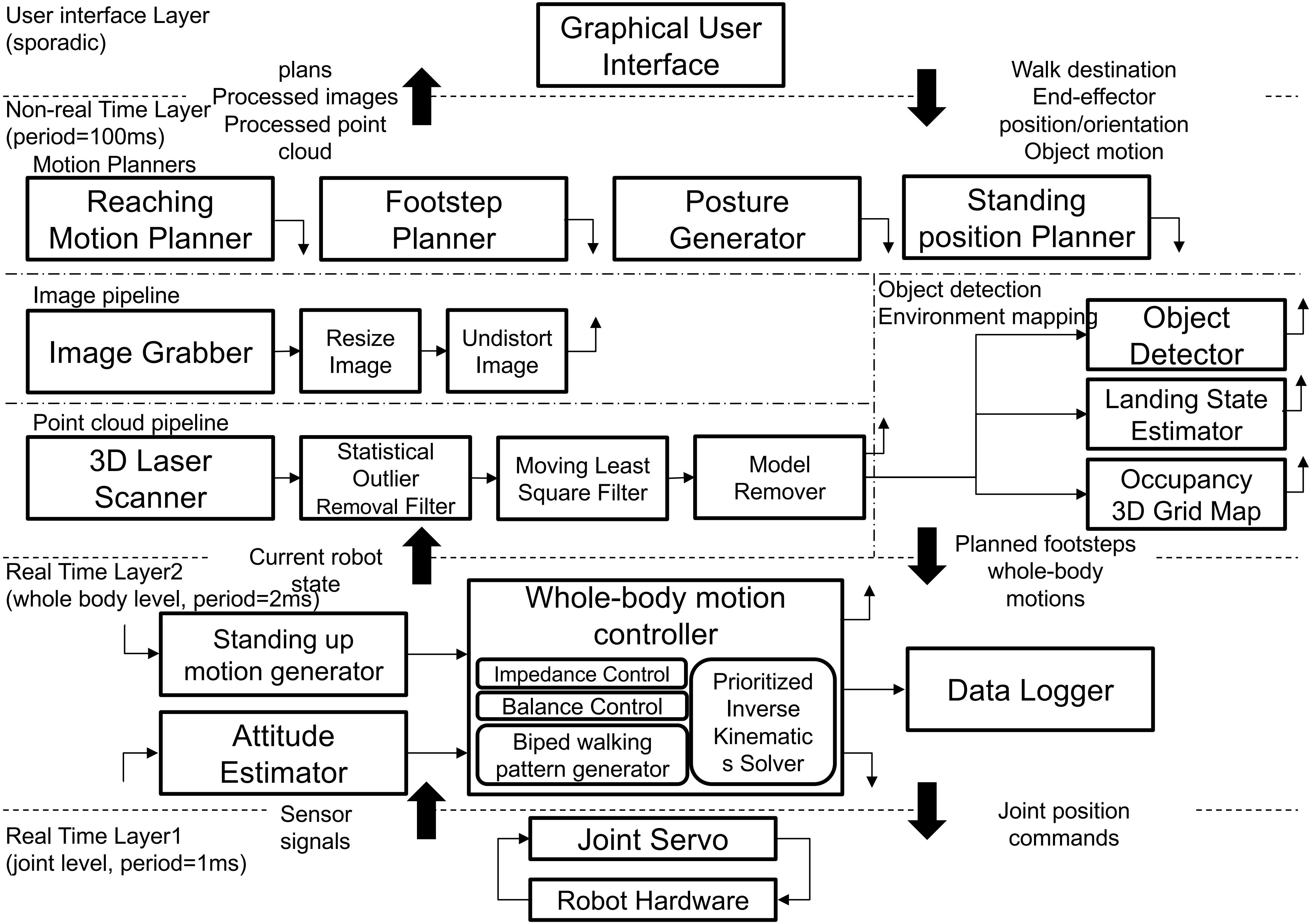
Software development environment for HRP series

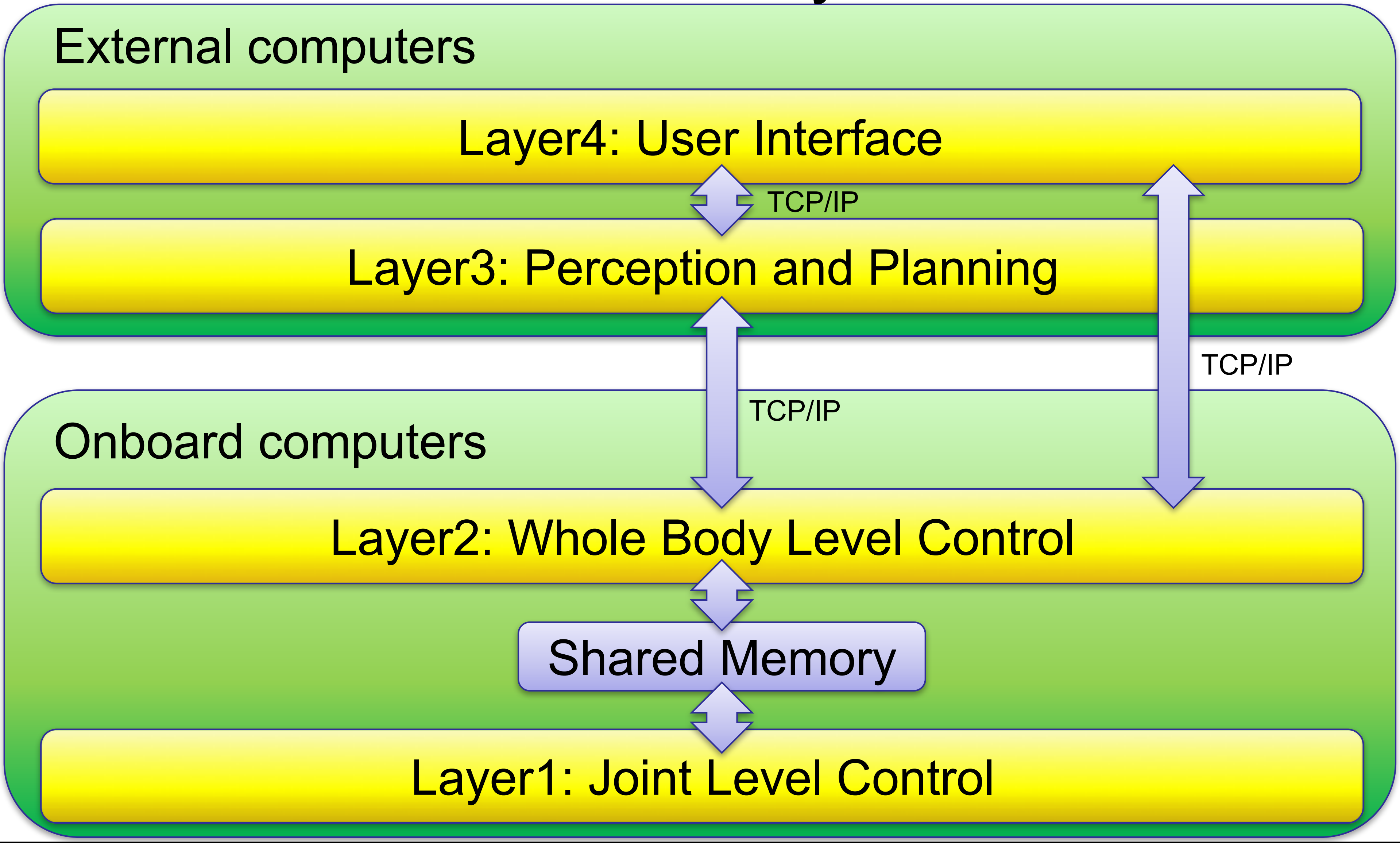
Fumio Kanehiro (AIST)

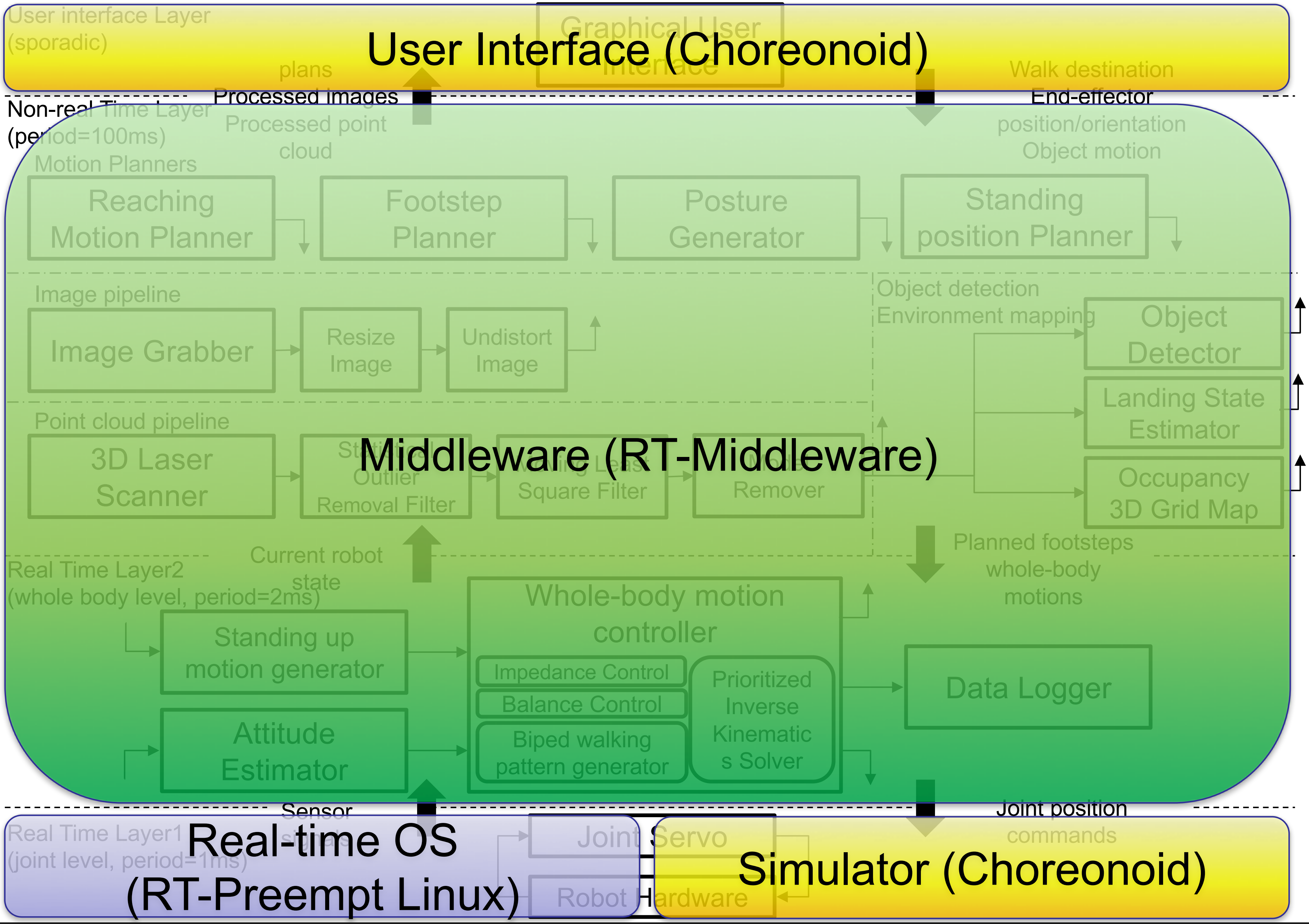
Outline

1. Overview
2. Software platforms
   a. RT-Middleware
   b. Choreonoid
3. Continuous integration using dynamics simulation


User interface Layer
(sporadic)
Graphical User Interface
plans
Processed images
Processed point cloud
Walk destination
End-effector position/orientation
Object motion
Non-real Time Layer
(period=100ms)
Motion Planners
Reaching Motion Planner
Footstep Planner
Posture Generator
Standing position Planner
Image pipeline
Image Grabber
Resize Image
Undistort Image
Object detection
Environment mapping
Object Detector
Landing State Estimator
Occupancy 3D Grid Map
Point cloud pipeline
3D Laser Scanner
Statistical Outlier Removal Filter
Moving Least Square Filter
Model Remover
Current robot state
Planned footsteps
whole-body motions
Real Time Layer2
(whole body level, period=2ms)
Standing up motion generator
Attitude Estimator
Whole-body motion controller
Impedance Control
Balance Control
Biped walking pattern generator
Prioritized Inverse Kinematics Solver
Data Logger
Sensor signals
Joint position commands
Real Time Layer1
(joint level, period=1ms)
Joint Servo
Robot Hardware

Physical location and communication between layers




User Interface (Choreonoid)
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Middleware (RT-Middleware)
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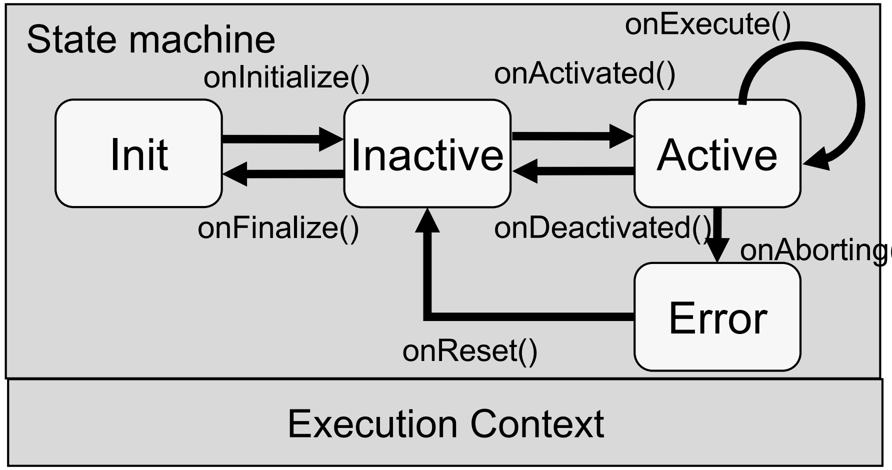
Real Time Layer1
(joint level, period=1ms)
Real-time OS
(RT-Preempt Linux)
Joint Servo
Robot Hardware
Simulator (Choreonoid)

RT-Middleware[Ando IROS05]

- http://www.openrtm.org
- RT = Robot Technology
- A software platform to develop RT system as a network of software components (RT-component, RTC)
- OpenRTM-aist is one of implementations
- RT components can be deployed on a computer network

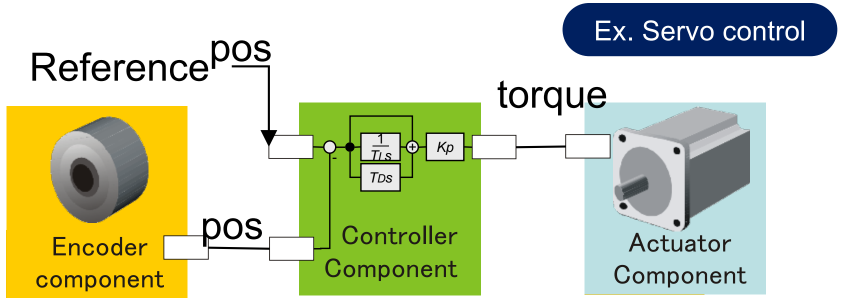
RT-Component Architecture

Activity, Execution context



Data Port

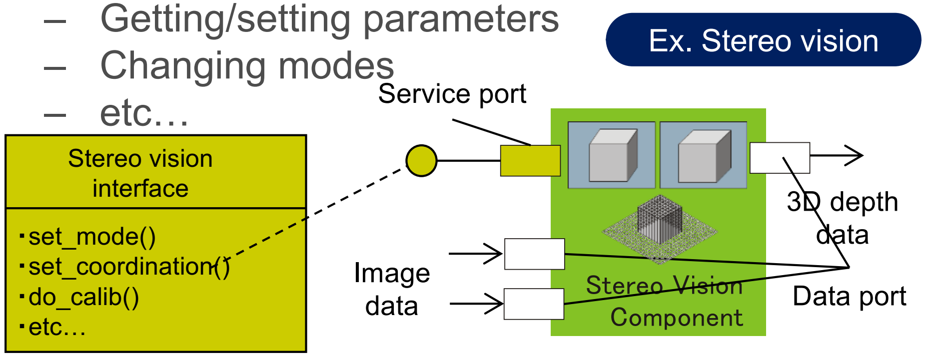
- Data centric communication
- Continuous data transfer
- Dynamic connection/disconnection



Data-centric communication

Service Port

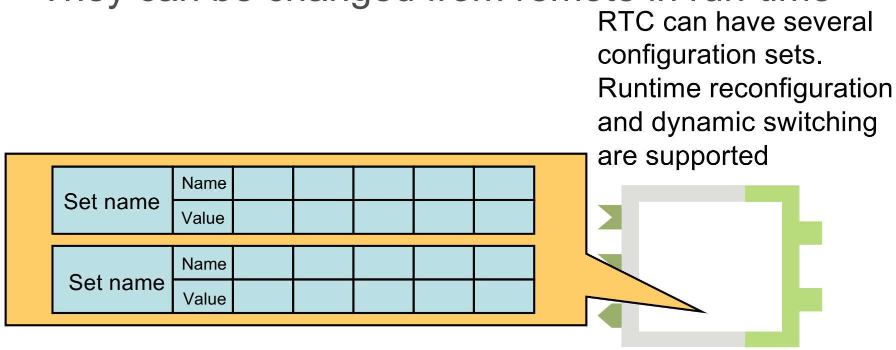
- User defined interface
- Access to detailed functionality of RTC
  - Getting/setting parameters
  - Changing modes
  - etc…



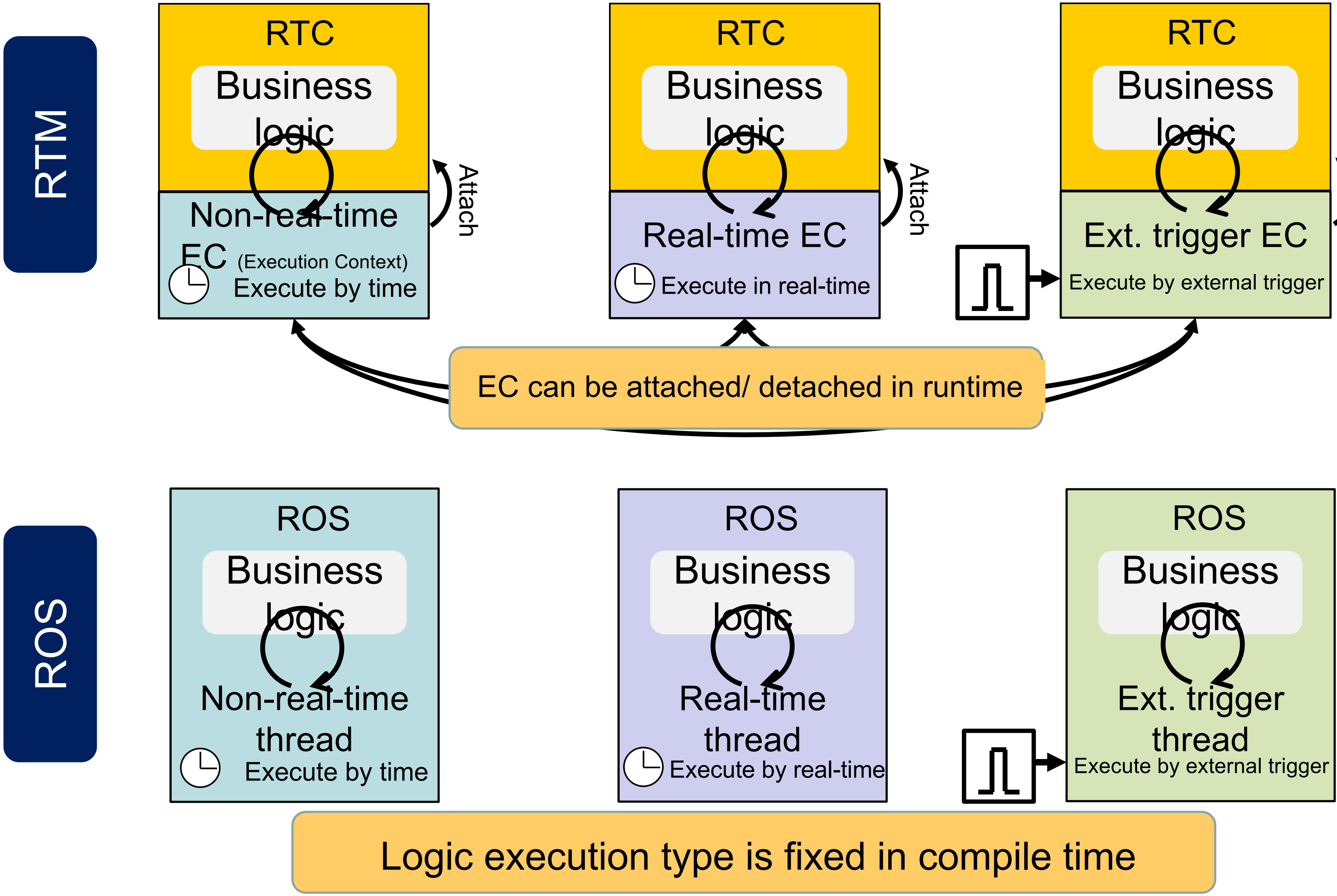
Service oriented interaction

Configuration

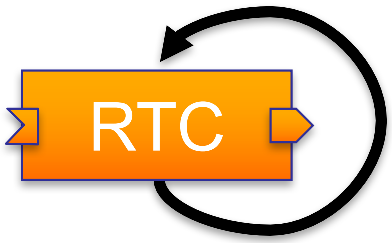
- Function for internal parameter
- Multiple parameter sets
- They can be changed from remote in run-time



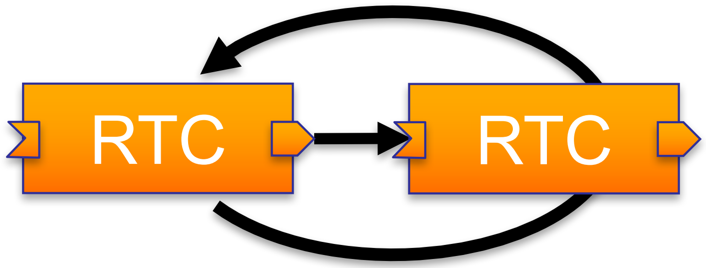
Component execution in RTM/ROS



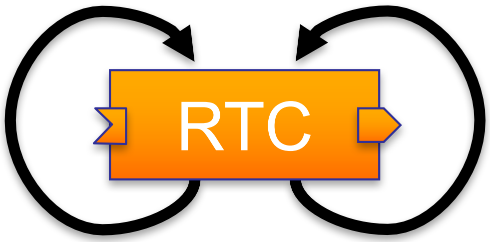
Combination of execution contexts and RTCs



One EC and one RTC
(default)

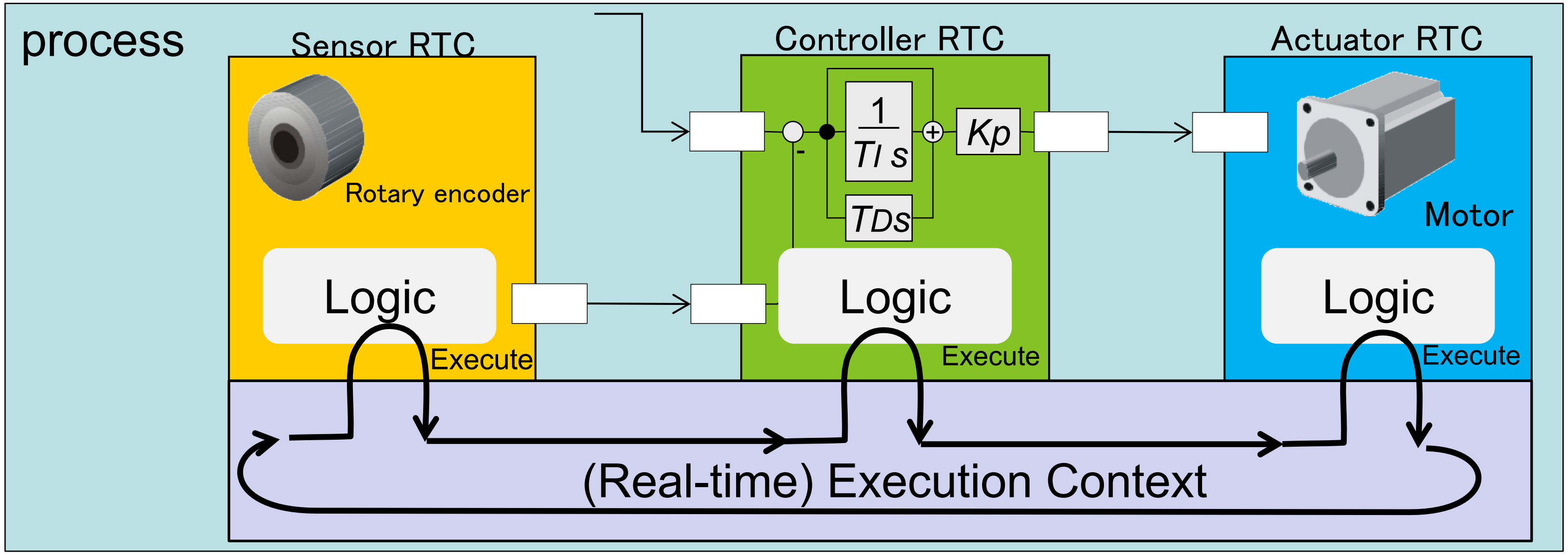


One EC and multiple RTCs
Sequential execution of RTCs
ex) image processing



Multiple ECs and one RTC
Parallel execution using shared data
ex) short cycle control and long cycle visualization

Real-time/composite execution

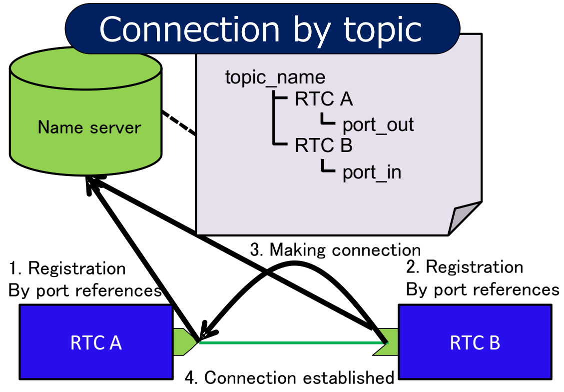


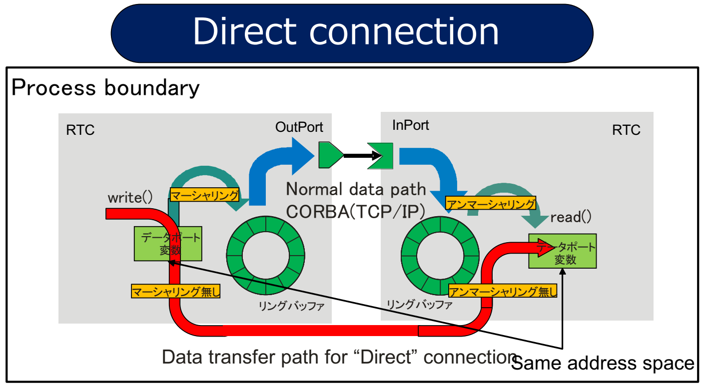
RTC architecture realizes composition, real-time execution for multiple RTCs
Execution and logic are separated, and various execution type can be realized

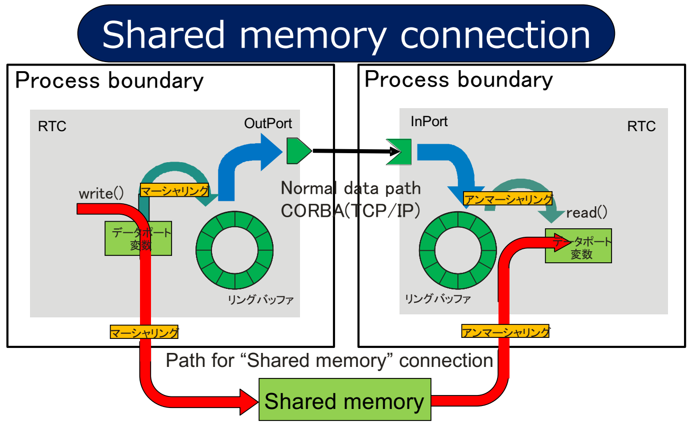
- ROS: 1-node = 1-process
  - Sequential execution, close coupled composition are impossible
  - Some tools such as ros_control, realtime-tools can supports such requirement
  - However, node must be designed different way from normal ROS node

New communication features

- Topic connection
  - DDS, ROS like connection scheme
  - Topics are registered and matched on naming servers
- Direct connection
  - OutPort directly write into InPort's variable
  - Two RTCs must be in a same process
  - Thread-safe implementation. Execution context isn't necessarily shared RTCs
- Shared memory connection
  - Same node, but different process/language RTCs can communicate.
  - Marshalled data are stored/read into/from shared memory area.

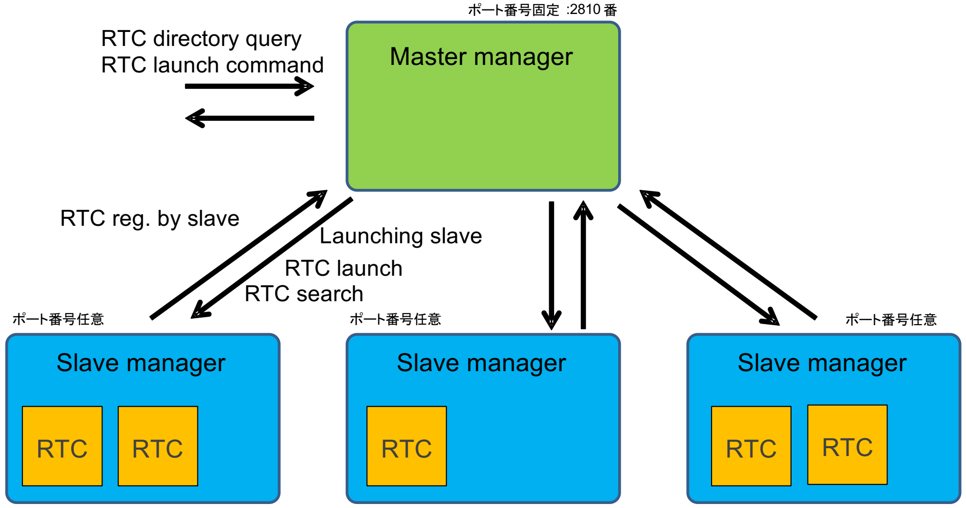


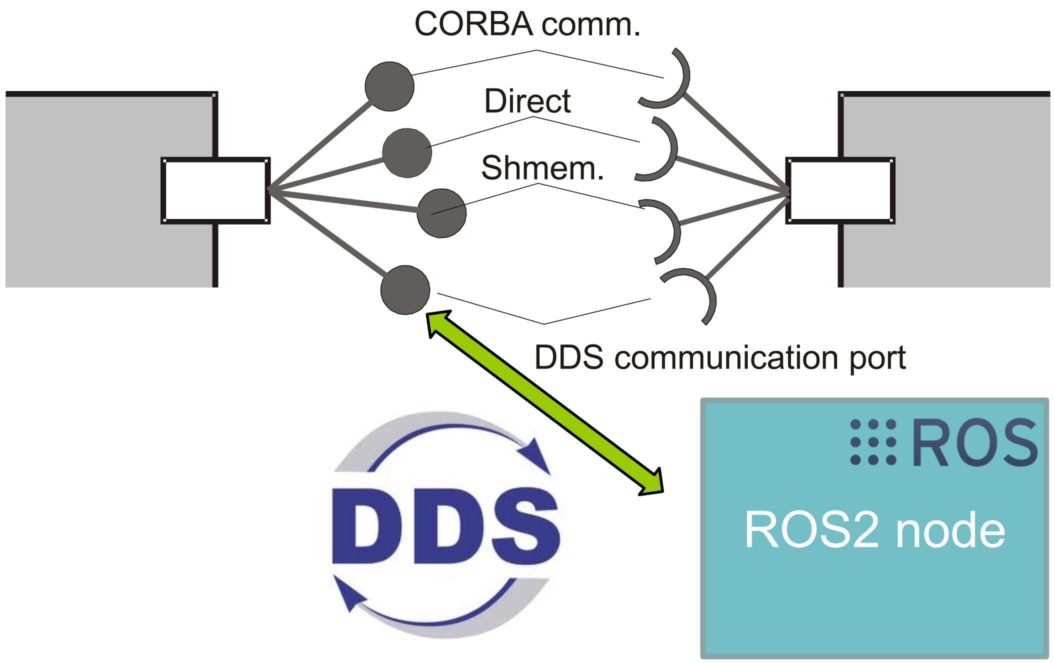




Other features

- Master-slave manager
  - Master: Frontend process to application, slave management
  - Slave: It actually hosts RTCs.
- Secure communication (SSL)
  - CORBA's SSL features are used
- DDS port implementation will be included
  - ROS2 compatibility might be realized





Choreonoid[Nakaoka SII12]

Choreonoid is an extensible framework for robot applications.

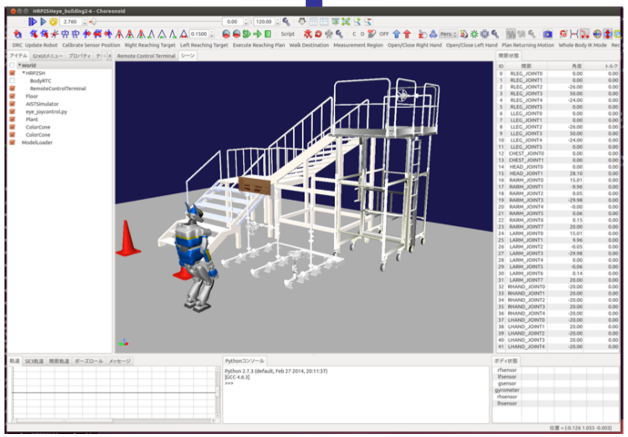
- www.choreonoid.org
- Windows and Linux are supported
- Open source software（MIT license）
- Basic functions to handle robot models are included
- Dynamics simulator is embedded
- Users can extend by developing/adding plugins
- Lightweight and efficient single process architecture

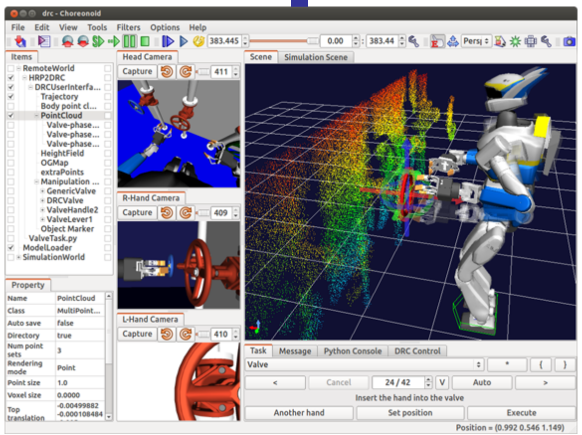
Use cases of Choreonoid

1. Robot world simulator
The official simulator of JVRC
(Japan Virtual Robotics Challenge)

2. Teleoperation interface
User interface for supervised
autonomy used at DRC Finals

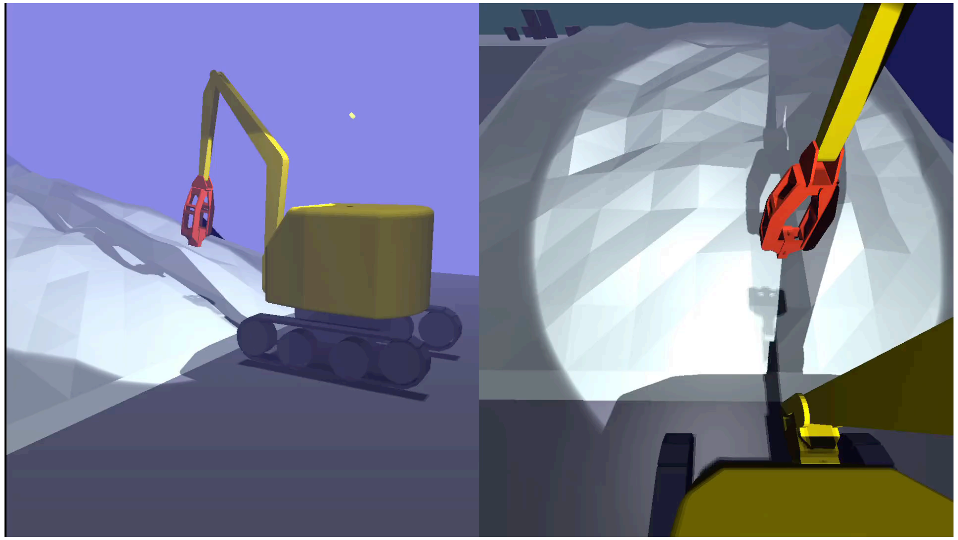
3. Robot choreographer
CG software-like interface and
automatic balance compensation

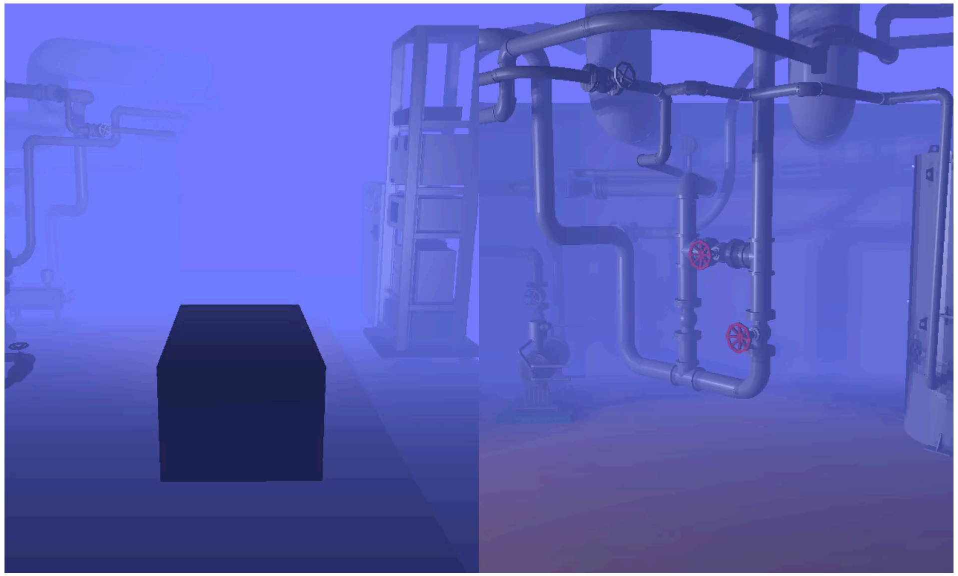




Choreonoid as a simulator

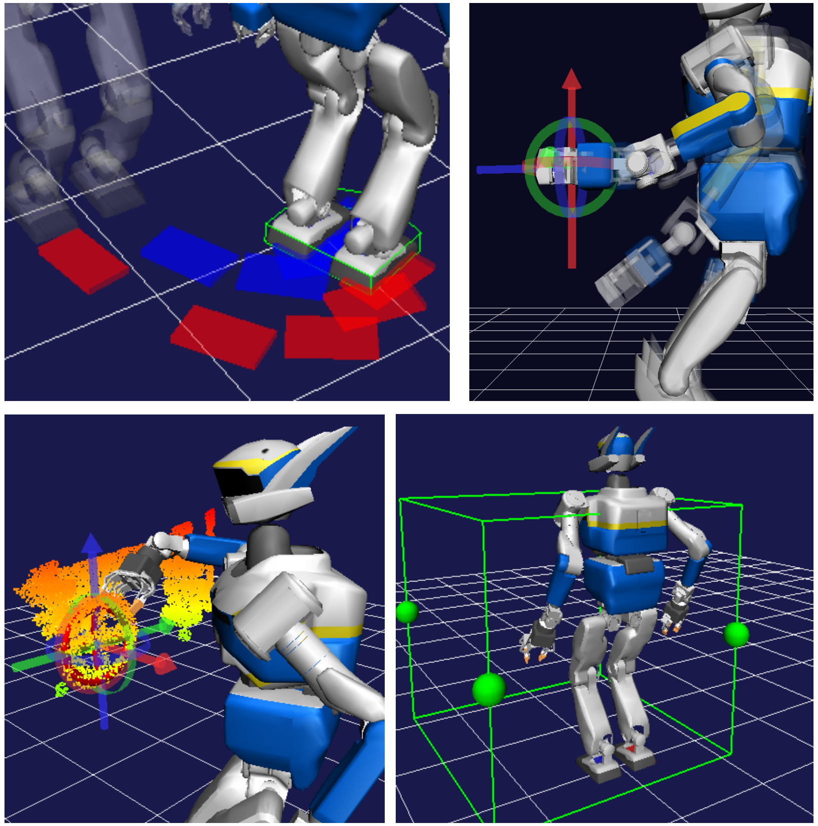
- Joints
  - Free, fixed, rotate, slide
- Sensors
  - Force/torque sensor, gyrometer, accelerometer, camera, RGBD camera, range finder
- Shape description
  - VRML97, COLLADA, STL
- Middleware
  - RTM, ROS
- Physics engines
  - AIST, ODE, PhysX, AgX, Bullet
- Not implemented
  - Deformable objects, cable, aerial robots, radio wave, sound, …

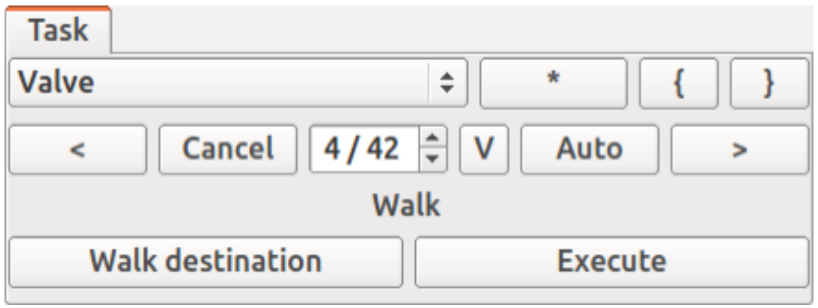




Choreonoid as a User Interface

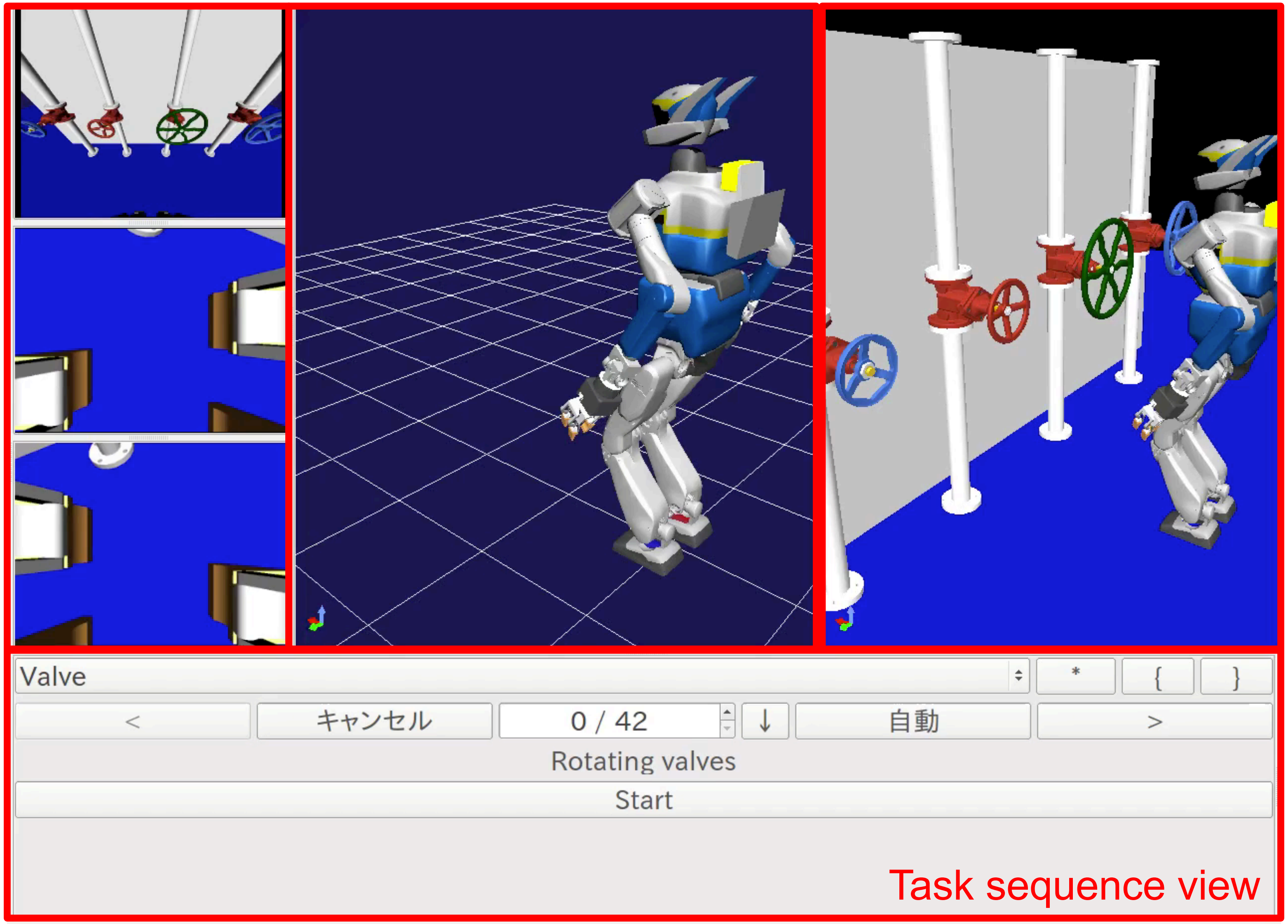
- Markers
  - Walk destination marker
  - Body part marker
  - Manipulation marker
  - Measurement marker
- Task sequence system
  - Task description by Python



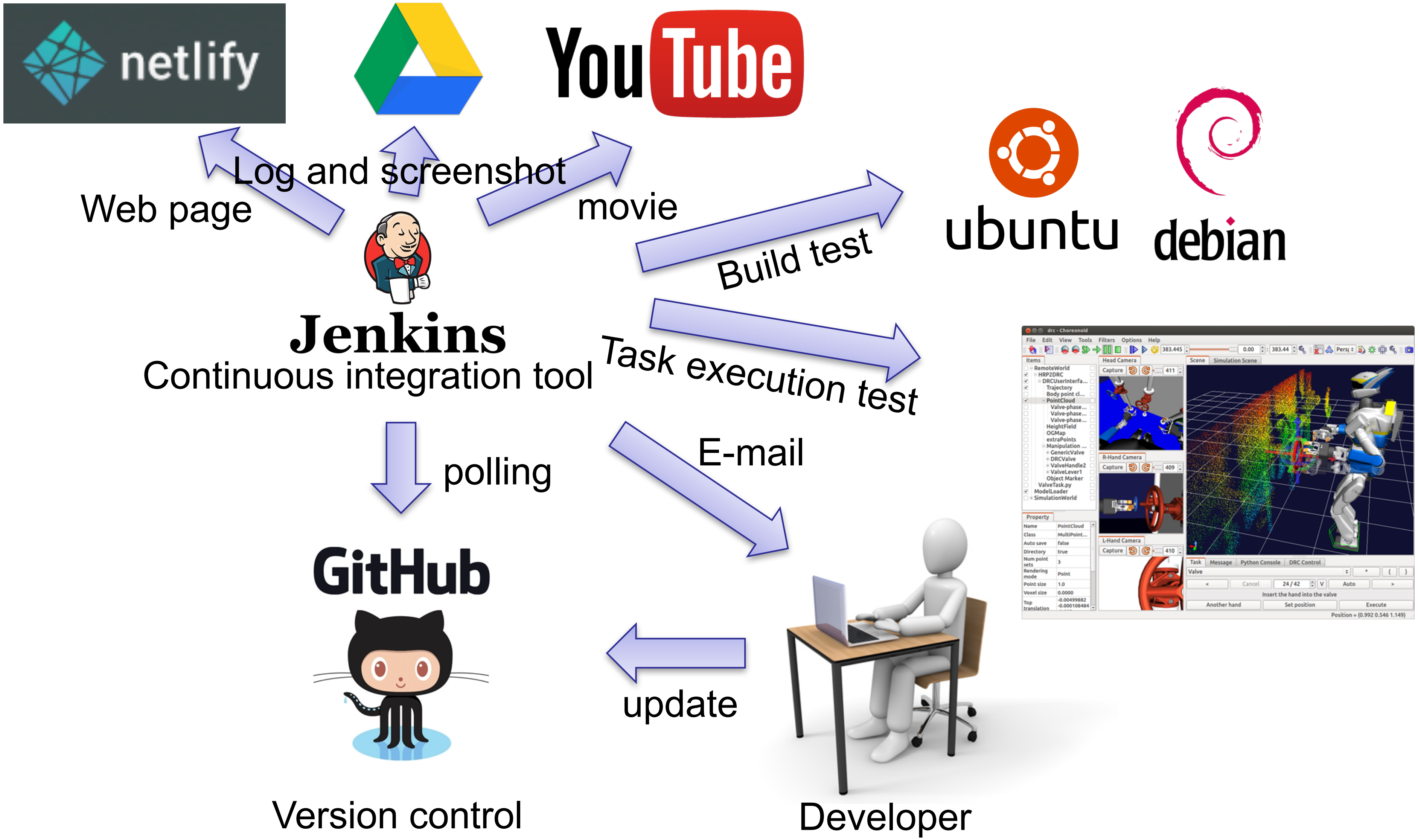


Example: turning a valve

Robot's views Main view Simulation view



Continuous Integration using dynamics simulation



AIST

Summary page of test results

Jenkins CI report

Last update : 2016/05/24 17:04:51

Job Summary

Name	Status	Latest Results									
build-debian7-32	build passing										
build-ubuntu1404-64	build passing										
build-ubuntu1604-64	build passing										
task-hrp2kai-balancebeam	build passing				FALL						
task-hrp2kai-button	build passing									NG	
task-hrp2kai-door	build passing										
task-hrp2kai-terrain	build passing			FALL		FALL	FALL	FALL			
task-hrp2kai-valve	build running		STOP	STOP		STOP	STOP	STOP		STOP	STOP
task-hrp2kai-wall	build passing				FALL		STOP		STOP	STOP	STOP

build results on different OSs

task execution results

Latest 10 test results

Link

History page of test results

task-hrp2kai-valve-building2-6

Build Stability

36%

Link to a build log and a screenshot on Google Drive

Build History

#	Status	Time	Duration	Slave	Inspection	Test	Coverage	Changes	Logs	Notes
2456	SUCCESS	2016/11/01 15:57	14 min.	slave8(Ubuntu 16.04.1 LTS)		0 err.			console.log task.png task.ogv	2307744KB used 1039004KB change
2455	SUCCESS	2016/11/01 14:57	14 min.	slave8(Ubuntu 16.04.1 LTS)		0 err.			console.log task.png task.ogv	2318820KB used 1027500KB change
2454	SUCCESS	2016/11/01 13:57	17 min.	slave8(Ubuntu 16.04.1 LTS)		0 err.		hrpsys-base/4d22e45 hrpsys-base/2bb1d2e	console.log task.png task.ogv	2323916KB used 1009376KB change
2453	SUCCESS	2016/11/01 12:57	21 min.	slave3(Ubuntu 14.04.5 LTS)		0 err.			console.log task.png task.ogv	1987244KB used 927176KB change
2452	SUCCESS	2016/11/01 11:57	29 min.	slave3(Ubuntu 14.04.5 LTS)		0 err.		hrpsys-base/4d22e45 hrpsys-base/2bb1d2e	console.log task.png task.ogv	1995596KB used 916352KB change
2451	SUCCESS	2016/11/01 10:57	21 min.	slave3(Ubuntu 14.04.5 LTS)		0 err.			console.log task.png task.ogv	1991880KB used 935456KB change

Link to GitHub pages

Link to a movie on YouTube

Link

Links

- Choreonoid
  http://www.choreonoid.org
- OpenRTM-aist
  http://www.openrtm.org