

13 Sequence Diagrams

2025-10-19

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1 Sequence Diagrams - Vision-Based Pick and Place System

1.1 Document Control

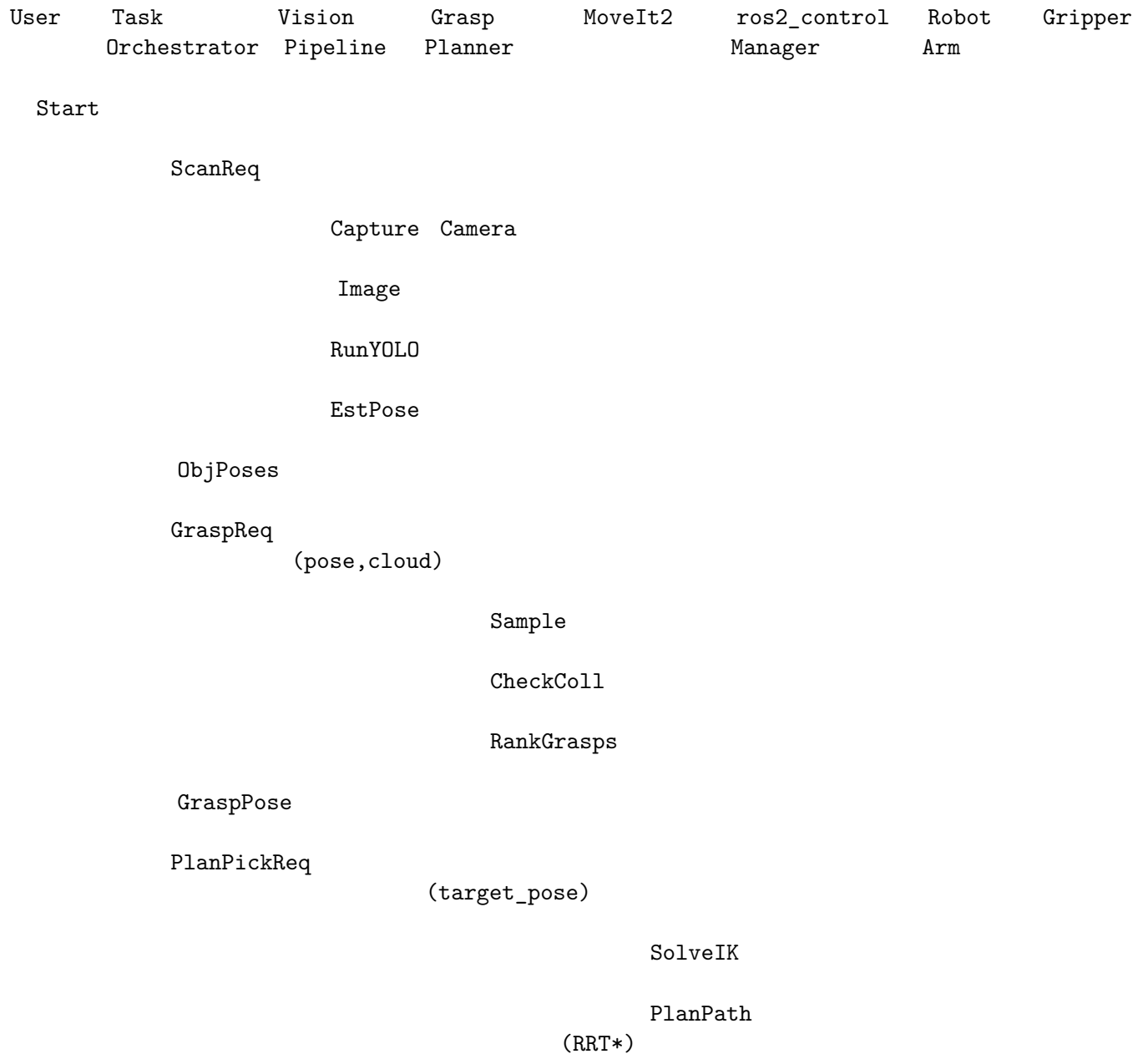
Item	Details
Document Title	Sequence Diagrams
Version	1.0
Date	2025-10-18
Status	Draft
Author(s)	System Architect

1.2 1. Introduction

This document provides sequence diagrams showing time-ordered interactions between system components. All diagrams use ASCII art and can be rendered with Mermaid or PlantUML.

1.3 2. End-to-End Pick-Place Sequence

1.3.1 2.1 Complete Workflow (Nominal Path)





Timing: - Total cycle time: ~2 seconds - Vision (Scan → ObjPoses): 150ms - Grasp planning: 200ms - Motion planning (pick): 300ms - Execution (pick): 800ms - Motion planning (place): 250ms - Execution (place): 300ms

1.4 3. Vision Pipeline Sequence

1.4.1 3.1 Object Detection & Pose Estimation

Task	Camera	Image	Object	Pose	TF2
Orchestrator	Driver	Processor	Detector	Estimator	

ScanRequest

Trigger

RGB+Depth

PublishRGB
(topic)

PublishDepth
(topic)

Preprocess
(resize)

RunYOLO
(TensorRT)

NMS

Filter
(conf>0.7)

Publish Task
Detections

(for each det)

ExtractROI

Deproject
(depth→3D)

EstPose
(PnP/ICP)

LookupTF
(camera→base)

Transform

	Publish Task Poses (base frame)
ObjPoses	

1.5 4. Grasp Planning Sequence

1.5.1 4.1 Grasp Synthesis & Collision Checking

Task	Grasp	Grasp	Collision	Grasp
Orchestrator	Planner	Sampler	Checker	Ranker

GraspRequest
(pose, cloud)

Sample

GenCandidates
(N=50)

Grasps

ForEach
Grasp

CheckGripper
-Object

CheckGripper
-Scene

CollFree
(boolean)

IfCollFree

CompQuality
(force closure)

Quality

AddToValid
List

EndLoop

```

Sort
  ByQuality

RankedList

SelectTop

GraspPose
  +Quality

```

1.6 5. Motion Planning Sequence (MoveIt2)

1.6.1 5.1 Path Planning with Collision Checking

Task	MoveIt	Planning	IK	OMPL	Trajectory
Orchestrator	MoveGroup	Scene	Solver	Planner	Generator

```

PlanRequest
(target_pose)

```

```

UpdateScene

```

```

AddObstacles
(point cloud)

```

```

SceneReady

```

```

SolveIK

```

```

ComputeIK
(KDL/TRAC-IK)

```

```

JointAngles

```

```

ValidateGoal

```

```

PlanPath
(start, goal)

```

```

RunRRT*
(5 sec timeout)

```

```

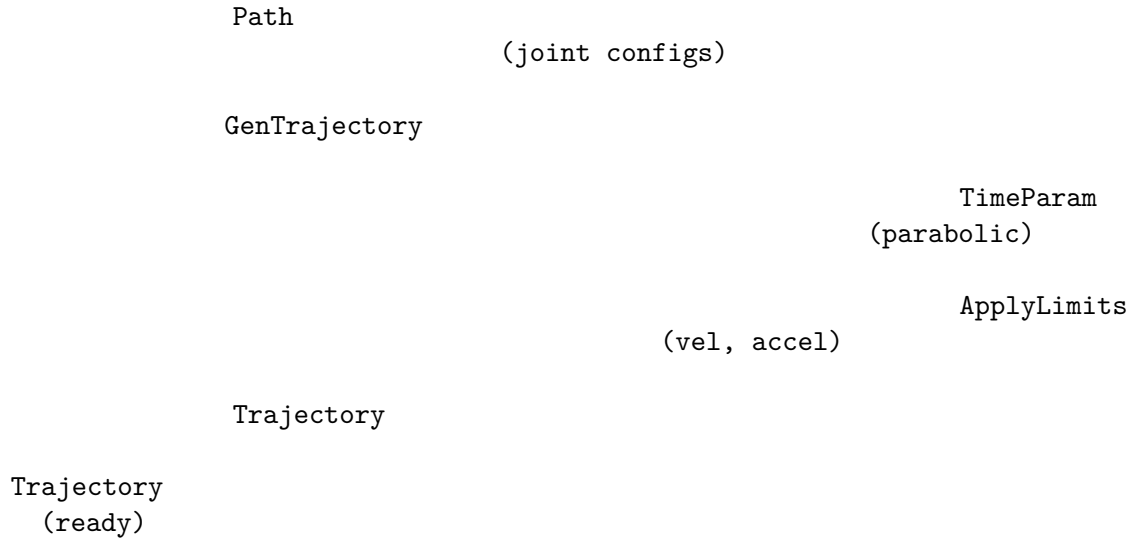
CheckColl Scene
(repeated)

```

```

CollFree

```



1.7 6. Trajectory Execution Sequence

1.7.1 6.1 ros2_control Execution Loop

MoveIt	Controller	Trajectory	PID	Hardware	Motor
MoveGroup	Manager	Follower	Controller	Interface	Driver

ExecAction
(trajectory)

LoadTraj

Start
Loop
@1kHz

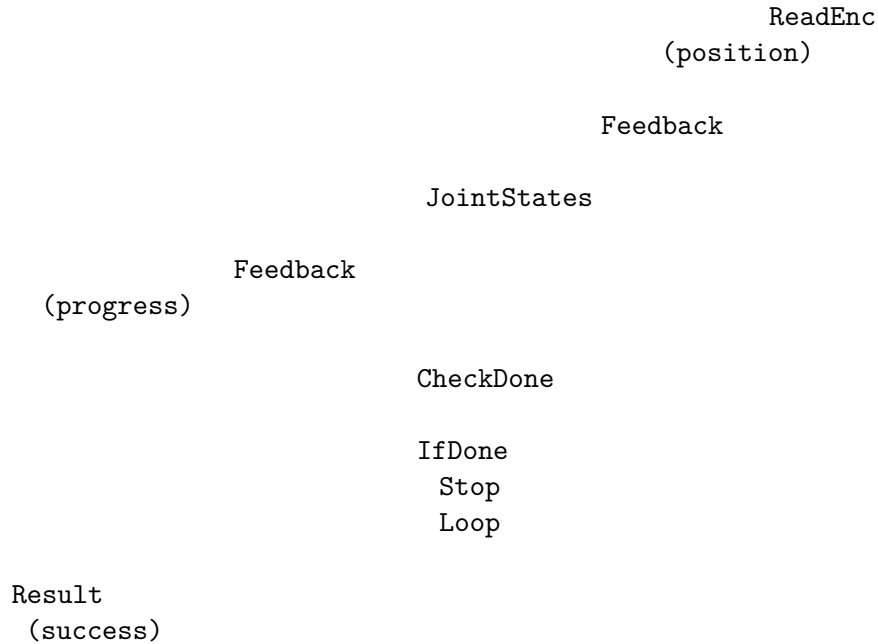
Interpolate
Setpoint
(t=now)

SendSetpoint

CompPID
(error = sp-fb)

AddFF
(gravity comp)

Output
(torque cmd)



Loop Timing: - Control frequency: 1000 Hz (1ms period) - Setpoint interpolation: <50 s - PID computation: <100 s - EtherCAT communication: <200 s - Total loop time: <1ms (with margin for jitter)

1.8 7. Error Recovery Sequence

1.8.1 7.1 Grasp Failure → Retry

Task	F/T	Error	Grasp	MoveIt2	ros2_control
Orchestrator	Sensor	Detector	Planner		Manager

ExecPick

MoveToPre Robot

MoveToGrsp Robot

CloseGripper

Gripper

ForceReading
(5N, low!)

DetectDrop

RaiseFault

ErrorEvent
(GRASP_FAIL)

LogError

CheckRetry
Count

IfRetry<Max

Retract

MoveBack Robot

ReplanGrasp
(increase
force)

AdjustForce
(50%→100%)

NewGrasp

RetryPick

Execute Robot

CloseGripper

Gripper

ForceReading
(20N, OK!)

Success

Continue
(place)

1.9 8. Calibration Sequence

1.9.1 8.1 Hand-Eye Calibration

Calib	Robot	Camera	Detection	Calibration
Wizard	Controller	Driver	Node	Solver

Start

MoveToPos1

Execute

AtPosition

CaptureImg

Trigger

Image

Detect
Checkerboard

Corners

ReadRobotPose

TcpPose

StoreData
(corners,
robot_pose)

RepeatFor
Pos2-5

(loop 4 more times)

AllDataCollected

SolveCalib

($AX=XB$)

ComputeTF
(camera→base)

Transformation
Matrix

Validate

PlaceObject

DetectObject

Pos(camera)

TransformTo

```

BaseFrame                (using TF)

Pos(base)

MeasureActual
  (CMM/ruler)

ActualPos

CompError
  (predicted-
   actual)

IfError<5mm

SaveCalib
      (to YAML file)

Success

```

1.10 9. System Startup Sequence

1.10.1 9.1 Boot & Initialization

User	Init Script	ROS2 Daemon	Vision Nodes	MoveIt2 Nodes	ros2_control Manager	Robot Hardware
------	----------------	----------------	-----------------	------------------	-------------------------	-------------------

```
PowerOn
```

```
    StartROS2
```

```
        LaunchCore
```

```
            CoreReady
```

```
    LaunchVision
```

```
        InitCamera
```

```
            CamReady
```

```
                LoadModel
                (YOLOv8)
```

```
                    ModelReady
```

```
    LaunchMoveIt
```



1.11 10. Shutdown Sequence

1.11.1 10.1 Graceful Shutdown

User	Task	ros2_control Orchestrator Manager	MoveIt2 Nodes	Vision Nodes	ROS2 Daemon
	Shutdown				
	StopTasks				
	MoveHome				
	Execute				

```

    AtHome

    DisableMotors

        Deactivate

    MotorsOff

    StopVision

        UnloadModel

        CloseCamera

    VisionStopped

    StopMoveIt

    MoveItStopped

    StopControl

        UnloadCtrl

        CloseHW

    ControlStopped

    ShutdownROS

        KillNodes

Shutdown
Complete

PowerOff

```

1.12 Summary

This document provides **10 comprehensive sequence diagrams** covering:

1. **End-to-End Pick-Place** - Complete workflow with all subsystems
2. **Vision Pipeline** - Object detection and pose estimation
3. **Grasp Planning** - Synthesis and collision checking
4. **Motion Planning** - MoveIt2 path planning
5. **Trajectory Execution** - ros2_control real-time loop

6. **Error Recovery** - Grasp failure retry logic
7. **Calibration** - Hand-eye calibration procedure
8. **System Startup** - Boot and initialization
9. **System Shutdown** - Graceful shutdown

Key Insights: - Vision pipeline: 150ms (camera→poses) - Grasp planning: 200ms (pose→grasp)
- Motion planning: 300-500ms (IK→trajectory) - Control loop: 1ms period @ 1kHz - Startup time:
~45 seconds - Total cycle time: ~2 seconds (scan→place)

Document Status: Complete **Last Updated:** 2025-10-18 **Format:** ASCII sequence diagrams
(convertible to Mermaid) **Review Status:** Pending Technical Review