



Fusion of sensor and robot

November 15, 2022

Haruhisa Fukano, Fujitsu

Masao Shimizu, Ph.D., Professor, RITSUMEIKAN UNIVERSITY

Jeff Brower, CEO, Signallogic, Inc.





Haruhisa Fukano

Fujitsu

TSC member, LF Edge Akraino Project

- Current work
 - Business and architecture planning about edge computing
- Career:
 - Heterogeneous computing R&D
 - FPGA design for NW equipment
- Favorite things:
 - Camping



Masao Shimizu, Ph.D.
Professor, RITSUMEIKAN

- Robot hand R&D using electronic device
- Career:
 - R&D about application of sensors to medicine and industry
 - Sensor device R&D
- Favorite things: Aikido

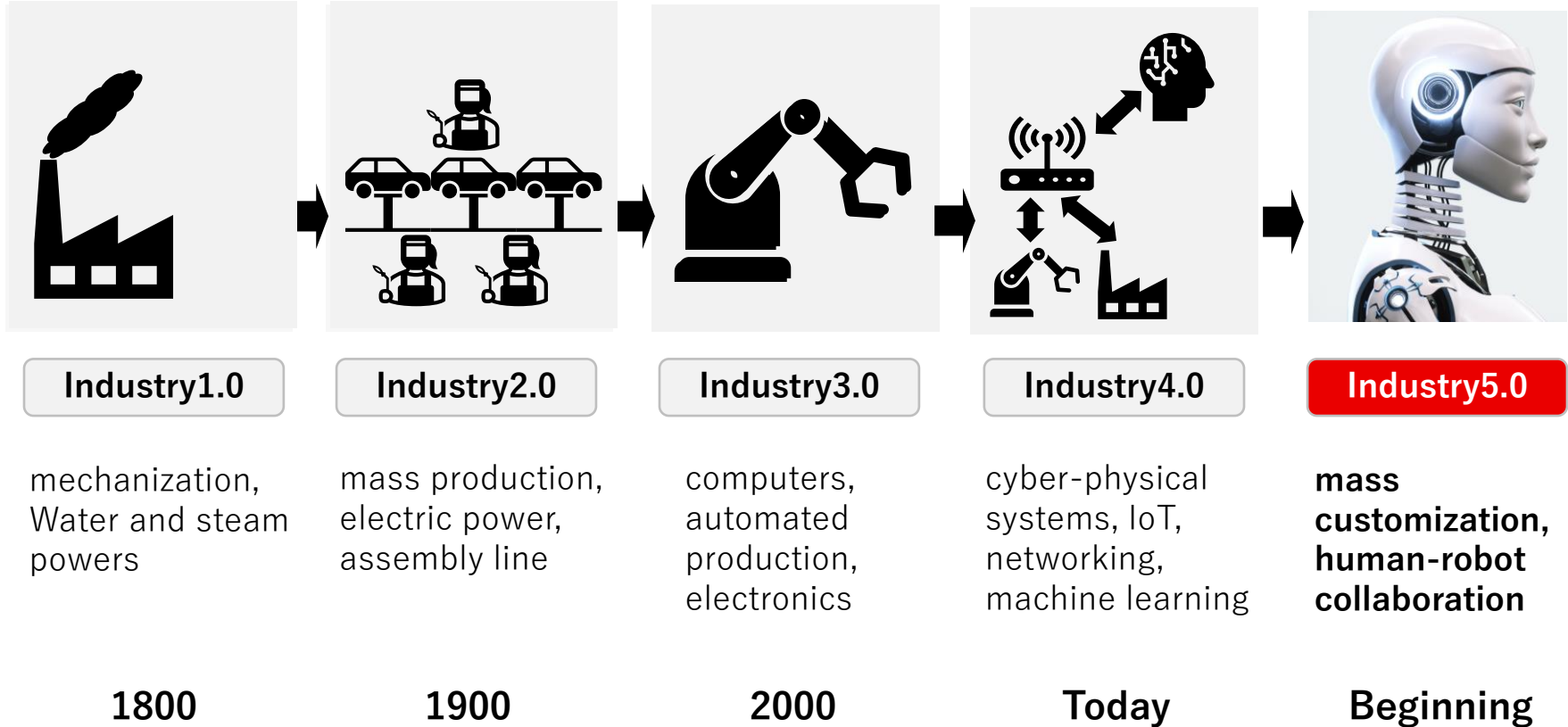


Jeff Brower
CEO, Signalogic

- Real-time ASR (automatic speech recognition) in edge computing and telecom applications
- Deep learning
- Telecom
- HPC, supercomputing
- Signal and image processing and algorithms

- What is Industry 5.0?
- Robot Challenges in Industry 5.0
- Solutions for these challenges
 - What is SSES (Sensor-Rich Soft End-Effector System)?
 - What is light weight ASR (Automatic Speech Recognition)?
- Activities at Akraino
 - CPS Robot blueprint family
 - Robot basic architecture based on SSES blueprint
- PoC in food factory
- Activities in future

Industrial Revolutions



1. Human and robot collaboration

2. Mass customization

1.robotと人間の協働

- ・人間の知見をマシンへ還元。幅広い分野の自動

2.マスカスタマイゼーション

- ・自動化された大量生産＋カスタマイゼーション

Robots are important for realizing industry 5.0

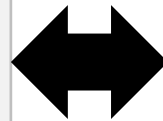
Can we use today's robot in industry5.0?

Robot today

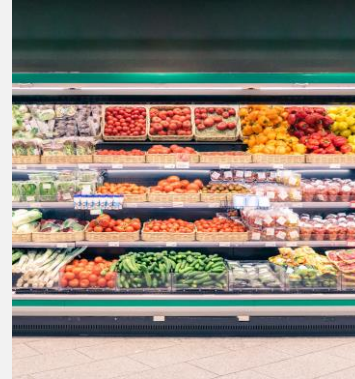


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- Object: standardized, uniform
- Field circumstance: stable



Robot in Industry 5.0



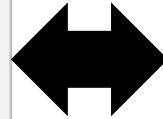
- diverse shapes, flexibility, frictional properties
- ever-changing

Challenge: Autonomous handling control by robot

Robot today



- Isolated from human
- Programmed routine



Robot in Industry 5.0



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- Work with human in same field
- Act flexibly

Challenge: Rapid communication with human

Challenge 1 - Autonomous handling control by robot

Solution

Flexible robot handling for various objects under various environments “SSES (Sensor-Rich Soft End-Effector System)”

Challenge 2 - Rapid communication with human

Solution

Reliable and low-latency speech recognition

What is SSES?

SSES (Sensor-Rich Soft End-Effector System)

Ritsumeikan University and other companies research and develop SSES in SIP ¹

- SSES Approach
 - Enhancement of cognitive ability
 - Sensor-rich technology for multi-dimensional data acquisition
 - AI/IoT technology with force/contact information
 - IoT maintenance and inspection technology
 - New Mechanical
 - Flexible manipulators using polymer materials
 - Advanced 3D printing technology

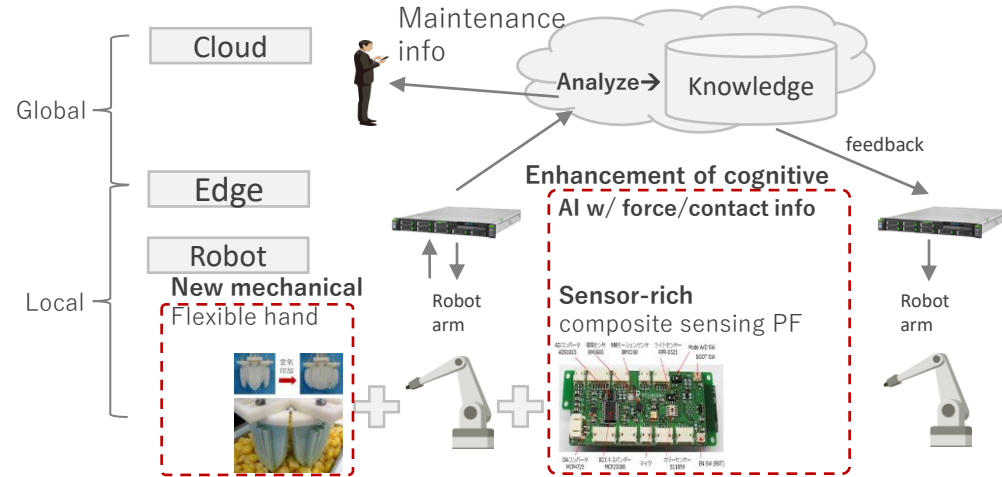


Figure: SSES architecture(<https://sip-sSES.net/>)

¹ Cross-Ministerial Strategic Innovation Promotion Program

SSES from network perspective

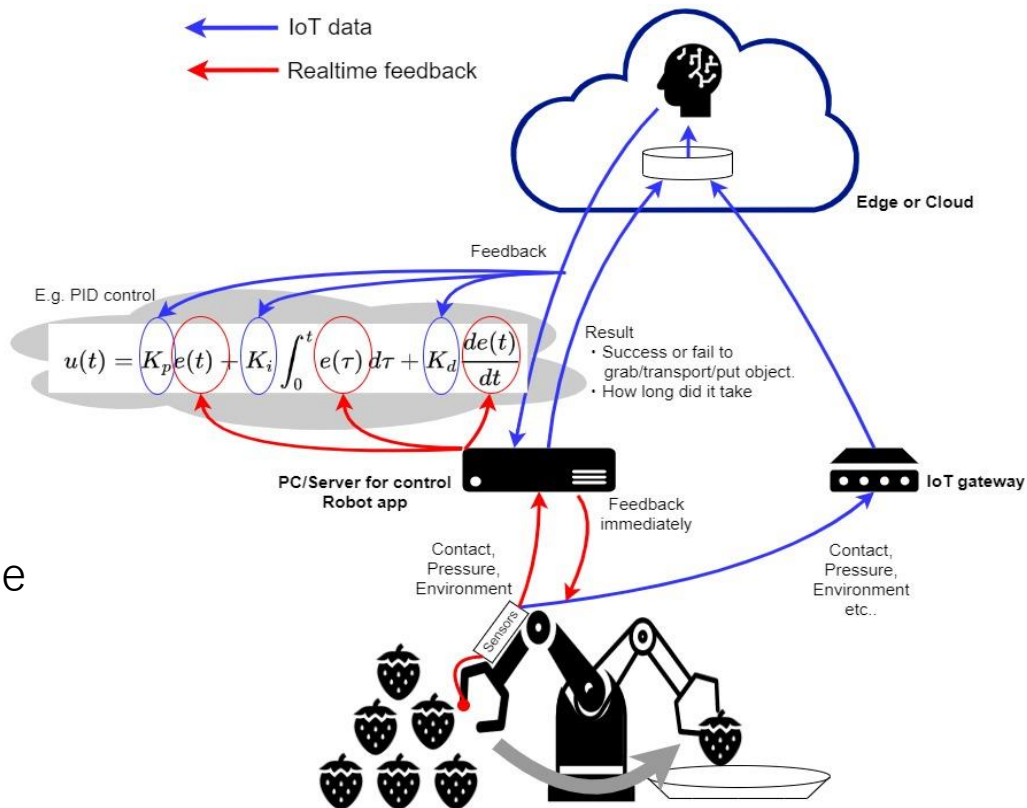
SSES has two data path

- Real-time feedback path

- Latency: 1ms
- Immediately reflected in robot control

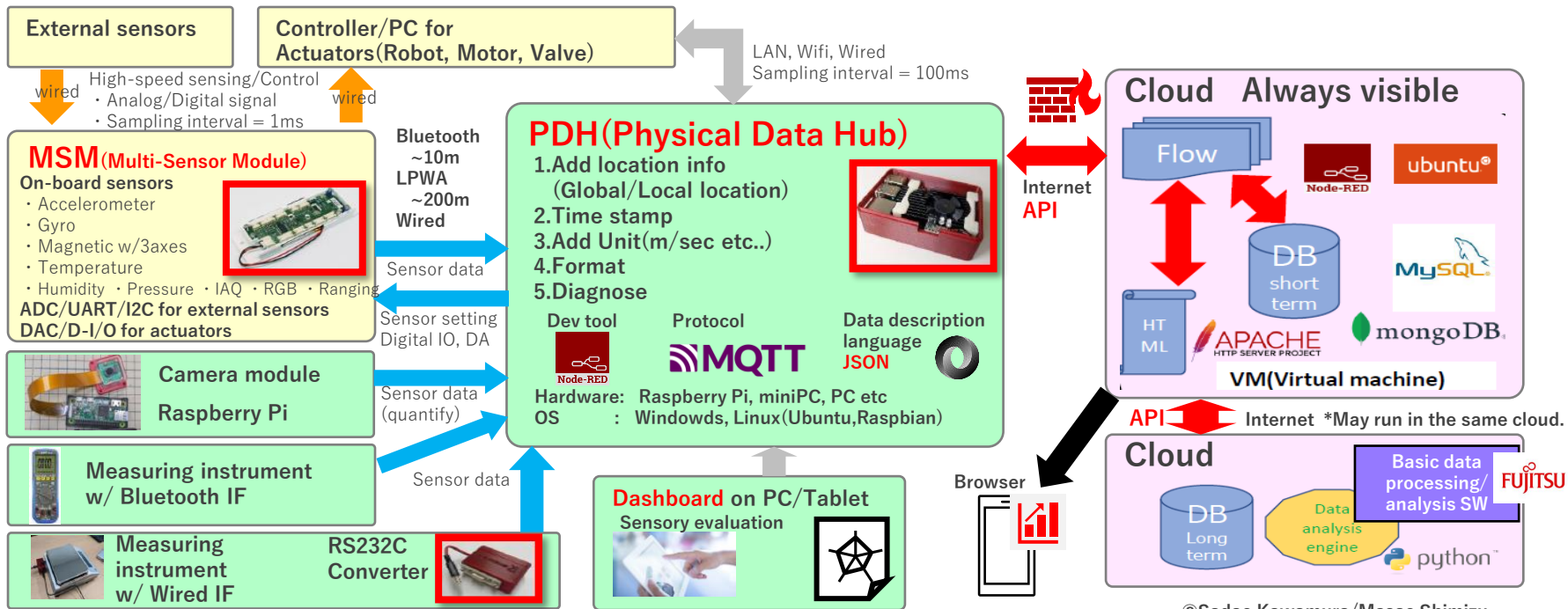
- IoT data path

- Latency: 100ms~
- Analyze by cloud AI and update robot control in non-real-time



R-CPS (Reconstructable basic system for Cyber Physical System)

- Data collection/analysis and feedback to physical space for SSES
- Construct and reconstruct various systems easily and at low cost



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SSES use case and demo



Remove dishes from table



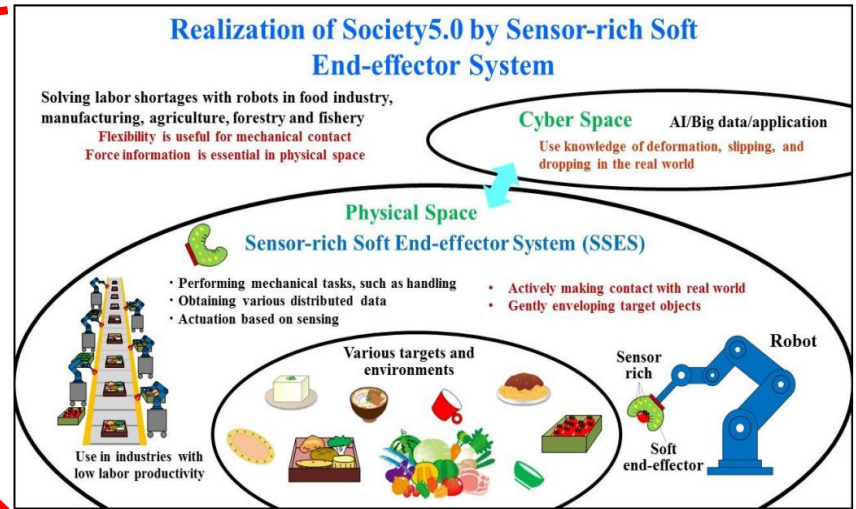
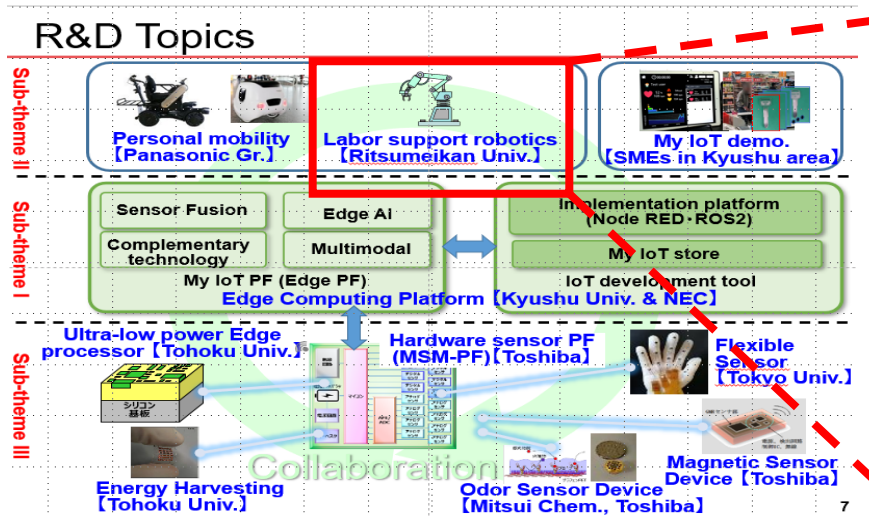
Dishwashing



Serve on plates

All video from
SIP SSES project
<https://sip-sses.net/publicinformation/>

○ Japan Cabinet Office invests in R&D on flexible robot handling “SSES” through SIP ¹



SIP Symposium 2021

https://www.sip2021.go.jp/docs/02_briefing_paper_SIP2021.pdf

SIP R&D Plan

<https://www.nedo.go.jp/content/100903325.pdf>

¹ Cross-Ministerial Strategic Innovation Promotion Program

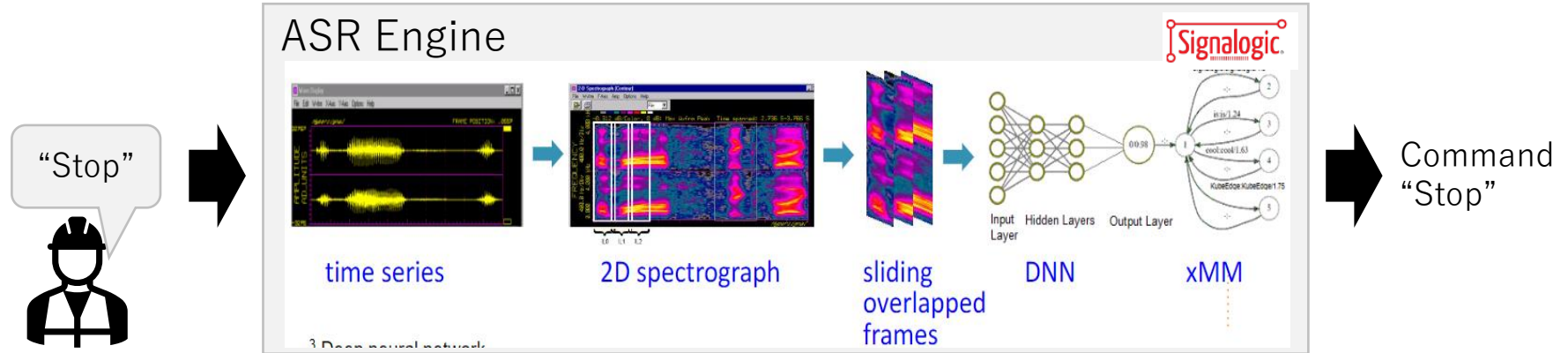
What is Signalogic ASR Engine?

ASR (Automatic Speech Recognition)

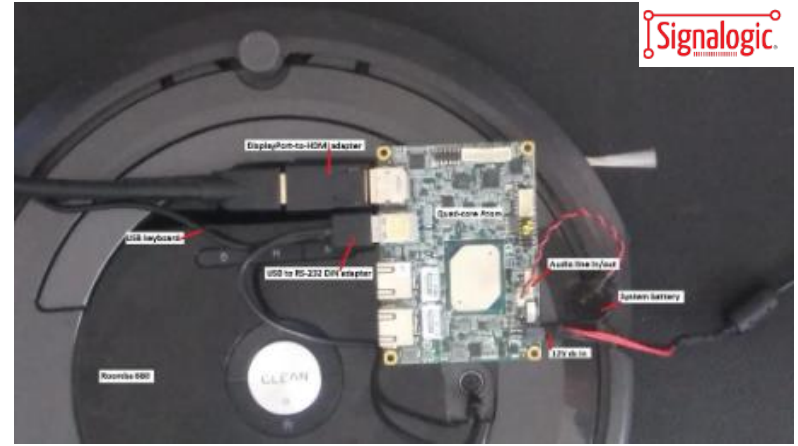
Signalogic developed light weight ASR engine

○ Capabilities

- Urgent/safety voice commands; e.g. “stop”
- Operating commands; e.g. “change mode”
- 100% reliable and private – runs without cloud connectivity



- Light weight
 - ~50W power consumption, no fans
 - Consumes one Atom CPU core(x5-E3940)
 - 20k word vocabulary
- Noise removal
 - Spectral subtraction and sound classification minimize robot background noise; e.g. servo motors, wheels



Roomba onboard ASR demo

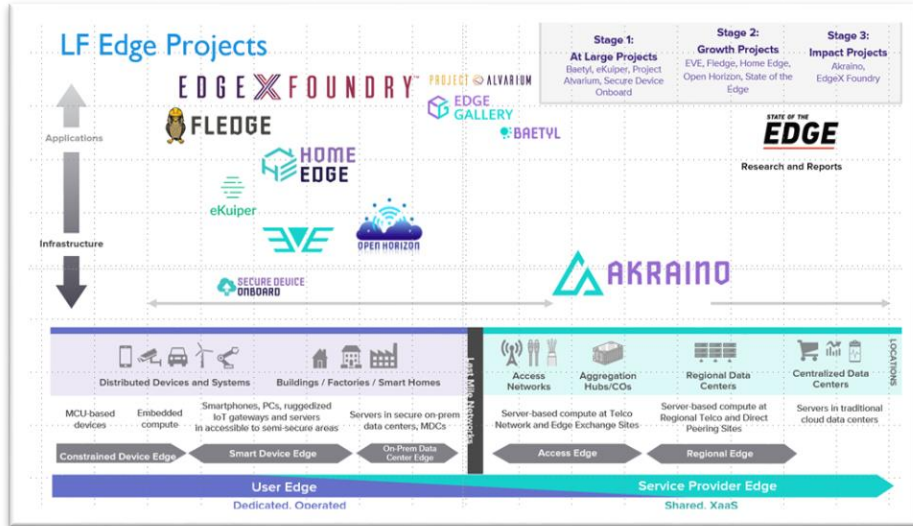
Accurately recognize voice commands in the field, regardless of internet connectivity – prioritize human safety

Activity in open community

Activity in LF Edge Akraino project

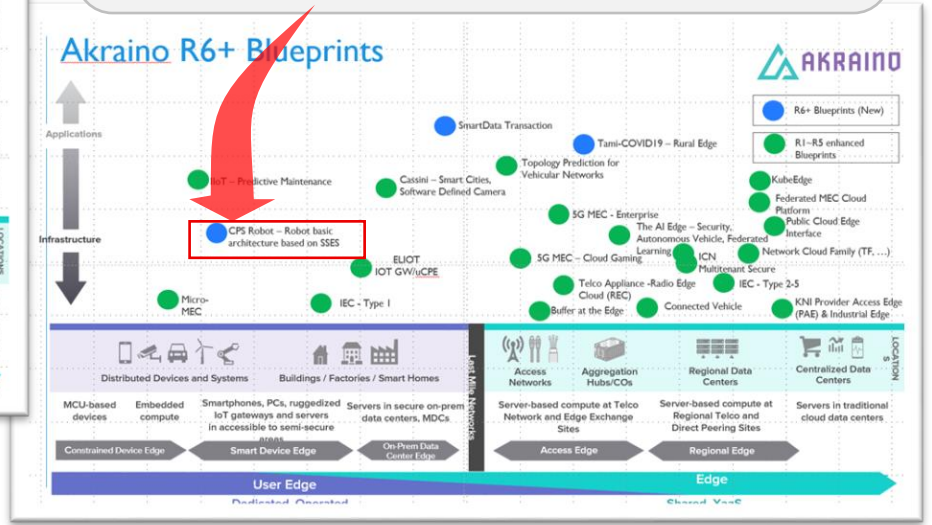
- Publishes solutions as OSS stack "Blueprints" for everyone to use

Akraino community creates edge computing use case OSS stacks



LF Edge - long form - MASTER

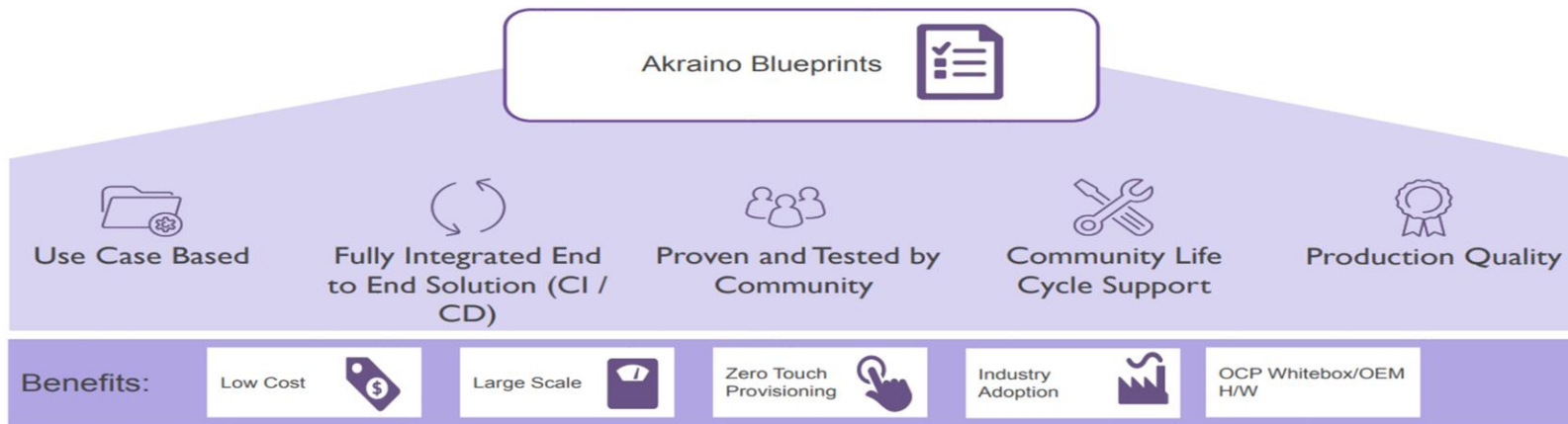
- SSES (Sensor-Rich Soft End-Effector System)
- R-CPS (Reconstructable basic system for Cyber Physical System)
- ASR (Automatic Speech Recognition)



What is Akraino Blueprint?

What is an Akraino Blueprint?

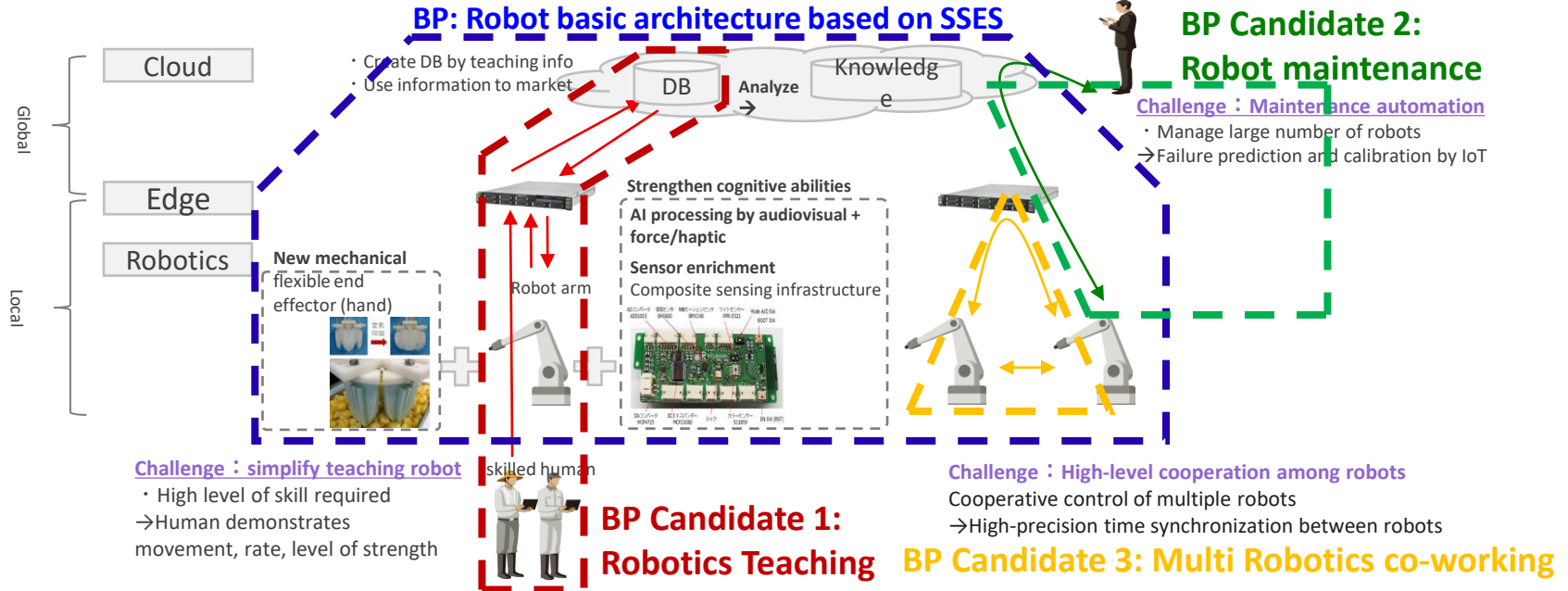
Community Integrated, tested, deployable, end to end Edge Stack



Since launch in 2018, Akraino continues to gain community support for collaboration and validation with 30+ blueprints

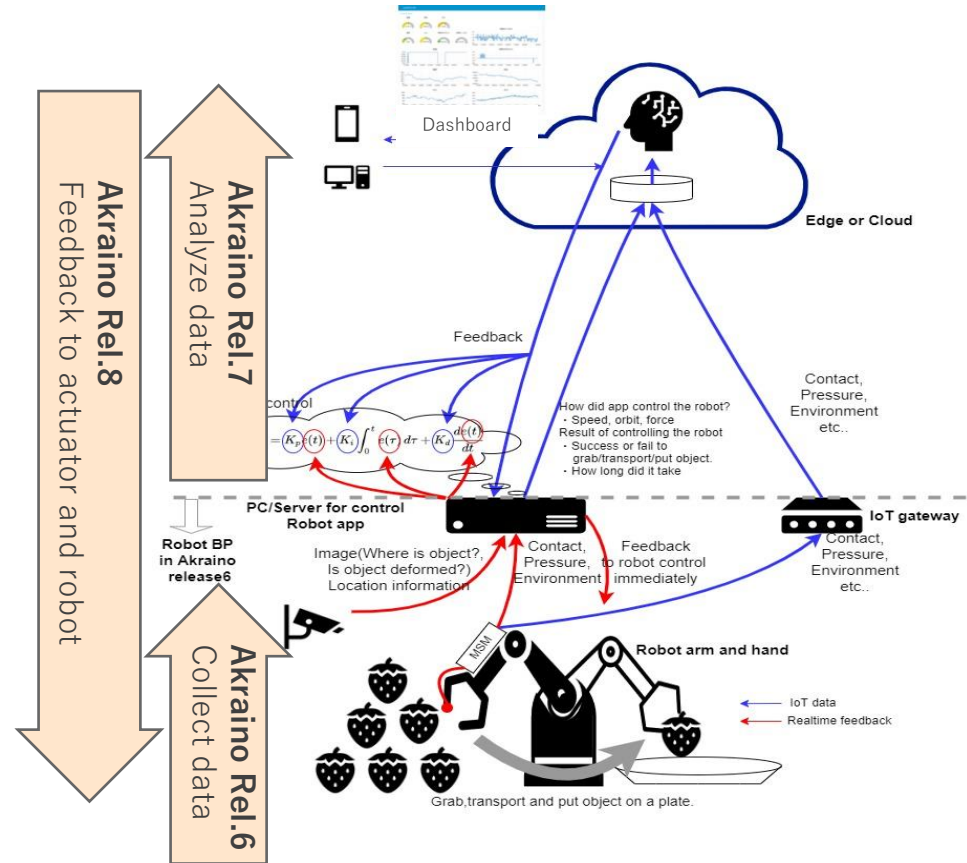
CPS Robot Blueprint family overview

- There are many challenges and use cases, and solutions will be a combination of elemental tech
- We launched CPS Robot Blueprint family in the Akraino community
- Focus is on "Robot basic architecture Blueprint" to provide OSS stack based on SSES/R-CPS

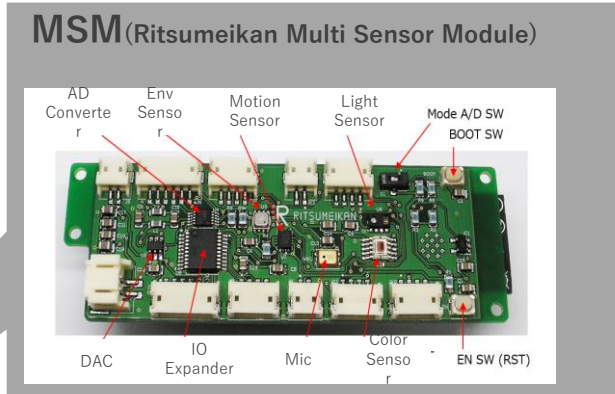
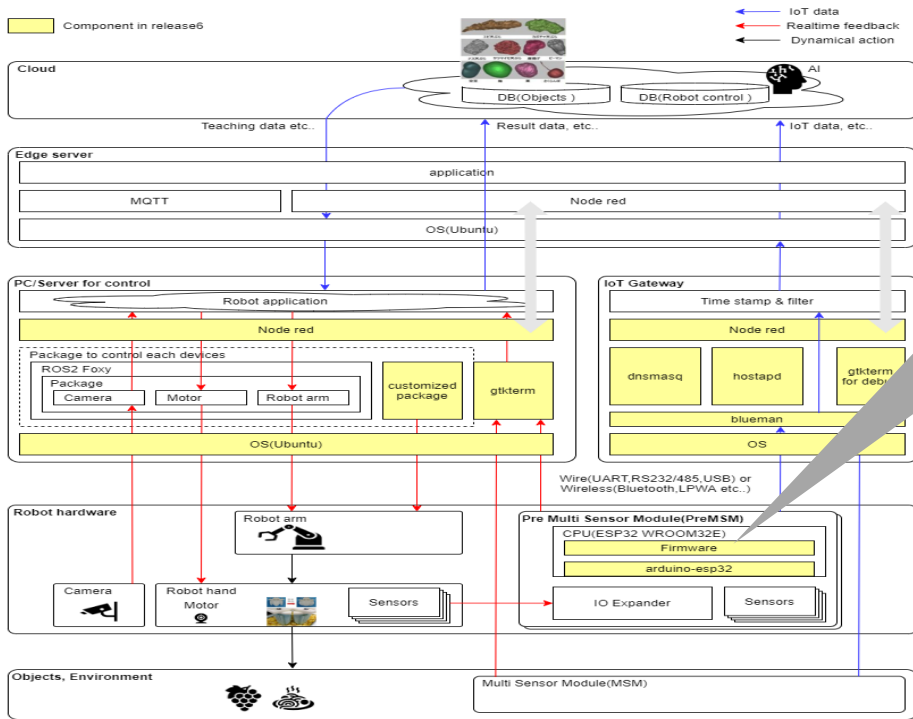


Robot basic architecture based on SSES Blueprint

- Open software stack for
 - Collect sensor/robot data
 - Analyze data
 - Feedback to robot control
- Received Akraino award
 - Blueprint of the year 2022



Detail of blueprint in Akraino R6



- Documents are available on wiki
[Robot basic architecture based on SSES - Akraino - Akraino Confluence](#)
- Architecture document
- Installation/Test document

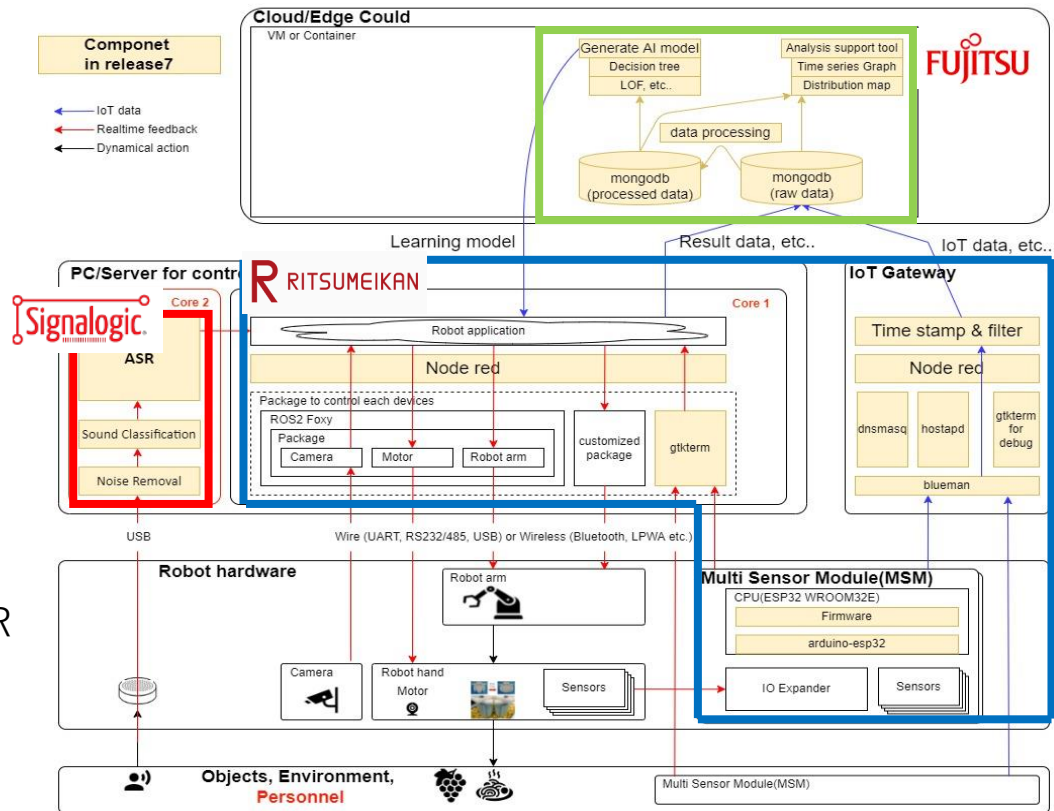
You can easily build data collection function

Detail of blueprint in Akraino R7

- Enhance functionality
 - Data processing
 - Data analysis

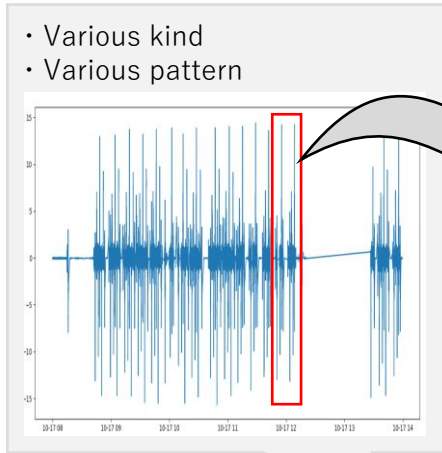
Release basic data processing and analysis software libraries to support a variety of use cases

- Light weight, high performance ASR



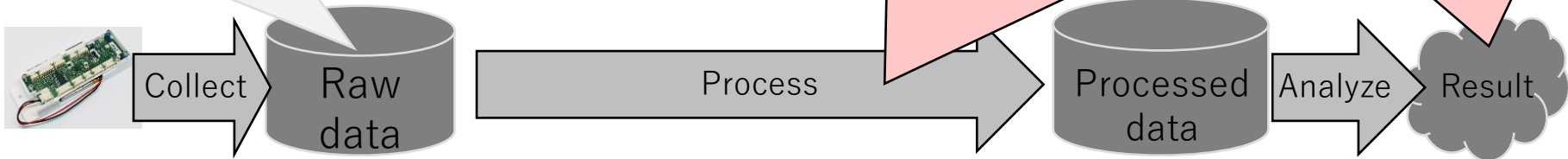
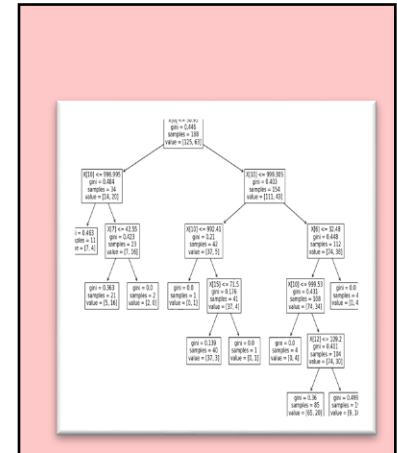
Basic data processing and analysis software

- Data processing and analysis methods differ depending on use case
- Software library accelerates implementation of data processing and analysis



Basic data processing and analysis SW Example

- Split time series data
- Detect peak
- Calculus
- FFT
- Remove noise
- ...

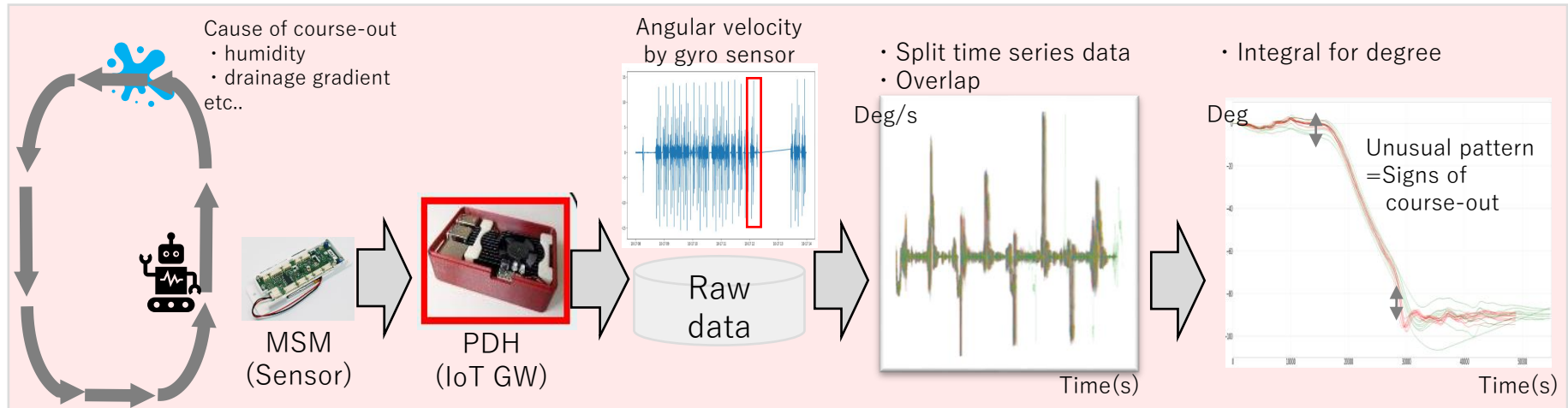


Classification	function	Summary	FUJITSU
Data processing	read_db_env	Returns the environment data for the specified time period.	
	detect_change	Detect the point of change in data for a specified time period.	
	resample	Resampling Input time series data.	
	calc_maxminavg	Calculate the maximum, minimum, and average values for a specified time period.	
	integral	Calculate integral of Input time series data.	
Data analysis	kmeans	Classify time series data by k-means method.	
	plt_ouerrap_fig	Create a chart that overlays multiple time series data.	
others	diagnose	Graph the reception period of R-MSM data and detect reception errors.	

Poof of Concept in food factory

Poof of Concept in food factory

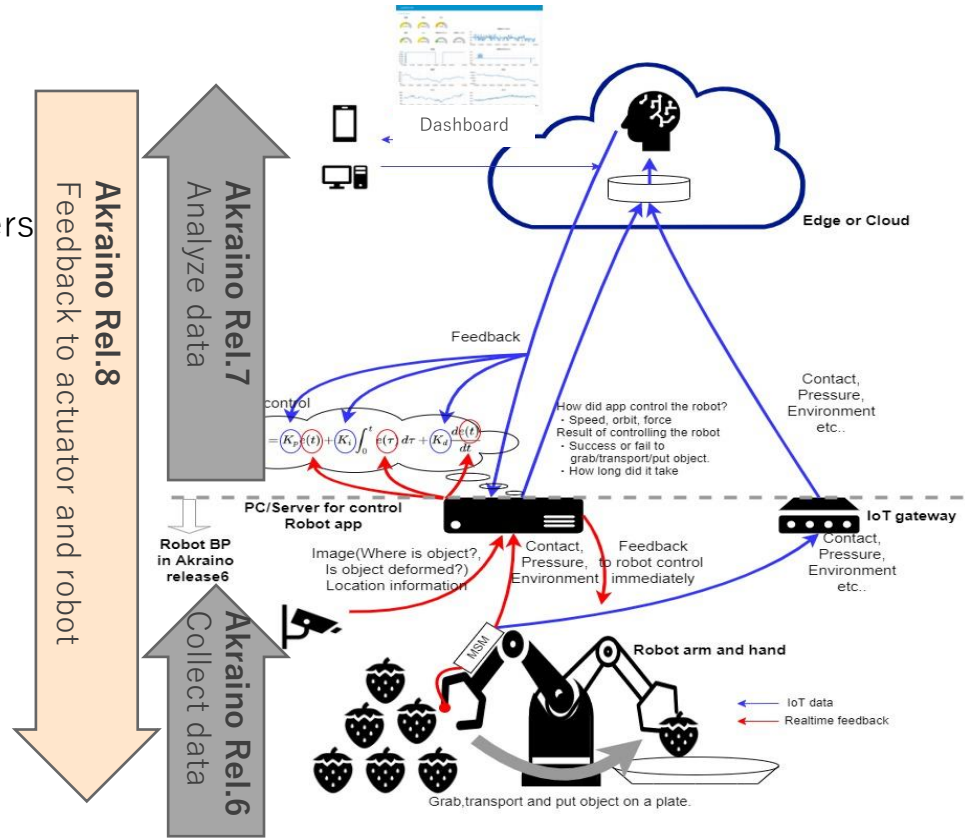
- Theme: detect signs of AGV (Automatic Guided Vehicle) course-out (i.e. off course)
 - Road surface of a food factory is unstable due to humidity, drainage gradient, etc.
 - Difficult to operate AGVs stably without course-out
 - Confirmed that R-CPS and Basic data process and analysis SW can detect course-out indicators



Robot Blueprint activities in future

- Enhance current blueprint functionality
 - Autonomous optimization of Robot; e.g. Parameter optimization of PID control
 1. Store data measured by sensors
 2. Analyze data in cloud for better parameters
 3. **Feedback new parameters**
- **Interface with Robot arm and hand**
 - There are various kind of arm and hands depends on use cases
 - Need to absorb difference of HW
 - ROS2 is a candidate solution

Welcome participants
Contact: fukano.haruhisa@fujitsu.com



Appendix

- Showcase objectives:
 - Promote LF Edge projects and highlight edge computing use case
 - Increase user adoption of LF Edge projects
- Showcases
 - **Robotics (Akraino)** • IoT (Fledge, eKuiper, Akraino)
 - Clean Energy (EVE, Alvarium) • MEC (Akraino)
 - Retail (EdgeX, OpenHorizon, SDO) • Factory, Plant (Fledge, EVE)

We are exhibiting in booth XX at ONE summit

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Cabinet Office

<https://www.cao.go.jp/index-e.html>



NEDO New Energy and Industrial Technology
Development Organization

<https://www.nedo.go.jp/english/index.html>



SIP Cross-ministerial Strategic
Innovation Promotion Program

<https://www.jst.go.jp/sip/en/index.html>

Thank you

