ROS-Industrial Basic Developer's Training Class

October 2021

Southwest Research Institute

Session 2:
ROS Basics Continued

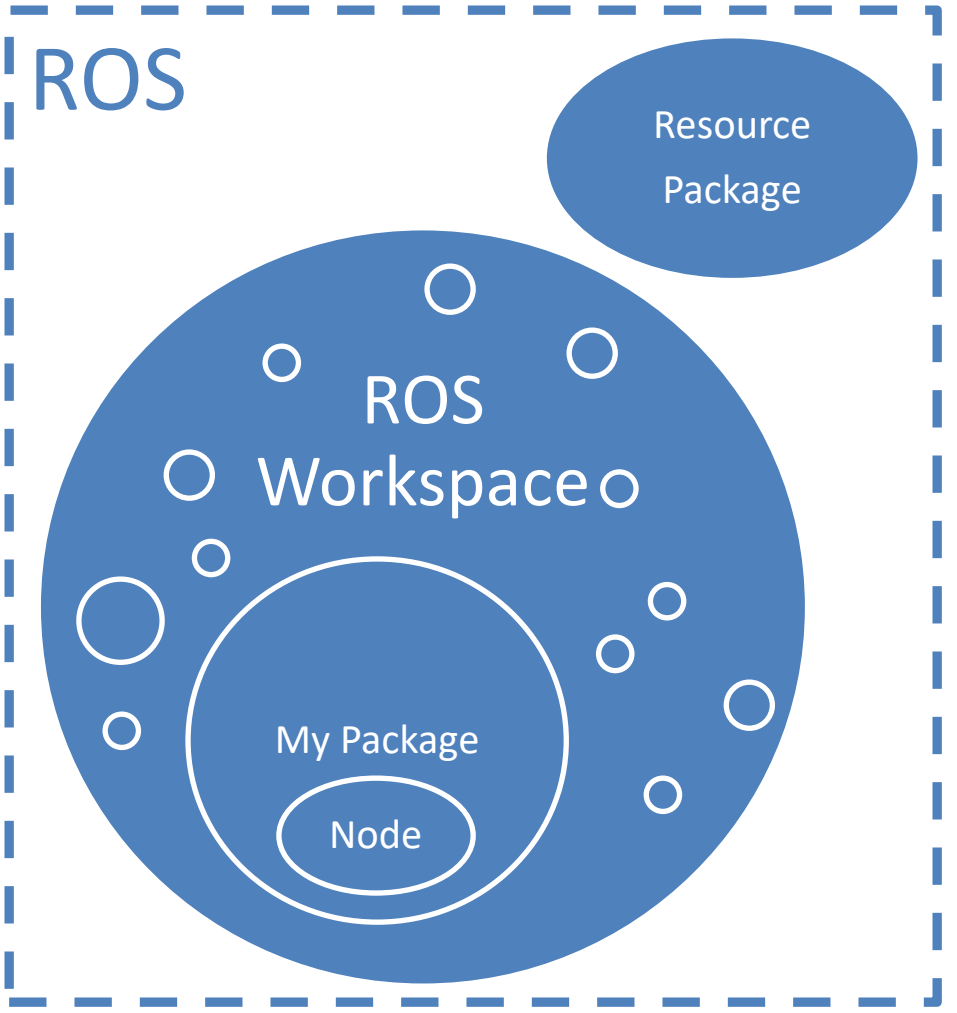
Southwest Research Institute

Outline

- Services
- *Actions*
- Launch Files
- Parameters

Day 1 Progression

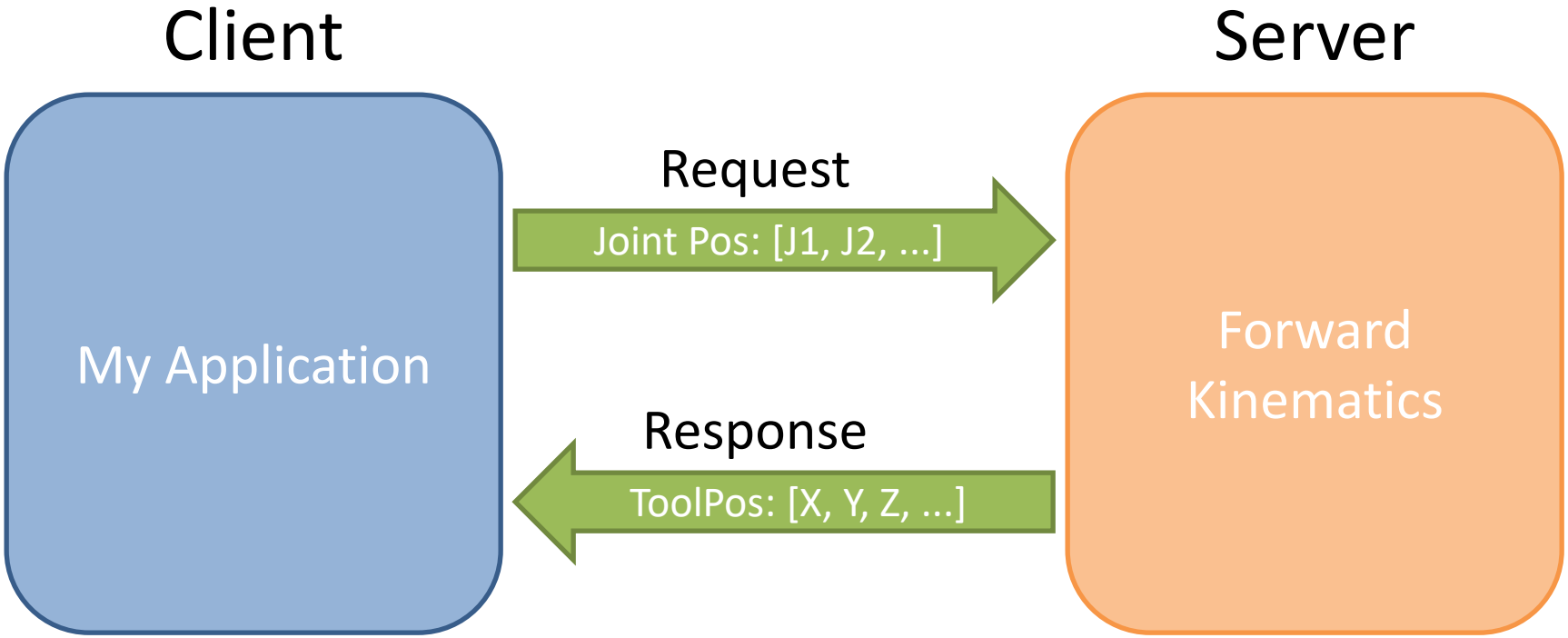
- ✓ Install ROS
- ✓ Create Workspace
- ✓ Add “resources”
- ✓ Create Package
- ✓ Create Node
  - ✓ Basic ROS Node
  - ✓ Interact with other nodes
    - ✓ Messages
    - ❑ Services
- ✓ Run Node
  - ✓ ros2 run
  - ❑ ros2 launch



Services

Services : Overview

Services are like **Function Calls**

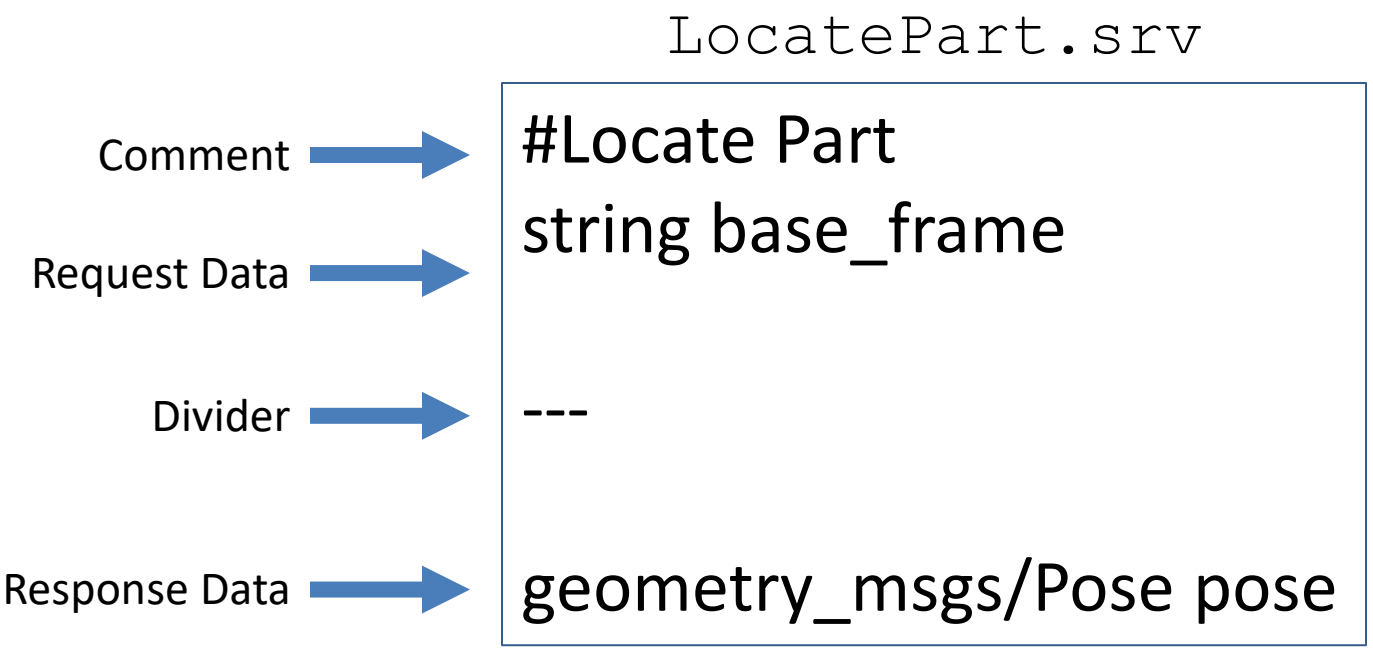


Services: Details

- Each Service is made up of 2 components:
  - *Request* : sent by **client**, received by **server**
  - *Response* : generated by **server**, sent to **client**
- Usually the client **blocks** when calling a service
  - ROS2 Service Calls are **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.

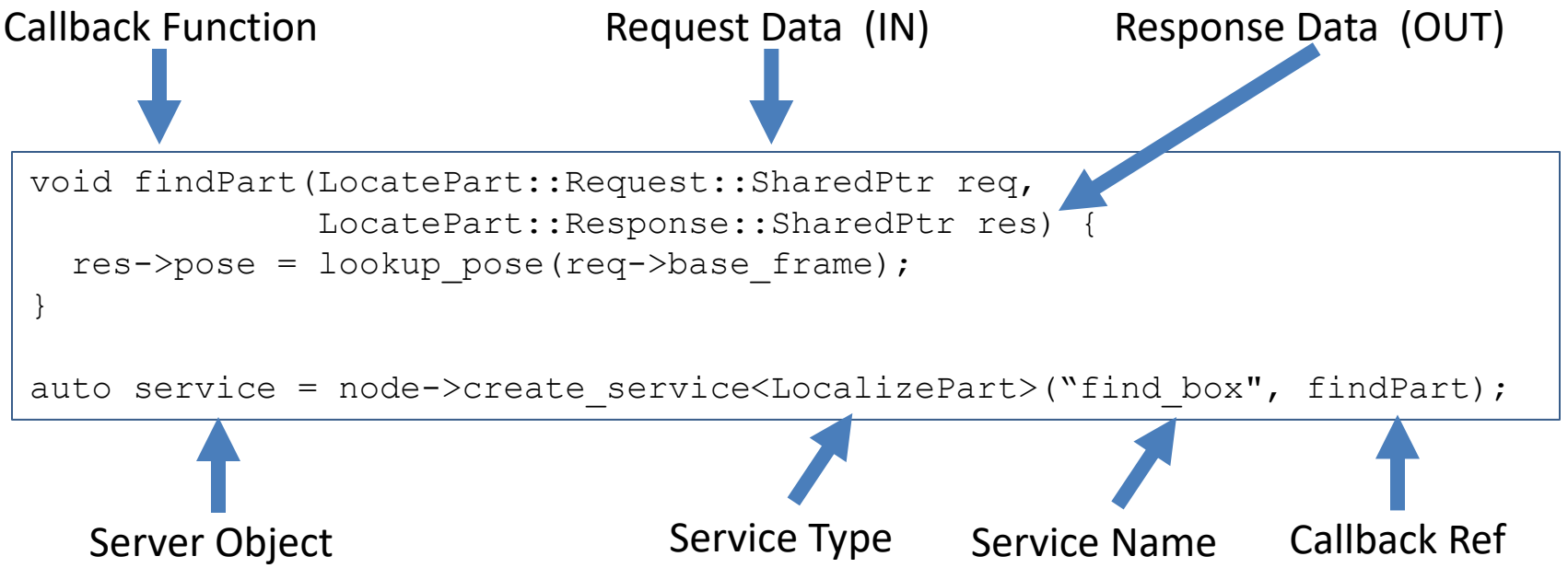


“Real World” – Services

- 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

Client Object

Service Type

Service Name

```
auto client = node->create_client<LocatePart>("find_box");

auto req = make_shared<LocatePart::Request>();
req->base_frame = "world";

auto future = client->async_send_request(req);
rclcpp::spin_until_future_complete(node, future);

auto resp = future.get();
RCLCPP_INFO_STREAM(node->get_logger(), "Response: " << resp);
```

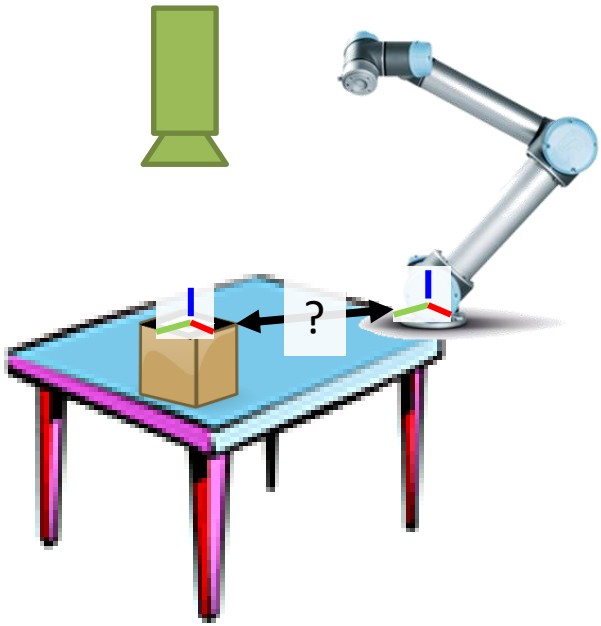
Service Request

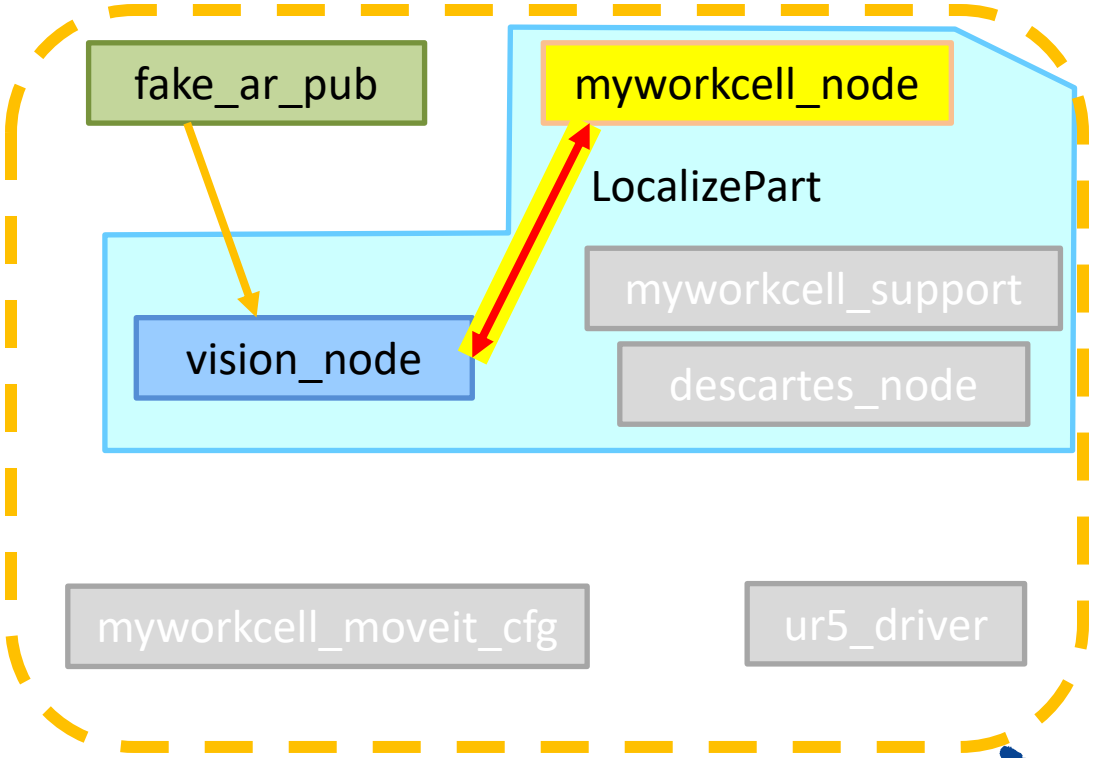
Call Service
(and wait for response)

Service Response

Exercise 2.0

Creating and Using a Service





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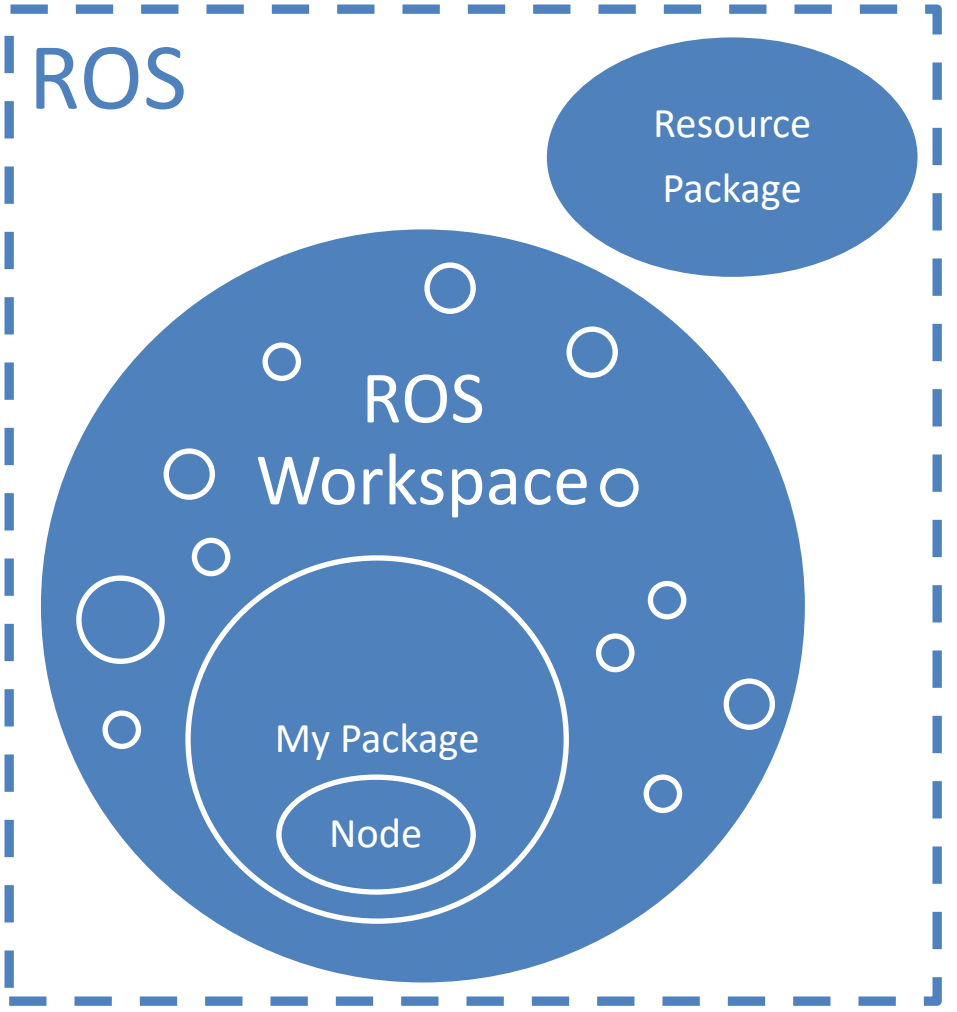
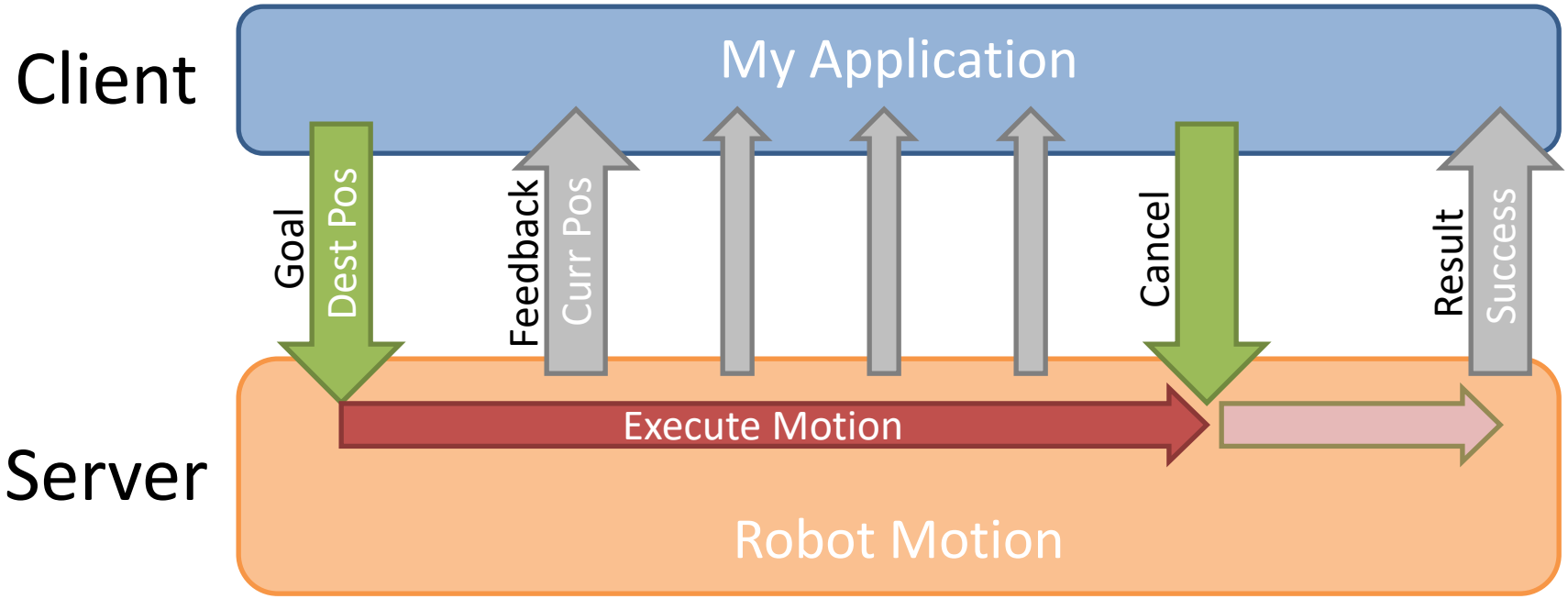


Actions

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.

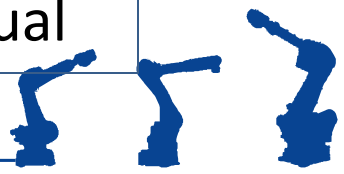
`FollowJointTrajectory.action`

```
# 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 →



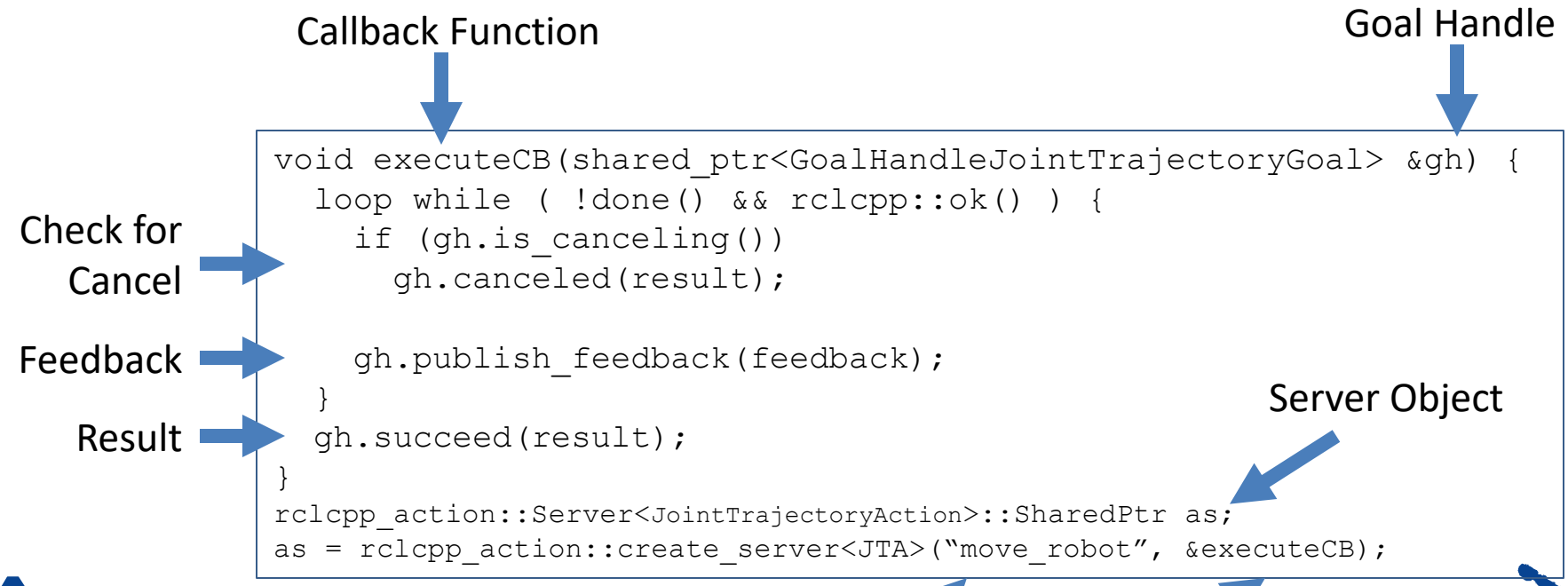
“Real World” – Actions

- 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)*

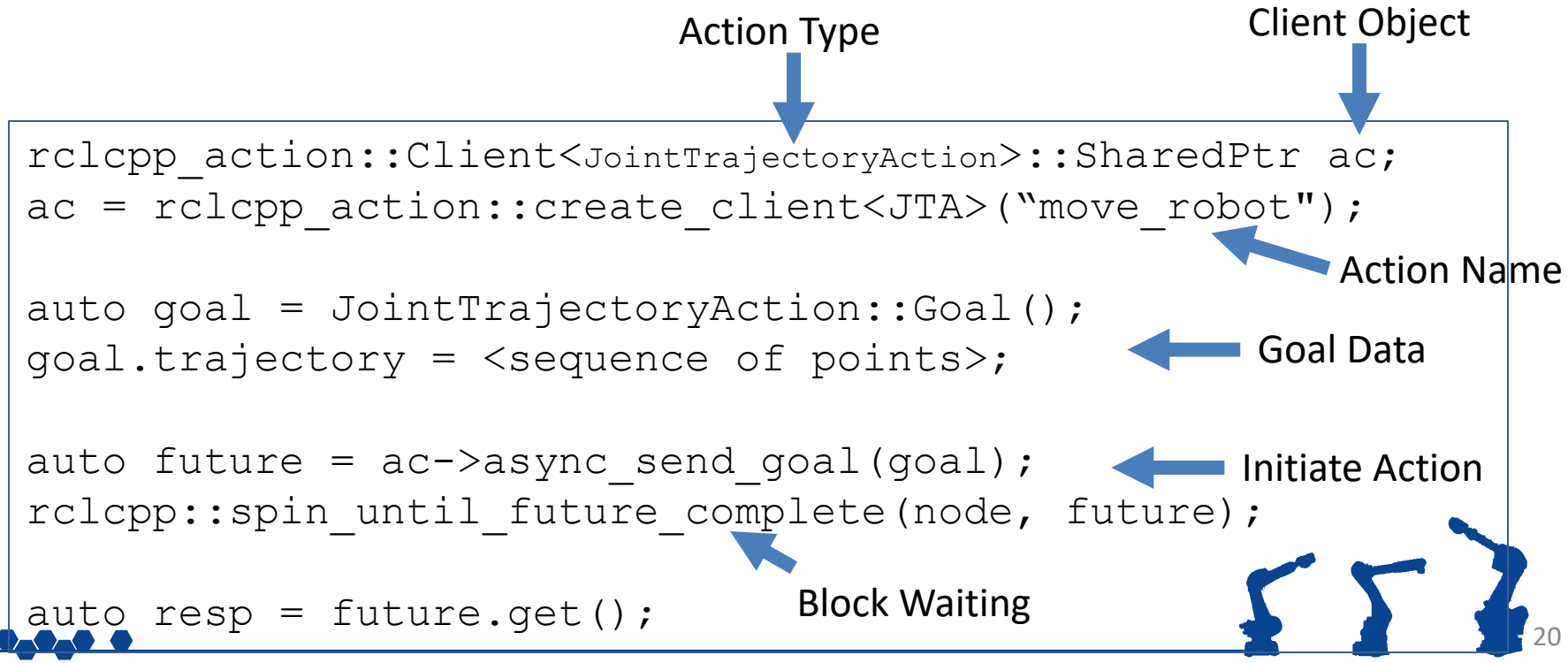



```
void executeCB(shared_ptr<GoalHandleJointTrajectoryGoal> &gh) {
  loop while ( !done() && rclcpp::ok() ) {
    if (gh.is_canceling())
      gh.canceled(result);

    gh.publish_feedback(feedback);
  }
  gh.succeed(result);
}
rclcpp_action::Server<JointTrajectoryAction>::SharedPtr as;
as = rclcpp_action::create_server<JTA>("move_robot", &executeCB);
```

Action Client: Syntax

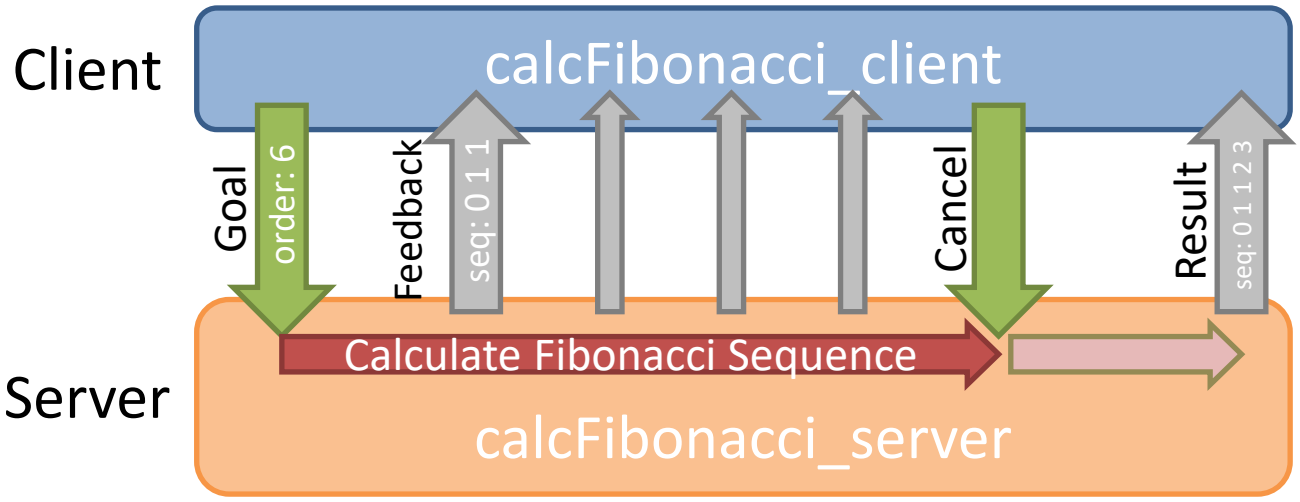
- Action **Client**
  - Connects to specific Action *(Name / Data Type)*
  - Fills in Goal data
  - Initiate Action / Waits for Result



Exercise 2.1

Creating and Using an Action

We'll skip this exercise.
Work through it on your own time later, if desired.



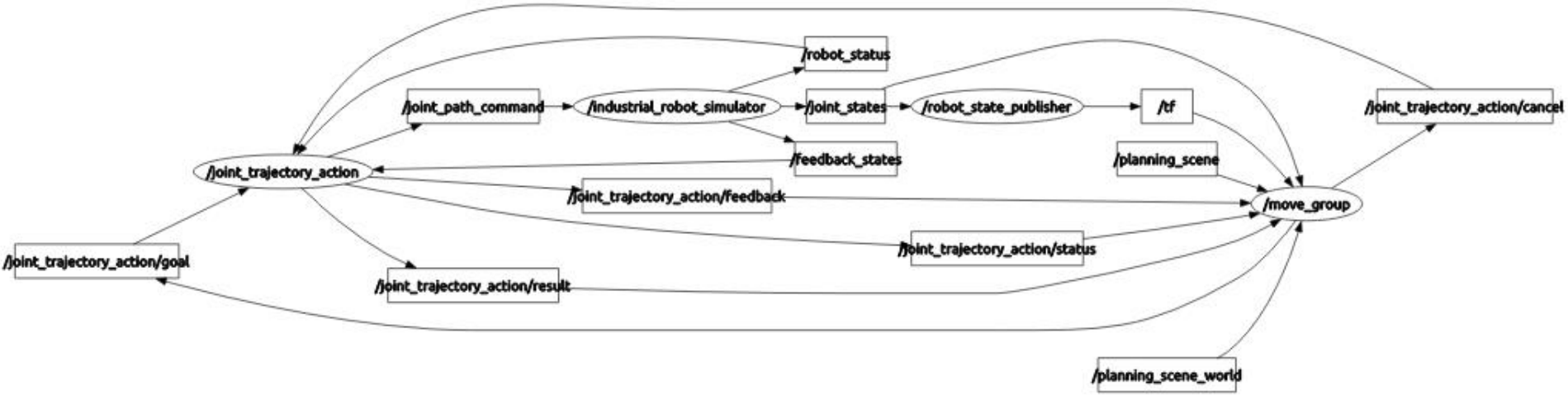
Message vs. Service vs. Action

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

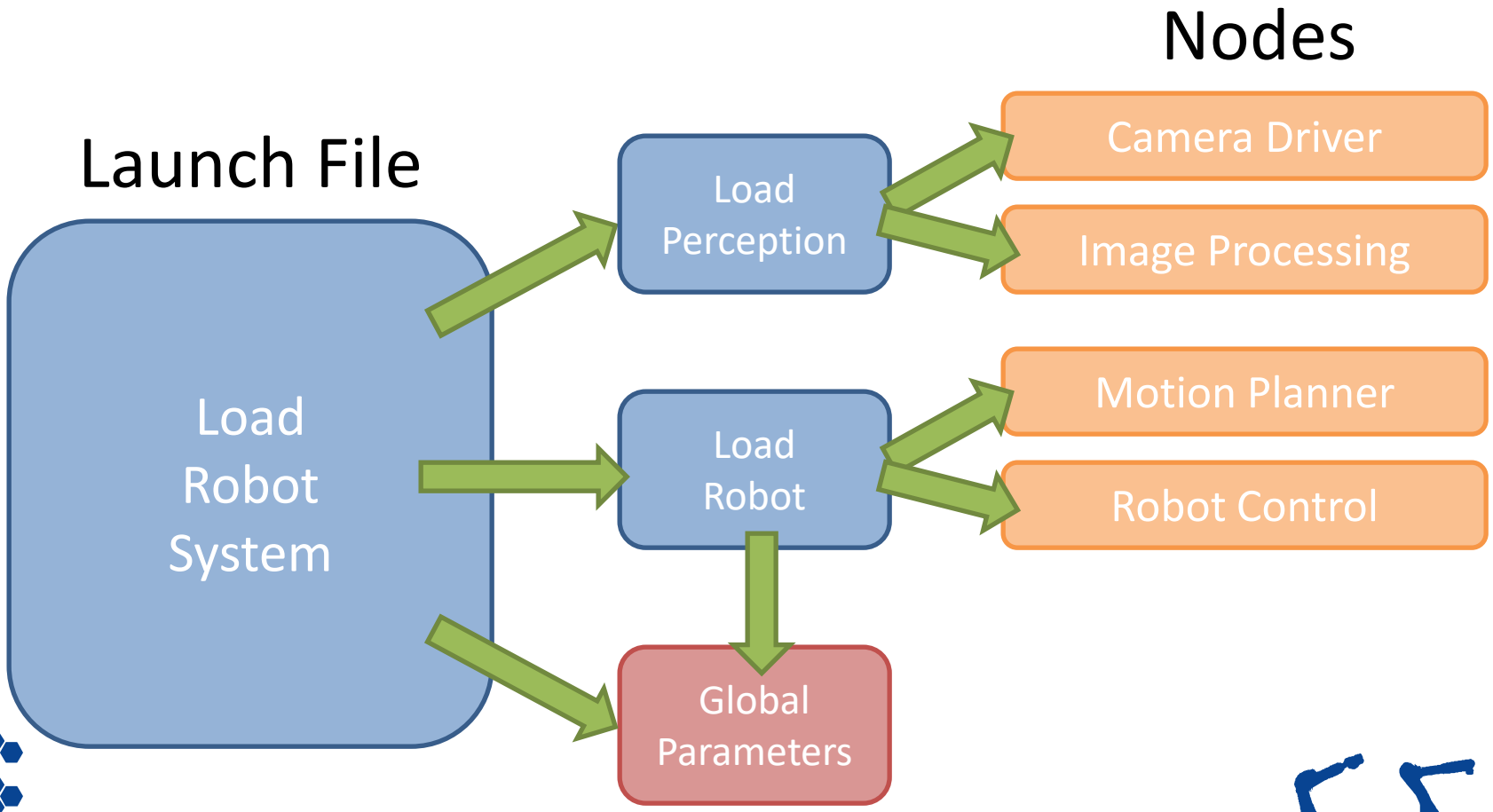
Launch Files: Motivation

- 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

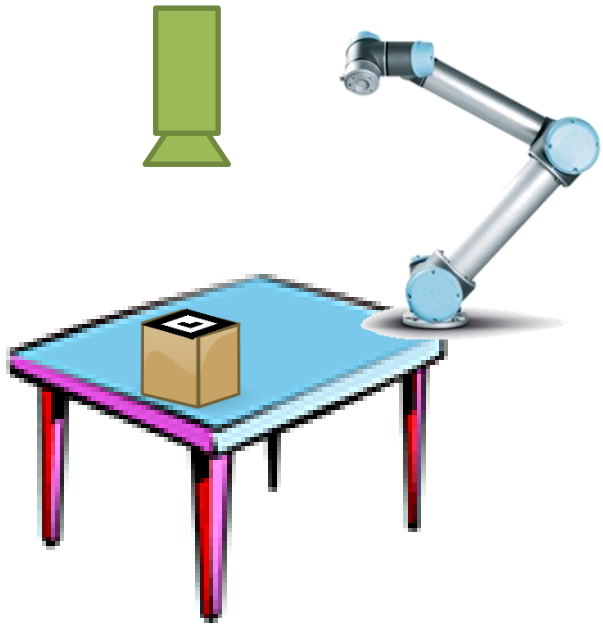
- **remappings** – topic/service name remapping (list of (“old”, “new”) tuples)
- **condition** – conditional expression for whether to launch this node or not
- **GroupAction** – define group of actions
- **TimerAction** – delay actions by a specified period

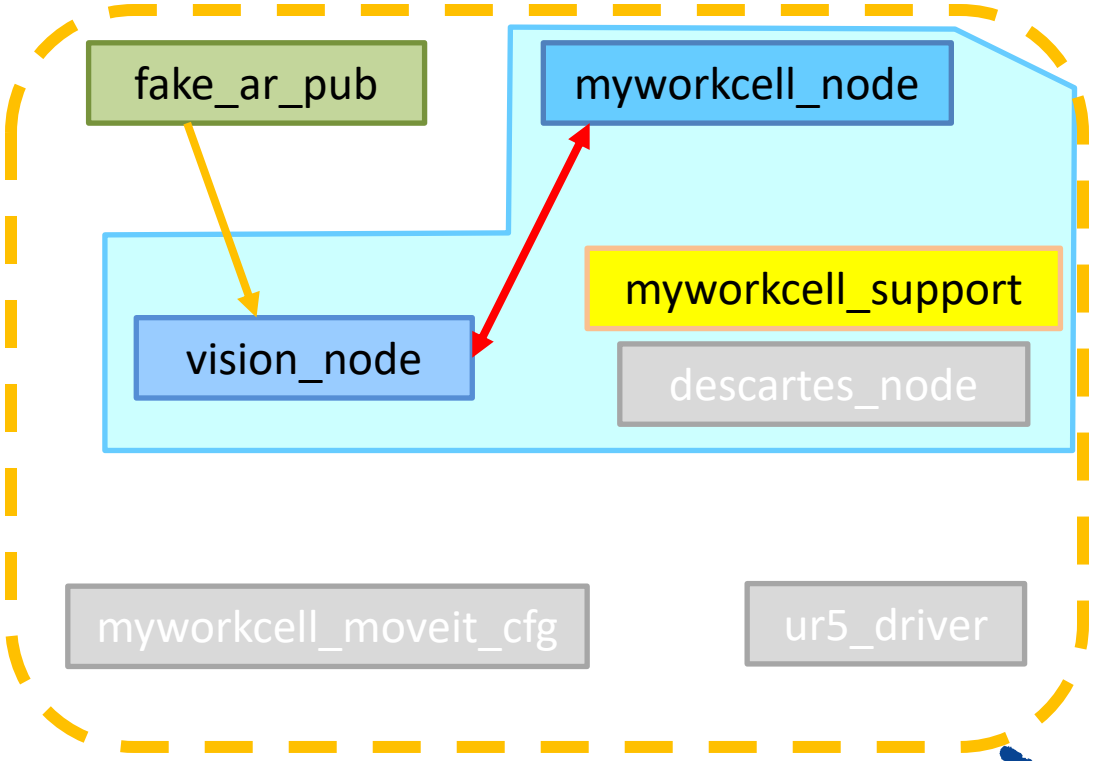
```
launch_ros.actions.Node(
  ...
  remappings = [('rgb', 'image')],
)

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





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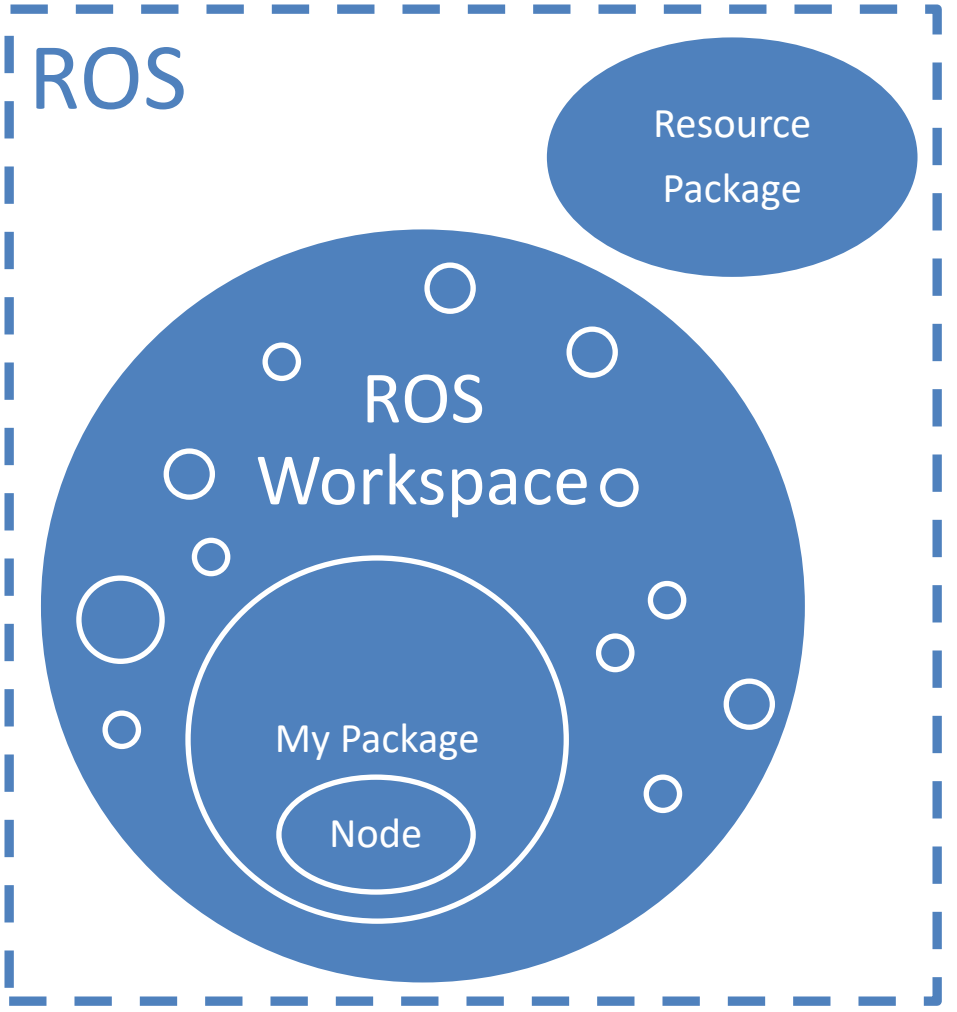
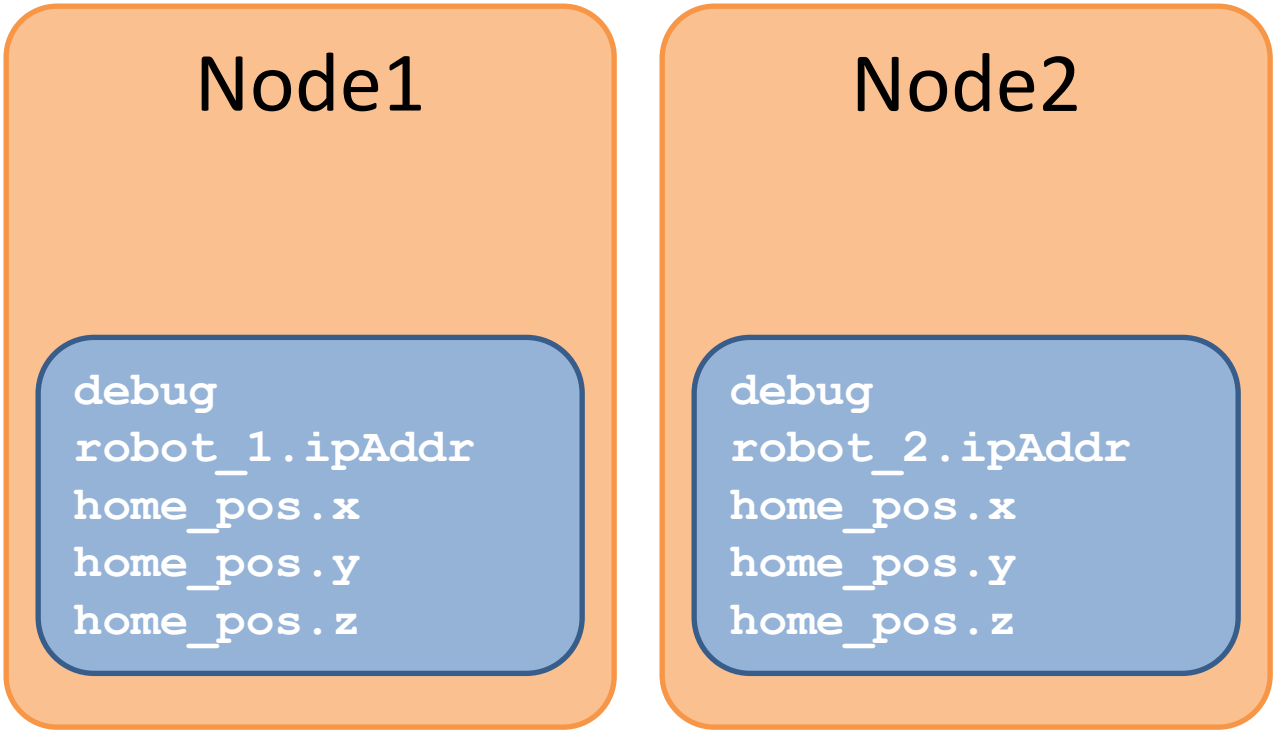


Parameters

Parameters: Overview

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

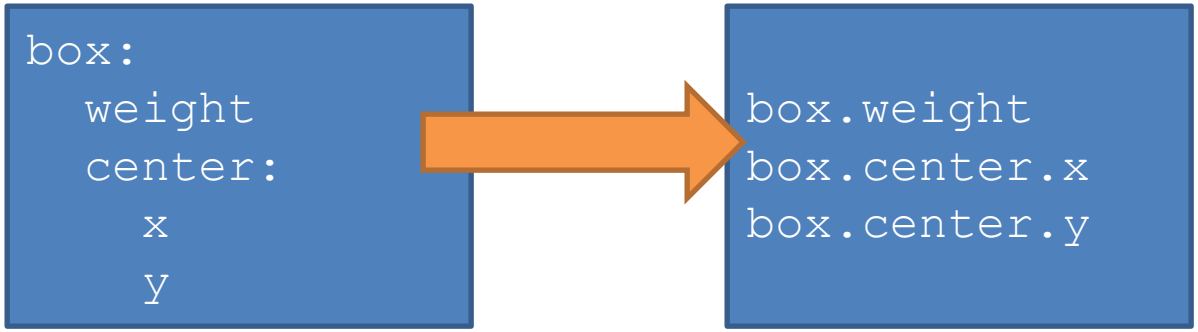


ROS Parameters

- 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.

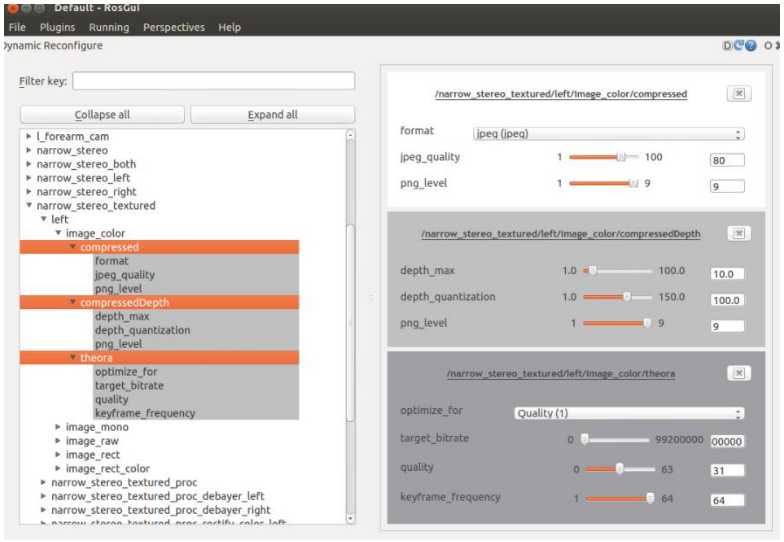
- This API requires you to explicitly read param values
  - no on-the-fly updating
  - typically read only when node first started

Dynamic Parameters

- For dynamic params: register a callback

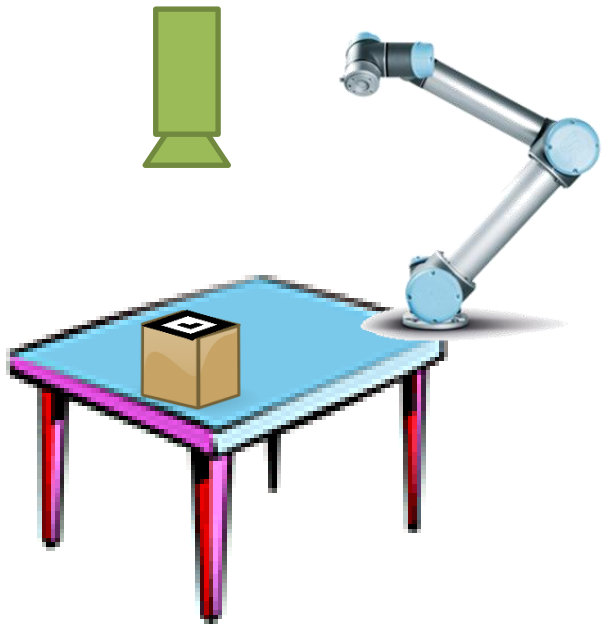
```
SetParametersResult paramCB(const vector<Parameter> &params)
{
  // loop over changed params
  // react to those changes (save to local vars, push to h/w)
  // set result.successful to accept/reject changes
}

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

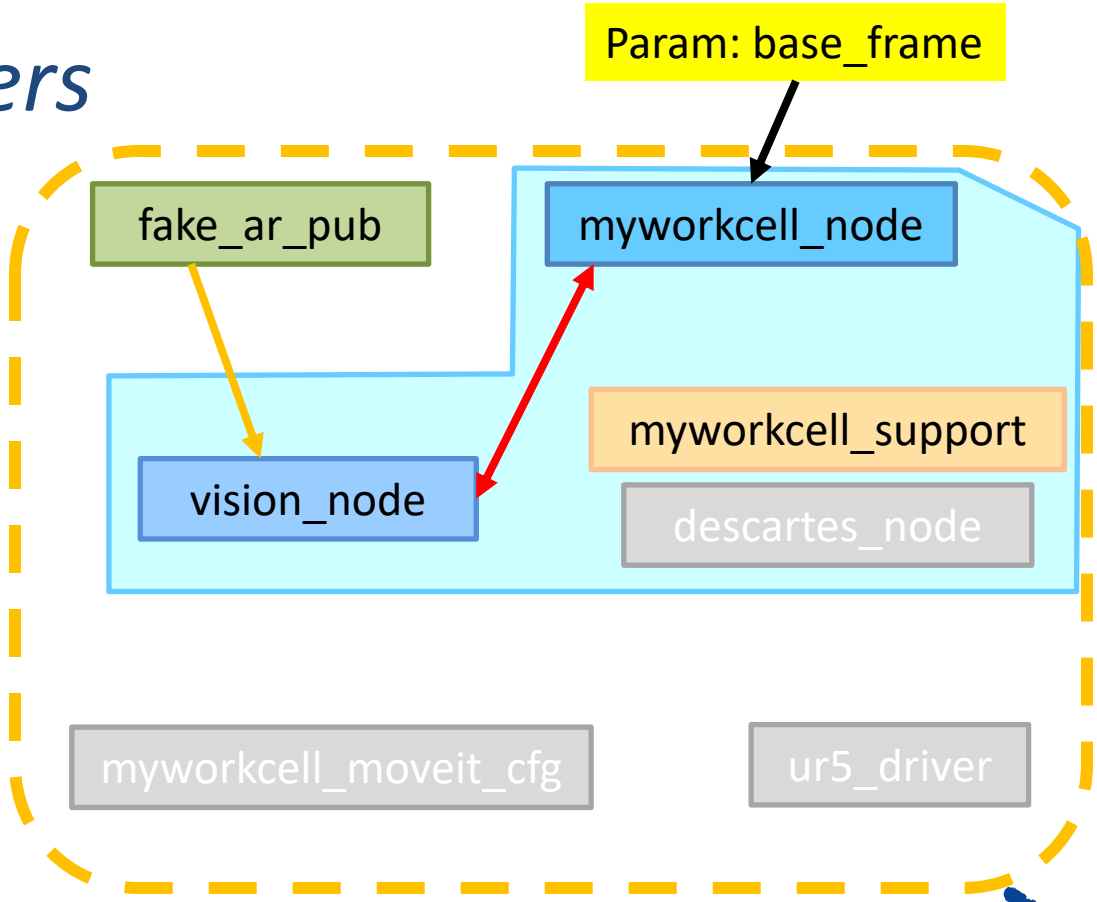
rqt_reconfigure GUI



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