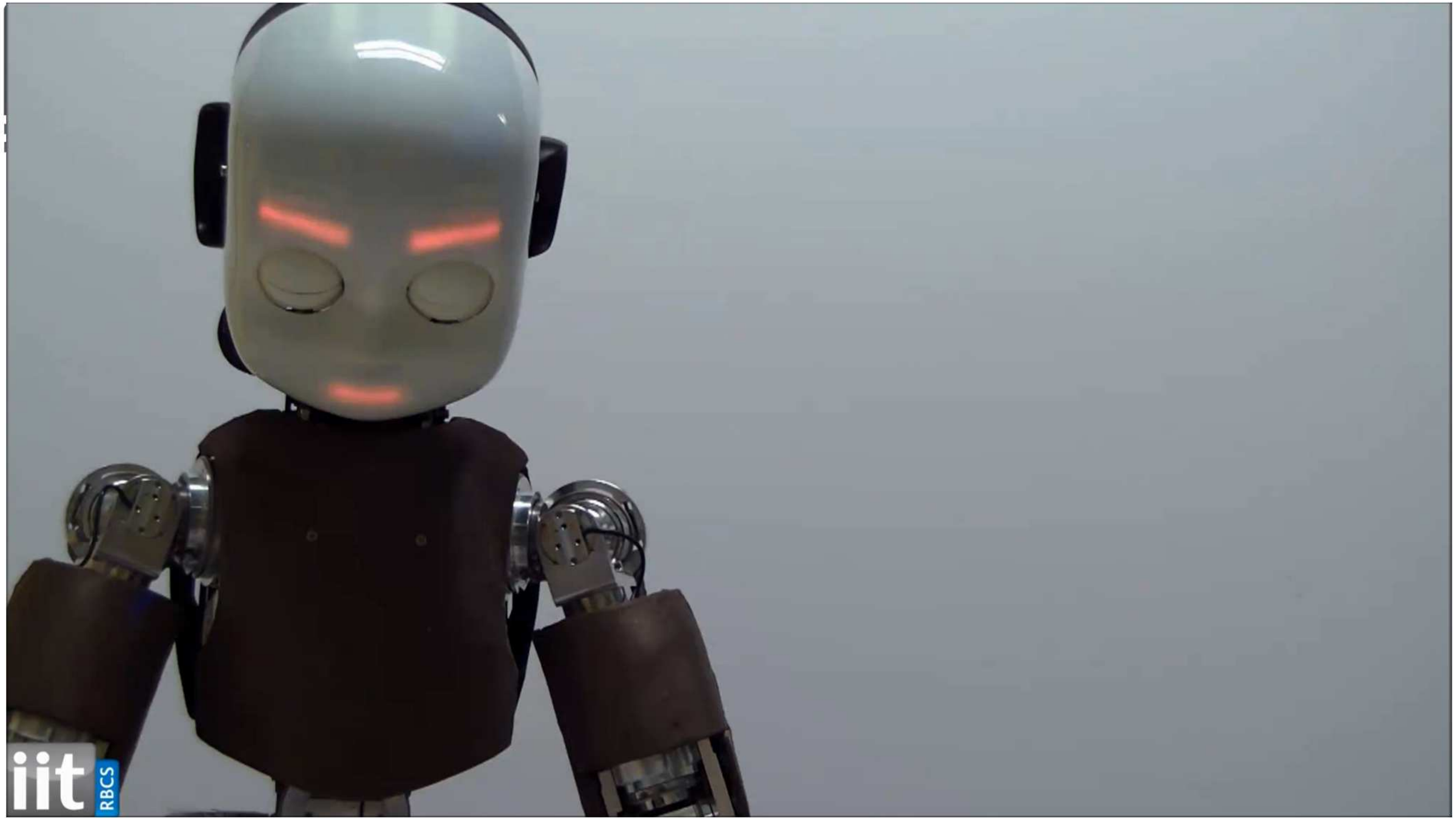
the iCub



price: 250K€
30 iCub
distributed since 2008
about 3-4 iCub’s/year

open hardware



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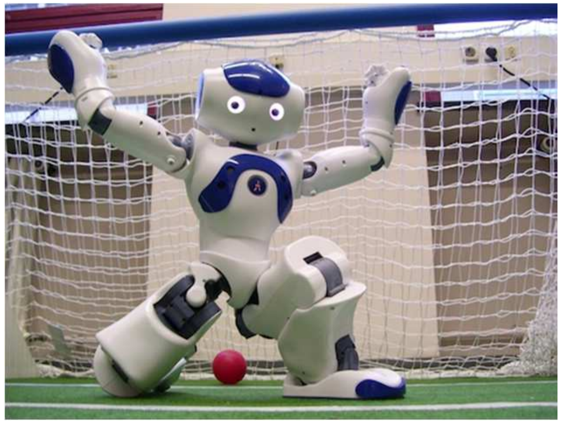
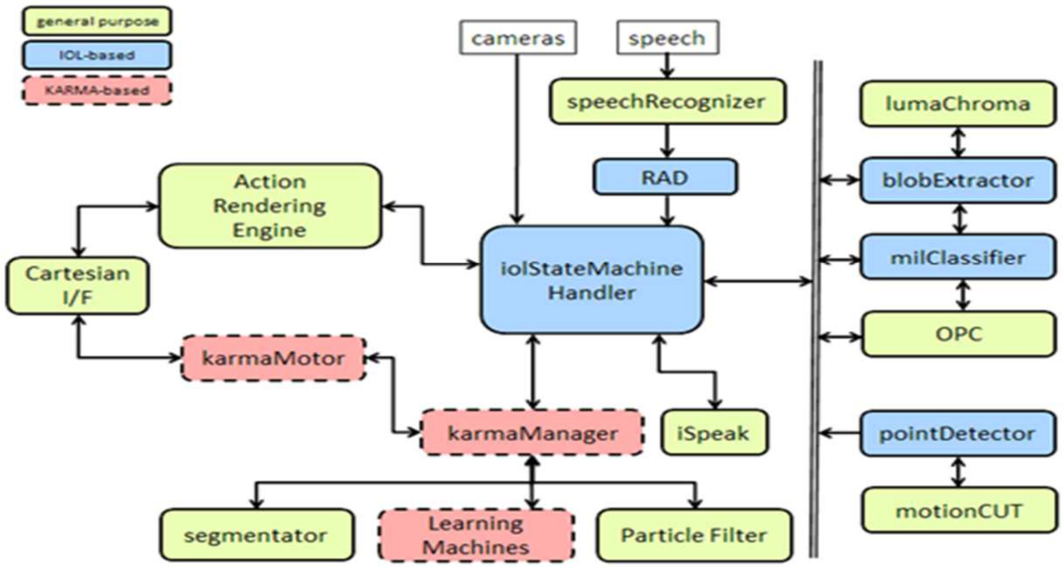
Applications for humanoid robotics

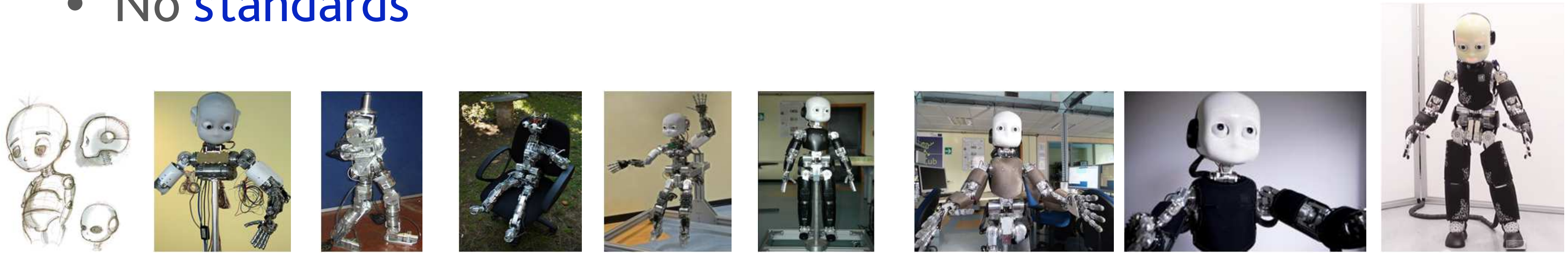


Programming complex behaviors



Key Issues

- Inherent complexity, distributed processing, lots of sensors, real-time
- Asynchronous development
- Various scenarios and platforms
- Fluctuation in hardware and algorithms, lots of open questions
- No standards



Why Yet Another Robot Platform

Why Yet Another Robot Platform

- Started ~2001 as been adopted as the iCub software middleware

CMake
Cross-platform Make
SWIG

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- YCM, support for build system based on CMake

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- YCM, support for build system based on CMake
- Facilitate interoperability and coordination

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this talk

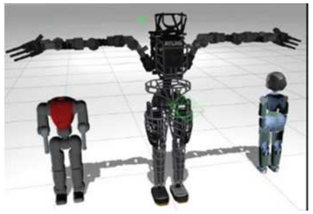
Robot Interface

- Communicating through ports becomes easily complex
- Abstraction layers
  - Separate communication details from interface (streaming, rpc etc)
  - Allows remotization
  - Protect from hardware fluctuations

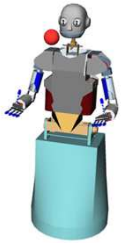
Control loops

```
…
…
read encoders
read IMU
read FT
…
get image
…
set position
```

Robot Interface



Gazebo



Armar III

iCub

COMAN

Robotran

Multibody Models Online

iit

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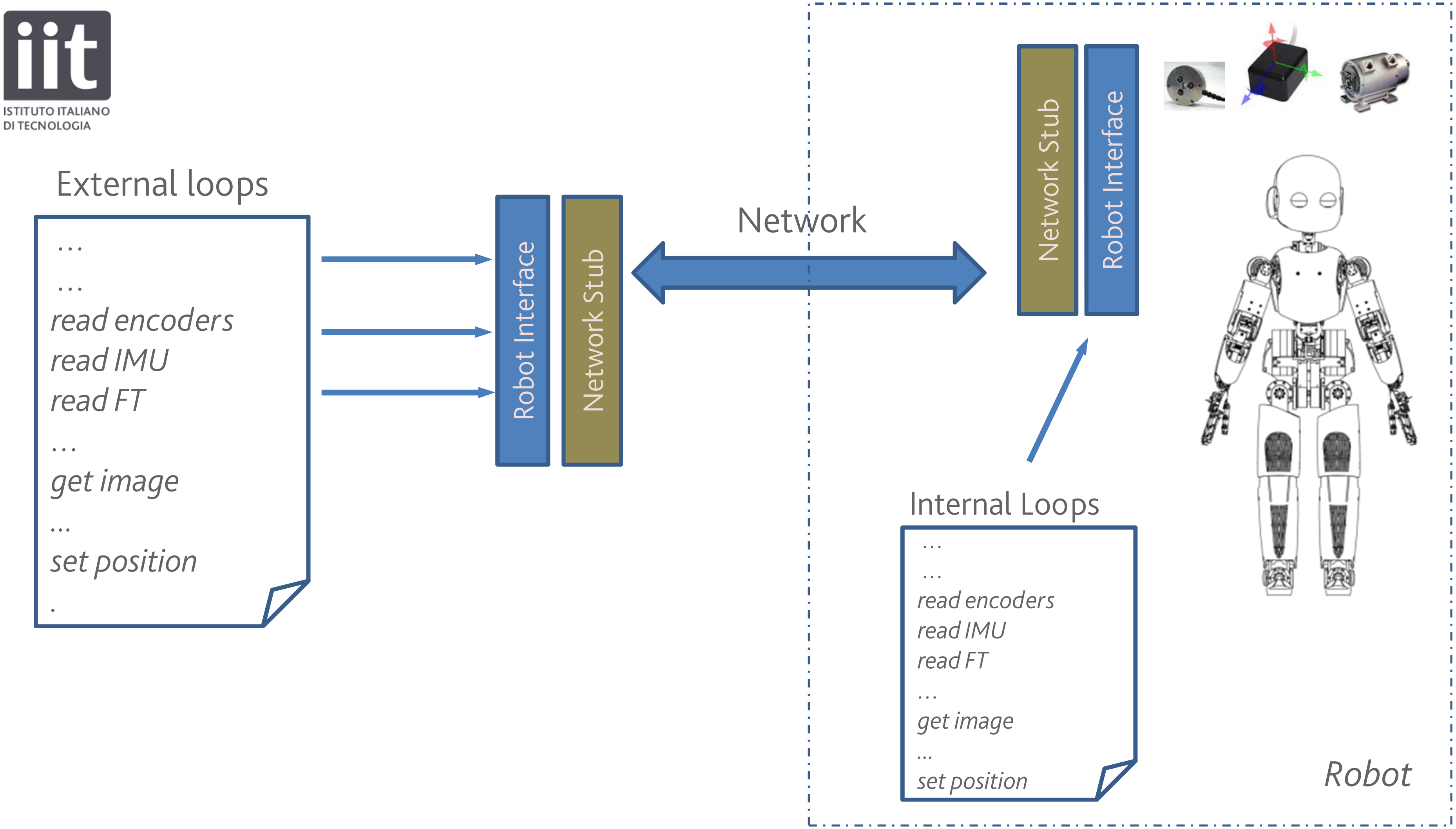


External loops

…
…
read encoders
read IMU
read FT
…
get image
…
set position
.

Robot Interface

Network Stub

Network

Network Stub

Robot Interface

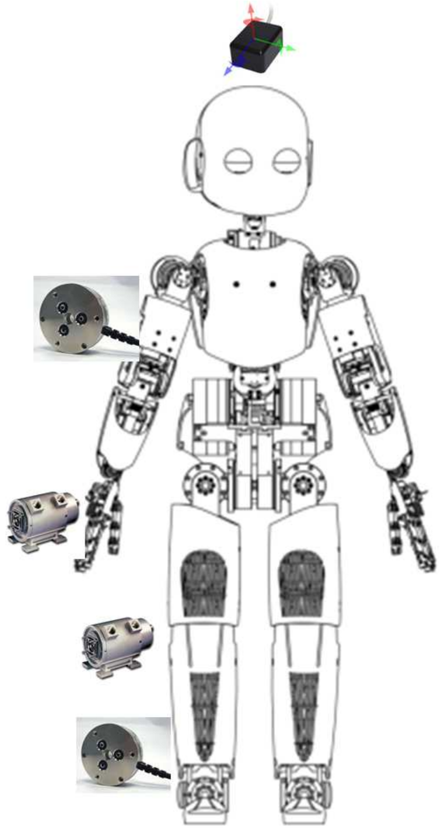
Internal Loops

…
…
read encoders
read IMU
read FT
…
get image
…
set position

Robot

Type of interfaces

- Motor control (position, velocity, open-loop, torque, impedance)
- Sensors: IMU, cameras, torques, F/T, encoders, skin
- Devices can also be virtual



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…more on this later this morning

YCM distributed development

- Development is distributed in small repositories
- Libraries and modules are agglomerated in large builds
- Share code not binaries
- Mixed software management tools (GIT, svn, …)

- Built on top of CMake (several patches contributed upstream)

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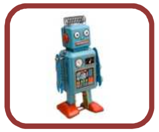

FooProject

foo-project.org

```
ml-libraries
grasping-lib
slam
```

github
SOCIAL CODING

github.com

```
YARP
stereo-vision
speech
```

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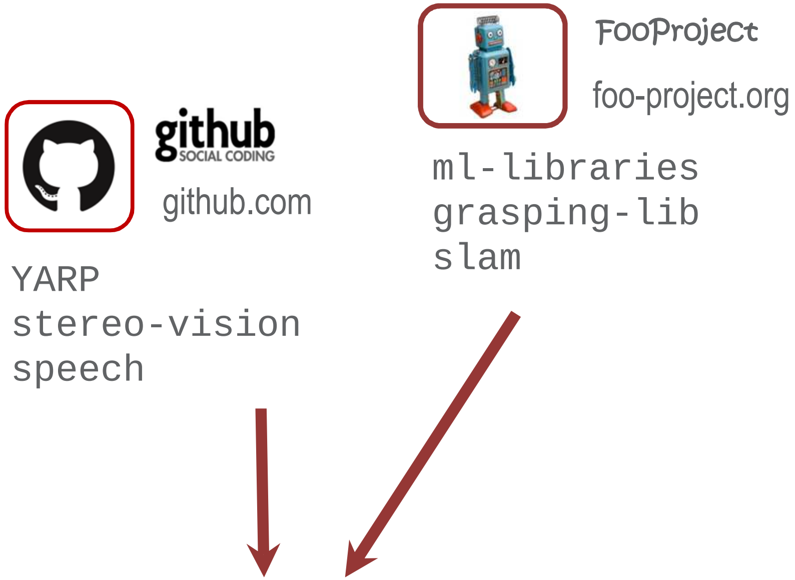

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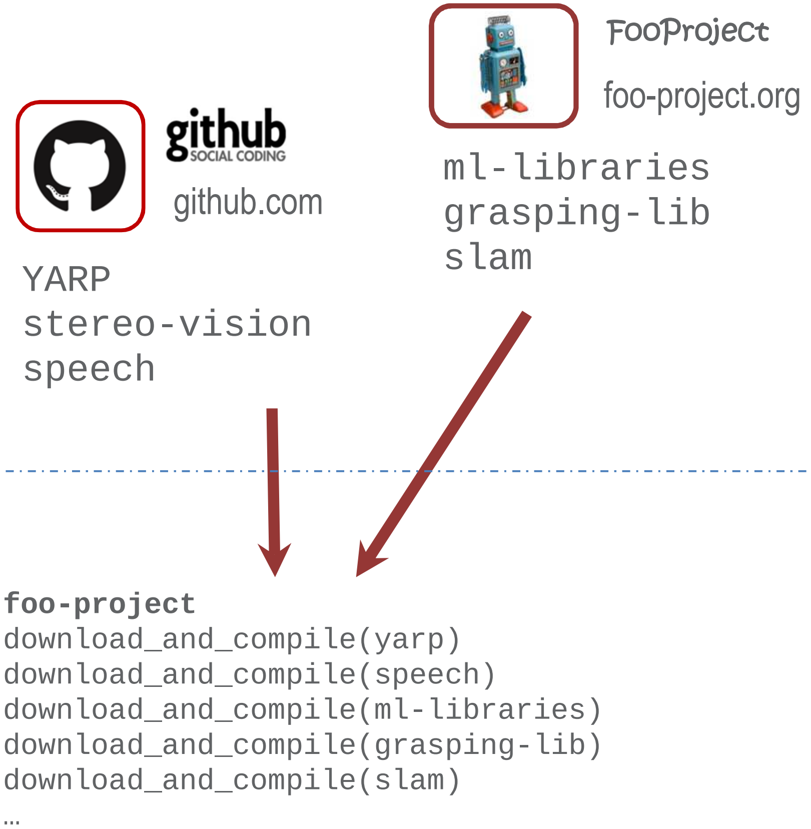

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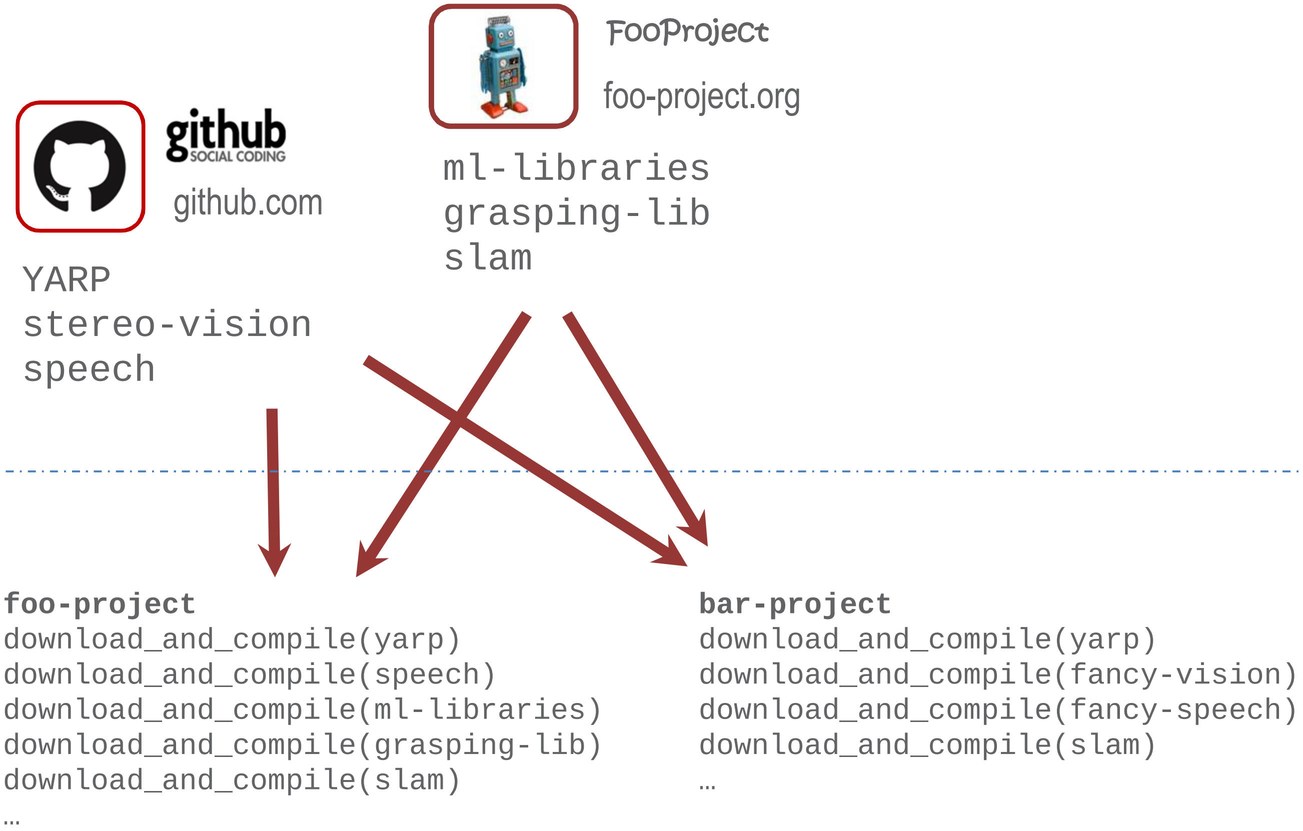
Issue & Bug Tracking
Documentation
Continuous integration
Better visibility

Easier deployment
Documentation
Continuous Integration



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```

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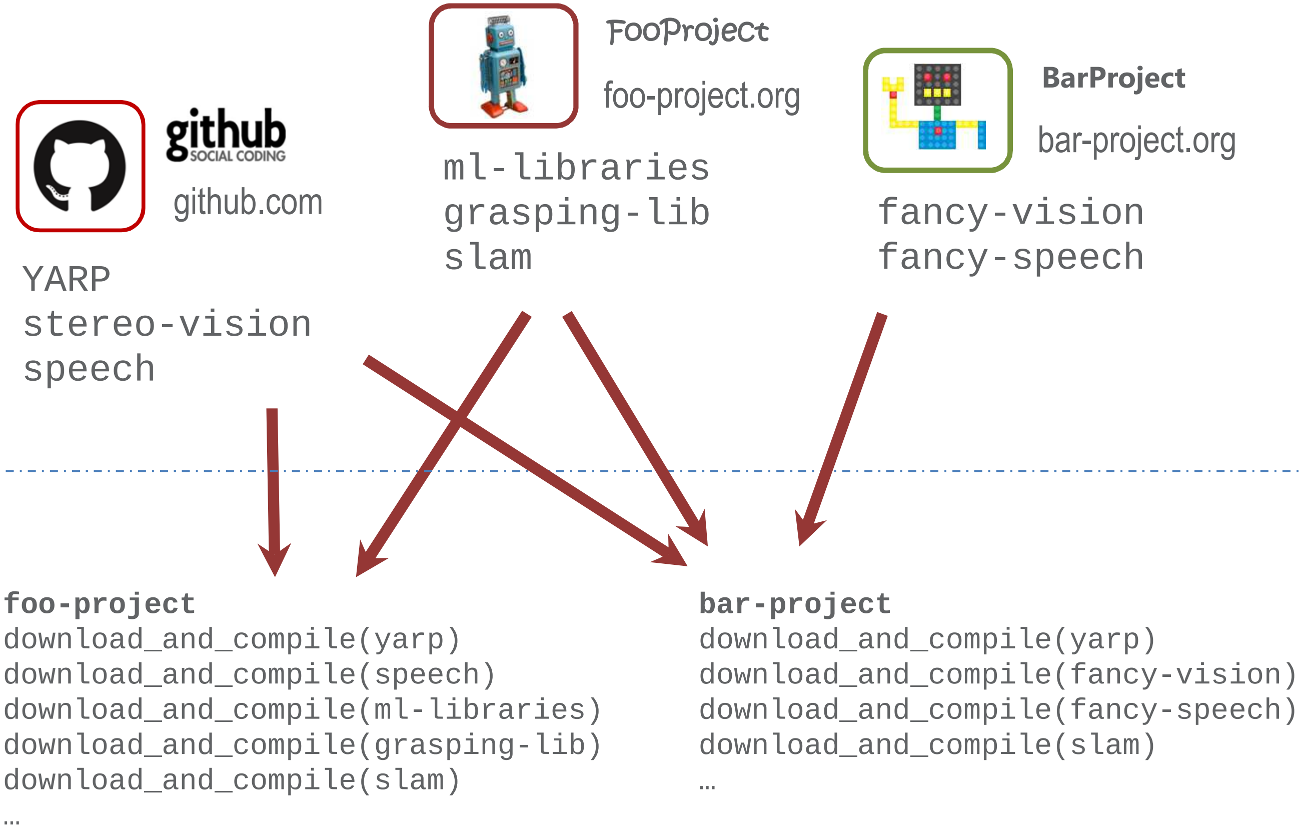

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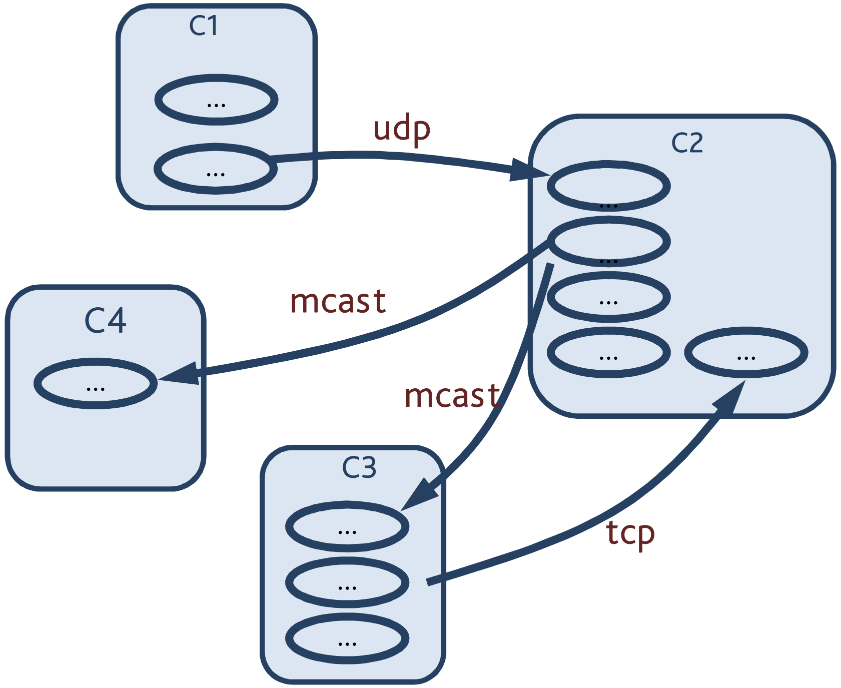
Communication

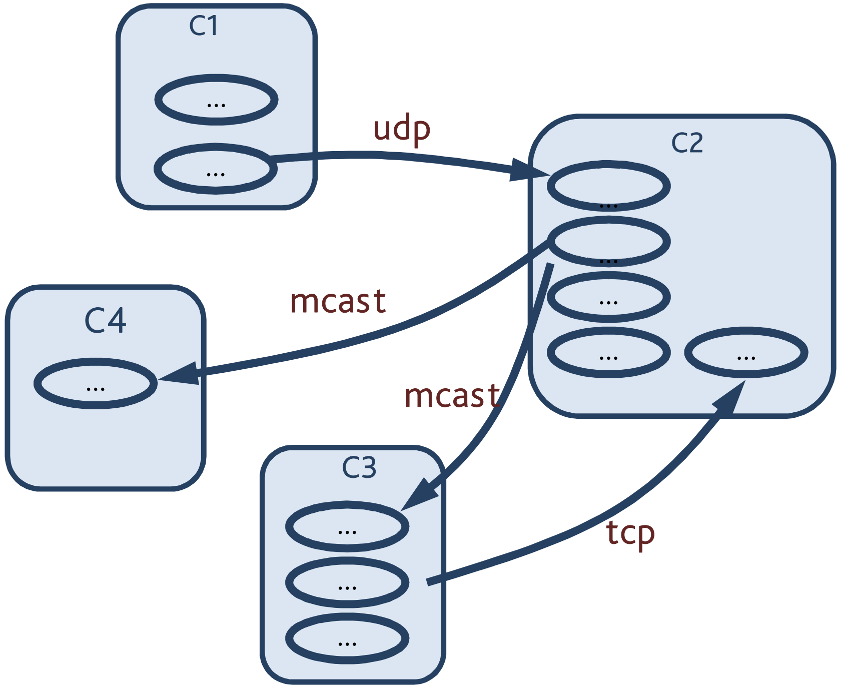
Communication

- Peer-to-peer



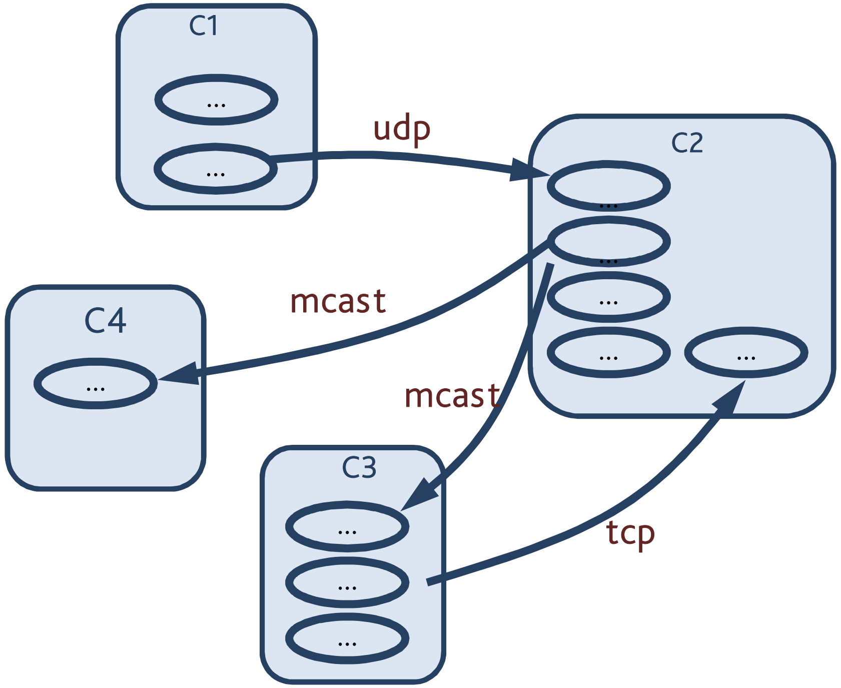
Communication

- Peer-to-peer
- Dynamic topology (can also be statically defined)



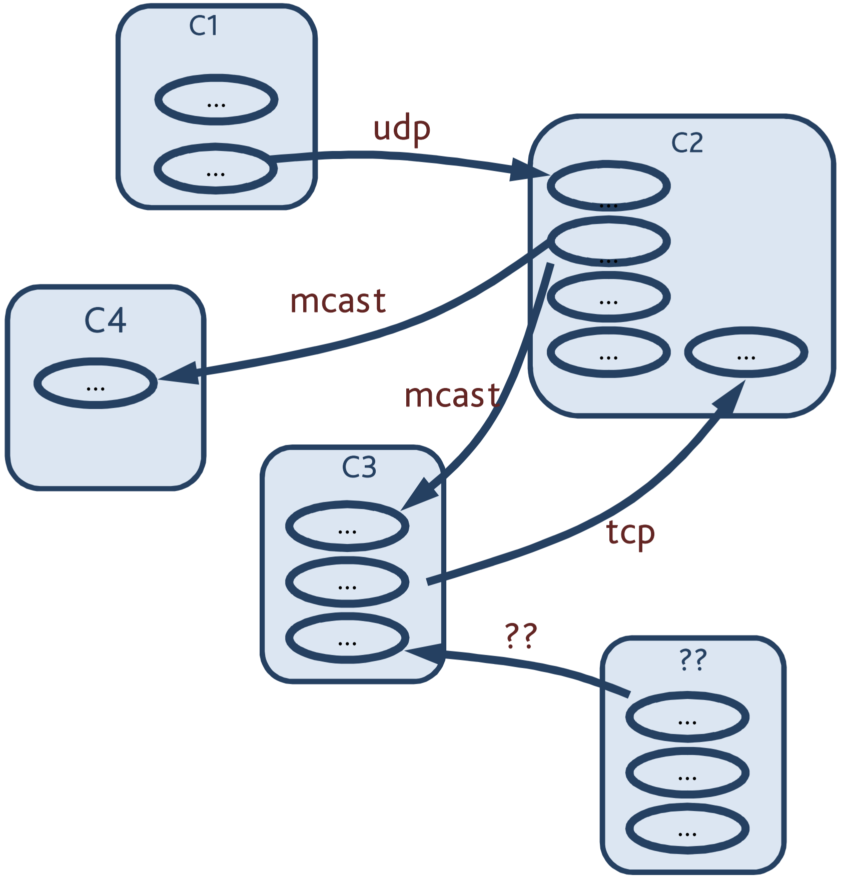
Communication

- Peer-to-peer
- Dynamic topology (can also be statically defined)
- Loosely typed, but IDL language can specify types and interfaces



Communication

- Peer-to-peer
- Dynamic topology (can also be statically defined)
- Loosely typed, but IDL language can specify types and interfaces
- Carriers: protocols can be extended as plugins and configured at runtime



YARP plugins

- YARP includes a plugin system for drivers and protocols (carriers)
- Interchangeable carriers allow:
  - interfacing existing software with ports (without bridges)
  - change significantly port behavior
- Examples:
  - mjpeg, xml rpc, ROS, …
  - Bayer carrier, port-monitor

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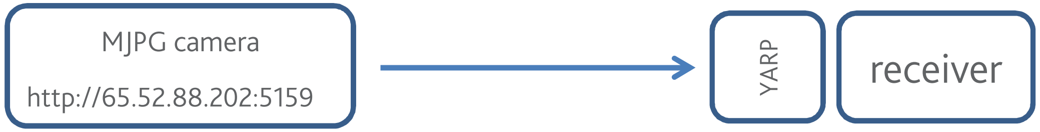
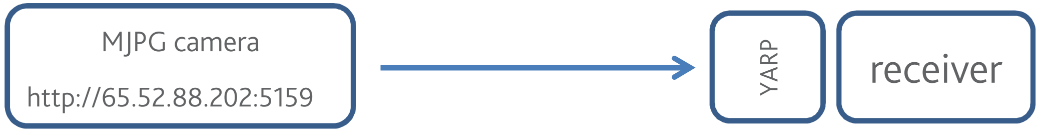
Examples

Examples



```
yarp  connect  /65.52.88.202:5159  /receiver  mjpeg
```

Examples



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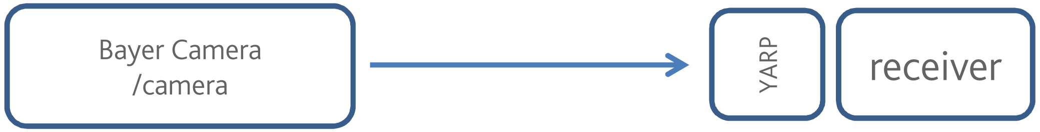
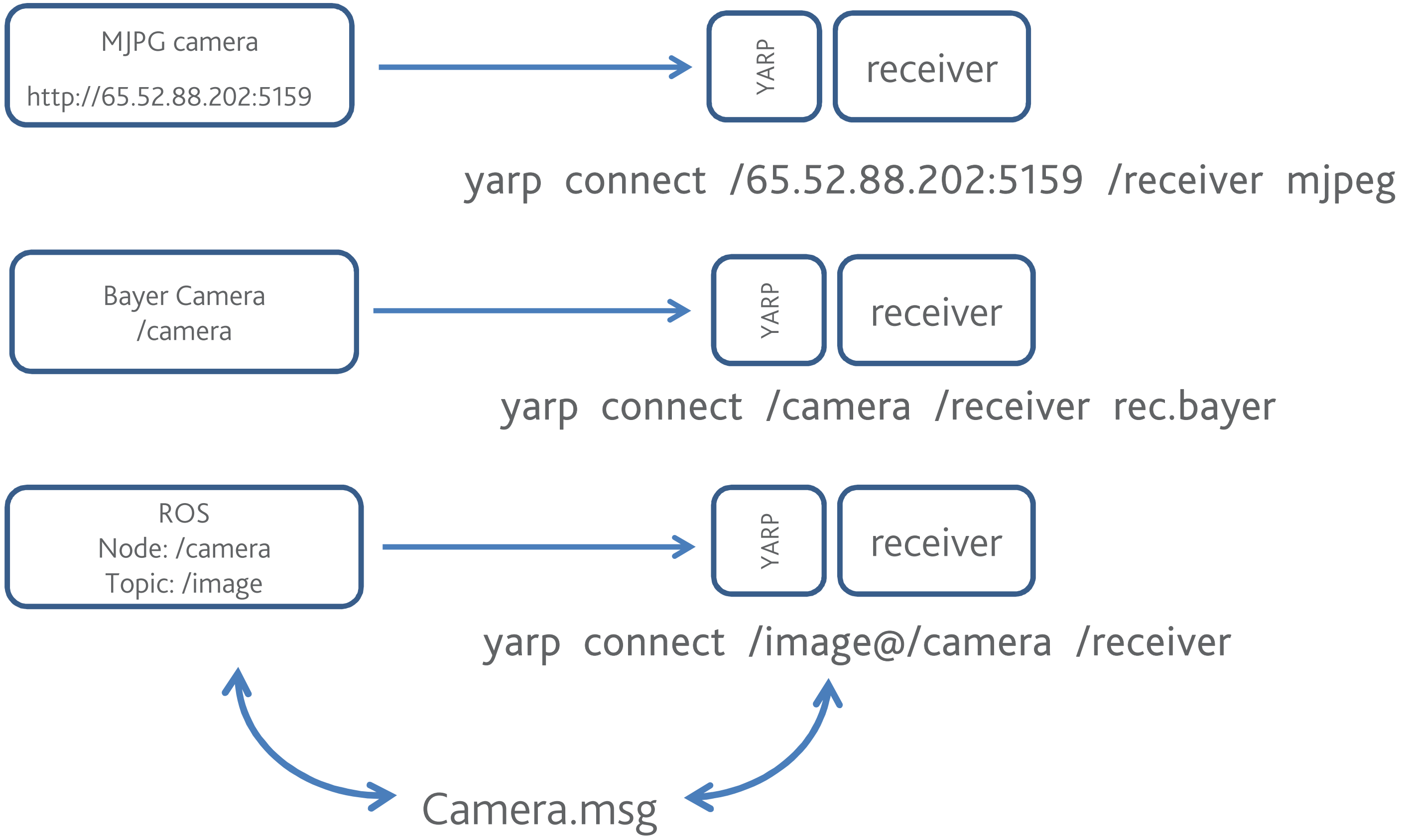


```
yarp  connect  /camera  /receiver  rec.bayer
```

Examples



MJPG camera

http://65.52.88.202:5159

YARP

receiver

```
yarp  connect  /65.52.88.202:5159  /receiver  mjpeg
```

Bayer Camera
/camera

YARP

receiver

```
yarp  connect  /camera  /receiver  rec.bayer
```

ROS
Node: /camera
Topic: /image

YARP

receiver

```
yarp  connect  /image@/camera  /receiver
```

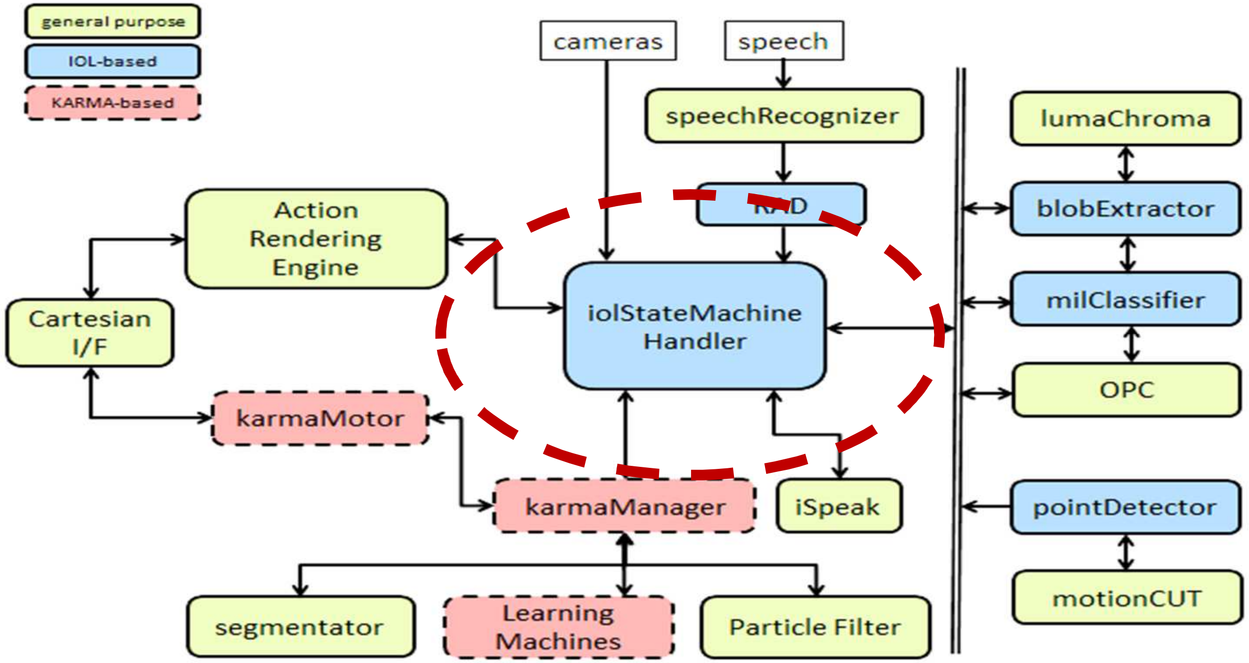
Camera.msg

More on YARP-ROS

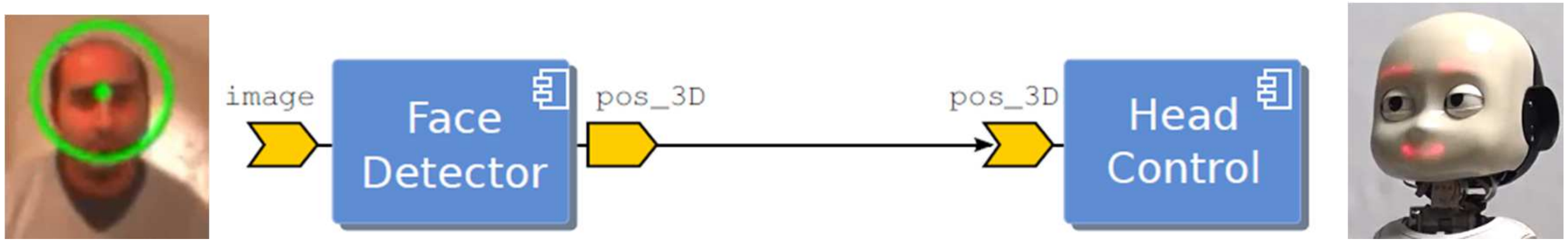
- Type server providing type information at runtime (YARP-ROS without ROS)
- Compatibility with ROS nameserver
- Concept of nodes
- Type and direction information within ports

- Check-out www.yarp.it → YARP with ROS

Coordinating modules



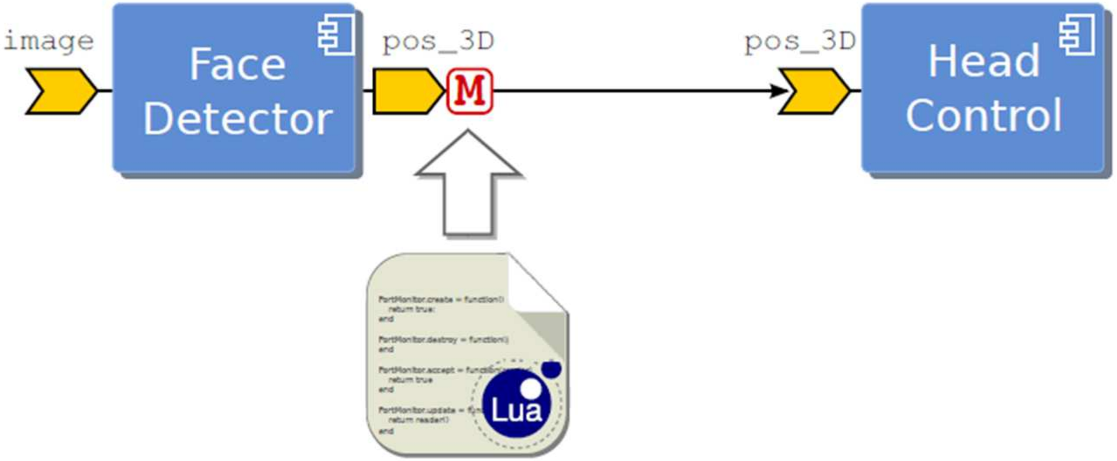
A simple example



Track a face if and only the confidence level (certainty) of the Face Detector is above a desired threshold.

- Simple scenario poses questions on the design of the components
- Some functionalities are application dependent
- Should we:
  - extend Head Control, Face Detector?
  - Add a a separate filtering module?

Port monitor plug-in



```
PortMonitor.create = function()
    return true;
end

PortMonitor.destroy = function()
end

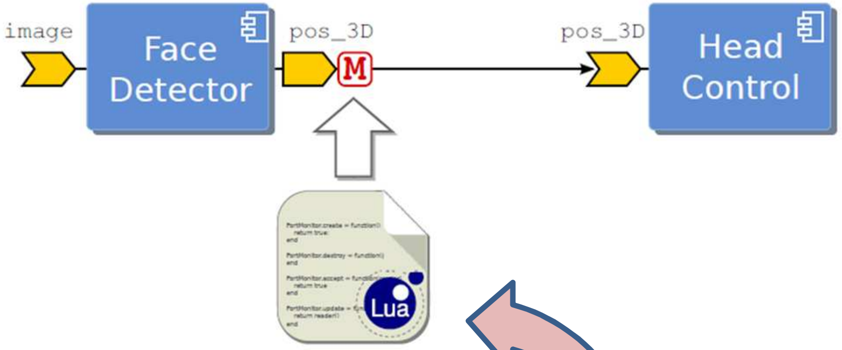
PortMonitor.accept = functi
    return true
end

PortMonitor.update = f
    return reader()
end
```

The port monitor approach:

- Add code that handles outgoing (or incoming) data
- Dynamically loading or configuring a run-time script (e.g. Lua)
- Monitoring, filtering, and transforming....

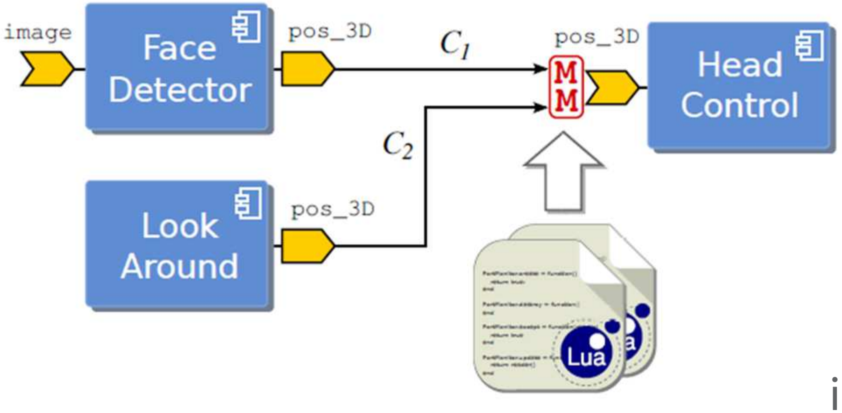
Track a face if and only the confidence level (certainty) of the Face Detector is above a desired threshold (e.g. 80%).



Application configuration (not compile time)

```
if (data.certainty > 0.9)
    accept(data)
else
    drop(data)
```

Port arbitration using plug-ins



```
if (C1.certainty > 0.9)
    accept(C1)
else
    accept(C2)
```

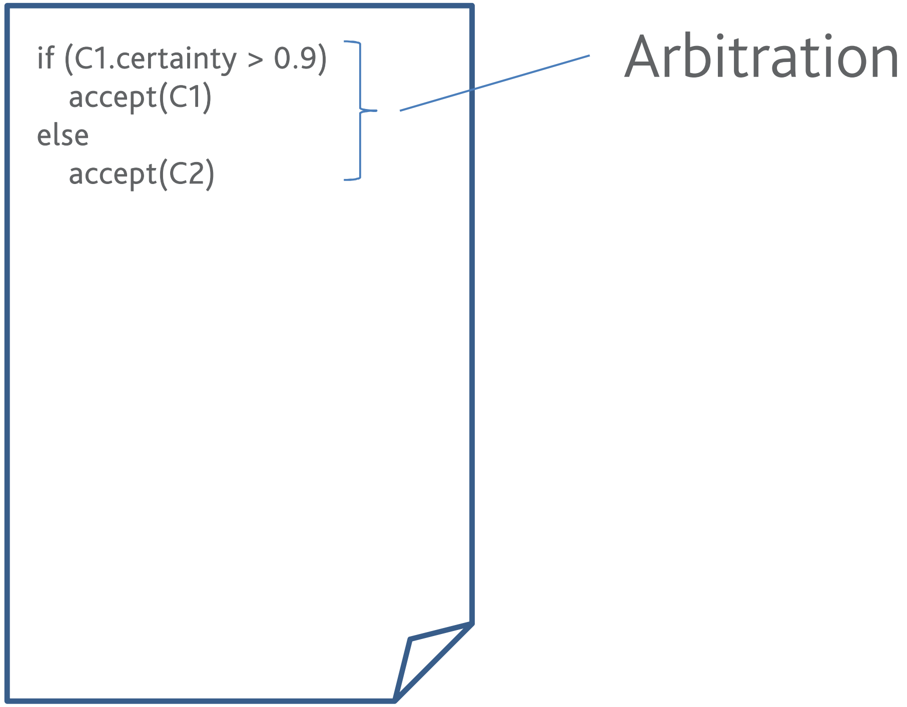
Example:

- Search and Track a face

Requirements:

- Monitoring the confidence level of Face Detector
- Arbitrating the connections

Potential applications

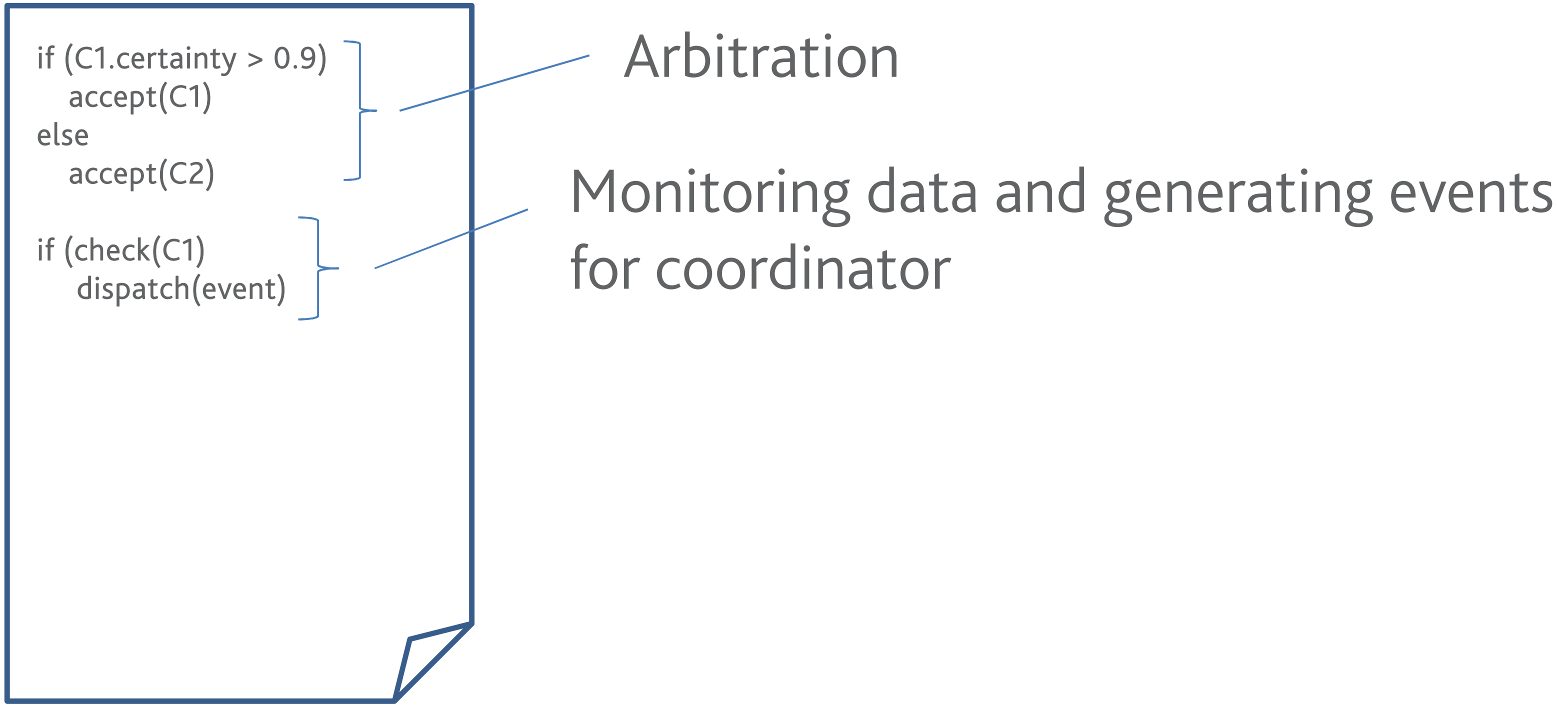


```
if (C1.certainty > 0.9)
    accept(C1)
else
    accept(C2)
```

Arbitration

Online tutorials: www.yarp.it → Port monitoring and arbitration

Potential applications



```
if (C1.certainty > 0.9)
    accept(C1)
else
    accept(C2)

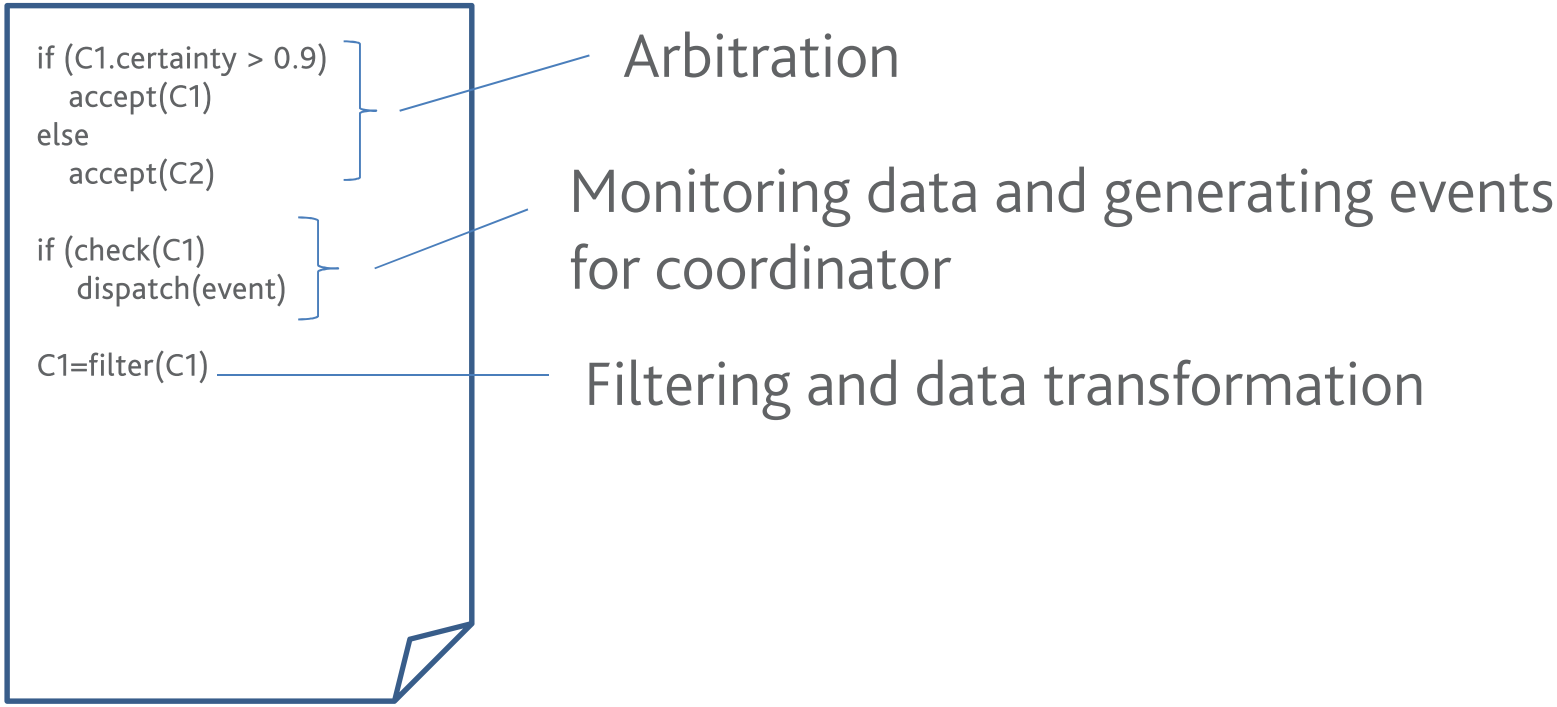
if (check(C1)
     dispatch(event)
```

Arbitration

Monitoring data and generating events for coordinator

Online tutorials: www.yarp.it → Port monitoring and arbitration

Potential applications



```
if (C1.certainty > 0.9)
    accept(C1)
else
    accept(C2)

if (check(C1)
     dispatch(event)

C1=filter(C1)
```

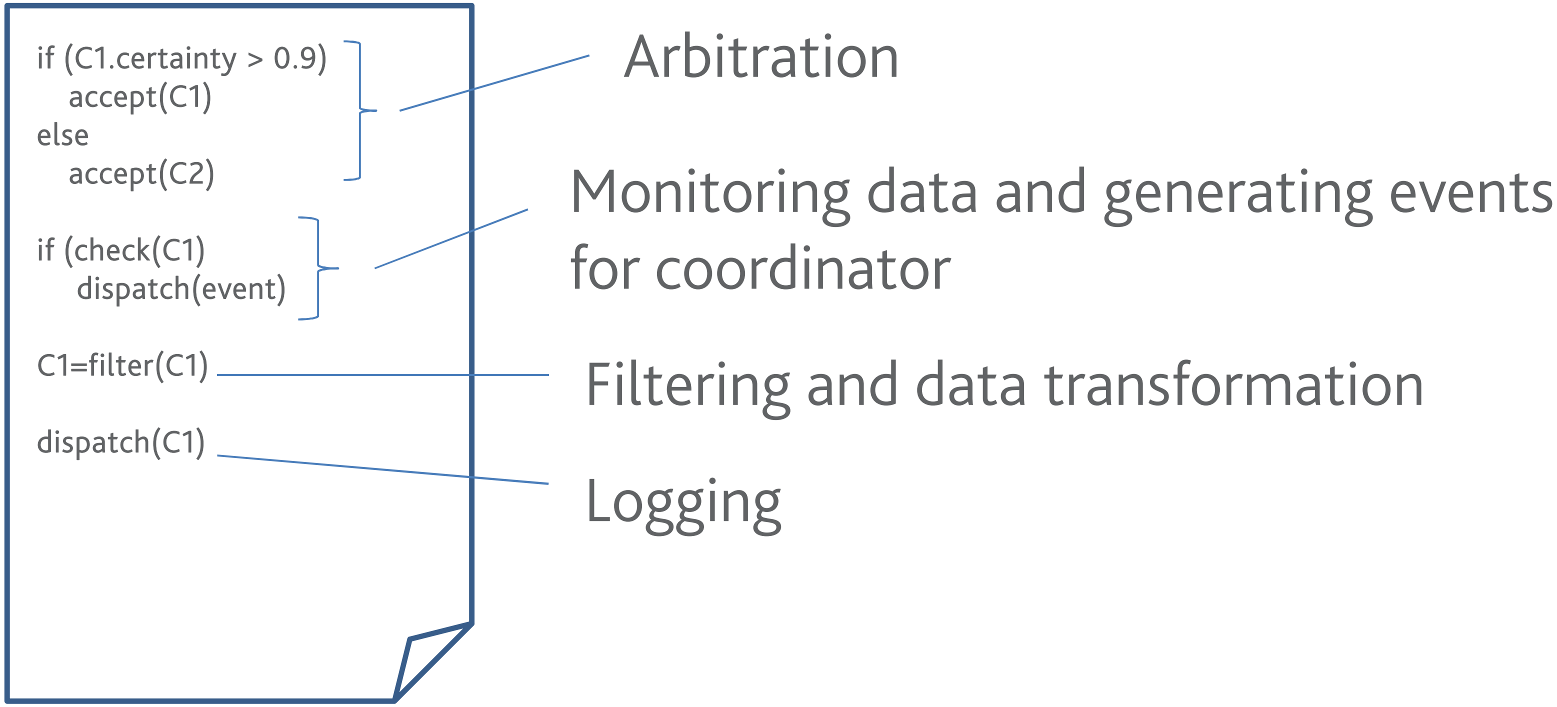
Arbitration

Monitoring data and generating events for coordinator

Filtering and data transformation

Online tutorials: www.yarp.it → Port monitoring and arbitration

Potential applications



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C1=filter(C1)

dispatch(C1)
```

Arbitration

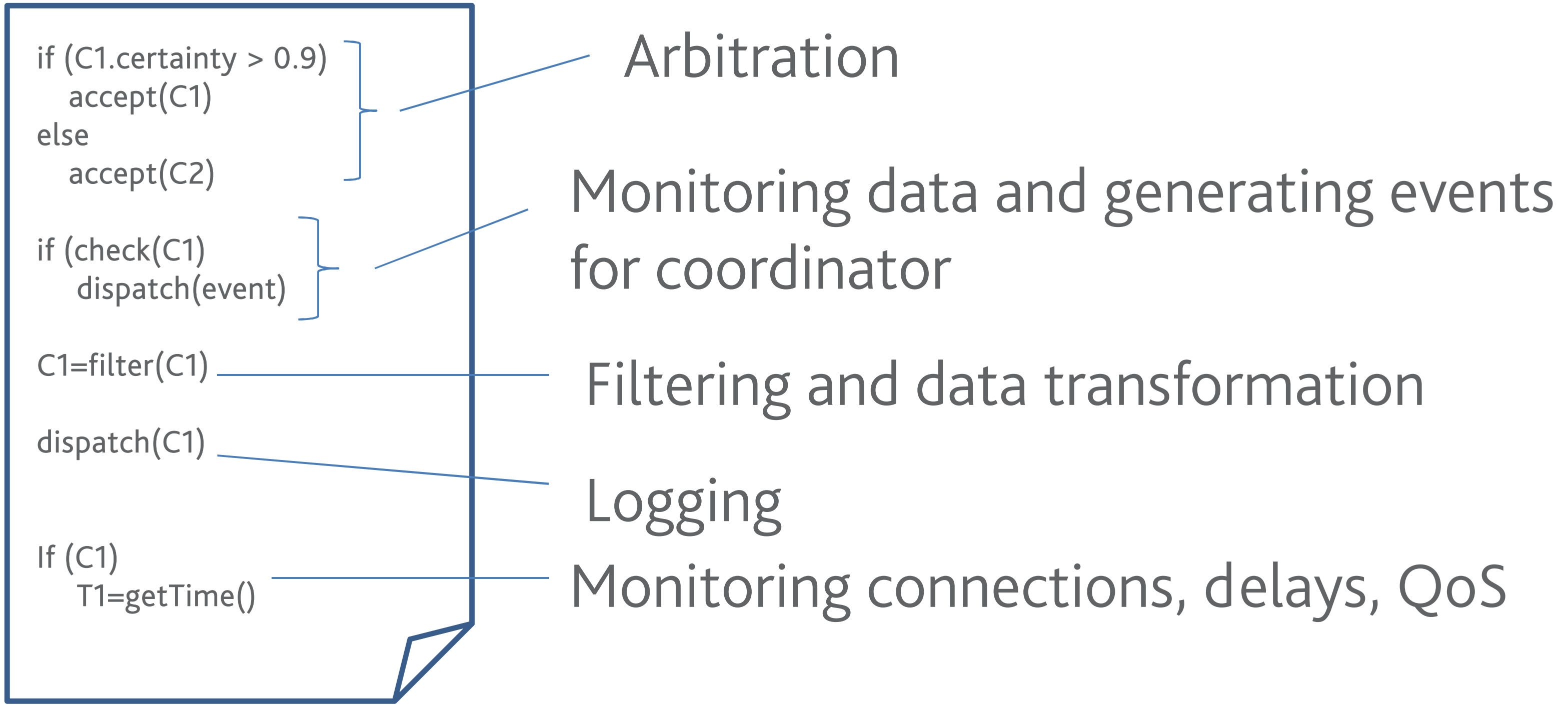
Monitoring data and generating events for coordinator

Filtering and data transformation

Logging

Online tutorials: www.yarp.it → Port monitoring and arbitration

Potential applications



```
if (C1.certainty > 0.9)
   accept(C1)
else
   accept(C2)

if (check(C1)
    dispatch(event)

C1=filter(C1)

dispatch(C1)

If (C1)
    T1=getTime()
```

Arbitration

Monitoring data and generating events for coordinator

Filtering and data transformation

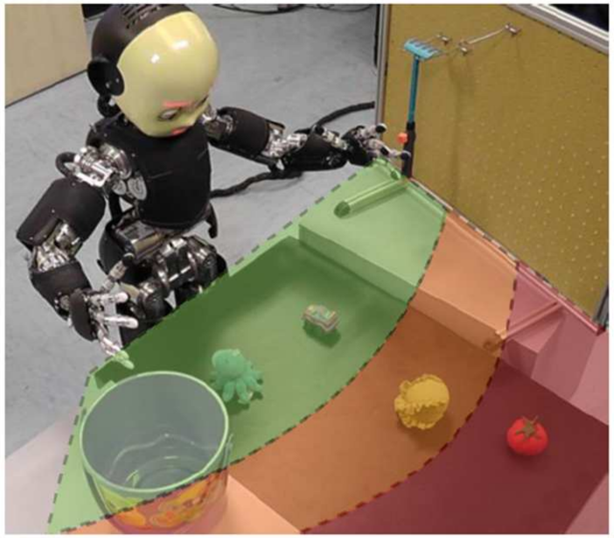
Logging

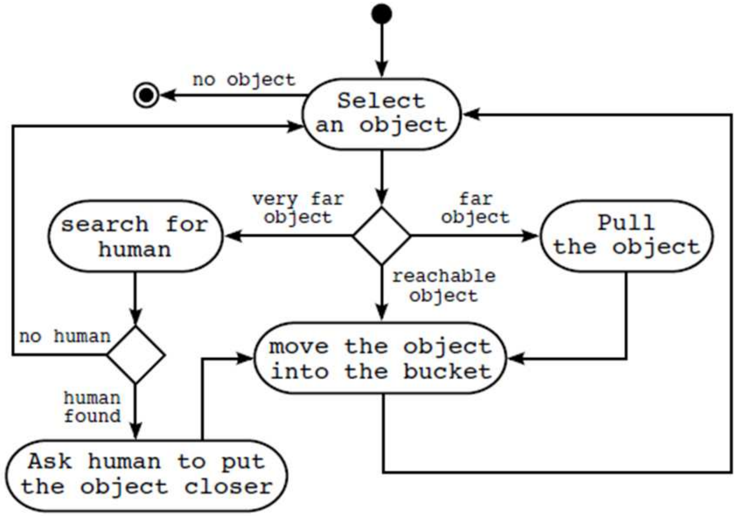
Monitoring connections, delays, QoS

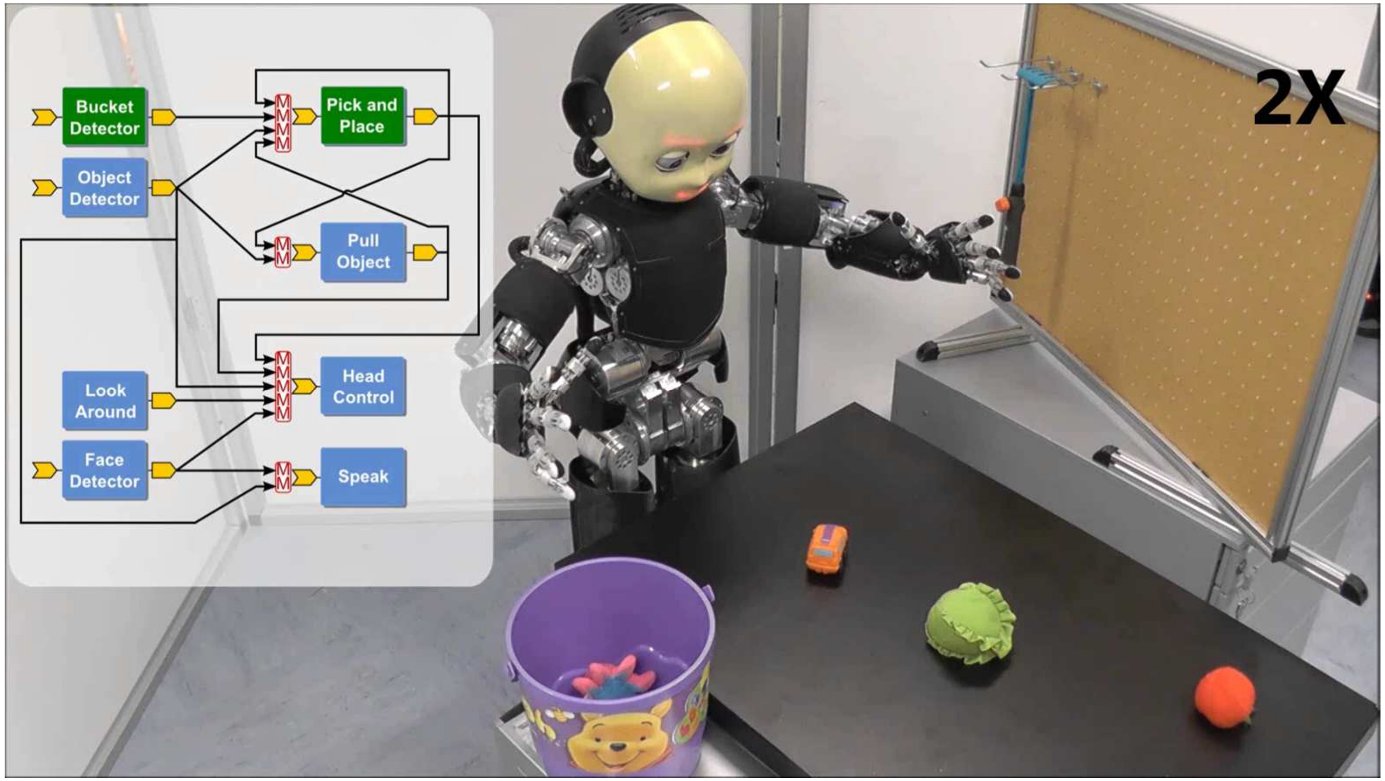
Online tutorials: www.yarp.it → Port monitoring and arbitration

Table-cleaning application

- Completely built using modules from the iCub repository
- No modifications to the existing modules
- Extending the required functionalities (e.g., for coordination) using port plug-ins







A. Paikan, V. Tikhanoff, G. Metta and L. Natale, IROS 2014

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