SONY

# aibo with ROS

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Sony Corporation

R&D Center  System Technology Development Division  Base System Development Department

# What is “aibo”?

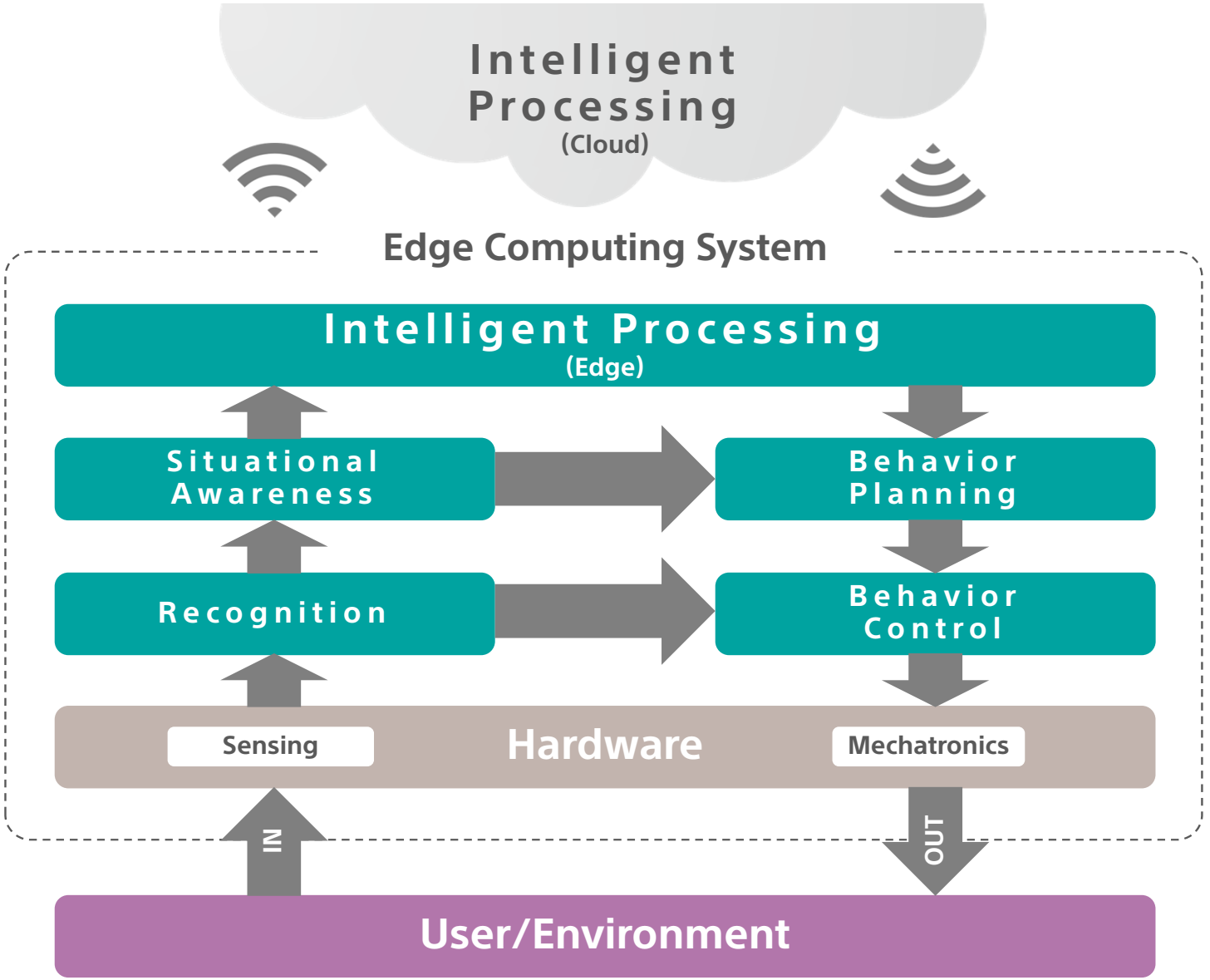
# aibo
# ERS-1000

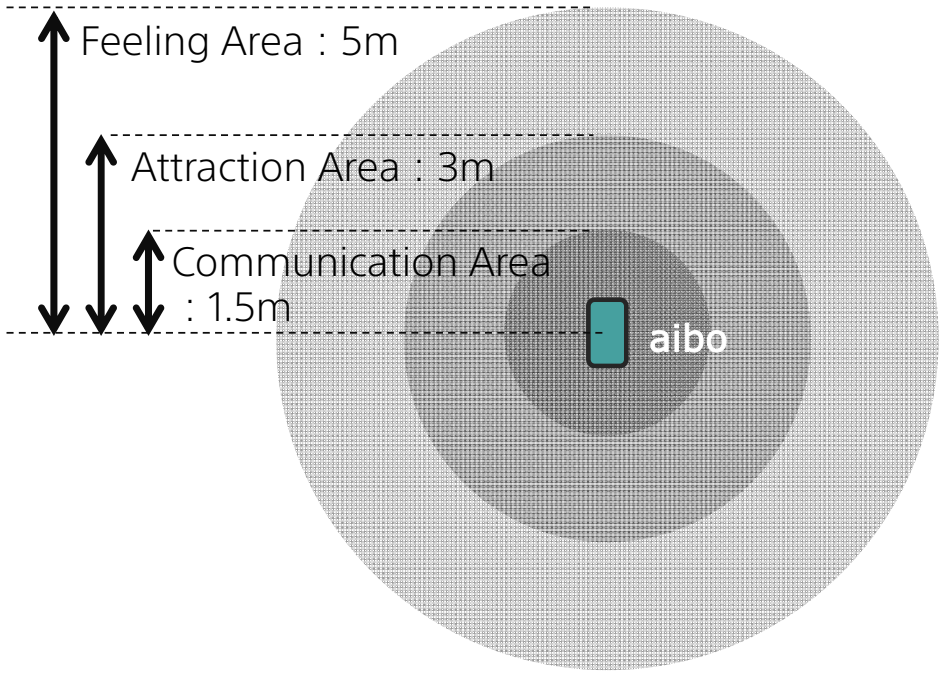
# Coming up in US
# Very soon

**Comes close to you**

**&**

**Makes interaction**


Intelligent Processing
(Cloud)
Edge Computing System
Intelligent Processing
(Edge)
Situational Awareness
Behavior Planning
Recognition
Behavior Control
Sensing
Hardware
Mechatronics
IN
OUT
User/Environment

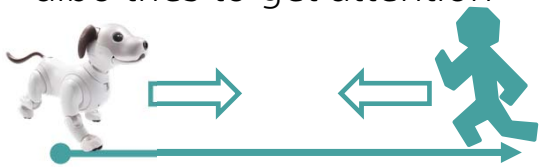



## Feeling Area

aibo can feel someone is there.

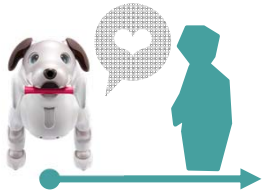
## Attraction Area

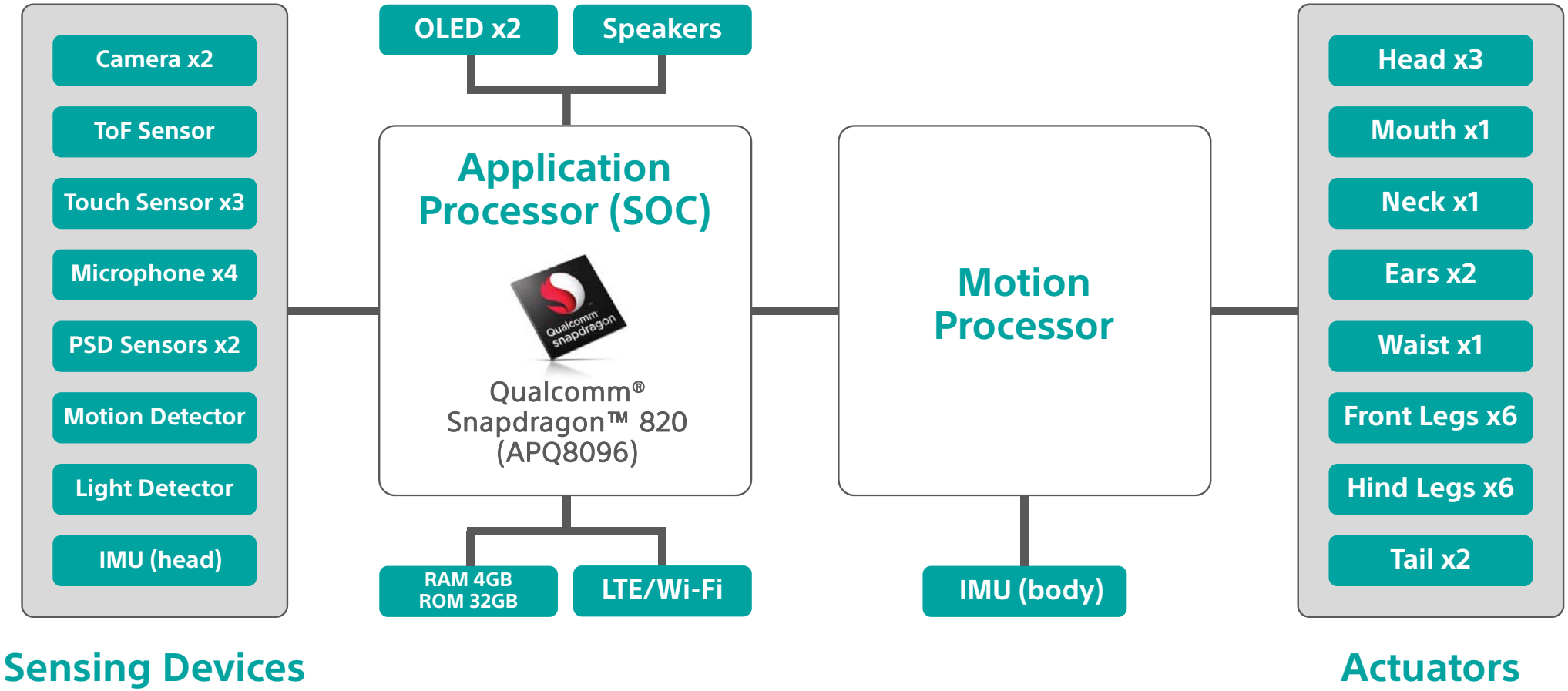
aibo tries to get attention



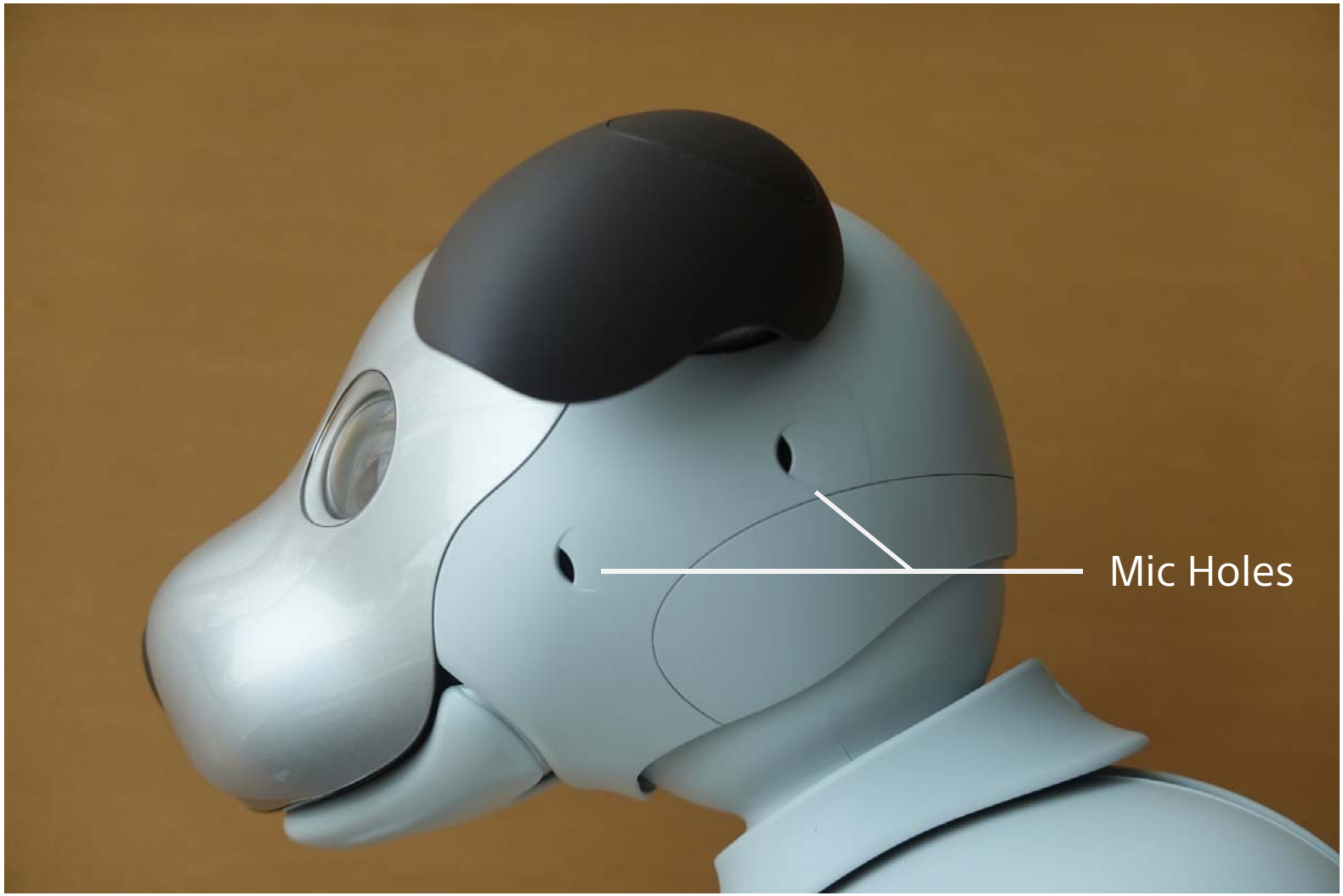
## Communication Area

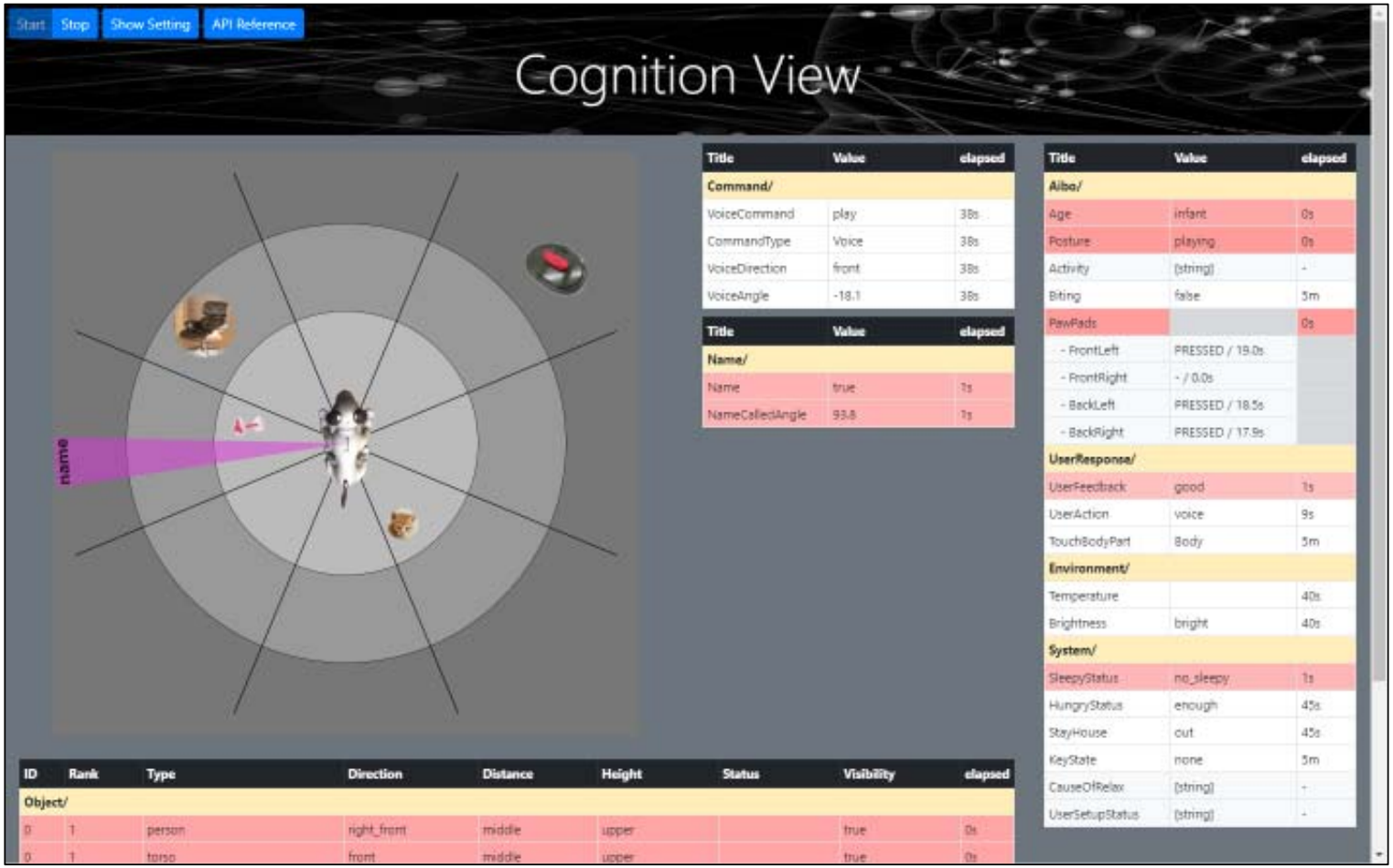
aibo communicates with user/owner




Camera x2
ToF Sensor
Touch Sensor x3
Microphone x4
PSD Sensors x2
Motion Detector
Light Detector
IMU (head)
Sensing Devices
OLED x2
Speakers
Application Processor (SOC)
Qualcomm® Snapdragon™ 820 (APQ8096)
RAM 4GB ROM 32GB
LTE/Wi-Fi
Motion Processor
IMU (body)
Head x3
Mouth x1
Neck x1
Ears x2
Waist x1
Front Legs x6
Hind Legs x6
Tail x2
Actuators

| Sensor | Location | Perpose |
| --- | --- | --- |
| Image (fisheye camera) | Front Face | Face / Body / Hand / Object / Color / QR code |
| Image (fisheye camera) | Back | SLAM(Simultaneous Localization and Mapping) |
| ToF (Time of Flight) | Front Face | Object Detection |
| PSD (Position Sensitive Detector) | Chest | Cliff Detection |
| Touch Pressure | Back | Patting / Slapping Detection |
| Touch Capacitive | Head, Chin | Patting Detection |
| 6 axis (gyro x accelerometer) | Head | Lift / Cliff Detection |
| 6 axis (gyro x accelerometer) | Body | Lift Detection<br>Walk Balance Calibration |
| Human Detect | Body | Human Detection |
| Ambient Light | Body | Environment Prediction |
| Ground | Paw | Floor Contact Detection |


Mic Holes

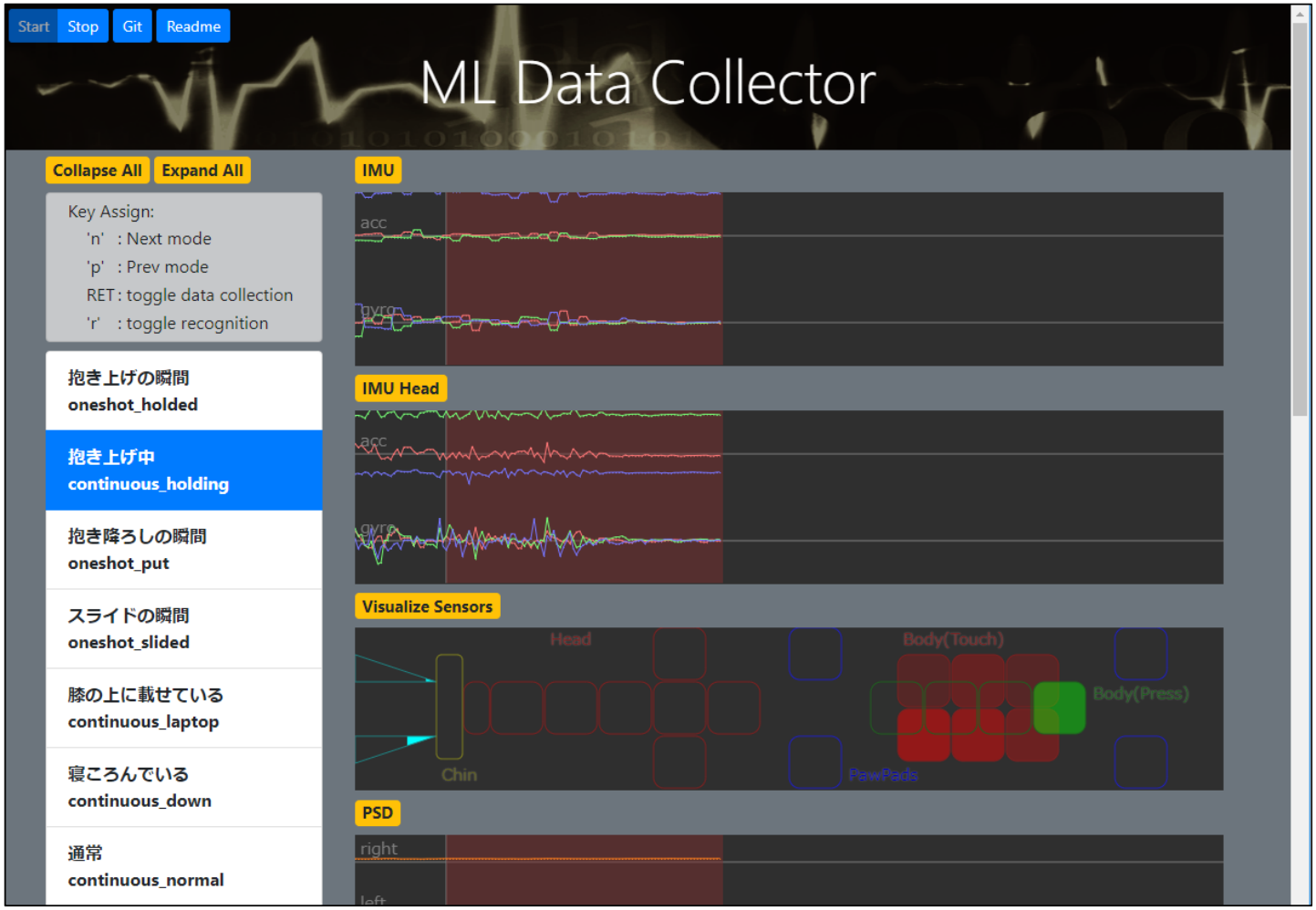


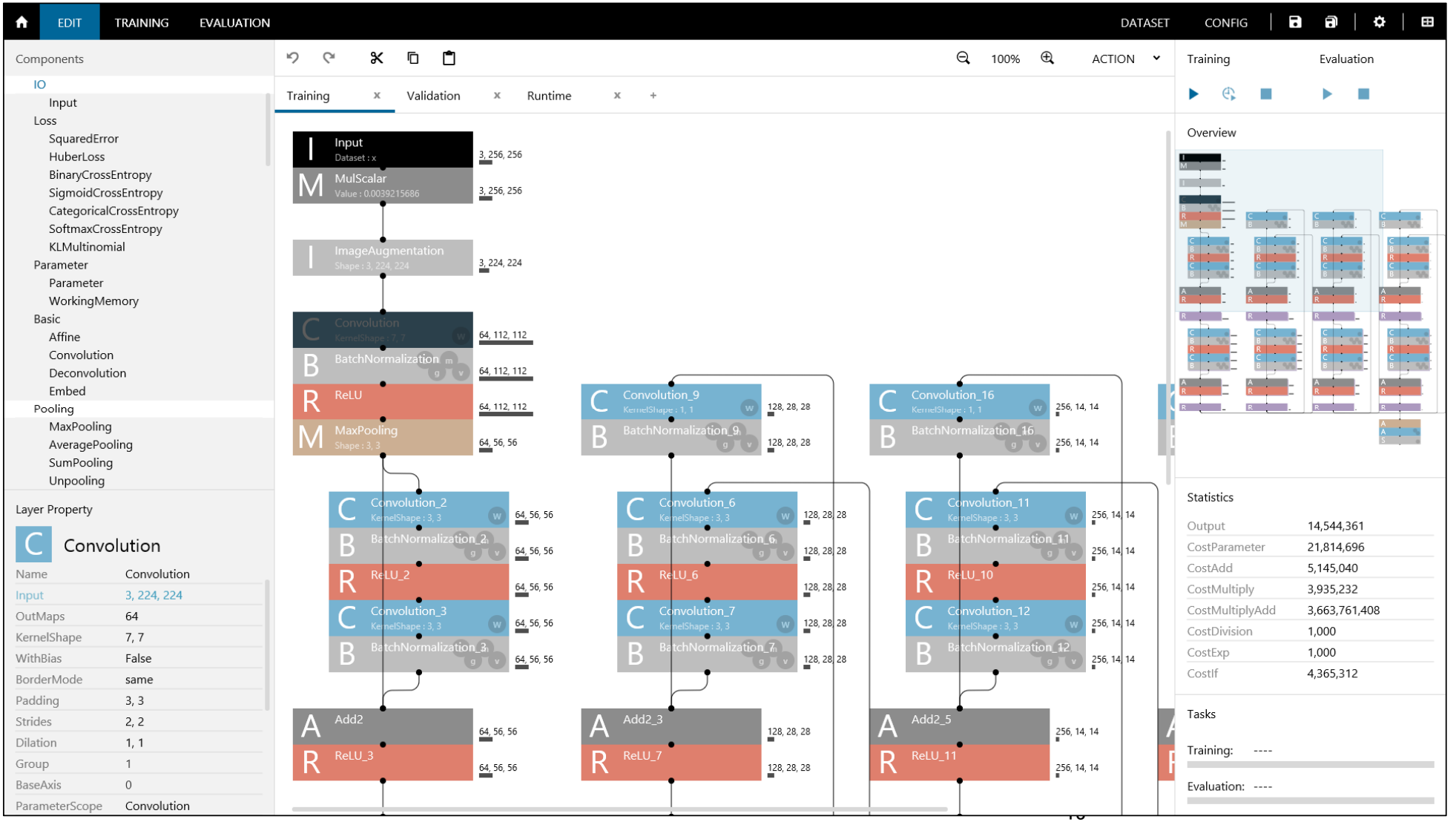

| Title | Value | elapsed |
|---|---|---|
| **Command/** | | |
| VoiceCommand | play | 38s |
| CommandType | Voice | 38s |
| VoiceDirection | front | 38s |
| VoiceAngle | -18.1 | 38s |

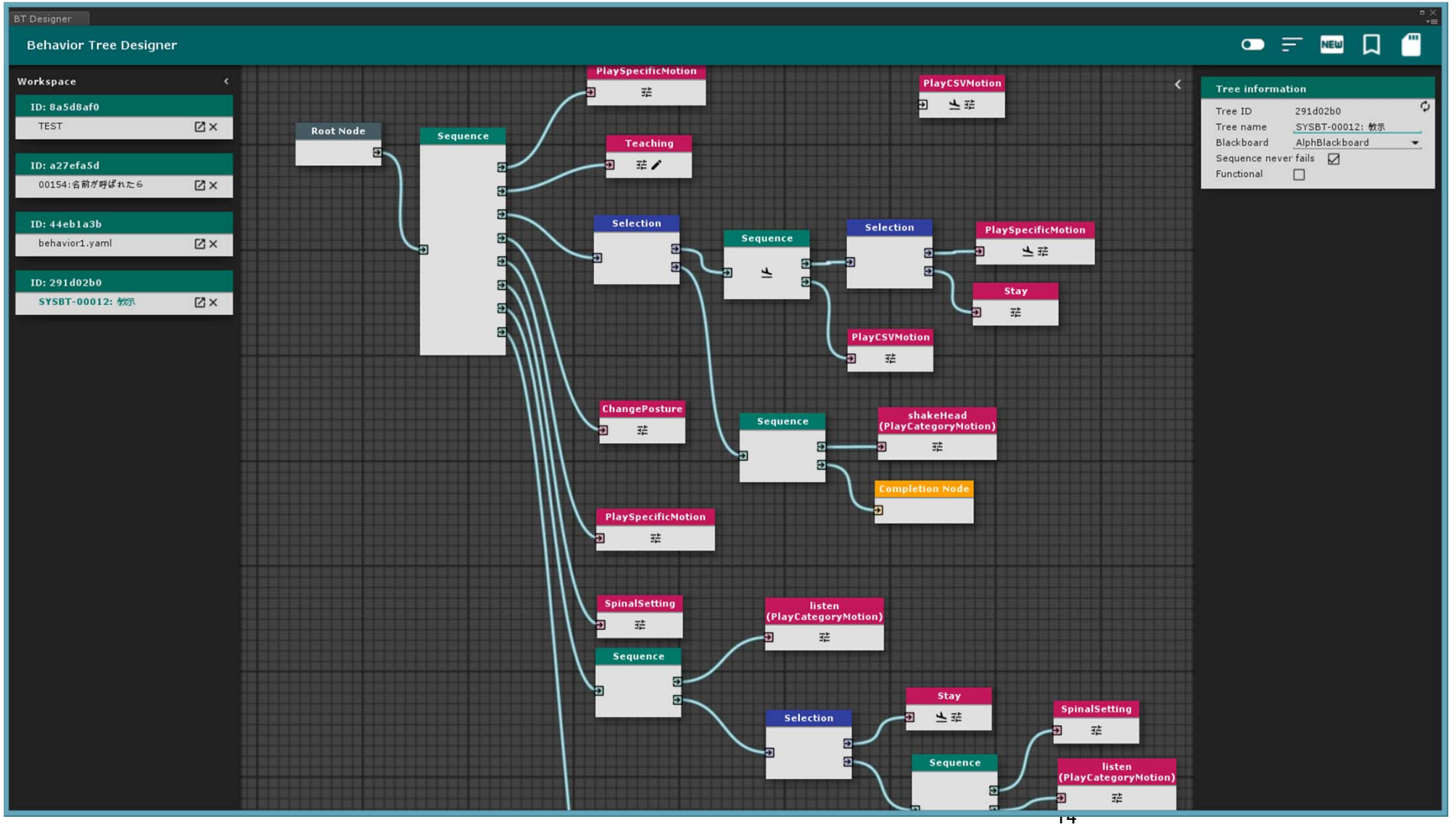
| Title | Value | elapsed |
|---|---|---|
| **Name/** | | |
| Name | true | 1s |
| NameCalledAngle | 93.8 | 1s |

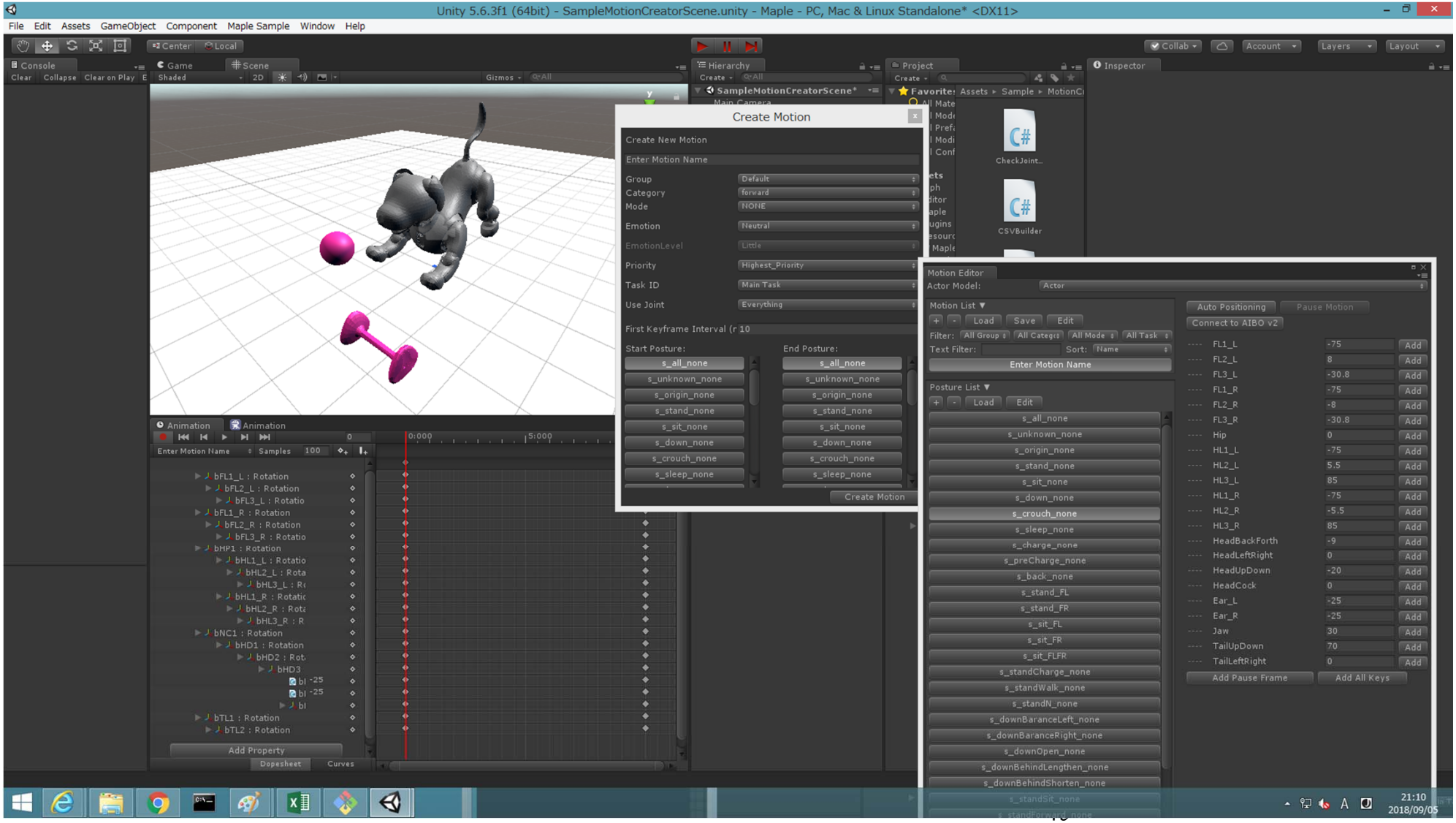
| Title | Value | elapsed |
|---|---|---|
| **Aibo/** | | |
| Age | infant | 0s |
| Posture | playing | 0s |
| Activity | (string) | - |
| Biting | false | 5m |
| PawPads | | 0s |
| - FrontLeft | PRESSED / 19.0s | |
| - FrontRight | - / 0.0s | |
| - BackLeft | PRESSED / 18.5s | |
| - BackRight | PRESSED / 17.9s | |
| **UserResponse/** | | |
| UserFeedback | good | 1s |
| UserAction | voice | 9s |
| TouchBodyPart | Body | 5m |
| **Environment/** | | |
| Temperature | | 40s |
| Brightness | bright | 40s |
| **System/** | | |
| SleepyStatus | no_sleepy | 1s |
| HungryStatus | enough | 45s |
| StayHouse | out | 45s |
| KeyState | none | 5m |
| CauseOfRelax | (string) | - |
| UserSetupStatus | (string) | - |

| ID | Rank | Type | Direction | Distance | Height | Status | Visibility | elapsed |
|---|---|---|---|---|---|---|---|---|
| **Object/** | | | | | | | | |
| 0 | 1 | person | right_front | middle | upper | | true | 0s |
| 0 | 1 | torso | front | middle | upper | | true | 0s |

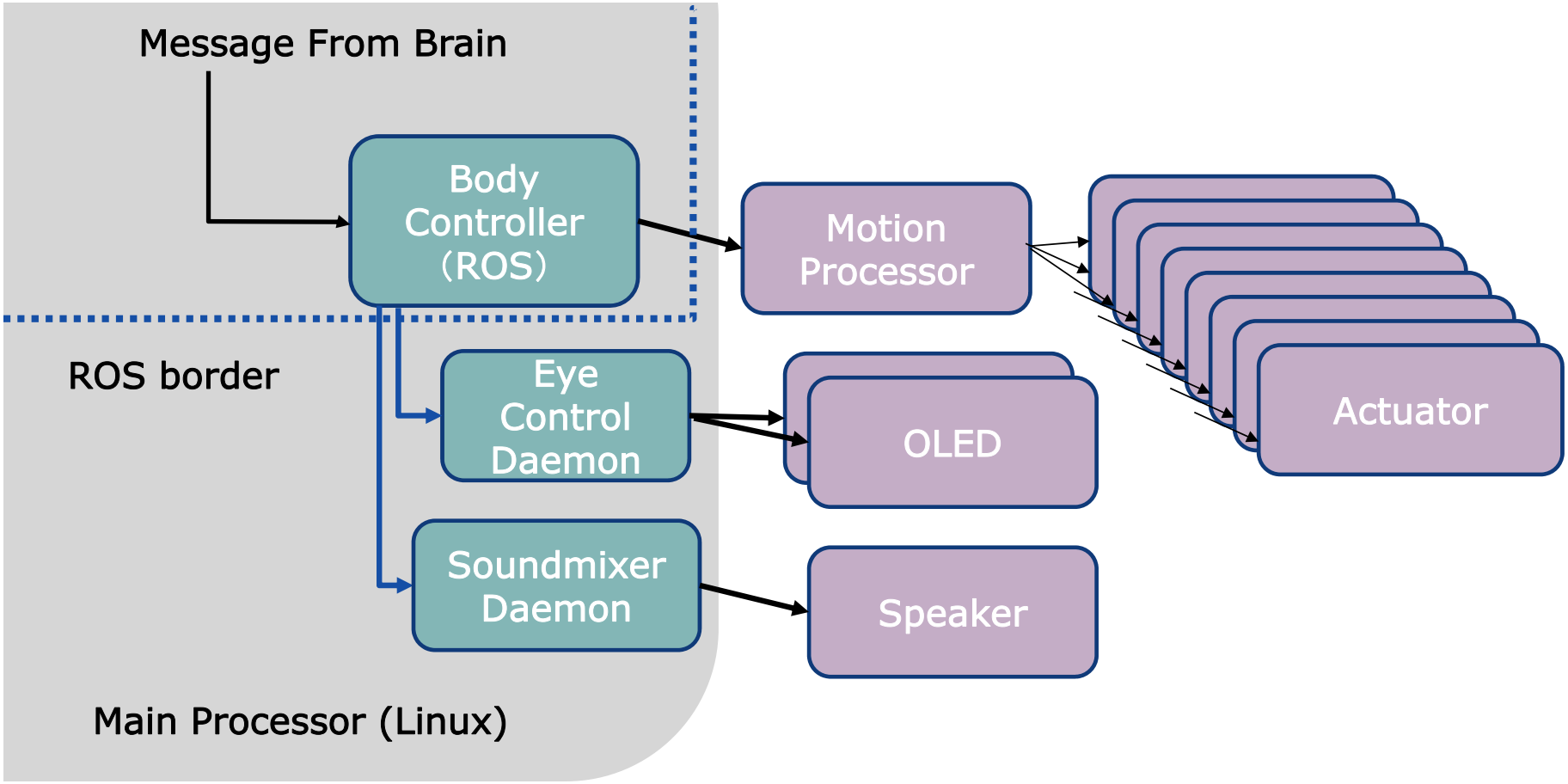

Start
Stop
Git
Readme
ML Data Collector
Collapse All
Expand All
Key Assign:
'n' : Next mode
'p' : Prev mode
RET : toggle data collection
'r' : toggle recognition
抱き上げの瞬間
oneshot_holded
抱き上げ中
continuous_holding
抱き降ろしの瞬間
oneshot_put
スライドの瞬間
oneshot_slided
膝の上に載せている
continuous_laptop
寝ころんでいる
continuous_down
通常
continuous_normal
IMU
acc
gyro
IMU Head
acc
gyro
Visualize Sensors
Head
Body(Touch)
Body(Press)
Chin
PawPads
PSD
right
left

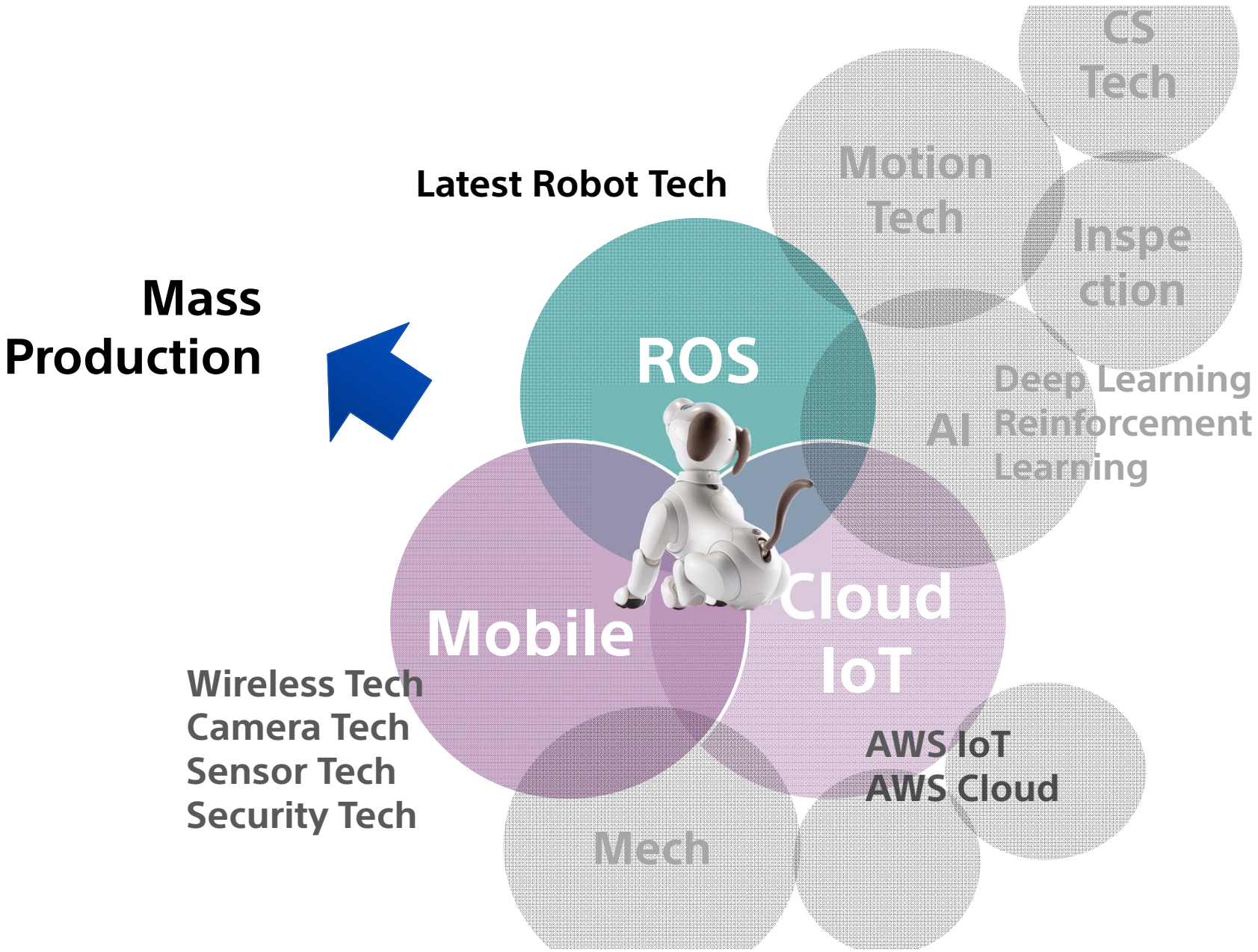

EDIT
TRAINING
EVALUATION
DATASET
CONFIG
Components
IO
Input
Loss
SquaredError
HuberLoss
BinaryCrossEntropy
SigmoidCrossEntropy
CategoricalCrossEntropy
SoftmaxCrossEntropy
KLMultinomial
Parameter
Parameter
WorkingMemory
Basic
Affine
Convolution
Deconvolution
Embed
Pooling
MaxPooling
AveragePooling
SumPooling
Unpooling
Layer Property
Convolution
Name Convolution
Input 3, 224, 224
OutMaps 64
KernelShape 7, 7
WithBias False
BorderMode same
Padding 3, 3
Strides 2, 2
Dilation 1, 1
Group 1
BaseAxis 0
ParameterScope Convolution
100%
ACTION
Training
Validation
Runtime
Input
Dataset : x
3, 256, 256
MulScalar
Value : 0.0039215686
3, 256, 256
ImageAugmentation
Shape : 3, 224, 224
3, 224, 224
Convolution
KernelShape : 7, 7
64, 112, 112
BatchNormalization
64, 112, 112
ReLU
64, 112, 112
MaxPooling
Shape : 3, 3
64, 56, 56
Convolution_2
KernelShape : 3, 3
64, 56, 56
BatchNormalization_2
64, 56, 56
ReLU_2
64, 56, 56
Convolution_3
KernelShape : 3, 3
64, 56, 56
BatchNormalization_3
64, 56, 56
Add2
64, 56, 56
ReLU_3
64, 56, 56
Convolution_9
KernelShape : 1, 1
128, 28, 28
BatchNormalization_9
128, 28, 28
Convolution_6
KernelShape : 3, 3
128, 28, 28
BatchNormalization_6
128, 28, 28
ReLU_6
128, 28, 28
Convolution_7
KernelShape : 3, 3
128, 28, 28
BatchNormalization_7
128, 28, 28
Add2_3
128, 28, 28
ReLU_7
128, 28, 28
Convolution_16
KernelShape : 1, 1
256, 14, 14
BatchNormalization_16
256, 14, 14
Convolution_11
KernelShape : 3, 3
256, 14, 14
BatchNormalization_11
256, 14, 14
ReLU_10
256, 14, 14
Convolution_12
KernelShape : 3, 3
256, 14, 14
BatchNormalization_12
256, 14, 14
Add2_5
256, 14, 14
ReLU_11
256, 14, 14
Training
Evaluation
Overview
Statistics
Output 14,544,361
CostParameter 21,814,696
CostAdd 5,145,040
CostMultiply 3,935,232
CostMultiplyAdd 3,663,761,408
CostDivision 1,000
CostExp 1,000
CostIf 4,365,312
Tasks
Training: ----
Evaluation: ----


BT Designer
Behavior Tree Designer
NEW
Workspace
ID: 8a5d8af0
TEST
ID: a27efa5d
00154:名前が呼ばれたら
ID: 44eb1a3b
behavior1.yaml
ID: 291d02b0
SYSBT-00012: 教示
Root Node
Sequence
PlaySpecificMotion
Teaching
Selection
Sequence
Selection
PlaySpecificMotion
Stay
PlayCSVMotion
PlayCSVMotion
ChangePosture
Sequence
shakeHead (PlayCategoryMotion)
Completion Node
PlaySpecificMotion
SpinalSetting
listen (PlayCategoryMotion)
Sequence
Stay
Selection
SpinalSetting
Sequence
listen (PlayCategoryMotion)
Tree information
Tree ID 291d02b0
Tree name SYSBT-00012: 教示
Blackboard AlphBlackboard
Sequence never fails
Functional


Unity 5.6.3f1 (64bit) - SampleMotionCreatorScene.unity - Maple - PC, Mac & Linux Standalone* <DX11>
File Edit Assets GameObject Component Maple Sample Window Help
Create Motion
Create New Motion
Enter Motion Name
Group
Category
Mode
Emotion
EmotionLevel
Priority
Task ID
Use Joint
First Keyframe Interval (r 10
Start Posture:
End Posture:
Create Motion
Motion Editor
Actor Model:
Motion List
Load
Save
Edit
Text Filter:
Sort:
Enter Motion Name
Posture List
Auto Positioning
Pause Motion
Connect to AIBO v2
Add Pause Frame
Add All Keys


aibo
Home
About this trick
Back
Happy birthday
Tell aibo, "Happy birthday!" or "Happy birthday to you!" and your aibo will sing a birthday song.
Seat the birthday boy or girl in front of your aibo, and have aibo sing as a special present. Make birthdays magical with aibo!
Let aibo know how proud you are of him or her!
Creator:Sony Corporation
Version:1.0.0
Copyrights:Copyright 2018 Sony Corporation
Make aibo forget
Try trick

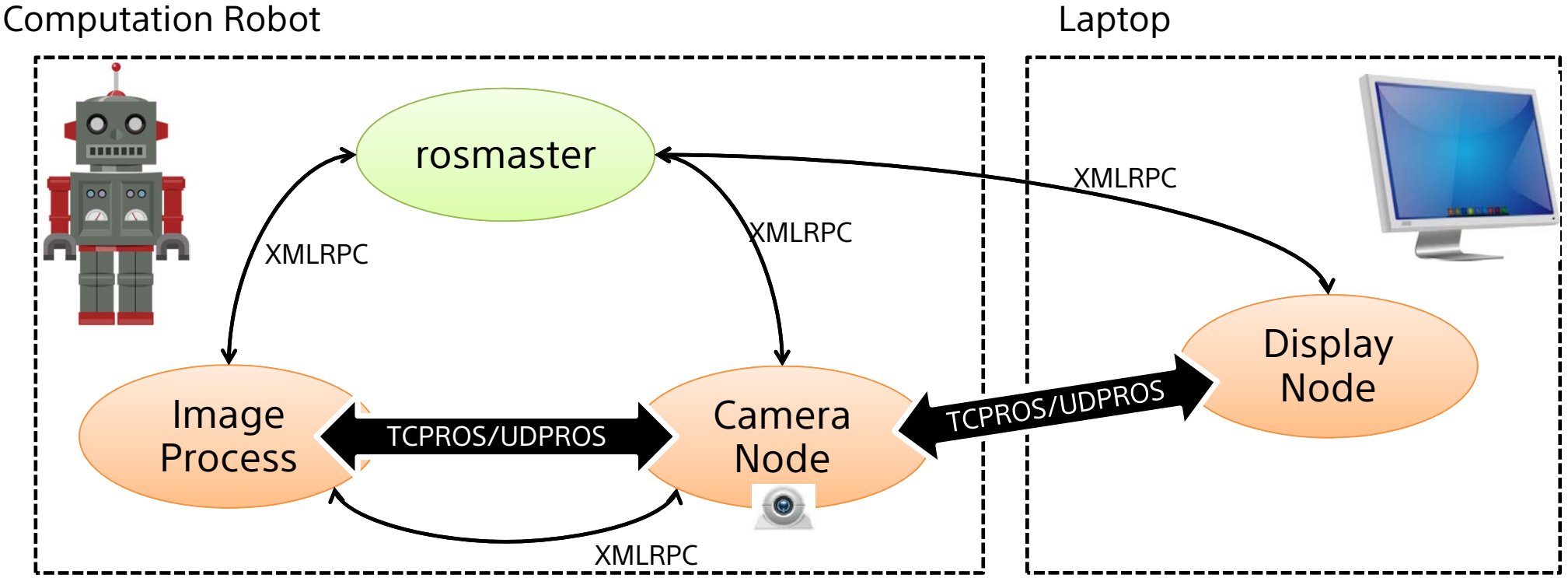

Message From Brain
Body Controller (ROS)
Motion Processor
Actuator
ROS border
Eye Control Daemon
OLED
Soundmixer Daemon
Speaker
Main Processor (Linux)


Latest Robot Tech
Mass Production
ROS
Mobile
Cloud
IoT
Motion Tech
CS Tech
Inspection
AI
Deep Learning
Reinforcement Learning
Wireless Tech
Camera Tech
Sensor Tech
Security Tech
AWS IoT
AWS Cloud
Mech

# ROS Embedded Optimization

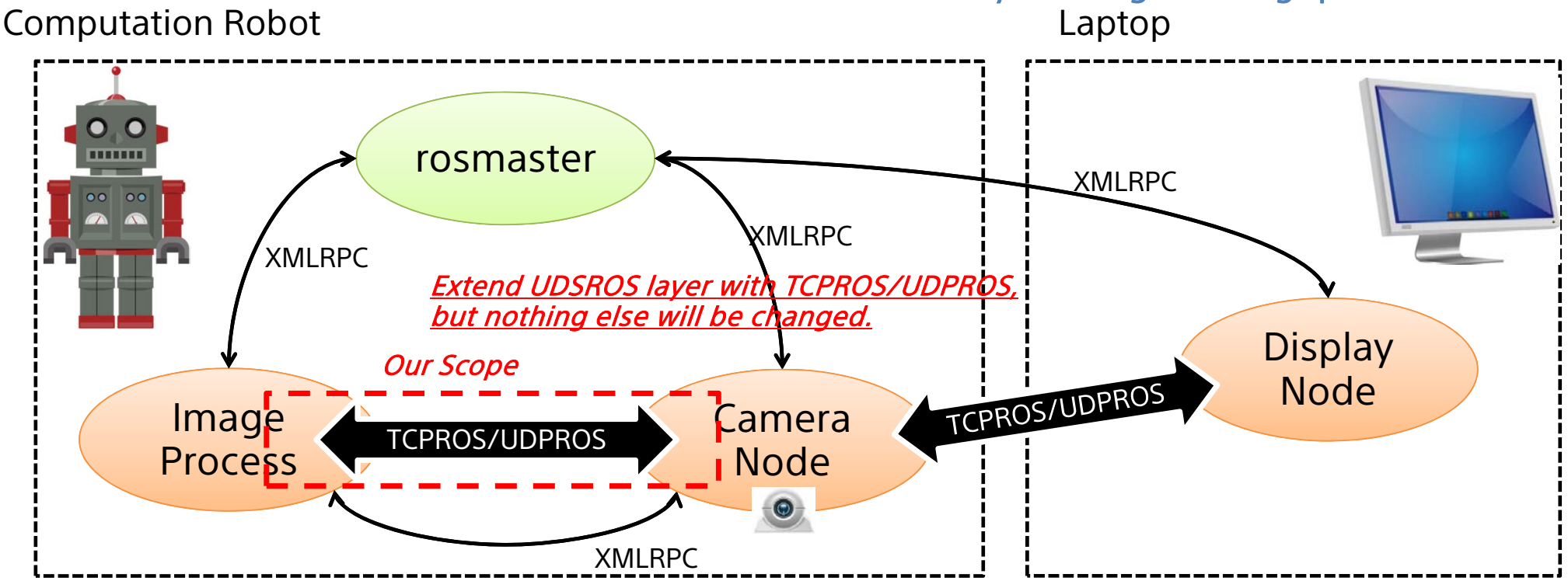
# ROS Transport Overview

XMLRPC:
  configuration information
TCPROS/UDPROS:
  data payload such as topic and services.



# ROS Transport Overview

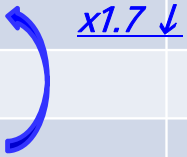
- What's the problem?
  - CPU resource stress
  - Latency and Throughput.
- Countermeasure Preconditions
  - No change required for applications.
  - Good affinity with TCP/UDP
  - small latency and high throughput.

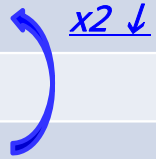


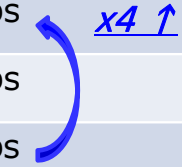
# Expected Improvement as System

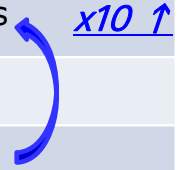
- Source Code
  - https://github.com/tomoyafujita/ipc-bench
- Environment
  - skylake(amd64) / hikey(arm64)
  - CPU frequency governor is “performance”
  - 100byte data payload / 10000 test loop average
- Performance Improvement for System

| Category | | Skylake | Hikey |
|---|---|---|---|
| Latency | UDS(STREAM) | 1.82 us | 44.4 us |
| [usec] | UDS(DGRAM) | 2.14 us | 19.9 us |
| | TCP/IP | 3.14 us | 87.7 us |
| | UDP/IP | 2.78 us | 67.2 us |
| Through-Put | UDS(STREAM) | 1.95 Gbps | 127 Mbps |
| | UDS(DGRAM) | 1.98 Gbps | 92 Mbps |
| | TCP/IP | 0.43 Gbps | 12 Mbps |

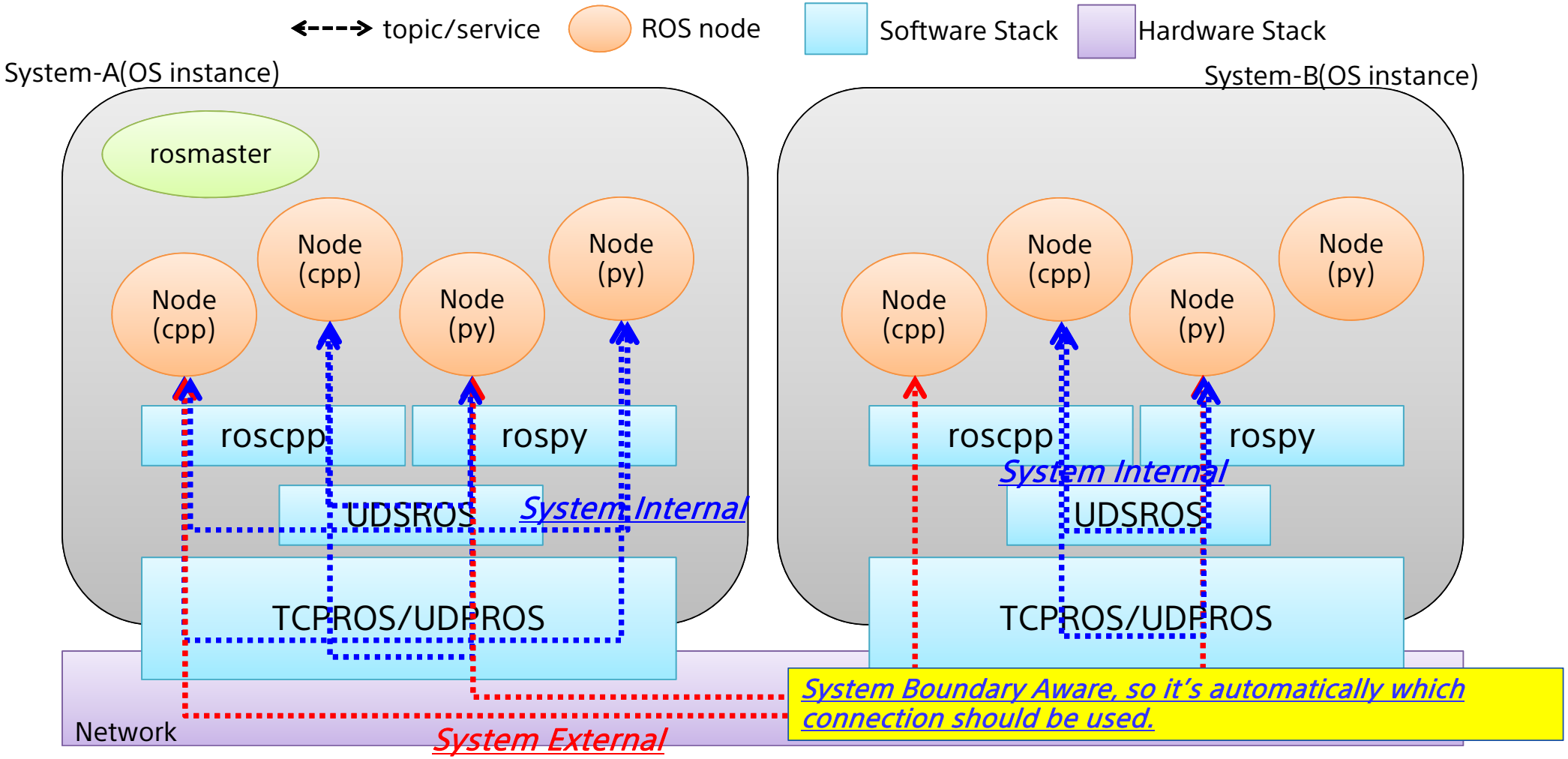


# Extended Transport Overview



# Improvement Result

- HelloWorld Benchmark
  - Publisher:Subscriber=1:1
  - Synchronous test loop using shared memory.
  - Latency is the time window between publish and callback entrance.
  - Environment: amd64(skylake) and arm64(hikey)

- Result Comparison

| Platform | ROS Transport | Duration [nsec] | | |
|---|---|---|---|---|
| | | min | max | average |
| Skylake | TCP/IP | 46,582 | 287,173 | 70,393 |
| | UDS | 42,877 | 286,130 | 64,796 |
| Hikey | TCP/IP | 552,224 | 6,040,312 | 1,145,881 |
| | UDS | 435,833 | 10,075,833 | 872,981 |

8% ↓

24% ↓

Github Repository

https://github.com/fujitatomoya/ros_comm/tree/topic-kinetic-devel-uds-support

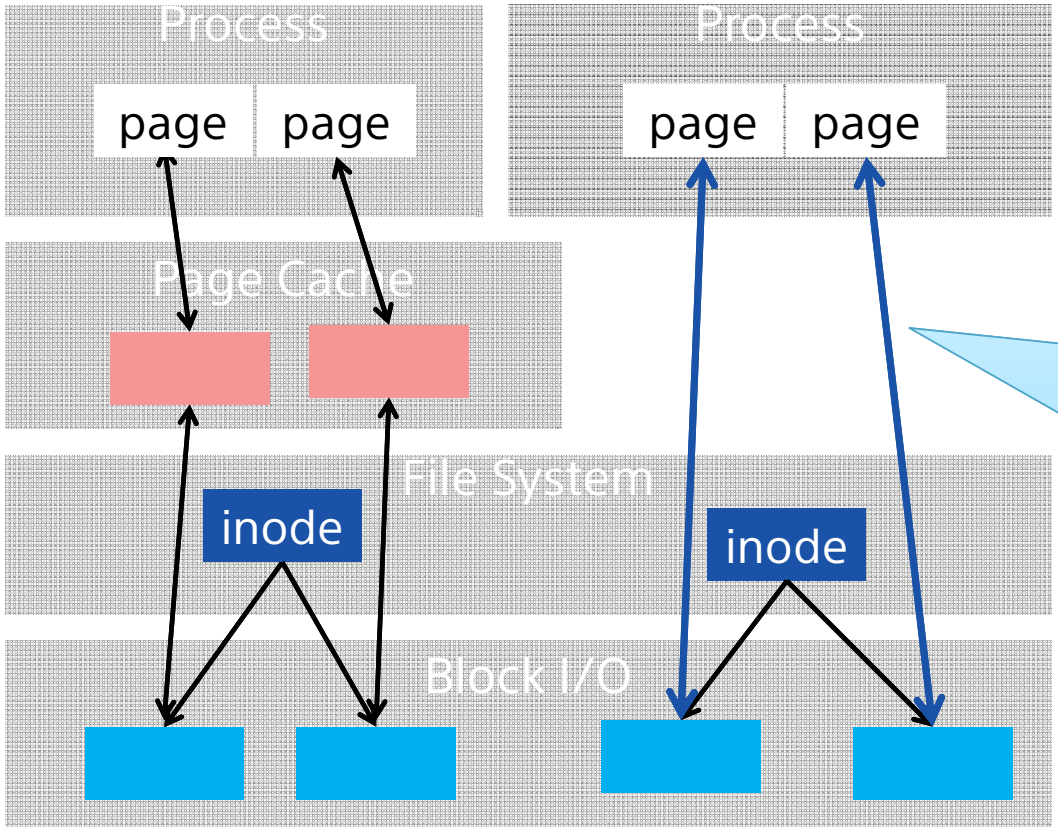
Pull Request

https://github.com/ros/ros_comm/pull/1510

Tomoya Fujita <Tomoya.Fujita@sony.com>
Barry Xu <Barry.Xu@sony.com>

# Direct I/O with rosbag

- Reference
  - https://github.com/osrf/rosbag_direct_write




Data in userland will be stored directly to the storage device without CPU workload.

(*) memory alignment constraints

# Epoll

- What is the problem?
  - The more ROS topic connection, the more CPU stress with ros::spin()
    - Waiting for the stimulus during ros::spin without any message transmission.
  - Poll system call is not good enough to take care of many file descriptors.

- Countermeasure
  - Using epoll instead, to reduce CPU stress.
  - Already introduces as following commit, so backport the fix into 1.12.7 ros_comm.

```
commit 9c0db37d9231003a7f162857e4aeb45675839609
Author: Mike Purvis <mike@uwmike.com>
Date:   Thu Dec 21 11:31:08 2017 -0500

    Topic subscription scalability fix (#1217)

    Switching to using epoll system calls to improve performance of the topic polling code by a factor of 2.
    This required disabling the addDelMultiThread test.
```

# Polling Frequency

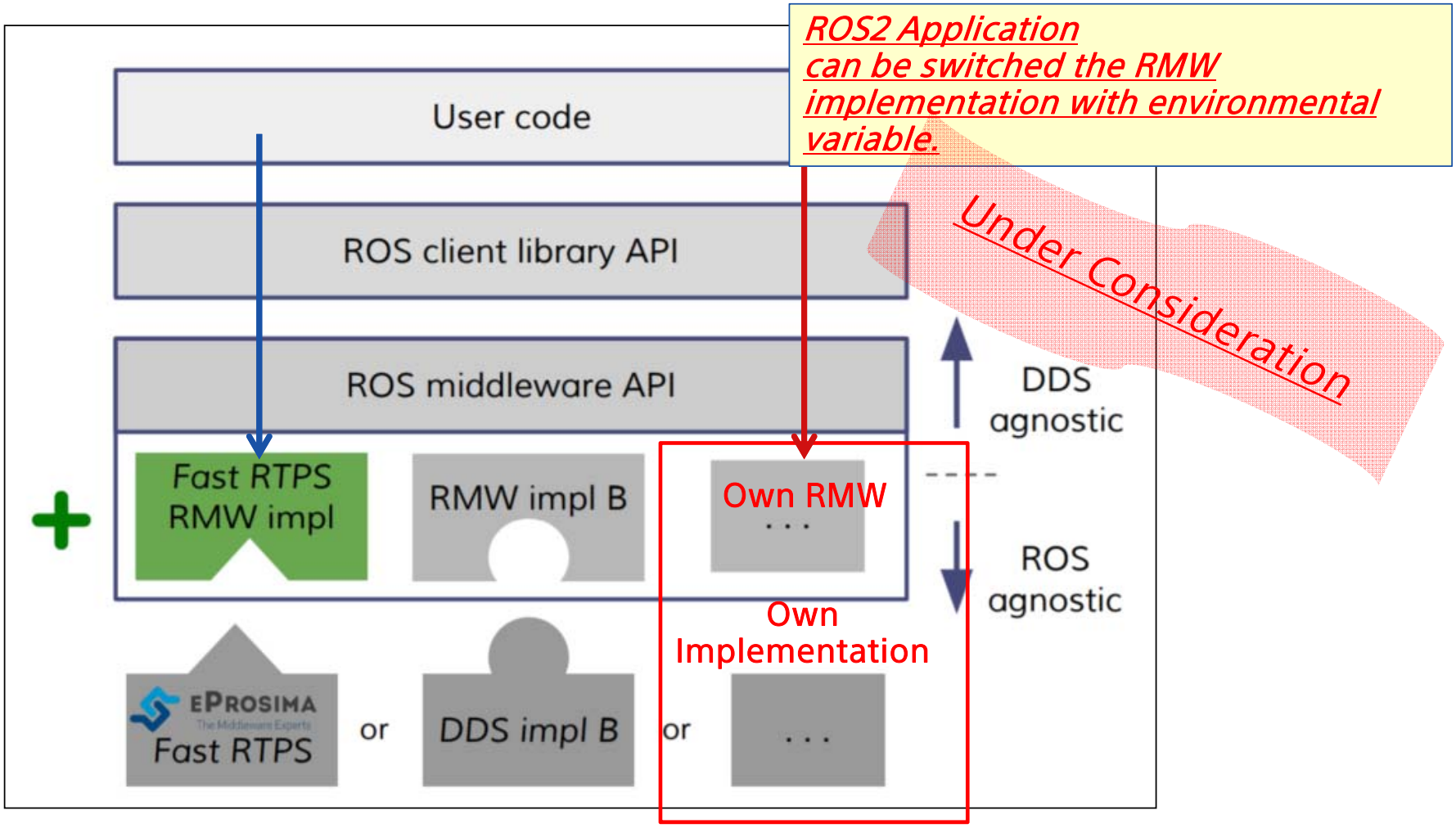
- ROS Threads

| Thread Name | Use |
|---|---|
| Main | Main thread |
| PollManager | Publish/Subscribe I/O Polling |
| XMLRPCManager | Talk to rosmaster for connectivity map and services |
| ROSOutAppender | Logging |
| internalCallbackQueue | Connection drop, data store etc… |

Polling Frequency Tunable for each processes, less CPU stress. (default freq is 100msec)

No Logging thread, less CPU stress. (instead of that, using own log system)

# For ROS2


ROS2 Application
can be switched the RMW
implementation with environmental
variable.
Under Consideration
User code
ROS client library API
ROS middleware API
DDS
agnostic
ROS
agnostic
Fast RTPS
RMW impl
RMW impl B
Own RMW
. . .
Own
Implementation
eProsima
Fast RTPS
or
DDS impl B
or
. . .

# *Special Thanks to ROS Community*

SONY