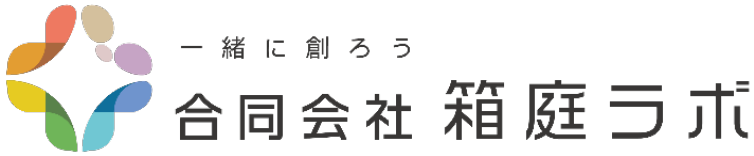
An Integrated Distributed Simulation Environment weaving by Hakoniwa and mROS 2



Hideki Takase (The Univ. of Tokyo)
Shintaro Hosoai (The Univ. of Tokyo)
Tatsuya Fukuta (INTEC Inc.)
Mitsutaka Takada (Nagoya Univ.)
Shin Kuboaki (Change Vision, Inc.)
Takashi Mori (ESM, Inc. & Hakoniwa Lab.)

We are TOPPERS/Hakoniwa WG!!

- Hideki Takase
- @takasehideki
- The Univ. of Tokyo
- EMB/IoT PF, ROS

- Tatsuya Fukuta
- @fudekunjp
- INTEC Inc.
- Cloud, Robotics

- Shin Kuboaki
- @kuboaki
- Change Vision, Inc.
- MBD/MDD, App

- Shintaro Hosoai
- @s-hosoai
- The Univ. of Tokyo
- IDE, Modeling

- Mitsutaka Takada
- @mitsu48
- Nagoya Univ.
- Kernel, Automotive

- Takashi Mori
- @kanetugu2020
- ESM & Hakoniwa Lab
- **Tech Leader!!**

- About TOPPERS Project (Toyohashi OPen Platform for Embedded Real-time Systems)
  - NPO in Japan to promote embedded systems technology and its industry by developing and releasing high-quality open-source software, especially in real-time kernels and components
- Hakoniwa WG: working group to establish simulation technology for the IoT fields

TOPPERS

TOPPERS
Toyohashi OPen Platform
for Embedded Real-time Systems

Agenda

1. What is Hakoniwa?
2. Our Past Achievements, especially for ROS Robot
3. Latest Update: hakoniwa-mros2sim
4. Fusion of Virtual and Real weaving by Hakoniwa and mROS 2
5. Wrapping Up

Agenda

1. **What is Hakoniwa?**
   - **What's the issue**
   - **Concept: HUB to Everything for Simulation!**
   - **Key Functions: Hakoniwa Core, Conductor and Protocol Data Unit**
2. Our Past Achievements, especially for ROS Robot
3. Latest Update: hakoniwa-mros2sim
4. Fusion of Virtual and Real weaving by Hakoniwa and mROS 2
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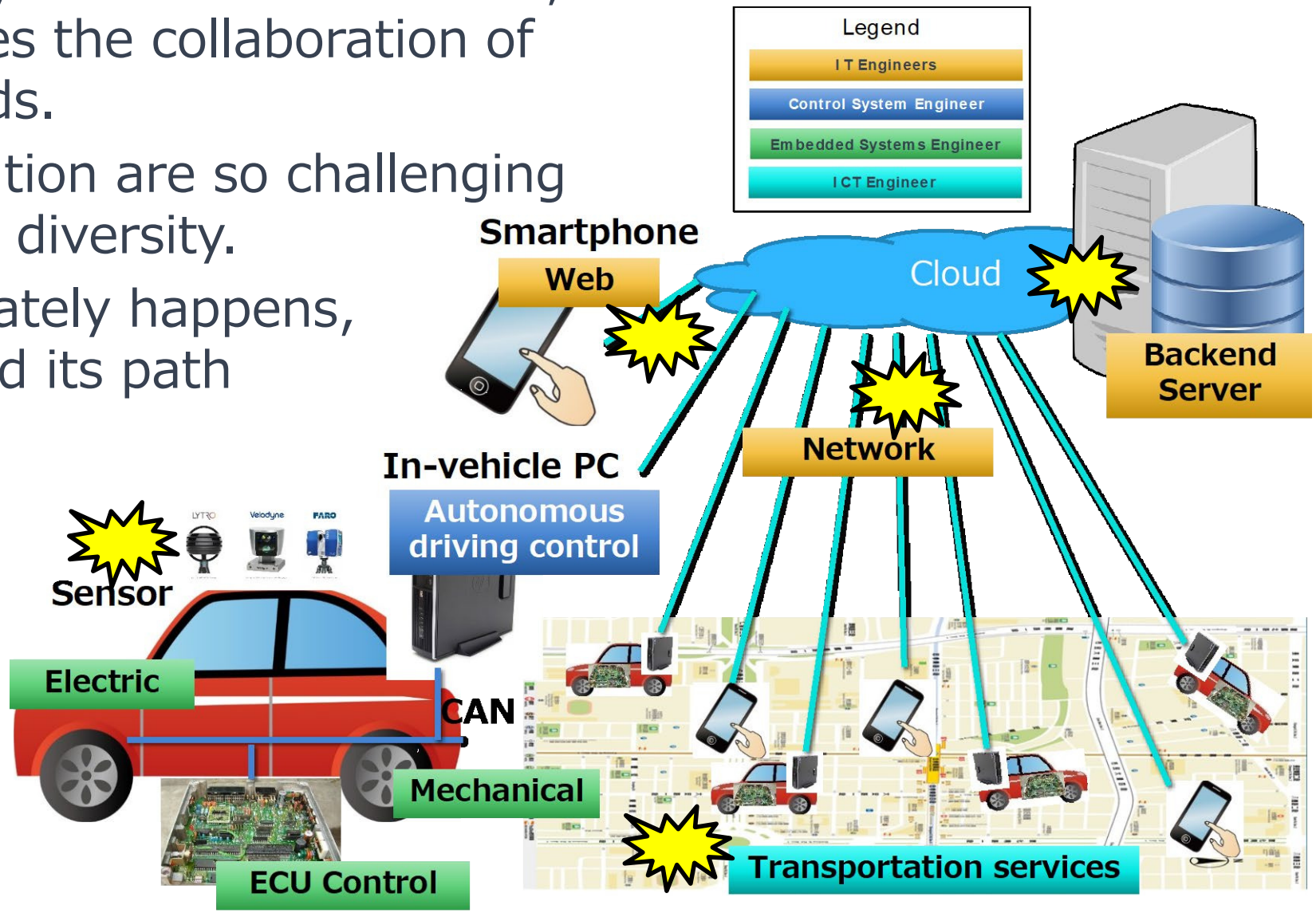
Issue and Background

- IoT system spans a variety of technical domains, so its development requires the collaboration of experts from different fields.
- Integration test and validation are so challenging due to these technologies' diversity.
- When a problem unfortunately happens, investigating the cause and its path becomes intricate.
- Costs for conducting empirical experiments also increase significantly.



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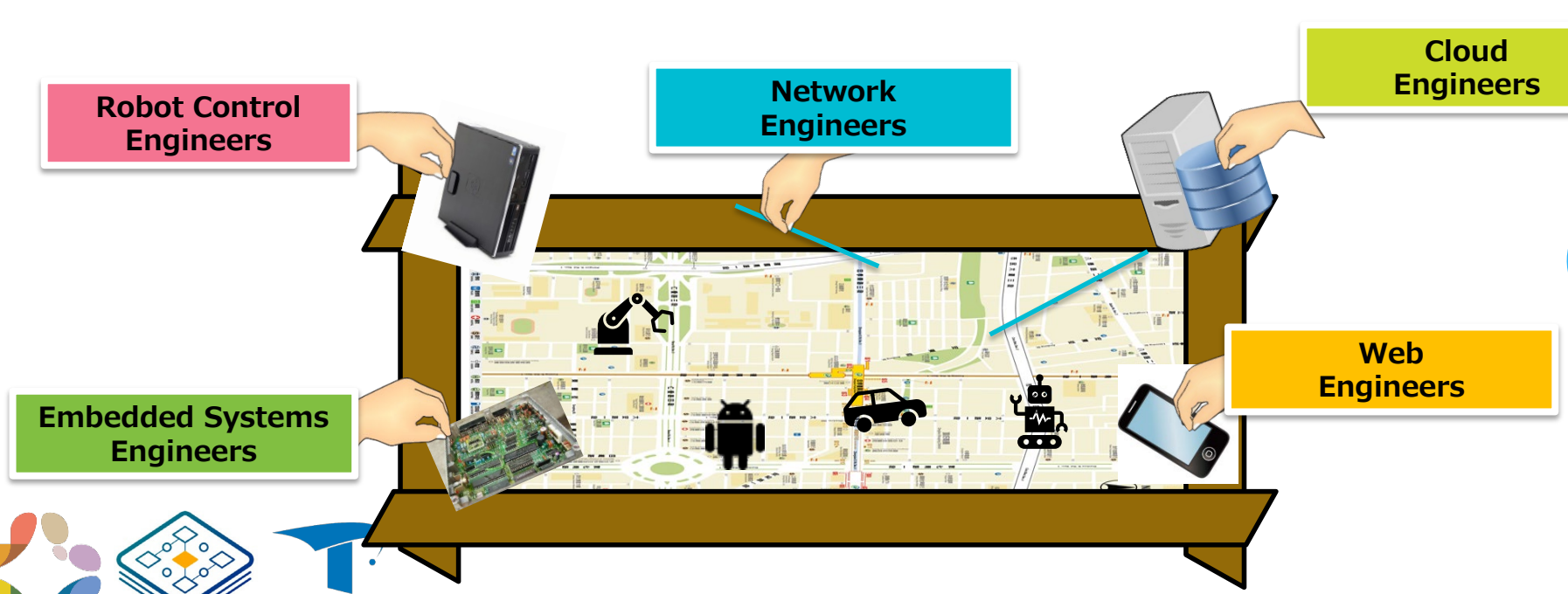
Let’s bring them into a BOX!!

- Arranging various technologies according to everyone's preferences
- Trying out various combinations as often we want
- Observing them according to everyone's preferences into the same box
- Bringing together things (e.g., software) from various tech fields to perform end-to-end integration, and verification on the desk!

-> Developing IoT/robot systems in a virtual environment **Hakoniwa**



BTY, why ”Hakoniwa”?
- Hako(箱) = box
- Niwa(庭) = garden

a miniature garden, one of the traditional JP cultures (like “Bonsai”)

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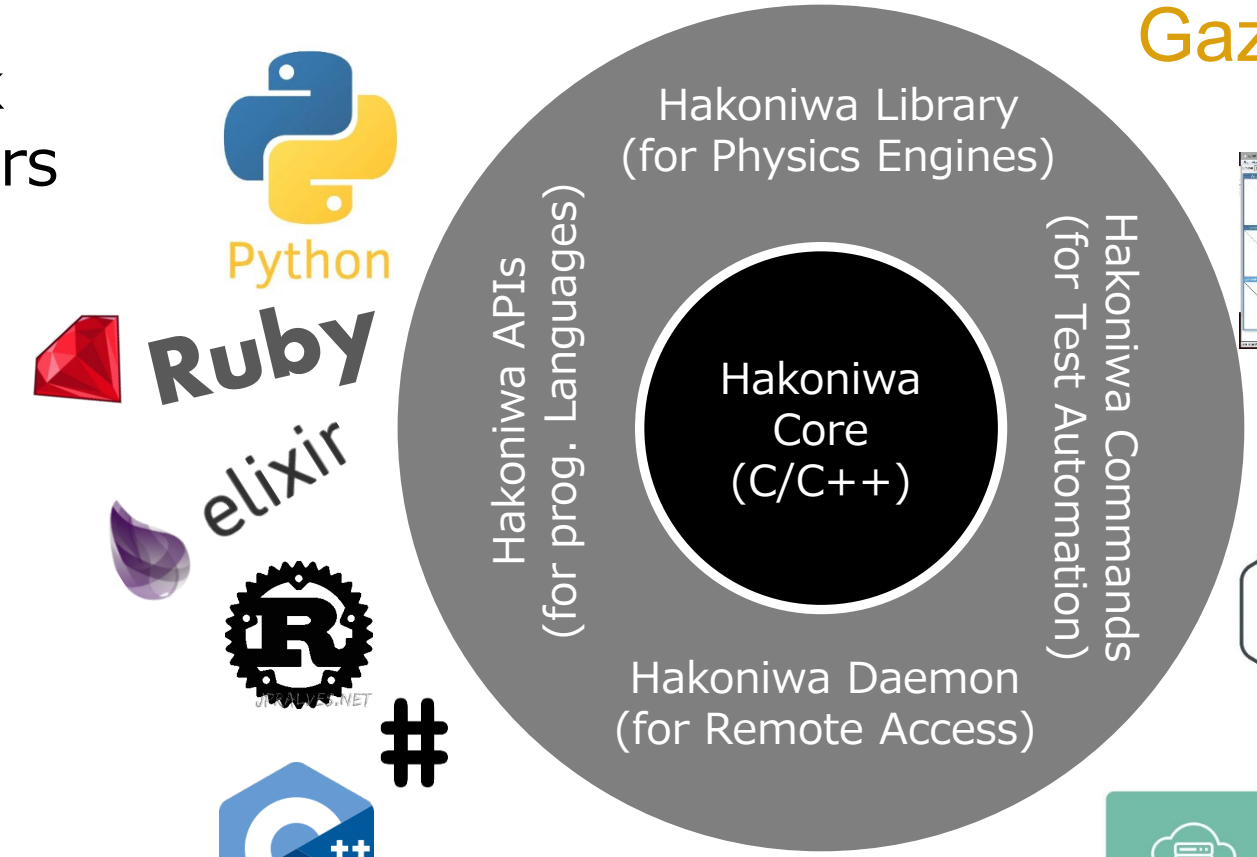
Concept

- HUB to Everything for Simulation!
  - not just a simulator, but also a framework to construct simulators
  - Hakoniwa Assets: the components of the simulation target

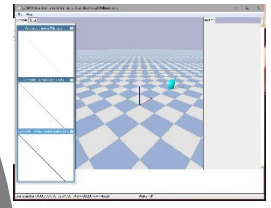


Unity

ROS
Robot Operating System

Gazebo

MATLAB



PyBullet

Python

Ruby

elixir

BASH
THE BOURNE-AGAIN SHELL

GRPC

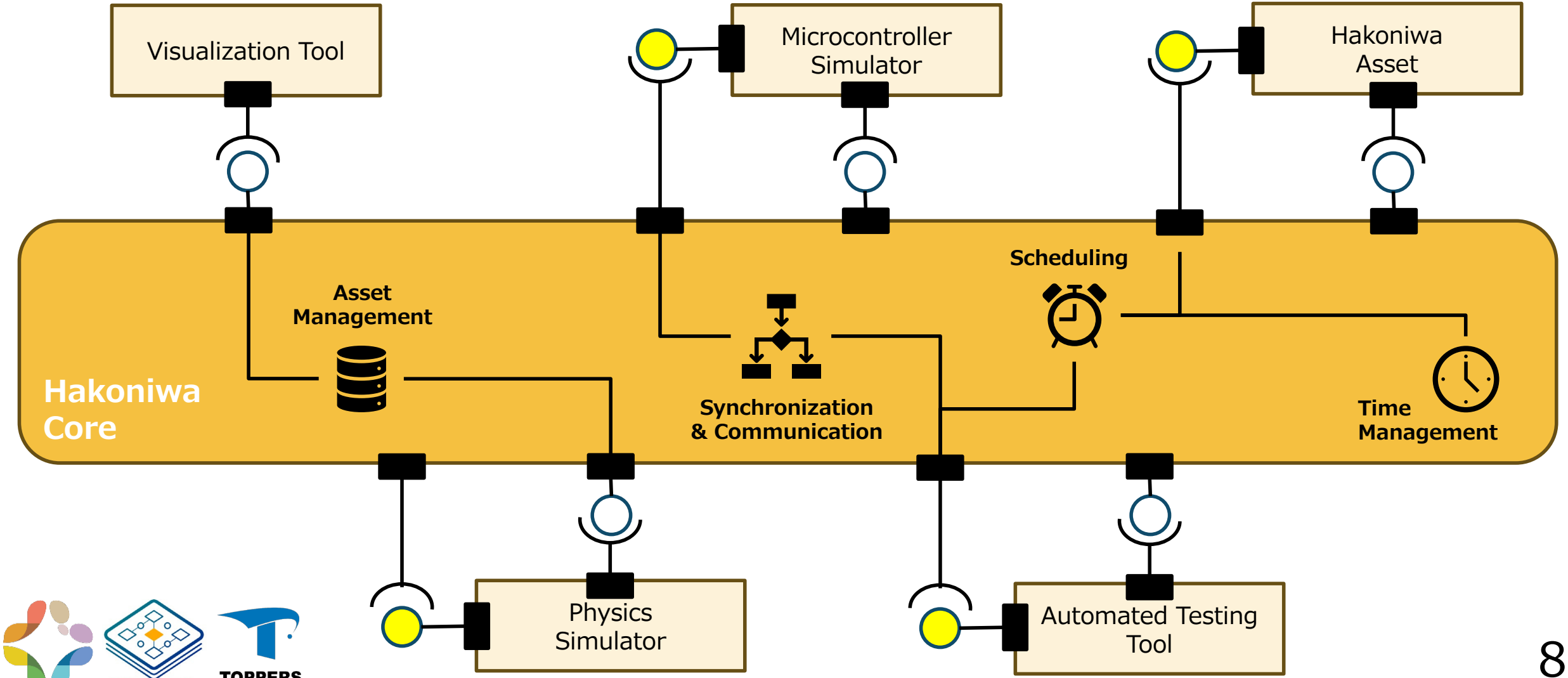
DDS

UDP

TOPPERS

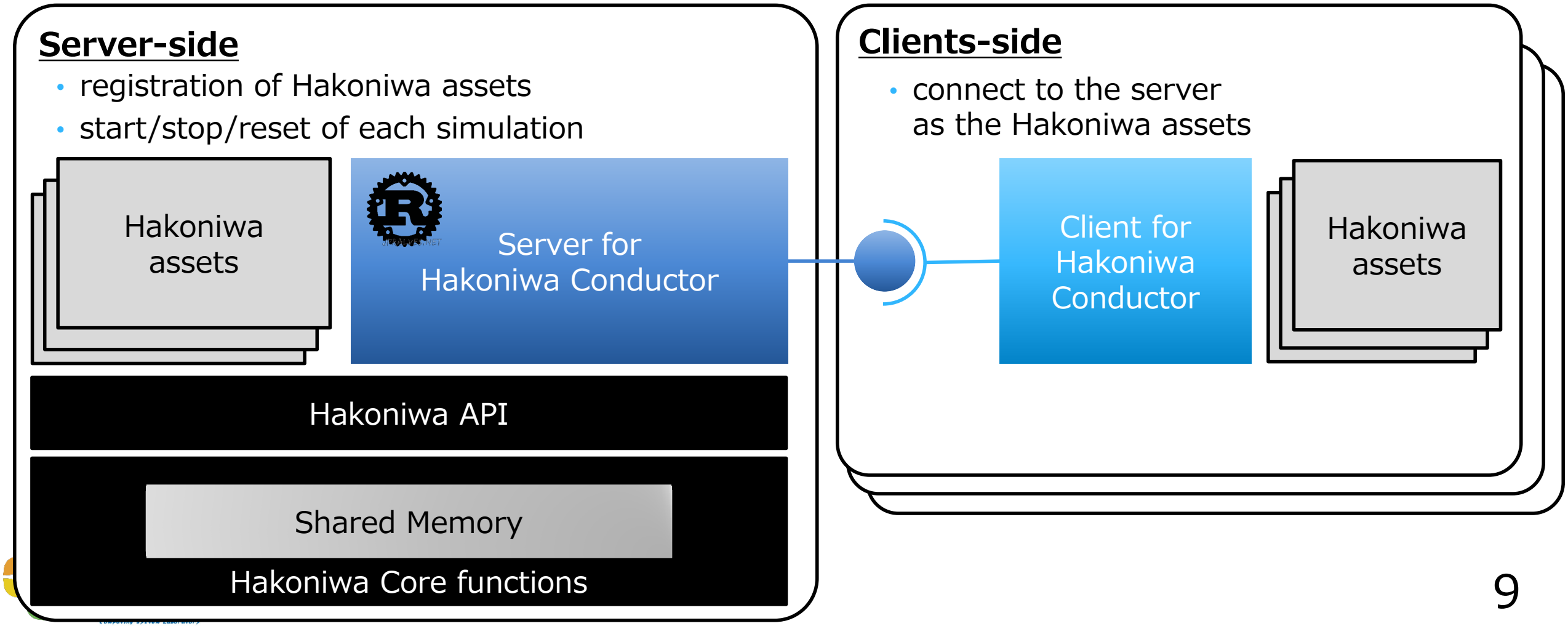
Hakoniwa Core

- Functions for the seamless integration of various assets



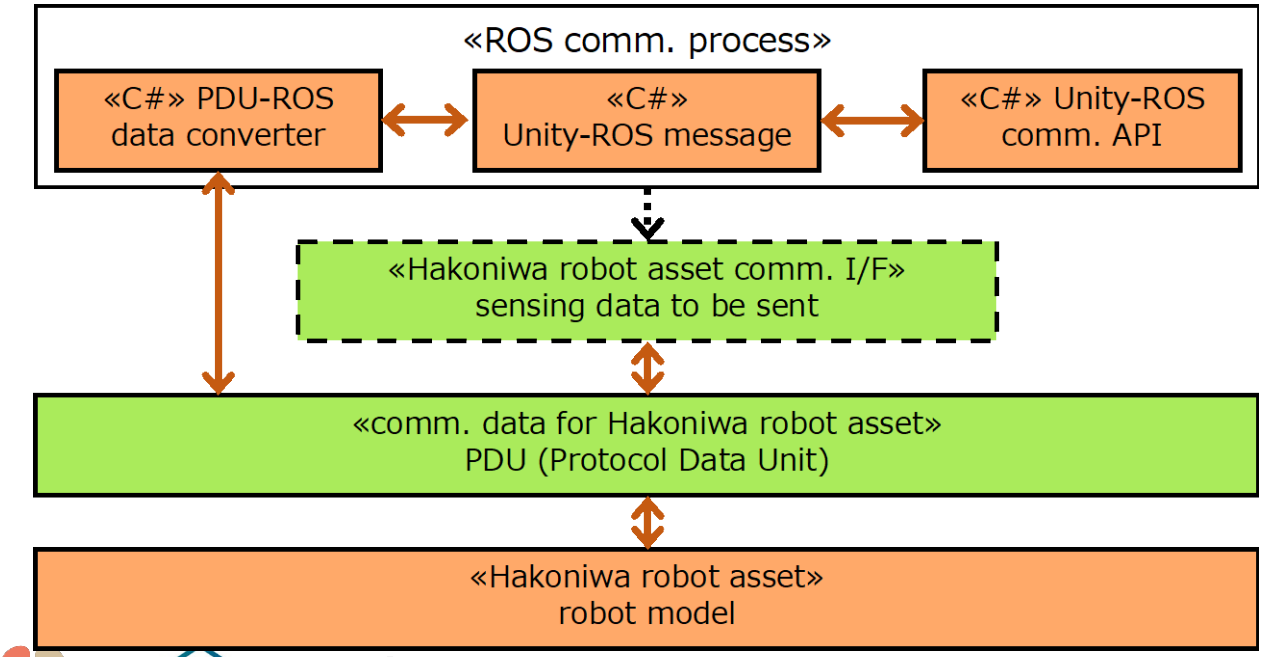
Hakoniwa Conductor

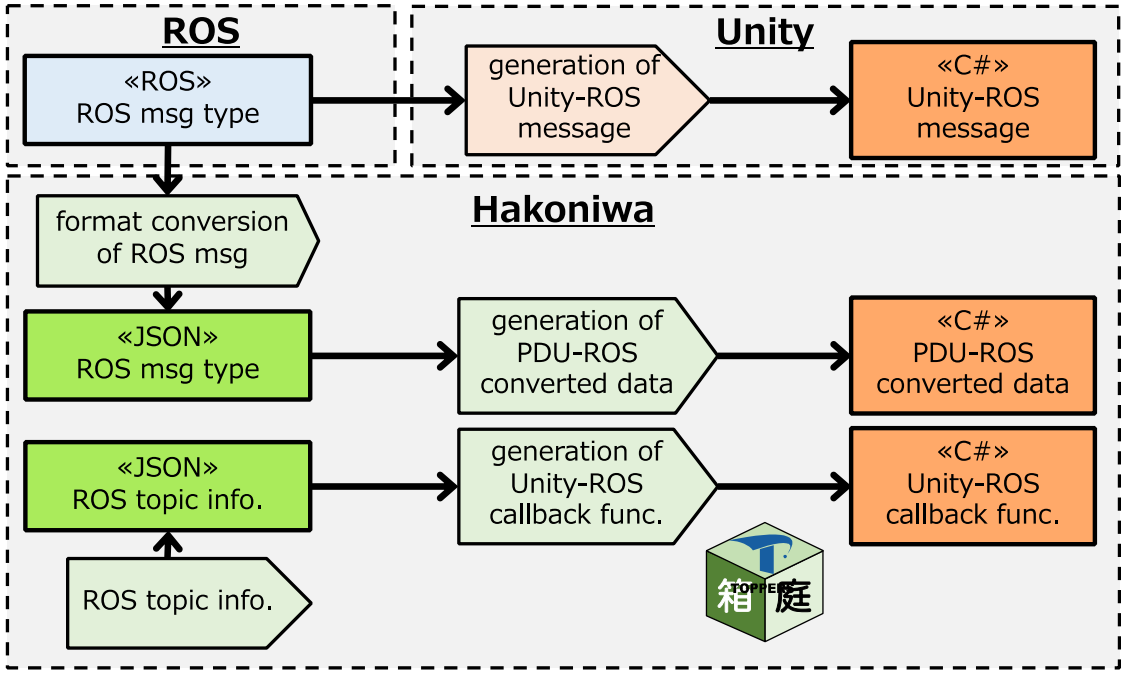
- Mediate simulation between assets on Hakoniwa
  - gRPC based communication between the server and clients



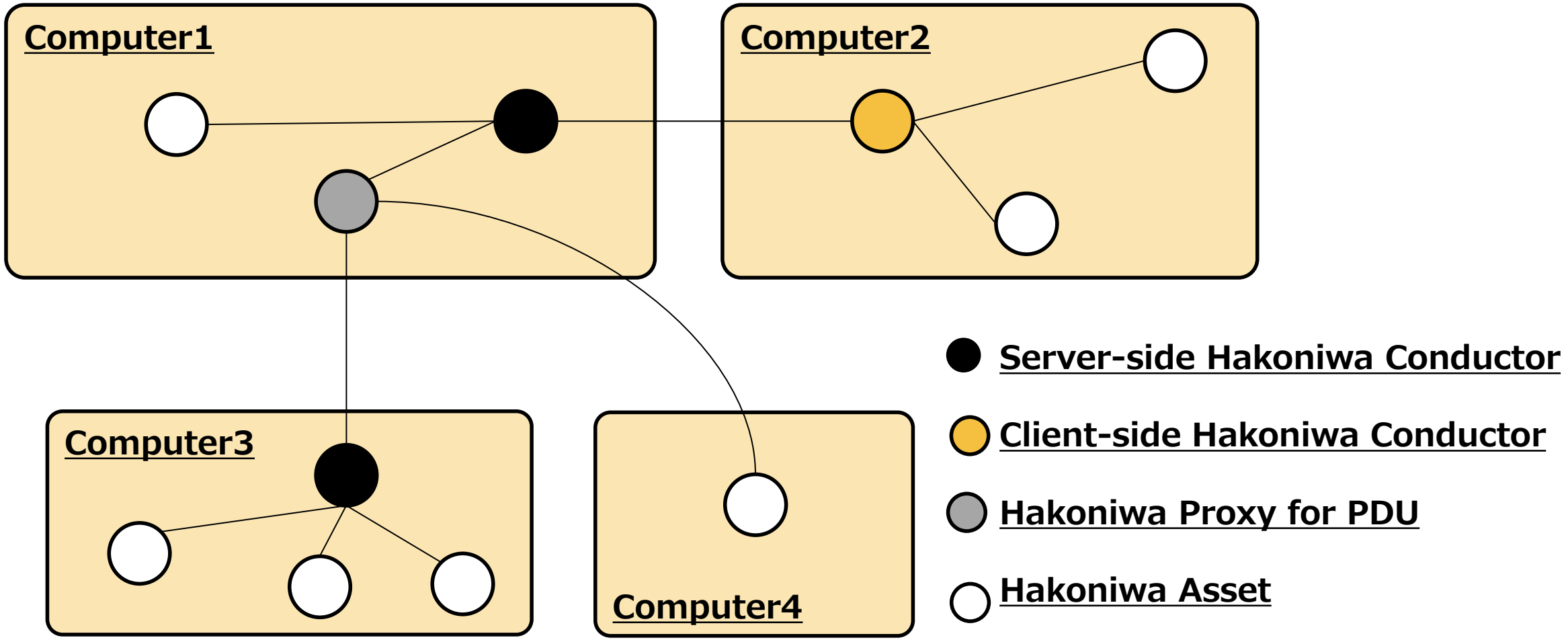
Protocol Data Unit (PDU)

- Common data format to exchange in Hakoniwa
- Function design is separated to asset-dependent and -independent
- An example between Unity and ROS (topics)
  - Note: Unity and ROS are positioned as one of the "assets" in Hakoniwa





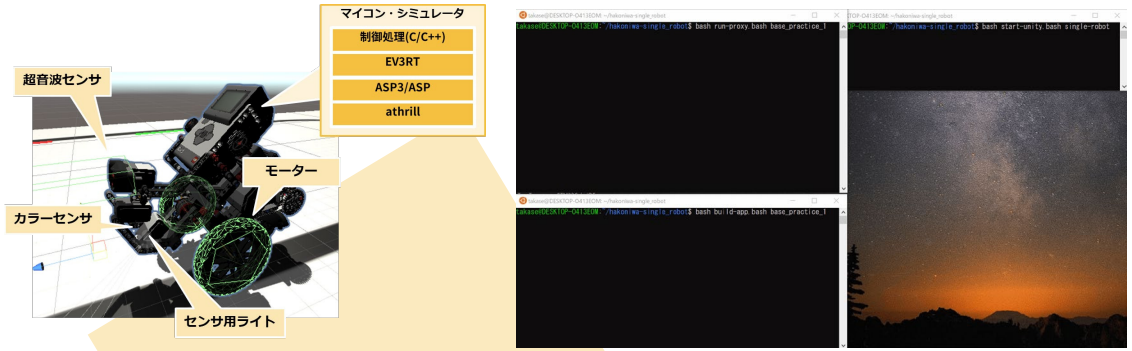
Distributed Simulation with Hakoniwa



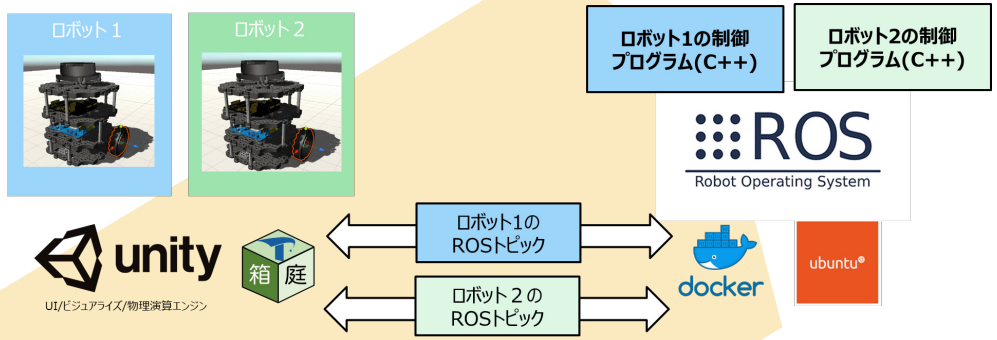
Agenda

1. What is Hakoniwa?
2. **Our Past Achievements, especially for ROS Robot**
   - **4 Prototypes to Ensure the Hakoniwa's Concept**
   - **hakoniwa-ros2sim: ROS controlled Robot Simulation**
   - **Actual Use Cases**
3. Latest Update: hakoniwa-mros2sim
4. Fusion of Virtual and Real weaving by Hakoniwa and mROS 2
5. Wrapping Up

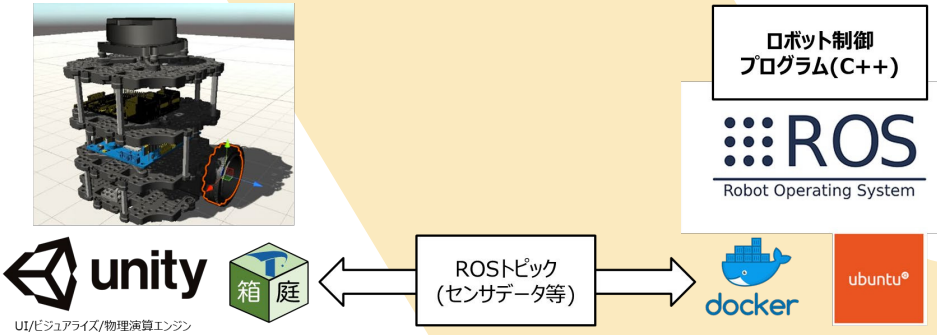

Hakoniwa Prototypes Previously Achieved

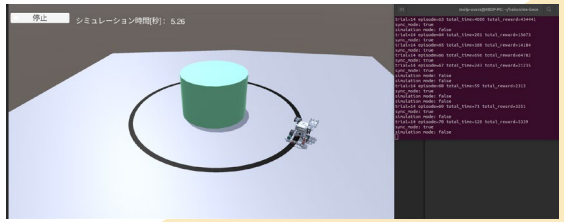


Microcomputer-controlled robot simulation



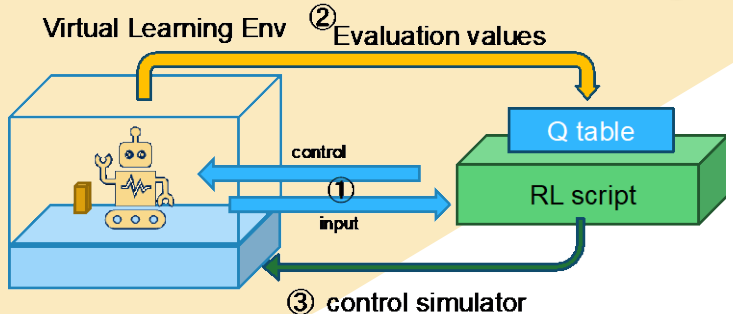
Collaborative simulation of multiple robots

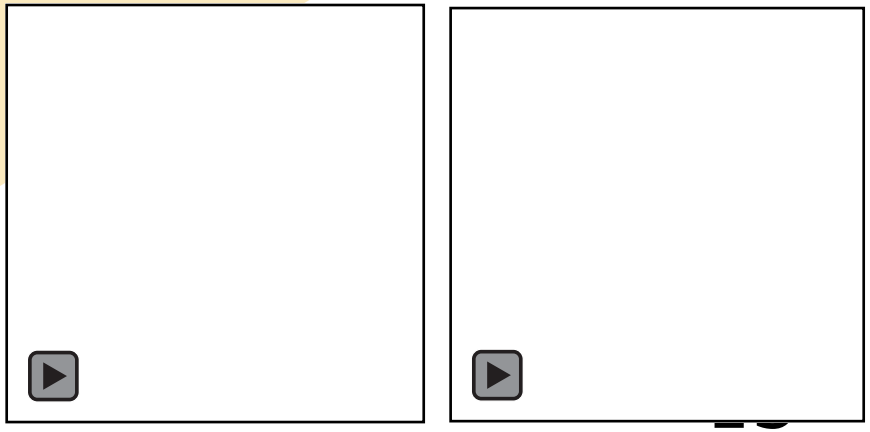




Integration with reinforcement learning

ROS controlled Robot Simulation





Lab#8. IPC, IST, UTokyo Computing System Laboratory

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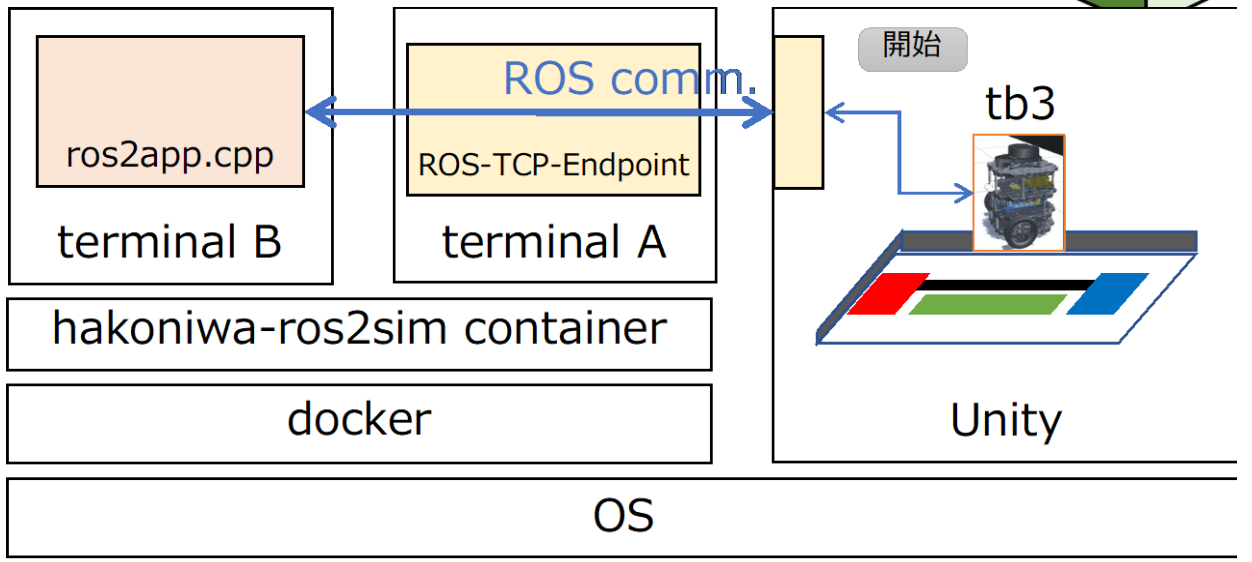
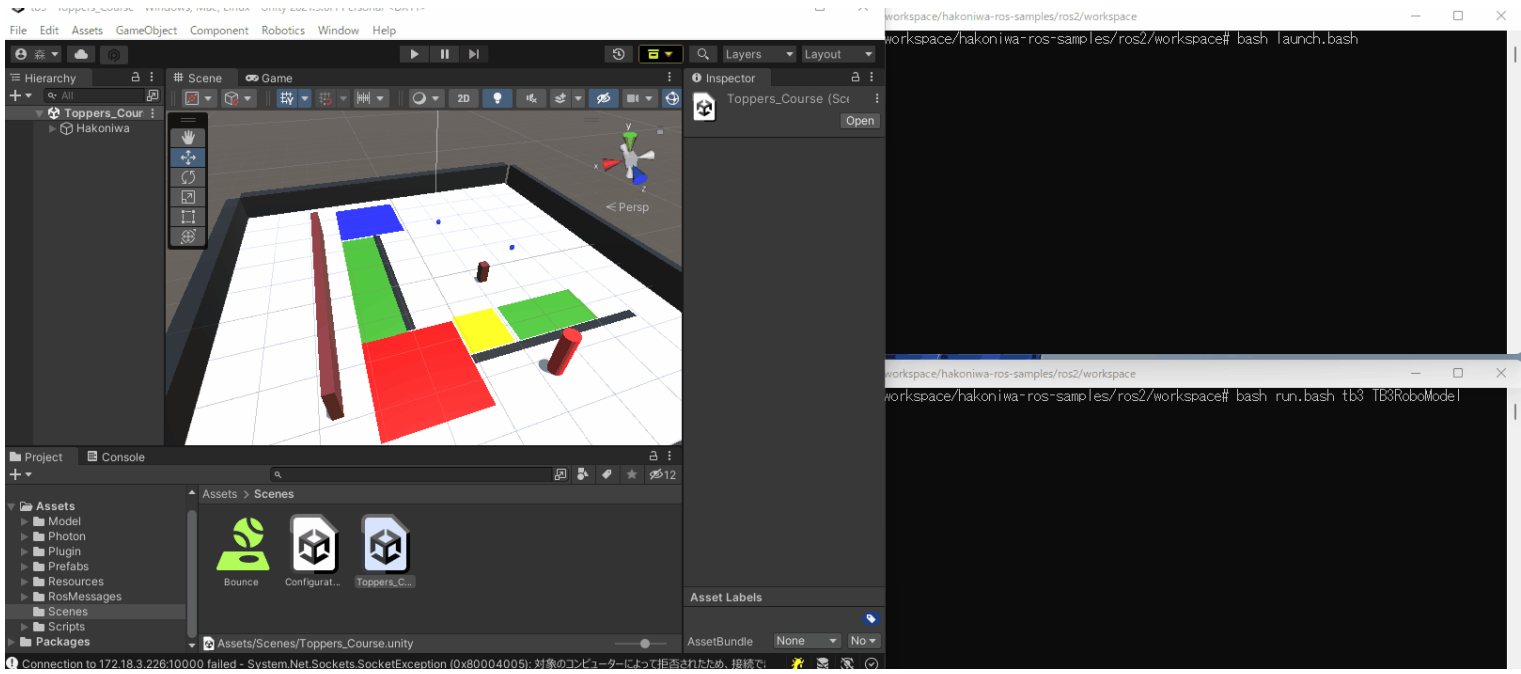
ROS controlled Robot Simulation

- Docker for the platform
  - pre-built container image
    for building & executing ros2app
  - able to use on multiple environments
    (Windows/WSL2 as the default)
- Unity for physics and visualization
  - TurtleBot3 as the reference
  - ROS-TCP-Endpoint for
    assets communication

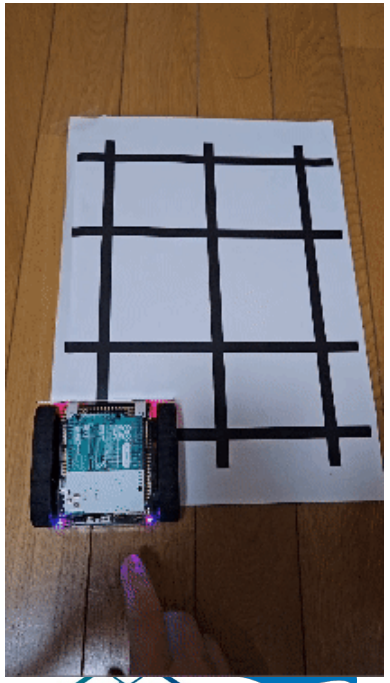


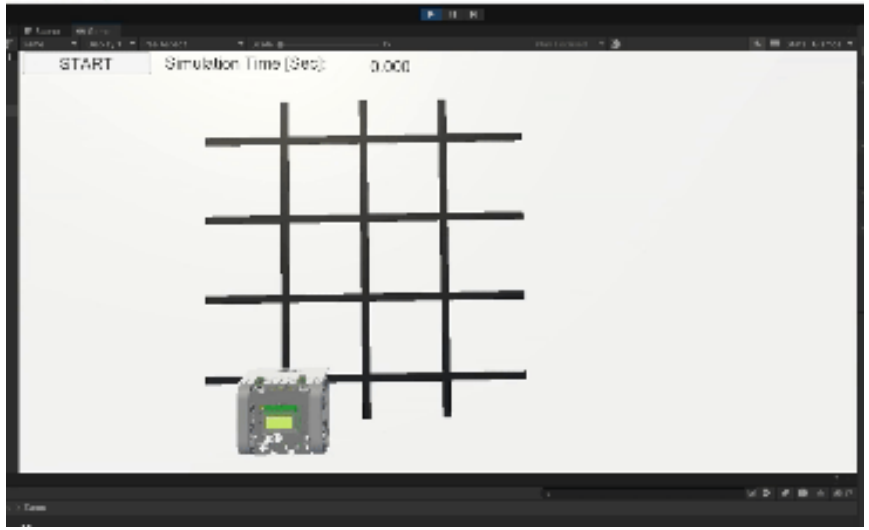


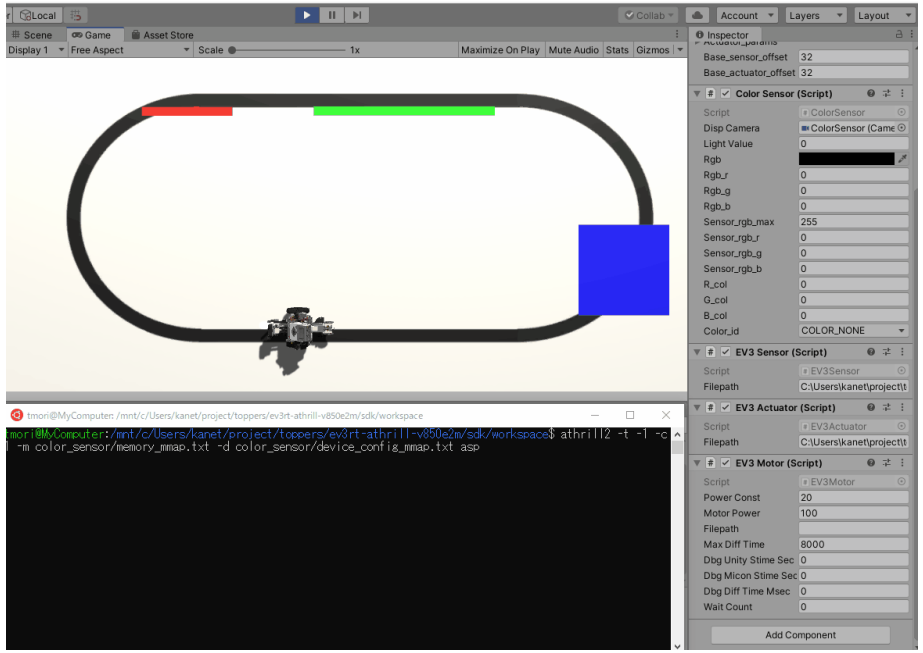
TOPPERS

Actual Use Cases

- Athrill (micro-controller simulator) for ET-robocon https://www.etrobo.jp/
- Group exercises (PBL) in some Japanese universities
- Automotive software education for embedded engineers
  https://github.com/ncesnagoya/autosar_os_training



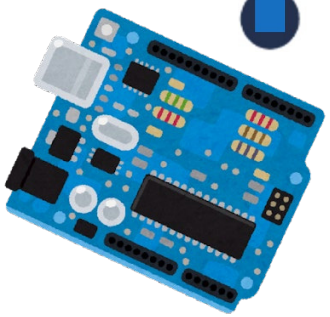




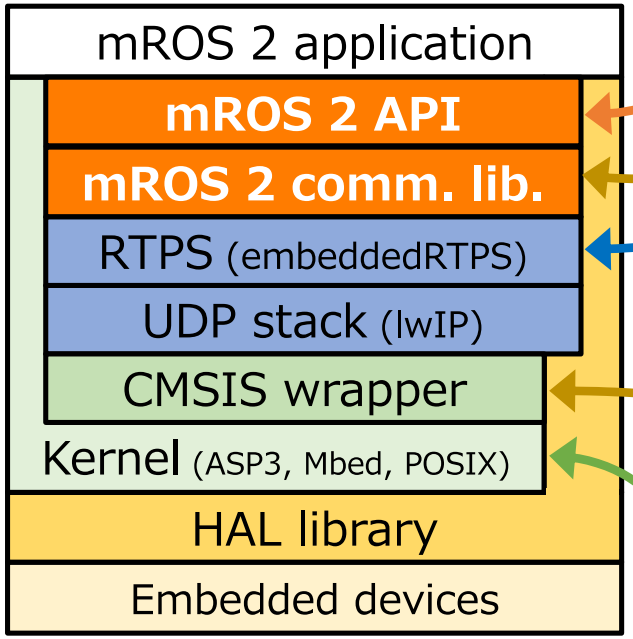
Agenda

1. What is Hakoniwa?
2. Our Past Achievements, especially for ROS Robot
3. **Latest Update: hakoniwa-mros2sim**
   - **Introduction of mROS 2**
   - **[FYI] ROSCon JP 2023 Workshop**
   - **hakoniwa-mros2sim: Simulator for mROS 2 app by Hakoniwa Tech.**
4. Fusion of Virtual and Real weaving by Hakoniwa and mROS 2
5. Wrapping Up

What is mROS 2?



mROS 2
on EMB board
better perf. & mem. usage
partially compatible with rclcpp
only **for Topic comm.**,
and many unsupported features
such as QoS, Service,,,



pub/sub messaging for Topic
partially compliant with rclcpp

autonomous communication
in accordance with RTPS specification

lightweight and efficient process
by C/C++ for <~200MHz / <~1MB

real-time kernels for EMB
contributes perf. and mem. usage

mROS-base/mros2
agent-less and lightweight communication library compatible with rclcpp for embedded d ...
★ 151 14

https://vimeo.com/showcase/9954564/video/767140724

Currently Supported

NEW!!

mROS-base/mros2-asp3-f767zi

reference implementation of mROS 2 for STM32 NUCLEO-F767ZI with TOPPERS/ASP3 kernel

★ 16 2

mROS-base/mros2-esp32

reference implementation of mROS 2 for ESP32 boards

★ 27 3

mROS-base/mros2-mbed

reference implementation of mROS 2 for Mbed OS

★ 40 6

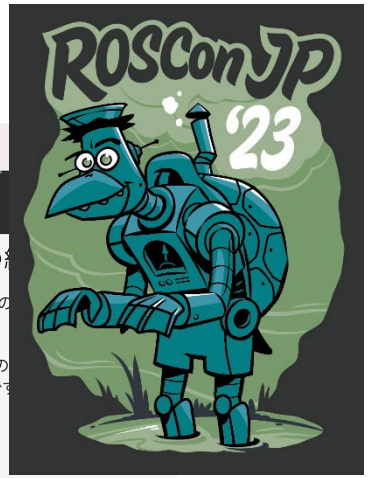
watch later!!

mROS-base/mros2-posix

reference implementation of mROS 2 for POSIX layer

★ 4 1

m2 News!!



https://roscon.jp/2023/#workshop

HOME スケジュール スポンサー 開催会場&参加登録 プログラム 講演募集

9月25日: 講習会：ROS 2の組込みマイコン向け技術の

ROS 2の組込みマイコン向け技術に関する講習会を実施いたします。組込みマイコン固有の
グ技術、ホストとのROS 2通信による移動ロボットの制御方法について学びます。

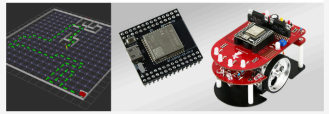
講習会には**別途で参加費**が必要であり、ROSCon JPの参加登録時点で「9/25,26両日」の
を選択してください（講習会のみの参加はできません）。参加人数は25人限定・先着順で
ください。

講習会の教材には、次のロボット・基板を使用します。

- Pi:Co Classic3 マイクロマウス（受講者に貸出）
- Pi:Co Classic3 専用 ESP32-S3マイコンボード（参加費込み・持ち帰り可）

講習会では、下記スポンサーが提供するロボットを使用します。

RT CORPORATION



講習会の受講者は、次の環境のPCを用意して持参いただく必要があります。

- Ubuntu 22.04 LTS（ネイティブインストールされたもの・Docker等の仮想環境は不可）
- ROS 2 Humble Hawksbill
- USB Type-Aポート 1 口
- 有線LANと無線LANの双方

対象者：

- 上記の環境を自身で用意・持参いただける方
- ROS 2 Humbleの公式チュートリアルの内容を Intermediate まで理解されている方
- 組込みマイコン向けのソフトウェア開発に興味のある方

講習会資料(一般公開版)

https://roscon.jp/2023/#workshop

contents is public!!
(only in JP:D

TOPPERS

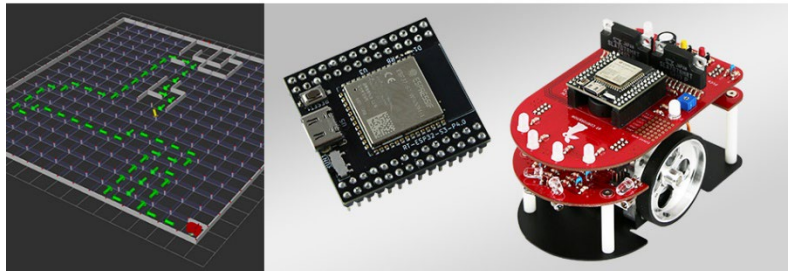
hakoniwa-mros2sim :D

- Target: mros2 app & robot

toppers/hakoniwa-mros2sim

★ 2 ⑂ 0

RT CORPORATION



Pi:Co Classic3 (MicroMouse)
https://rt-net.jp/products/pico-classic3/

mROS-base/rcjp2023_mros2

ROSCon JP 2023講習会の正解参照用のソースコード
ROSCon JP 2023講習会の正解参照用のソースコード

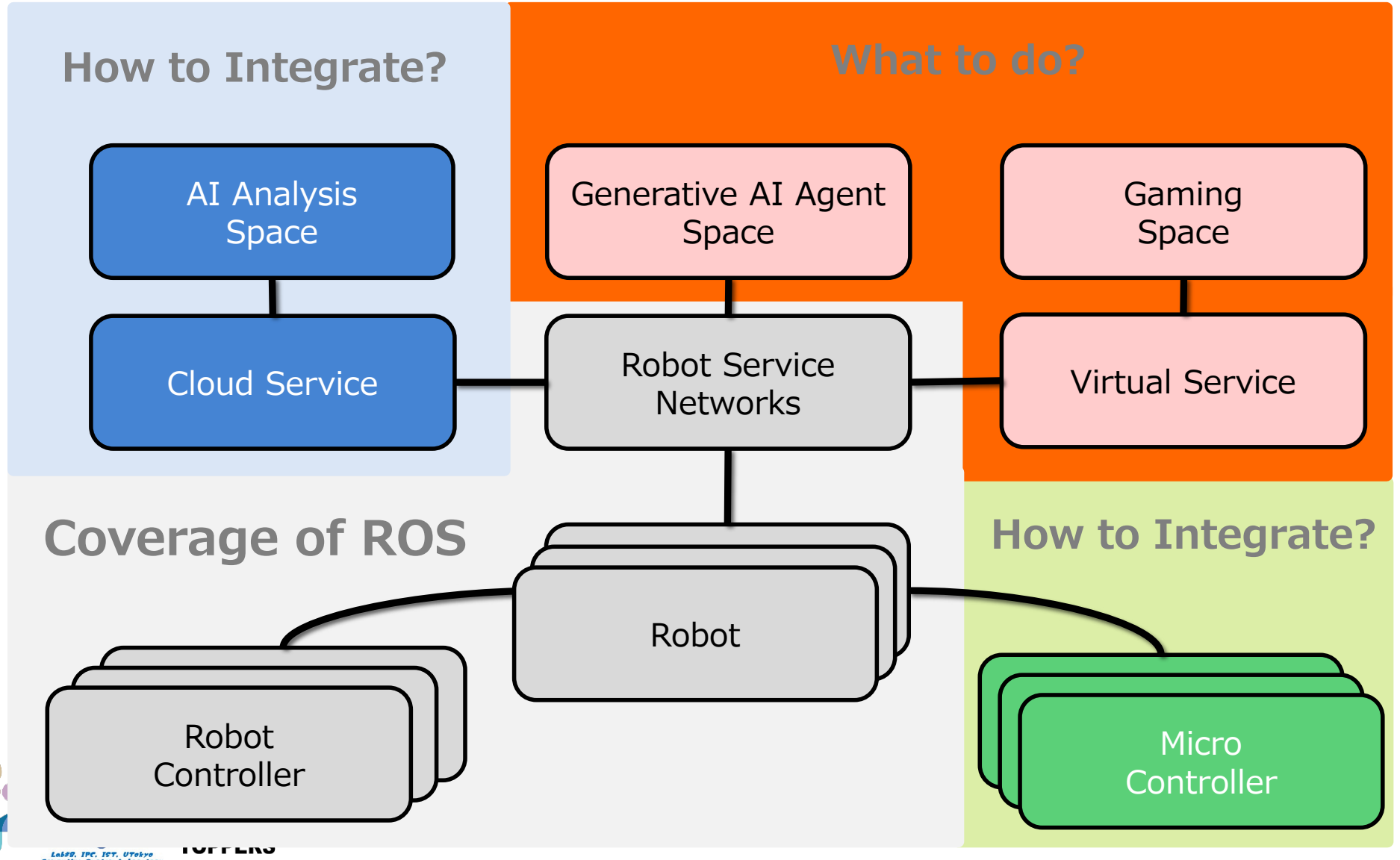
★ 0 ⑂ 0

https://github.com/mROS-base/rcjp2023_mros2

Agenda

1. What is Hakoniwa?
2. Our Past Achievements, especially for ROS Robot
3. Latest Update: hakoniwa-mros2sim
4. **Fusion of Virtual and Real weaving by Hakoniwa and mROS 2**
   - **Hakoniwa's Future Vision for Robotic Service**
   - **Expected System in the Future and its Architecture Design**
   - **Integration of mROS 2 into Hakoniwa Communication**
   - **Demonstration!!**
5. Wrapping Up

Our Future Vision for Robotic Service



A new trend!!

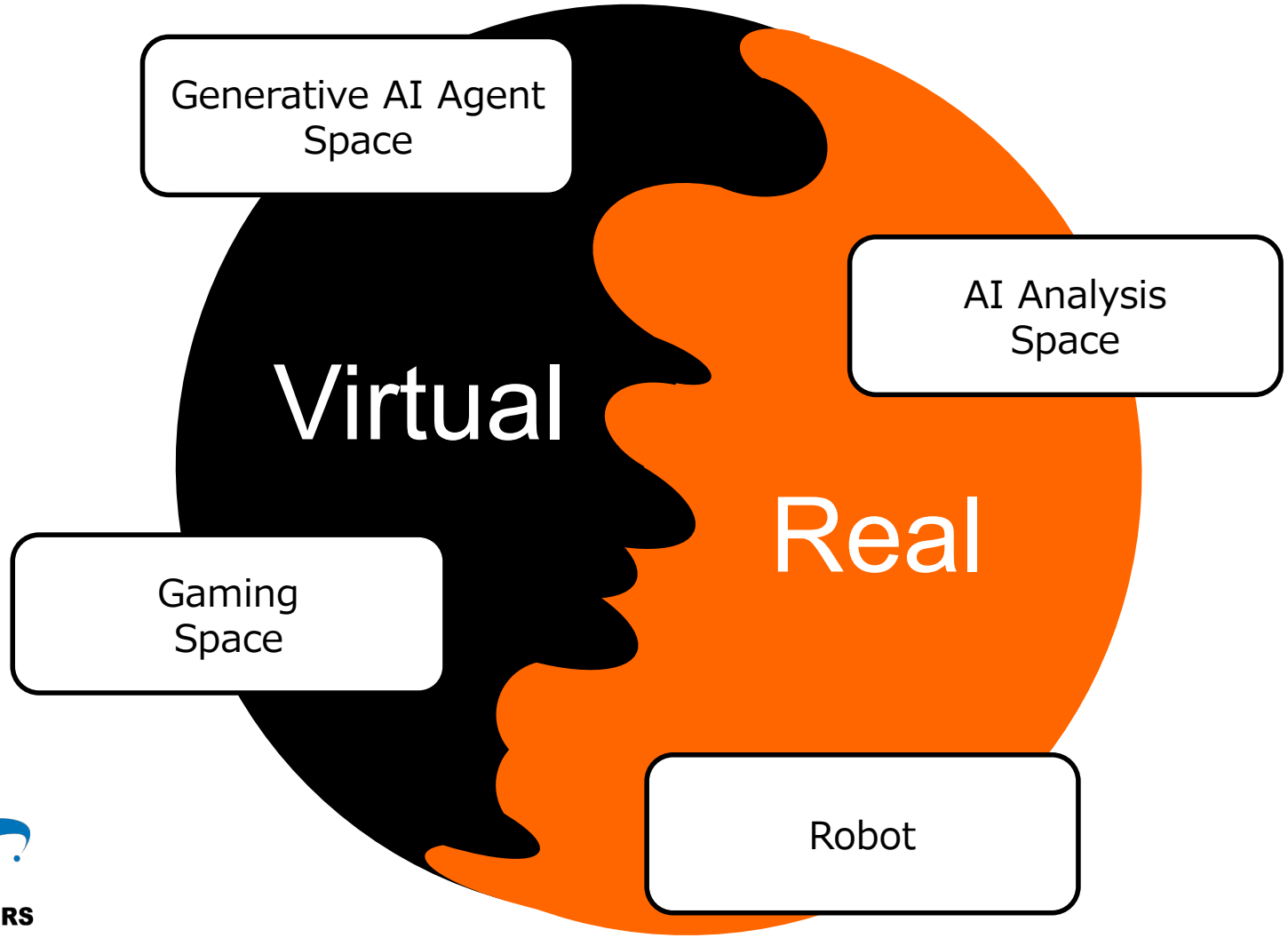
Challenges faced in the embedded systems domain

Challenges faced in the cloud domain

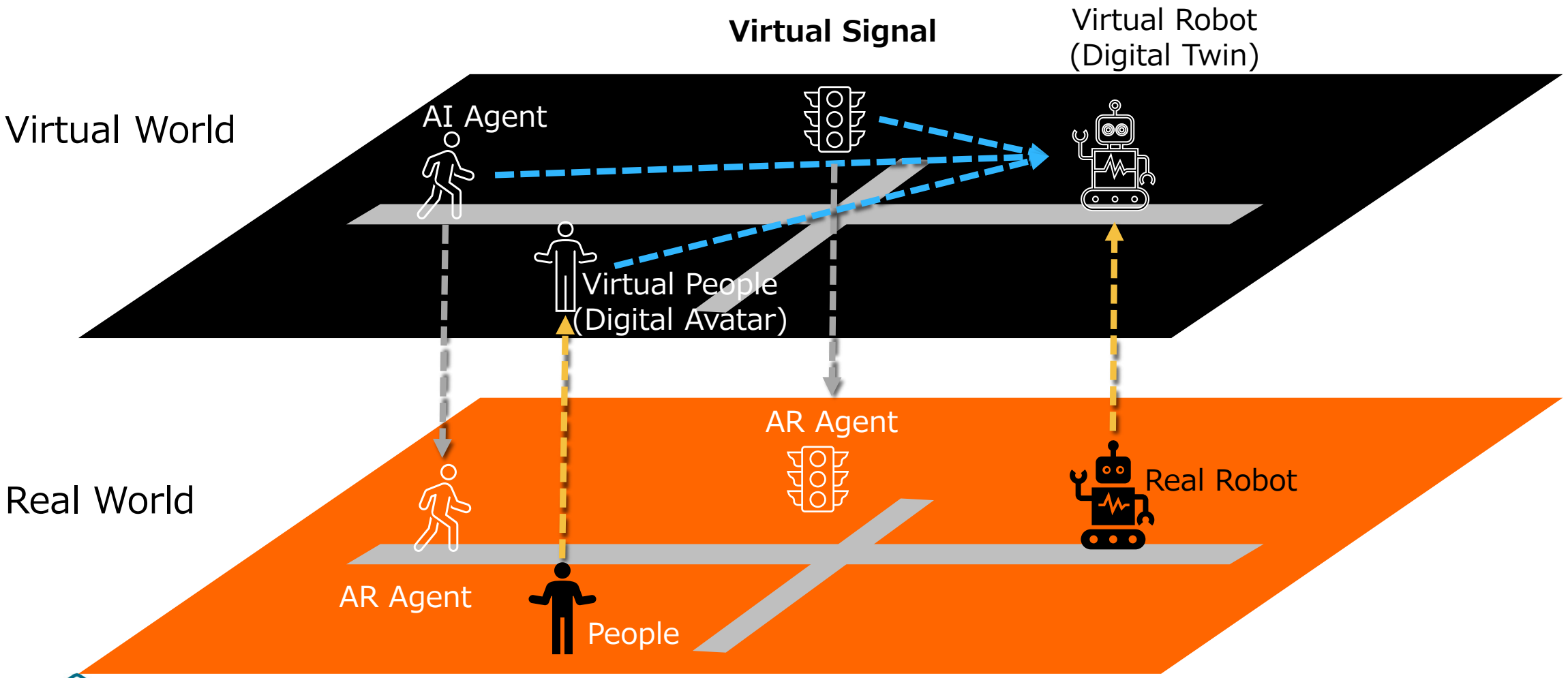
Coverage of ROS

Fusion of Virtual and Real

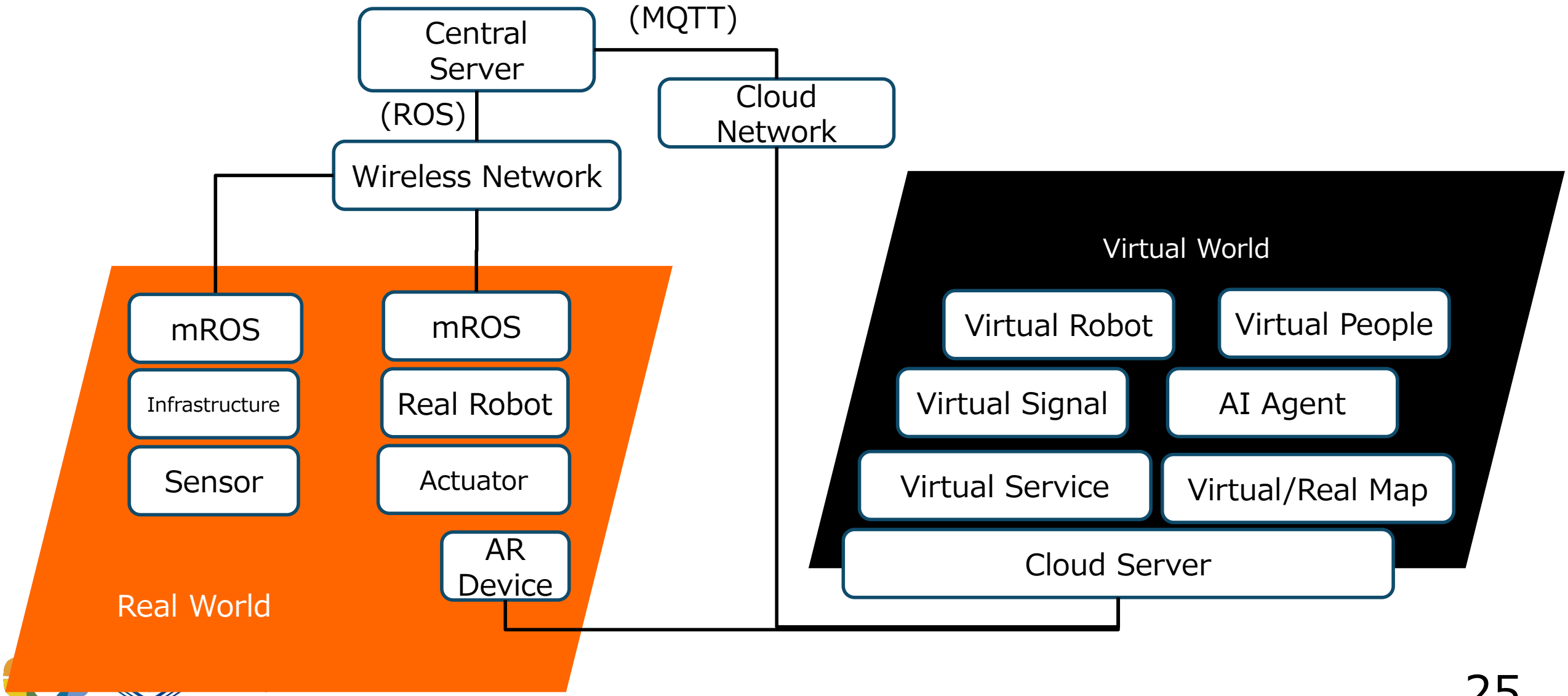
- Integration of Virtual and Real in Simulation



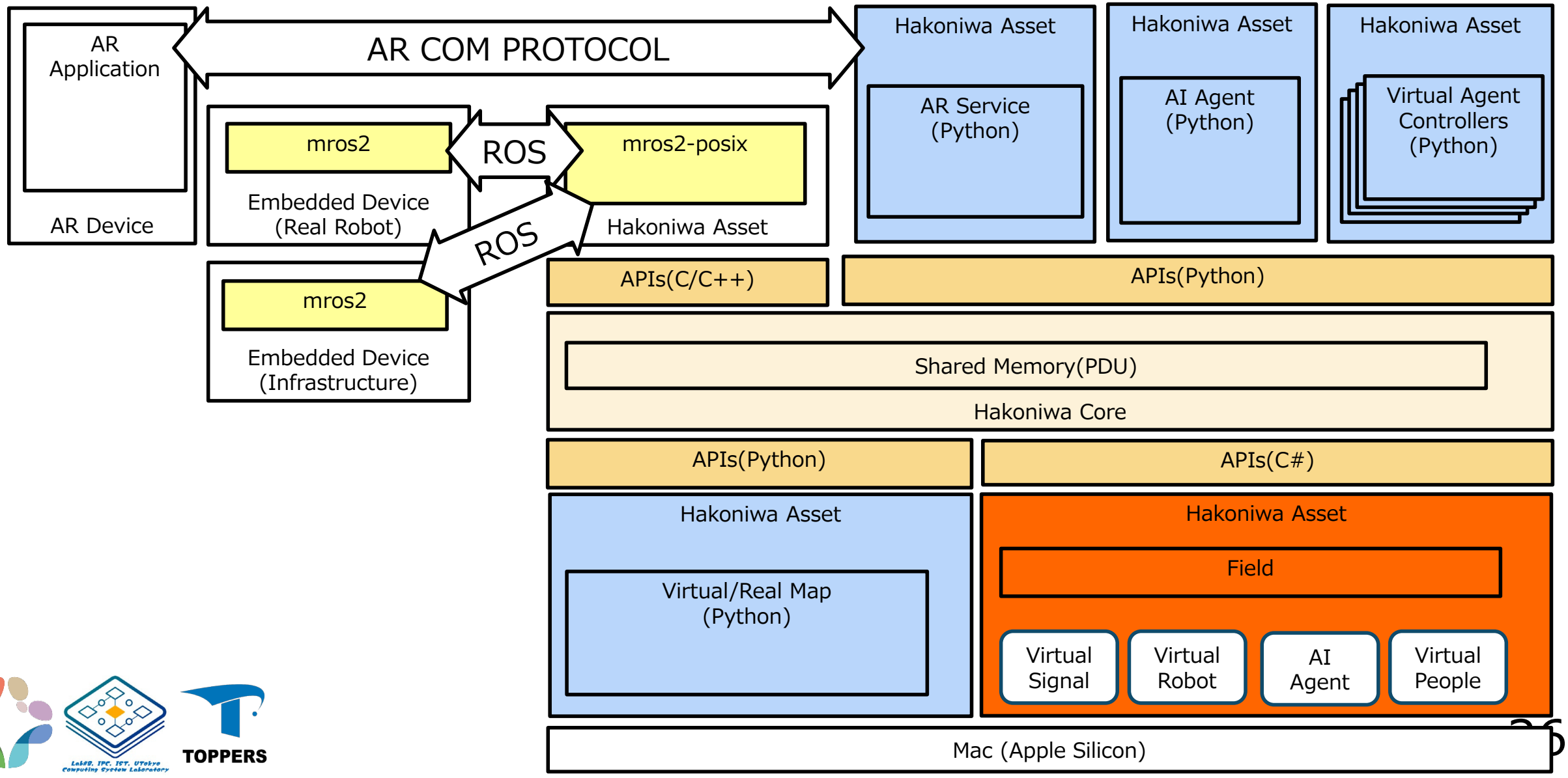
Expected System in the Future



Architecture Design: Overview



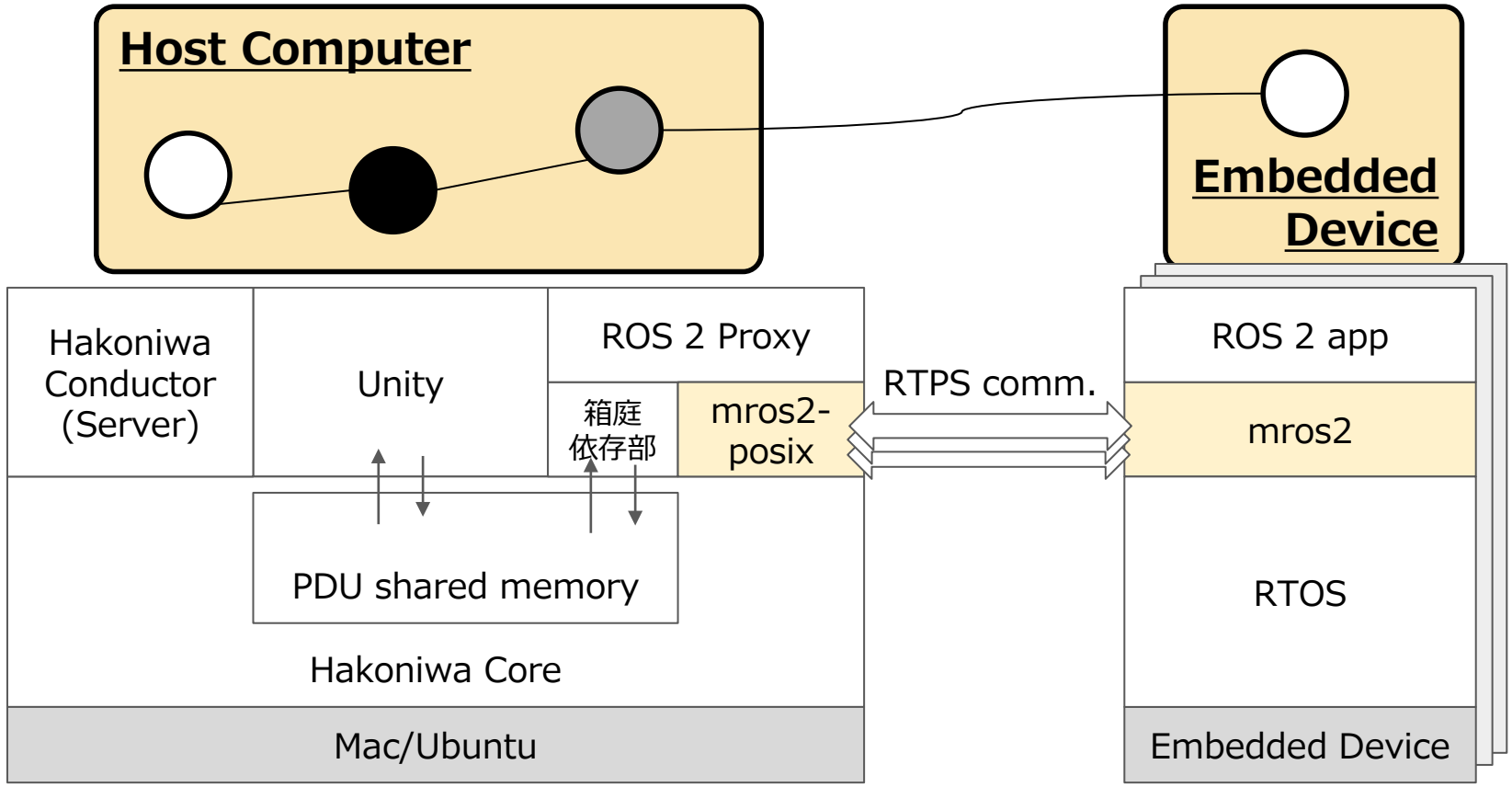
Architecture Design: Detail



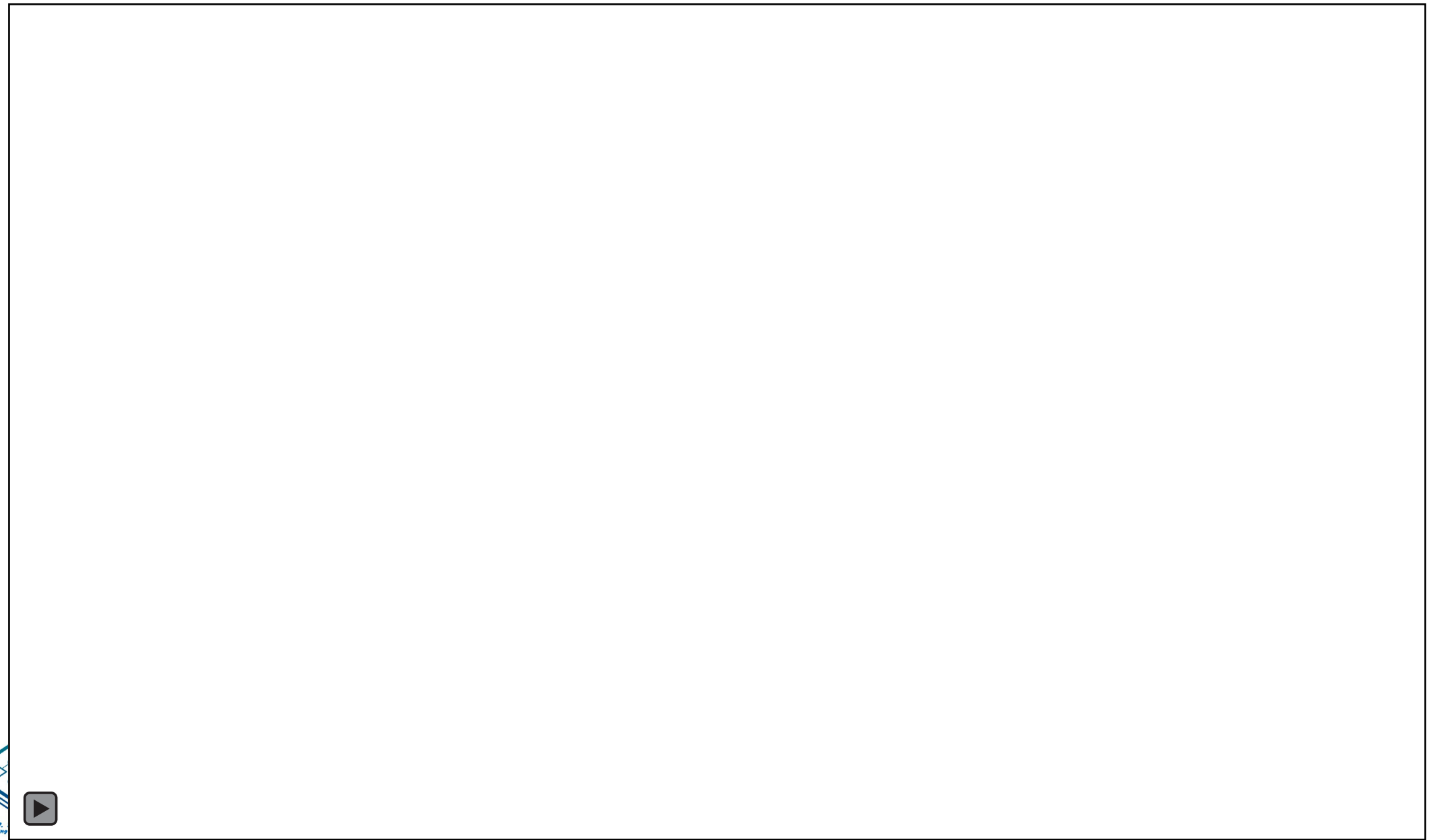
TOPPERS

but Why mROS 2?

- Integration of mROS 2 communication into Hakoniwa!
  - lightweight but direct communication on RTPS
  - mros2-posix can run on general-purpose OSes (even on macOS)
    -> support mros2 communication as one of Hakoniwa PDUs!!



Demonstration!!



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5. **Wrapping Up**


Wrapping Up!

- Introduction of Hakoniwa (箱庭)
  - HUB to Everything for Simulation!
    not just a simulator, but also a framework to construct simulators
  - hakoniwa-ros2sim: our past achievement for ROS robot
  - hakoniwa-mros2sim: new simulator for mros2 robot
- Fusion of Virtual and Real weaving by Hakoniwa and mROS 2
  - Integration of mROS 2 into Hakoniwa Communication
  - Expected System in the Future and its Architecture Design
- What's Next??
  - Open up the future by increasing the adoption in actual development scenes
  - and, enrich documentation, especially in English ;(