F1/10
Autonomous Racing

ROS services
roslaunch

Madhur Behl

CS 4501
Spring 2020
Rice Hall 120

AUTONOMOUS TURTLE

Assignment 1
F1/10 Autonomous Racing – CS 4501– Spring 2020
Due Tue, 18th February, at 3:30pm, before the lecture

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In this assignment, you will create an ~~self driving~~ ~~self swimming~~ autonomous turtle using the ROS turtlesim simulator.

The goal of the assignment is to understand:

- ROS nodes
- ROS topics
- ROS messages
- ROS parameters and services
- ROS launch files

And get familiar with:

- ROS workspace
- The catkin build system
- Creating your own ROS nodes.

To get started:

- Git pull to obtain the the autoturtle ROS package from https://github.com/linklab-uva/f1tenth-course-labs
- Link (or copy) the autoturtle package to the catkin workspace
  - ln -s ~/github/f1tenth-course-labs/autoturtle/ ~/catkin_ws/src/
  - Run catkin_make in the catkin_ws folder. Source your environment.
- The node turtlesim_move.py has been provided for reference.
- Make sure you are able to run the provided node successfully before attempting the remaining assignment:

```
rosrun autoturtle turtlesim_move.py
```

[should move the turtle towards the x direction until it hits the wall]

Problem 1: Turtle Swim School

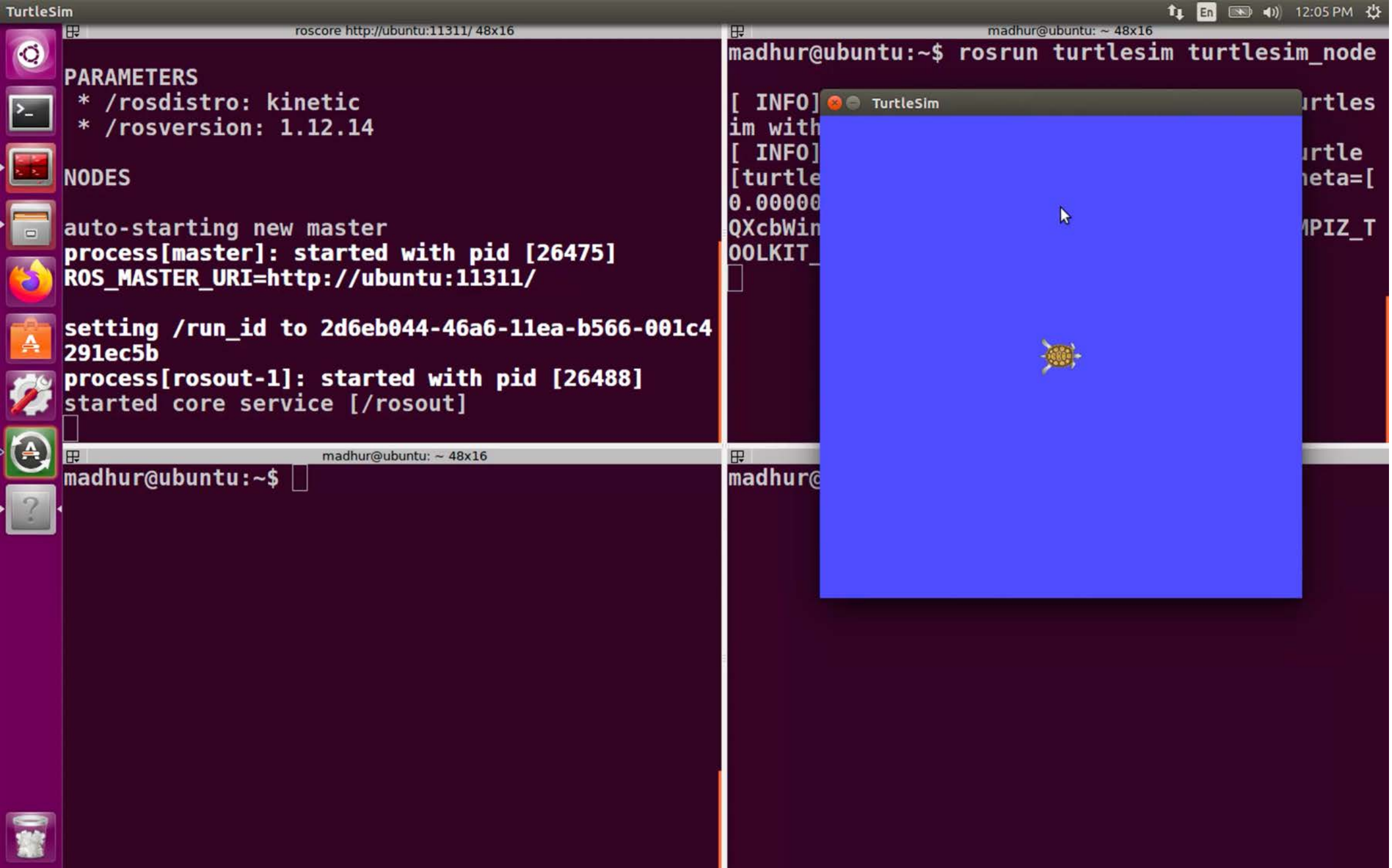
Problem 1a: swim_school.py

[20 points]

1. Using the turtlesim_move.py as reference, create a new ROS node called swim_school.py
2. Modify the code to demo the following:

[1a demo:] Upon running the command rosrun autoturtle swim_school.py

- User can input a linear (x) velocity
- User can input an angular (z) velocity
- The turtle then swims in a figure 8 shape, using the velocity and angular rate specified by the user.


TurtleSim
12:05 PM
roscore http://ubuntu:11311/ 48x16
PARAMETERS
* /rosdistro: kinetic
* /rosversion: 1.12.14
NODES
auto-starting new master
process[master]: started with pid [26475]
ROS_MASTER_URI=http://ubuntu:11311/
setting /run_id to 2d6eb044-46a6-11ea-b566-001c4
291ec5b
process[rosout-1]: started with pid [26488]
started core service [/rosout]
madhur@ubuntu: ~ 48x16
madhur@ubuntu:~$ rosrun turtlesim turtlesim_node
TurtleSim
madhur@ubuntu: ~ 48x16
madhur@ubuntu:~$

Problem 1b

[20 points]

random_swim_school.py

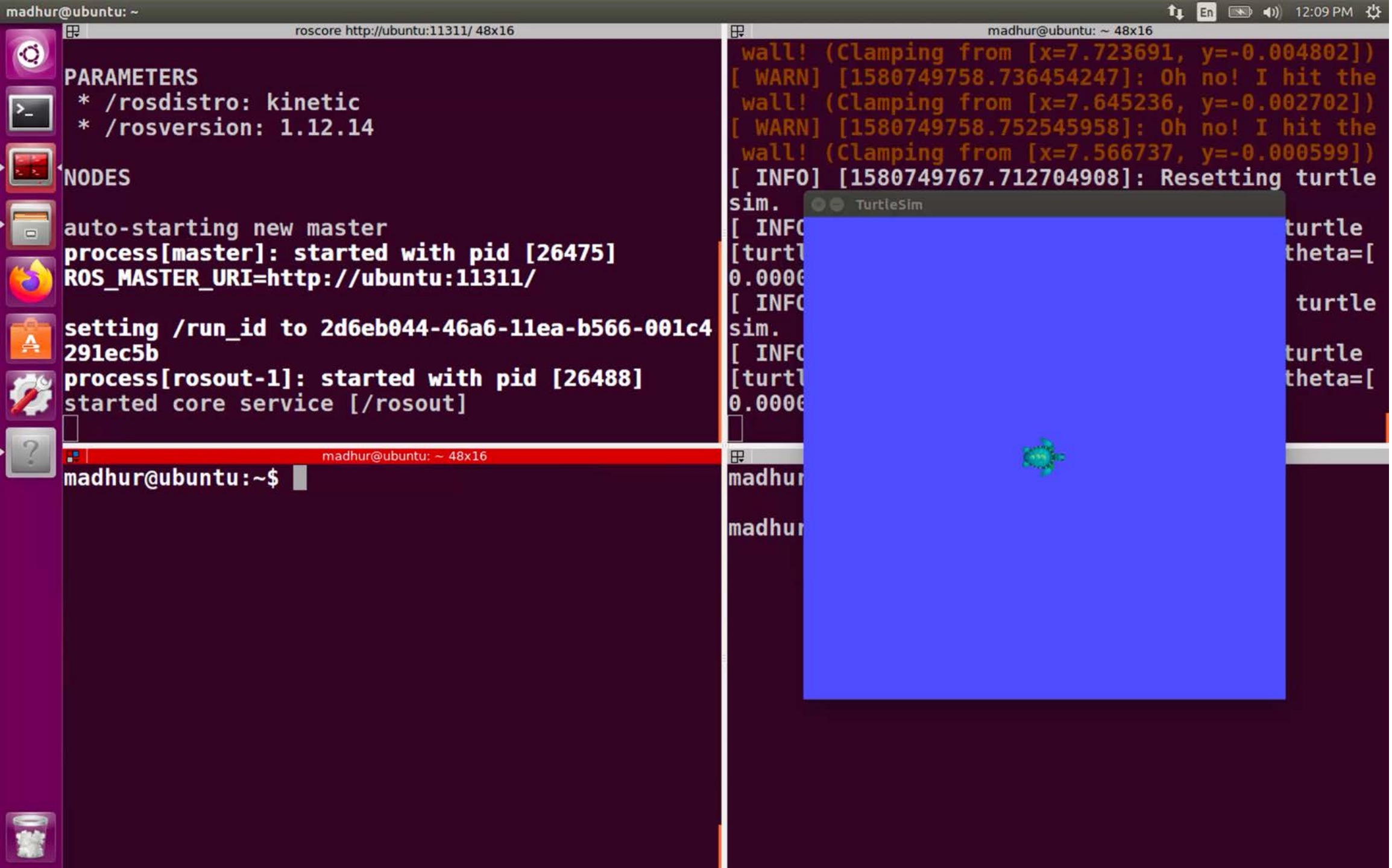
1. Create a new ROS node random_swim_school.py

[1b demo:]

Upon running the command rosrun autoturtle random_swim_school.py

- A random figure 8 is drawn in the ocean:
  - Turtle moves with a random linear velocity and a random angular velocity which is chosen every time the node is run.
  - The figure 8 is drawn at a random position during each run. Its fine if the figure 8 hits the turtlesim boundary.

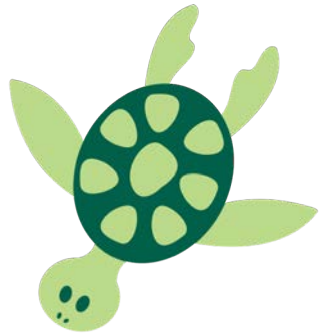
- The center position (x,y) of the random figure 8 is displayed on the terminal.


madhur@ubuntu: ~
12:09 PM
roscore http://ubuntu:11311/ 48x16
PARAMETERS
* /rosdistro: kinetic
* /rosversion: 1.12.14
NODES
auto-starting new master
process[master]: started with pid [26475]
ROS_MASTER_URI=http://ubuntu:11311/
setting /run_id to 2d6eb044-46a6-11ea-b566-001c4
291ec5b
process[rosout-1]: started with pid [26488]
started core service [/rosout]
madhur@ubuntu: ~ 48x16
madhur@ubuntu:~$
madhur@ubuntu: ~ 48x16
wall! (Clamping from [x=7.723691, y=-0.004802])
[WARN] [1580749758.736454247]: Oh no! I hit the
wall! (Clamping from [x=7.645236, y=-0.002702])
[WARN] [1580749758.752545958]: Oh no! I hit the
wall! (Clamping from [x=7.566737, y=-0.000599])
[INFO] [1580749767.712704908]: Resetting turtle
sim.
TurtleSim

Problem 1c: back_to_square_one.py

[30 points]

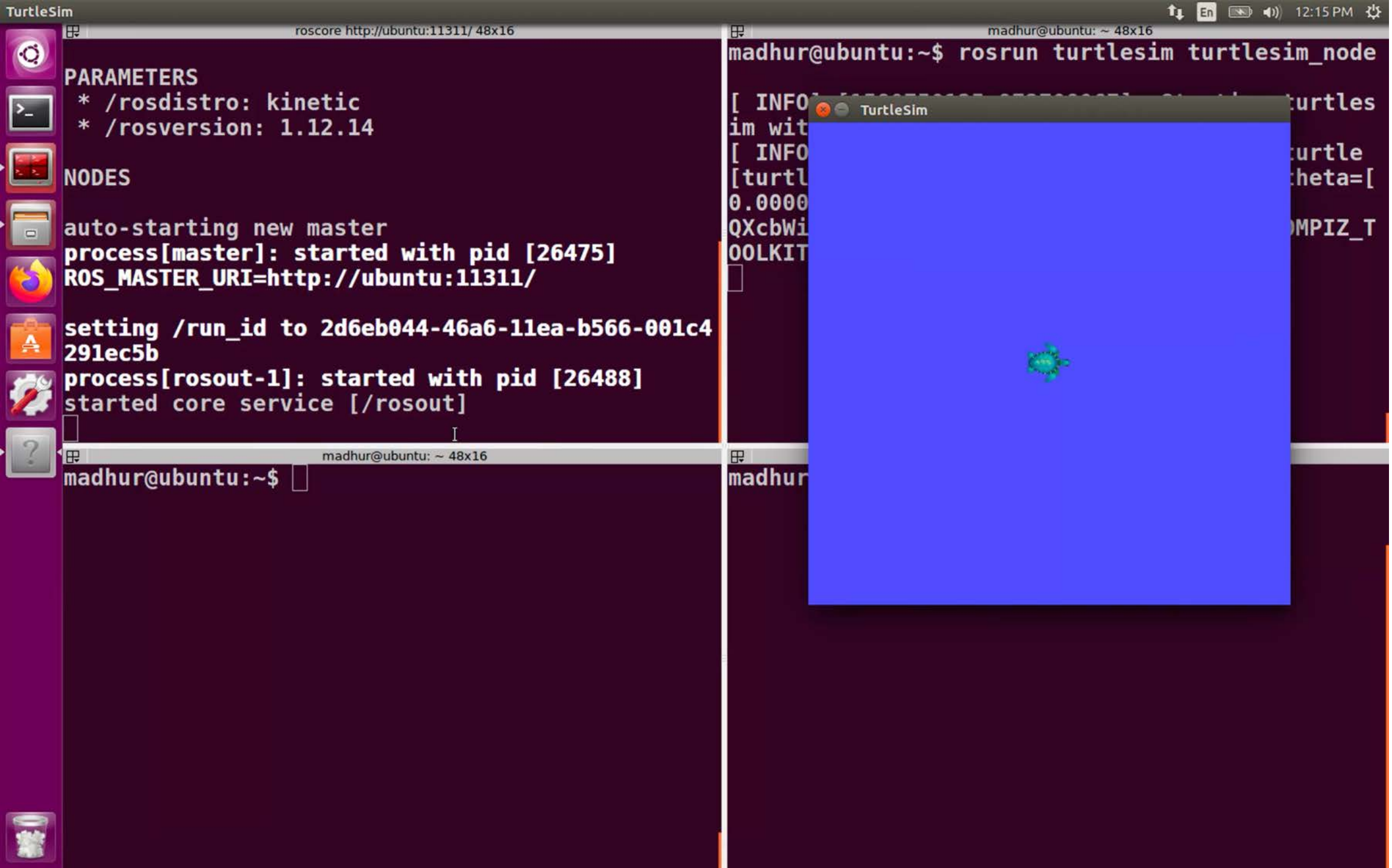
1. Using the turtlesim_move.py as reference, create a new ROS node called back_to_square_one.py
2. Modify the code to demo the following:



1b demo: Upon running the command

rosrun autoturtle back_to_square_one.py

- User inputs the length of the side of the square (number between 1 and 5, any number including floating points is allowed.)
- The ocean turns **red**
- A square is drawn with the length of the side of the square equal to the user input.
  - Note the square must be drawn as the turtle swims…do not use teleport absolute to draw the square.
- The bottom left corner of the square is always at (x,y) = (1,1), theta could be anything you want.


TurtleSim
12:15 PM
roscore http://ubuntu:11311/ 48x16
PARAMETERS
* /rosdistro: kinetic
* /rosversion: 1.12.14
NODES
auto-starting new master
process[master]: started with pid [26475]
ROS_MASTER_URI=http://ubuntu:11311/
setting /run_id to 2d6eb044-46a6-11ea-b566-001c4
291ec5b
process[rosout-1]: started with pid [26488]
started core service [/rosout]
madhur@ubuntu: ~ 48x16
madhur@ubuntu:~$
madhur@ubuntu: ~ 48x16
madhur@ubuntu:~$ rosrun turtlesim turtlesim_node
TurtleSim

Problem 2: Swim to goal

[30 points]

Problem 2: swim_to_goal.py

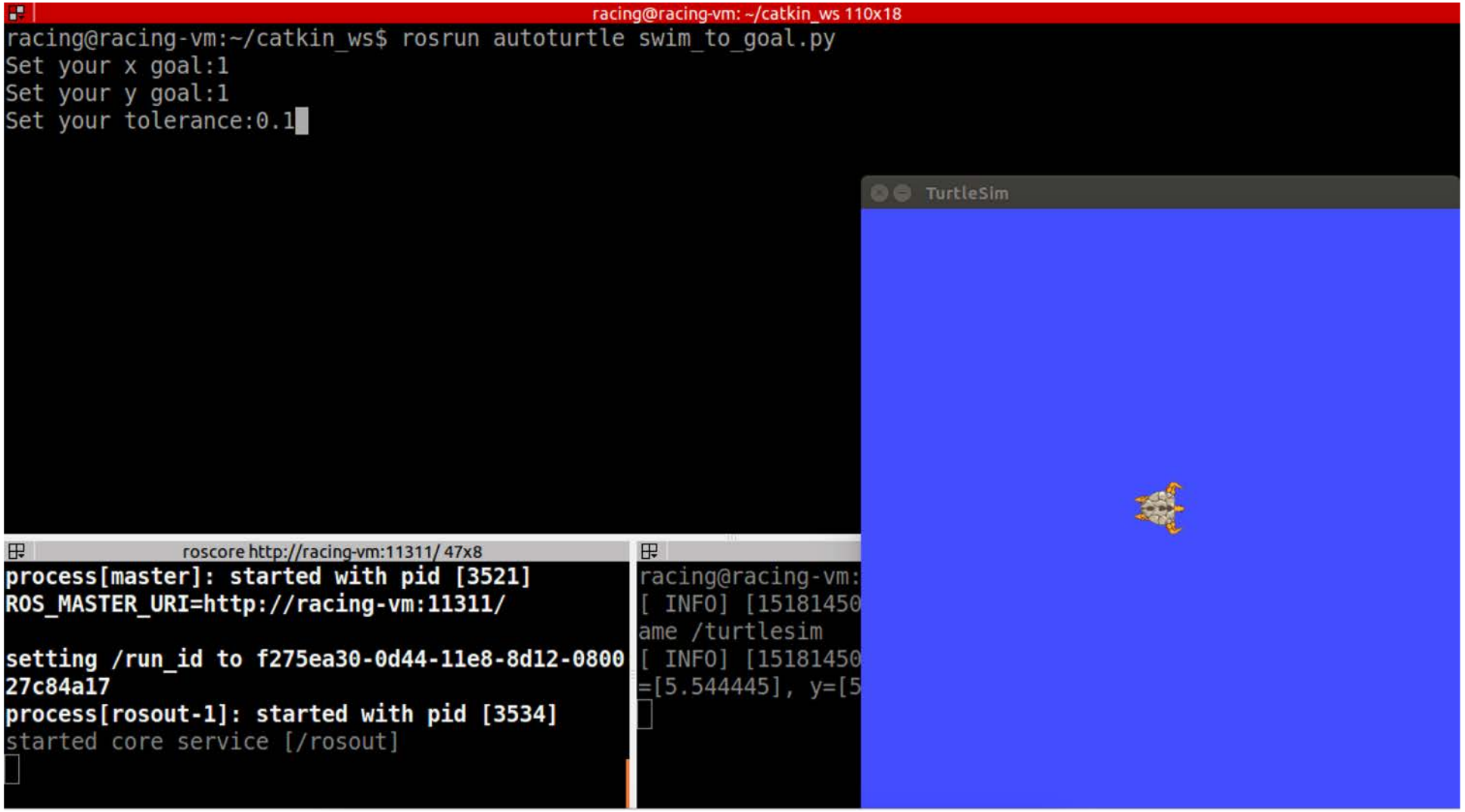
1. Create a new ROS node called swim_to_goal.py

Demo the following:

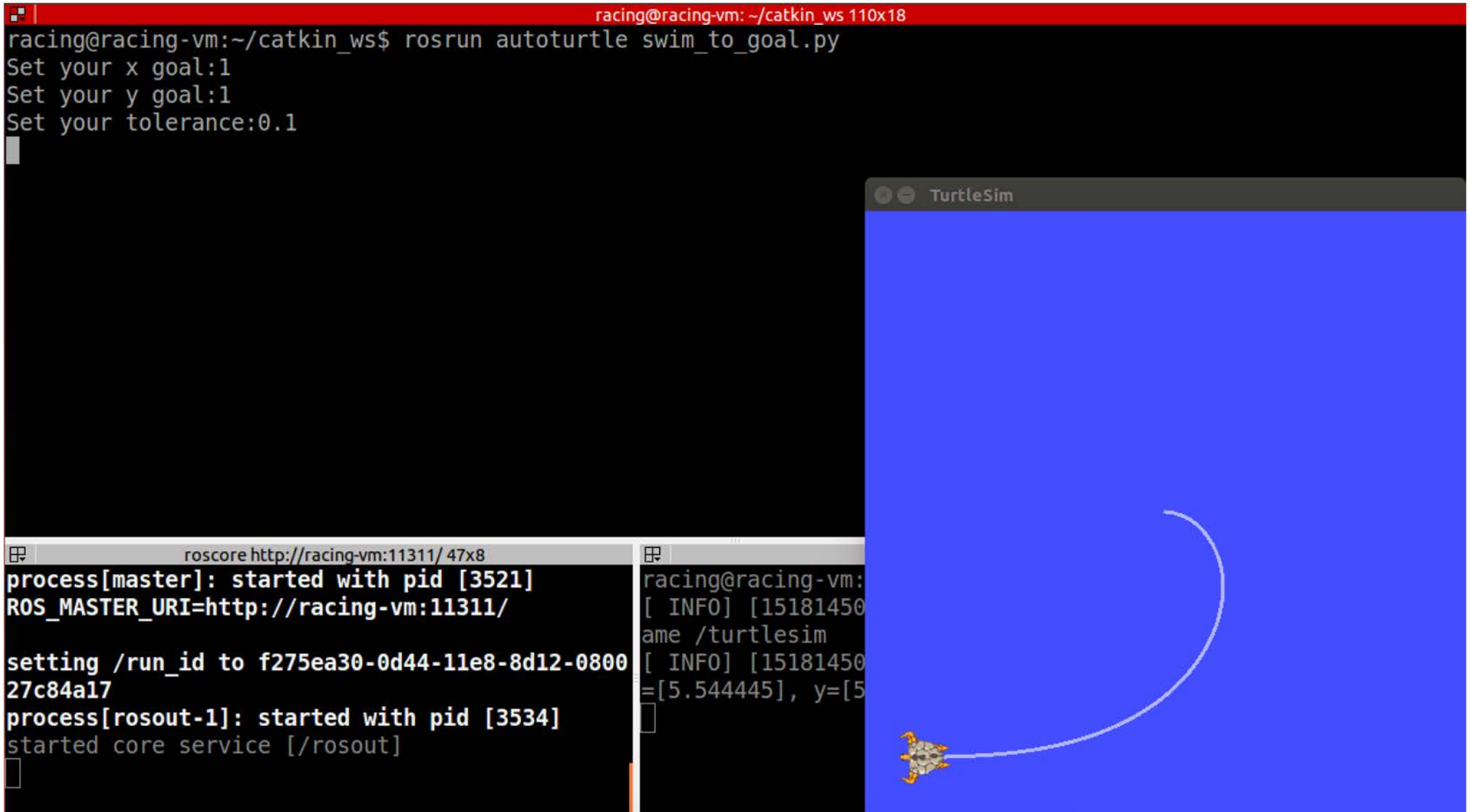
- User inputs the x coordinate for the goal: (e.g. 1)
- User inputs the y coordinate for the goal: (e.g. 1)
- User inputs a ‘tolerance’ value (defined in subsequent slides): (e.g. 0.1)
- The turtle swims (not teleports) to the goal with a velocity and angular rate, proportional to the distance between the current position and the goal.
- Display and explain the rqt_graph for this system

Problem 2: What should node execution look like ?

User enters x, y, goal, and a tolerance value.



Problem 2: What should the output look like ?



Problem 2: **swim_to_goal.py** - Hints

What does proportional velocity and angular command mean ?

Proportional speed and turning:

Velocity x = **1.5 *** (Euclidean distance between position at any time and the goal)

Angular z = **4 *** (atan2 (Euclidean distance between position at any time and the goal))

The 1.5 and 4 are constants but the velocity and angular rate will change as the turtle moves towards the goal, since the distance between the position of the turtle and the goal is always decreasing. **You can use 1.5 and 4 as the constants in your code**.

Tolerance is a constant which dictates how close does the turtle needs to be to the (x,y) goal before it is considered that it has reached the goal.

The tolerance is needed since the pose messages that turtlesim echoes is usually a floating point value.

A good value for the tolerance is between 0.1 and 1.

A useful command in python to use for dealing with pose data is:

round(number[, ndigits])

Useful declarations for this problem are:

```
import rospy
from geometry_msgs.msg  import Twist
from turtlesim.msg import Pose
from math import pow, atan2,sqrt
```

You will demo your code in the lab, but in addition to that you need to submit all your code by the assignment deadline.

What do I have to submit ?

- All the ROS nodes you create should be inside the /autoturtle/scripts directory. (The same as the turtlesim_move.py script).
- Compress the entire /autoturtle folder.
- **Rename the compressed file to <your_computing_ID>.zip and submit on Collab.**
  - **Only submit a single zip file.**
- Ensure, the code you are submitting does not throw any errors during a catkin_make.

- We will un-compress your submitted folder inside the `src` folder of our catkin workspace and run `catkin_make`.

- We will then test your code with the following commands:
  - rosrun autoturtle swim_school.py
  - rosrun autoturtle random_swim_school.py
  - rosrun autoturtle back_to_square_one.py
  - rosrun autoturtle swim_to_goal.py

Extra Credit >> Upto 40 points

There are 4 problems:

For each problem, you can earn 10 points for Extra Credit, if you can create and use a launch file to demonstrate that problem (i.e. you create the appropriate node, but use a launch file for each problem to launch the relevant nodes for that problem).

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ROS Client Libraries

Client Library	Language	Comments
roscpp	C++	Most widely used, high performance
rospy	Python	Good for rapid-prototyping and non-critical-path code
roslisp	LISP	Used for planning libraries
rosjava	Java	Android support
roslua	Lua	Light-weight scripting
roscs	Mono/.Net	Any Mono/.Net language
roseus	EusLisp	
PhaROS	Pharo Smalltalk	
rosR	R	Statistical programming

Experimental

Client API Commonly Used Features

Object / Feature	Description	roscpp	rospy
API root	Objects and methods for interacting with ROS	ros::NodeHandle	rospy
Parameter server client	Query and set parameter server dictionary entries	.getParam .param .searchParam .setParam	.get_param .search_param .set_param
Subscriber	Receive messages from a topic	.subscribe	.Subscriber
Publisher	Send messages to a topic	.advertise	.Publisher
Service	Serve and call remote procedures	.advertiseService .serviceClient	.Service .ServiceProxy
Timer	Periodic interrupt	.createTimer	.Timer
Logging	Output strings to rosconsole	ROS_DEBUG, ROS_INFO, ROS_WARN, etc.	.logdebug, .loginfo, .logwarn, .logerr, .logfatal
Initialization & Event Loop	Set node name, contact Master, enter main event loop	ros::init .spin	.init_node .spin
Messages	Create and extract data from ROS messages	Specifics depends on message	
		std_msgs::String	std_msgs.msg.String

Build and run

- To build your code do:

```
$ cd ~/catkin_ws
$ catkin_make
```

- To run it execute these three lines in three different terminals:

```
$ roscore
-----------------------------------------
$ rosrun beginner_tutorials talker.py
-----------------------------------------
$ rosrun beginner_tutorials listener.py
```

- To see the publis/subscriber connection do:

```
$ rosru rqt_graph rqt_graph
```

ROS Computational Graph / Communication:

ROS Services

- **Publish / subscribe, many-to-many, unidirectional topic model works well for most use cases**
- **Request / reply model is better for some use cases**
  - **Equivalent to a remote procedure call (RPC)**
  - **Request: client node sends a providing node a command and/or data**
  - **Reply: providing node sends data back to the client node**
  - **Example – set a camera's calibration matrix, receive confirmation of success**
- **Services: ROS implementation of the request / reply model**
  - **Services are named**
    - **Providing node advertises the service by name**
    - **Client node calls the service by name**
    - **Master performs name registration**
  - **Type defined in *.srv* files**
    - **Similar to *.msg* files, but include the both the request and response type**
  - **Should reply quickly / do not block (service call can not be preempted)**
  - **Limitations: not logged, difficult to inspect**
  - **Tend to be used infrequently**

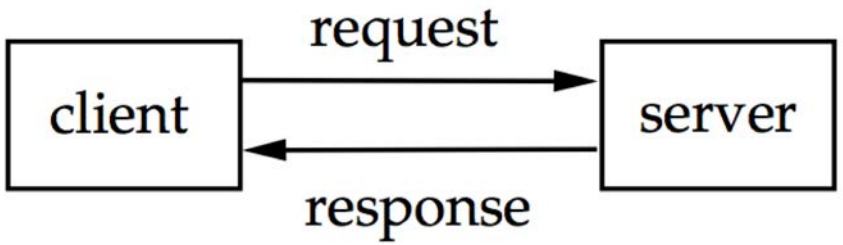
ROS Services: enable request/response communication between nodes.

- Service descriptions are stored in *.srv* files in the *srv/* subdirectory of a package.

- When you publish topics, you are sending data in a many-to-many fashion, but when you need a request or an answer from a node, you can't do it with topics.

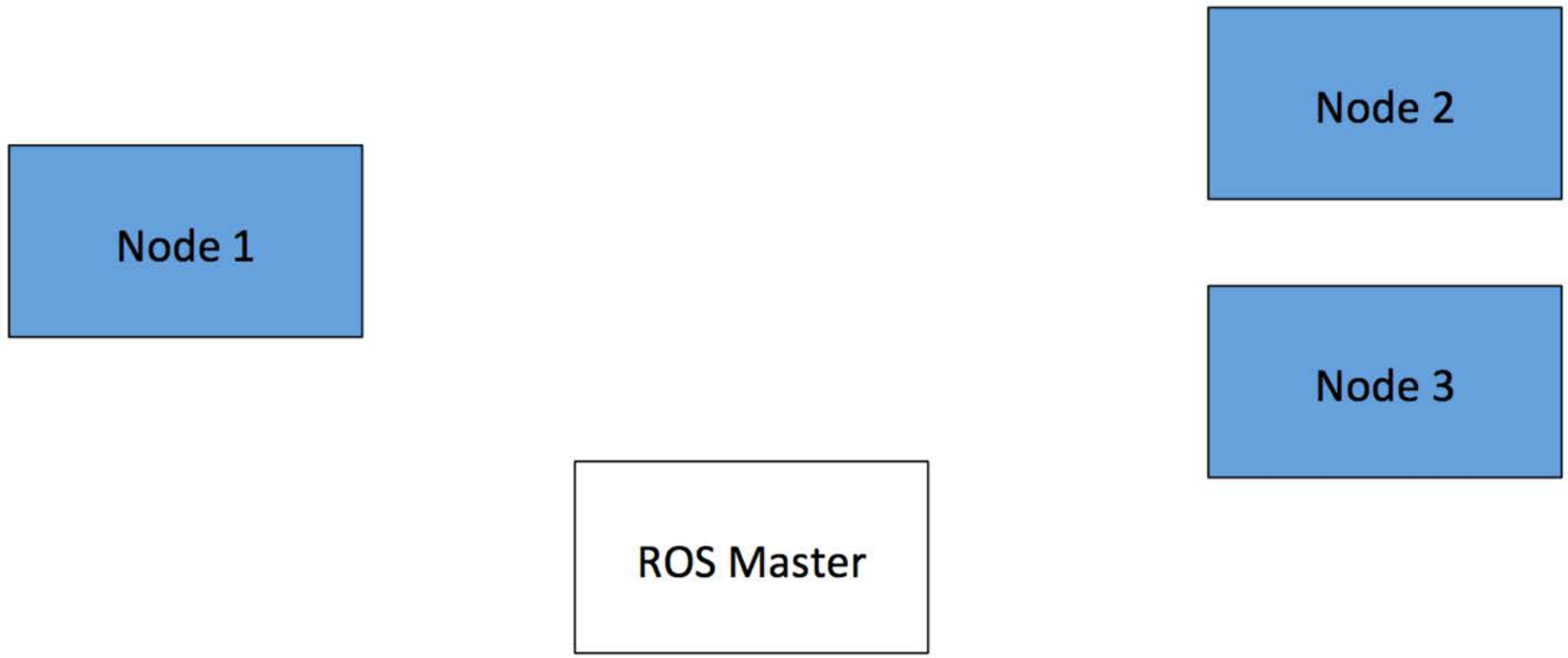
Service calls are **bi-directional**.

One node sends information to another node and waits for a response.



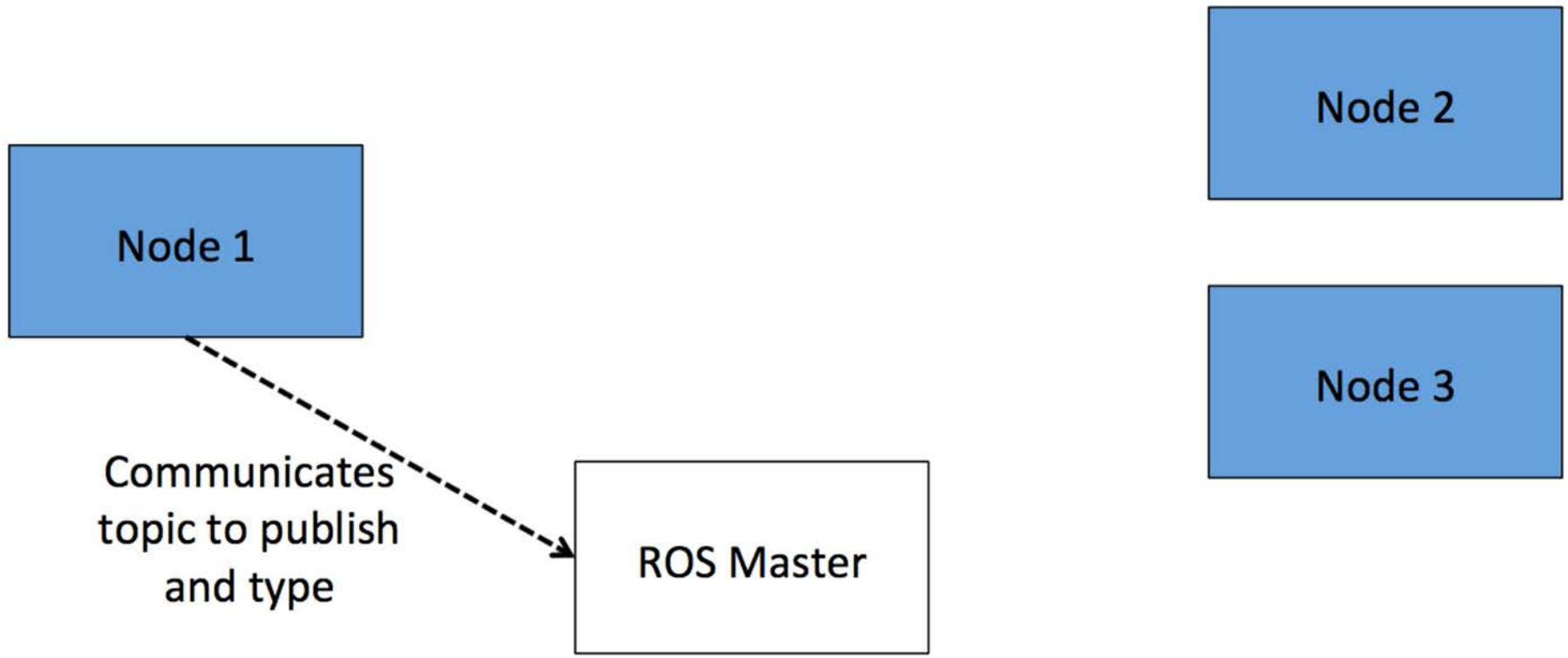
In contrast, when a message is published, there is no concept of a response, and not even any guarantee that anyone is subscribing to those messages.

Communications: Publish/Subscribe



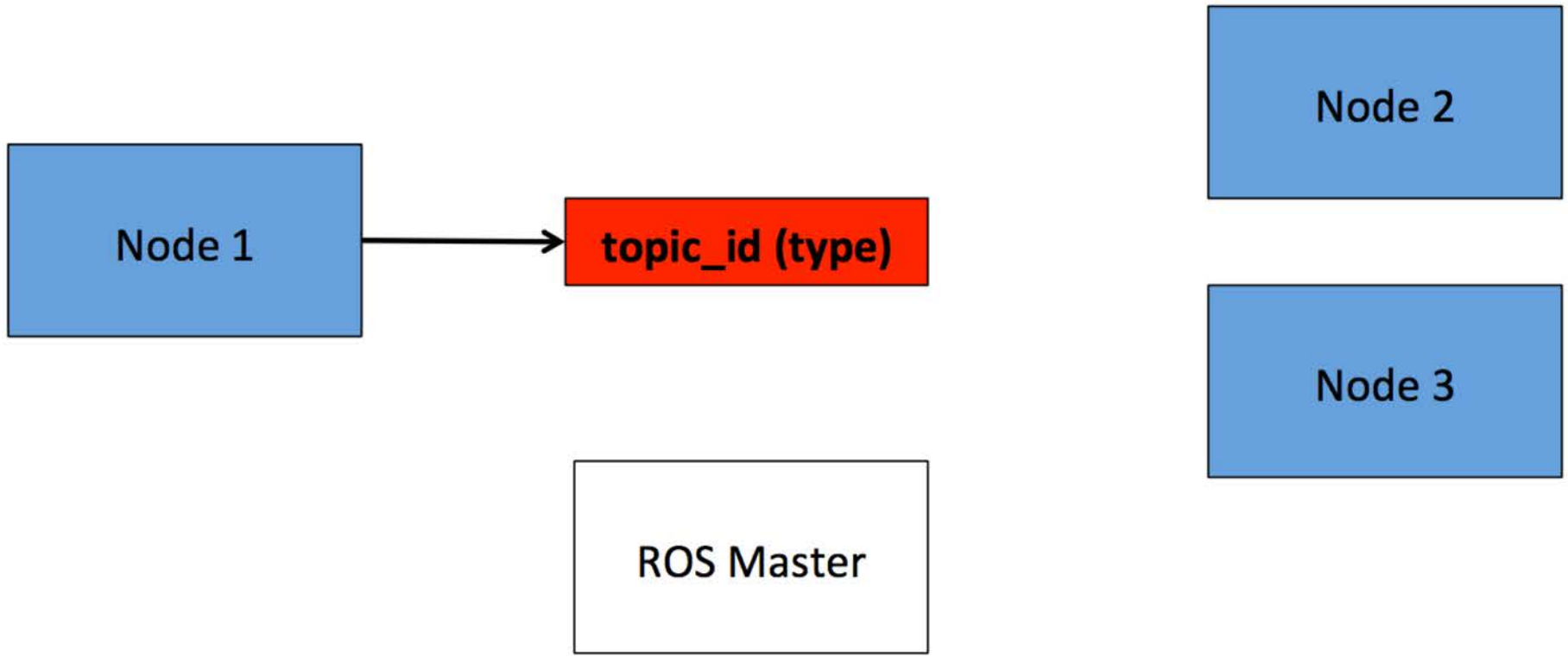
Asynchronous, many-to-many and one-way transport.

Communications: Publish/Subscribe



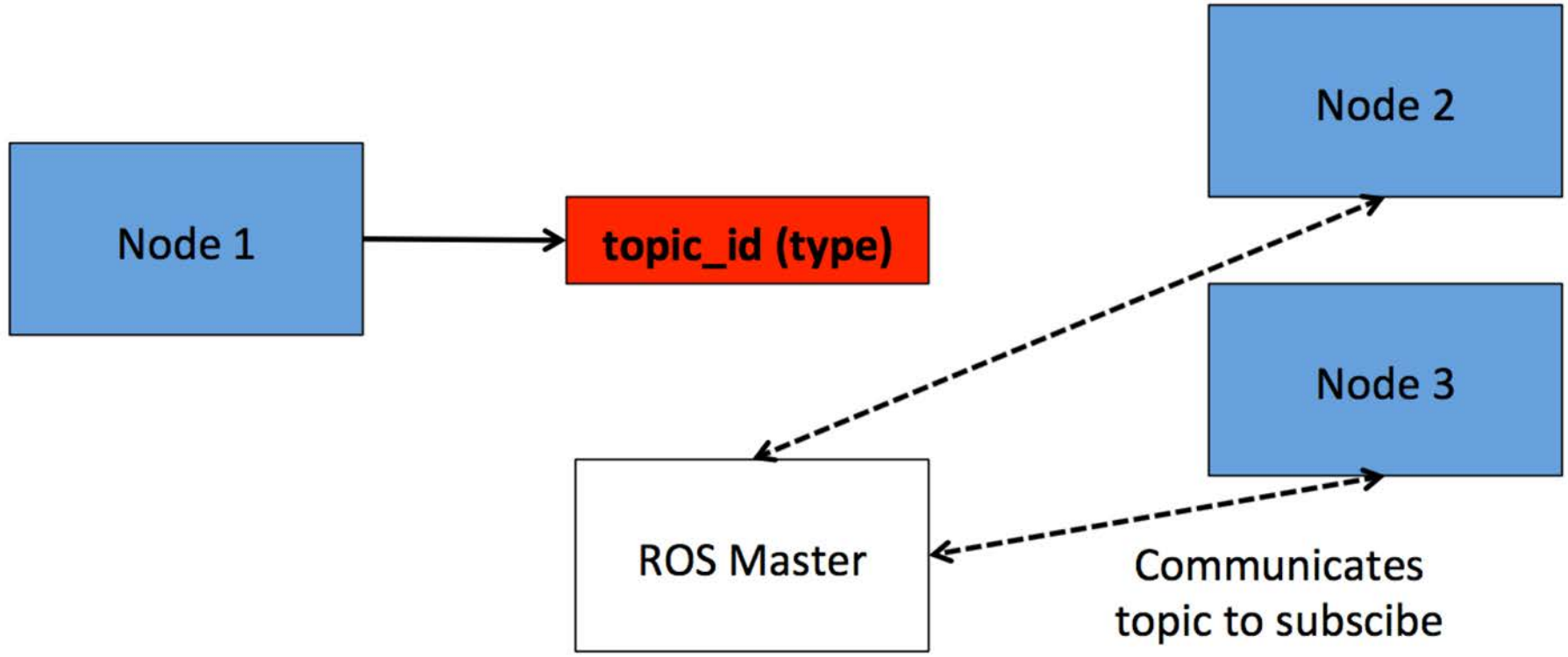
Asynchronous, many-to-many and one-way transport.

Communications: Publish/Subscribe



Asynchronous, many-to-many and one-way transport.

Communications: Publish/Subscribe



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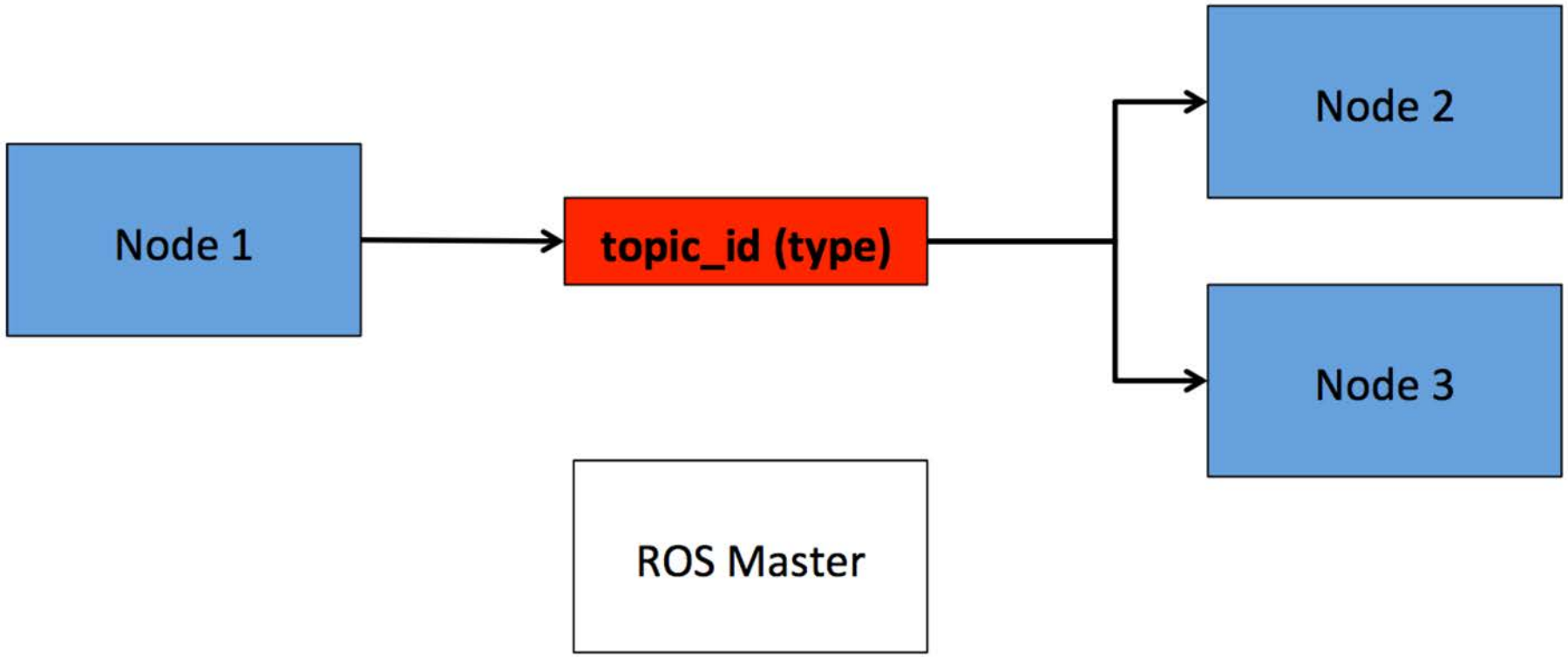
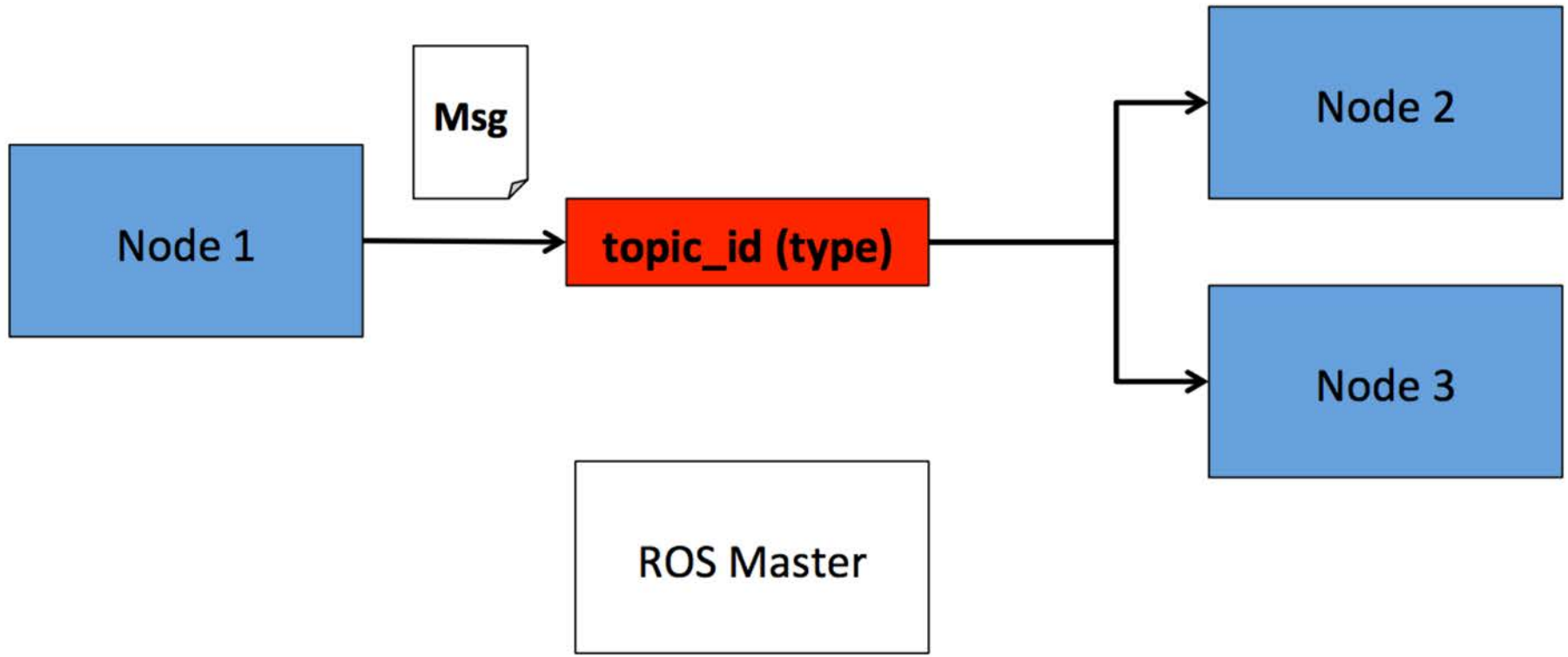
Communications: Publish/Subscribe



Asynchronous, many-to-many and one-way transport.

Communications: Publish/Subscribe



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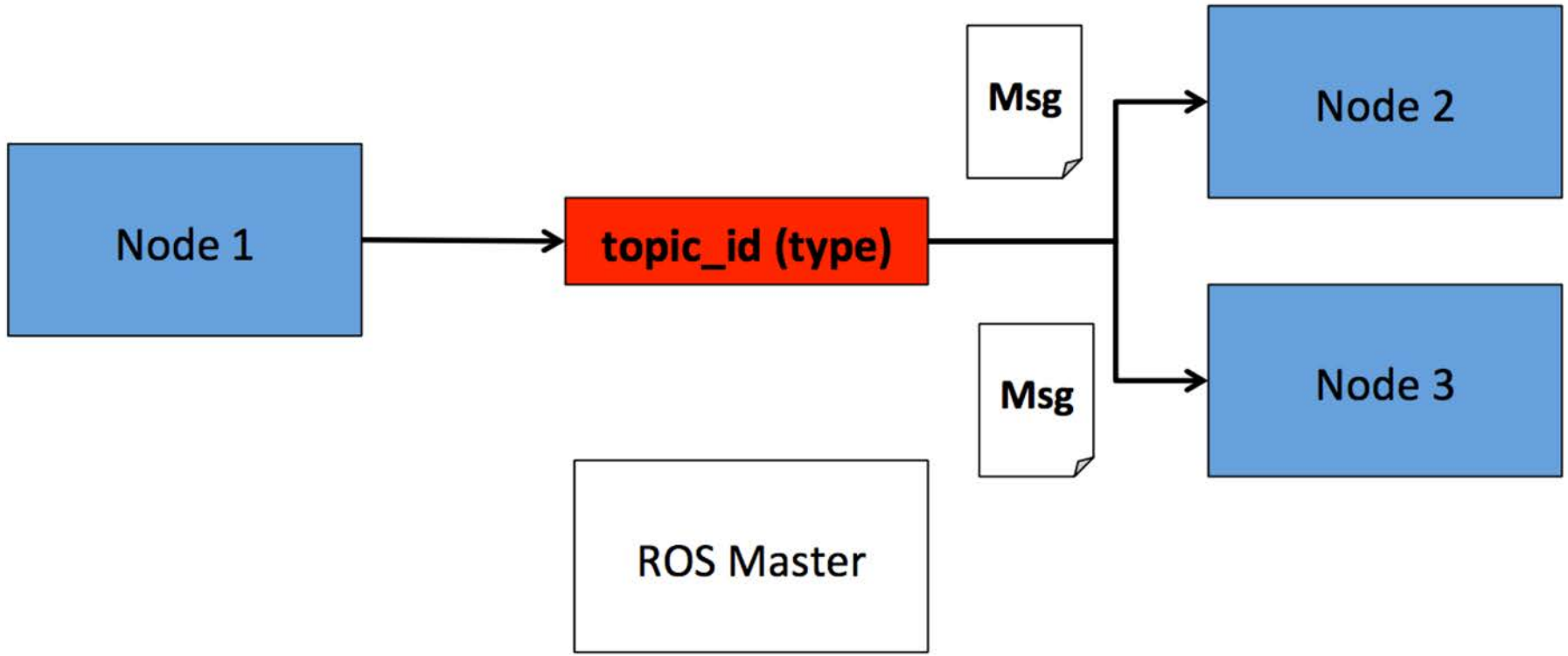
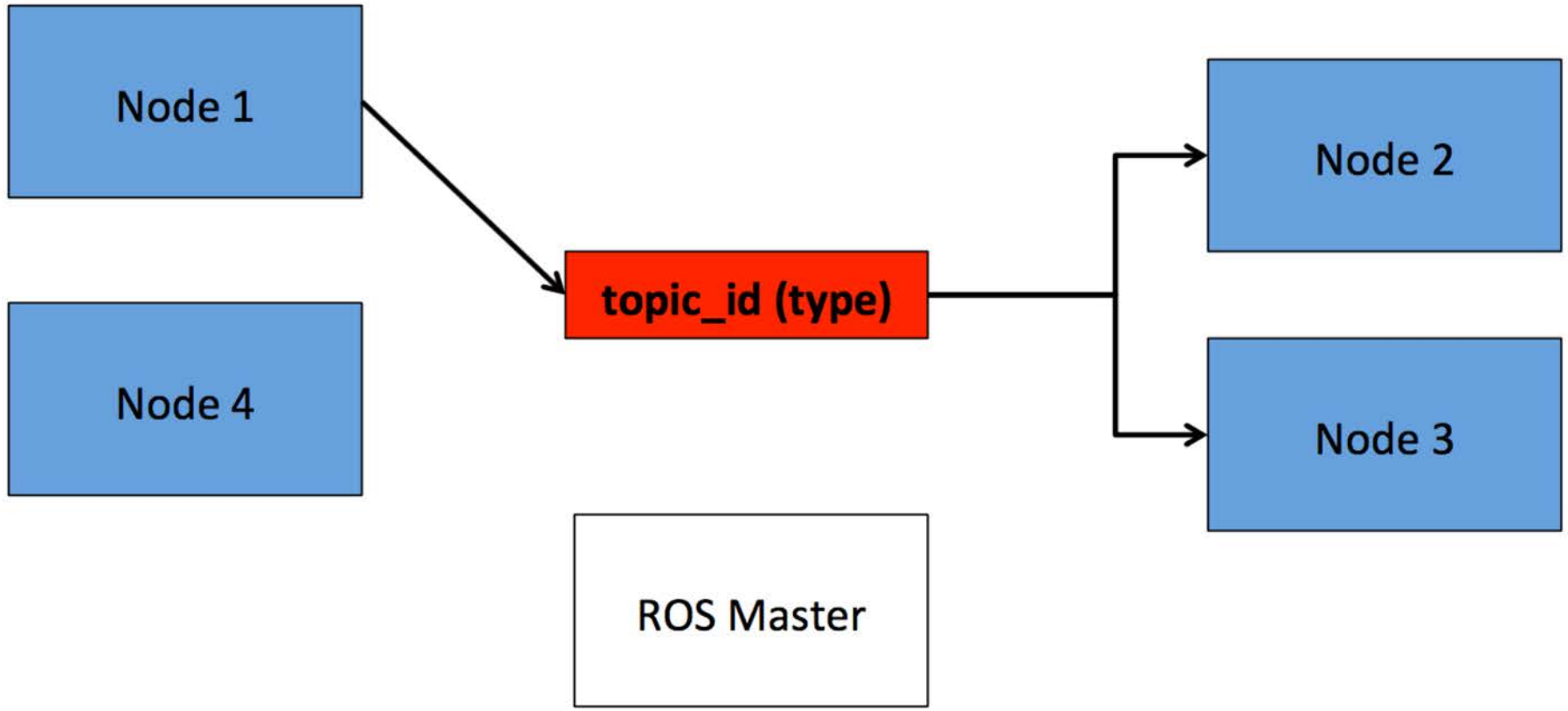
Communications: Publish/Subscribe



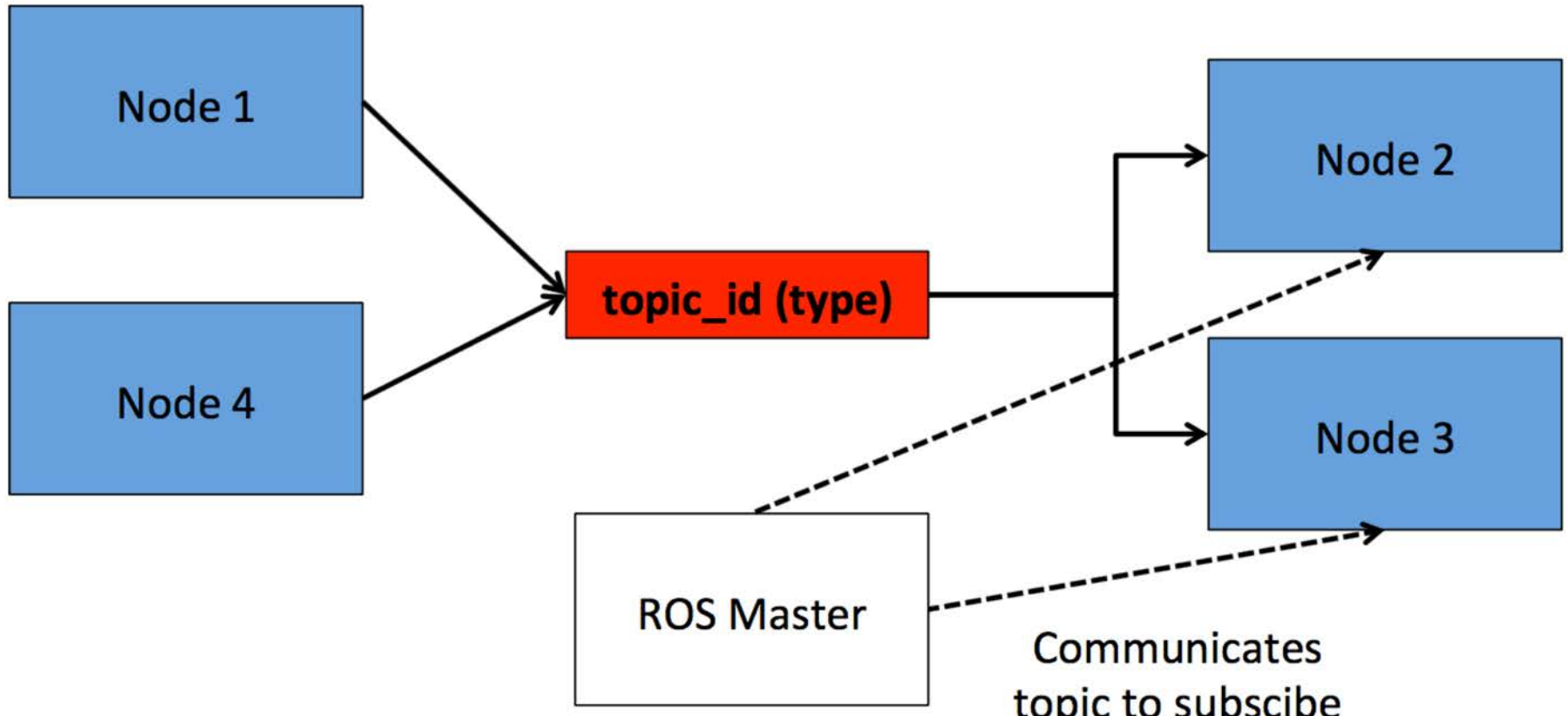
Asynchronous, many-to-many and one-way transport.

Communications: Publish/Subscribe



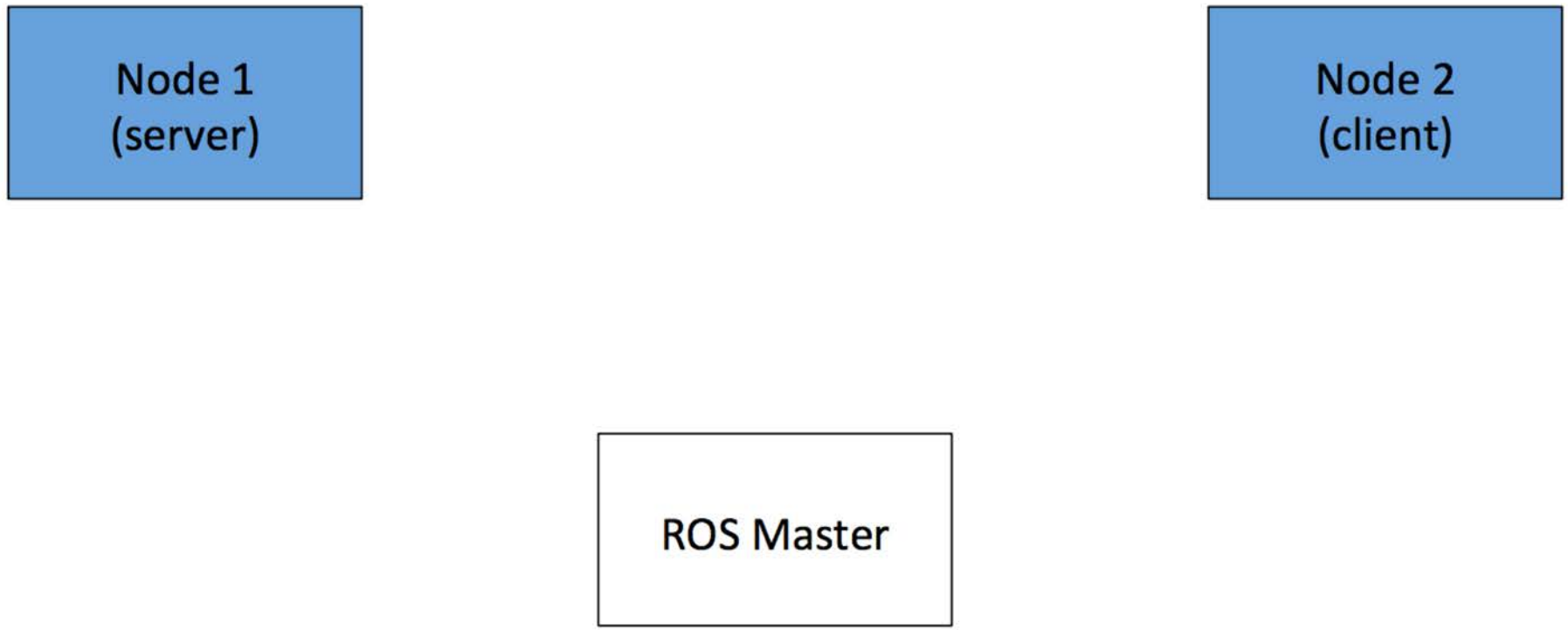
Asynchronous, many-to-many and one-way transport.

Communications: Publish/Subscribe



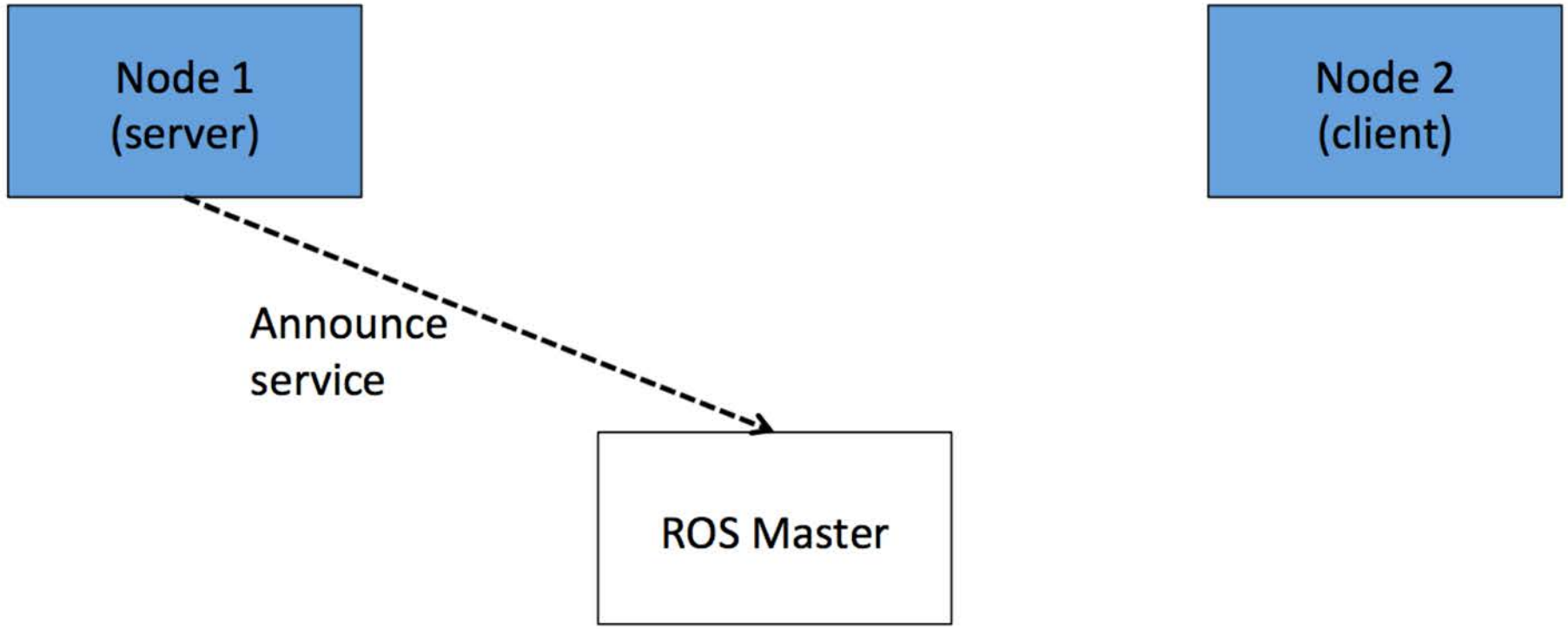
Asynchronous, many-to-many and one-way transport.

Communications: Client/Service



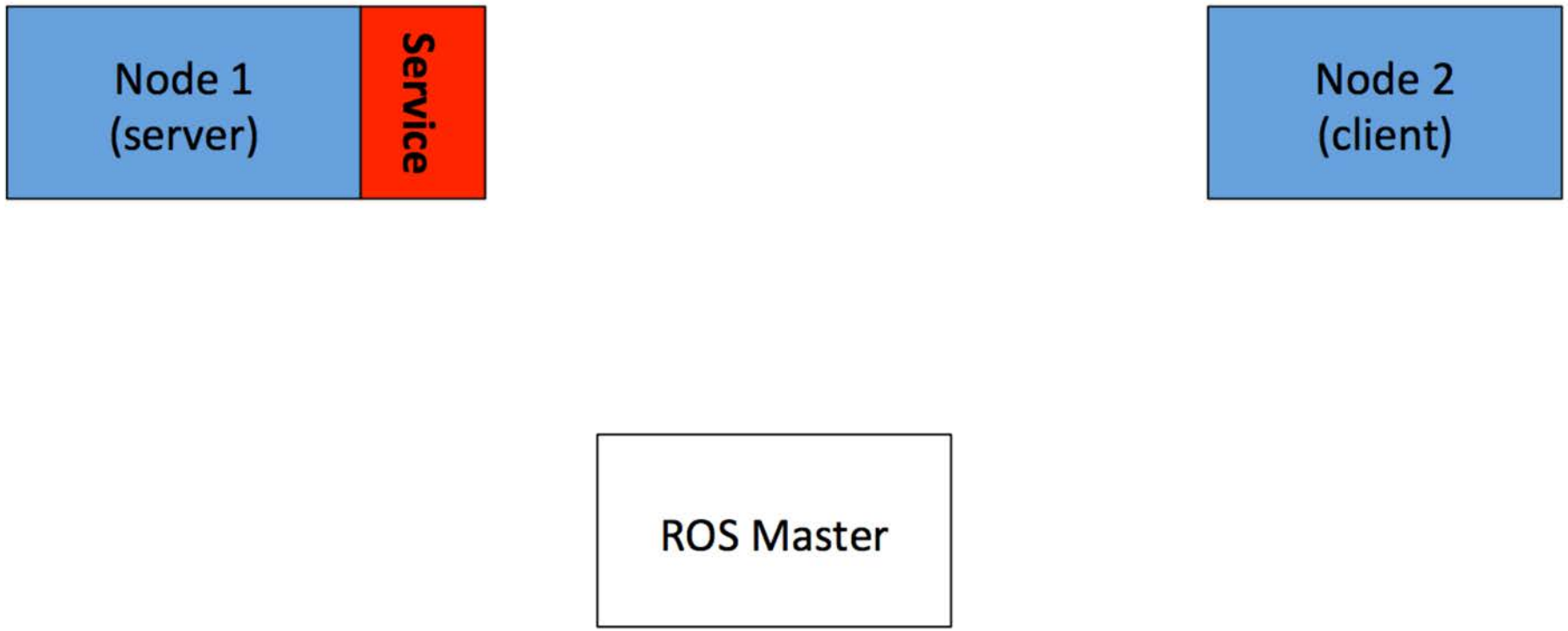
Synchronous, one-to-many

Communications: Client/Service



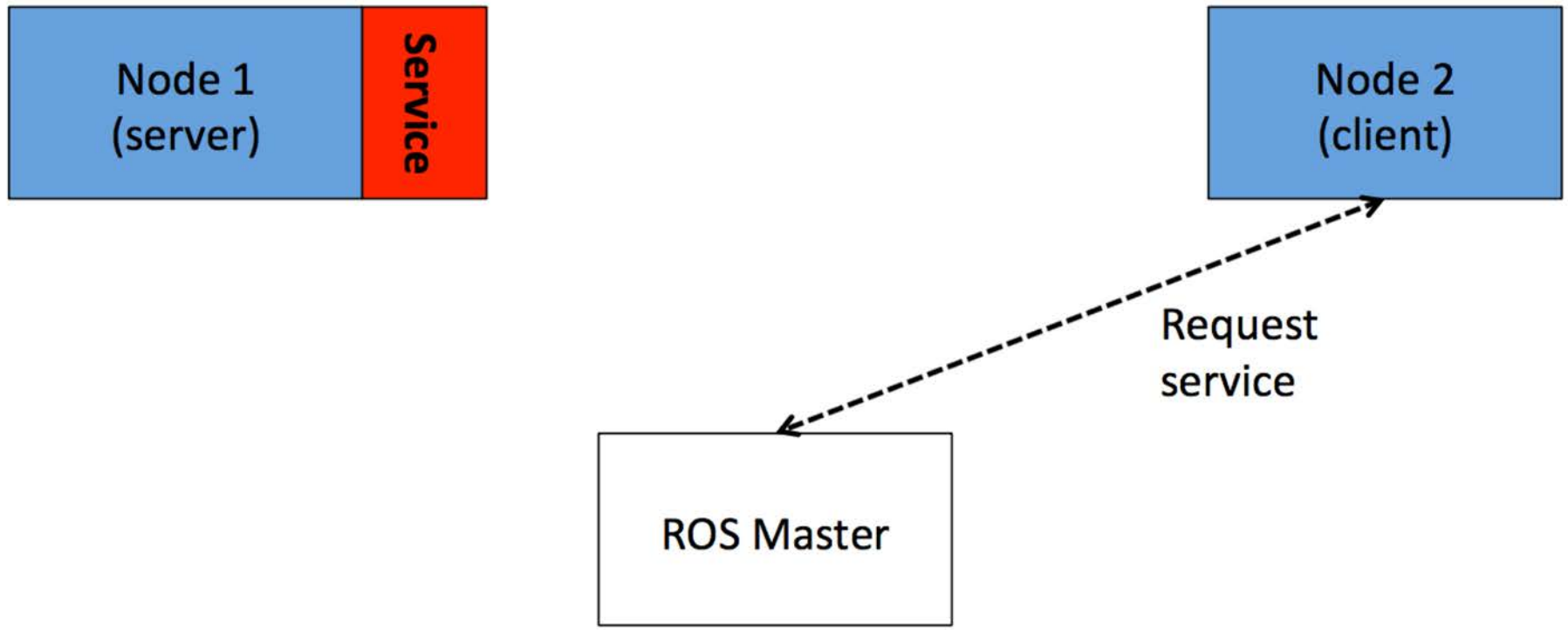
Synchronous, one-to-many

Communications: Client/Service



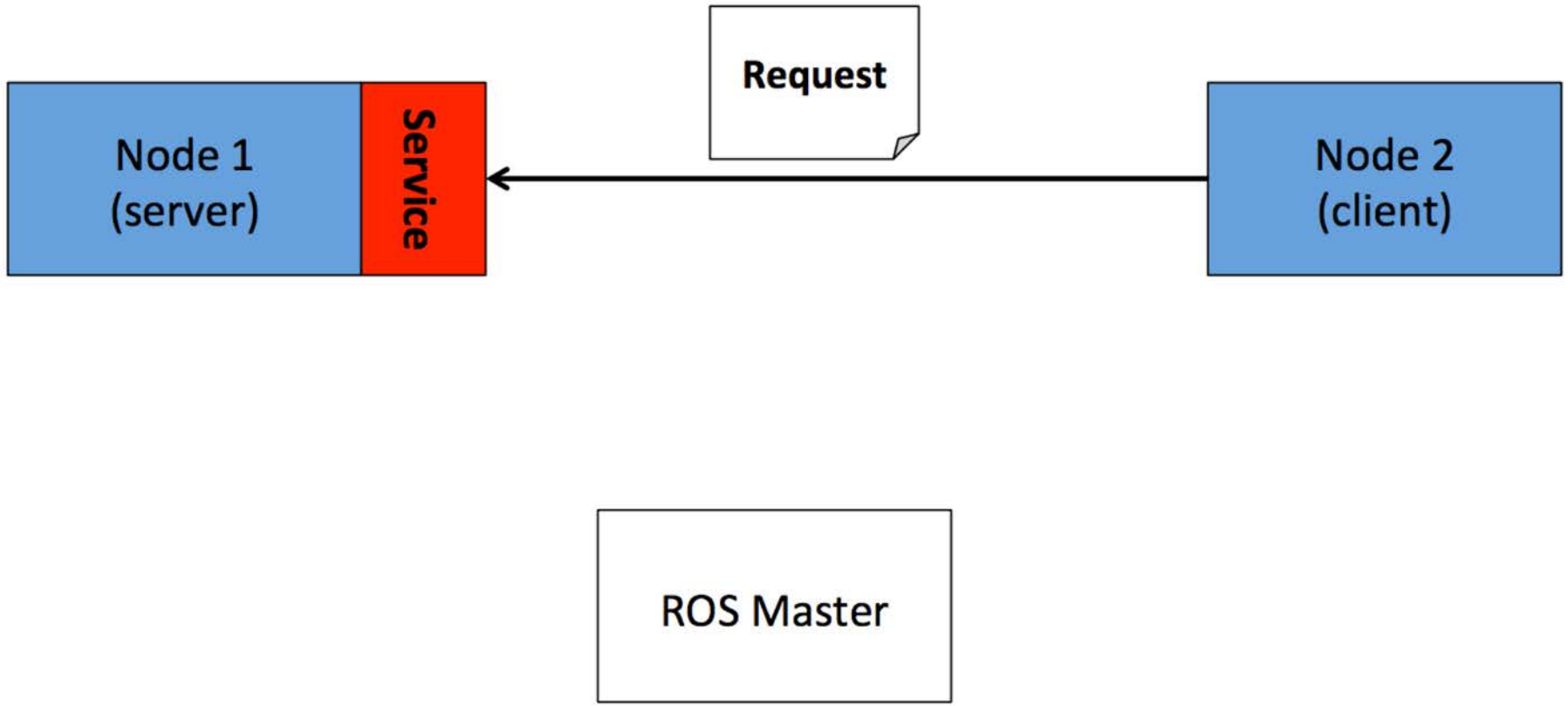
Synchronous, one-to-many

Communications: Client/Service



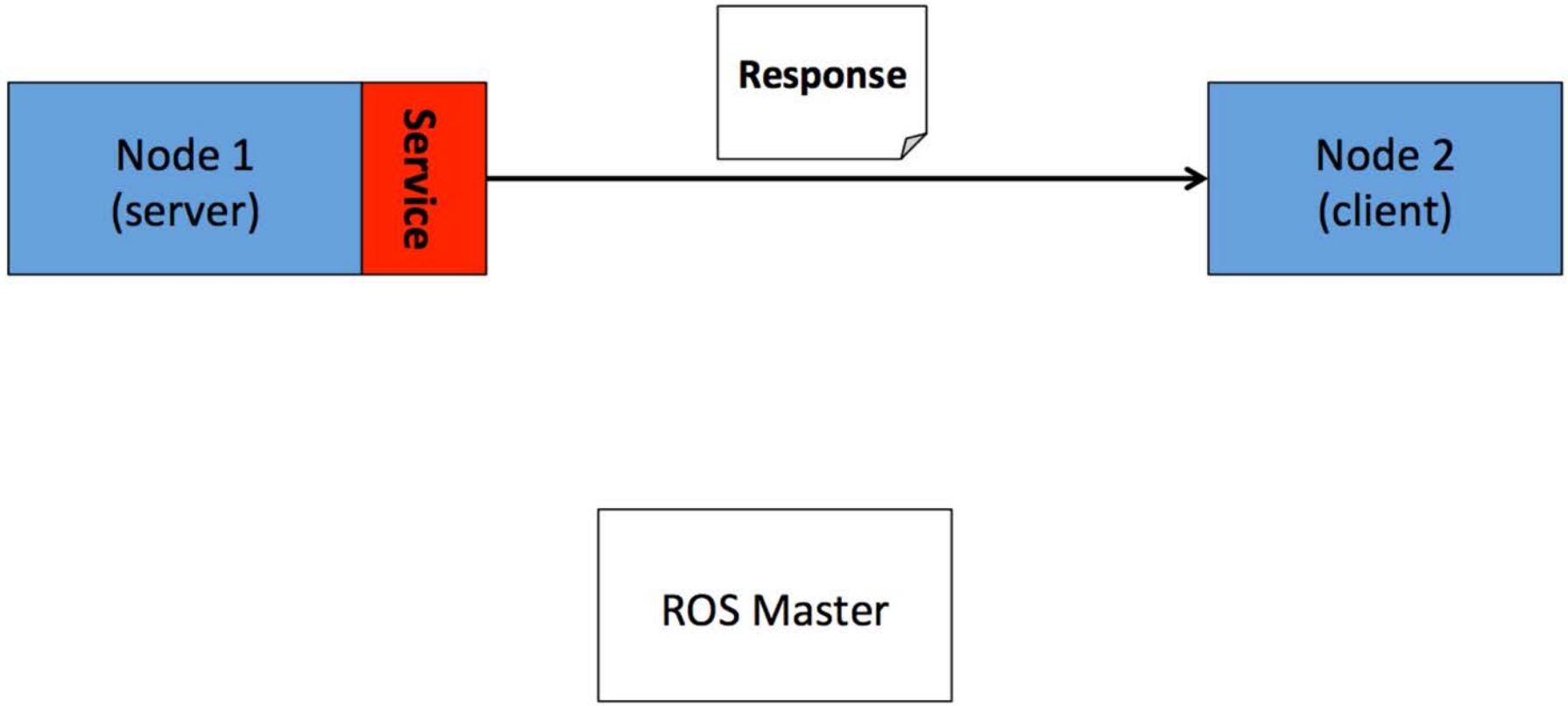
Synchronous, one-to-many

Communications: Client/Service



Synchronous, one-to-many

Communications: Client/Service



Synchronous, one-to-many

rospy client library: Services

ROS Services are defined by srv files, which contains a *request* message and a *response* message.

rospy converts these srv files into Python source code and creates three classes that you need to be familiar with: **service definitions, request messages, and response messages.**
The names of these classes come directly from the srv filename:

```
my_package/srv/Foo.srv → my_package.srv.Foo
my_package/srv/Foo.srv → my_package.srv.FooRequest
my_package/srv/Foo.srv → my_package.srv.FooResponse
```

Branch: master ▾ **f1tenth-course-labs** / beginner_tutorials / srv / **AddTwoInts.srv**

 **madhurbehl** name

1 contributor

5 lines (4 sloc) | 30 Bytes

```
1   int64 a
2   int64 b
3   ---
4   int64 sum
```

rospy client library: Service proxies

Create a callable proxy to a service.

```
rospy.ServiceProxy(name, service_class, persistent=False, headers=None)
```

Wait until a service becomes available.

```
rospy.wait_for_service(service, timeout=None)
```

rospy client library: Calling Service proxies

1. You call a service by creating a rospy.ServiceProxy with the name of the service you wish to call.

2. You often will want to call rospy.wait_for_service() to block until a service is available.

3. If a service returns an error for the request, a rospy.ServiceException will be raised. The exception will contain any error messages that the service sent.

rospy client library: Service call example

```
1 rospy.wait_for_service('add_two_ints')
2 add_two_ints = rospy.ServiceProxy('add_two_ints', AddTwoInts)
3 try:
4   resp1 = add_two_ints(x, y)
5 except rospy.ServiceException as exc:
6   print("Service did not process request: " + str(exc))
```

rospy client library: Calling services

Explicit style:

The explicit style is simple: you create your own `*Request` instance and pass it to publish, e.g.:

```
req = rospy_tutorials.srv.AddTwoIntsRequest(1, 2)
resp = add_two_ints(req)
```

Implicit style with in-order arguments:

In the *in-order* style, a new `Message` instance will be created with the arguments provided, in order. The argument order is the same as the order of the fields in the `Message`, and you must provide a value for all of the fields. For example, `rospy_tutorials.srv.AddTwoIntsRequest` has two integer fields:

```
resp = add_two_ints(1, 2)
```

Implicit style with keyword arguments

In the *keyword* style, you only initialize the fields that you wish to provide values for. The rest receive default values (e.g. 0, empty string, etc...). For example, `rospy_tutorials.srv.AddTwoIntsRequest` has two fields: `a` and `b`, which are both integers. You could call:

```
resp = add_two_ints(a=1)
```

which will set `a` to 1 and give `b` its default value of 0

rospy client library: Services

ROS Services are defined by srv files, which contains a *request* message and a *response* message.

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The names of these classes come directly from the srv filename:

```
my_package/srv/Foo.srv → my_package.srv.Foo
my_package/srv/Foo.srv → my_package.srv.FooRequest
my_package/srv/Foo.srv → my_package.srv.FooResponse
```

Creating a ROS srv

- An **.srv** file describes a service. It is composed of two parts: a request and a response. Service files are stored in the *package_name/srv* folder.
- The field types you can use are:
  - int8, int16, int32, int64 (plus uint*)
  - float32, float64
  - string
  - time, duration
  - Header
  - other msg files
  - variable-length array[] and fixed-length array[C]

Creating a ROS srv

- Create a **srv** folder inside the *beginner_tutorials* folder

```
$ roscd beginner_tutorials
$ mkdir srv
$ cd srv
```

- Create a file named **AddTwoInts.srv** with the following content:

```
int64 a
int64 b
---
int64 sum
```

Creating a ROS srv

- Open the file **package.xml** and add these two lines:

```
<build_depend>message_generation</build_depend>
<run_depend>message_runtime</run_depend>
```

- Open the file **CMakeList.txt** and add/uncomment:

```
find_package(catkin REQUIRED COMPONENTS
  roscpp rospy std_msgs message_generation
)
...
add_service_files(
  FILES
  AddTwoInts.srv
)
...
generate_messages(
  DEPENDENCIES
  std_msgs
)
```

Writing add_two_ints_server.py

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

from beginner_tutorials.srv import *
import rospy

def handle_add_two_ints(req):
    print "Returning ", req.a, "+", req.b," = ", (req.a + req.b)
    return AddTwoIntsResponse(req.a + req.b)

def add_two_ints_server():
    rospy.init_node('add_two_ints_server')
    s = rospy.Service('add_two_ints',
                      AddTwoInts, handle_add_two_ints)
    print "Ready to add two ints."
    rospy.spin()

if __name__ == "__main__":
    add_two_ints_server()
```

We declare our node using init_node() and then declare our service

All requests are passed to handle_add_two_ints function

rospy.spin() keeps your code from exiting until the service is shutdown.

Writing add_two_ints_client.py

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

import sys
import rospy
from beginner_tutorials.srv import *

def add_two_ints_client(x, y):
    rospy.wait_for_service('add_two_ints')
    try:
        add_two_ints = rospy.ServiceProxy('add_two_ints', AddTwoInts)
        resp1 = add_two_ints(x, y)
        return resp1.sum
    except rospy.ServiceException, e:
        print "Service call failed: %s"%e

def usage():
    return "%s [x y]"%sys.argv[0]

if __name__ == "__main__":
    if len(sys.argv) == 3:
        x = int(sys.argv[1])
        y = int(sys.argv[2])
    else:
        print usage()
        sys.exit(1)
    print "Requesting %s+%s"%(x, y)
    print "%s + %s = %s"%(x, y, add_two_ints_client(x, y))
```

For clients you don't have to call init_node()

Convenient method that blocks until the service named add_two_ints is available

Create a handle for calling the service

We can use this handle just like a normal function and call it

Build and run

- Make the scripts executable:

```
$ chmod +x add_two_ints_client.py
$ chmod +x add_two_ints_server.py
```

- Build the service message as usual:

```
$ cd ~/catkin_ws
$ catkin_make
```

- Run it as before:

```
$ roscore
-----------------------------------------------
$ rosrun beginner_tutorials talker.py
-----------------------------------------------
$ rosrun beginner_tutorials listener.py
```

	Topics	*Services*
active things	`rostopic`	`rosservice`
data types	`rosmsg`	`rossrv`

```
$ rosservice list
```

You will obtain the following output:

```
/clear
/kill
/reset
/rosout/get_loggers
/rosout/set_logger_level
/spawn
/teleop_turtle/get_loggers
/teleop_turtle/set_logger_level
/turtle1/set_pen
/turtle1/teleport_absolute
/turtle1/teleport_relative
/turtlesim/get_loggers
/turtlesim/set_logger_level
```

If you want to see the type of any service, for example, the `/clear` service, use the following command:

```
$ rosservice type /clear
```

```
$ rosservice type /spawn | rossrv show
```

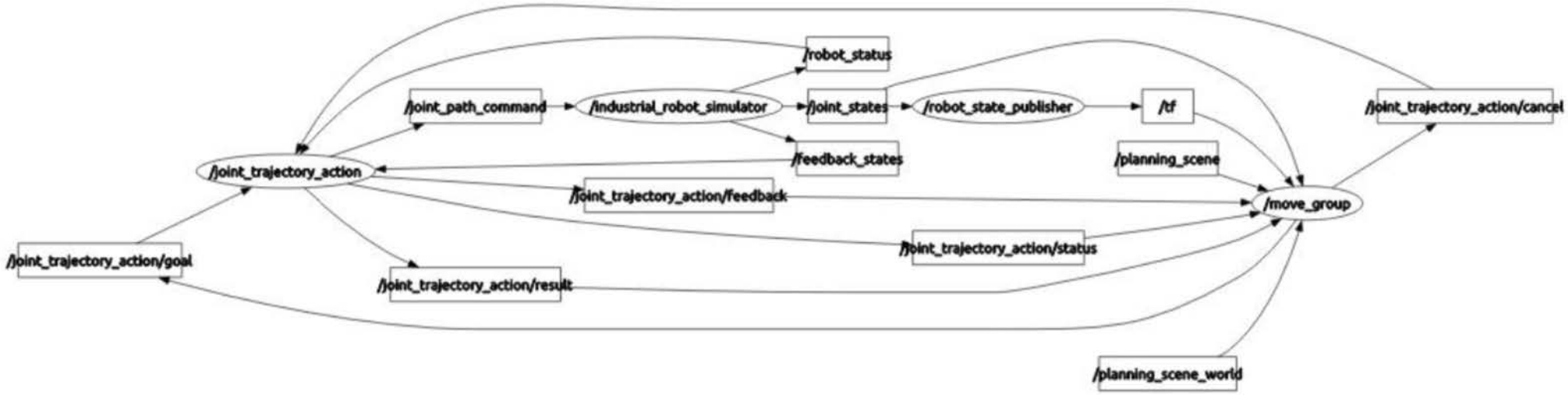
You will see something similar to the following output:

```
float32 x
float32 y
float32 theta
string name
---
string name
```

```
$ rosservice call /spawn 3 3 0.2 "new_turtle"
```

We then obtain the following result:

- ROS is a Distributed System
  - often 10s of nodes, plus configuration data
  - painful to start each node “manually”

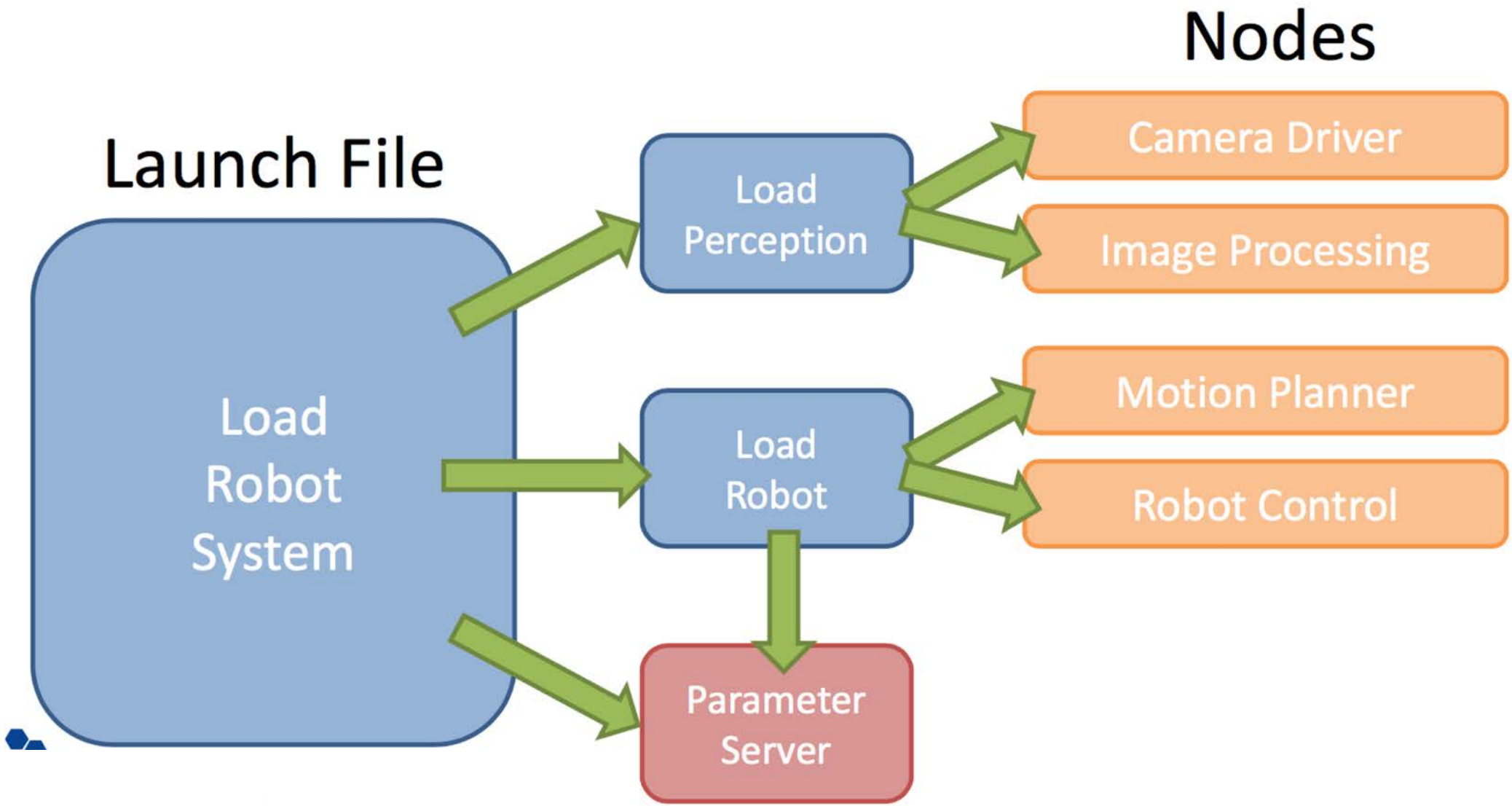



/remote_control
/joy
/mode_switch
/brake_teleop_publisher
/speed_teleop_publisher
/speed_command_publisher
/angle_teleop_publisher
commands
/commands/motor/brake
/commands/motor/speed
/commands/servo/position
/vesc_driver
move_base
/move_base/TebLocalPlannerROS/local_plan
/move_base/TebLocalPlannerROS/teb_poses
/move_base/local_costmap/costmap_updates
/move_base/TebLocalPlannerROS/teb_markers
/move_base/local_costmap/costmap
/move_base/global_costmap/costmap_updates
/move_base/goal
/move_base/global_costmap/costmap
/move_base/local_costmap/footprint
/move_base/global_costmap/footprint
/move_base/TebLocalPlannerROS/global_plan
move_base_simple
/move_base_simple/goal
/hokuyo_scanner
/odom
/base_odom_link
/scan
/move_base
/base_laser_link
/tf
/angle_command_publisher
zed
/zed/zed_wrapper_node
/zed/odom
/zed/zed_state_publisher
/tf_static
/amcl
/cmd_vel
/map_server
/map
/particlecloud
/initialpose

Launch files

roslaunch package_name file.launch

Launch Files are like **Startup Scripts**



Launch Files: Notes

- Can launch *other* launch files
- Executed in order, without pause or wait*

  * *Parameters set to parameter server before nodes are launched*

- Can accept arguments
- Can perform simple IF-THEN operations
- Supported parameter types:
  - Bool, string, int, double, text file, binary file

Example: Launch files

- Open an editor and save the following as ~/turtlesim_test.launch

```
<launch>
  <group ns="turtlesim1">
    <node pkg="turtlesim" name="sim" type="turtlesim_node" />
  </group>
  <group ns="turtlesim2">
    <node pkg="turtlesim" name="sim" type="turtlesim_node" />
  </group>
  <node pkg="turtlesim" name="mimic" type="mimic">
    <remap from="input" to="turtlesim1/turtle1"/>
    <remap from="output" to="turtlesim2/turtle1"/>
 </node>
</launch>
```

```
<launch>
```

start the launch file with the launch tag, so that the file is identified as a launch file

```
  <group ns="turtlesim1">
    <node pkg="turtlesim" name="sim" type="turtlesim_node"/>
  </group>

  <group ns="turtlesim2">
    <node pkg="turtlesim" name="sim" type="turtlesim_node"/>
  </group>
```

start two groups with a namespace tag of turtlesim1 and turtlesim2 with a turtlesim node with a name of sim.
This allows us to start two simulators without having name conflicts.

```
  <node pkg="turtlesim" name="mimic" type="mimic">
    <remap from="input" to="turtlesim1/turtle1"/>
    <remap from="output" to="turtlesim2/turtle1"/>
  </node>
```

start the mimic node with the topics input and output renamed to turtlesim1 and turtlesim2. This renaming will cause turtlesim2 to mimic turtlesim1.

```
</launch>
```

This closes the xml tag for the launch file

$ roslaunch beginner_tutorials turtlemimic.launch

$ rostopic pub /turtlesim1/turtle1/cmd_vel geometry_msgs/Twist -r 1 -- '[2.0, 0.0, 0.0]' '[0.0, 0.0, -1.8]'

$ rqt_graph

Example launch file for the F1/10 car

```
<launch>

  <arg name="debug" default="false" />
  <arg name="bag_path" default="$(find autonomous_driving)/bags/calibrated_140.bag"/>

  <node pkg="rosbag" type="play" name="player" output="screen" args="-l $(arg bag_path)" if="$(arg debug)" ns="autonomous_driving"/>

  <include file="$(find autonomous_driving)/launch/camera.launch">
    <arg name="debug" value="$(arg debug)" />
  </include>
  <include file="$(find autonomous_driving)/launch/lane_detection.launch">
    <arg name="debug" value="$(arg debug)" />
  </include>
  <include file="$(find autonomous_driving)/launch/object_detection.launch">
    <arg name="debug" value="$(arg debug)" />
  </include>
  <include file="$(find autonomous_driving)/launch/rovercontrol.launch">
    <arg name="debug" value="$(arg debug)" />
  </include>
</launch>
```

rosbags: Recording and playing back data

all published topics should be accumulated in a bag file.

```
mkdir ~/bagfiles
cd ~/bagfiles
rosbag record -a
```

ROS Bags

- A *bag* is a format for storing message data
- Binary format with file extension *.bag
- Suited for logging and recording datasets for later visualization and analysis

Record all topics in a bag

```
> rosbag record --all
```

Record given topics

```
> rosbag record topic_1 topic_2 topic_3
```

Stop recording with `Ctrl` + `C`
Bags are saved with start date and time as file name in the current folder (e.g. `2017-02-07-01-27-13.bag`)

rosbags: Recording specific topics

```
rosbag record -O subset /turtle1/cmd_vel /turtle1/pose
```

-O argument tells **rosbag record** to log to a file named subset.bag

rosbags: Recording specific topics

```
path:        subset.bag
version:     2.0
duration:    12.6s
start:       Dec 10 2014 20:20:49.45 (1418271649.45)
end:         Dec 10 2014 20:21:02.07 (1418271662.07)
size:        68.3 KB
messages:    813
compression: none [1/1 chunks]
types:       geometry_msgs/Twist [9f195f881246fdfa2798d1d3eebca84a]
             turtlesim/Pose      [863b248d5016ca62ea2e895ae5265cf9]
topics:      /turtle1/cmd_vel    23 msgs    : geometry_msgs/Twist
             /turtle1/pose      790 msgs    : turtlesim/Pose
```

rosbags: Examining and playing the bag file

```
rosbag info <your bagfile>
```

```
path:        2014-12-10-20-08-34.bag
version:     2.0
duration:    1:38s (98s)
start:       Dec 10 2014 20:08:35.83 (1418270915.83)
end:         Dec 10 2014 20:10:14.38 (1418271014.38)
size:        865.0 KB
messages:    12471
compression: none [1/1 chunks]
types:       geometry_msgs/Twist [9f195f881246fdfa2798d1d3eebca84a]
             rosgraph_msgs/Log   [acffd30cd6b6de30f120938c17c593fb]
             turtlesim/Color     [353891e354491c51aabe32df673fb446]
             turtlesim/Pose      [863b248d5016ca62ea2e895ae5265cf9]
topics:      /rosout                4 msgs    : rosgraph_msgs/Log   (2 connections)
             /turtle1/cmd_vel     169 msgs    : geometry_msgs/Twist
             /turtle1/color_sensor 6149 msgs  : turtlesim/Color
             /turtle1/pose        6149 msgs   : turtlesim/Pose
```

year, date, and time and the suffix .bag

rosbags: Playing back data

```
rosbag play <your bagfile>
```

```
[ INFO] [1418271315.162885976]: Opening 2014-12-10-20-08-34.bag

Waiting 0.2 seconds after advertising topics... done.

Hit space to toggle paused, or 's' to step.
```

rosbags: Playing back data

```
rosbag play -r 2 <your bagfile>
```

allows you to change the rate of publishing by a specified factor.

Sensors Udacity Lincoln MKZ

Camera 3x Blackfly GigE Camera, 20 Hz

Lidar Velodyne HDL-32E, 9.5 Hz

IMU Xsens, 400 Hz

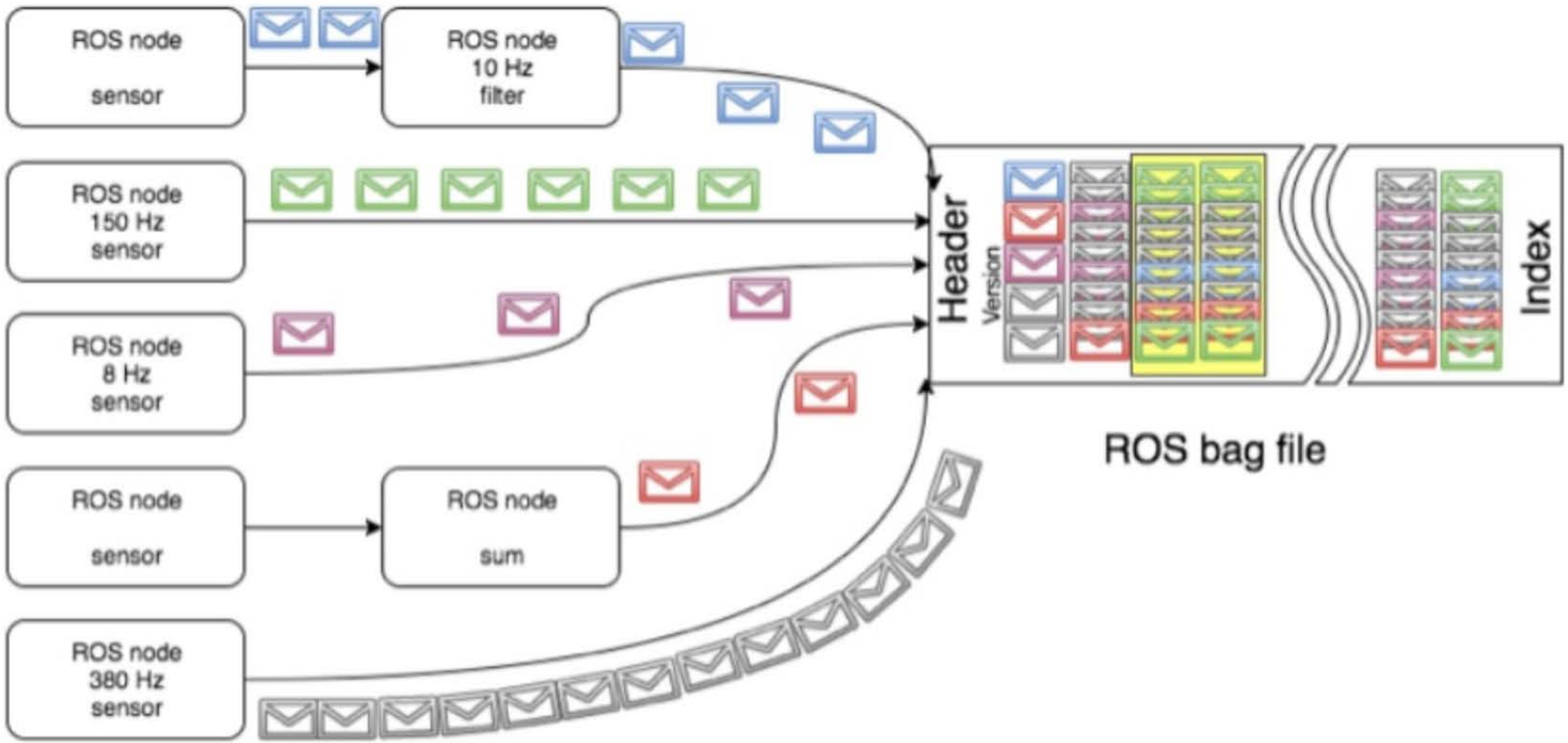
GPS 2x fixed, 1 Hz

CAN bus, 1,1 kHz

Robot Operating System

Data 3 GB per minute

ROS bag data structure



Training & Evaluation

+ Tensorflow ROSRecordDataset
+ Protocol Buffers to serialize records
+ Save time because data conversion not needed
+ Save storage because data duplication not needed

Ros bag

Ros msg

protobuf
Protocol Buffers

TensorFlow

ROS

ROS Dataset

hadoop

Machine Learning

Training Engine

Computer Network Storage

Re-Simulation & Testing

+ Use Spark for preprocessing, transformation, cleansing, aggregation, time window selection before publish to ROS topics
+ Use Re-Simulation framework of choice to subscribe to the ROS topics


Runtime Manager
Quick Start
Setup
Map
Sensing
Computing
Interface
Database
Simulation
Status
Topics
/media/ando/ssd/log/rosbag/rosbag.bag
Ref
Rate:
Start Time (s):
Repeat
Play
Stop
Pause
path: /media/ando/ssd/log/rosbag/rosbag.bag
version: 2.0
duration: 11:35s (695s)
start: Jun 23 2015 10:57:55.84 (1435024675.84)
end: Jun 23 2015 11:09:31.80 (1435025371.80)
size: 26.1 GB
messages: 17393
compression: none [17393/17393 chunks]
types: sensor_msgs/Image [060021388200f6f0f447d0fcd9c64743]
sensor_msgs/PointCloud2 [1158d486dd51d683ce2f1be655c3c181]
topics: /image_raw 10439 msgs : sensor_msgs/Image
/points_raw 6954 msgs : sensor_msgs/PointCloud2
ROSBAG
RViz
RQT
0.0%
0.0%
9.1%
0.0%
0.0%
0.0%
0.0%
0.0%
CPU0
CPU1
CPU2
CPU3
CPU4
CPU5
CPU6
CPU7
compiz (9.2 %CPU)
/sbin/init (0.0 %CPU)
[kthreadd] (0.0 %CPU)
[ksoftirqd/0] (0.0 %CPU)
[kworker/0:0H] (0.0 %CPU)
1GB/31GB(4%)
Memory
AutoWare