ROS-Industrial Basic Developer's Training Class

July 2023

Southwest Research Institute

Session 2:
ROS Basics Continued

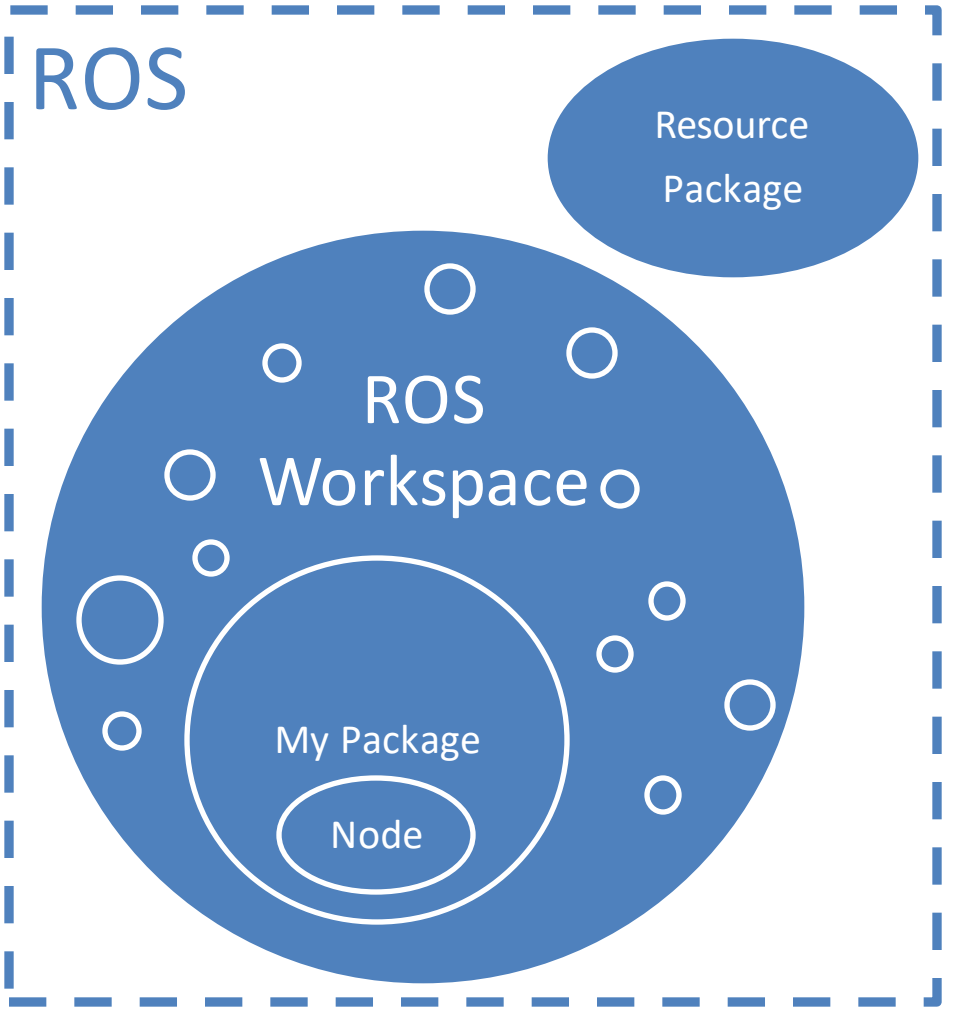
Southwest Research Institute

Outline

- Services
- *Actions*
- Launch Files
- Parameters

Day 1 Progression

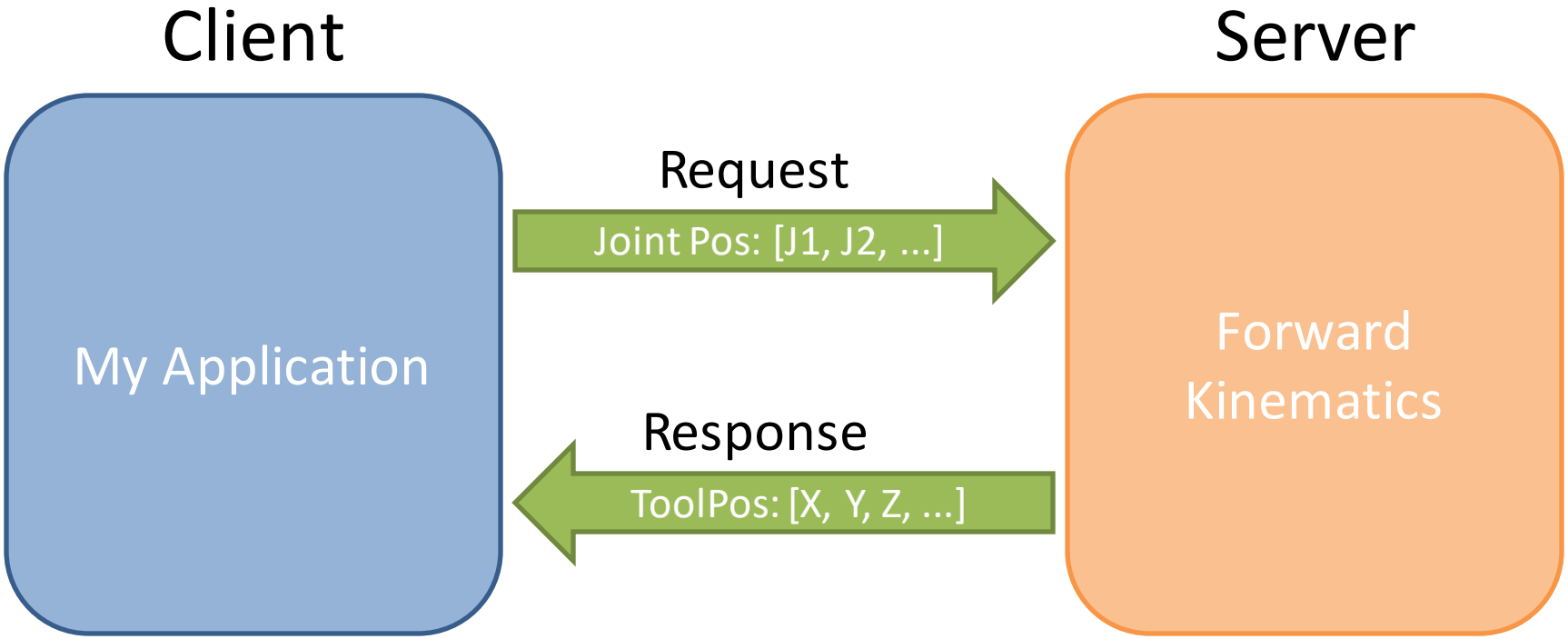
- ✓ Install ROS
- ✓ Create Workspace
- ✓ Add “resources”
- ✓ Create Package
- ✓ Create Node
  - ✓ Basic ROS Node
  - ✓ Interact with other nodes
    - ✓ Messages
    - ❑ Services
- ✓ Run Node
  - ✓ ros2 run
  - ❑ ros2 launch



Services

Services : Overview

Services are like **Function Calls**



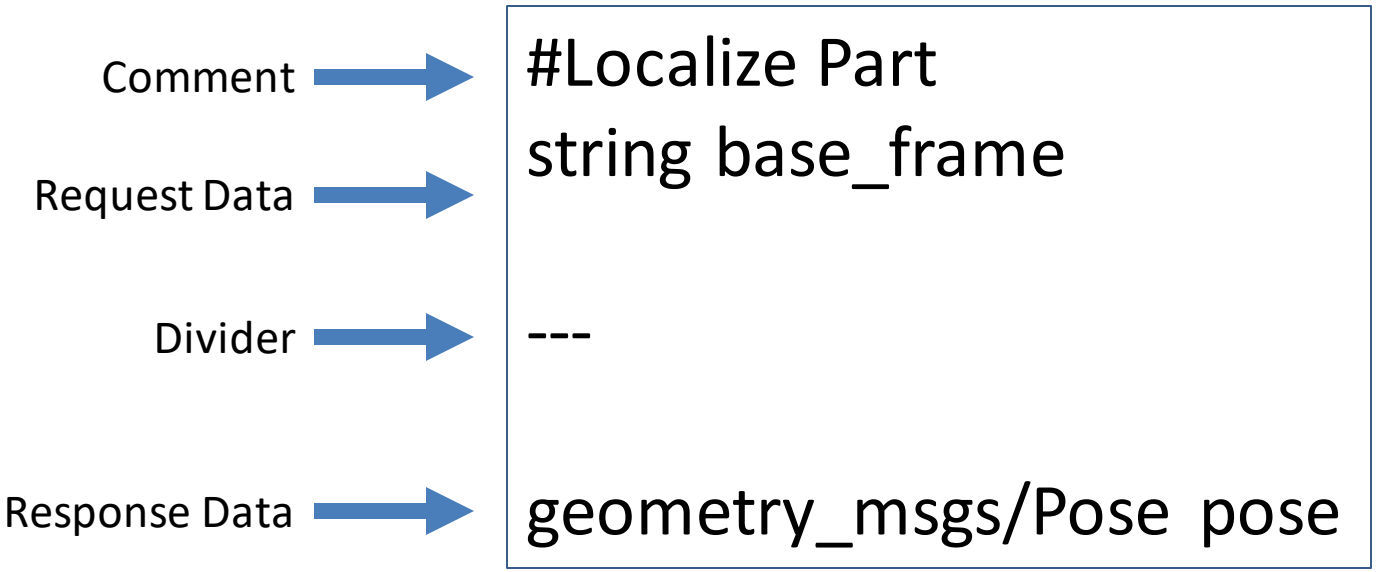
Services: Details

- Each Service is made up of 2 components:
  - *Request* : sent by **client**, received by **server**
  - *Response* : generated by **server**, sent to **client**
- In ROS1, the client **blocks** when calling a service
  - In ROS2 Service Calls can be **Asynchronous**, so don't have to wait
  - Separate connection for each service call
- Typical Uses:
  - Algorithms: kinematics, perception
  - Closed-Loop Commands: move-to-position, open gripper

Services: Syntax

- Service **definition**
  - Defines Request and Response **data types**
    - *Either/both data type(s) may be **empty.** Always receive "completed" handshake.*
  - Auto-generates C++ Class files (.hpp/.cpp), Python, etc.

`LocalizePart.srv`

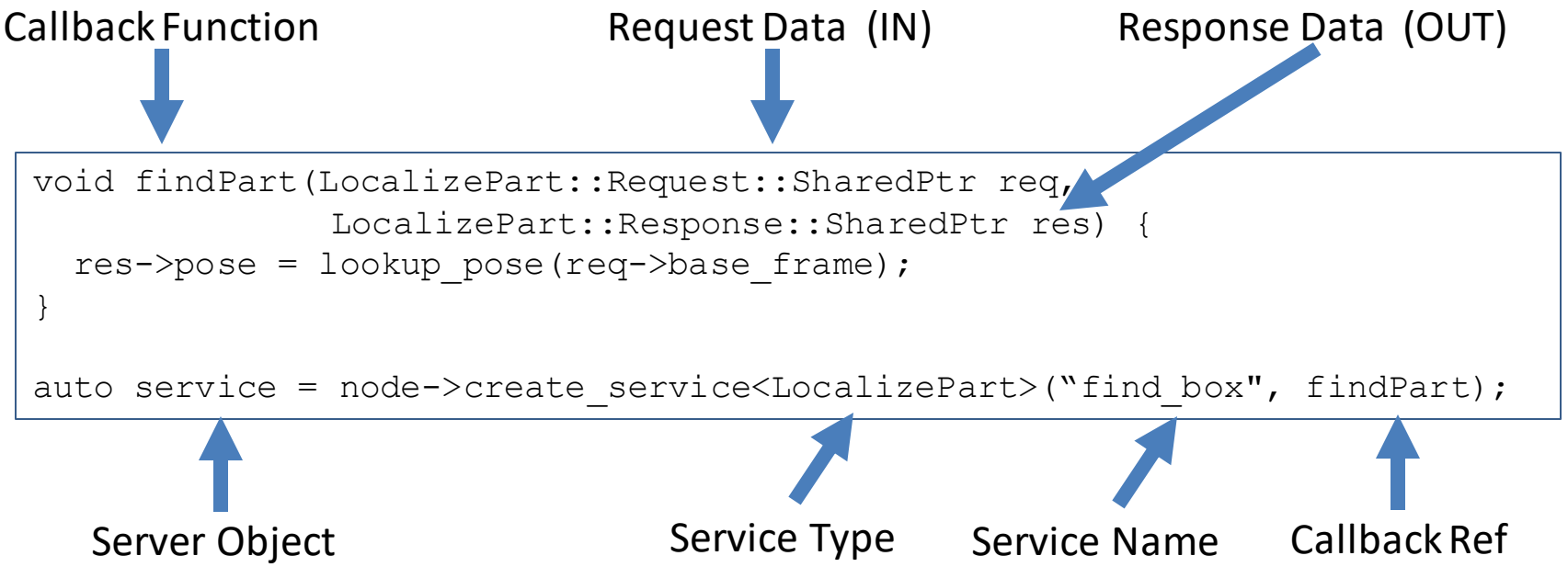


“Real World” – Services

- Use *rqt_srv* / *rqt_msg* to view:
  - `moveit_msgs/GetPositionIK`
  - `rcl_interfaces/GetParameters`
  - `moveit_msgs/GetMotionPlan`

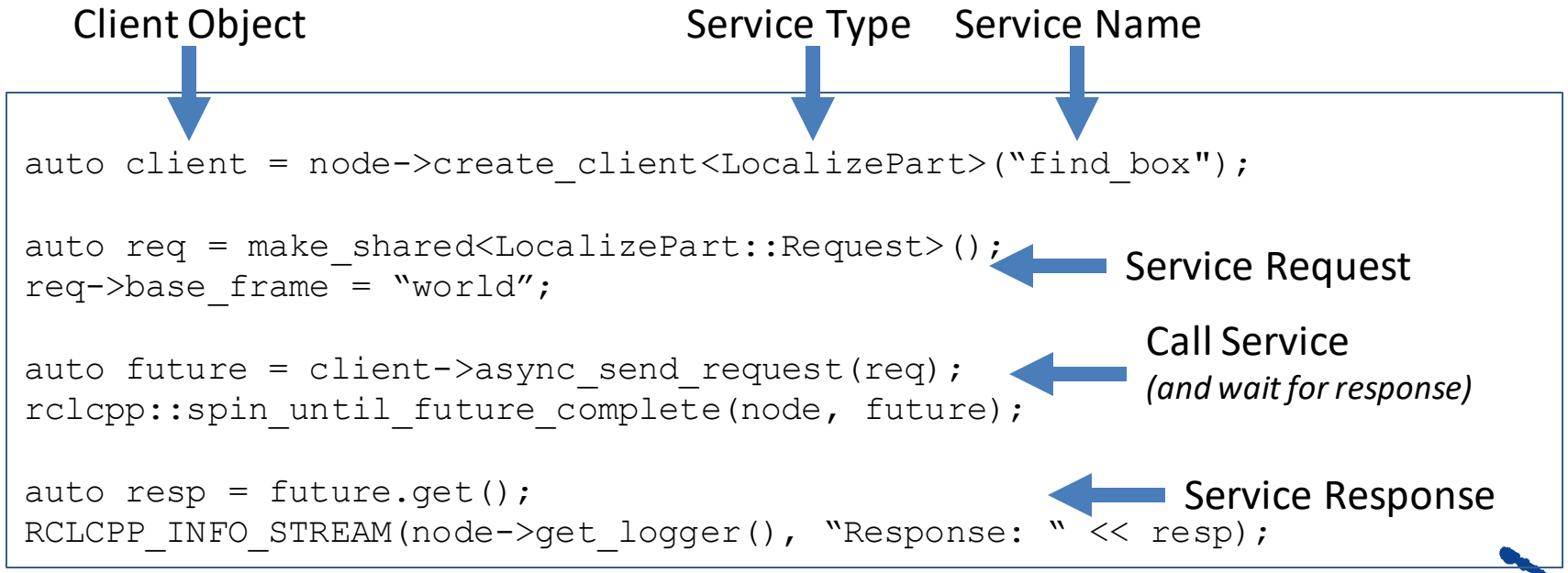
Services: Syntax

- Service **Server**
  - Defines associated **Callback Function**
  - Advertises available service *(Name, Data Type)*



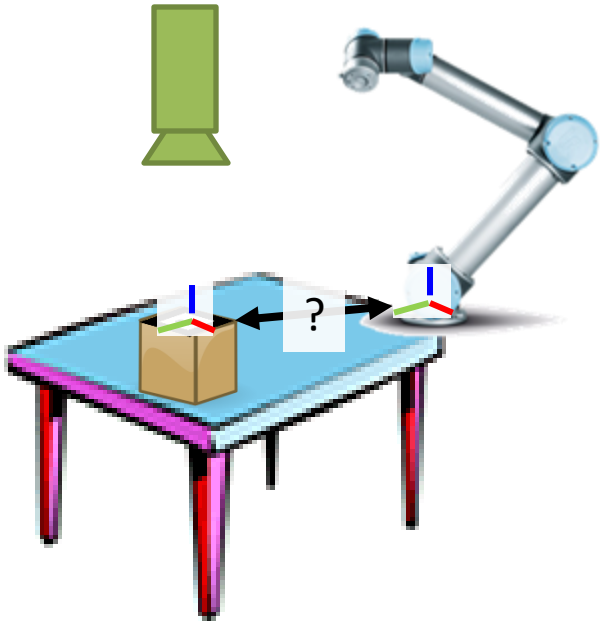
Services: Syntax

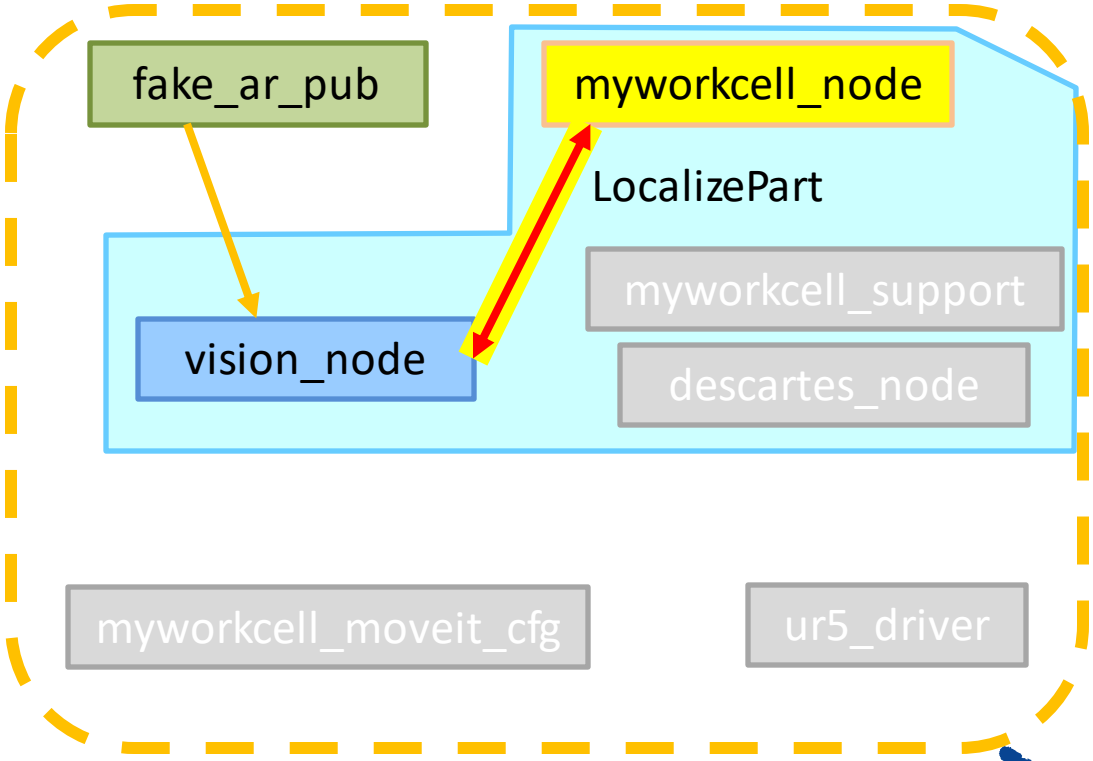
- Service **Client**
  - Connects to specific Service *(Name / Data Type)*
  - Fills in Request data
  - Calls Service



Exercise 2.0

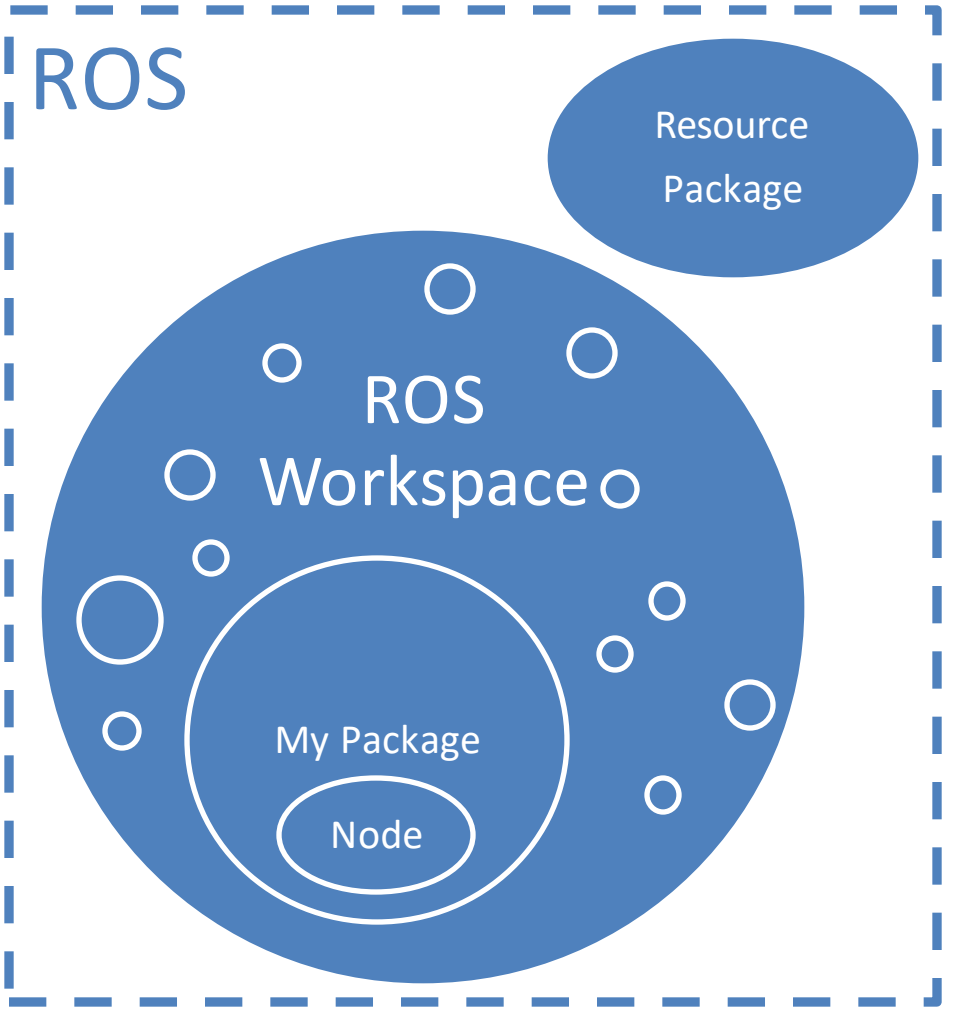
Creating and Using a Service





Day 1 Progression

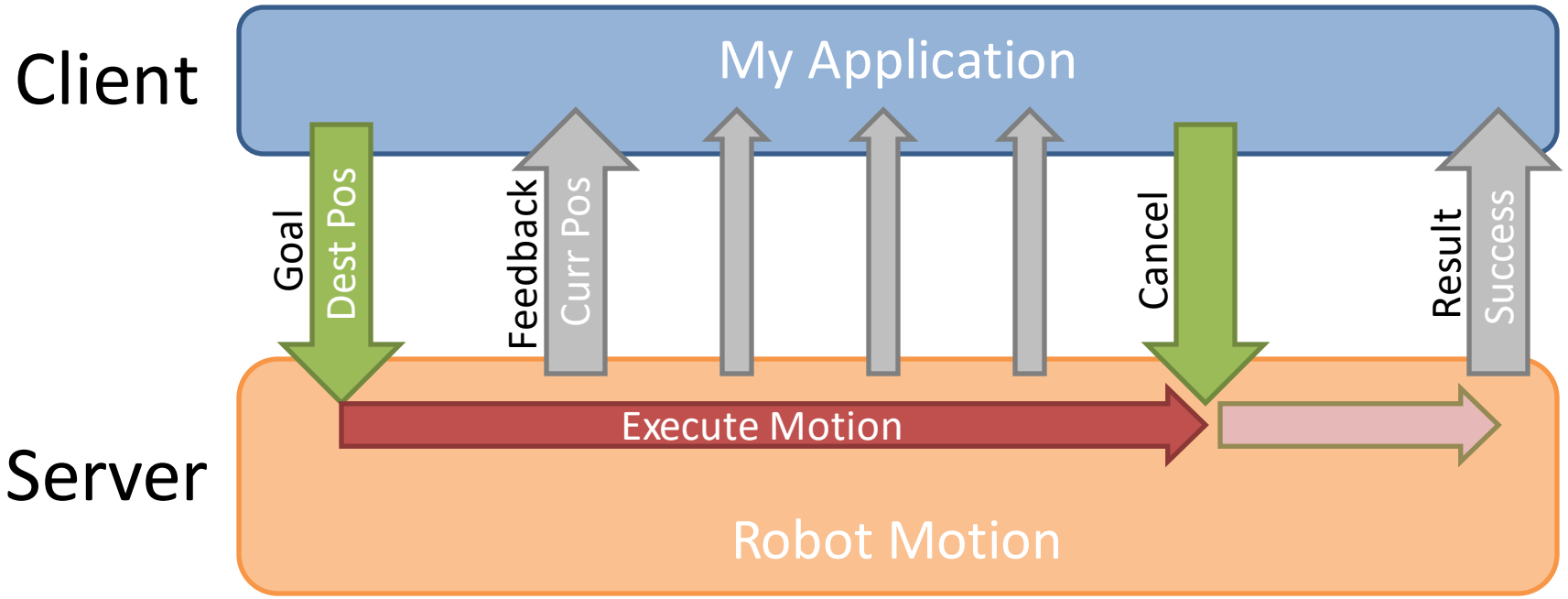
- ✓ Install ROS
- ✓ Create Workspace
- ✓ Add “resources”
- ✓ Create Package
- ✓ Create Node
  - ✓ Basic ROS Node
  - ✓ Interact with other nodes
    - ✓ Messages
    - ✓ Services
- ✓ Run Node
  - ✓ ros2 run
  - ❑ ros2 launch



Actions

Actions : Overview

Actions manage **Long-Running Tasks**



Actions: Detail

- Each action is made up of 3 components:
  - *Goal*, sent by **client**, received by **server**
  - *Result*, generated by **server**, sent to **client**
  - *Feedback*, generated by **server**
- Non-blocking in client
  - Can **monitor feedback** or **cancel** before completion
- Typical Uses:
  - "Long" Tasks: Robot Motion, Path Planning
  - Complex Sequences: Pick Up Box, Sort Widgets

Actions: Syntax

- Action **definition**
  - Defines Goal, Feedback and Result **data types**
    - *Any data type(s) may be **empty.** Always receive handshakes.*
  - Auto-generates C++ Class files (.h/.cpp), Python, etc.

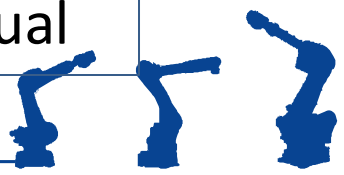
`FollowJointTrajectory.action`

```
# Command Robot Motion
traj_msgs\JointTrajectory trajectory
---
int32  error_code
string error_string
---
uint8 status
traj_msgs\JointTrajectoryPoint actual
```

Goal Data →

Result Data →

Feedback Data →



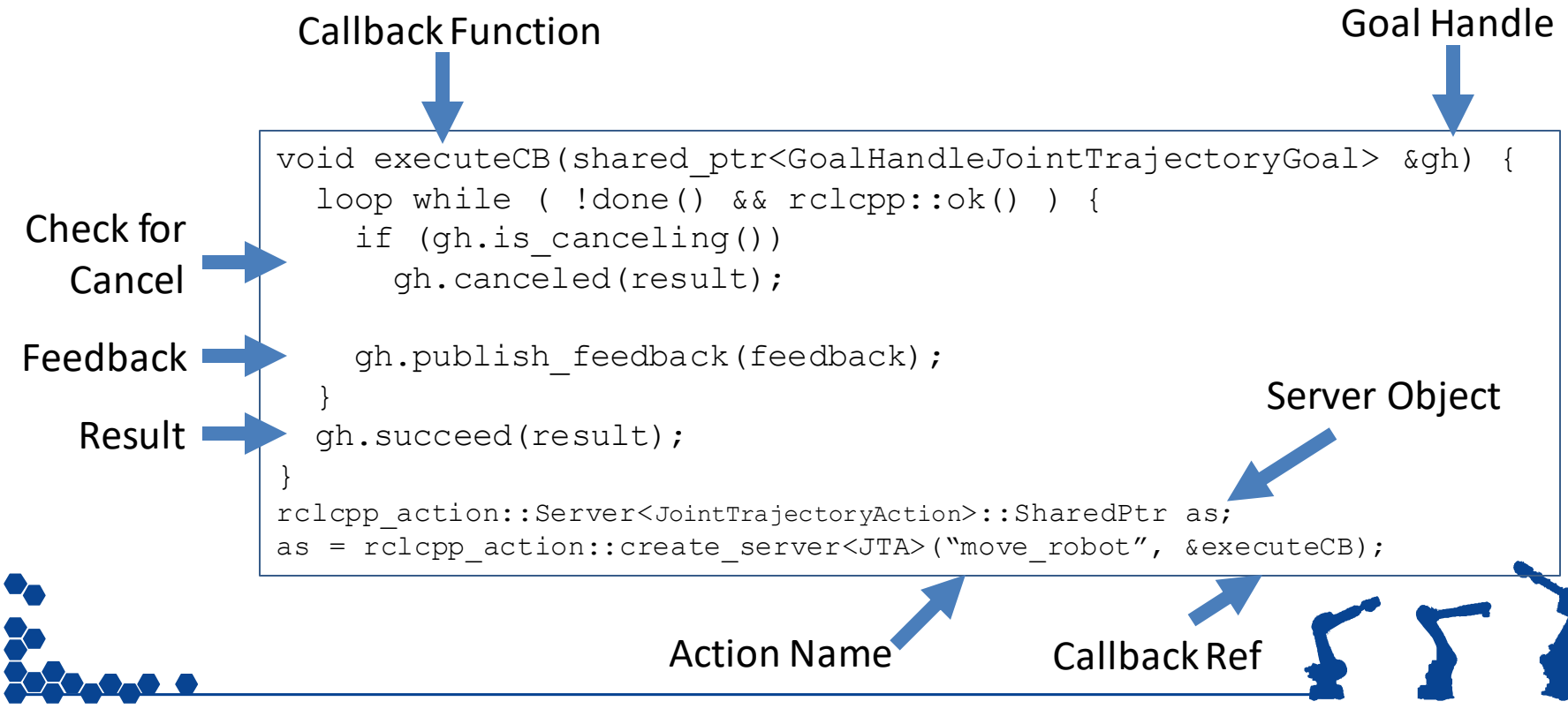
“Real World” – Actions

- FollowJointTrajectoryAction
  - command/monitor robot trajectories
  - use rqt_msg to view Goal, Result, Feedback

- Should be an Action…
  - GetMotionPlan
- Should not be an Action…
  - GripperCommandAction

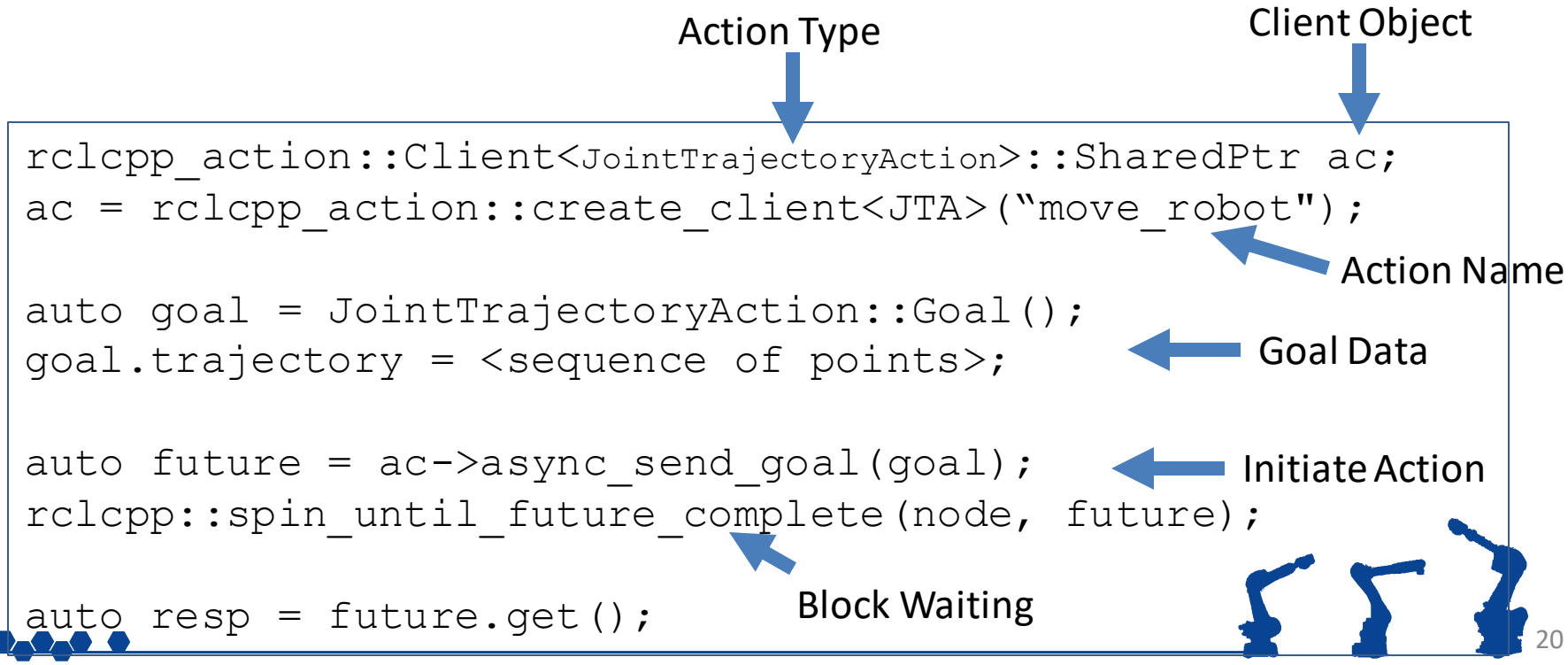
Action Server: Syntax

- Action **Server**
  - Defines **Execute Callback**
  - Periodically **Publish Feedback**
  - Advertises available action *(Name, Data Type)*



Action Client: Syntax

- Action **Client**
  - Connects to specific Action *(Name / Data Type)*
  - Fills in Goal data
  - Initiate Action / Waits for Result



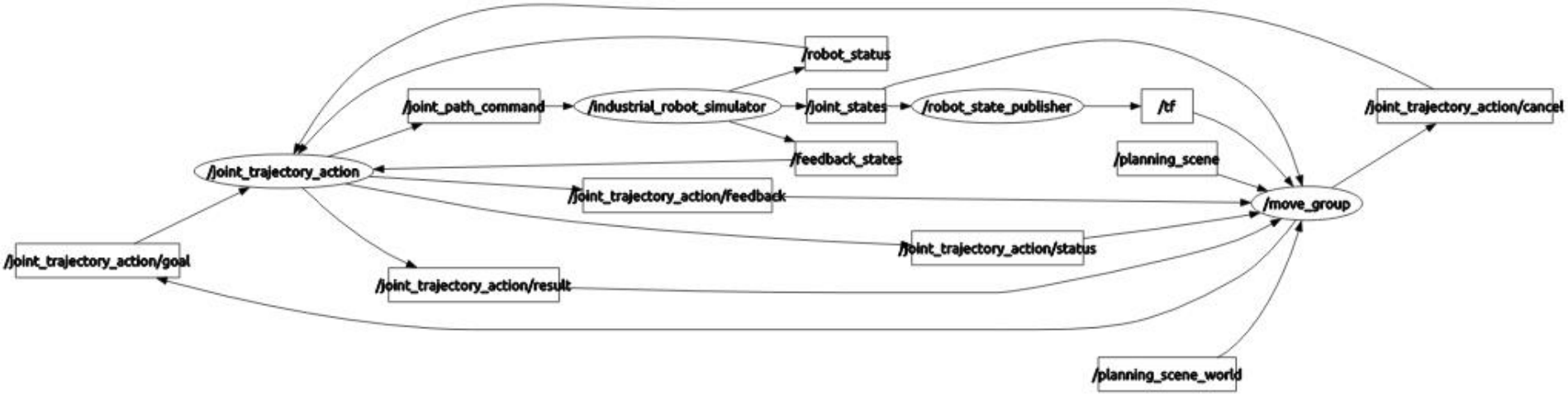
Message vs. Service vs. Action

Type	Strengths	Weaknesses
Message	•Good for most sensors (streaming data) •One - to - Many	•Messages can be dropped without knowledge •Easy to overload system with too many messages
Service	•Knowledge of missed call •Well-defined feedback	•Connection typically re-established for each service call (slows activity)
Action	•Monitor long-running processes •Handshaking (knowledge of missed connection)	•Complicated

Launch Files

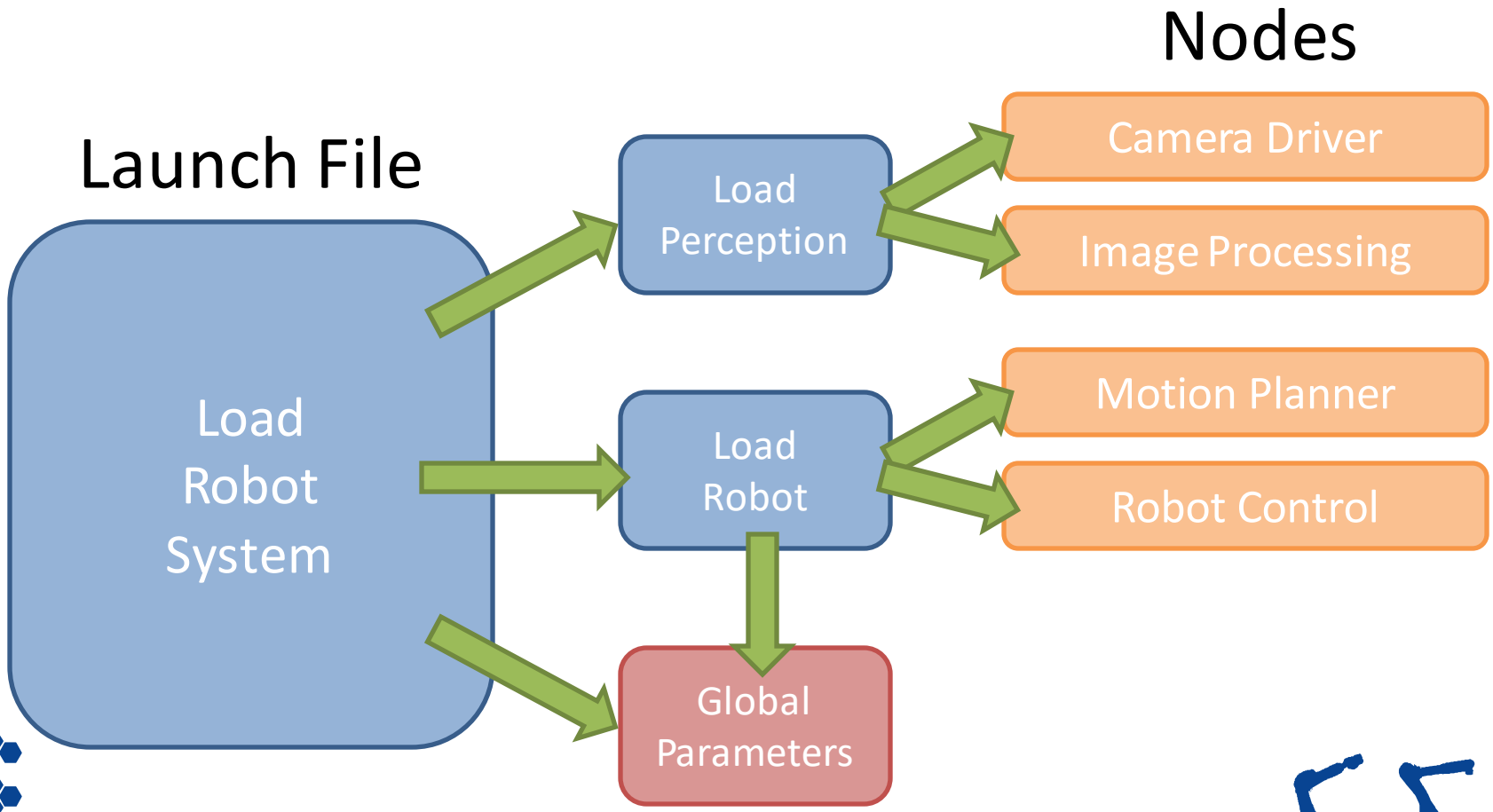
Launch Files: Motivation

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



Launch Files: Overview

Launch Files are like **Startup Scripts**



Launch Files: Overview

- Launch files automate system startup
- Python script for running nodes and setting parameters
  - Python preferred, but XML and YAML also supported
  - ROS1 Launch files are typically XML
- Ability to pull information from other packages
  - load parameter (or other) data
  - “include” other launch files

Launch Files: Python

- Script returns a list of launch **actions**
  - *Can use other Python logic to generate complex startup logic*

example.launch.py

```
import launch

def generate_launch_description():
  return launch.LaunchDescription(
  [
    <Action1>,
    <Action2>,
    ...
  ])
```

Launch Files: Actions

Common Actions

- **`Node`** - *launch a Node*
- **`IncludeLaunchDescription`** - *include other launch file*
- **`DeclareLaunchArgument`** - *define input arg*
- **`GroupAction`** - *define group of actions (e.g. for conditional)*
- **`TimerAction`** - *trigger action after a fixed period of time*

Launch Files: Node Action

launch_ros.actions.Node(

- **executable** – name of the executable file [REQUIRED]
- **package** – name of the package containing the executable
- **name** – unique name to assign to this node
- **namespace** – ROS namespace for this node
- **parameters** – node parameters to set (list of dictionaries or YAML filenames)
- **output** – control whether node output is echoed to the terminal window or not

```
launch_ros.actions.Node(
  package = "usb_camera",
  executable = "camnode",
  name = "camera_1",
  parameters = [{'ip_addr', "192.168.1.1"}],
  output = 'screen',
)
```

Launch Files: Include

`launch.actions.IncludeLaunchDescription(`

- **`<1st arg>`** – absolute filename of the launch file to include [REQUIRED]
- **`launch_arguments`** – dictionary of launch-file arguments

```
launch.actions.IncludeLaunchDescription(
   PythonLaunchDescriptionSource(
      get_package_share_directory('turtlesim') + '/launch/multisim.launch.py'
   ),
   launch_arguments={}.items()
)
```

Launch Files: Arguments

launch.actions.DeclareLaunchArgument(

- **<1st arg>** – name of the input argument [REQUIRED]
- **default_value** – default value if no argument specified (makes this an OPTIONAL arg)
- **description** – user-friendly description of this argument

```
launch.actions.DeclareLaunchArgument(
    'ip_addr',
     default_value='192.168.1.1',
     description='IP address of the robot'
)

launch_ros.actions.Node(
   package = "abb_driver",
   executable = "abb_robot_state",
   parameters = [{'ip_addr', LaunchConfiguration('ip_addr')}],
)
```

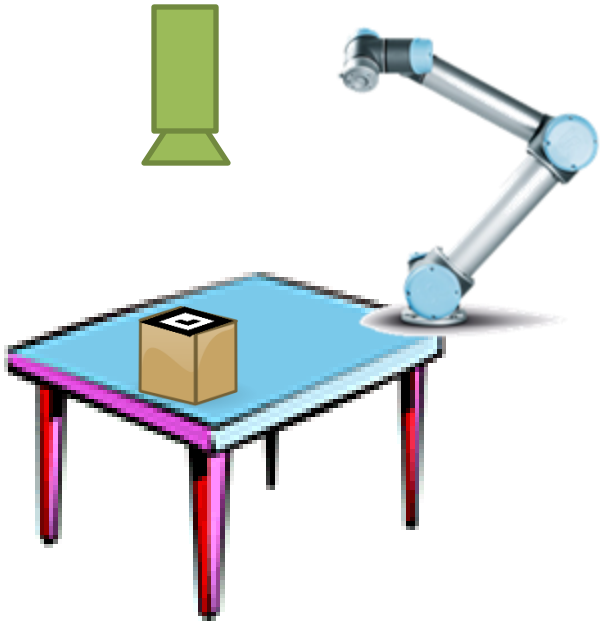
Launch Files: Advanced

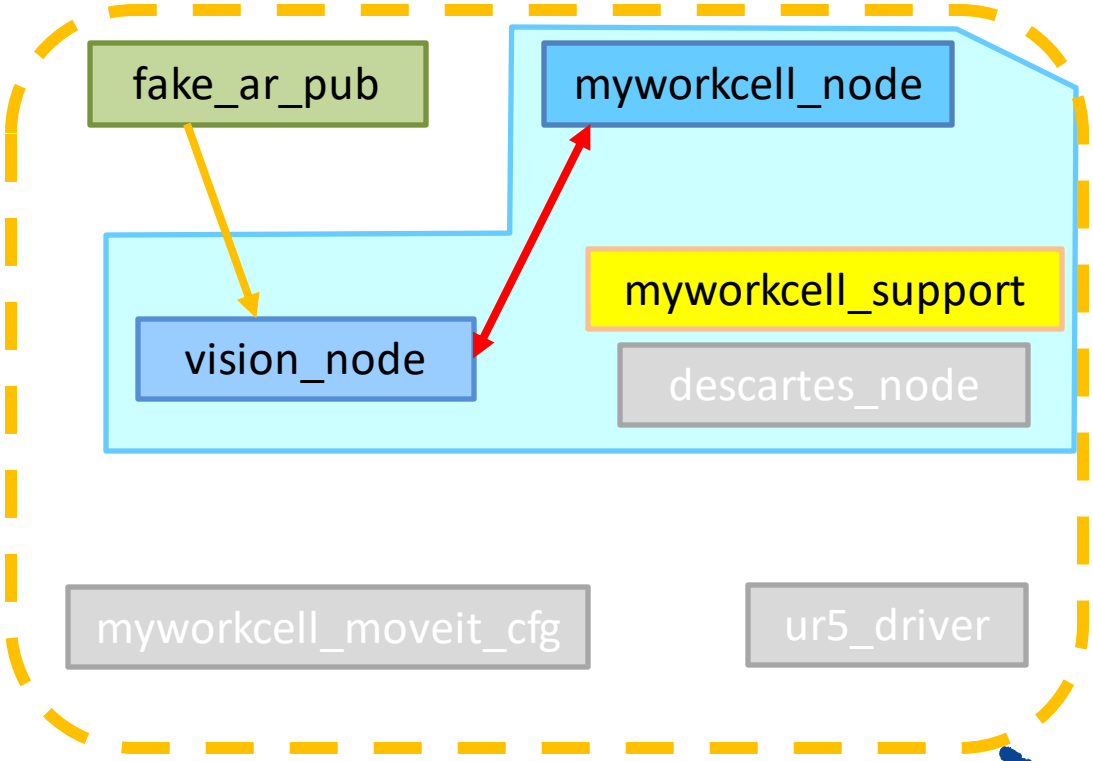
Advanced features

- **remappings** – topic/service name remapping (list of (“old”, “new”) tuples)
- **condition** – conditional expression for whether to launch this node or not
- **GroupAction** – define group of actions
- **TimerAction** – delay actions by a specified period

```
launch_ros.actions.Node(
  ...
  remappings = [('rgb', 'image')],
)

launch.actions.GroupAction(
  [
    Node(name='node1', ...),
    Node(name='node2', ...),
  ],
  condition = IfCondition(use_robot)
)

launch.actions.TimerAction(
   period=1.0,
   actions=[
     Node(name='imageProcessing', ...)
   ]
)
```

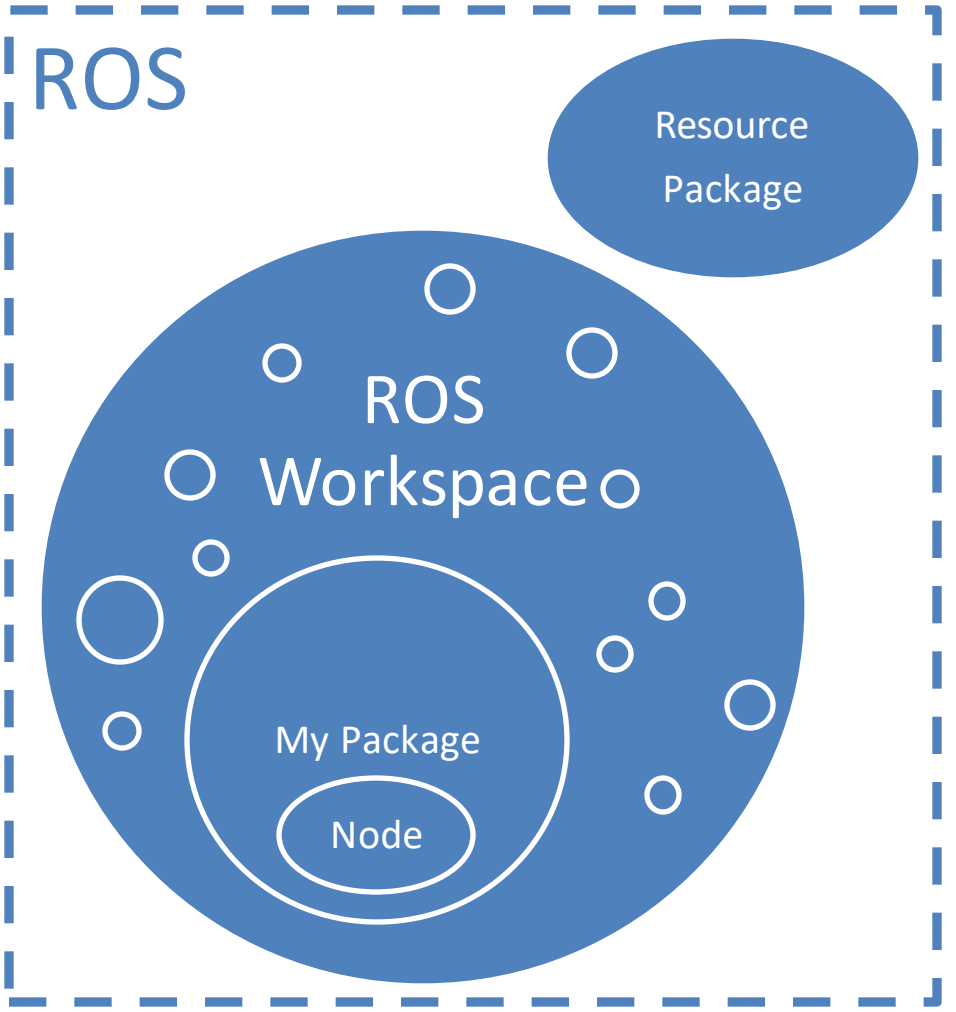
Exercise 2.2 - Launch Files





Day 1 Progression

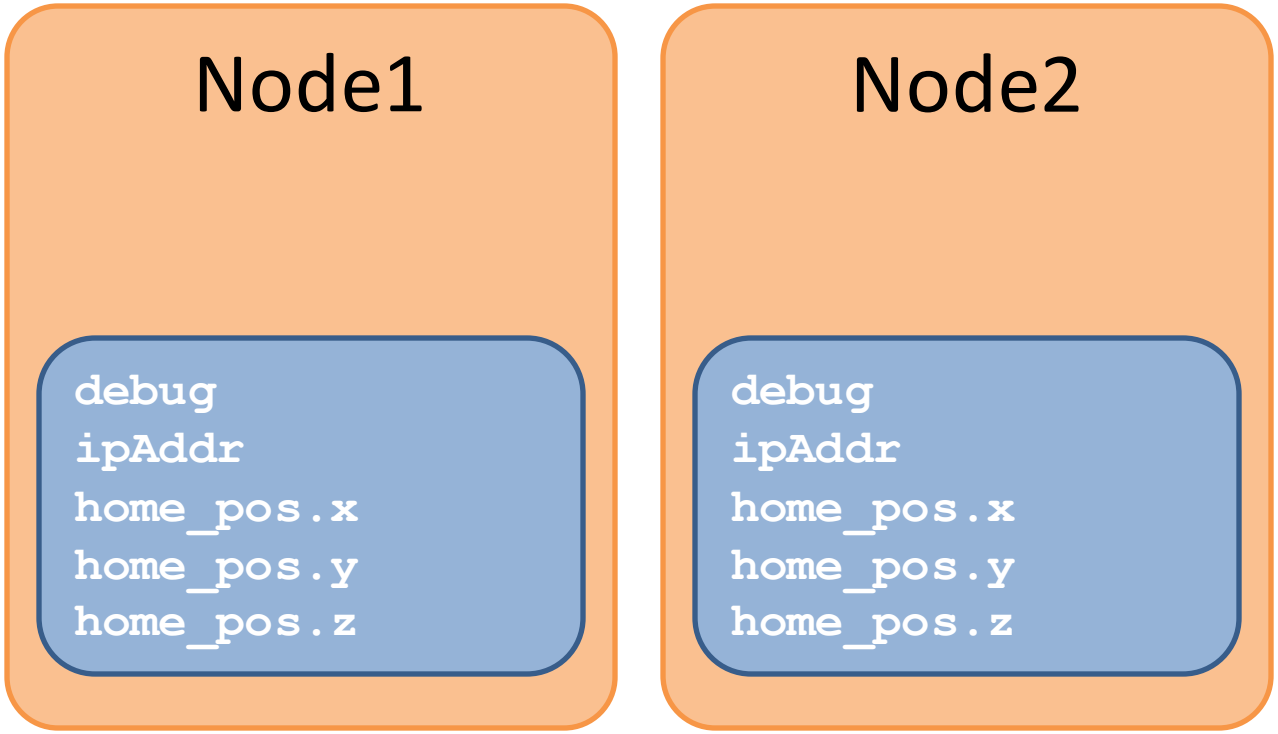
- ✓ Install ROS
- ✓ Create Workspace
- ✓ Add “resources”
- ✓ Create Package
- ✓ Create Node
  - ✓ Basic ROS Node
  - ✓ Interact with other nodes
    - ✓ Messages
    - ✓ Services
- ✓ Run Node
  - ✓ ros2 run
  - ✓ ros2 launch



Parameters

Parameters: Overview

Parameters are remotely-accessible **Global Data** associated with **each node**

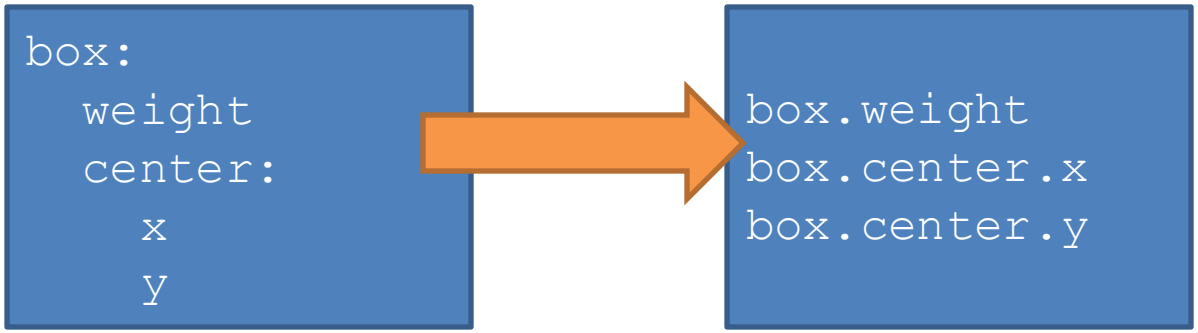


ROS Parameters

- Typically configuration-type values
  - robot kinematics
  - hardware config: IP Address, frame rate
  - algorithm limits / tuning
- Each Node manages its own parameters
  - can't get/set parameters when node is not running
- Parameter Notifications
  - typically parameters are loaded/read by nodes at startup
  - nodes can also register callbacks to get notified of parameter changes on-the-fly
  - this callback can also reject parameter changes, if invalid

Parameter Datatypes

- Native Types
  - *int, real, boolean, string*
- Lists (vectors)
  - *of single type: [1.1, 1.2, 1.3]*
- Dictionaries (structures)
  - *translated to "dot" naming hierarchy in node*



Setting Parameters

- YAML Files

```
manipulator_kinematics:
  solver: kdl_plugin/KDLKinematics
  search_resolution: 0.005
  timeout: 0.005
  attempts: 3
```

- Command Line

```
ros2 run my_pkg load_robot --ros-args -p ip:="192.168.1.21"
ros2 param set load_robot /debug true
```

- Programs

```
node->set_parameter(rclcpp::Parameter("name", "left"));
```

Parameter Commands

- **ros2 param**
  - ros2 param set <node> <key> <value>
  - ros2 param get <node> <key>
  - ros2 param delete <node> <key>
  - ros2 param list <node>
  - ros2 param dump <node>
  - ros2 param load <node> <file.yaml>

Parameters: C++ API

- Accessed through `rclcpp::Node` object
  - `node->declare_parameter<type>(key, default)`

    Declare parameter for this node (with default value)
  - `node->get_parameter(key).as_int()`

    Gets value. Must use helper method to convert to std type.
  - `node->set_parameter(rclcpp::Parameter(<key>,<value>))`

    Sets value. Need to construct the Parameter object.

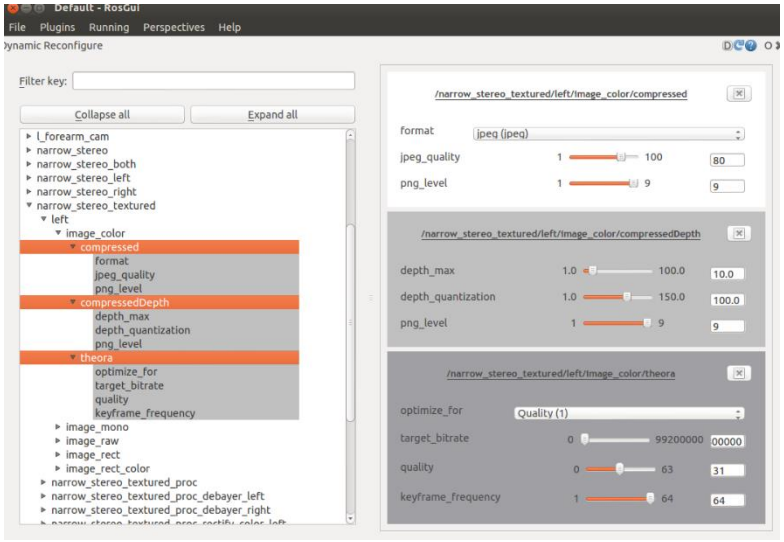
- This API requires you to explicitly read param values
  - no on-the-fly updating
  - typically read only when node first started

Dynamic Parameters

- For dynamic params: register a callback

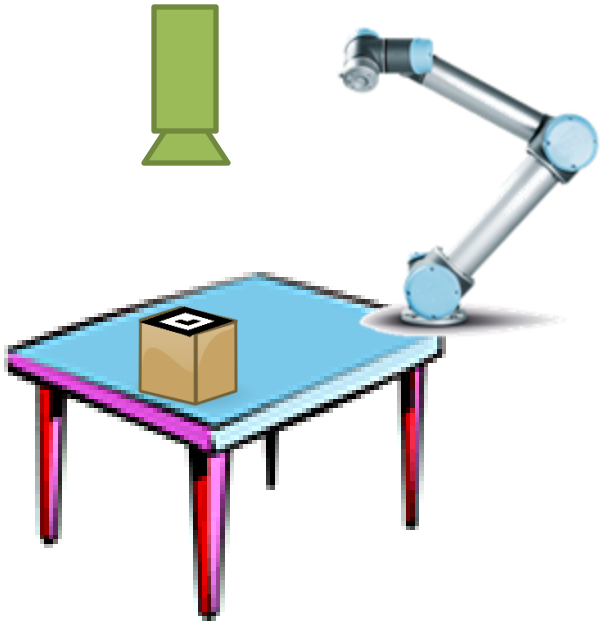
```
SetParametersResult paramCB(const vector<Parameter> &params)
{
  // loop over changed params
  // react to those changes (save to local vars, push to h/w)
  // set result.successful to accept/reject changes
}

this->set_on_parameters_set_callback(&paramCB);
```

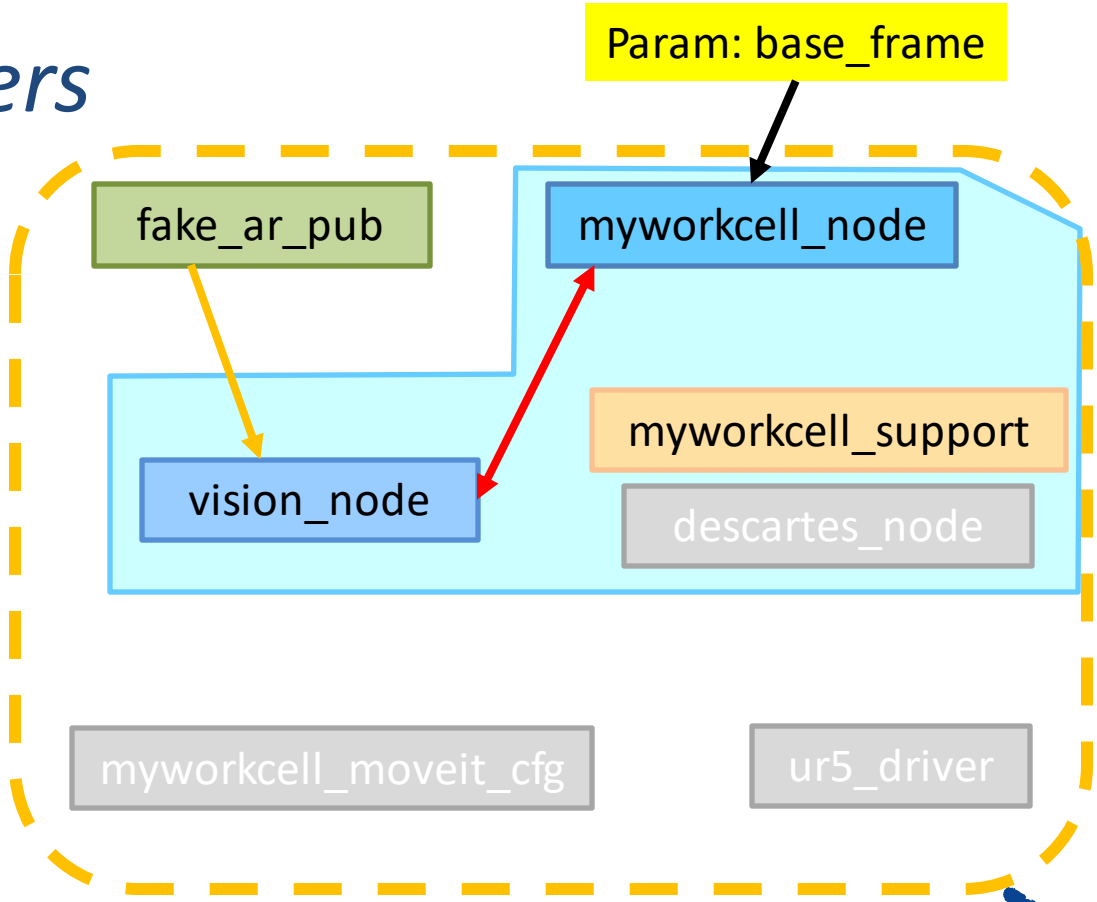
rqt_reconfigure GUI



Exercise 2.3

ROS Parameters





Review/Q&A

Session 1

Intro to ROS

Installing ROS/Packages

Packages

Nodes

Messages/Topics

Session 2

Services

Actions

Launch Files

Parameters