ROS orodja

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www.fe-ros.si
www.robolab.si
www.cobotic.si
agro.cobotic.si

Vsebina

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

- Konzolni ukazi za posamezne funkcionalnosti

- Python 3.8

ROSMASTER

ROSMASTER

```
$ roscore
```

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

```
$ echo $ROS_MASTER_URI
```

CATKIN WORKSPACE

- CATKIN – official build system for ROS

```
$ cd
$ 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
```

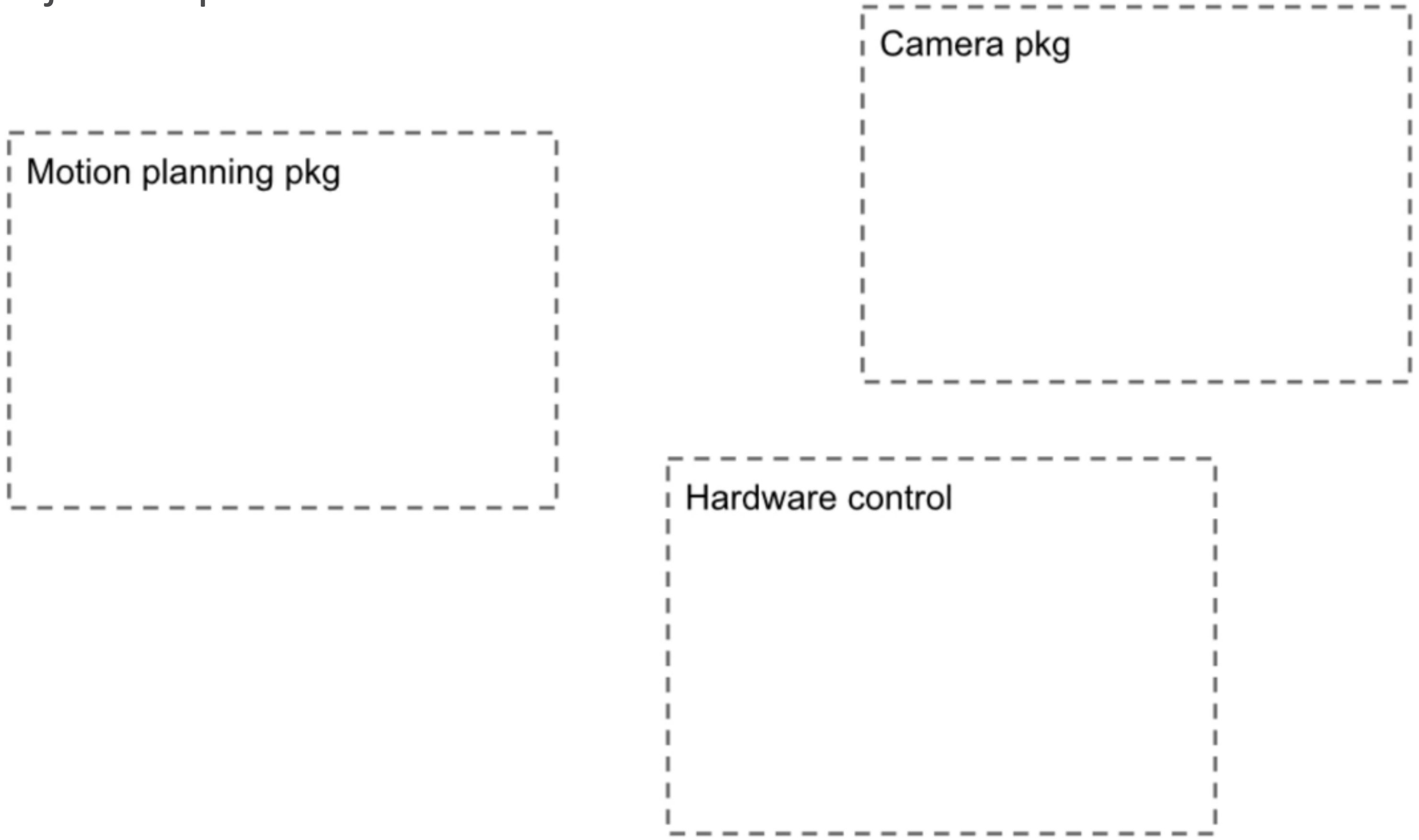
PACKAGES

Packages

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

Packages

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

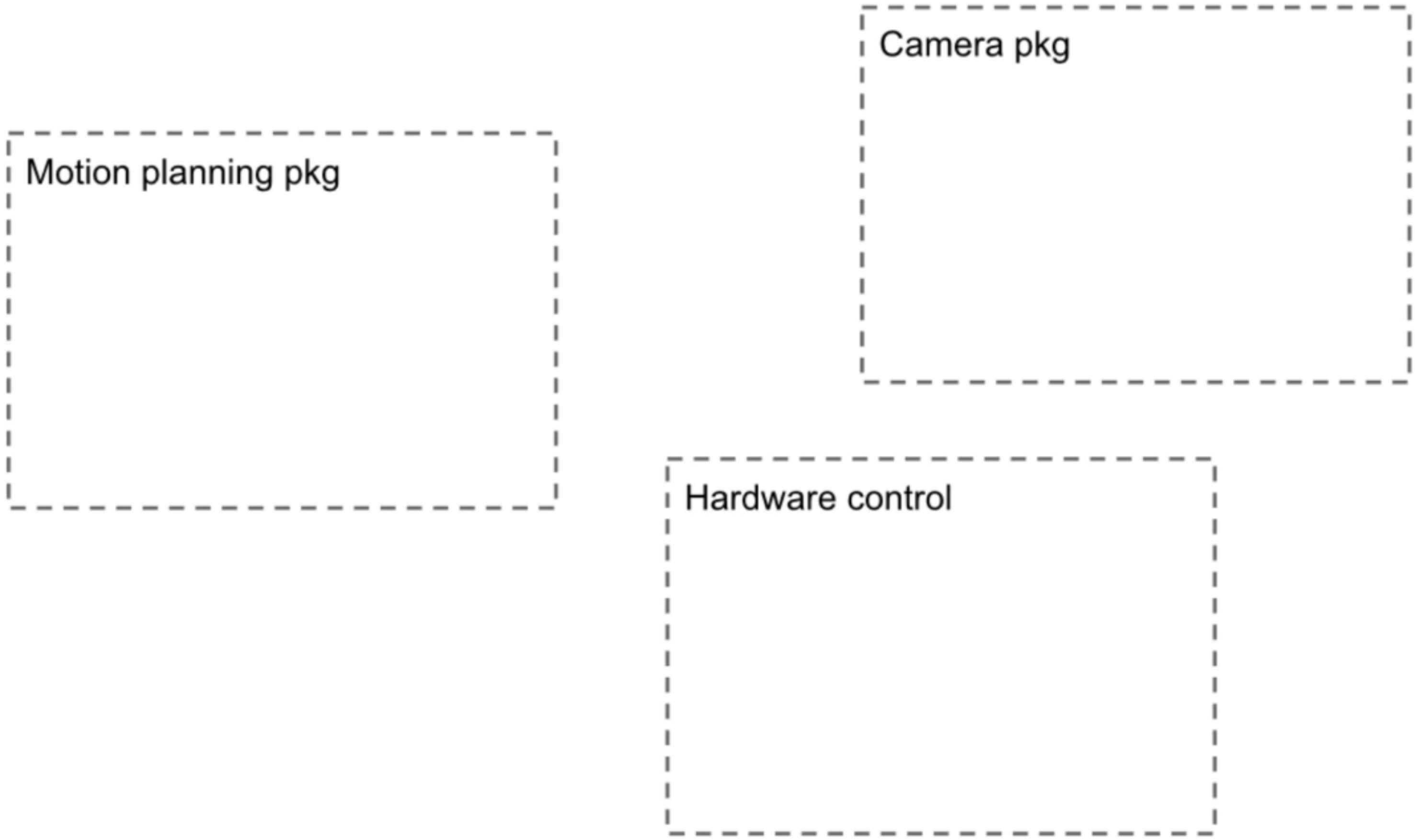


Nov paket

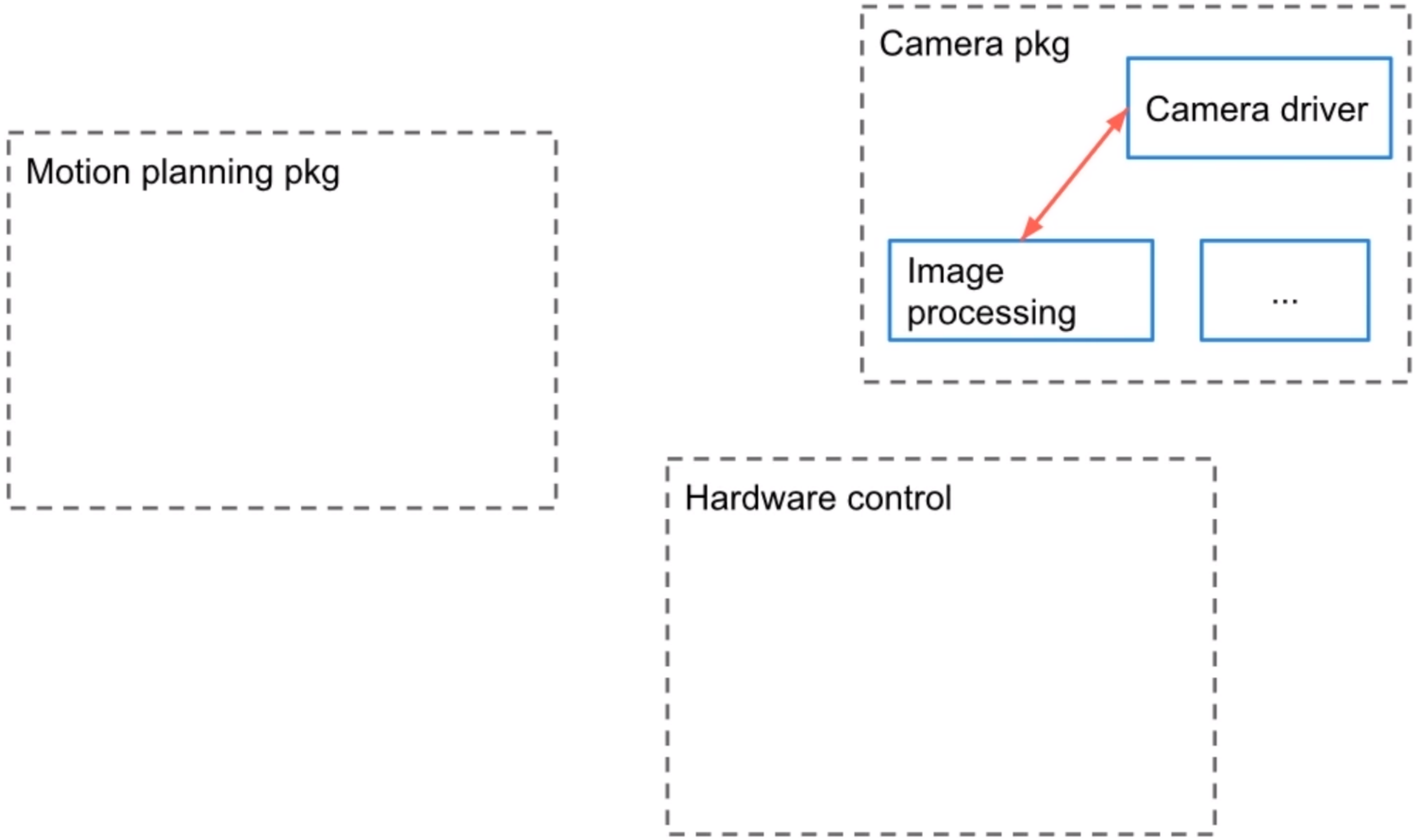
```
$ catkin_create_pkg <ime_paketa> <razširitve>

$ catkin_make



$ catkin_create_pkg rpi_test rospy std_msgs
```

NODE

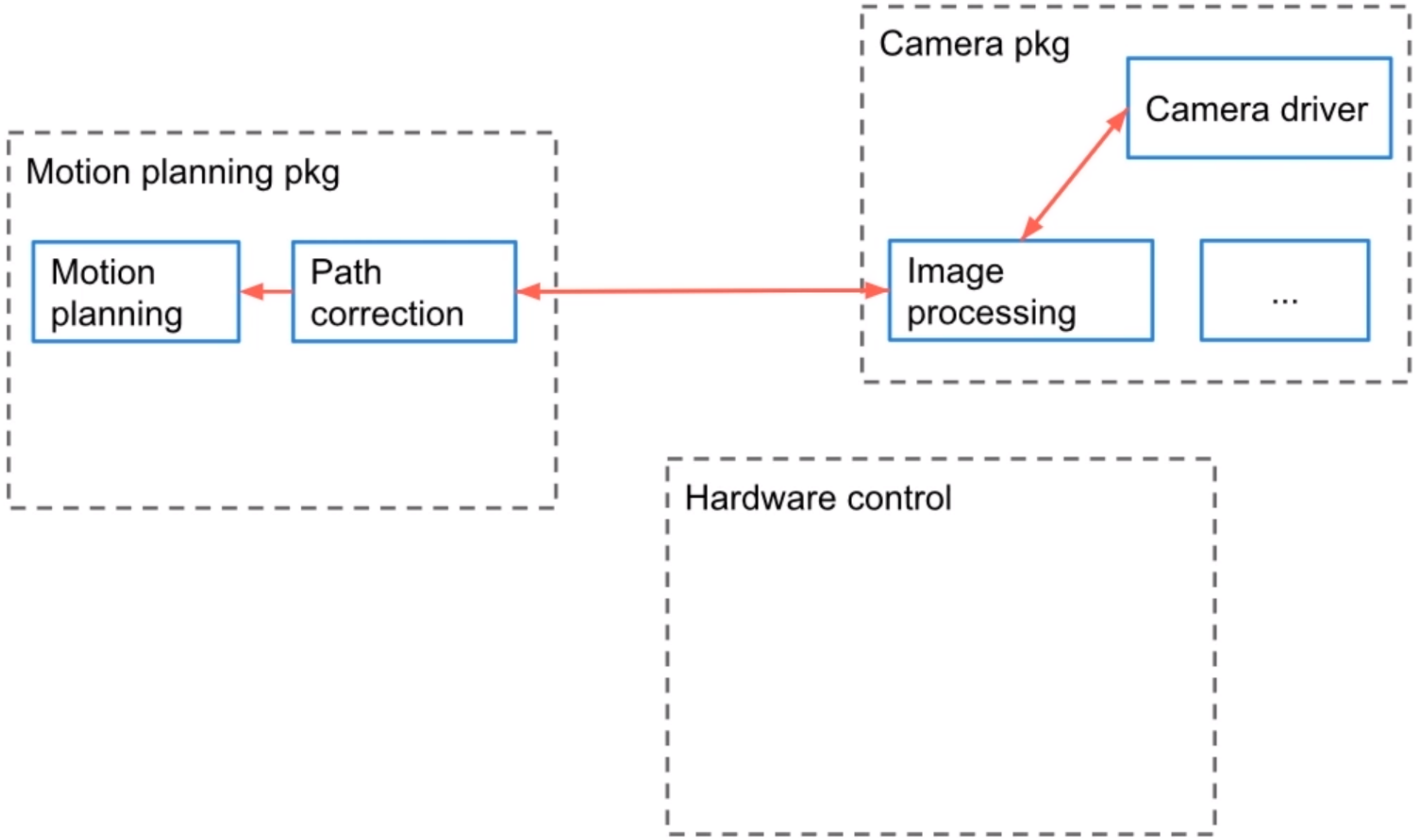
Node



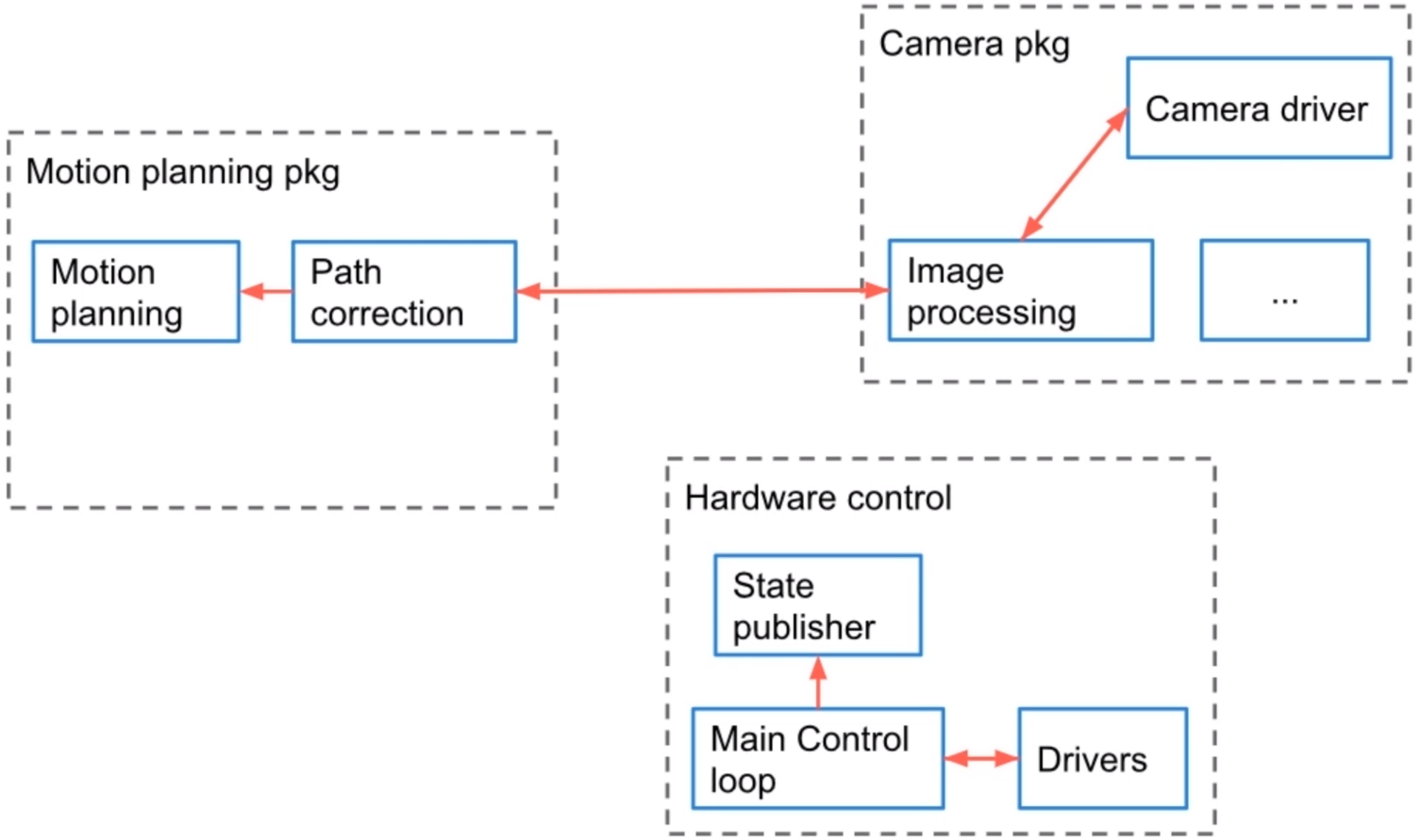
Node


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

Node

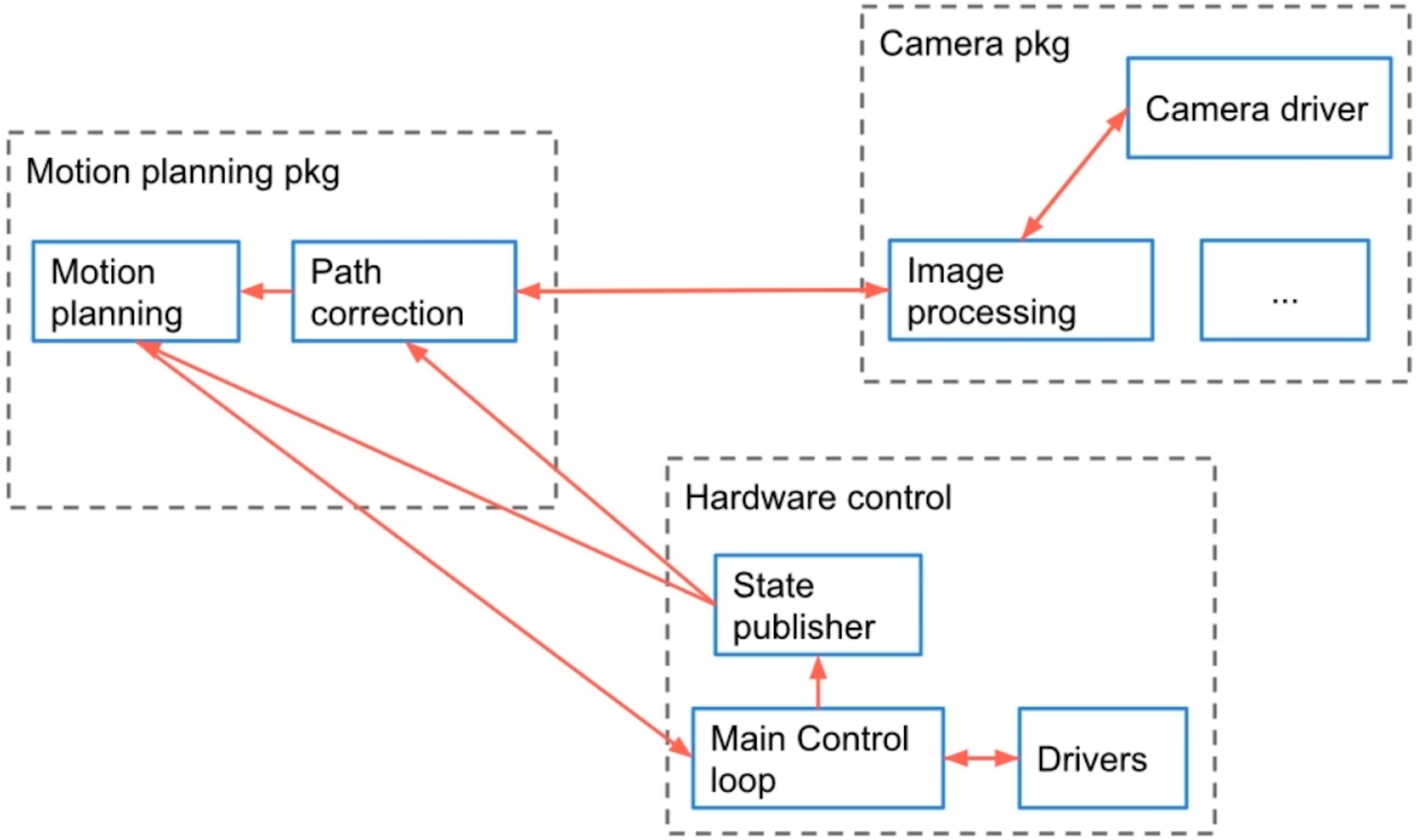

Motion planning pkg
Motion planning
Path correction
Camera pkg
Camera driver
Image processing
...
Hardware control

Node



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

Node


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

```
$ roscd rpi_test
$ mkdir scripts
$ cd scripts
$ touch my_first_node.py
$ chmod +x my_first_node.py
$ code my_first_node.py
```

```
#!/usr/bin/env python3

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')
```

```
$ python3 my_first_node.py
```

FEROS

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)
```

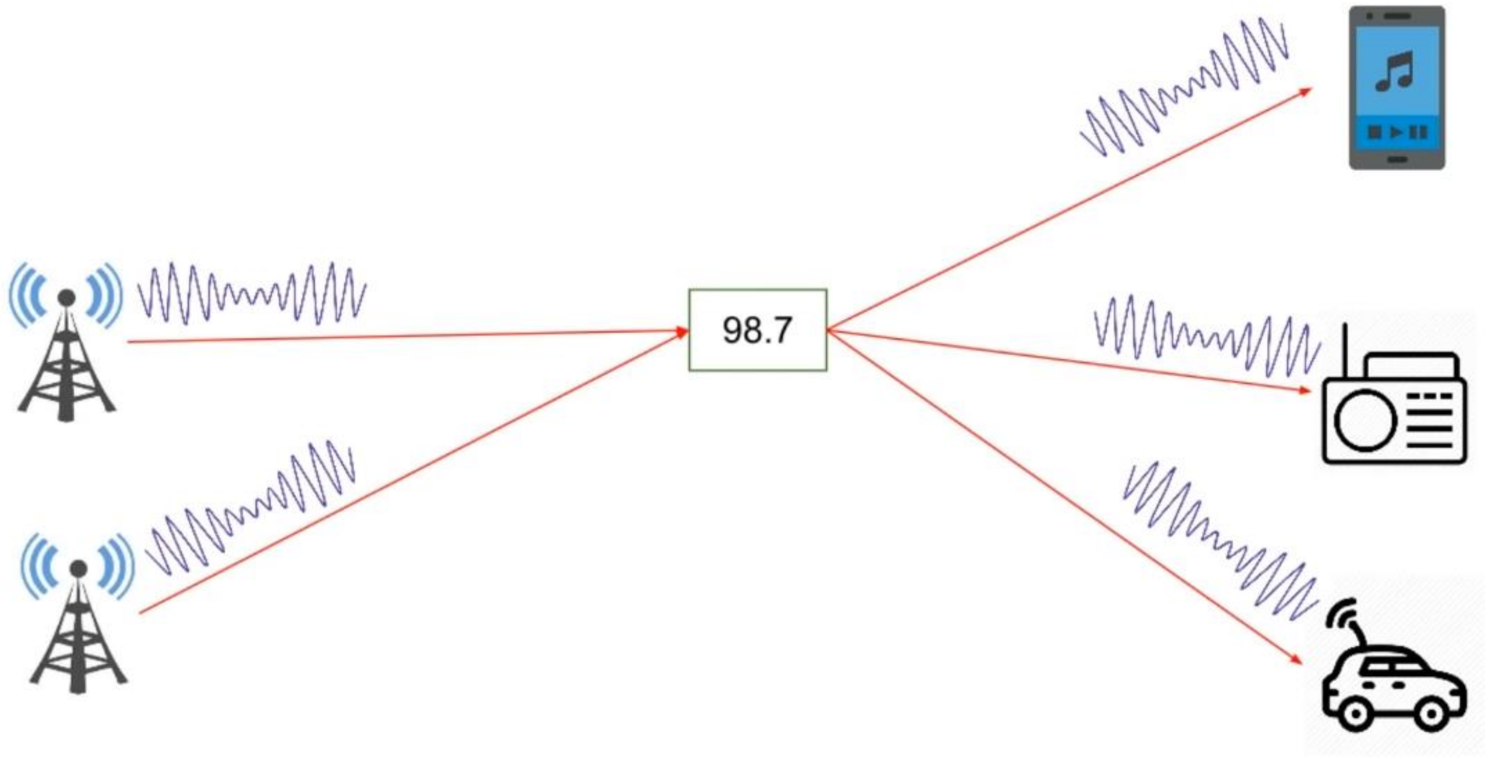
PRIMERI

Prenos primerov

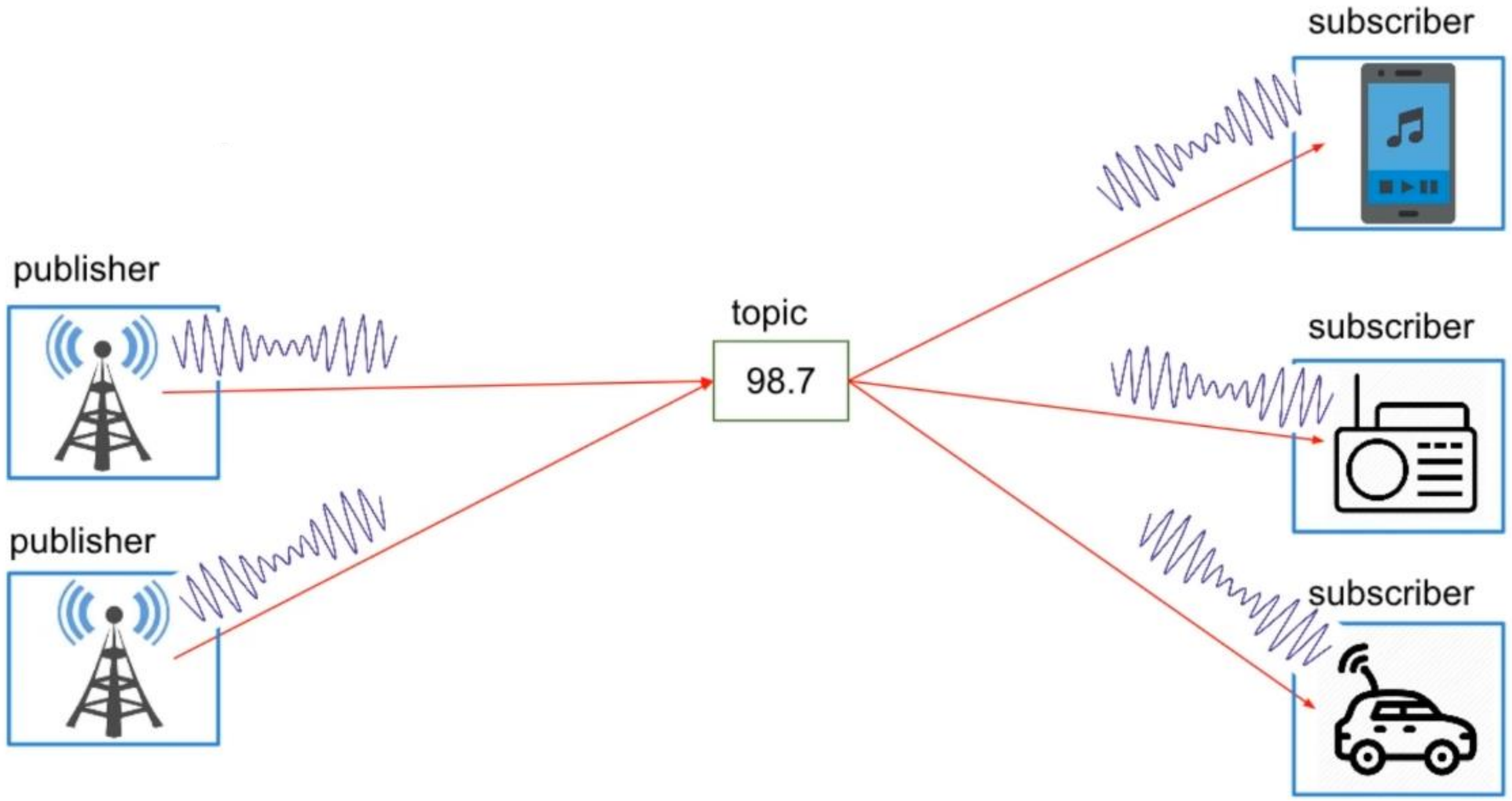
```
$ roscd
$ cd ..
$ cd src

$ git clone https://github.com/ROS-FE/rpi_ros_examples.git .

$ roscd
$ cd ..
$ catkin_make
```

TOPICS

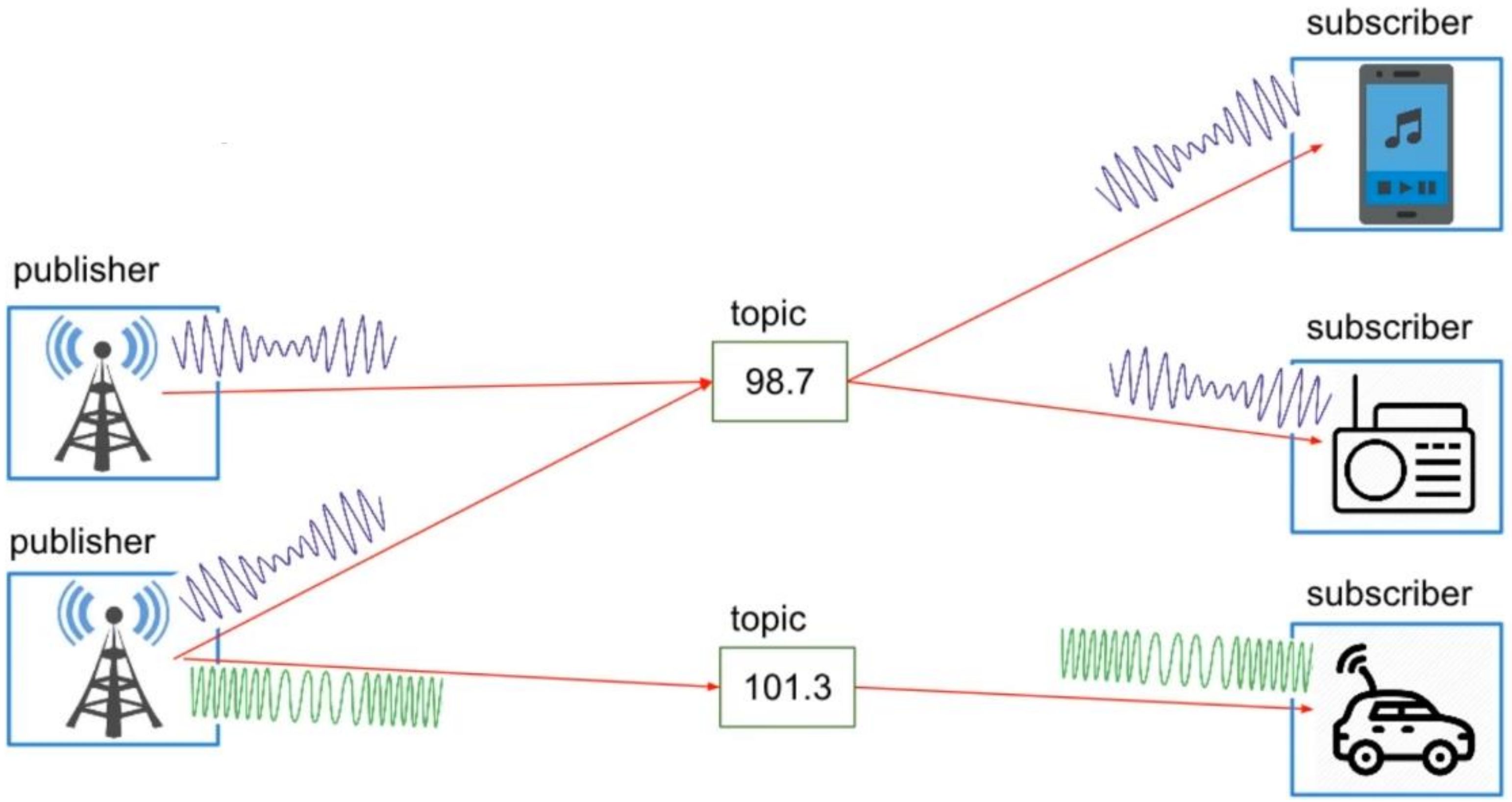
Topic



Topic

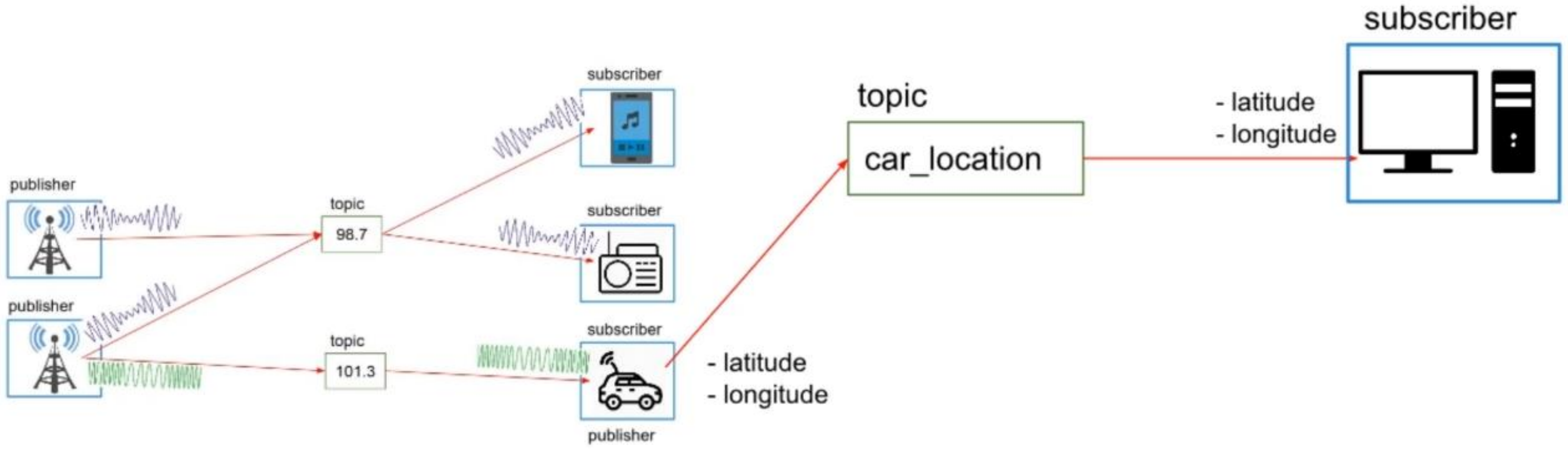

subscriber
publisher
topic
98.7
subscriber
publisher
subscriber

Topic


subscriber
publisher
topic
98.7
subscriber
publisher
topic
101.3
subscriber

FEROS

Topic


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

Topic

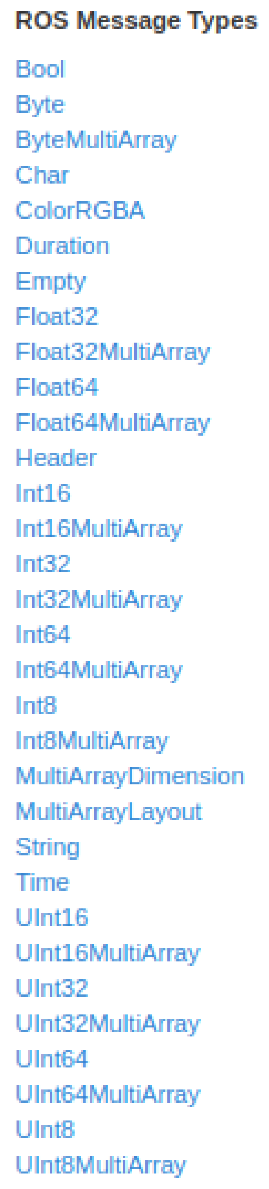
- Vodilo, preko katerega si nodi izmenjujejo sporočila
- Enosmerni prenos sporočil (publisher > subscriber)
- Anonimno
- Topic ima svoj tip sporočila
- ROS master skrbi za ustrezni povezavo publisher/subscriber
- Vsak node ima lahko več publishers/subscribers za različne topics

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

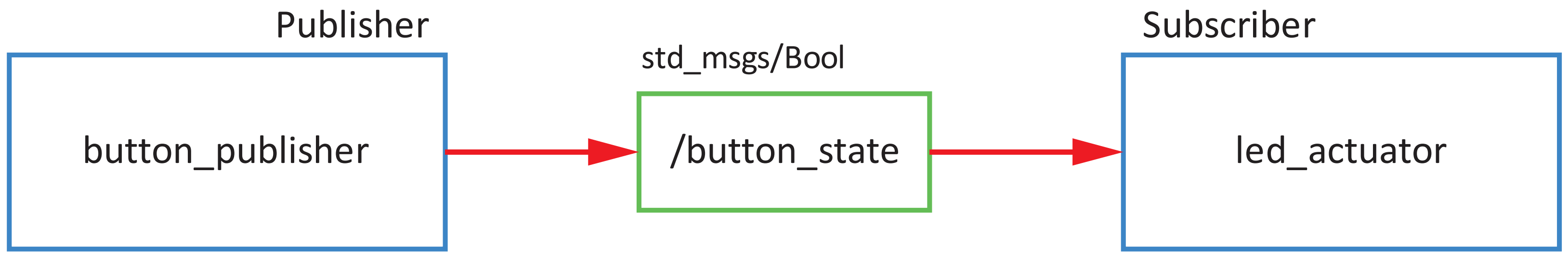
```
sub = rospy.Subscriber('topic_name', msg_type, callback_fcn)
```

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
  - `-r5` ... Pošilja s 5 Hz

Primer

- ob pritisku tipke prižgi LED
- **button_publisher.py**
- **led_actuator.py**



Rpi GPIO

```
import RPi.GPIO as GPIO
```

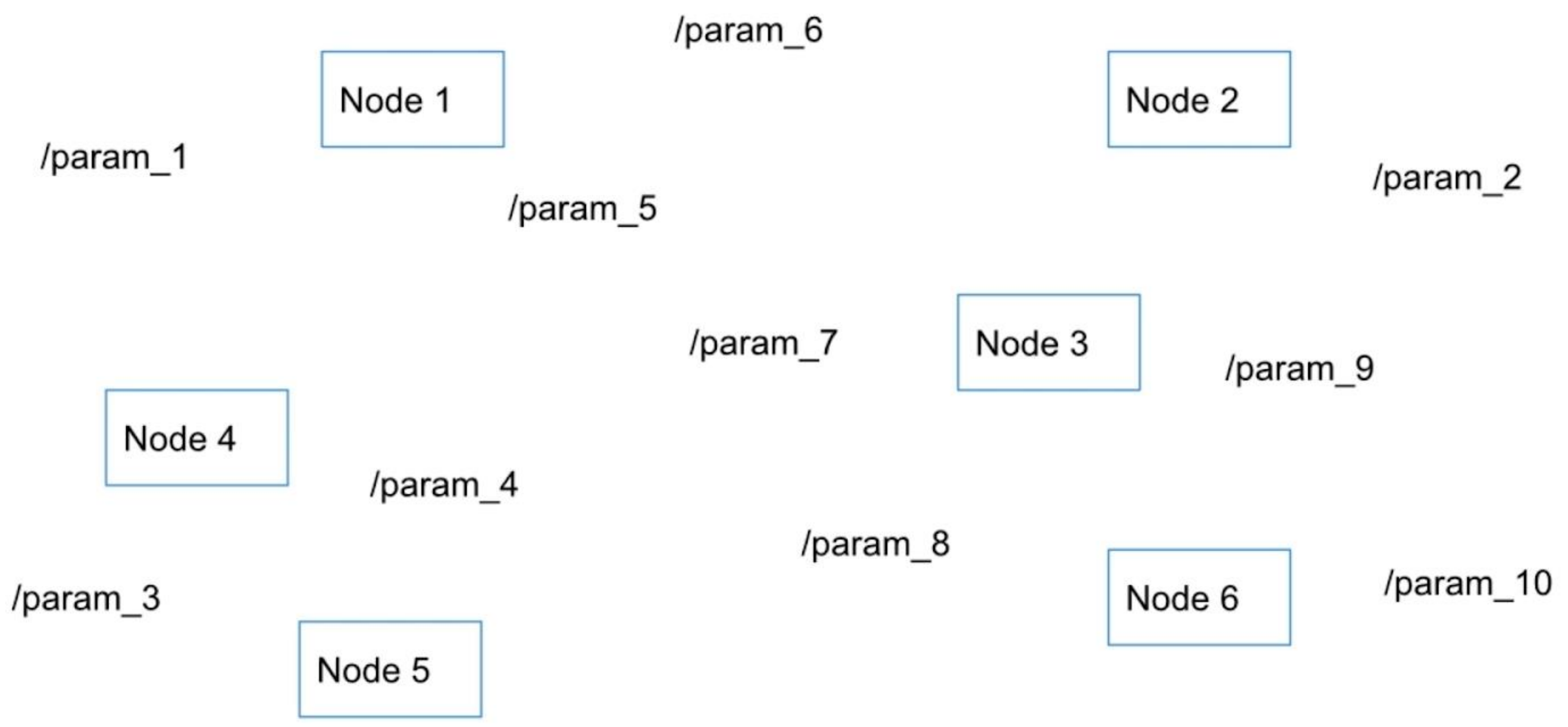
# Green 1 - GPIO 2
# Green 2 - GPIO 3
# Yellow 1 - GPIO 4
# Yellow 2 - GPIO 5
# Red 1 - GPIO 6
# Red 2 - GPIO 7

# Gumb 1 - GPIO 11
# Gumb 2 - GPIO 12

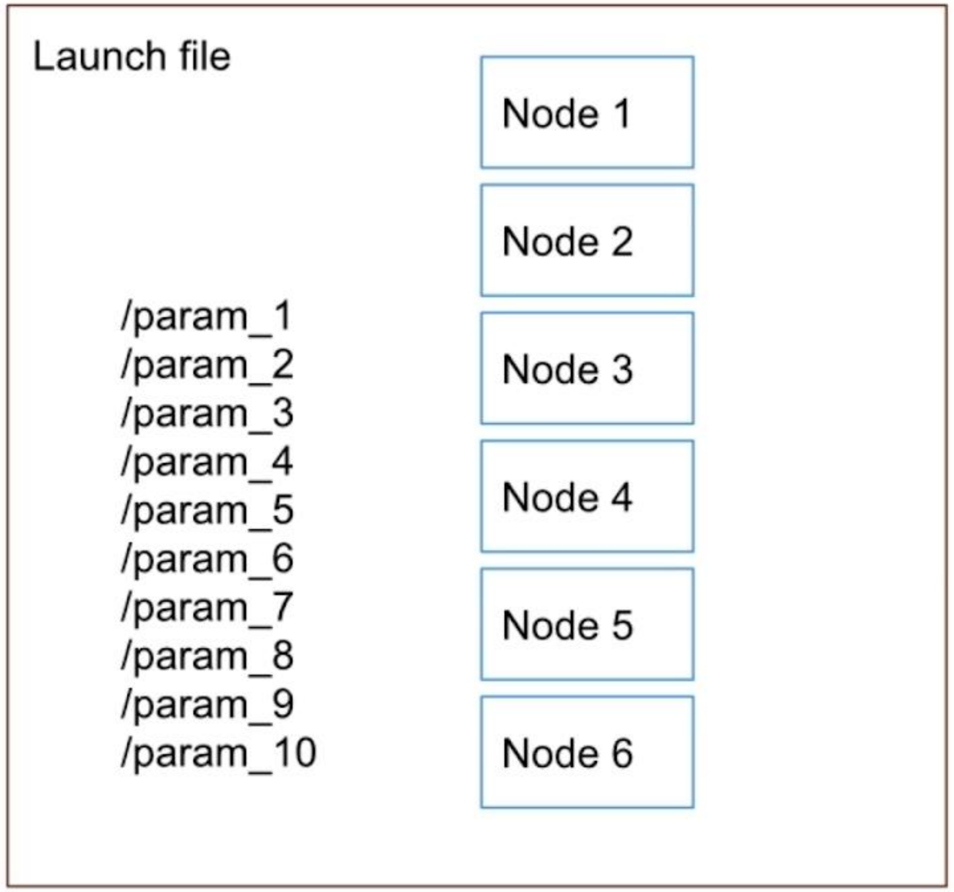
```
def resetLed():
    # nastavi in resetiraj vse LED
    for ii in range(2,8):
        GPIO.setup(ii,GPIO.OUT)
        GPIO.output(ii,False)

GPIO.setmode(GPIO.BCM)
GPIO.setup(BTN_GPIO, GPIO.IN)
btn_state = GPIO.input(BTN_GPIO)
GPIO.cleanup()
```

LAUNCH FILES

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
Node 6
/param_10
/param_3
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

```
$ roscd
$ cd ..
$ cd src
$ catkin_create_pkg rpi_feros_bringup
$ cd ..
$ catkin_make
```

Nov .launch

```
$ roscd rpi_feros_bringup
$ mkdir launch
$ touch rpi_led.launch
```

```
<launch>
   <param name="/ime_parametra" type="tip_spremenljivke" value="vrednost"/>
   <node name="ime" pkg="paket" type="source_file.py" />
   <include file="included.launch">
     <arg name="arg_name" value="arg_val" />
   </include>
</launch>
```

```
$ roslaunch rpi_feros_bringup rpi_led.launch
```

ROS OMREŽJE

ROS OMREŽJE

- en ROS master v celotnem omrežju
- vsi nodi morajo uporabljati isti ROS master (ROS_MASTER_URI)
- popolna dvosmerna povezava med napravami
- vsaka naprava se mora predstaviti z imenom, ki ga ostale naprave prepoznajo

http://wiki.ros.org/ROS/Tutorials/MultipleMachines

http://wiki.ros.org/ROS/NetworkSetup

PING

Ping hostname:

```
$ ping lr-legs
```

Ping IP:

```
$ ping 192.168.65.110
```

TEŽAVE

Remapping:

```
$ sudo nano /etc/hosts
```

Dodate ustrezne pare IP - hostname

```
192.168.65.110      lr-legs
```

TEŽAVE

Ubuntu firewall

```
$ sudo ufw status

$ sudo ufw disable

$ sudo ufw enable
```

ROS_MASTER_URI

Določi, kje je ROS master

- potrebno zagnati v vsaki konzoli

```
$ export ROS_MASTER_URI=http://[ime_master_racunalnika]:11311
```

```
$ export ROS_MASTER_URI=http://lr-legs:11311
```

Preverite nastavitev:

```
$ echo $ROS_MASTER_URI
```

ROS_MASTER_URI

Avtomatska postavitev ROS_MASTER_URI ob odprtju konzole:

```
$ sudo nano ~/.bashrc
```

Doda se vrstico:

```
export ROS_MASTER_URI=http://lr-legs:11311
```

POZOR!

Možne težave, če boste poganjali ROS master na lokalnem računalniku!

TEST

Potrebno preveriti povezave!

Master (publisher) **>>>** ostali (subscriber)

Master (subscriber) **<<<** ostali (publisher)

Publisher:

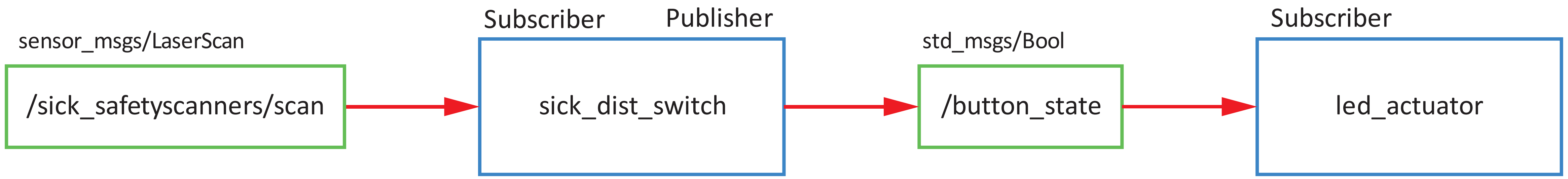
```
$ rostopic pub -r5 /test_connection std_msgs/Bool "data: True"
```

Subscriber:

```
$ rostopic list
$ rostopic echo /test_connection
```

Naloga

- prižgi LED, ko je objekt bližje kot 0,2 m



SICK NanoScan3 – namestitev

```
$ sudo apt-get install ros-noetic-sick-safetyscanners

$ source /opt/ros/noetic/setup.bash
$ cd ~/catkin_ws/src/
$ git clone https://github.com/SICKAG/sick_safetyscanners.git
$ cd ..
$ catkin_make install
$ source ~/catkin_ws/install/setup.bash
```

SICK NanoScan3

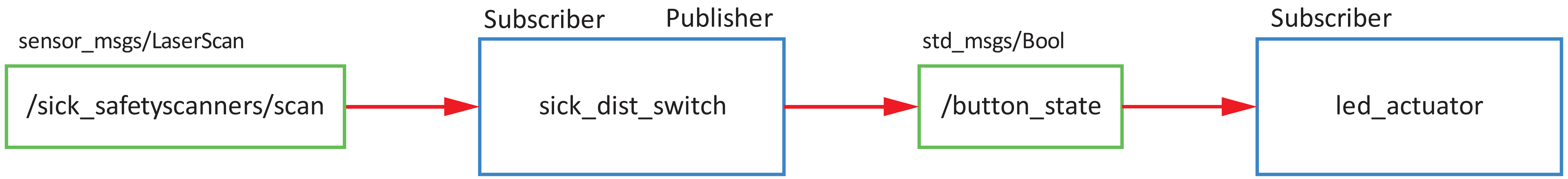
- 1651 meritev
- Korak meritev: 0,002909 rad (0,1667°)
- Kot skeniranja: 275°

- Topic: `/sick_safetyscanners/scan`
- Msg: `from sensor_msgs.msg import LaserScan`

```
$ roslaunch sick_safetyscanners sick_safetyscanners.launch
sensor_ip:=192.168.65.YYY host_ip:=192.168.65.XX
```

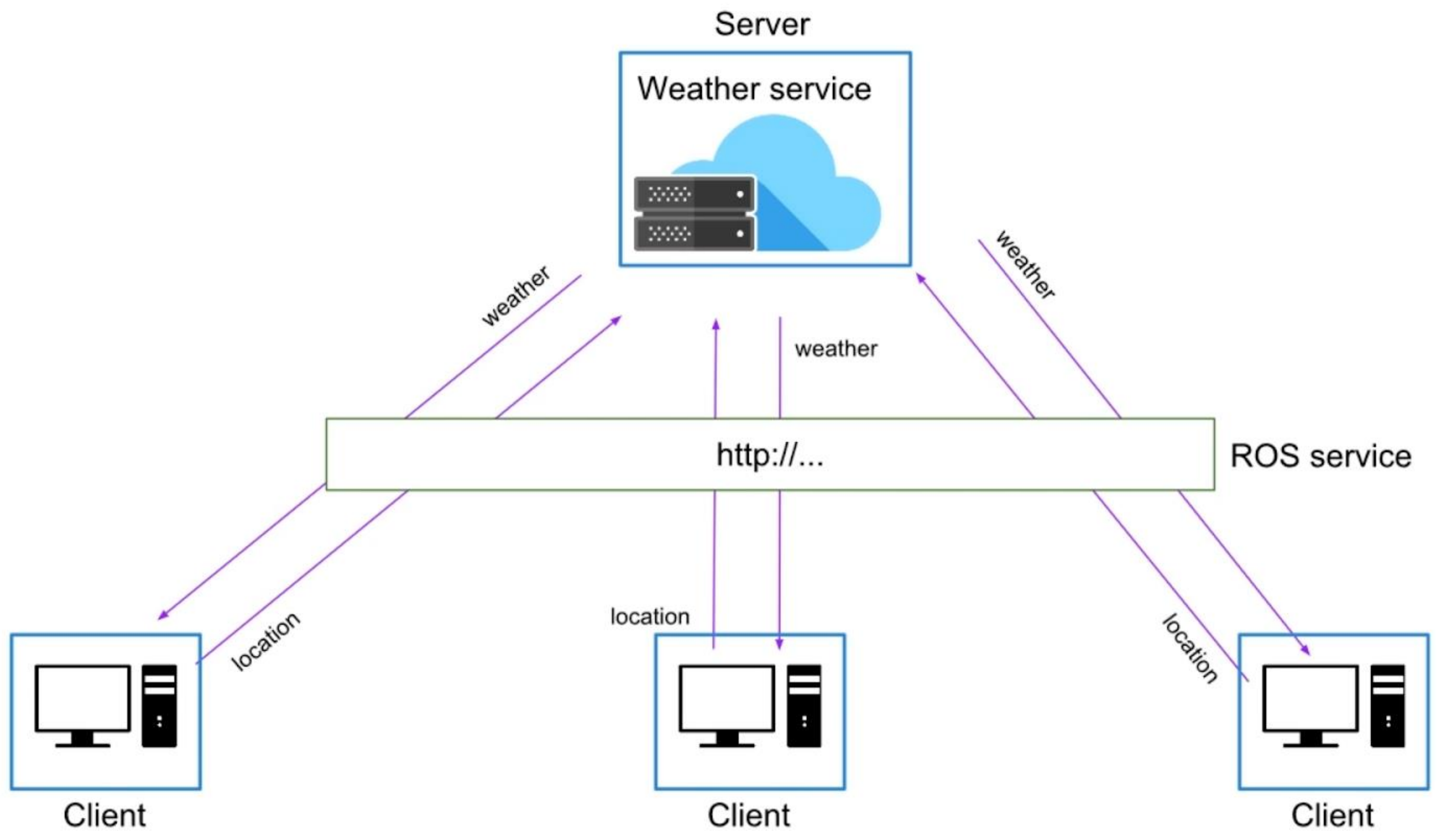
Naloga

- prižgi LED, ko je objekt bližje kot 0,2 m

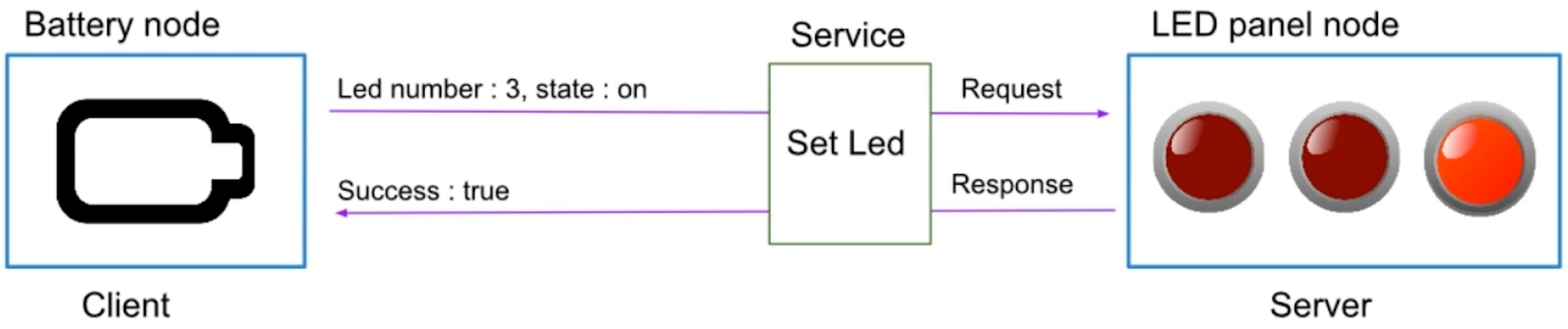


SERVICES

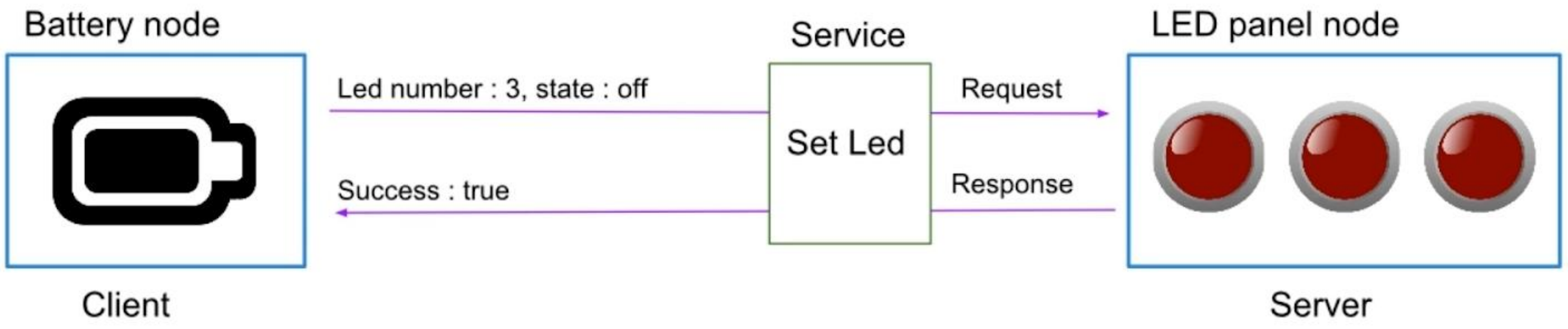
Services


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

Services


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

Services


Battery node
Led number : 3, state : off
Success : true
Client
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

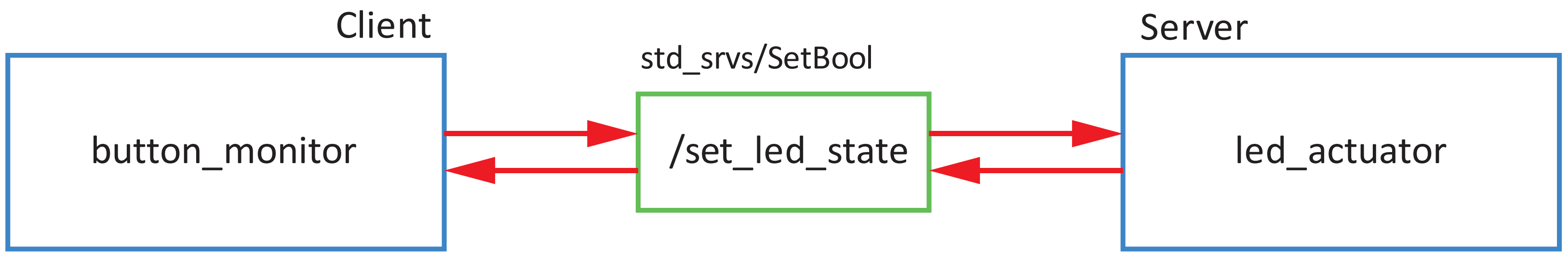
```
rospy.wait_for_service('ime_service')

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

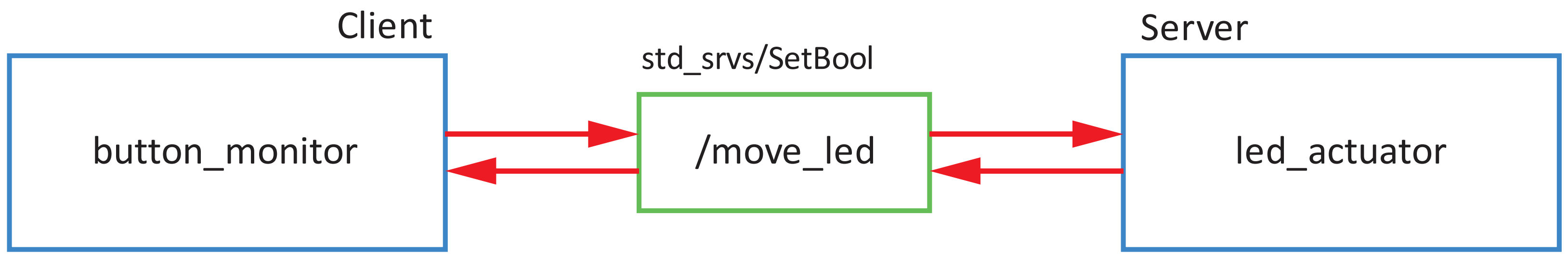
- prižgi/ugasni LED ob pritisku tipke (prekinitve)
- **led_service_server.py**
- **button_service_client.py**



```
GPIO.add_event_detect(BTN_GPIO, GPIO.RISING, callback=btn_cbk, bouncetime=500)
```

Naloga

- s tipkami premikajte prižgano LED levo/desno



MSG & SRV

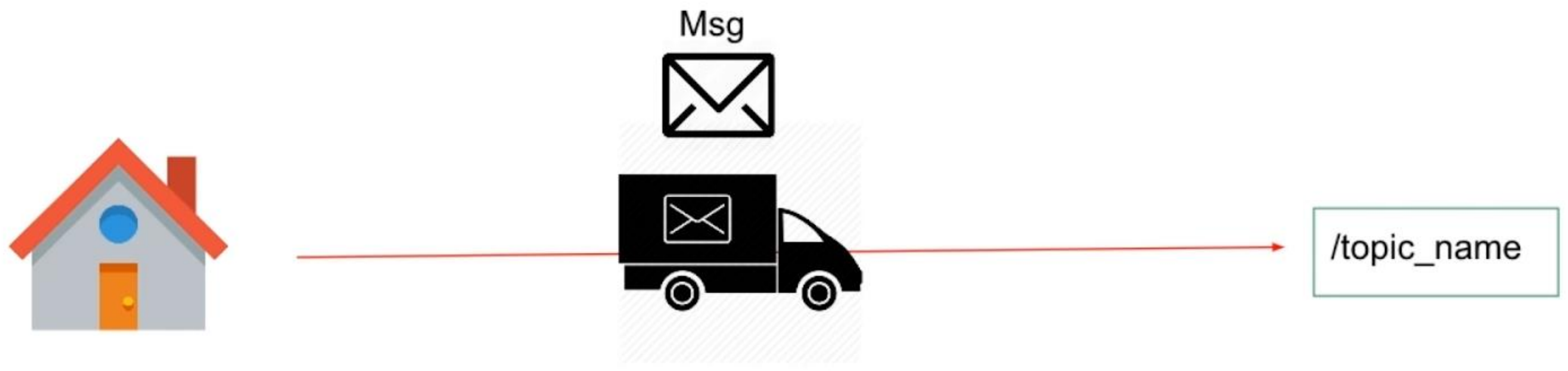
MSG in SRV

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

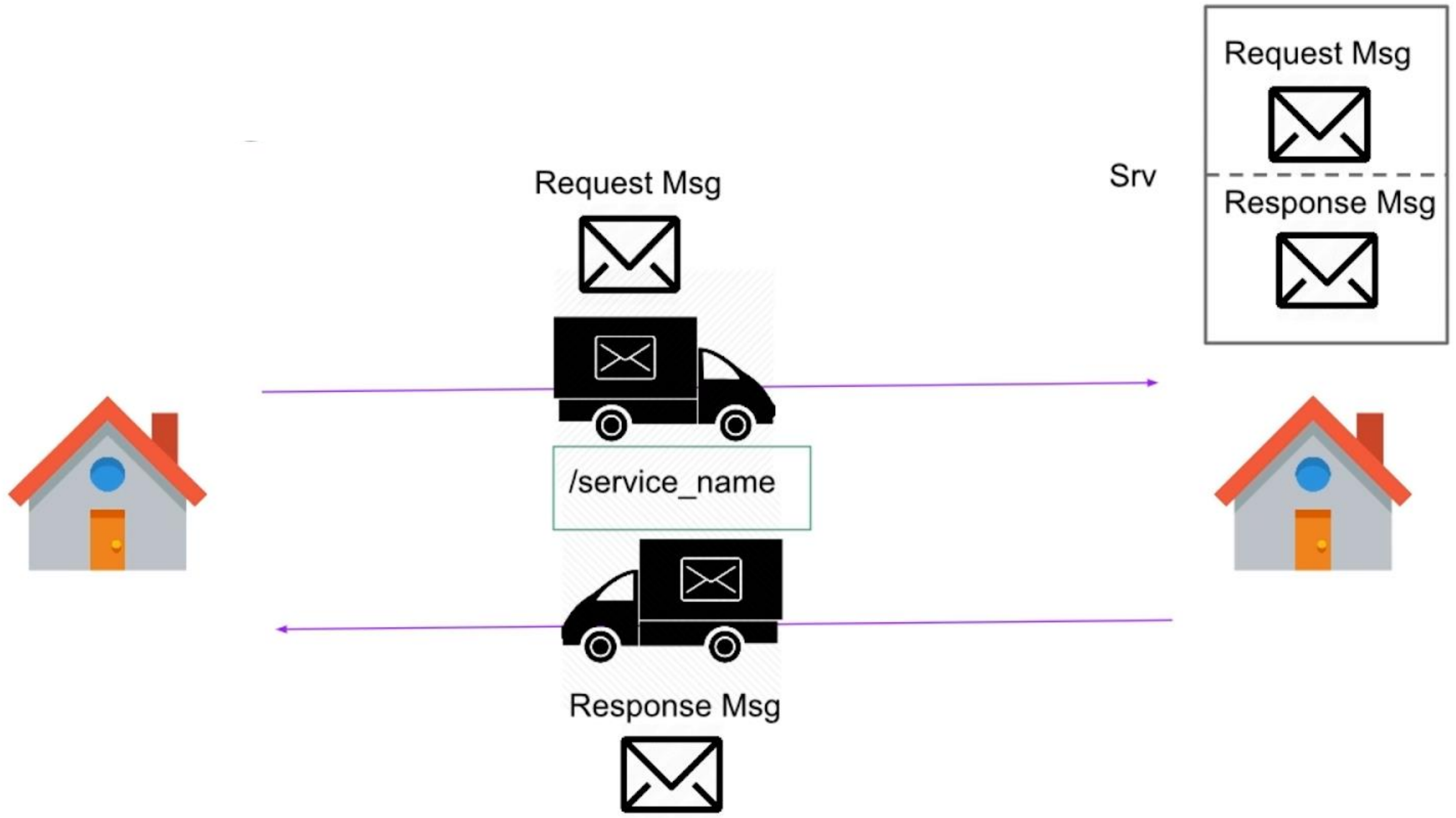
- Service:
  - Ime: `/set_led_state`
  - Definicija sporočila SRV: `std_srvs/SetBool`
    - Request: MSG
    - Response: MSG

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

MSG



SRV


Request Msg
Srv
Request Msg
Response 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 rpi_msgs rospy std_msgs
```

package.xml (rpi_msgs)

```
<build_depend>message_generation</build_depend>

<exec_depend>message_runtime</exec_depend>
```

CMakeLists.txt (rpi_msgs)

```
find_package(catkin REQUIRED COMPONENTS

  rospy
  std_msgs
  message_generation

)

…

# Generate messages in the 'msg' folder

add_message_files(

  FILES
  IME_SPOROCILA.msg

)
```

CMakeLists.txt (rpi_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
```

Nov MSG (rpi_msgs)

```
$ roscd rpi_msgs
$ mkdir /msg
$ touch ledStatus.msg
$ code ledStatus.msg
```

```
int64 ledNumber
string ledStatus
```

```
$ catkin_make
```

Uporaba

package.html (rpi_feros)

```
<depend>my_robot_msgs</depend>
```

CMakeLists.txt (rpi_feros)

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

Nov SRV (rpi_msgs)

```
$ roscd rpi_msgs
$ mkdir /srv
$ touch safetyZone.srv
$ code safetyZone.srv
```

```
int16 zone
---
bool success
string message
```

```
$ catkin_make
```

Uporaba

- CMakeLists.txt (rpi_feros)

```
# Generate services in the 'srv' folder
add_service_files(
  FILES
  safetyZone.srv
)
```

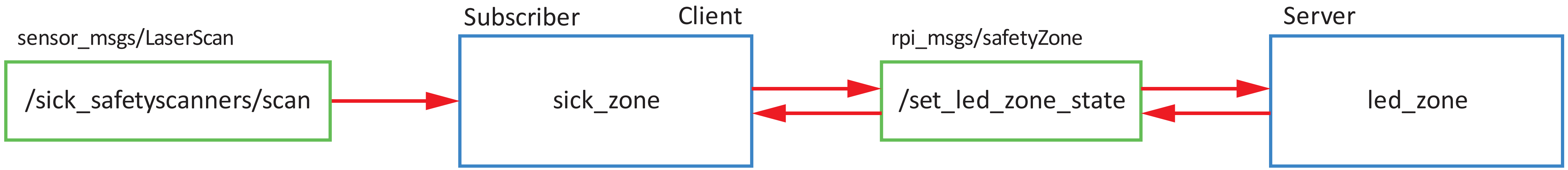
DEBUG MSG/SRV

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

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

Naloga

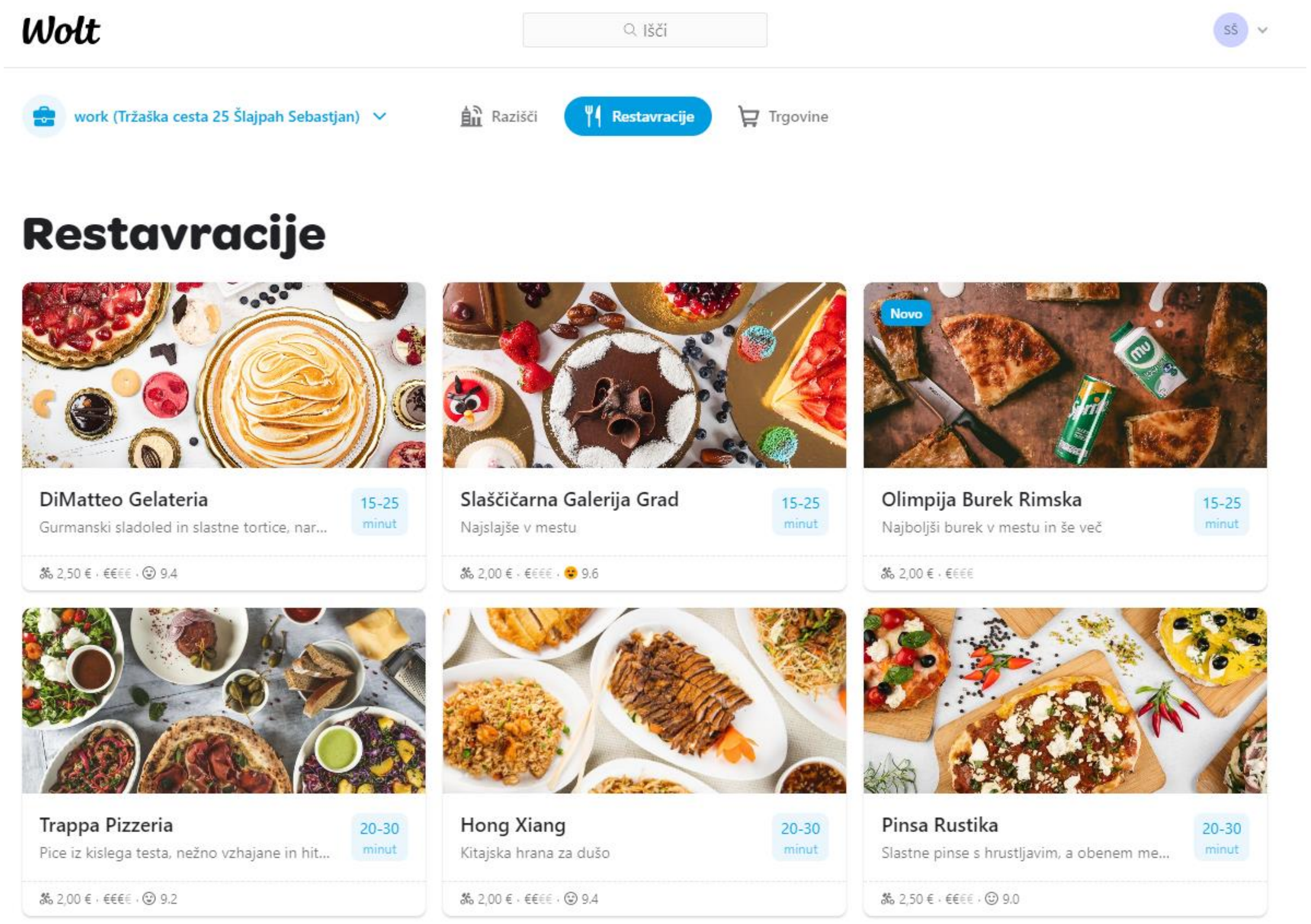
- prižgi LED glede na razdaljo *d*:
  - Zelena: *d* > 0,4 m
  - Rumena: 0,4 m > *d* > 0,2 m
  - Rdeča: *d* < 0,2 m



FEROS

ACTIONS

Actions


Wolt

Išči

SŠ

work (Tržaška cesta 25 Šlajpah Sebastjan)

Razišči Restavracije Trgovine

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

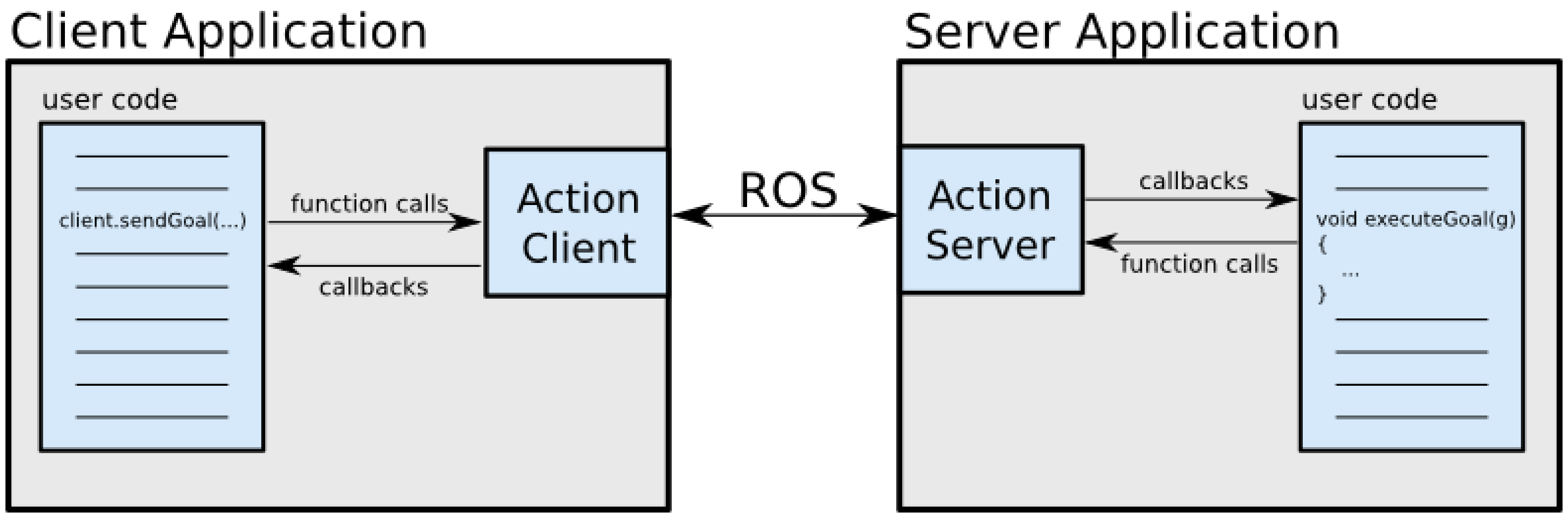
Novo
Olimpija Burek Rimska
Najboljši burek v mestu in še več
15-25 minut
2,00 € · €€€€

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

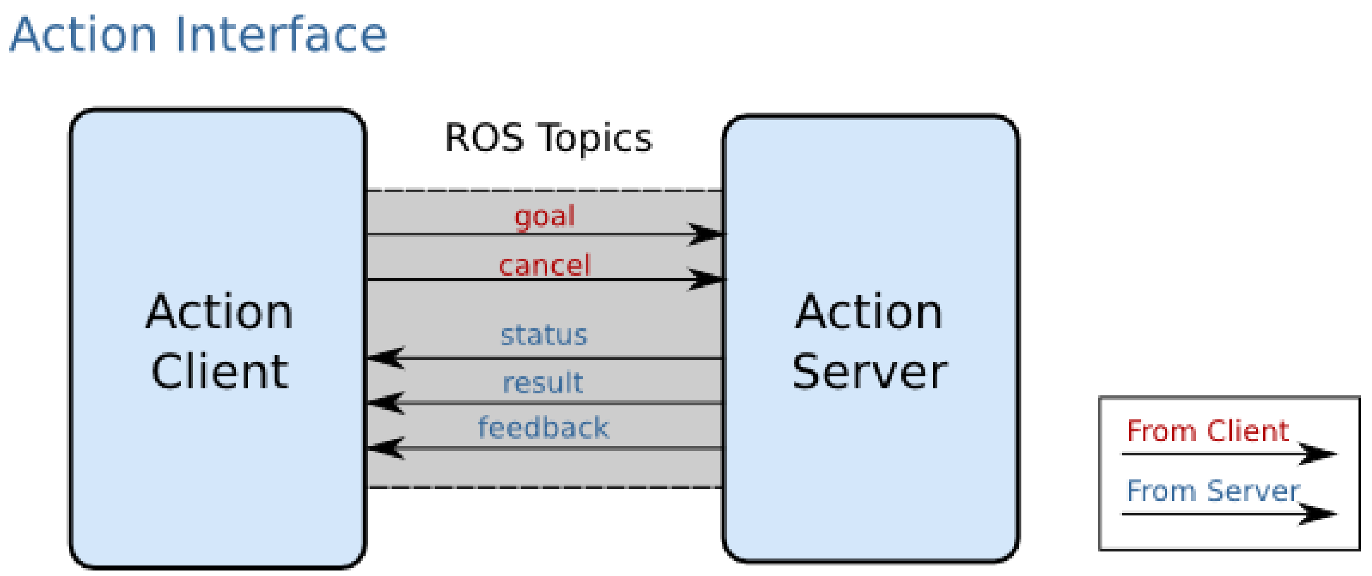
Pinsa Rustika
Slastne pinse s hrustljavim, a obenem me...
20-30 minut
2,50 € · €€€€ · 9.0

Actions



Client Application
user code
client.sendGoal(...)
function calls
callbacks
Action Client
ROS
Action Server
callbacks
function calls
Server Application
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?

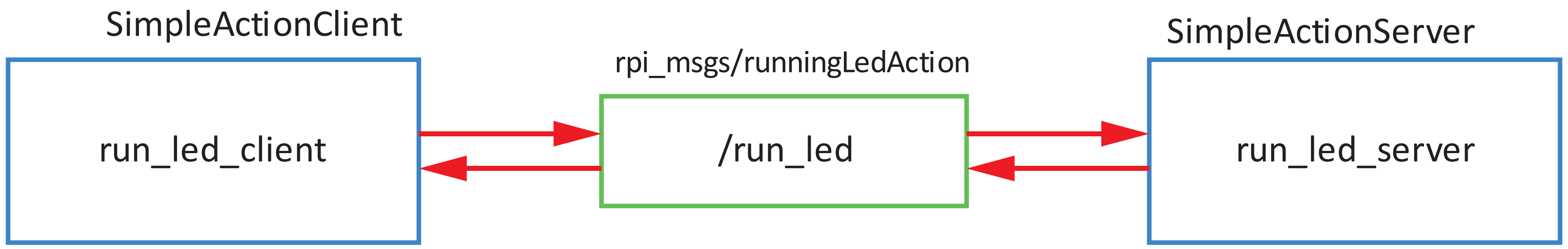
```
$ rostopic list
```

Struktura: namespace (`as_name`)

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

Primer

- n-kratno izvajanje sekvenčnega prižiganja LED
- **ledrun_client.py**
- **ledrun_server.py**



MSG .action (rpi_msgs)

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

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

CMakeLists.txt

```
find_package(
        actionlib_msgs
)


add_action_files(
        FILES
        NAME.action
)
```

```
generate_messages(
        DEPENDENCIES
        actionlib_msgs
)


catkin_package(
        CATKIN_DEPENDS rospy
)
```

package.xml

```
<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 rpi_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)
    GPIO.setmode(GPIO.BCM)

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

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 rpi_msgs.msg import runningLedAction, runningLedGoal

client = None

def run_led_client(goalNum):
    pass

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

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

SimpleActionClient

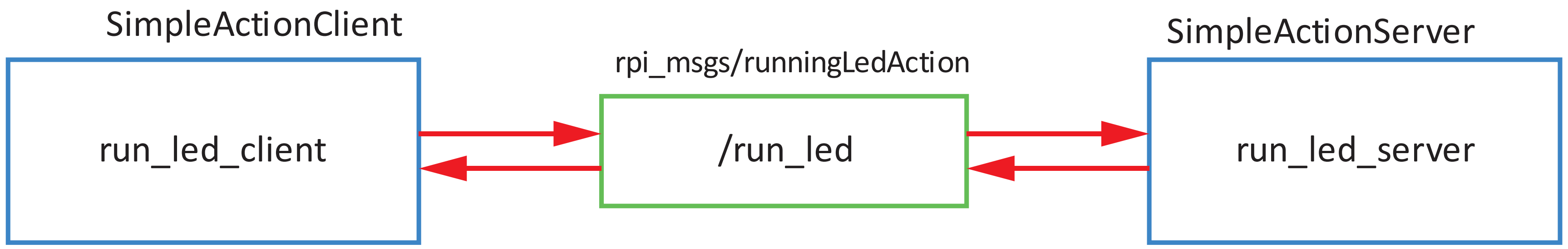
```
def run_led_client(goalNum):
    global client
    client = actionlib.SimpleActionClient('run_led', runningLedAction)
    client.wait_for_server()    # Waits until the action server has started up and started
                                  listening for goals.
    goal = runningLedGoal()     #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

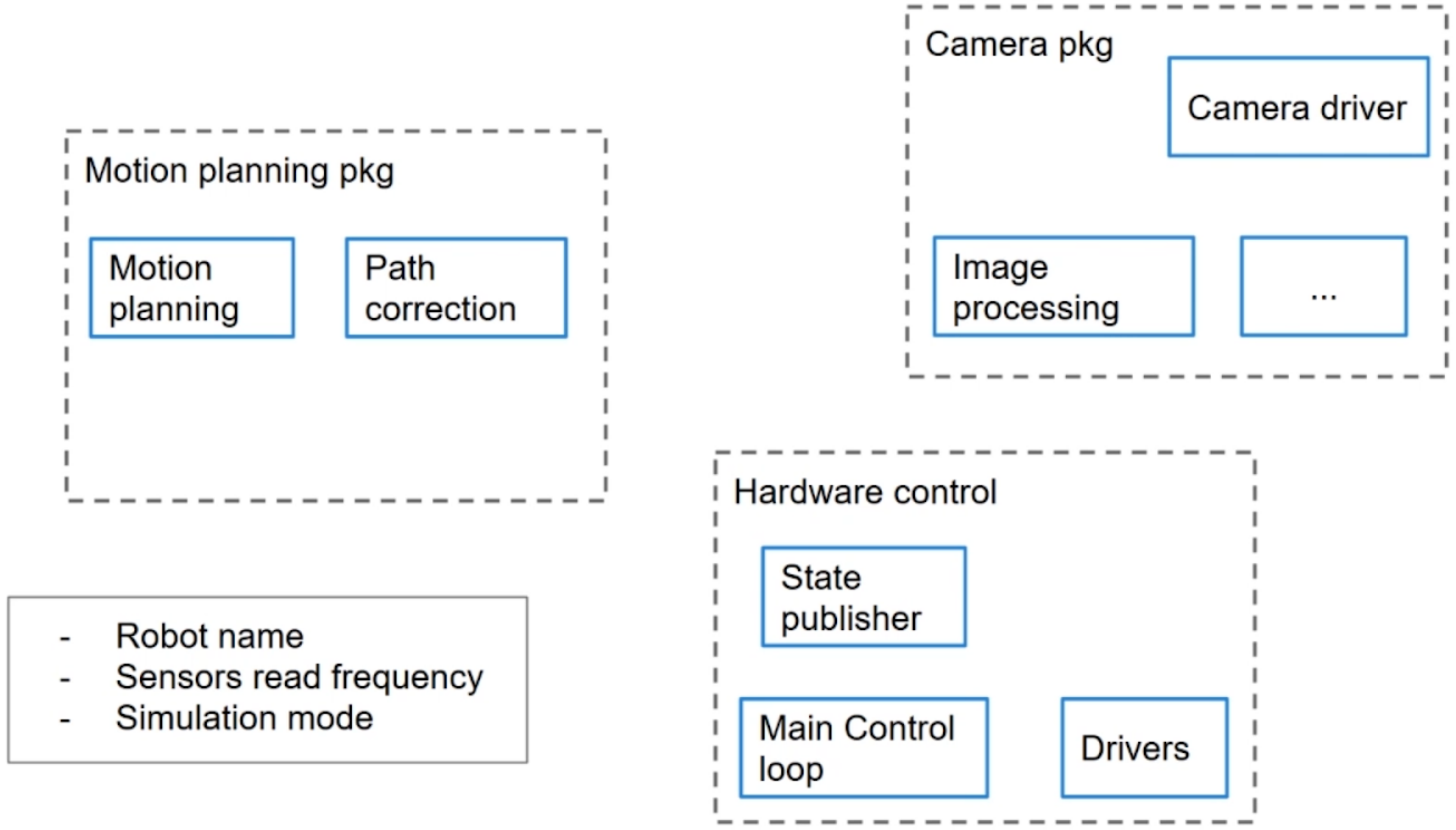
Naloga

- n-kratno izvajanje sekvenčnega prižiganja LED
- **ustavi prižiganje LED, če je objekt bližje kot 20 cm.**

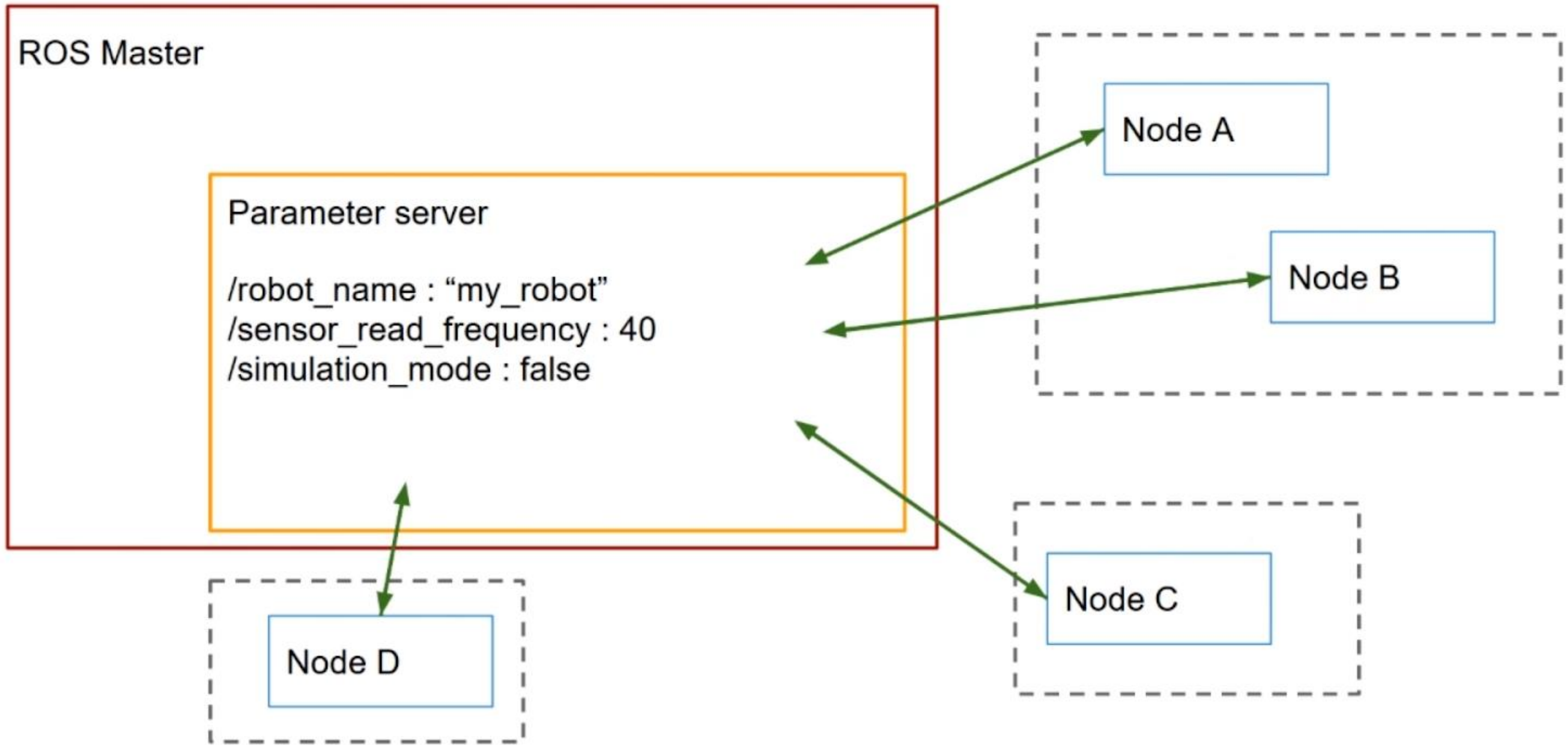


PARAMETERS

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
```

Naloga

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

- Naredite `.launch` datoteko za Action Server