March 2020

ROS-INDUSTRIAL DEVELOPER'S MEETING

Presenters: Erik Unemyr, Consortium Manager
Dr. Dejanira Araiza, Technical Lead
Bey Hao Yun, Development Engineer
Date: 10th March 2020

Agenda

- 09.00-09.10 Introduction
- 09.10-09.20 Key Updates from Asia Pacific Consortium
- 09.20-09.30 Technical Presentation – PackML
- 09.30-09.40 Technical Presentation – Robotic Vision Integration Pipeline
- 09.40-10.00 Community Discussion

The Advanced Remanufacturing and Technology Centre

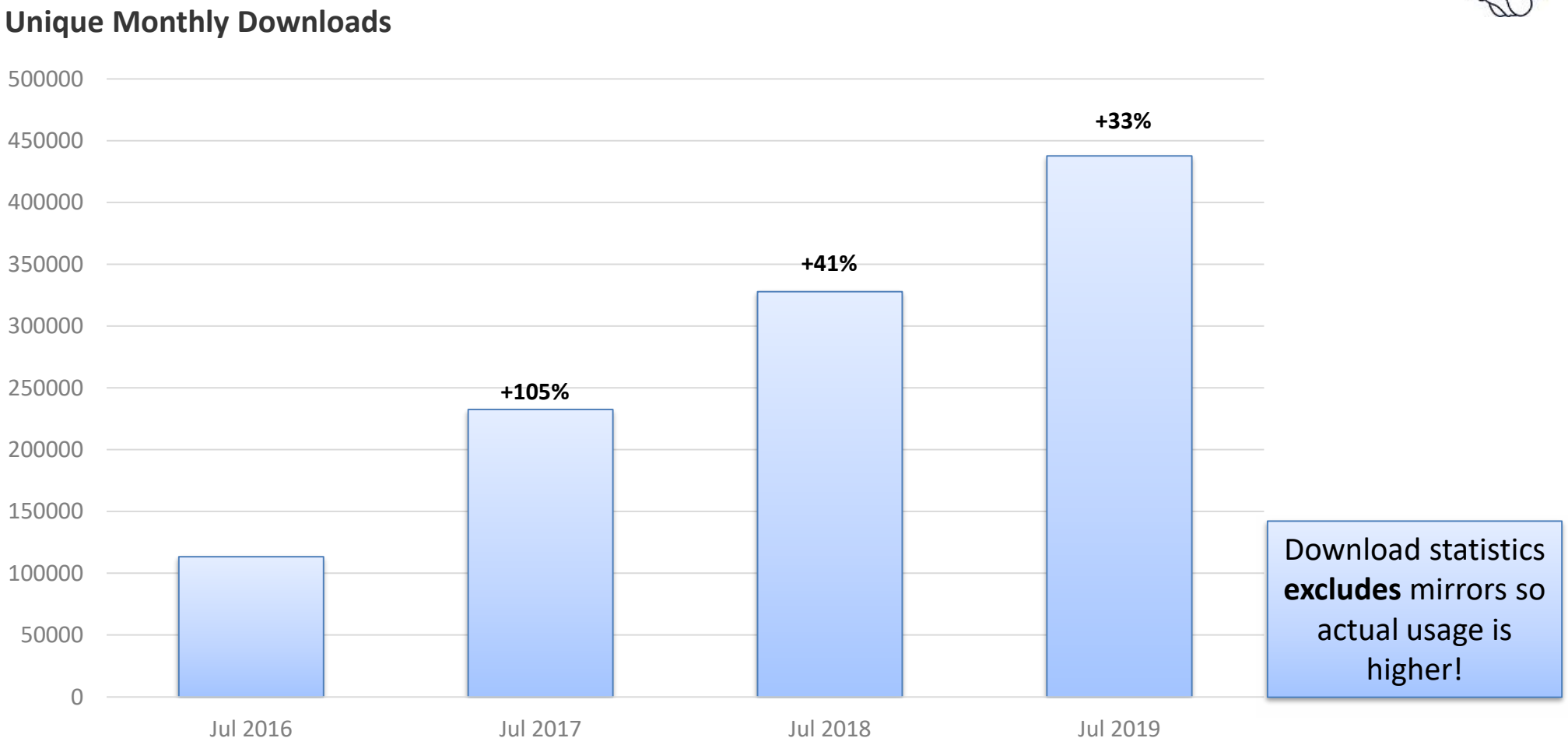
Leading Public-Private Partnership Research Centre in Asia

- Bridging the gap between Research and Industry
- Focus in Developing Advanced Manufacturing and Remanufacturing Capabilities
- Co-Create and Value Capture with Industry through the Implementation of Solutions

Cleantech Park: Courtesy of JTC

Key Updates from Asia Pacific Consortium

ROS Growth Trend



Reaching towards 0.5 million unique downloads per month

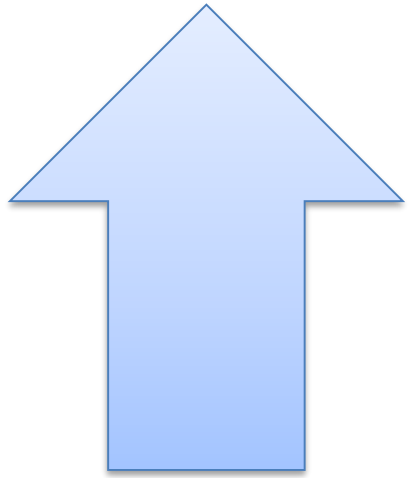
Source: Open Robotics ROS Metrics Reports 2016-2019

ROS Growth Trend

Unique monthly Wiki visitors Jul 2018 → Jul 2019

1.	United States	34,710 (19.08%)
2.	China	31,946 (17.56%)
3.	Japan	15,518 (8.53%)
4.	Germany	12,711 (6.99%)
5.	India	8,400 (4.62%)
6.	Philippines	7,235 (3.98%)
7.	South Korea	6,790 (3.73%)
8.	United Kingdom	4,325 (2.38%)
9.	Taiwan	4,233 (2.33%)
10.	France	3,725 (2.05%)
11.	Canada	3,354 (1.84%)
12.	Spain	2,955 (1.62%)
13.	Singapore	2,842 (1.56%)
14.	Italy	2,744 (1.51%)
15.	Russia	2,465 (1.35%)
16.	Indonesia	2,461 (1.35%)
17.	Australia	2,436 (1.34%)
18.	Brazil	2,231 (1.23%)
19.	Hong Kong	2,147 (1.18%)
20.	Turkey	1,928 (1.06%)

1.	China	41,357 (19.88%)
2.	United States	36,531 (17.56%)
3.	Japan	19,738 (9.49%)
4.	Germany	15,525 (7.46%)
5.	South Korea	9,382 (4.51%)
6.	India	9,345 (4.49%)
7.	United Kingdom	4,972 (2.39%)
8.	Taiwan	4,856 (2.33%)
9.	France	4,056 (1.95%)
10.	Canada	3,854 (1.85%)
11.	Singapore	3,516 (1.69%)
12.	Italy	3,464 (1.66%)
13.	Russia	3,207 (1.54%)
14.	Australia	3,114 (1.50%)
15.	Spain	3,080 (1.48%)
16.	Hong Kong	2,941 (1.41%)
17.	Brazil	2,548 (1.22%)
18.	Turkey	2,253 (1.08%)
19.	Netherlands	1,822 (0.88%)
20.	Poland	1,820 (0.87%)



- 8 APAC countries in top 20
- APAC user base grew 12% YoY

- China now number #1 ROS user
- China user base grew 29% YoY

- Japan user base grew 27% YoY

Source: Open Robotics ROS Metrics Reports 2018-2019

Consortium Membership

- Currently 17 members in Asia Pacific (and over 70 worldwide):

ADLINK Leading EDGE COMPUTING
NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE
BLUE OCEAN ROBOTICS - for humans
Johnson & Johnson
KONICA MINOLTA
M8M
OMRON
Panasonic
PEPPERL+FUCHS
REPUBLIC POLYTECHNIC
SIAA
SINGAPORE POLYTECHNIC SP
Tokyo Opensource Robotics Kyokai
TONY ROBOTICS
UniTech
Woodside
YOKOGAWA

Asia Pacific Workshop 2020 - Postponed

- Originally scheduled for May 20-21st this year, we have are postponing the ROS-Industrial Asia Pacific Workshop for the time being, due to the on-going COVID-19 situation. **We will be announcing updates on our key events and activities through our e-mail distribution list.**

See you later this year at Asia's leading Open Source robotics event!

ROS Developer's Training

- We will publish and open for registration our training sessions for 2020 soon – stay tuned for the official announcement. Our tentative training schedule is:

Run	Date	Additional Notes
1	Mon 11 May – Thu 15 May	Member's Only Run
2	Mon 1 Jun – Thurs 4 Jun	
3	Mon 24 Aug – Thurs 27 Aug	
4	Mon 21 Sep – Thurs 24 Sep	Member's Only Run
5	Mon 12 Oct – Thurs 15 Oct	
6	Mon 7 Dec – Thurs 10 Dec	

Leading ROS 2.0 Development Programme

Development of **industry-grade ROS 2.0 components** addressing common pain points and needs by the industry:

Advanced Perception

- Object detection, classification, tracking and accurate positioning module

Smart Manipulation

- Flexible and fast grasping library that works with many different types of end effectors
- Integrated collision avoidance

Unified Robotic Communication (Interoperability)

- Allows for robots of different brands to interoperate seamlessly together within an environment and communicate with building infrastructure and equipment

Intelligent Navigation

- Porting of I2R's navigation stack to ROS 2
- Integrated obstacle avoidance

Robotics Middleware Framework (RMF) for Industry

- **Project Overview**
  - ROS-Industrial Consortium and Open Robotics will collaborate **to develop enhancements required to adopt RMF for commercial and industry** sectors
  - **ROS 2.0 middleware** allowing:
    - **Connectivity** to brownfield systems
    - **Interoperability** between robots as well as edge devices (including building infrastructure)
    - **Task and fleet scheduling**
  - Significant portions of project will be **Open Sourced**

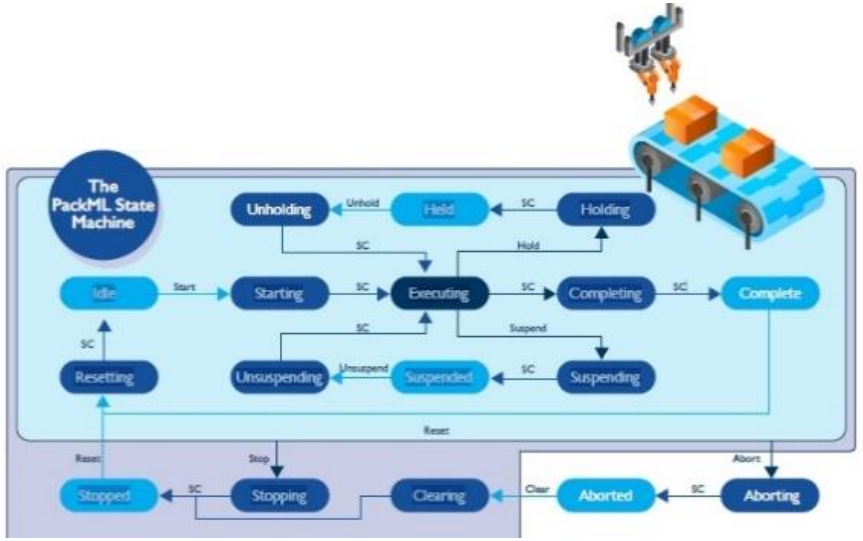
- **Sponsor**
  - National Robotics Programme (NRP)

- **Participating Organizations**

Robotics Interoperability – Allowing for Large Scale Deployments

Packages Open Sourced

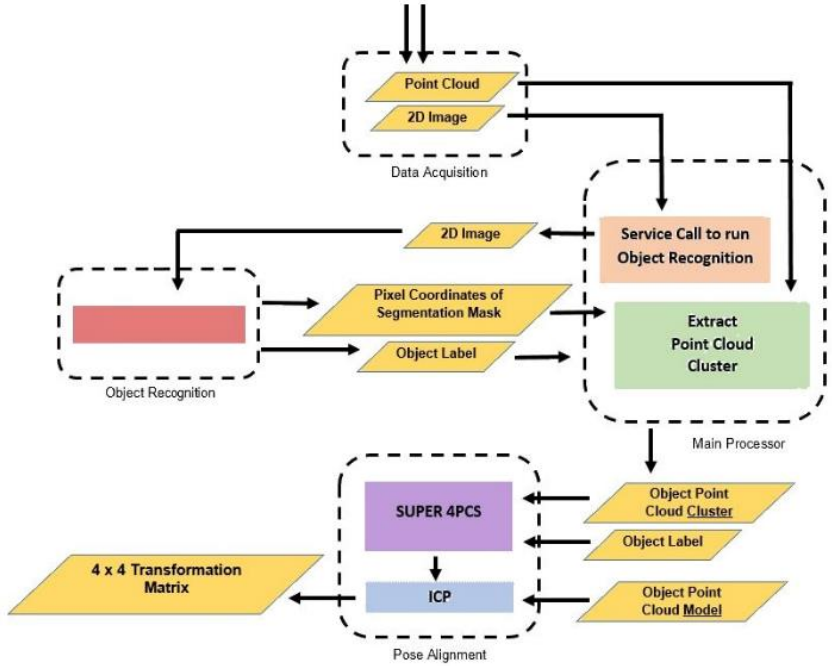
- **PackML2**
  - Solution that enables control of a PackML state machine that communicate between PLCs and ROS
  - Has been upgraded from original ROS 1.0 support to ROS 2.0 (tested on Dashing)



PackML (Packing Machine Language) state machine is commonly used by PLCs in packaging

https://github.com/dejaniraai/packml_ros2

- **Robotic Vision Integration Pipeline (RVIP)**
  - Skeleton project that implements a complete pipeline for object detection, accurate object positioning using ML models, and pose estimation



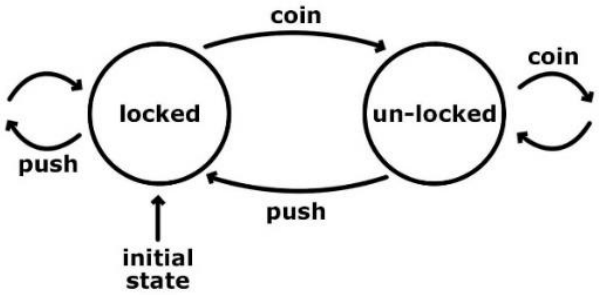
https://github.com/cardboardcode/rvip-1

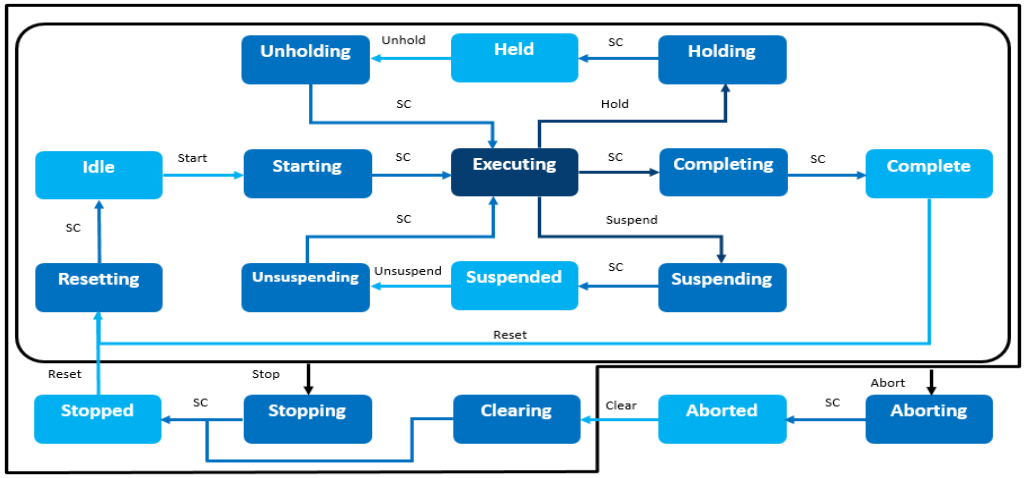
PackML

PackML_ROS2: State Machine Based System Programming, Monitoring and Control in ROS2

Motivation

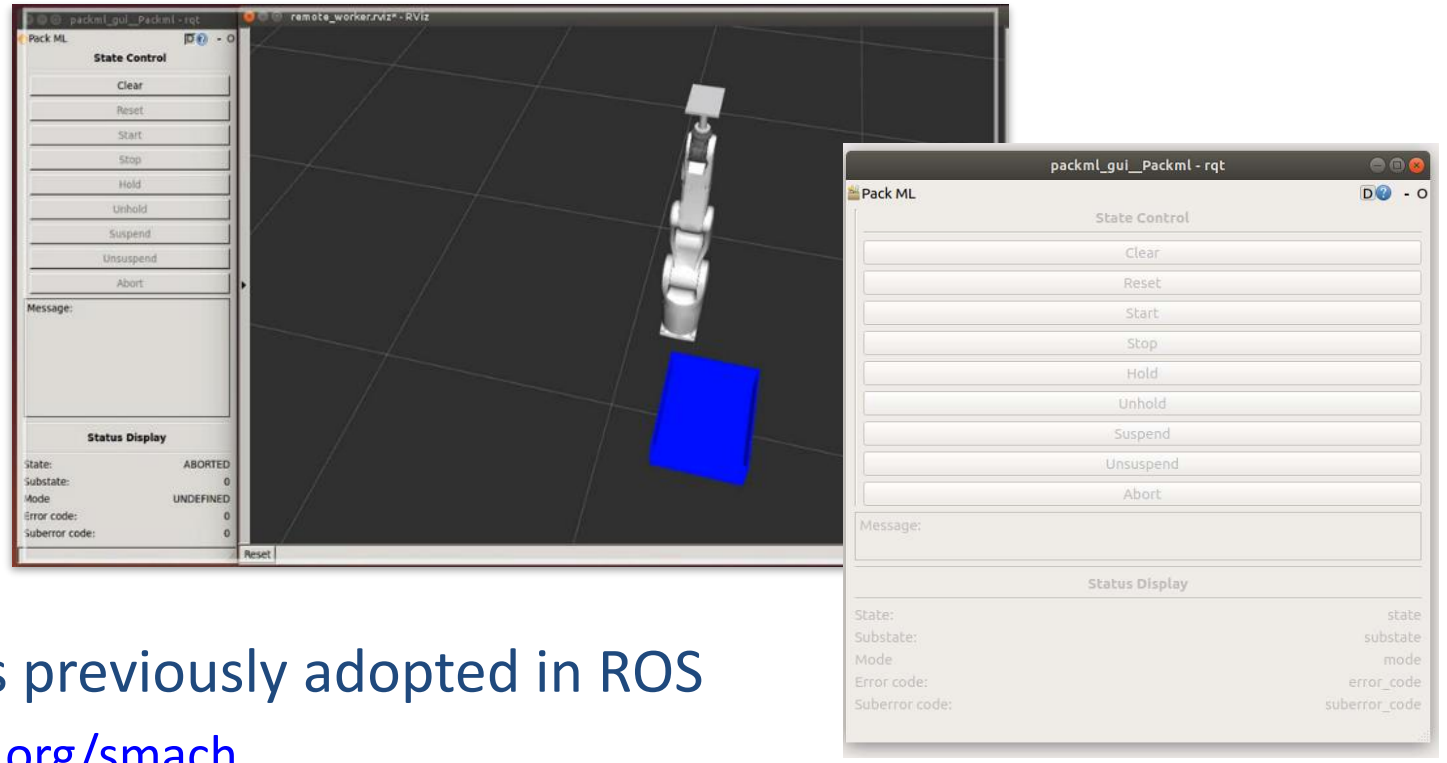
- State machines allow…
  - Modelling sequential and concurrent processes and systems
  - Composability
  - Simplified implementation of robot control code
  - (Formal) analysis
  - IP protection through abstraction
- The PackML standard
  - State machines to model, program and control packing processes
  - Standard template with states, transitions and triggering events





Background

- PackML ROS package
  - Released in 2016-2017
  - RViz plugin (Indigo)
  - Qt GUI (Kinetic)
  - State machine simulator in C++



- Existing state machine libraries previously adopted in ROS
  - SMACH (Python) http://wiki.ros.org/smach
  - Lifecycle (C++, ROS 2 Crystal and newer) https://github.com/ros2/demos/tree/master/lifecycle
  - Qt state machine libraries https://doc.qt.io/qt-5/statemachine.html

Methodology for Implementation

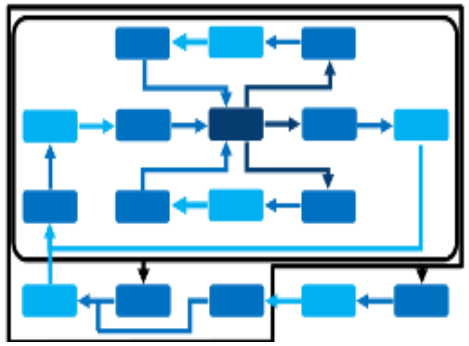
1. Porting PackML (Kinetic) packages 

2. PackML use case
3. Comparison of PackML ROS 2 and first ROS implementation

1. Porting PackML Kinetic Packages to Dashing

packml_msgs

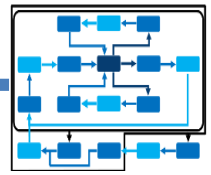
...
Transition.srv
AllStatus.srv
...



packml_sm

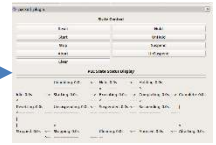
Continuous Execute state

Time limited Execute state



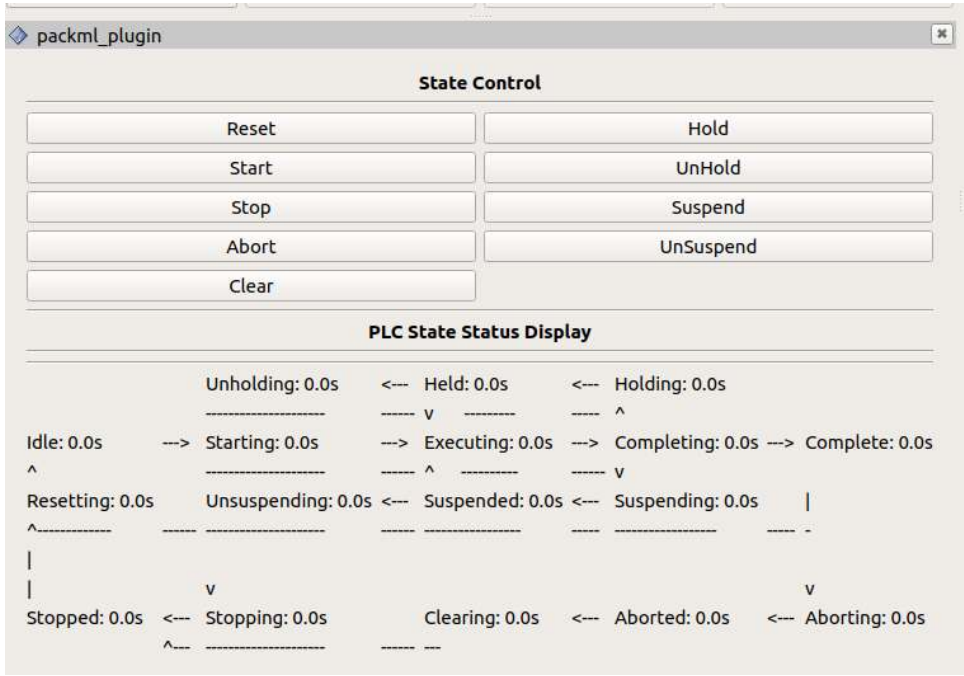
Transition service server

Status service server



packml_ros

packml_plugin



1. Porting PackML Kinetic Packages to Dashing

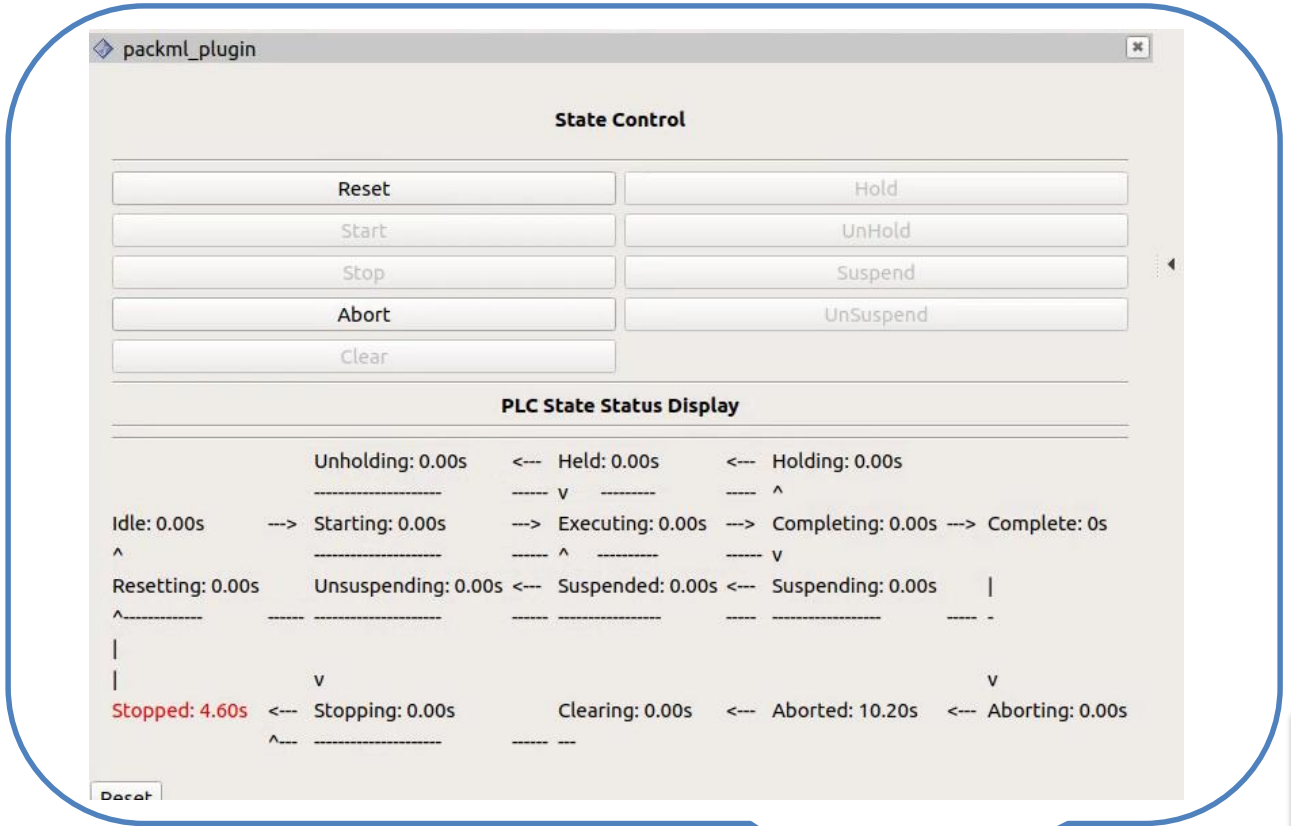
Issues

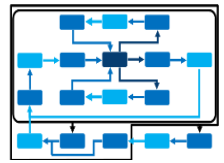
- ⚠ Lack of documentation and examples in ROS 2
- ⚠ Syntax changes in ROS API, CMakeLists.txt and package.xml
- ⚠ Intertwined ROS code
- ⚠ Tests that fail and only for the state machine library

Lessons Learned

- Documenting and sharing the code for the future
- Separation of libraries without ROS content vs. ROS nodes
- Modularity, functions, classes, package structure
- New unit testing implemented, for all the code

2. PackML Use Case





PackML state machine in ladder code

Siemens PLC

OPCUA over TCP/IP

packml_plc

ROS 2 OPCUA client in Python 3

3. PackML ROS 2 vs PackML ROS

- No more *roscore* overhead

In Melodic: 327564K (Core) + 833636K (Master) + 344528K (Logger)+ 504492K (Node) + 1481356K (Qt GUI) ~ 3.5GB

In Dashing: 617824K (Node) + 1864192K (RViz plugin) ~ 2.5GB

- No more topics, only services

- Visualization of state machine state and elapsed time per state

- More code unit testing (>80% LOC)

Robotic Vision Integration Pipeline (RVIP)

Offering easy integration of 2D-3D hybrid pose alignment processes in ROS

What RVIP does? [1/2]

Objective:
To make use of both **2D** and **3D** information of an object to produce **a robust picking action by a robot**.

What RVIP does? [2/2]

INPUTS

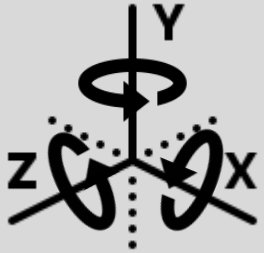
2D RGB Images
[sensor_msgs::Image]

3D PointCloud
[sensor_msgs::PointCloud2]

2D Computer Vision Architecture

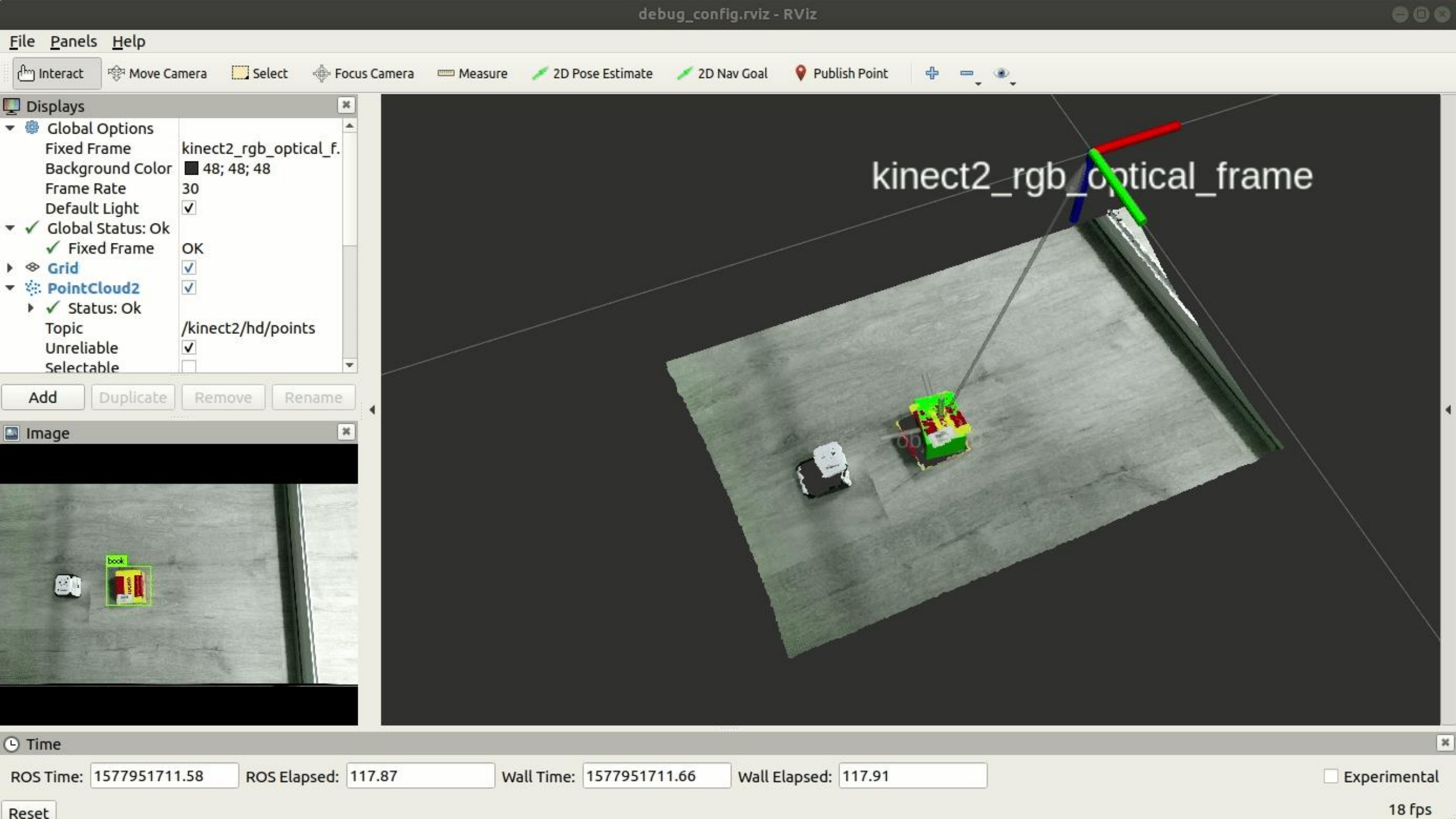
RVIP

OUTPUTS

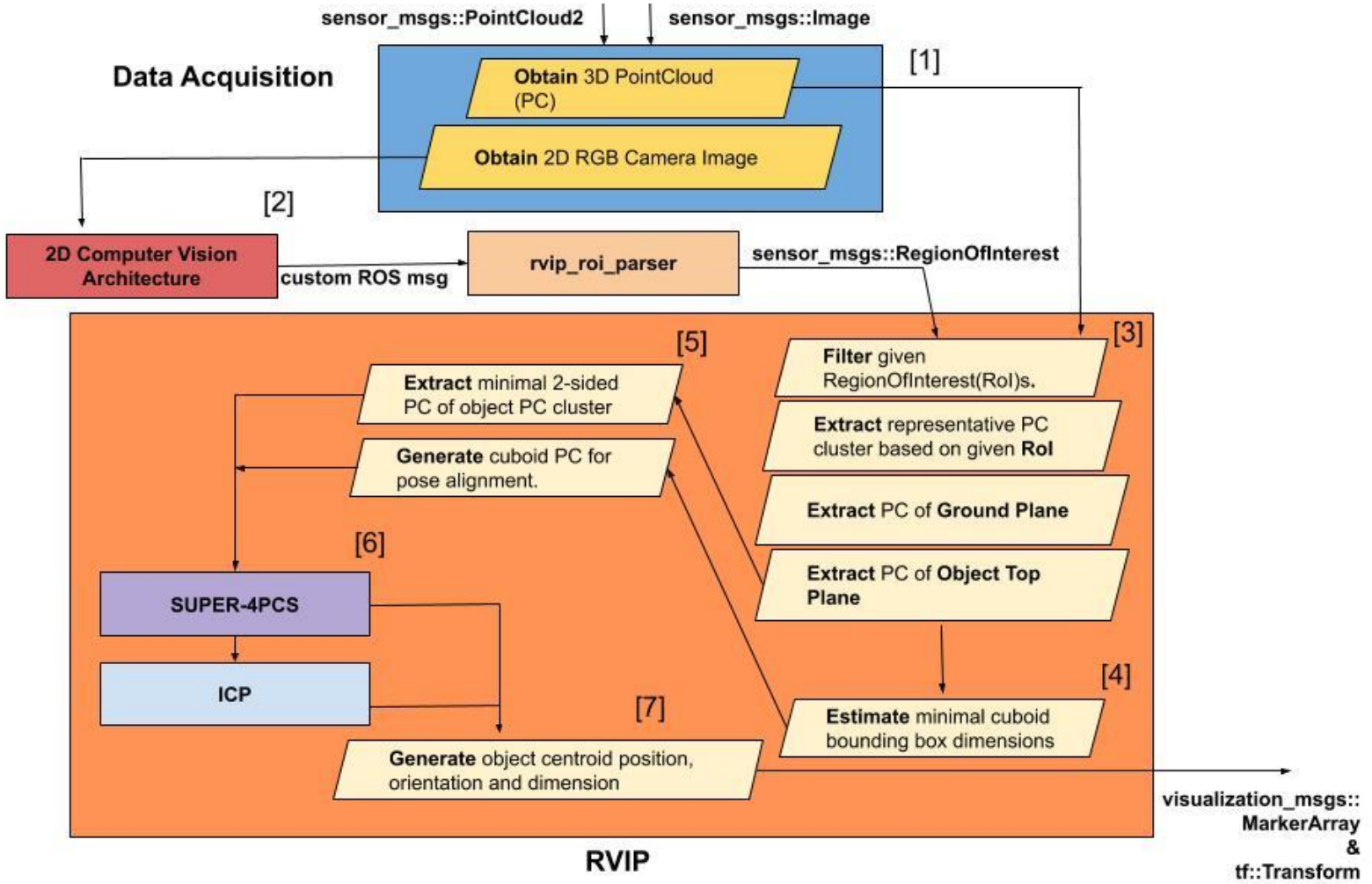


1. Object Centroid Position
2. Object Position
3. Object Dimensions

[visualization_msgs::MarkerArray]
[tf::Transform]


debug_config.rviz - RViz
File Panels Help
Interact Move Camera Select Focus Camera Measure 2D Pose Estimate 2D Nav Goal Publish Point
Displays
Global Options
Fixed Frame kinect2_rgb_optical_f.
Background Color 48; 48; 48
Frame Rate 30
Default Light
Global Status: Ok
Fixed Frame OK
Grid
PointCloud2
Status: Ok
Topic /kinect2/hd/points
Unreliable
Selectable
Add Duplicate Remove Rename
Image
book
kinect2_rgb_optical_frame
Time
ROS Time: 1577951711.58 ROS Elapsed: 117.87 Wall Time: 1577951711.66 Wall Elapsed: 117.91
Experimental
Reset
18 fps

RVIP Architecture Diagram **[1/2]**

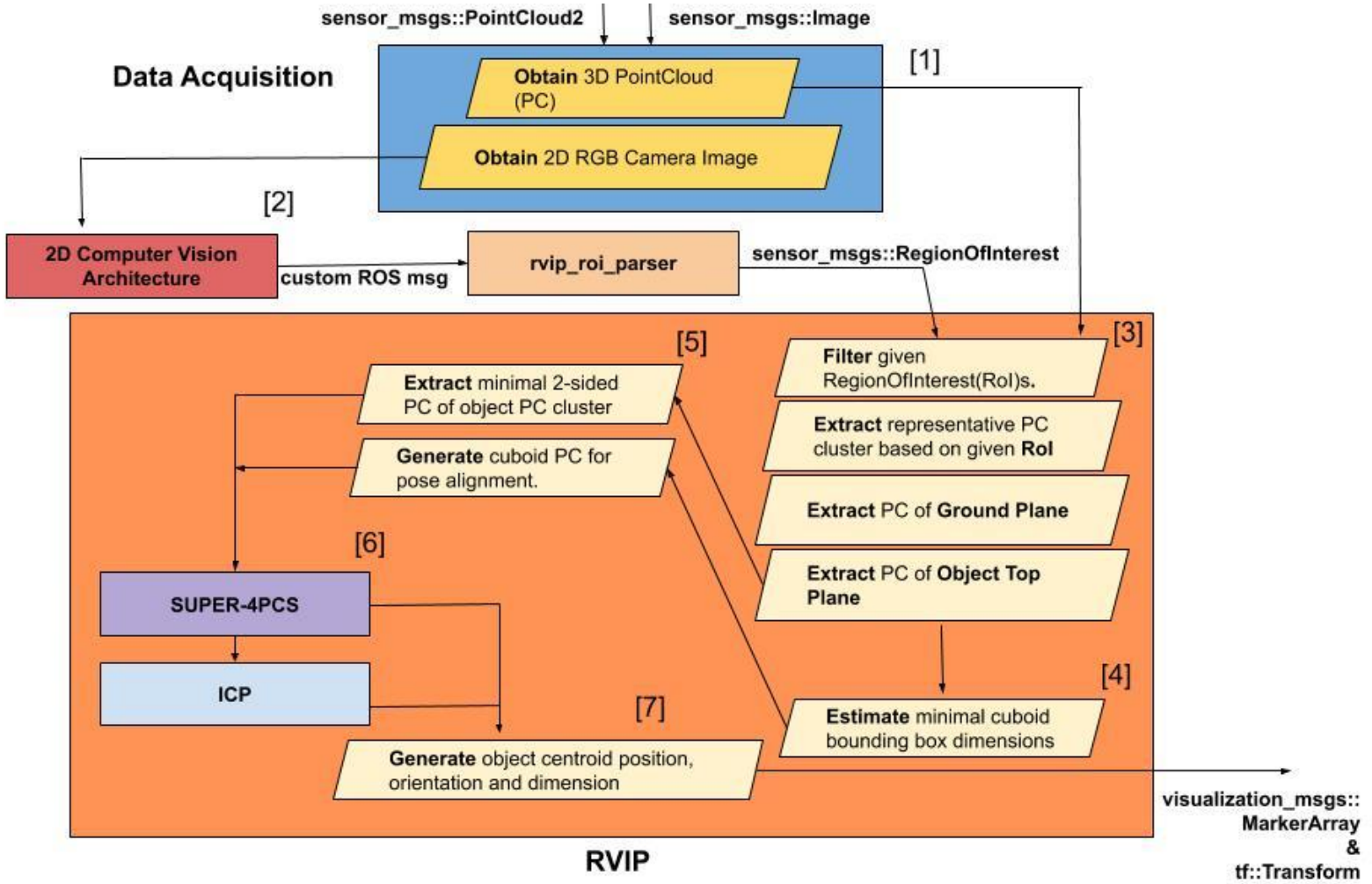


RVIP Architecture Diagram **[2/2]**

darknet_ros

yolact_ros

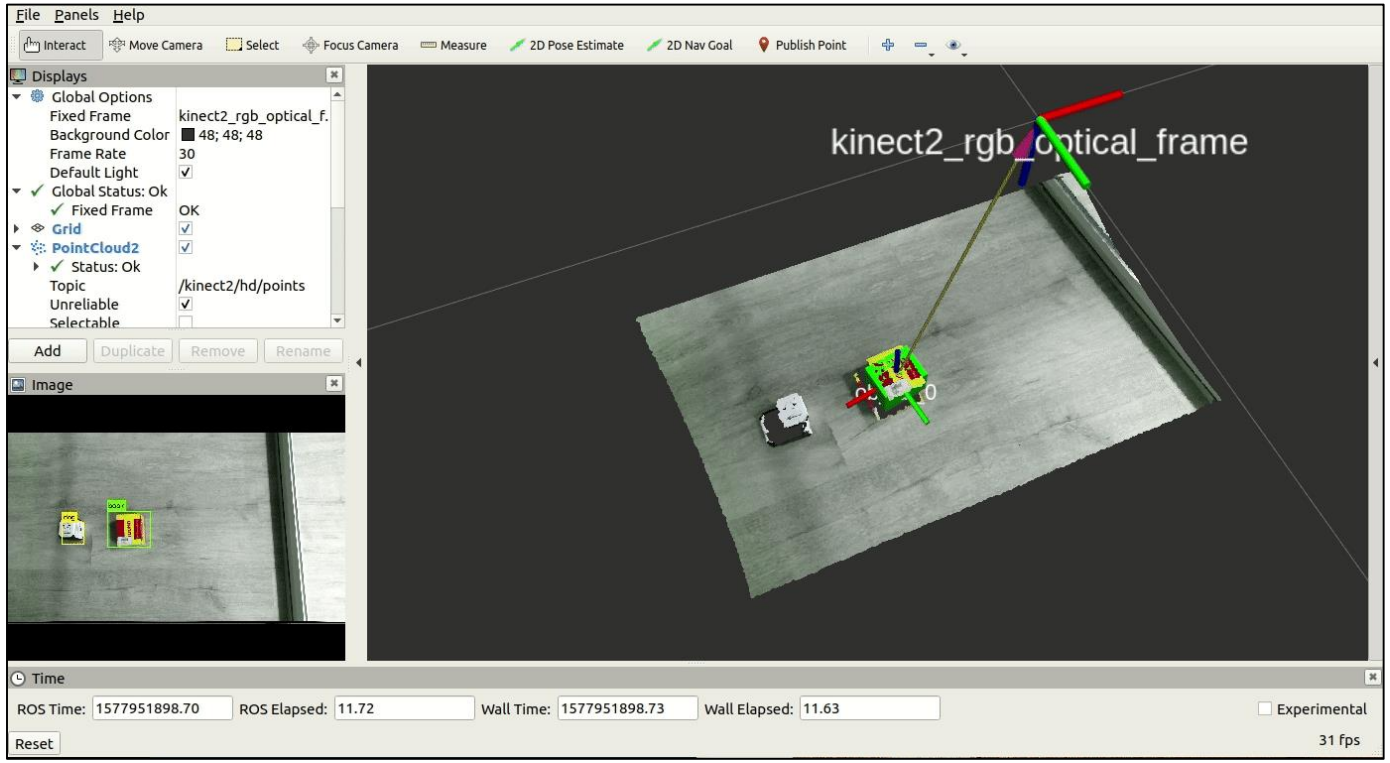
ros_faster_rcnn



Why use RVIP?

Benefits

- Provides **real-time** object localization (given the right hardware).
- Operates under **permissive BSD** license.
- Integrates **easily** with existing **Manipulation** packages (Eg. MoveIt)
- Requires no customized training of Machine Learning neural network.
  - *But allows it.*
- Requires no CAD models.



Get Started with RVIP

Ongoing work is being done to host it on the official **ros_industrial** GitHub repository.

https://github.com/ros-industrial/rvip/pull/1

But, in the meantime, you can already find it on my GitHub repository, **cardboardcode**.

Get Started with RVIP

If you already have a 2D Computer Vision Architecture (other than **darknet_ros**) in mind, you can follow the vanilla documentation.

BUT if you would like an **Out-Of-Box** complete robotic vision suite using **RVIP**, be sure to refer to **demo.md** In the documentation.

Setup

This section provides instructions on how to install and use **RVIP**. These instructions are only to set up RVIP to run in isolation.

To run RVIP as a complete robotic vision suite, please follow the instructions in demo.md.

Community Discussion

Community Discussion

- **Technical**
  - ROS 2.0 related
  - Missing features/capabilities
  - Packages that need more support/maintenance
  - Packages that need performance enhancements
  - Hardware/robots/peripherals support

- **Quality**
  - Packages that need better quality/analysis
  - Development and test processes
  - Continuous integration

- **Commercial**
  - Software licensing
  - Intellectual property

- **Other questions and/or requests**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Thank You