University *of Ljubljana*
Faculty *of Electrical Engineering*

COLLABORATIVE
ROBOTICS CENTRE

KDR-ROS
ROS orodja

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www.robolab.si
www.cobotic.si

Vsebina

- Nodes
- Topics
- Services
- Msg & Srv files
- Actions
- Parameter
- Launch files

- Konzolni ukazi za posamezne funkcionalnosti
- Python 2.7
- https://github.com/sslajpah/kdr_ros

ROSMASTER

ROSMASTER

```
>> roscore
```

- Povezava med posameznimi funkcionalnostmi
- Lahko je samo en naenkrat
- Povezava med več ROS sistemi

CATKIN WORKSPACE

- CATKIN – official build system for ROS

```
>> mkdir catkin_ws
>> cd catkin_ws
>> mkdir src
>> catkin_make
```

CATKIN WORKSPACE

- Povezava konzole z ROS spremenljivkami

```
>> cd devel
>> source setup.bash
```

- Dodaj v bashrc.sh (avtomatsko, ko se odpre konzola)

```
>> echo "source ~/catkin_ws/devel/setup.bash" >> ~/.bashrc
>> source ~/.bashrc
```

Generiranje sistema

- Kodo pišeš v **`/catkin_ws/src`** mapi

```
>> catkin_make
```

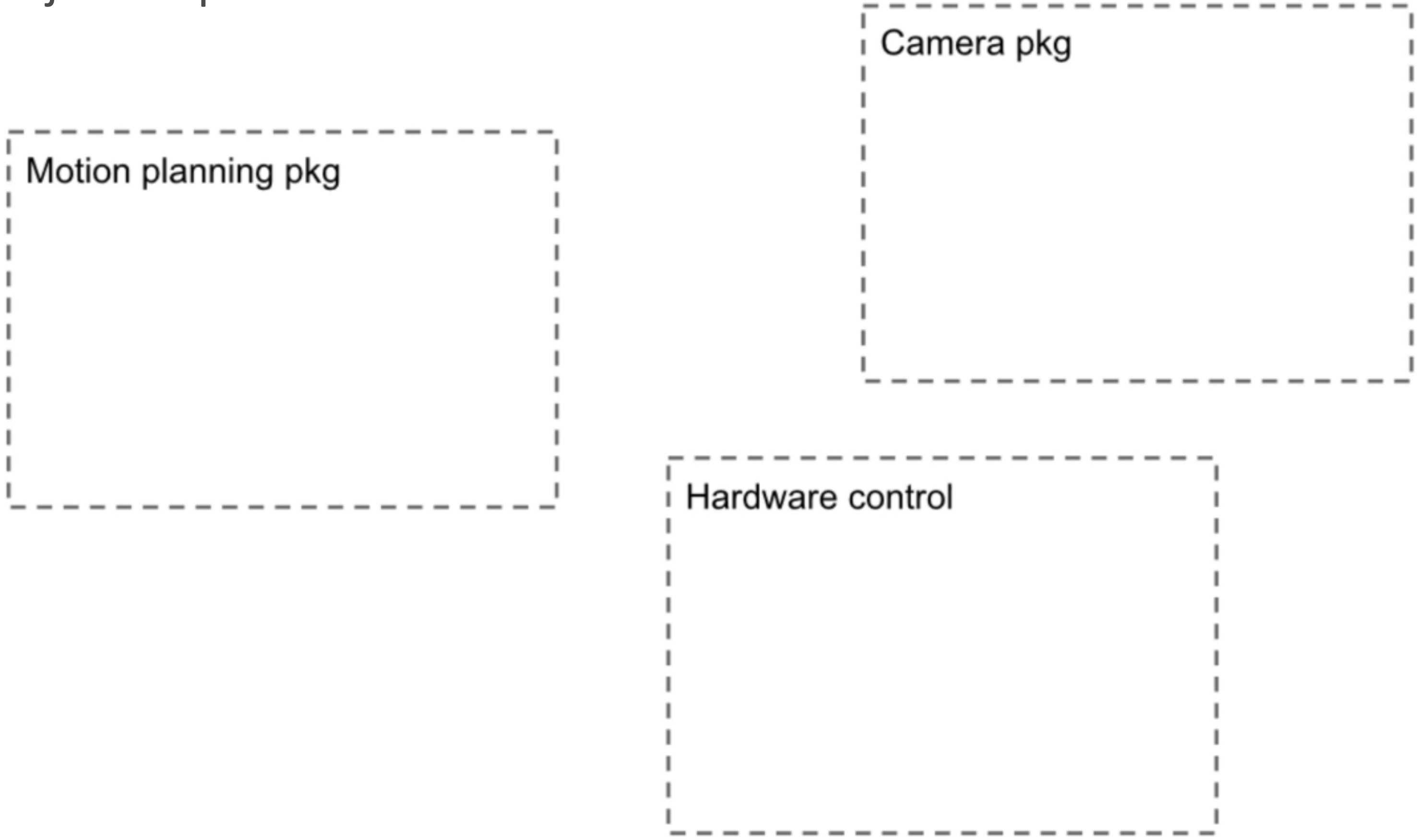
PACKAGES

Packages

- Neodvisne enote, ki se jih da uporabiti na več mestih

Packages

- Neodvisne enote, ki se jih da uporabiti na več mestih



Nov paket

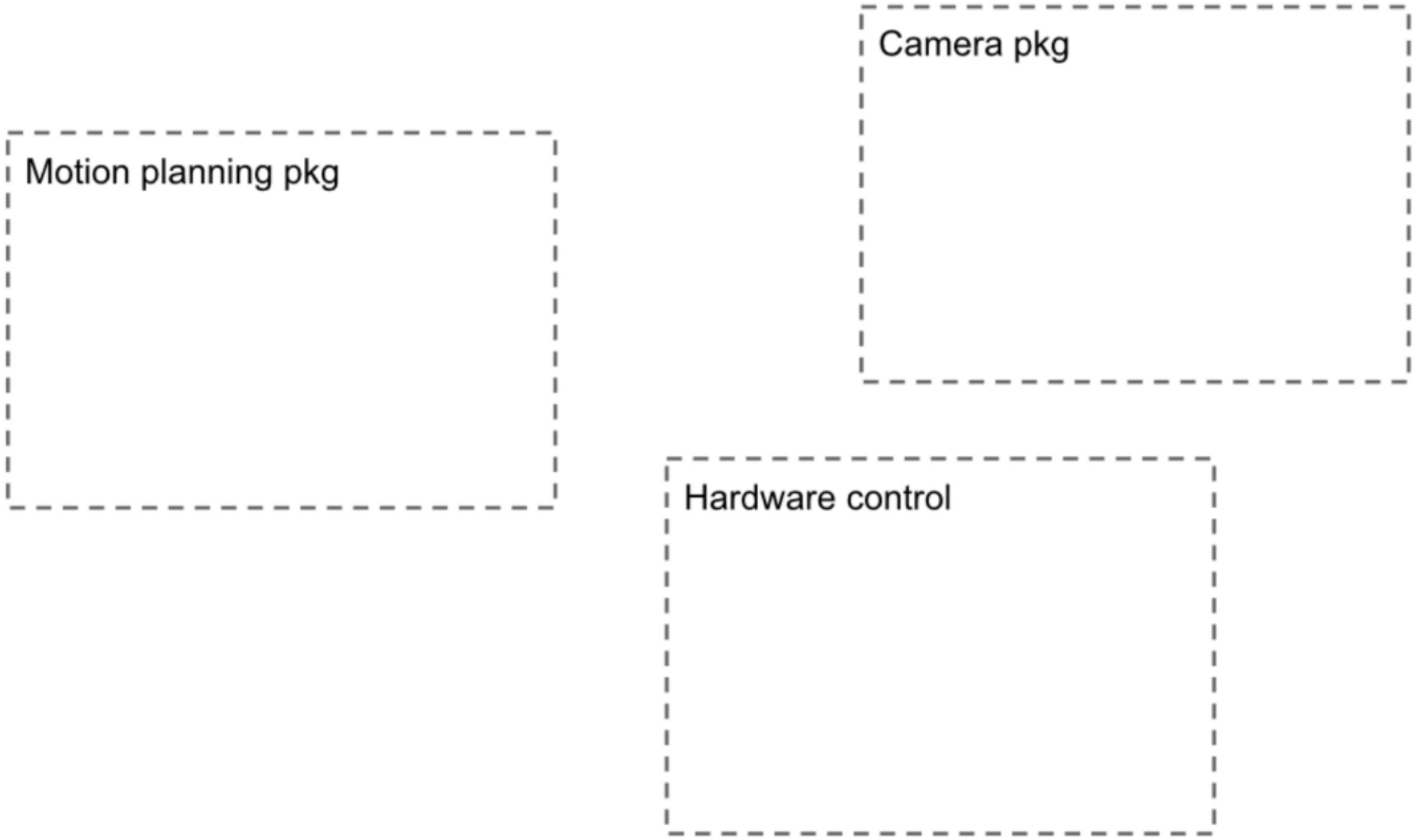
```
>> catkin_create_pkg <ime_paketa> <razširitve>
```

```
>> catkin_make
```

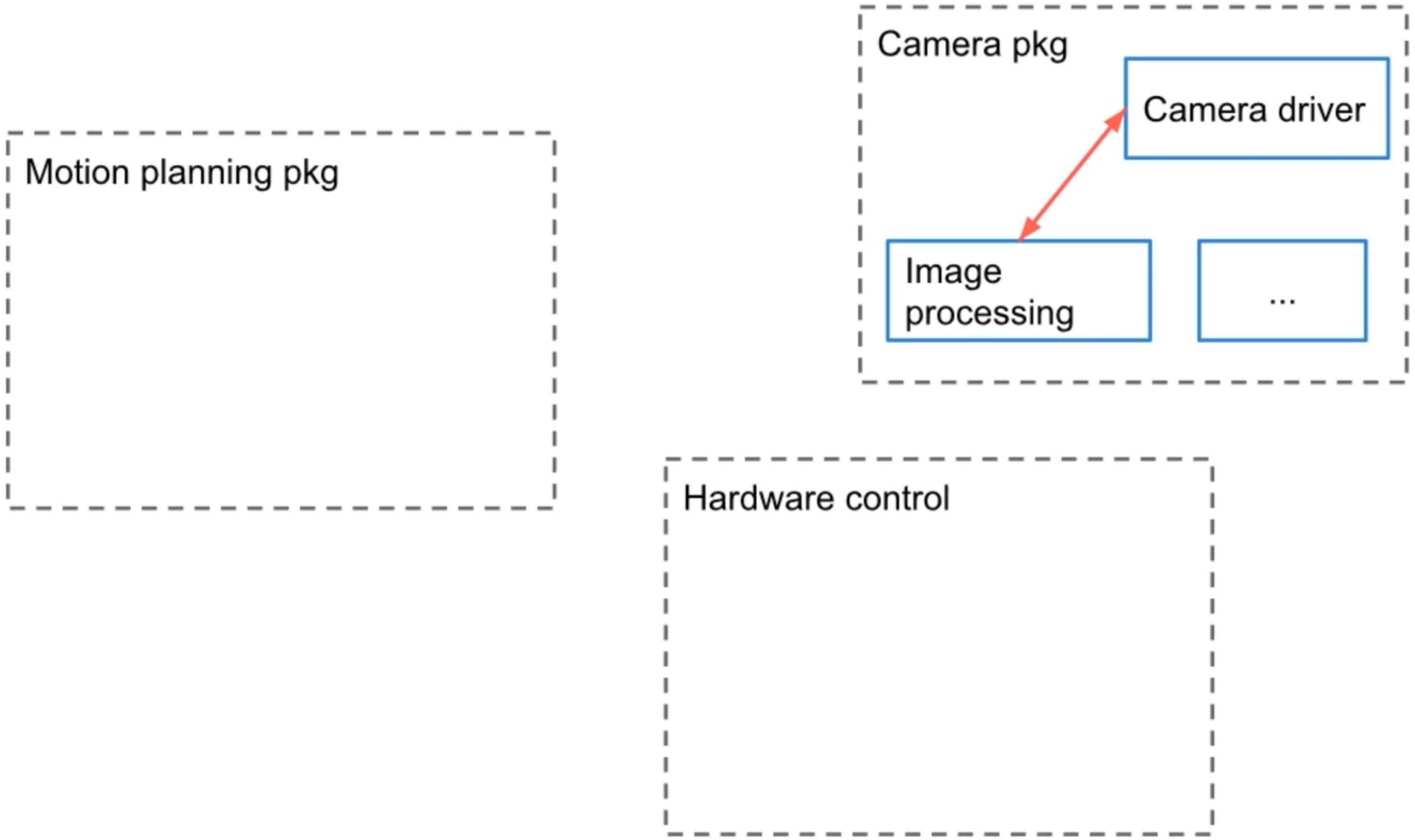
```
>> catkin_create_pkg kdr rospy std_msgs actionlib_msgs
```

NODE

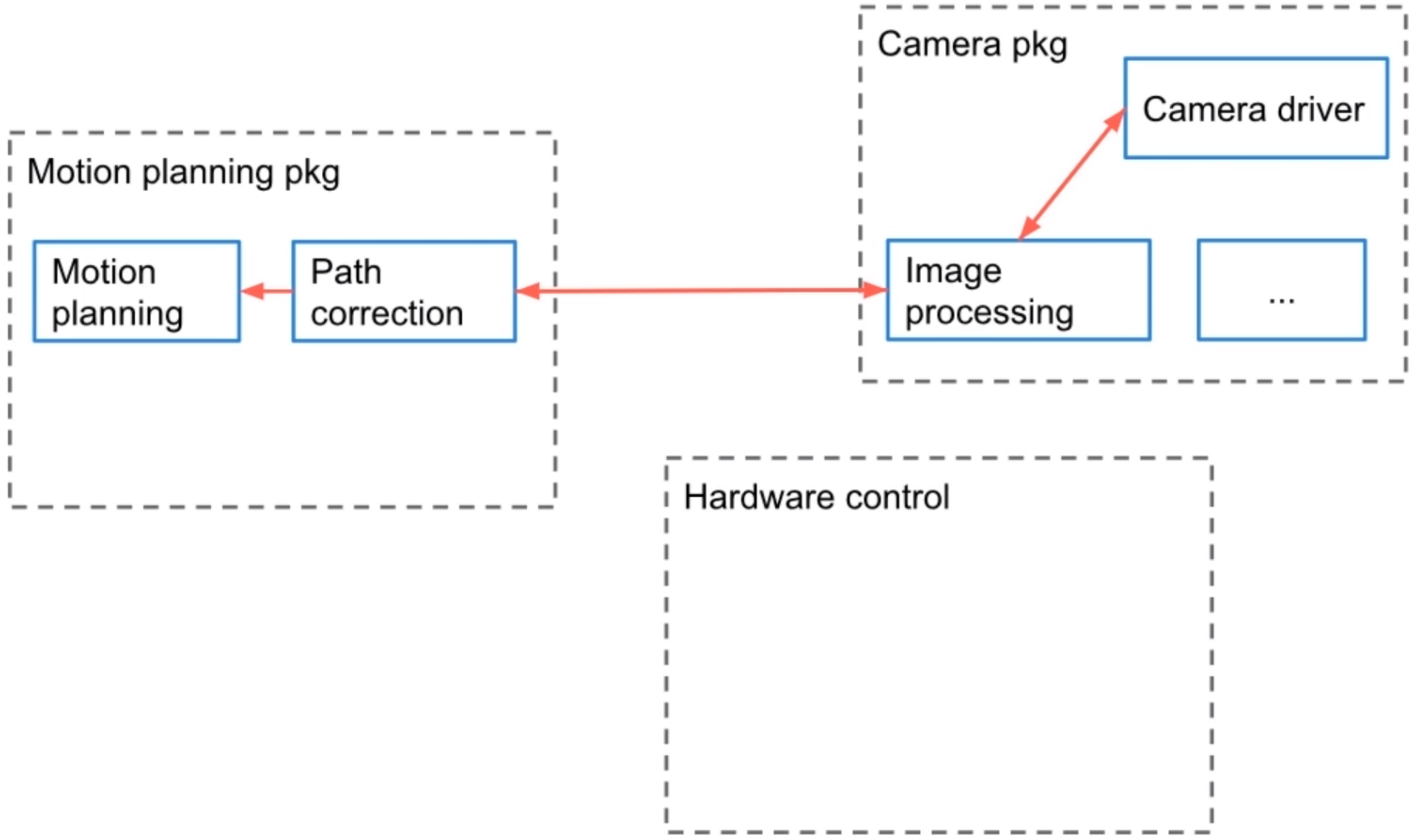
Node



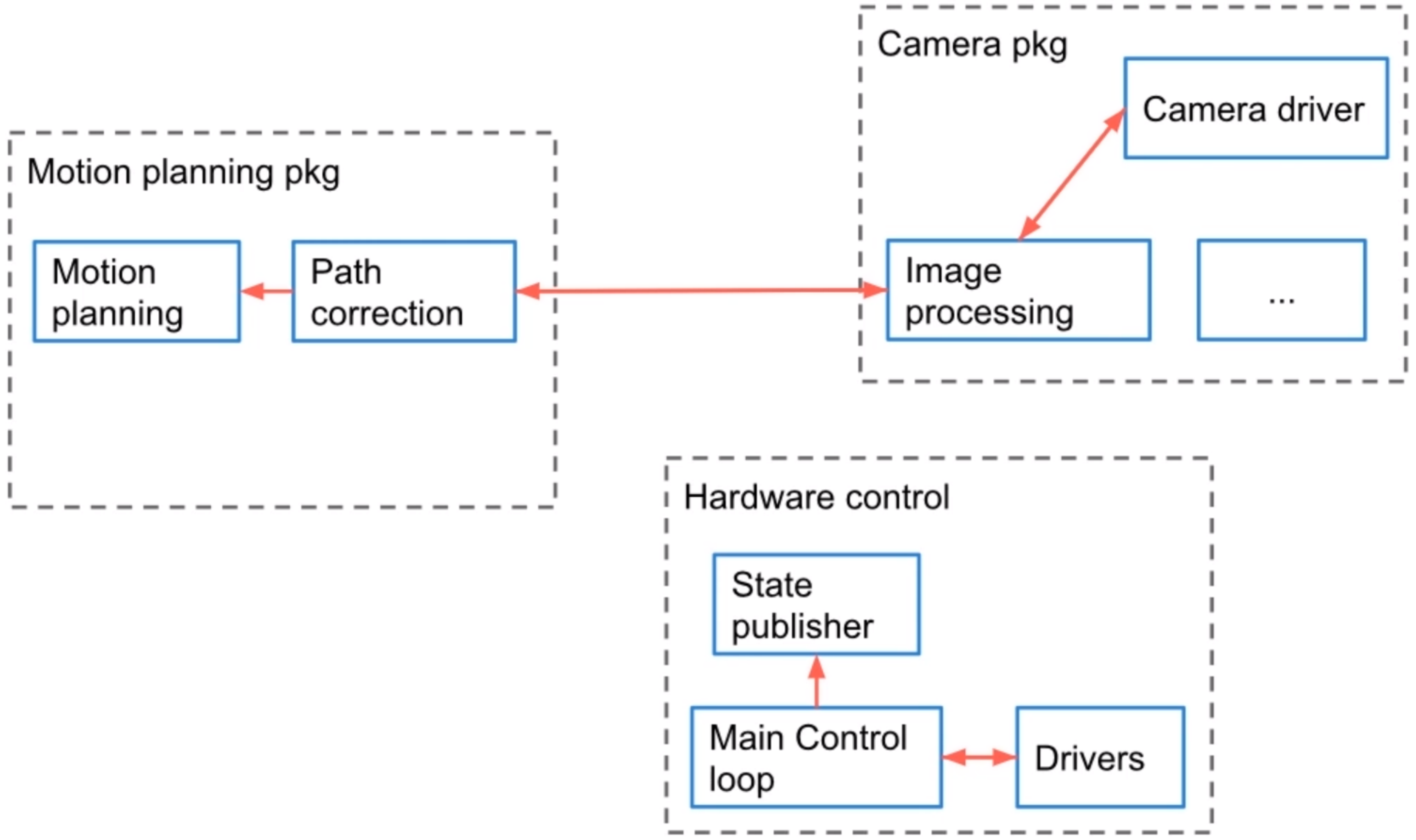
Node


Camera pkg
Camera driver
Image processing
...
Motion planning pkg
Hardware control

Node

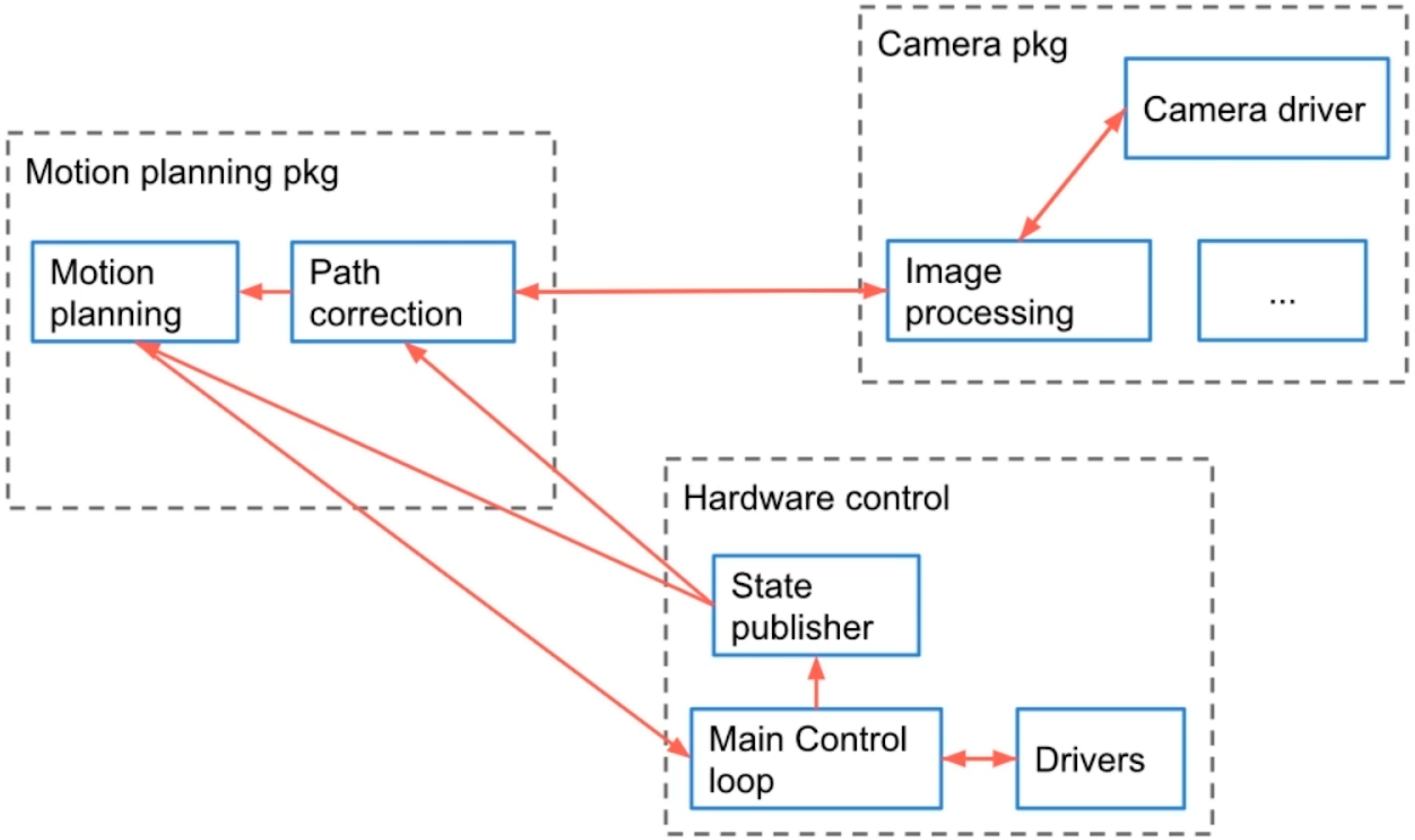

Camera pkg
Camera driver
Motion planning pkg
Motion planning
Path correction
Image processing
...
Hardware control

Node



Camera pkg
Camera driver
Motion planning pkg
Motion planning
Path correction
Image processing
...
Hardware control
State publisher
Main Control loop
Drivers

Node


Camera pkg
Camera driver
Motion planning pkg
Motion planning
Path correction
Image processing
...
Hardware control
State publisher
Main Control loop
Drivers

Node

- proces, ki izvaja računanje
- program, ki teče znotraj robotske aplikacije
- združeni so v pakete
- med seboj komunicirajo (topics, servers, actions, parameter servers)

- zmanjšujejo kompleksnost kode
- koda je bolj odporna na napake
- uporaba različnih programskih jezikov

Nov Node

```
>> mkdir scripts
>> cd scripts
>> touch my_first_node.py
>> chmod +x my_first_node.py
>> code my_first_node.py
```

```
#!/usr/bin/env python

import rospy

if __name__ == '__main__':
   rospy.init_node('my_first_python_node')

   rospy.loginfo('This node has been started.')
   rospy.sleep(1)
   print('Exit now')
```

```
>> python my_first_node.py
```

DEBUG Node

• **`rosrun <pkg name> <node name>`**	… poganjanje
• **`rosnode list`**	… seznam vseh aktivnih
• **`rosnode info <node name>`**	… info o node
• **`rosnode kill <node name>`**	… ugasni node
• **`rosnode ping <node name>`**	… ping (preveri, če deluje)

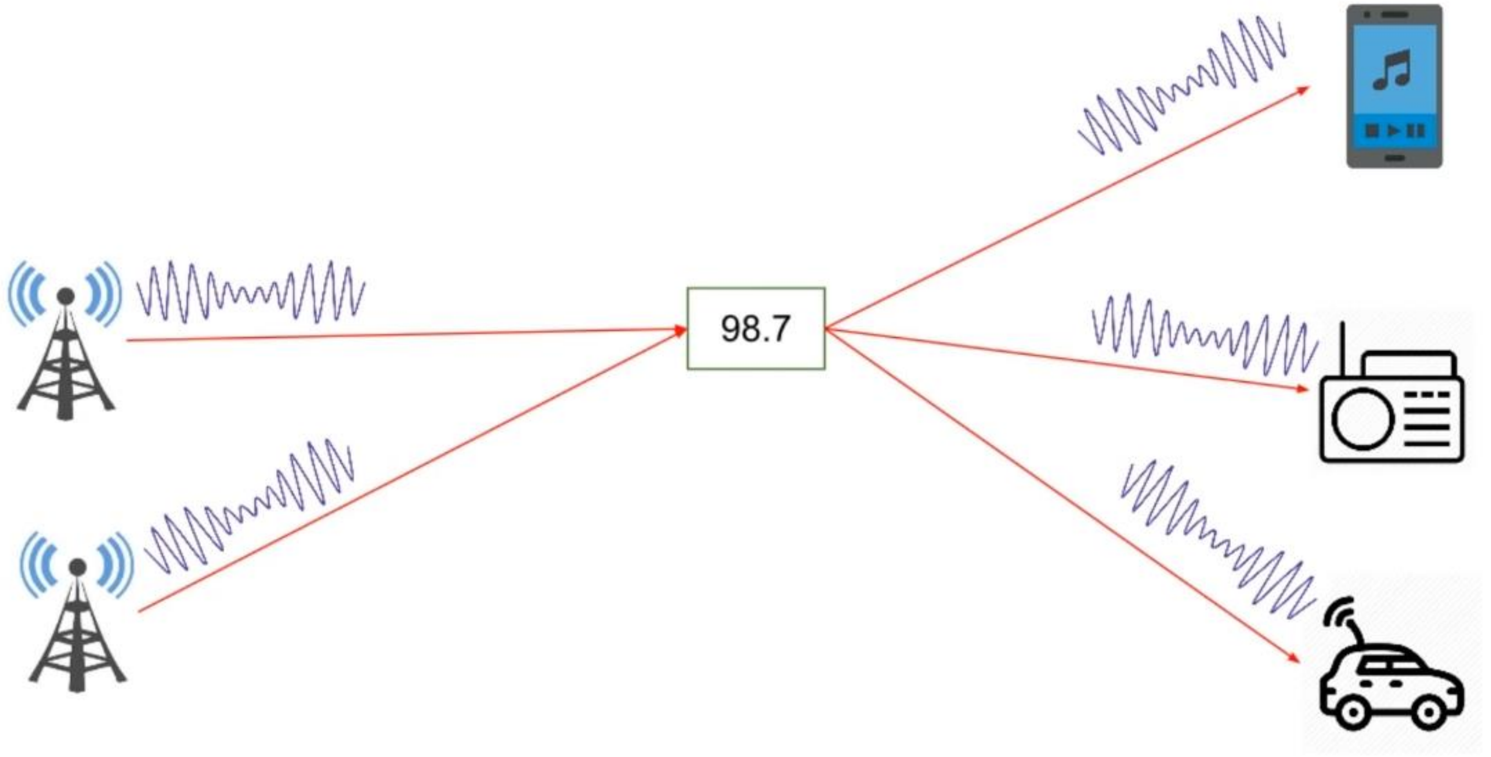
Node

- naenkrat se lahko izvaja samo en node z določenim imenom
- če želiš več istih, jih je potrebno preimenovati

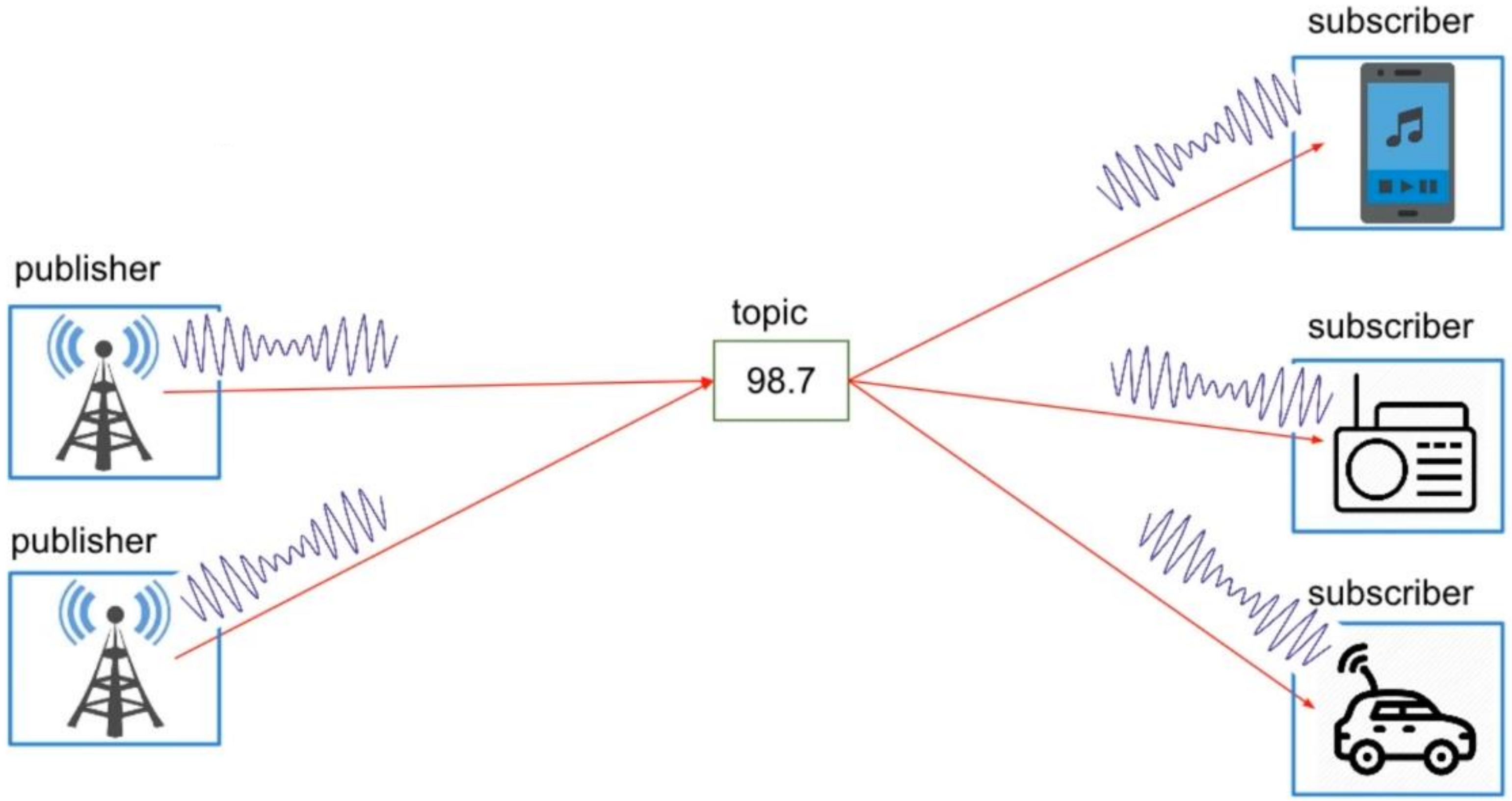
```
rospy.init_node('my_first_python_node', anonymous=True)
```

TOPICS

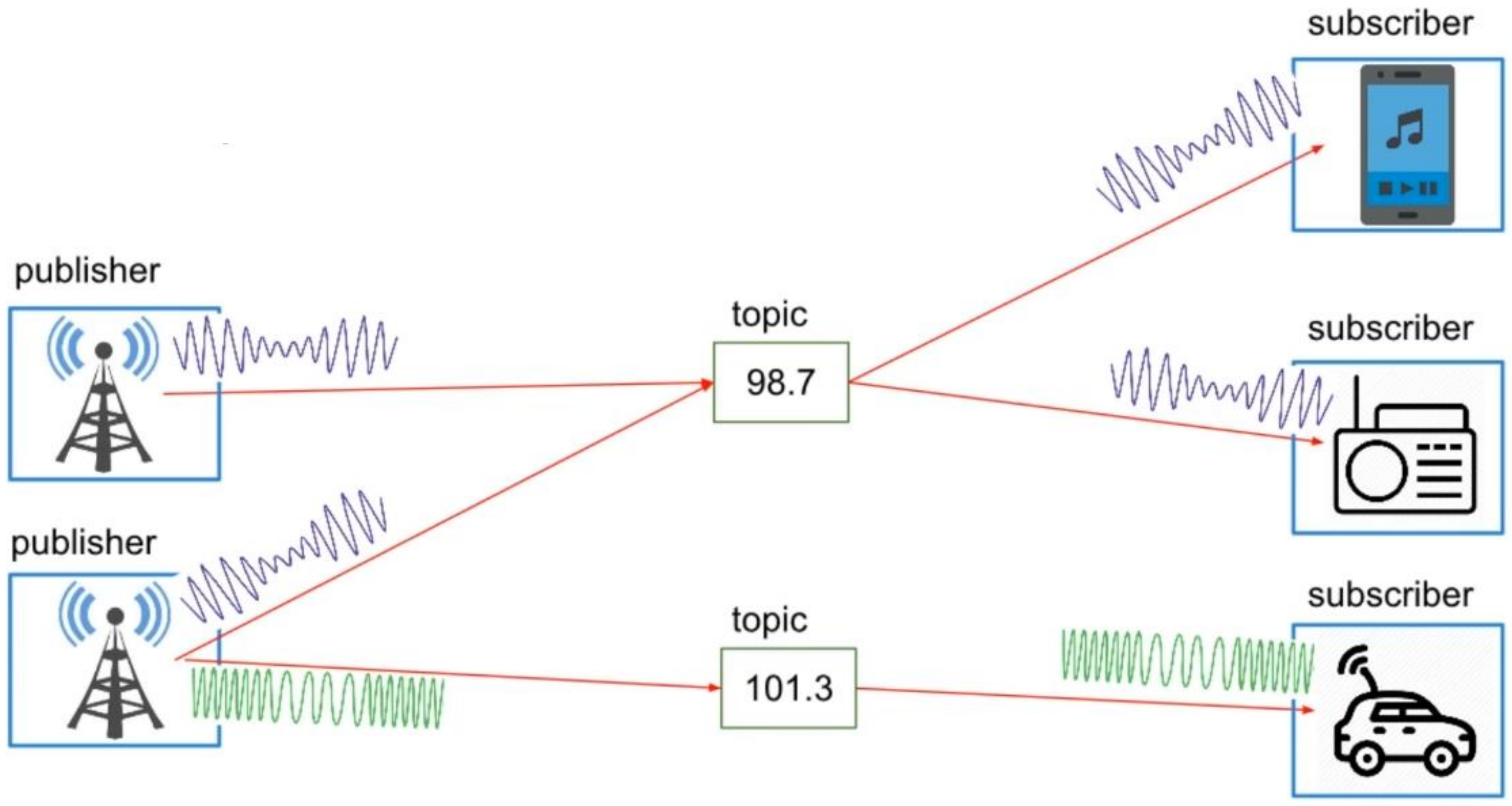
Topic



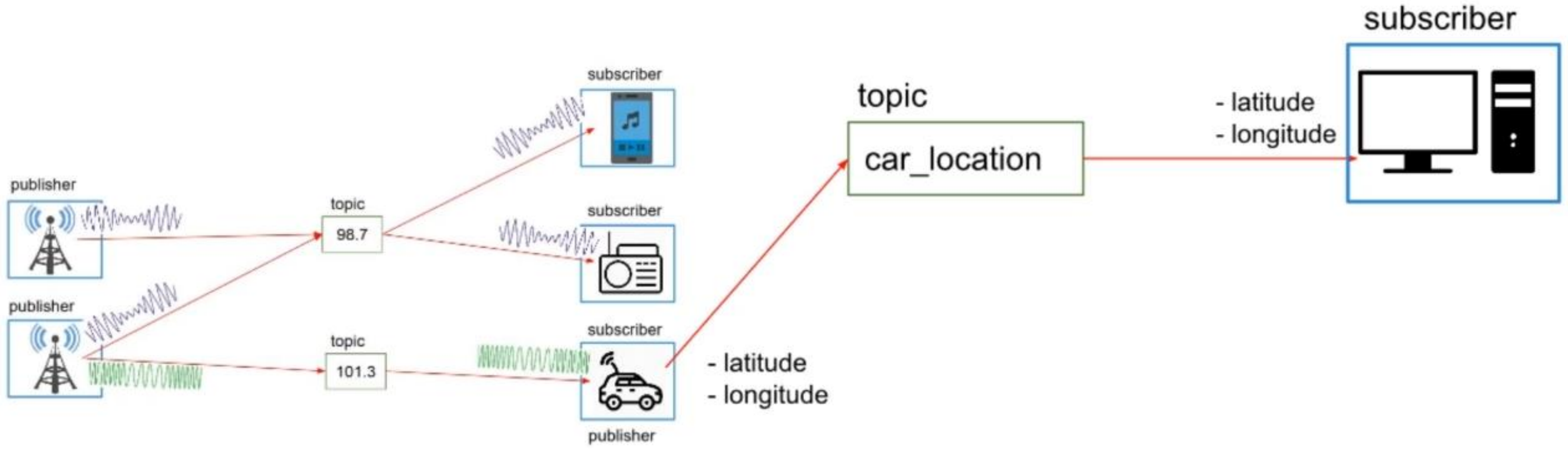
Topic


publisher
publisher
topic
98.7
subscriber
subscriber
subscriber

Topic


subscriber
publisher
topic
98.7
subscriber
publisher
topic
101.3
subscriber

Topic



publisher
publisher
topic
98.7
topic
101.3
subscriber
subscriber
subscriber
publisher
- latitude
- longitude
topic
car_location
- latitude
- longitude
subscriber

Topic

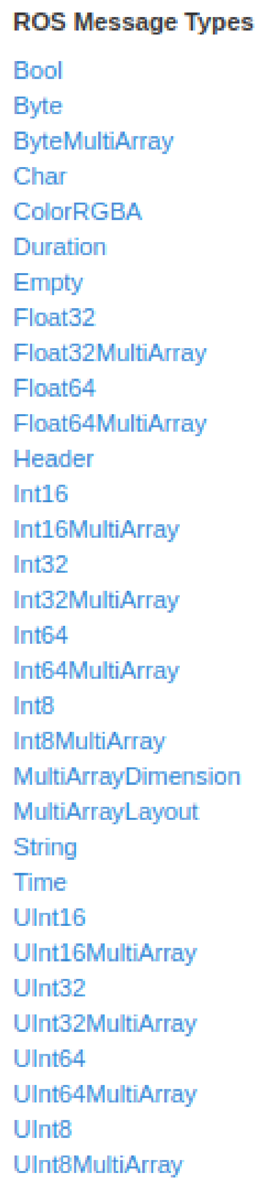
- Vodilo, preko katerega si nodi izmenjujejo sporočila
- Enosmerni prenos sporočil (publisher > subscriber)
- Anonimno
- Topic ima svoj tip sporočila
- ROS master skrbi za ustrezni povezavo publisher/subscriber
- Vsak node ima lahko več publishers/subscribers za različne topics

Publisher

```
pub = rospy.Publisher('topic_name', msg_type, queue_size=10)
```

Messages types:

http://wiki.ros.org/std_msgs



ROS Message Types

- Bool
- Byte
- ByteMultiArray
- Char
- ColorRGBA
- Duration
- Empty
- Float32
- Float32MultiArray
- Float64
- Float64MultiArray
- Header
- Int16
- Int16MultiArray
- Int32
- Int32MultiArray
- Int64
- Int64MultiArray
- Int8
- Int8MultiArray
- MultiArrayDimension
- MultiArrayLayout
- String
- Time
- UInt16
- UInt16MultiArray
- UInt32
- UInt32MultiArray
- UInt64
- UInt64MultiArray
- UInt8
- UInt8MultiArray

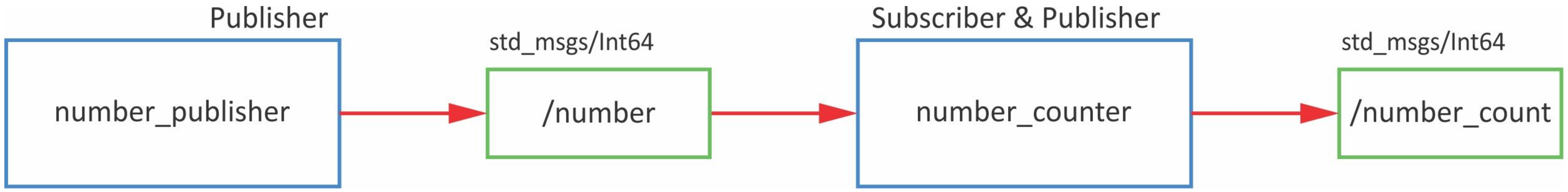
Subscriber

```
sub = rospy.Subscriber('topic_name', msg_type, callback_fcn)
```

DEBUG Topic

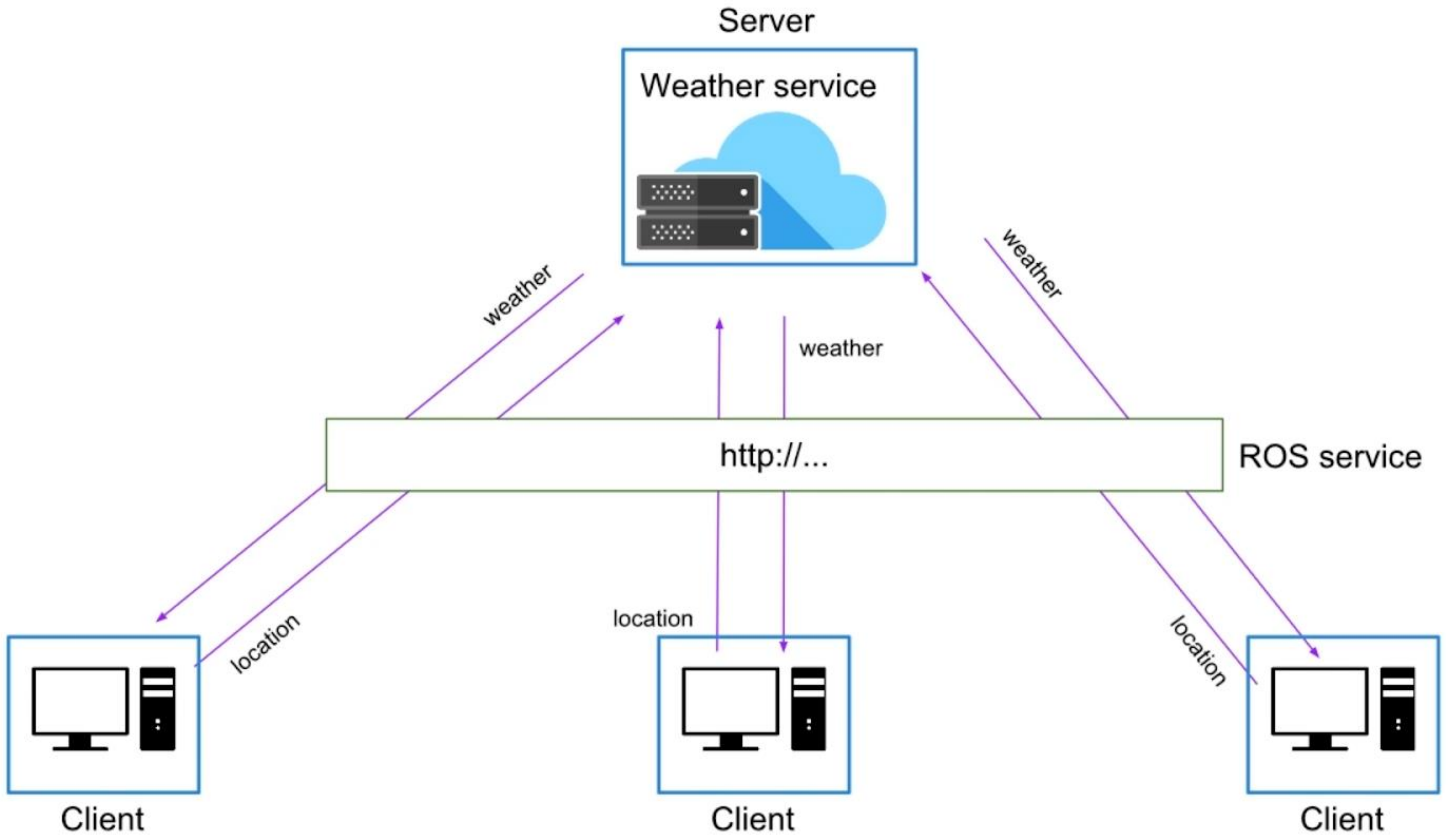
- **`rostopic -h`**
- **`rostopic list`**
- **`rostopic echo <ime topica>`**
- **`rostopic info <ime topica>`** … kateri tip pošilja
- **`rostopic pub <ime topica>`** + Tab za autocomplete
  - **`-1`** … Enkrat pošlje
  - **`-r 5`** … Pošilja s 5 Hz

Primer

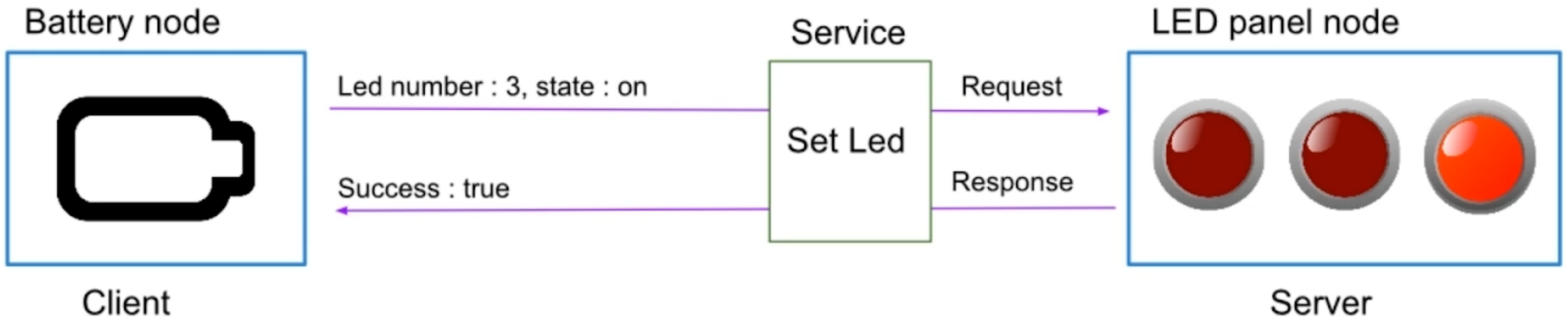

Publisher
number_publisher
std_msgs/Int64
/number
Subscriber & Publisher
number_counter
std_msgs/Int64
/number_count

SERVICES

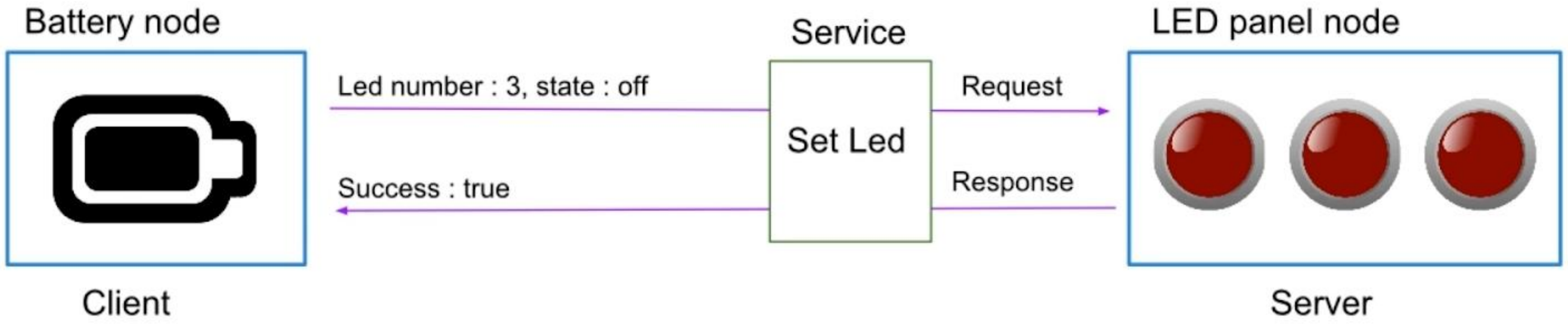
Services


Server
Weather service
weather
weather
weather
http://...
ROS service
location
location
location
Client
Client
Client

Services


Battery node
Client
Led number : 3, state : on
Success : true
Service
Set Led
Request
Response
LED panel node
Server

Services


Battery node
Client
Led number : 3, state : off
Success : true
Service
Set Led
Request
Response
LED panel node
Server

Services

Services

- Sistem server/klient
- Sinhrono delovanje
- Za izračunavanje in hitre akcije
- En tip sporočila za Request, drug tip sporočila za Response
- Server je samo eden, ki lahko odgovarja več klientom

Server

```
service = rospy.Service('ime_service', msg_type, handle_fcn)
```

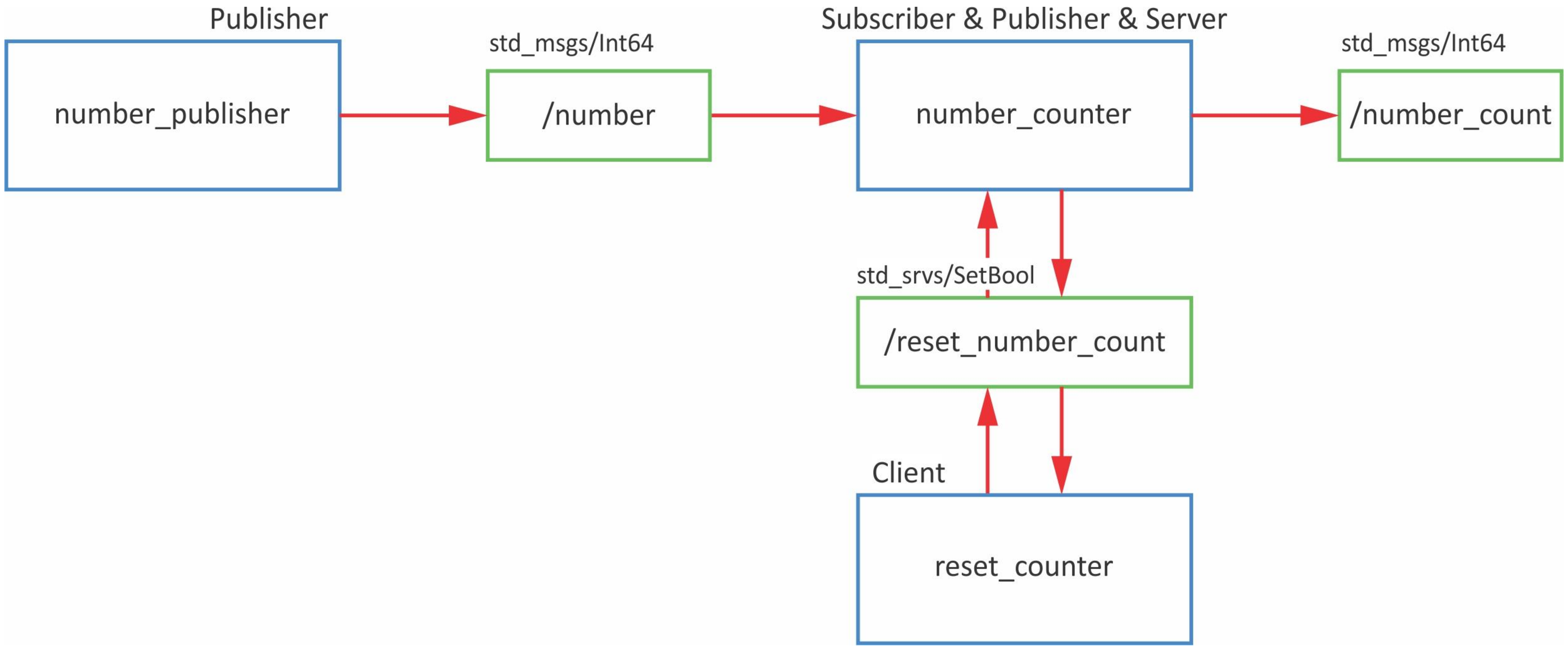
Klient

```
rospy.wait_for_service('ime_service')

try:
    client = rospy.ServiceProxy('ime_service',msg_type)
    ...
except rospy.ServiceException as e:
    rospy.logwarn('Service failed' + str(e))
```

DEBUG Services

• **`rosservice list`**	… vse registrirane services
• **`rosservice info <ime service>`**	… info o service
• **`rosservice call <ime service>`**	… klic iz konzole (brez klienta)

Primer


Publisher
number_publisher
std_msgs/Int64
/number
Subscriber & Publisher & Server
number_counter
std_msgs/Int64
/number_count
std_srvs/SetBool
/reset_number_count
Client
reset_counter

MSG & SRV

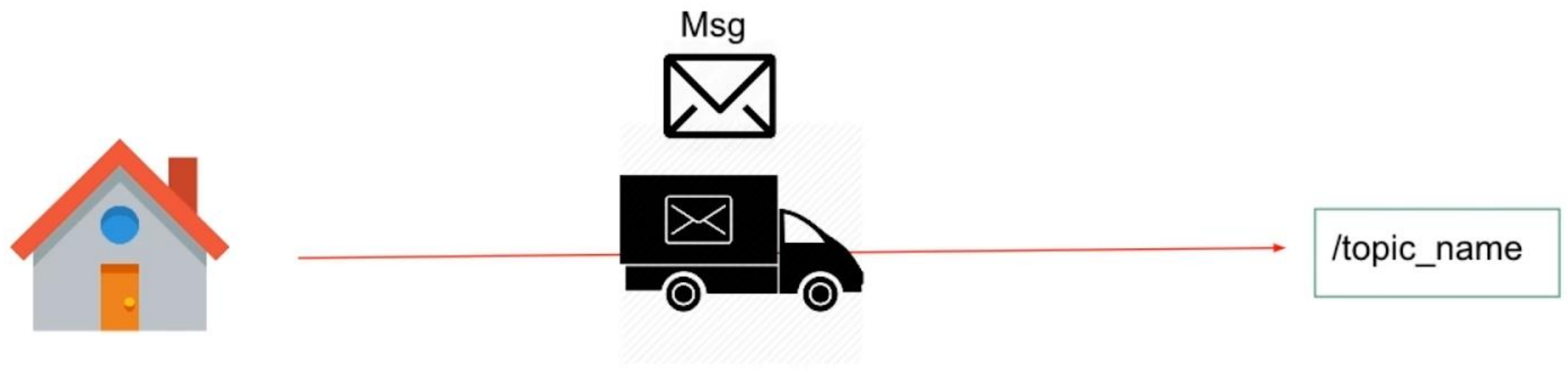
MSG in SRV

- Topic:
  - Ime: `/sick_safetyscanners/scan`
  - Definicija sporočila MSG: `sensors_msgs/LaserScan`

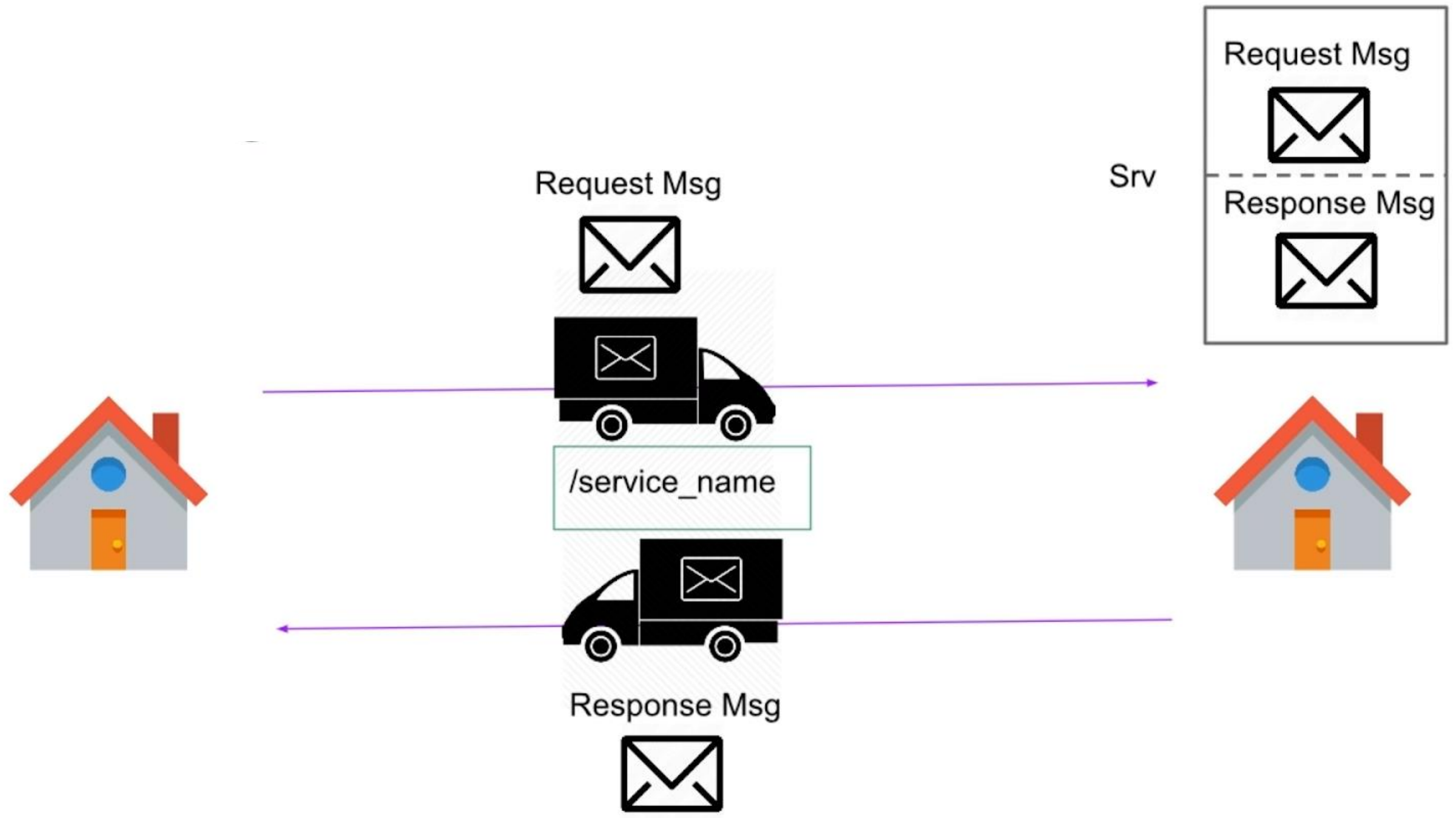
- Service:
  - Ime: `/set_led_state`
  - Definicija sporočila SRV: `std_srvs/SetBool`
    - Request: MSG
    - Response: MSG

```
Request: msg
---
Response msg
```

MSG



SRV


Request Msg
Srv
Response Msg
Request Msg
/service_name
Response Msg

MSG in SRV

- Uporaba MSG primitivov za definiranje sporočil
- Sporočila se lahko definira z uporabo obstoječih sporočil

- MSG:
  - std_msgs
  - sensor_msgs
  - geometry_msgs
  - actionlib_msgs
  - …
- SRV:
  - std_srvs
  - …

SRV

```
Request
---
Response
```

Nov MSG in SRV

```
>> catkin_create_pkg kdr_msgs rospy std_msgs
```

Nov SRV (kdr_msgs)

```
>> roscd kdr_msgs
>> mkdir /srv
>> touch SetLed.srv
>> code SetLed.srv
```

```
int64 LedNumber
---
bool success
string message
```

package.xml (kdr_msgs)

```
<build_depend>message_generation</build_depend>

<exec_depend>message_runtime</exec_depend>
```

CMakeLists.txt (kdr_msgs)

```
find_package(catkin REQUIRED COMPONENTS

  rospy
  std_msgs
  message_generation

)

…

# Generate services in the 'srv' folder

add_service_files(

  FILES
  SetLed.srv

)
```

CMakeLists.txt (kdr_msgs)

```
# Generate added messages and services with any dependencies listed here
generate_messages(
  DEPENDENCIES
  std_msgs
)
...
catkin_package(
#  INCLUDE_DIRS include
#  LIBRARIES my_robot_msgs
 CATKIN_DEPENDS rospy std_msgs message_runtime
#  DEPENDS system_lib
```

catkin_make

```
>> catkin_make
```

Uporaba

package.html (kdr)

```
<depend>kdr_msgs</depend>
```

CMakeLists.txt (kdr)

```
find_package(catkin REQUIRED COMPONENTS
 rospy
 std_msgs
 kdr_msgs
)
```

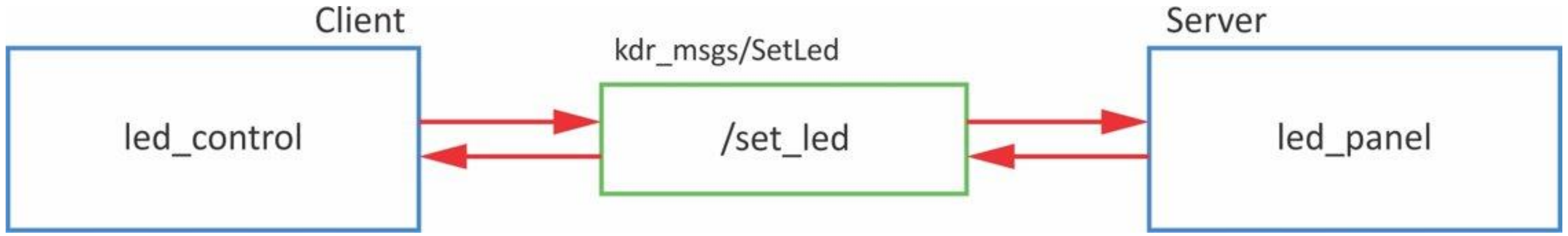
DEBUG MSG/SRV

- **`rosmsg list`**
- **`rosmsg show <ime msg>`**

- **`rossrv list`**
- **`rossrv show <ime srv>`**

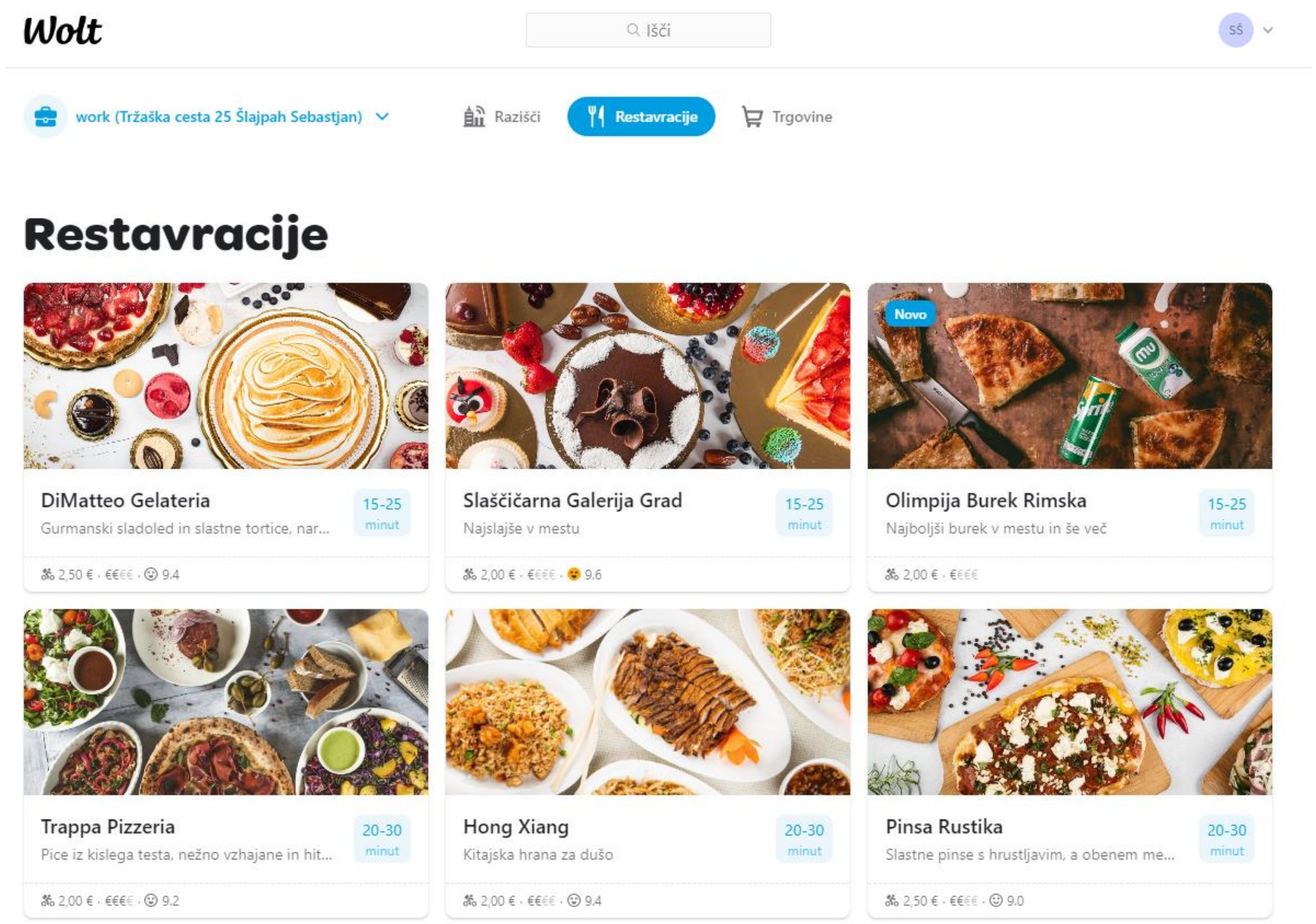
- `rossrv list |grep kdr`

Primer



ACTIONS

Actions



Restavracije

DiMatteo Gelateria
Gurmanski sladoled in slastne tortice, nar...
15-25 minut
2,50 € · €€€€ · 9.4

Slaščičarna Galerija Grad
Najslajše v mestu
15-25 minut
2,00 € · €€€€ · 9.6

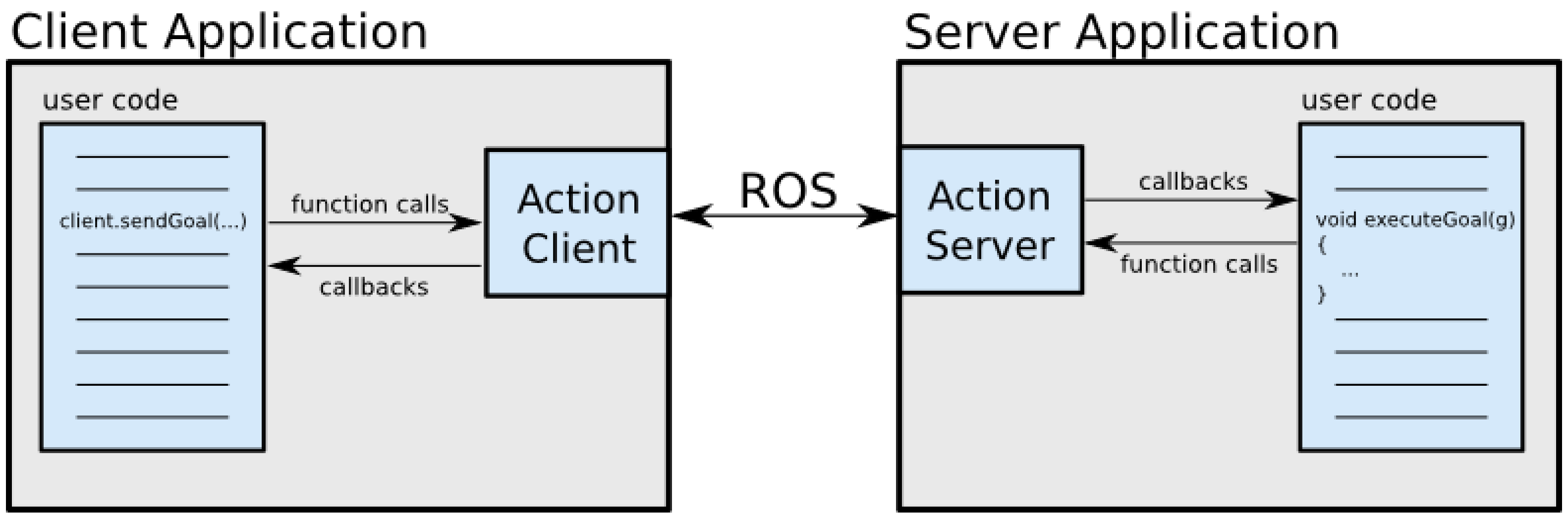
Olimpija Burek Rimska
Najboljši burek v mestu in še več
15-25 minut
2,00 € · €€€€

Trappa Pizzeria
Pice iz kislega testa, nežno vzhajane in hit...
20-30 minut
2,00 € · €€€€ · 9.2

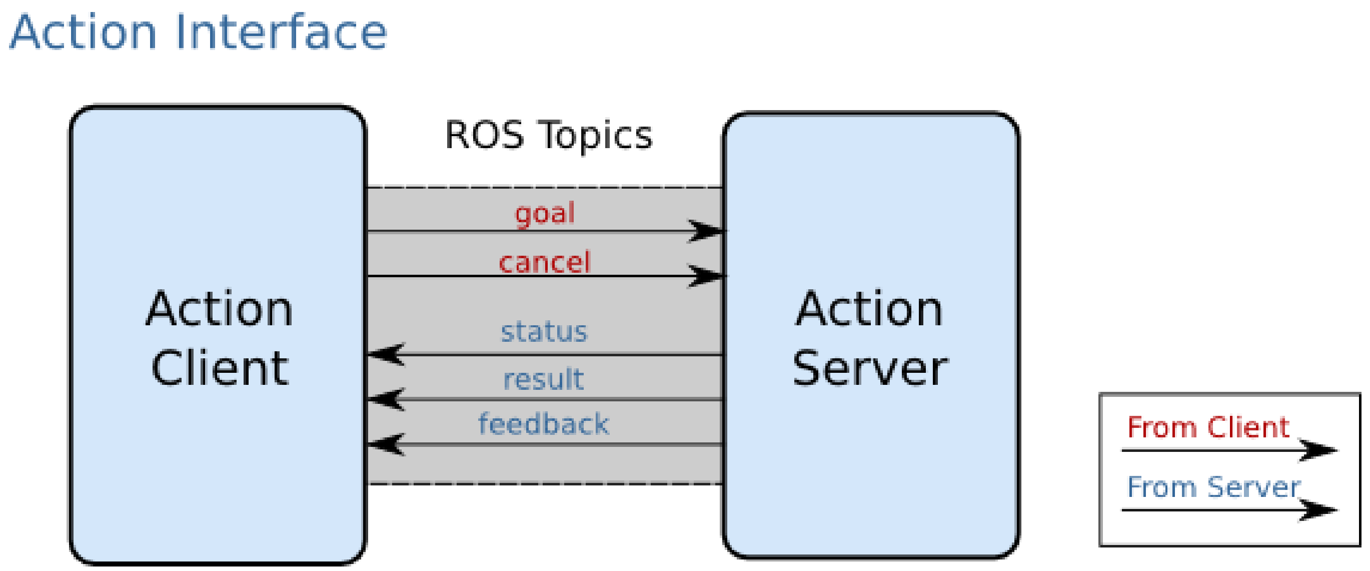
Hong Xiang
Kitajska hrana za dušo
20-30 minut
2,00 € · €€€€ · 9.4

Pinsa Rustika
Slastne pinse s hrustljavim, a obenem me...
20-30 minut
2,50 € · €€€€ · 9.0

Actions


Client Application
user code
client.sendGoal(...)
function calls
callbacks
Action Client
ROS
Server Application
Action Server
callbacks
function calls
user code
void executeGoal(g)
{
...
}

Actions


Action Interface
ROS Topics
Action Client
Action Server
goal
cancel
status
result
feedback
From Client
From Server

Actions

- Knjižnica `actionlib`
- Sistem server/klient
- Asinhrono delovanje
- Za funkcionalnosti, ki trajajo dlje časa
- Lahko izvajaš druge naloge, medtem ko je klicana osnovna funkcionalnost
- Posamezna sporočila za Goal, Feedback in Result

Kako prepoznati action?

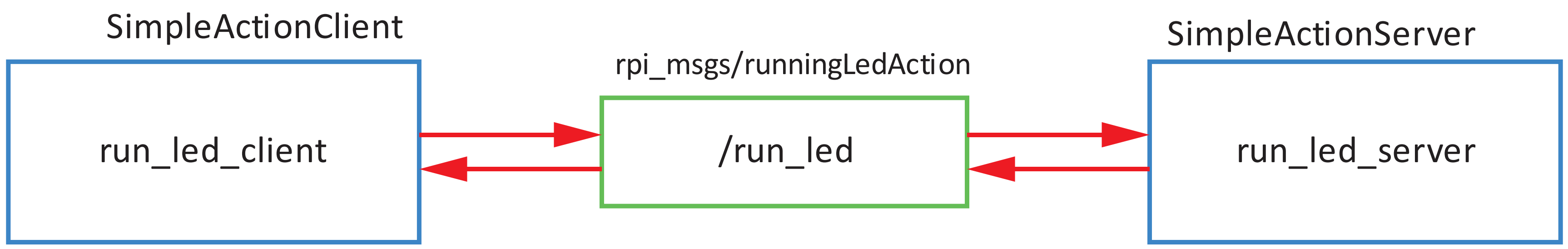
`>> rostopic list`

Struktura: namespace (`as_name`)

```
as_name/cancel
as_name/feedback
as_name/goal
as_name/result
as_name/status
```

Naloga

- n-kratno izvajanje sekvenčnega prižiganja LED



MSG .action (kdr_msgs)

```
>> mkdir action
>> cd ./action
>> touch runningLed.action
```

```
# goal
int16 numberOfRuns
---
# result
int16 finalRun
---
# feedback
int16 currentRun
```

CMakeLists.txt (kdr_msgs)

```
find_package(
        actionlib_msgs
)


add_action_files(
        FILES
        NAME.action
)
```

```
generate_messages(
        DEPENDENCIES
        actionlib_msgs
)


catkin_package(
        CATKIN_DEPENDS rospy
)
```

Package.xml (kdr_msgs)

```
<build_depend>actionlib_msgs</build_depend>
```

SimpleActionServer

```
sas = actionlib.SimpleActionServer('name', actionSpec, goal_callback,
        auto_start=False)

sas.start()


def goal_callback()

       sas.publish_feedback(_feedback_)

       sas.set_succeeded(_result_)


       if sas.is_preempt_requested():

              sas.set_preempted()
```

SimpleActionServer

```
import actionlib
from kdr_msgs.msg import runningLedAction, runningLedFeedback, runningLedResult,

ACserver = None
def goal_callback(goal):
    pass

if __name__ == '__main__':
    rospy.init_node('run_led_server')
    ACserver = actionlib.SimpleActionServer('run_led', runningLedAction, goal_callback, False)

    # start server
    ACserver.start()
    rospy.spin()
```

SimpleActionServer

```
def goal_callback(goal):
    runFeedback = runningLedFeedback()
    runResult = runningLedResult()

    # Do lots of awesome groundbreaking robot stuff here
    for ii in range(1,goal.numberofRuns+1):
        #
        # prizgi ustrezno LED
        #
        runFeedback.currentRun = ii
        ACserver.publish_feedback(runFeedback)

    # publish the result
    runResult.finalRuns = runFeedback.currentRun
    ACserver.set_succeeded(runResult)
```

SimpleActionClient

```
client = actionlib.SimpleActionClient('name', actionSpec)


client.send_goal(goal)          # Sends the goal to the action server.


client.wait_for_result()        # Waits for the server to finish performing the action.
client.get_result()             # Prints out the result of executing the action


client.get_state()              # Get current state of the server


# define action server status
PENDING = 0
ACTIVE = 1
DONE = 2
WARN = 3
ERROR = 4
```

SimpleActionClient

```
import actionlib
from kdr_msgs.msg import runningLedAction, runningLedGoal

client = None

def run_led_client(goalNum):
    pass

if __name__ == '__main__':
    rospy.init_node('run_led_client')

    try:
        result = run_led_client(goalNum = 10)
    except rospy.ROSInterruptException:
        print("Program interrupted before completion")
```

SimpleActionClient

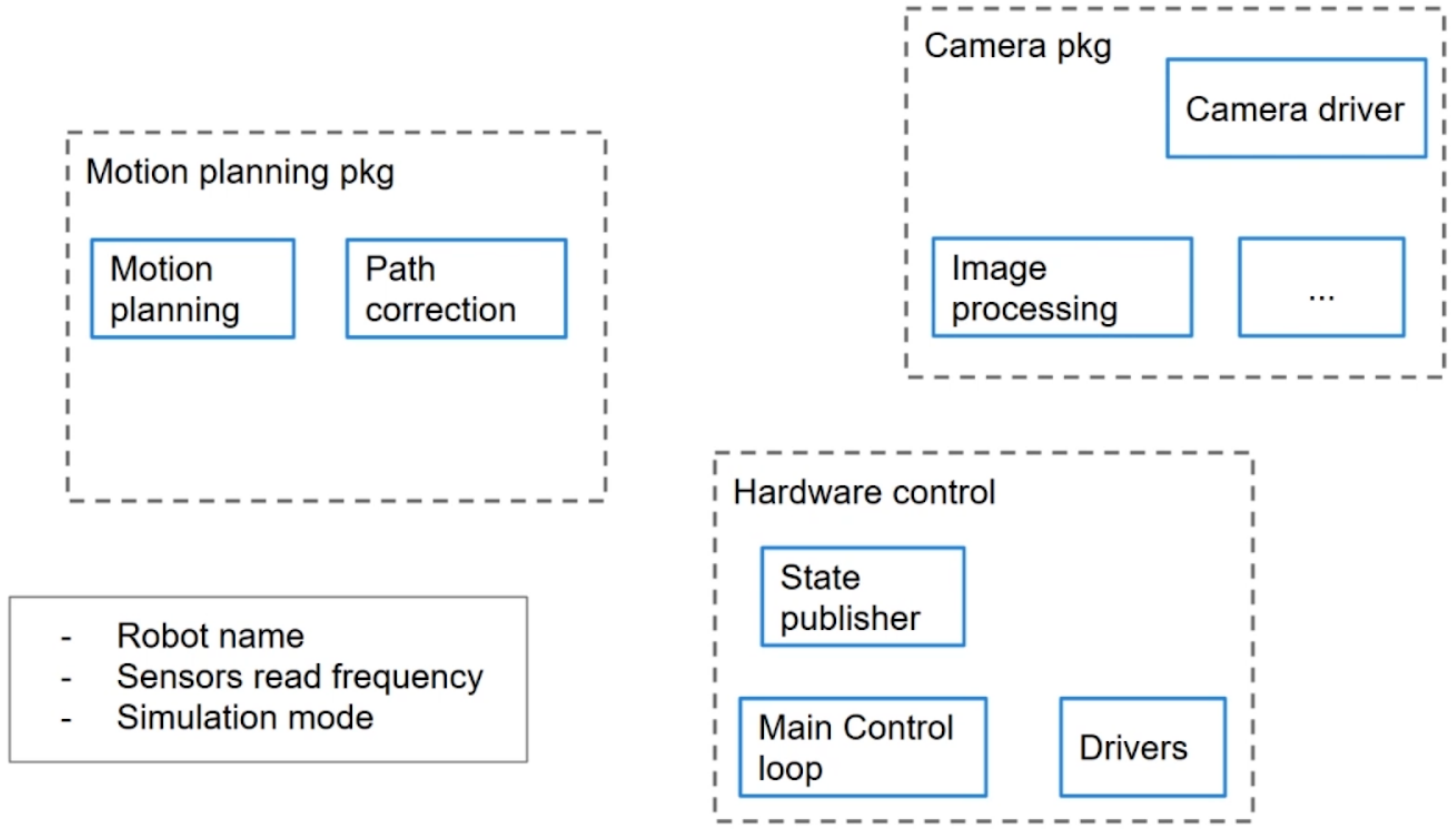
```
def run_led_client(goalNum):
    global client
    client = actionlib.SimpleActionClient('run_led', runningLedAction)
    client.wait_for_server()      # Waits until the action server has started up and started
                                    listening for goals.
    goal = runningLedGoal()       # Creates a goal to send to the action server.
    goal.numberOfRuns = goalNum

    client.send_goal(goal)        # Sends the goal to the action server.
    client.wait_for_result()      # Waits for the server to finish performing the action.
    return client.get_result()    # Prints out the result of executing the action
```

SimpleActionClient

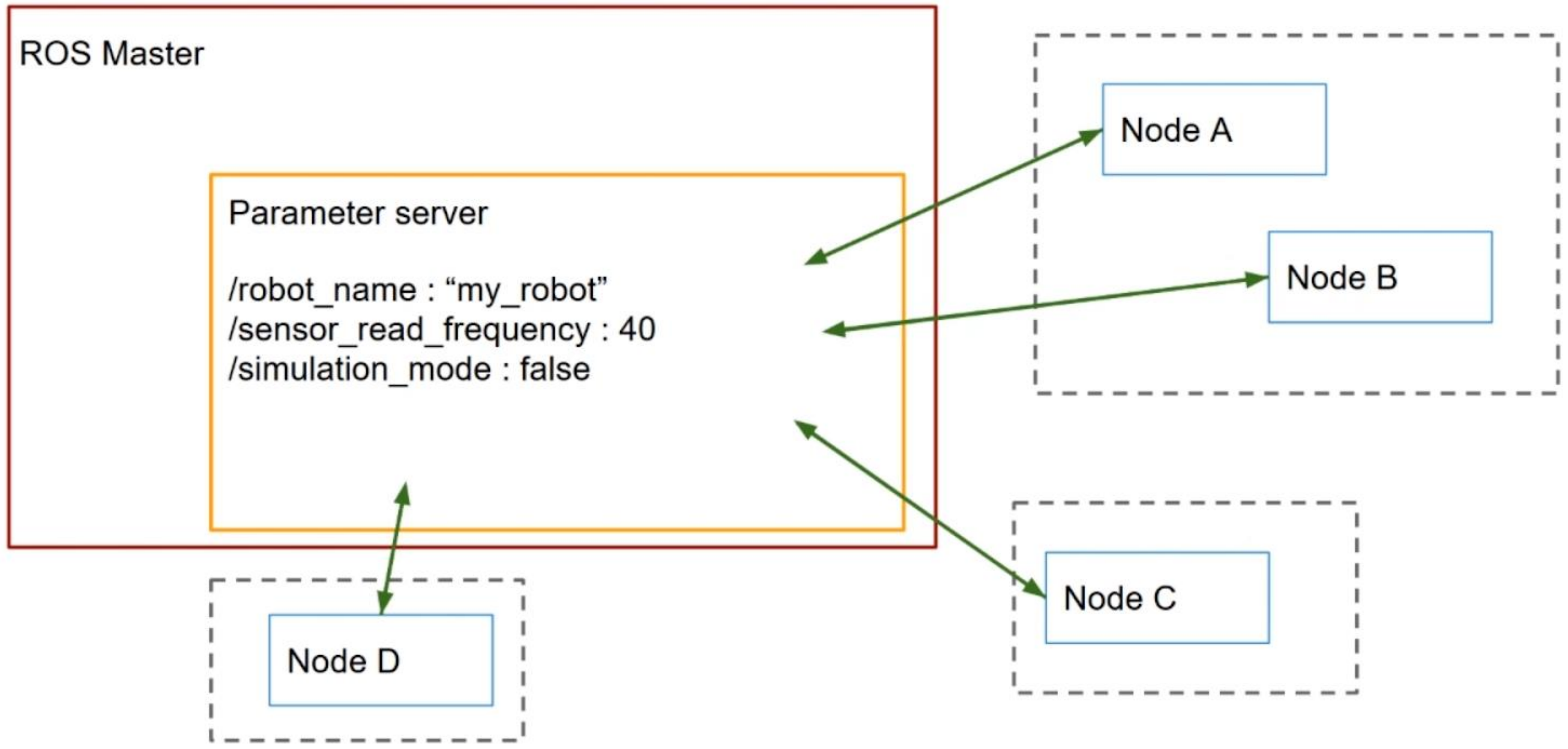
```
def run_led_client(goalNum):
    #... client defininiton ...
    client.send_goal(goal)    # Sends the goal to the action server.

    # let us do some other stuff
    current_state = client.get_state()

    while current_state < DONE:
        # action is still active, let us do something
        current_state = client.get_state()
        rate.sleep()

    if current_state == WARN:
        rospy.logwarn("[Warn] Warning on the action server side.")

    if current_state == ERROR:
        rospy.logerr("[Error] Error on the action server side.")

    return  client.get_result()
```

PARAMETERS and LAUNCH FILES

Parameters


Motion planning pkg
Motion planning
Path correction
Camera pkg
Camera driver
Image processing
...
Hardware control
State publisher
Main Control loop
Drivers
- Robot name
- Sensors read frequency
- Simulation mode

Parameters


ROS Master
Parameter server
/robot_name : “my_robot”
/sensor_read_frequency : 40
/simulation_mode : false
Node A
Node B
Node C
Node D

Parameters

- Parameter server: slovar znotraj ROS master, globalno dosegljiv
- ROS parameter: ena spremenljivka znotraj parameter serverja
- Tipi:
  - Boolean
  - Int
  - Double
  - String
  - Lists
  - …

Parameter

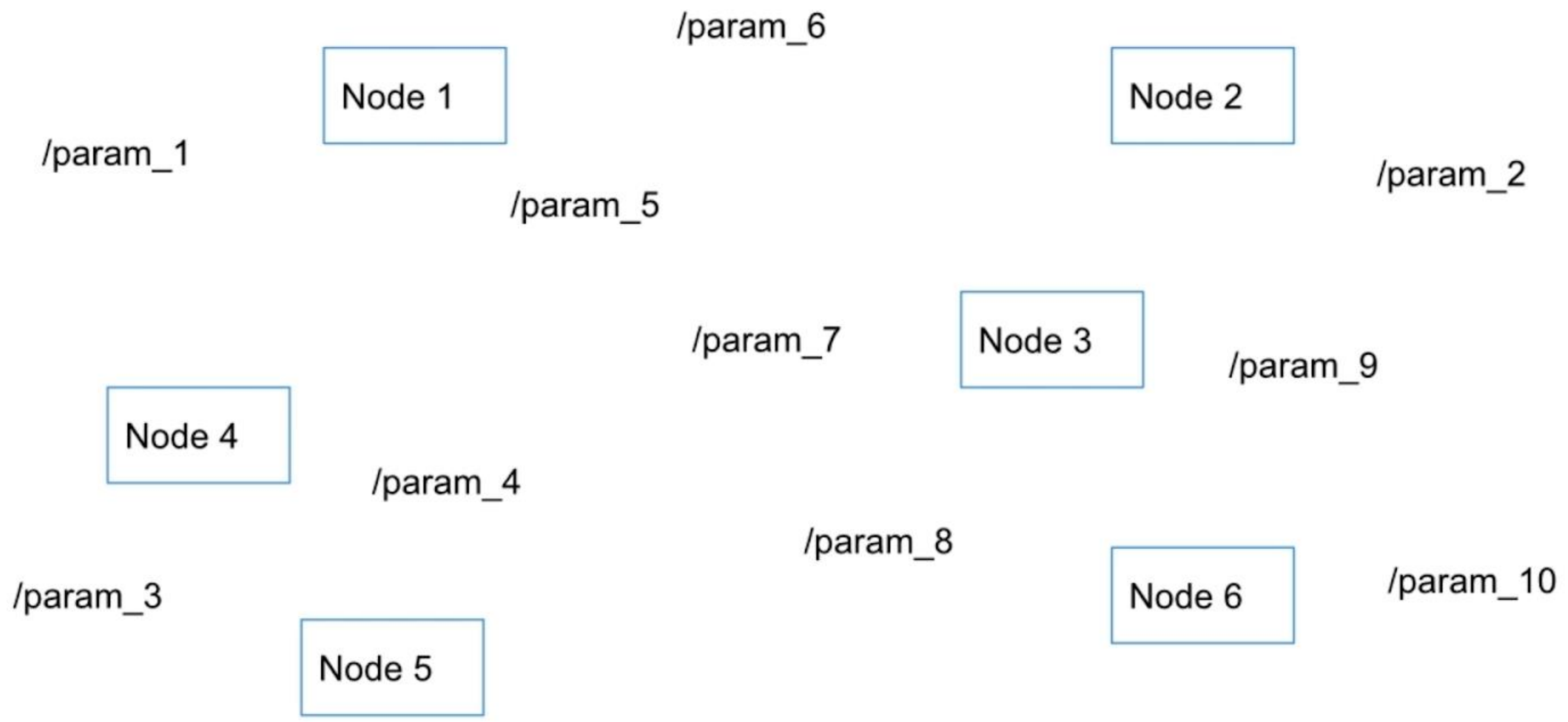
```
>> rosparam set <param name> <value>
```
… tako ga tudi ustvariš

```
>> rosparam get <param name>
>> rosparam list
```

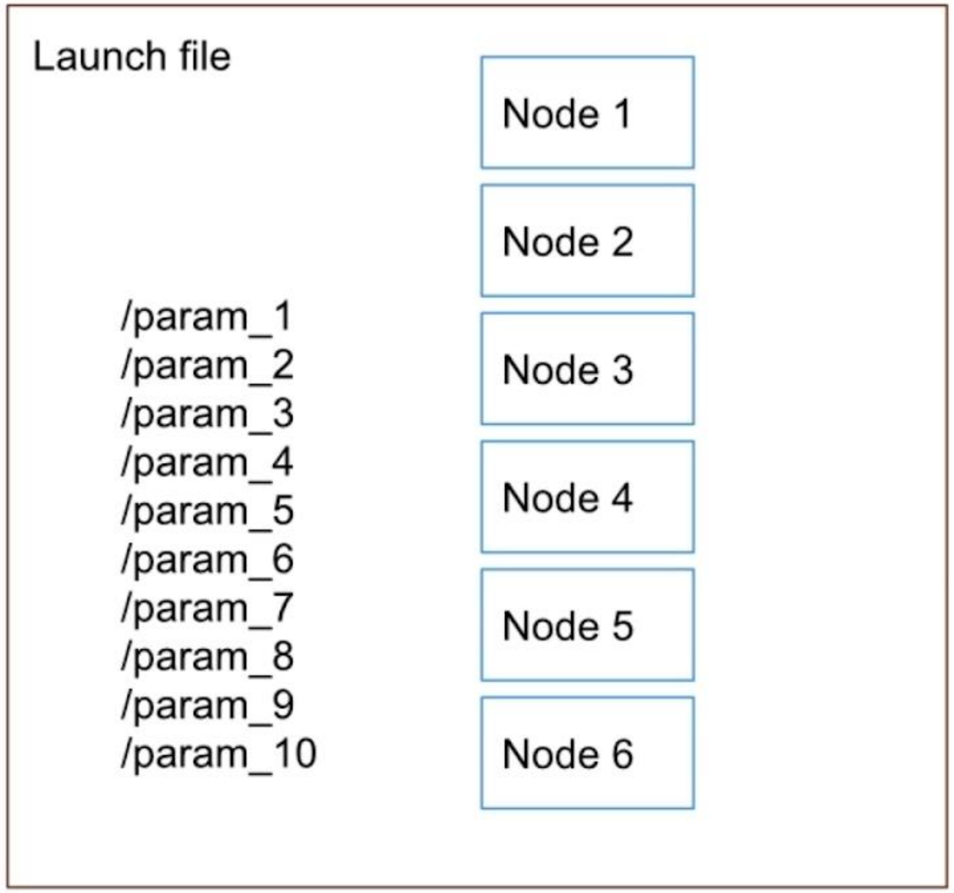
- Primer:

```
publish_freq = rospy.get_param('/number_publish_freq')
>> rosparam set /number_publish_freq 2
```

Launch file


/param_6
Node 1
Node 2
/param_1
/param_2
/param_5
/param_7
Node 3
/param_9
Node 4
/param_4
/param_8
/param_3
Node 6
/param_10
Node 5

Launch file


Launch file
Node 1
Node 2
Node 3
Node 4
Node 5
Node 6
/param_1
/param_2
/param_3
/param_4
/param_5
/param_6
/param_7
/param_8
/param_9
/param_10

Nov .launch

```
>> catkin_create_pkg /kdr_bringup
>> catkin_make
>> mkdir launch
>> touch kdr.launch
```

```
<launch>
   <param name="/ime_parametra" type="tip_spremenljivke" value="vrednost"/>
   <node name="ime" pkg="paket" type="source_file.py" output="screen"/>
</launch>
```

```
>> roslaunch kdr_bringup kdr.launch
```

Primer

- Nadgradnja SimpleActionClient s parametrom
  - Število sekvenc: `/number_of_runs`
- Nadgradnja SimpleActionServer s parametrom
  - Hitrost izvajanja sekvence: `/led_frequency`

- Izvedba `.launch` datoteke za Action Server