Plugfest 2020
MQTTv5
Smart Agriculture+Bluetooth+IoT

Keio University

Plugfest 2020

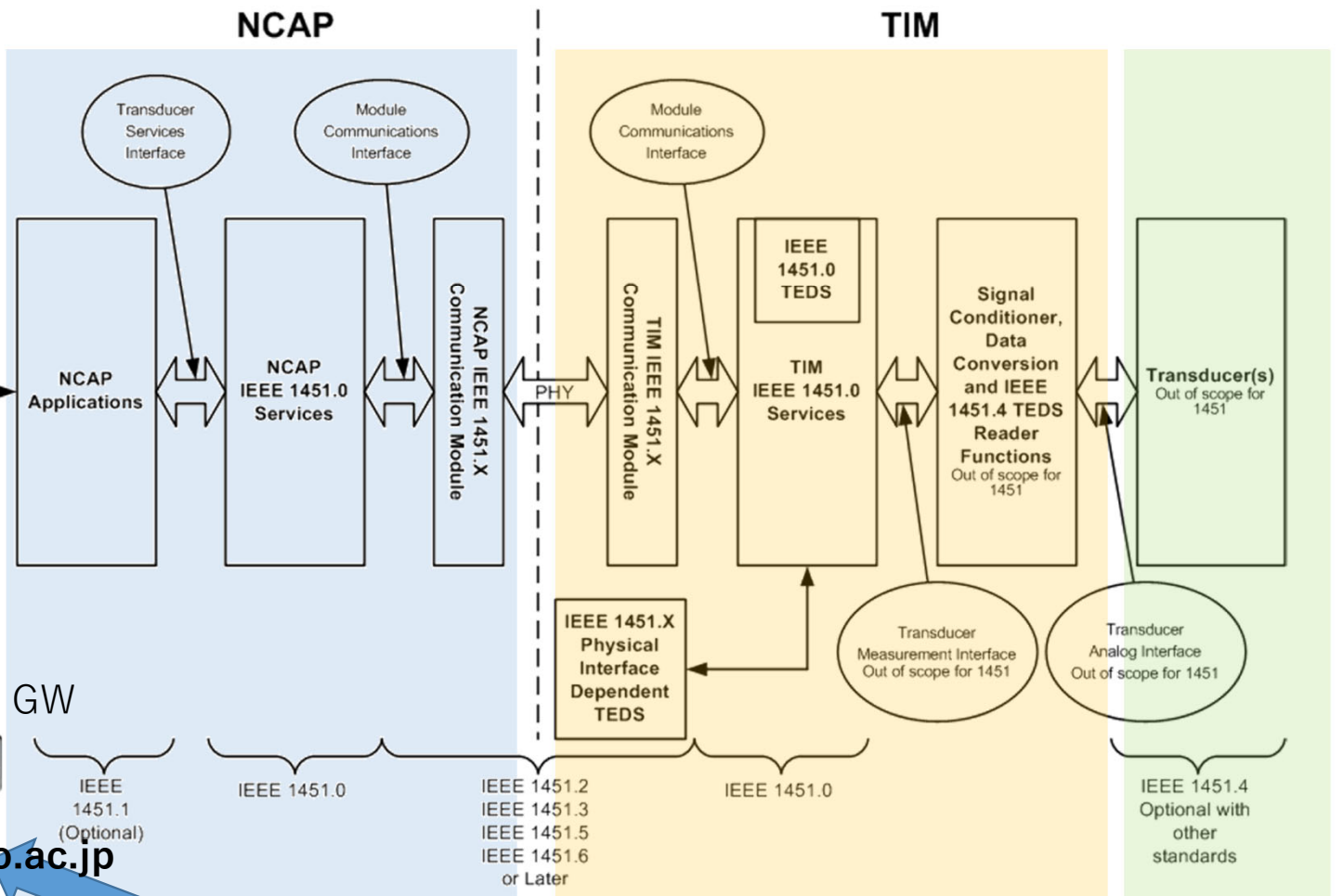
MQTT Broker / GW

plugrest.west.sd.keio.ac.jp

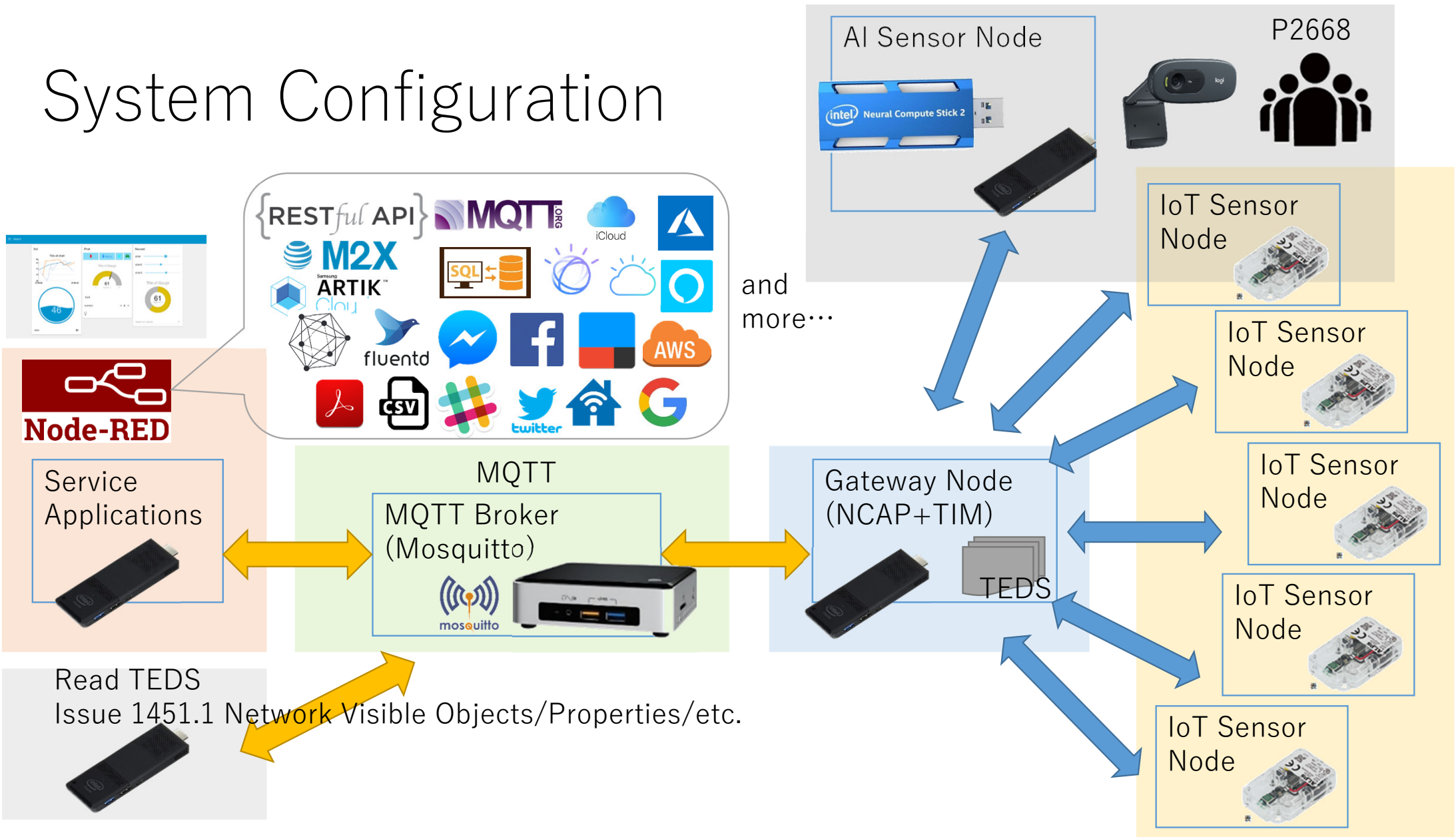
Application

TEDS

BLE
(Bluetooth Low Energy)



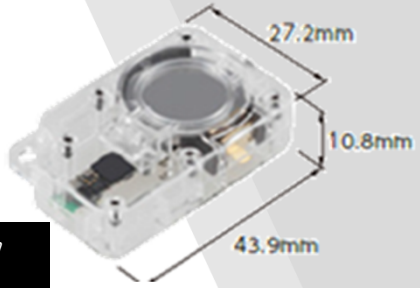
System Configuration



ALPS IoT Sensor Bluetooth Sensor Module

- ALPS IoT Sensor (BLE)
  - Power 2.35-3.30V 7mA(Peak)
  - Bluetooth 4.1
  - Sensors:
    - 6D Acceleration Sensor (-2G – 2G extendable)
    - Presser Sensor (300-1100hPa, 0.013hPa/LSB)
    - Temperature (-20 - +85 C, 0.02 C/LSB)
    - Humidity (0 – 100%, 0.016%/LSB)
    - UV (0 - 20.48mW/cm2)
    - Illuminance (0 – 81900Lx, 20Lx/LSB)

Top View



Bottom View

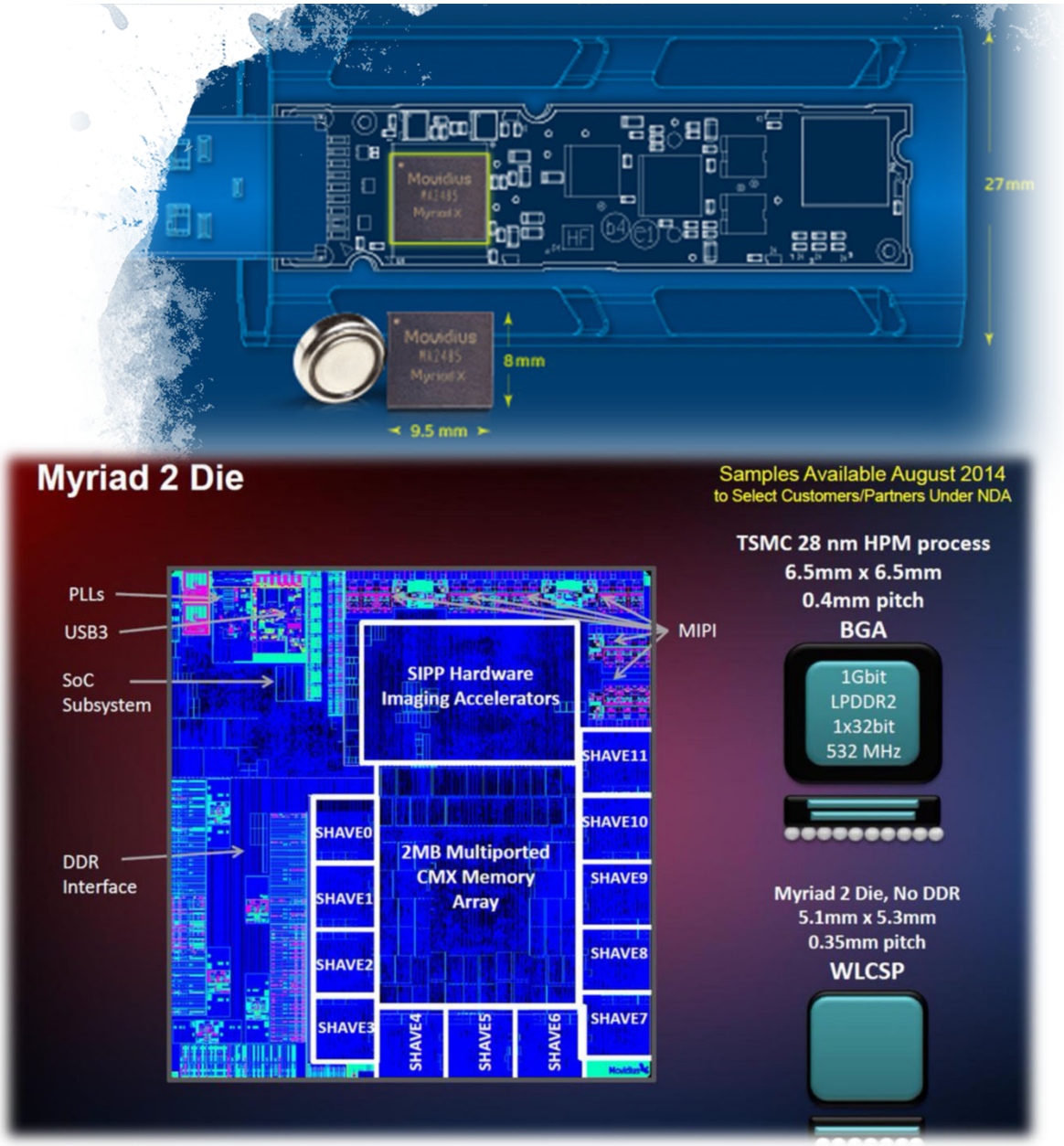
Intel Compute Stick

- Soldered-down BGA 14 nm Technology
- Embedded Storage 64 GB
- DC Input Voltage 5 VDC
- Included Storage 64GB eMMC
- Included Memory 4GB LPDDR3-1866 # of channel 2
- Memory Bandwidth 29.8 GB/s
- Memory Card Slot MicroSDXC with UHS-I support
- USB Configuration 3.0 (External 2+ Internal 1)
- Intel Wireless-AC 8260 + Bluetooth 4.2
- Integrated Bluetooth Yes (Not compatible to BLE)
- Intel VT-x, PTT, AES inst. Yes

- Linux Ubuntsu 19.04
- Bluetooth USB Adapter LBT-UAN05C2 (Bluetooth 4.0)
  - Integrated Bluetooth is not capable for stable BLE modules management

Intel Neural Compute Stick 2

- Accelerate Deep Neural Network Applications
  - Hardware: Intel® Movidius™ Myriad™ X VPU
  - Software: Intel® Distribution of OpenVINO toolkit
- Application Specific Hardware Accelerator
  - Neural Compute Engine
  - SHAVE Core: 16 powerful processing cores
  - High-throughput Memory Fabric



MQTT v5 is now available!

- mosquitto >1.6 supports MQTT v5
- It enables request-response style MQTT message
  - It can emulate 1451.1 message transaction rule
- It also advanced in security, authorization, and usability.
- MQTT v5 Request-Response feature was used for TEDS distribution

Status of MQTTv5 support

MQTTv5 brokers and clients

- Mosquitto support MQTTv5 (Thread safe, C) from release version 1.6
- EMQ X (Supports MQTT-SN, Erlang)
- net-mqtt (TCP support is not given, Haskel)
- Paho MQTT (Python client does not support v5)
- VerneMQ (Erlang, OTP)
- wolfMQTT (C)
- Flespi MQTT broker (Commercial online service, Not open source)
- HiveMQ (Commercial online service, Not open source)
- IBM WIoTP Message Gateway (Commercial, Not open source)
- Thingstream (Commercial, Not open source, Only MQTTv5)

Other MQTTv5 clients

- gmqtt (python asynchronous MQTT client)
- MQTT.js (MQTT client for Node.js and browsers)
- luamqtt (Lua MQTT client)

Used in Plufest2019

1451 + MQTTv5 + IoT + Edge Neural Computing

BLE IoT Modules (>10) are connected

Face, Age, Gender, Emotion, Direction Sensor by using Edge Deep Learning and Its Accelerator

MQTT v5 fully supported and used for 1451

How to communicate with NCAP via MQTT

- Sensor Data and TEDS Transmission over MQTT v5

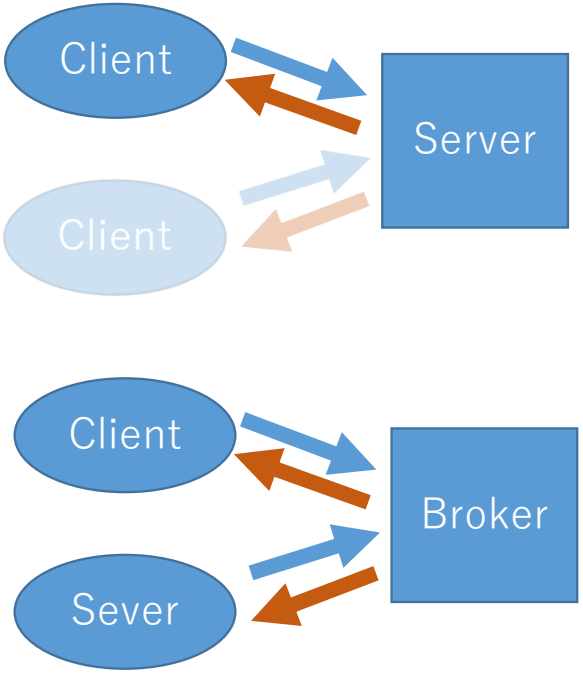
- 1451.1 provides publication-subscription based protocol
  - However, it is similar with old style server-client model and does not support broker
  - MQTT cannot use it.

- The controllability from MQTT depends on the design of MQTT communication block and object as function block

- There are several methods for the data transmission.
  - Use the diversity of topic expression
  - Use the new feature of MQTT v5

Native Support of 1451.1 by MQTT v5

- MQTT v5 Request-Response supports end-to-end communication.



Request message from a client can follow response message from the server. This mechanism is used for providing services and is known as server-client model.

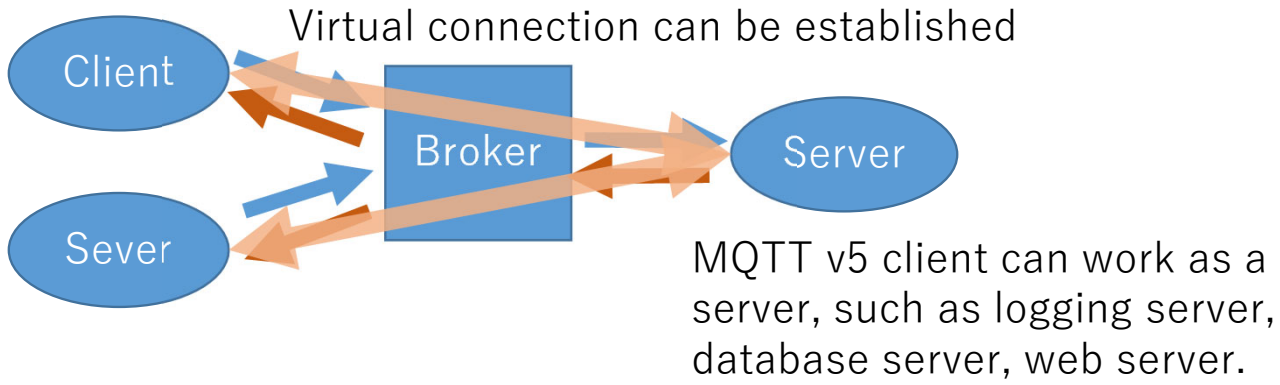
MQTT uses a publish and subscribe communication methods where there is no direct communication between the sending client and the destination client (server). It was difficult to send response message to client from the server.

From the perspective of physical communication, broker is a server, and server of this figure is a client of broker.
From the perspective of service function, broker is a communication hub and it does nothing.

1451.1 defines publish/subscribe style communication, but it is not based on this pure broker style communication.

Request-Response message

- MQTTv5 has an ability to publish a response topic which allows to implement the request/response pattern between clients that is common in general client server model communications.



How it works?

- Initialization
  - Client1: subscribes response topic (e/res/c1)
  - Server: subscribes common topic (e/com) All clients will publish on the topic
- Request
  - Client1 publish message to common topic (e/res/c1) and add its response topic to the response topic message property of the publish message.

    client.publish(‘e/com’, “msg", response_topic=“e/res/c1")
- Response
  - Server receives the message on the common topic (e/com) and publish it response on the response topic along with the correlation data from the received message.

    client.publish(‘e/res/c1’ as given in the response_topic,"response msg",response_topic="e/res/srv")
- Broker Security
  - You can configure access control lists on the broker for guaranteeing only client1 can subscribe to the topic e/res/c1.

§ 11.9.2.7.1 argument publication_contents behavior specification

- 0 PublisherInformation publisher_identification_information
- 1 UInteger8 content_code
- 2 UInteger32 event_sequence_number
- 3 ObjectTag response_object_tag
- 4 TimeRepresentation event_detection_time
- 5 String event_name
- Remaining Argument optional_arguments

- All these information can be managed in user_properties; however, it does not mention the existence of broker in 1451.1

How to communicate with NCAP over MQTT

- Sensor Data and TEDS Transmission over MQTT using 1451.1
- NCAP object operation (if required)
- Transducer values

- Sensor Data
  - Sequential Mode
    - Data come periodically
  - NCAP becomes Publisher with the Topic of
    1451/Manufacturer/Model/Version/SerialNumber[/Field]/XdcrNAMEorID
    1451/Country/Region/City/Area/Street/Building/Sensor[/Field]/XdcrNAMEorID
- Application
  - Becomes Subscriber to read the sensor data by using same Topic

How to send TEDS?

Independent from sensor data

Simple Method

Support NCAP Network Visible Object operation

Recognize system unavailability.

All these features on MQTT

How to send TEDS over MQTT

Retain

- Publisher can send a message with retain bit.
- The message with retain bit will be kept in MQTT broker.
  - When subscribed, “the last message with the retain bit” will return.
- MQTT brokers does not guarantee storing all messages with retain bit.
- Some MQTT brokers does not implement retain mechanism and the Retain message will be kept in the case of sudden client shutdown or lost.

WILL

- When subscribers becomes unavailable, WILL message returns to all subscribers of the sensor’s topics.
  - WILL message may observe HTTP status code (RFC7231)
- Keep Alive Timer function with PINGREQ/PINGRESP message will be used for checking availability of sensors.
- Clients cannot get TEDS when they required immediately.

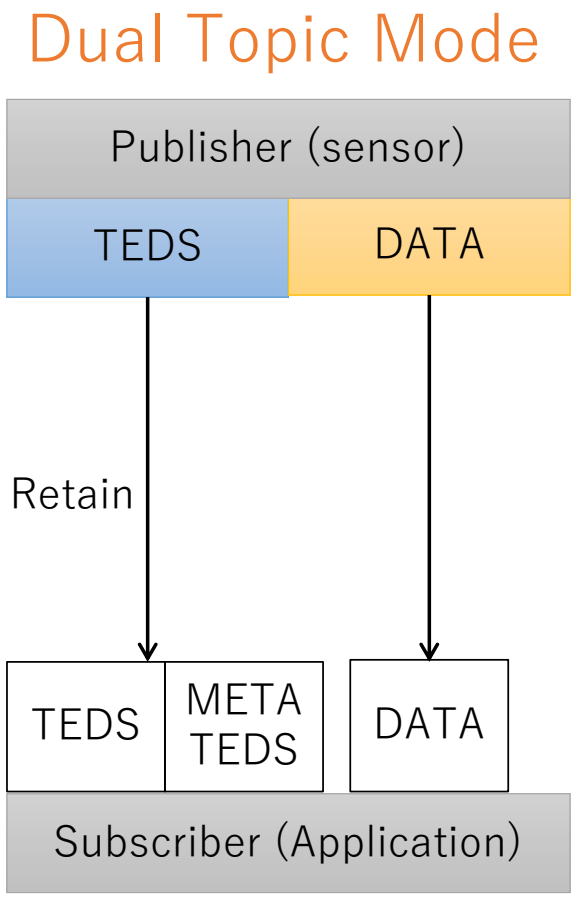
Request-Response messaging

- Use the new feature of MQTT v5

TEDS Dual Topic Mode

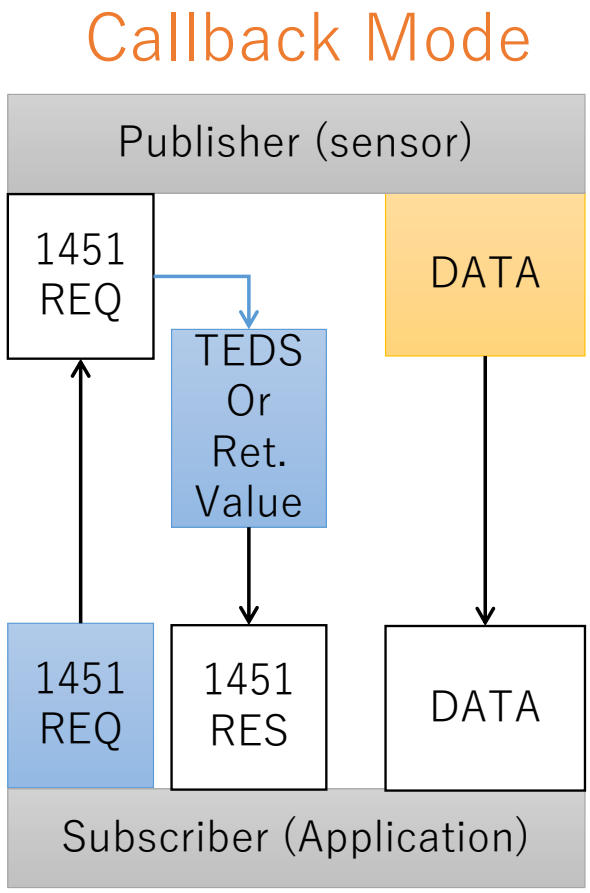
- Sensor Node
  - Publish TEDS with retain flag
    PREFIX/SensorName/TEDS
    PREFIX/SensorName/METATEDS　etc.
  - Use Keep-Alive-Timer (PINGREQ/PINGRESQ Message) [Opt-A]
    (We need to check MQTT behavior when Timer expires and retain-flagged message is lost or remains. This is case WILL is helpful.)

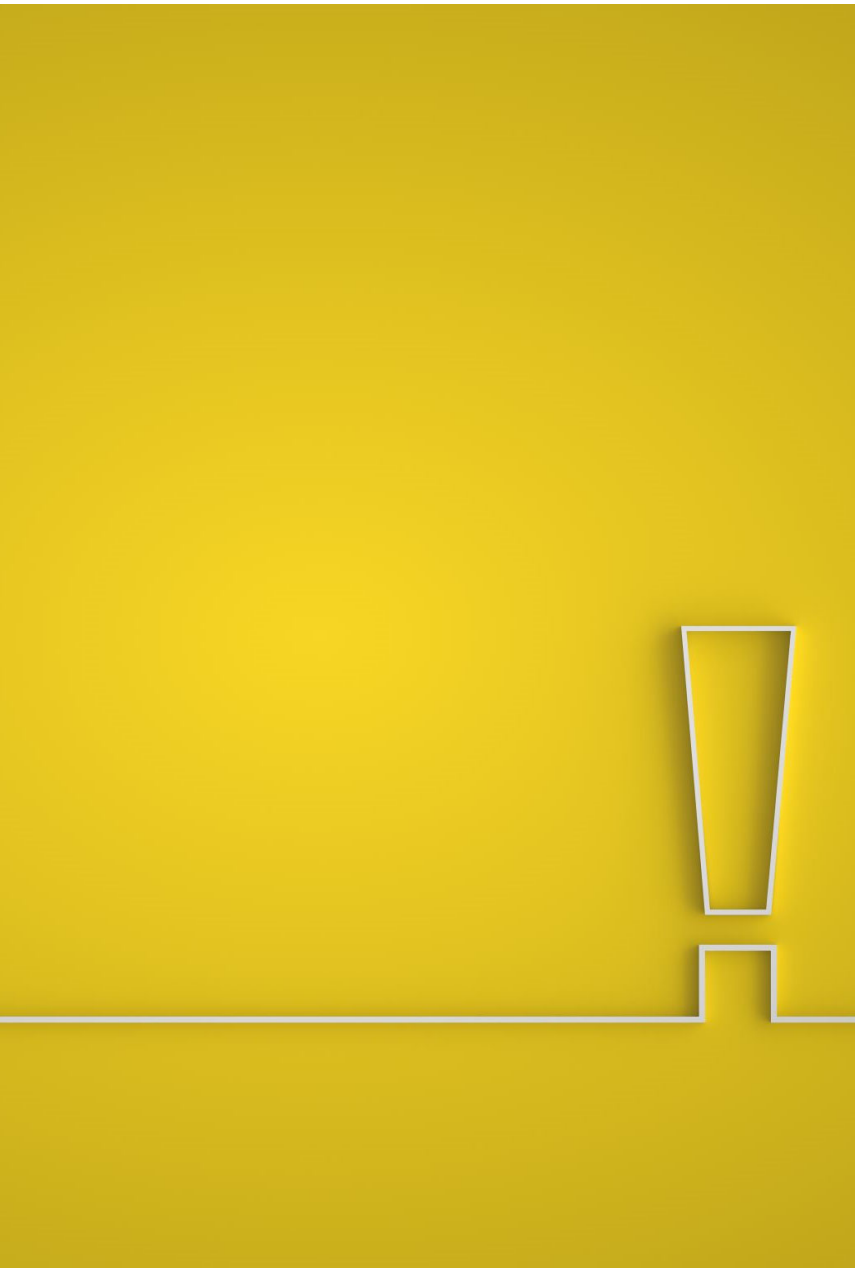
  OR
  - Subscribe PING topic with similar way of Option B [Opt-A' not good idea]
    PREFIX/SensorName/ALIVE
- Application
  - Subscribe TEDS by [A]
  - Check availability of sensor by TEDS availability, [A]+WILL, or [A']
- It has to prepare topics for all required TEDS
- ALIVE topic is required to recognize unavailability



TEDS Callback Mode

- Sensor Node
  - Subscribe predefined Topic to receive TEDS request
    PREFIX/SensorName/TEDSREQ [A]
- Application
  - Generate UID of Unique ID (Unique Topic Name)
  - Subscribe (wait) TEDS by using the topic of UID
    PREFIX/SensorName/TEDSRES/UID [B]
  - Publish UID to PREFIX/SensorName/TEDSREQ [A]
- Sensor Node
  - Receive ID by [A]
  - Publish TEDS to given Topic [B]

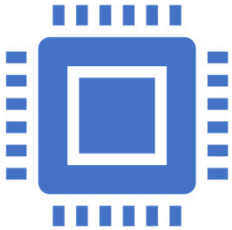




How to control/communicate with NCAP?

- Follow the hierarchy and mechanism of 1451.1 to full access of NCAP network visible functions
  - Publish the following information and get the result
  - Name or Operation ID of Network visible objects and operations defined in 1451.1
  - Send request to 1451REQ topic with the message of [Object name of Class name]/[Operation name or Operation ID]/Array of Required parameters given as /* in */ in 14151.1. It is recommended to add subscription ID (MQTT v5)
  - As the response of the request, OpReturnCode and the array of answer parameters given as /* out */ in 1451.1 will be returned.
- To find the object name, the following operation is useful.
  - LookupMembersByName, LookupMemberByDispatchAddress, LookupMemberByObjectTag, GetNumberOfMembers

TEDS



TEDS information was generated by using DeweTEDSEditor

Output TEDS binary data (HEX text) only

XML-based TEDS was also defined according to the input data to the editor (self-typed)

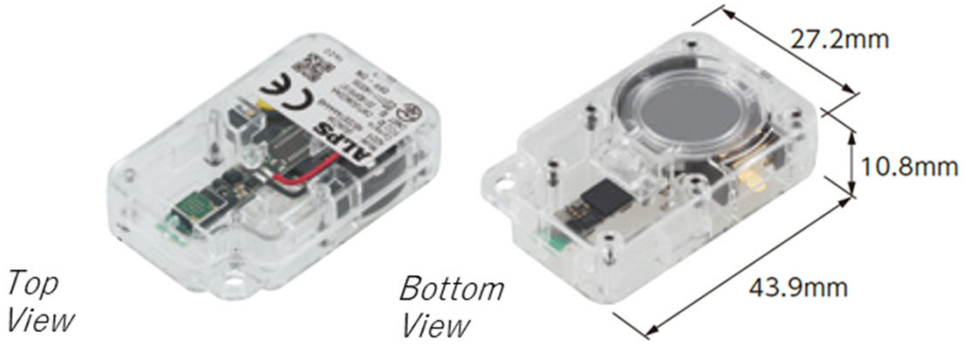
Currently using Meta-identification TEDS

It will be extended to XEP-0323
(http://www.sensei-iot.org/PDF/Transforming_TEDS.pdf)

Specification of ALPS IoT Sensor

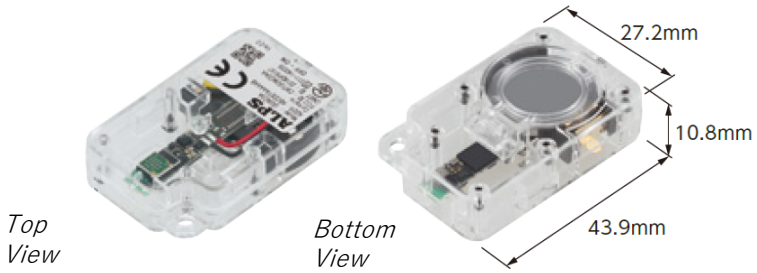
ALPS Electric Co.Ltd.
Smart IoT Sensor Module

	Items	Specification
Common Spec	Power	2.5～3.3V
	Consumption	Typ. 1mA @10Hz sampling
Bluetooth v.4.1	Receiver Sen.	-93dBm
	Transmit Pow.	0dBm
6-Axis Acceleration Sensor	Scales	Geo-magnetism : -2.4～+2.4mT Acceleration : -2～+2G ※-16～+16 Scale extendable
	Sensitivity	Geo-magnetism : 0.15uT/LSB Acceleration : 0.24mG/LSB (@+-2G scale)
Pressure Sensor	Scales	300～1100hPa
	Sensitivity	0.013hPa/LSB
Temperature / Humidity	Scales	Temperature : 0～100%RH Humidity : -20～+60℃
	Sensitivity	Temperature : 0.016%RH/LSB Humidity : 0.02°C/LSB
UV / Ambient Illuminance Sensor	Scales	UV-A : 0～20.48mW/cm² Illuminance : 0～81900Lx
	Sensitivity	UV-A : 0.005(mW/cm²)/LSB Illuminance : 20Lx/LSB



TEDS sample

- ALPS Electric Co.Ltd.
  Smart IoT Sensor Module



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UV / Ambient Illuminance Sensor	Scales	UV-A : 0～20.48mW/cm² Illuminance : 0～81900Lx
	Sensitivity	UV-A : 0.005(mW/cm²)/LSB Illuminance : 20Lx/LSB

Sensor BLE Format

- Write command

Event Code	Length	Data (Single/LSB,MSB)

- Read command

Event Code + 0x80	Length	Data (Single/LSB,MSB)

- Event Code
  - 0x20 (Measurement control)
  - 0x21 (Bluetooth configuration)
  - 0x23 (Disable data transfer)
  - 0x2D (Communication parameter)
  - 0x2E (Status / Data request)
  - 0x30 (Internal Clock adjustment)

TEDS example (Temperature Sensor)

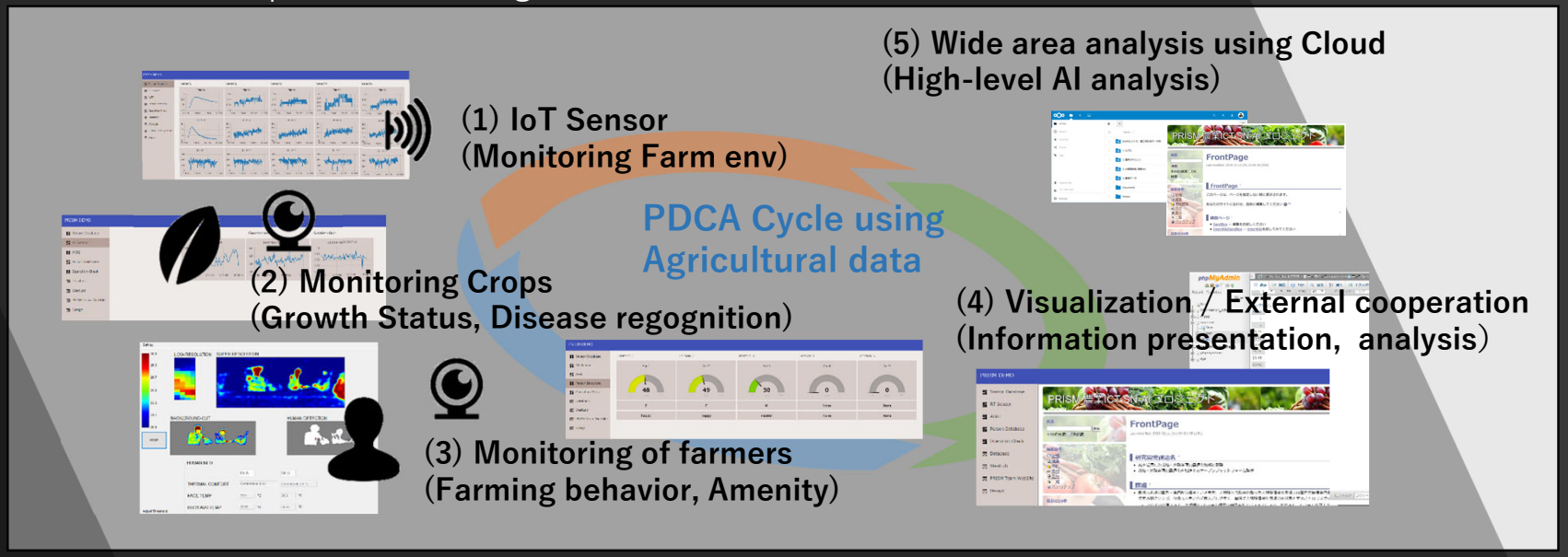
- TEDS
  40002004320000AA0107A1C0E00485953A3D0A660B928246586A56F3722DF93E124
  CCA0183933228A60000803F01004083010054850 0EA540773C1642FE654081C00

- METATEDS (XML)

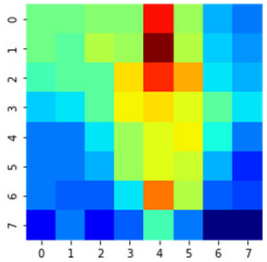
```
<?xml version="1.0" encoding="UTF-8"?>
<MetaIdentificationTEDSDataBlock>
        <manufacturer>Unknown</manufacturer>
        <manufacturerId>109</manufacturerId>
        <ModelNo>1A1</ModelNo>
        <SerialNo>50</SerialNo>
        <UserManufacturer>ALPS ELE</UserManufacturer>
        <UserModelNo>IOT SMART MDL</UserModelNo>
        <UserSerialNo>SUFOYUEYWO</UserSerialNo>
        <UserPhysicalMeasurand>TEMPARATURE</UserPhysicalMeasurand>
        <UnitScale>DEG C/DECIM/TXT</UnitScale>
        <UnitConvertionFactor>1</UnitConvertionFactor>
        <UserSensorLimits>Yes</UserSensorLimits>
        <PhysicalSensorMin>-20</PhysicalSensorMin>
        <PhysicalSensorMax>85</PhysicalSensorMax>
        <UserDataValue>S:0.02/LSB</UserDataValue>
</MetaIdentificationTEDSDataBlock>
```

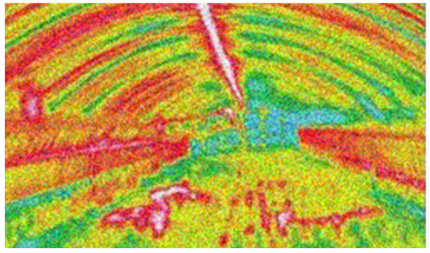
Use Case for Smart Farm

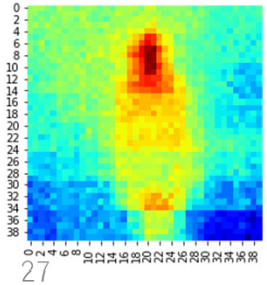
- Farm data management attracting interests
  - Cost down / Harvesting yield, date, quality
- What is required for Smart Farm data management?
  - Encapsulation： Encapsulate private farm data into its local
  - Mobility： Flexibly management of data for control, storage, copy, publication, etc.
  - Abstraction： Anonymization, Labeling using AI
  - Crystallization： Ultimate improvement using data



Low-cost High-functional Sensing System







The image of Low-cost IR array sensor (Grid-EYE)

- Low resolution image is processed to high precision image
- Imaging the whole of farm and workers

Monitoring plant, soil, environment, etc.

- Growth control
- Energy management

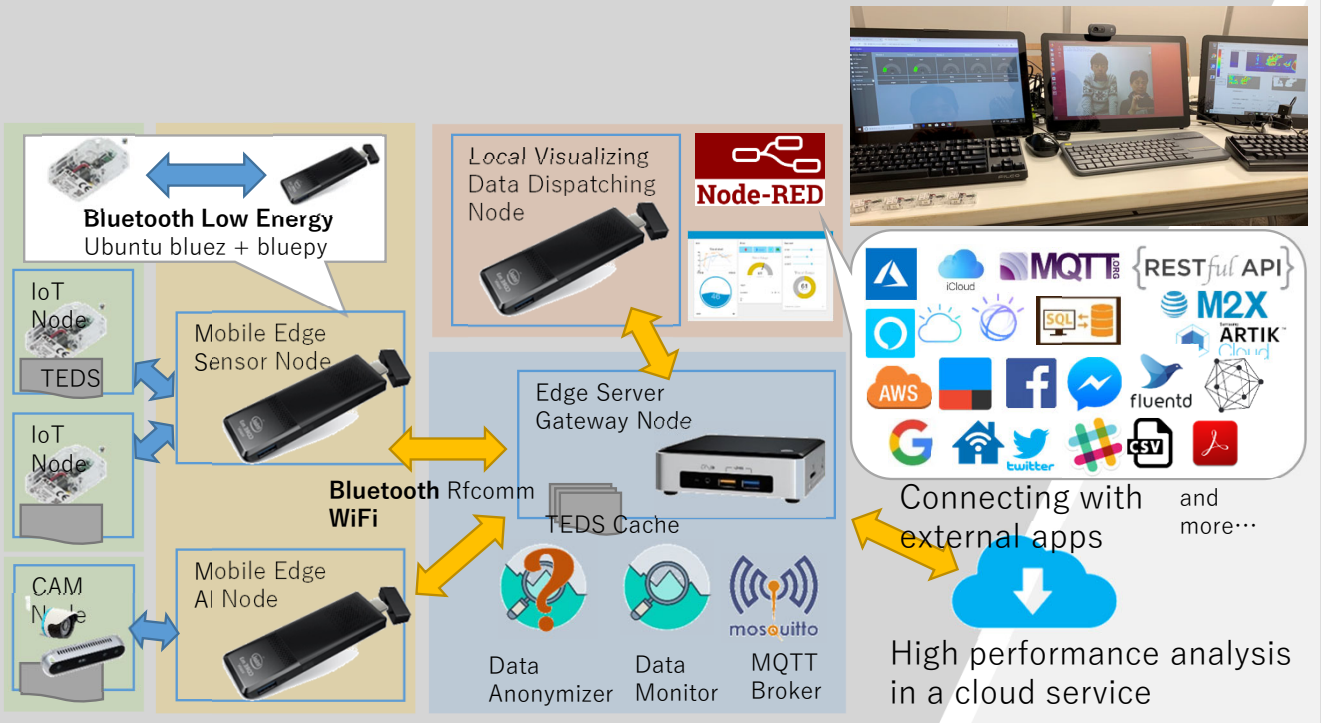
Monitoring farmers

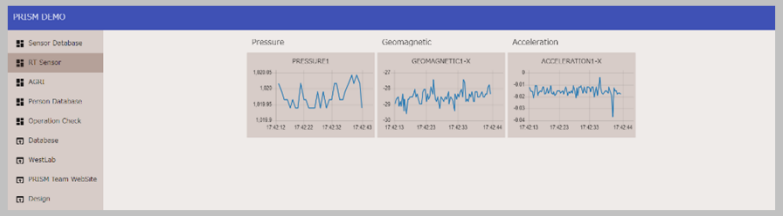
- Farming management
- Amount of close
- Amenity

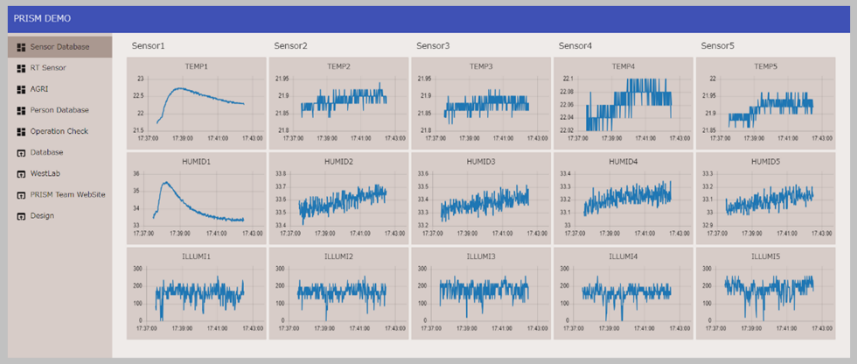
Item	Value
# of Pixels	64 (2×8)
Precision of Temp.	0.25°C
Range of Temp.	0°C~80°C
Error of Temp.	2.5°C
Max. Depth	5m
Measurement Range	60°
Frame rate	10 fps

Monitors Farm Environment

- Automated Environmental Control
- Abnormal Detection

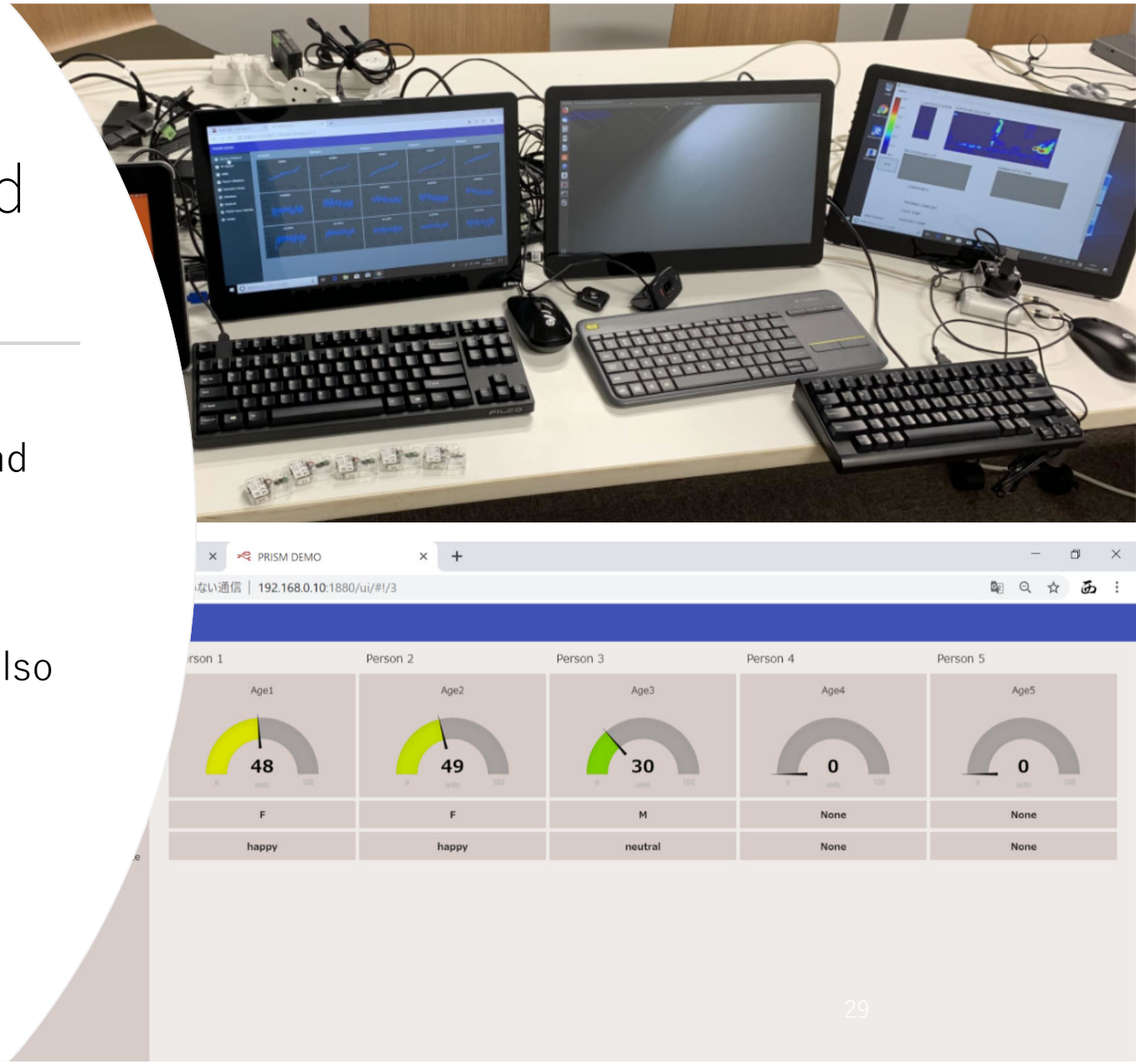




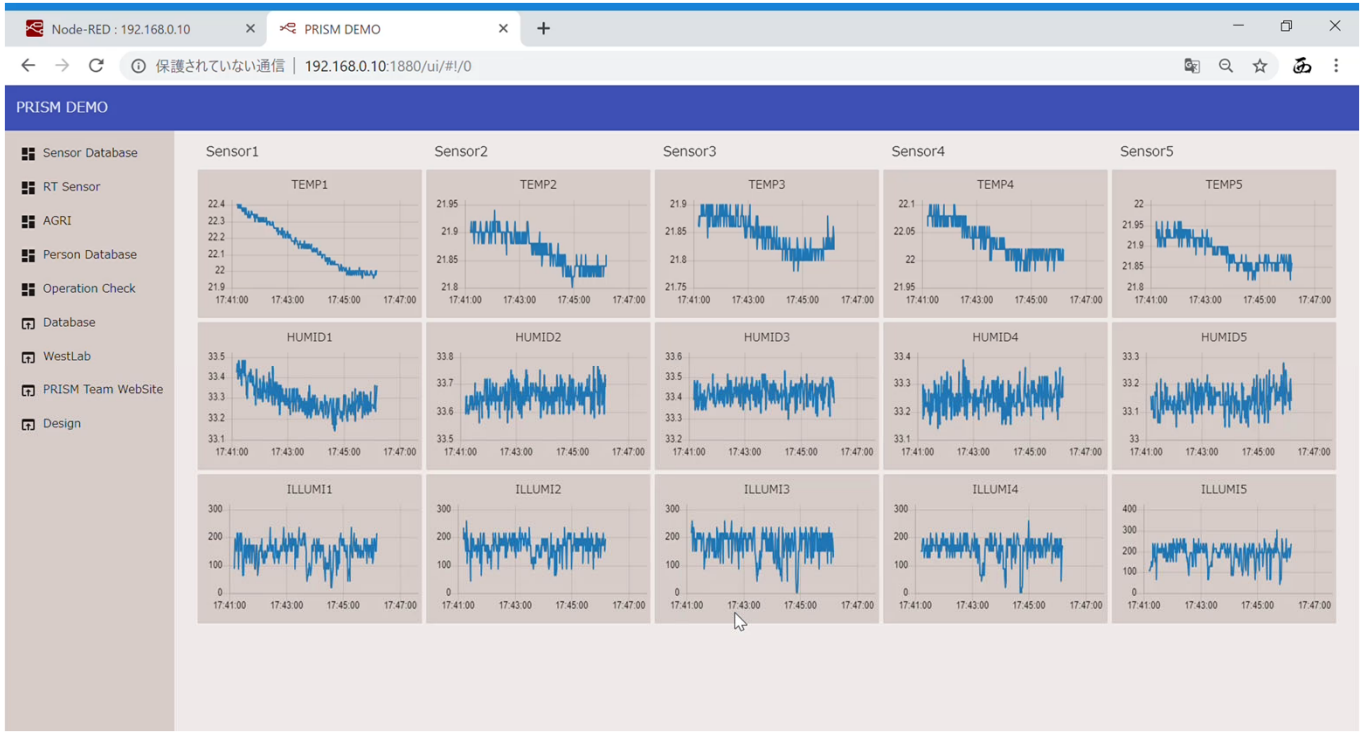


Individual Detection and Behavior Analysis

- Farmer's labor, activity, and works are detected for predicting yield and quality improvement.
- The system helps maximize the benefits from the farm.
- The data captured by the system also referred by retailer’s service management.

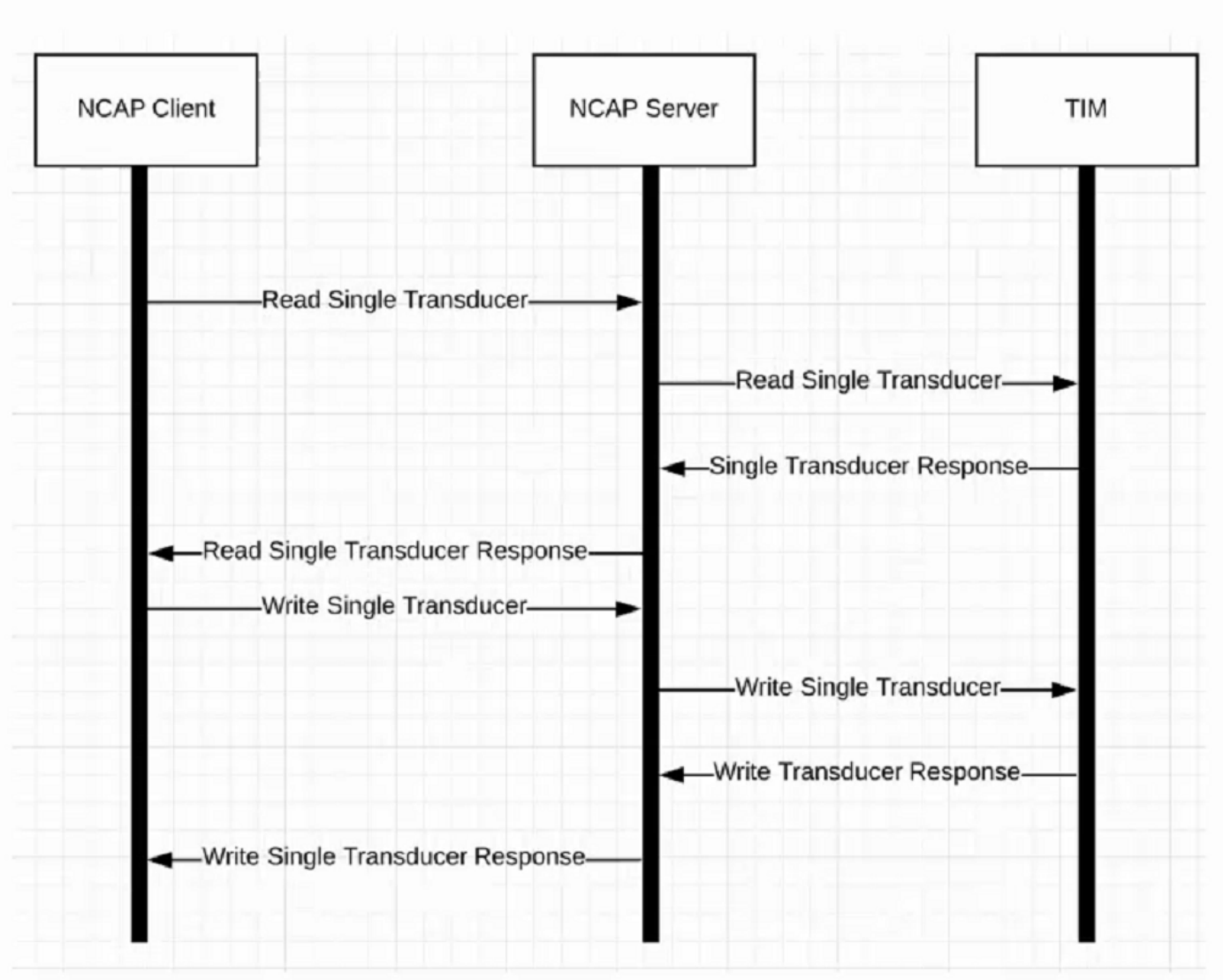


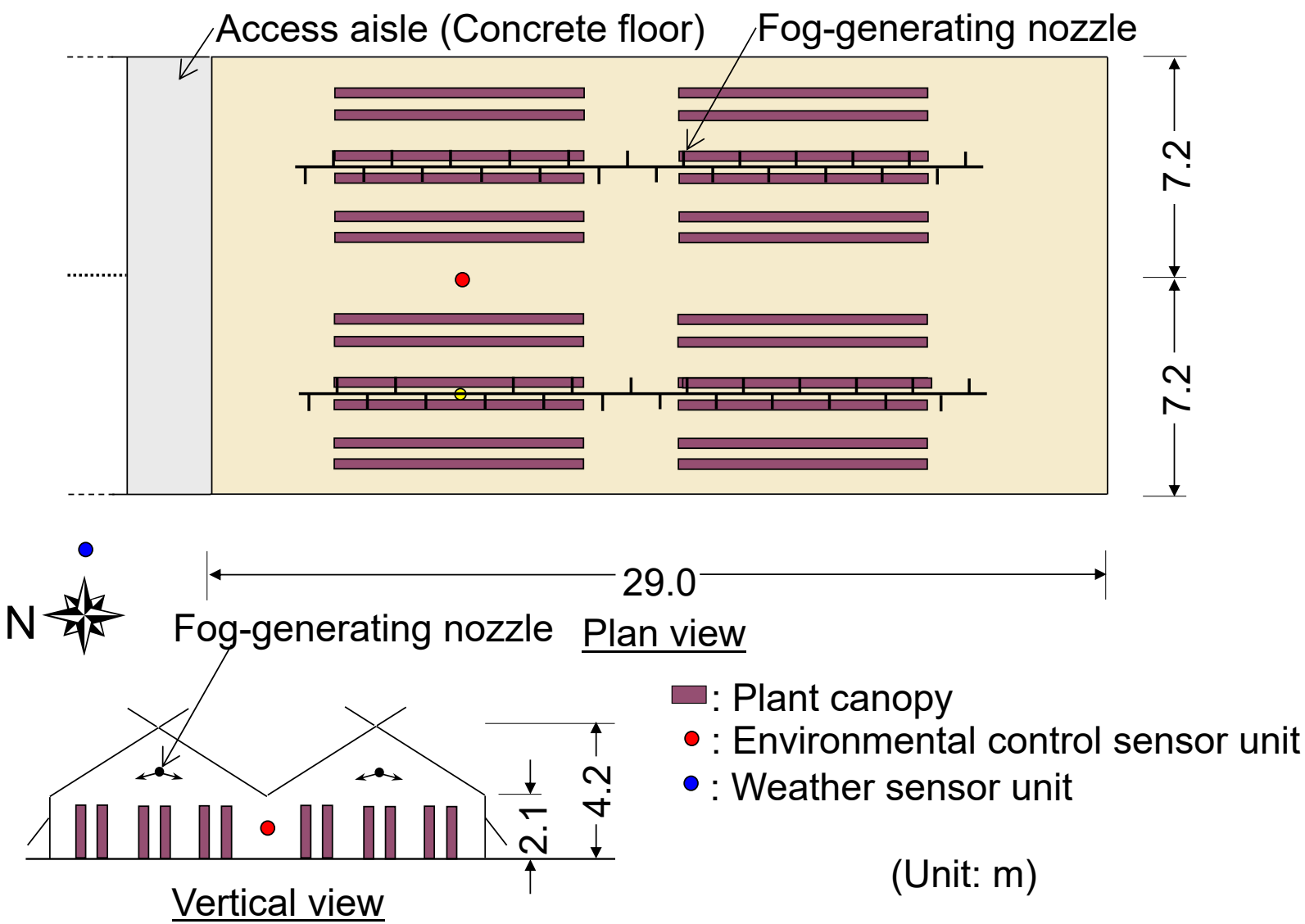
Demonstration Movie



In case of using MQTT, this request-response style communication is only defined by MQTTv5

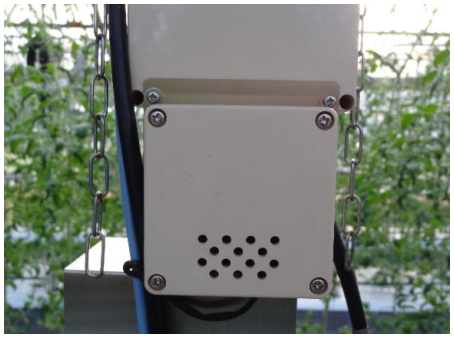
We provide this feature. However, this feature may not be popular for general MQTT users.




Access aisle (Concrete floor)
Fog-generating nozzle
7.2
7.2
29.0
N
Fog-generating nozzle
Plan view
: Plant canopy
: Environmental control sensor unit
: Weather sensor unit
4.2
2.1
Vertical view
(Unit: m)


屋内気象-A-S


複合制御 MCC16-A-S




警告

Demonstration System

- plugfest.west.sd.keio.ac.jp
  - MQTTv5 mosquitto is in active
  - Smart agriculture data will be provided (now preparing to connect with NARO)
  - The topic list will be provided
  - Protocol conversion system will be provided
  - Request-Response style MQTTv5 messaging will be available
    - Sample code will be provided on GItHub
  - Other sensor data will inherit the last our plugfest demo
- Access
  - User, Password: iesstd, P21451-1-6PW
  - IP address: 131.113.98.84 FQDN: plugrest.west.sd.keio.ac.jp
  - Port #: 1883, 8883(SSL/TOS) (WebSocket is not supported)
- URLs
  - https://github.com/westewest/Plugfest
  - https://gitpitch.com/westewest/Plugfest