

# Industrialization of Wireless Sensor Network



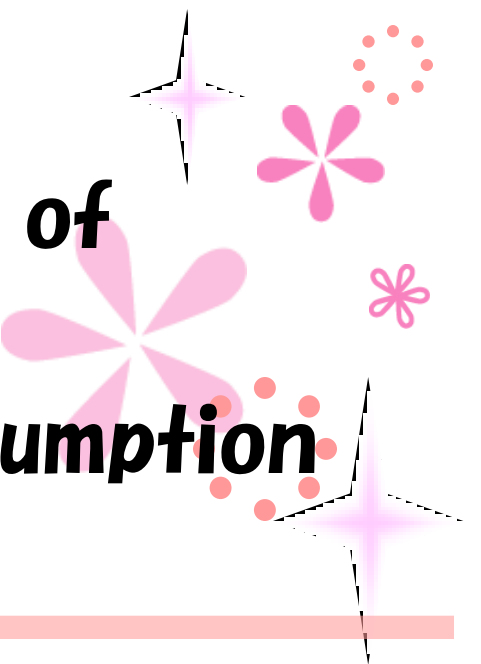
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Department of Electronics and Manufacturing  
AIST

# CONTENTS

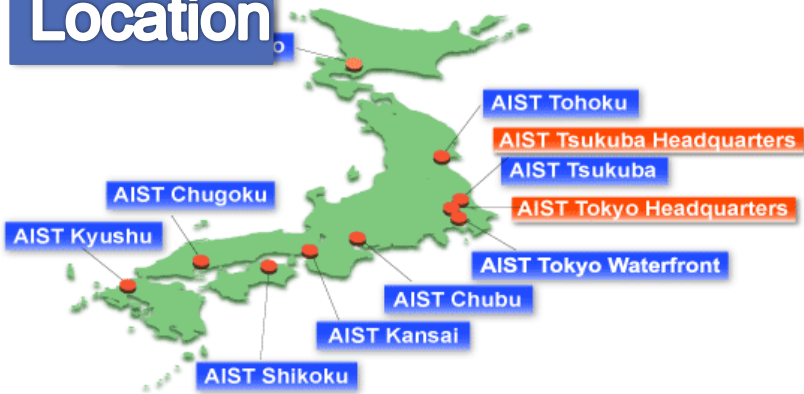
- **Difficulties of Industrialization of Wireless Sensor Network(WSN)**
  - **New ideas for Low Power Consumption (LPC) Sensor Node**

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    - **LPC sensor**
    - **LPC communication**
    - **Event driven**
  - **Application of Wireless Sensor Network**
    - **Green sensor and Smart - Agriculture**
  - **Conclusion**
- 

# AIST-UMEMSME

## Location



## Division

- Life Science and Biotechnology
- Information Technology and Electronics
- **Nanotech. , Materials and Manufacturing**
- Environment and Energy
- Geological Survey and Applied Geoscience
- Metrology and Measurement Science



## Staff

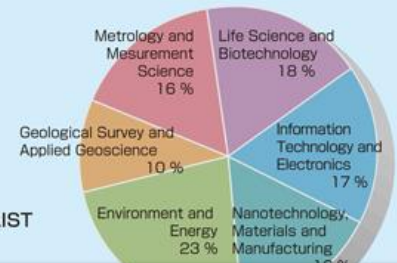
Number of Employees	
● Researchers	2,348
Tenured researchers	2,036
Fixed-term researchers	312
● Administrative staff	690
<b>Total number of employees</b>	<b>3,038</b>

As of April 2009  
(Excluding 13 executives)

### Number of Visiting Researchers at AIST

- Postdoctoral researchers 500
- From private companies
- From universities
- From corporation etc
- From overseas

(NOTE: Each figure is estimate of researcher's presence during the period)



2300 researchers

700 administration staff

# Facility Feature Detail

2G Existing  
4 inch Line

New Investment:

**3D (351 m<sup>2</sup>) 8inch MEMS and 12 inch Integration**  
**3F(60 m<sup>2</sup>) Bonding and Testing, 2A(84 m<sup>2</sup>) Evaluation**  
**3B (154 m<sup>2</sup>) Green Testing**



- Green and Safety Management
- Support HV prototyping and LV Production
- Invite SMEs of Polishing, Electroplating, etc.

2010

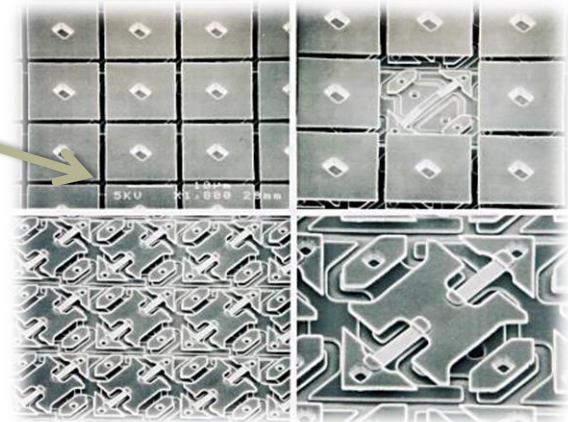
User Interfaces of Mobile Devices  
Accelerometer, Gyro, Microphone

# What's next for MEMS?



2000

Inkjet head, Digital Mirror Device



1990

Pressure sensor, Accelerometer



## Difficulties of industrialization of WSN

- Large size and difficulty of installation and expensive cost

Typical size of WSN prototype

IRIS:

Size : 64 x 34 x 29mm

Battery : 2xsize AA

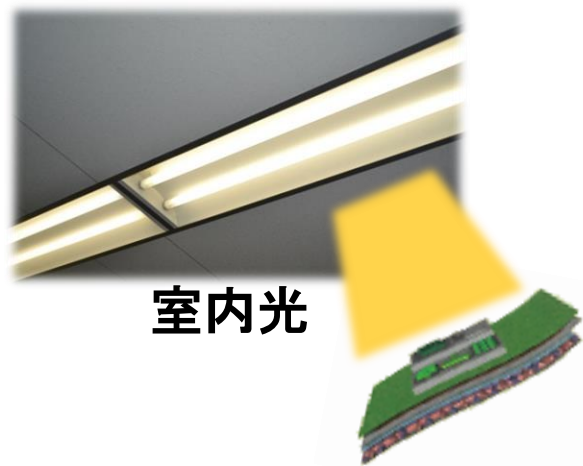
**Air Sence,  
ZigCube(Hitachi) etc.**

- Battery change of large number



Need of No battery change with easy installation sensor node (Low power consumption, less than  $150\mu\text{W}$ )

## New Idea 2 (LPC communication)



### グリーンセンサ

・自立電源 → 徹底した低消費電力化必要

特に無線は消費電力が大きいため、  
低消費電力化が必要

### 低消費電力無線通信プロトコル

- ・ ZigBee : メッシュネットワーク可
- ・ Bluetooth LE : 携帯電話への接続が容易

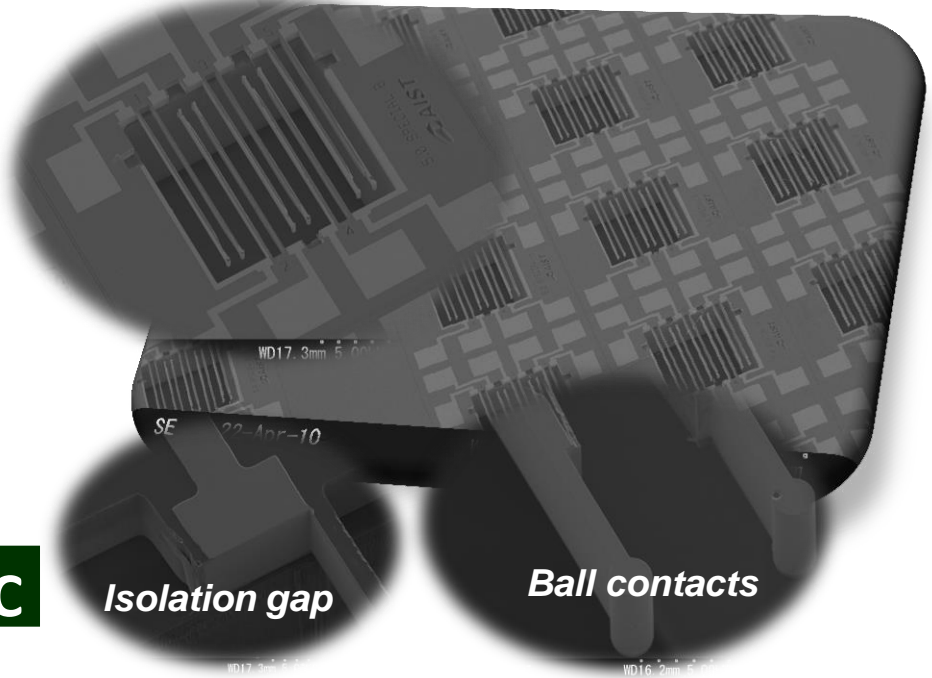
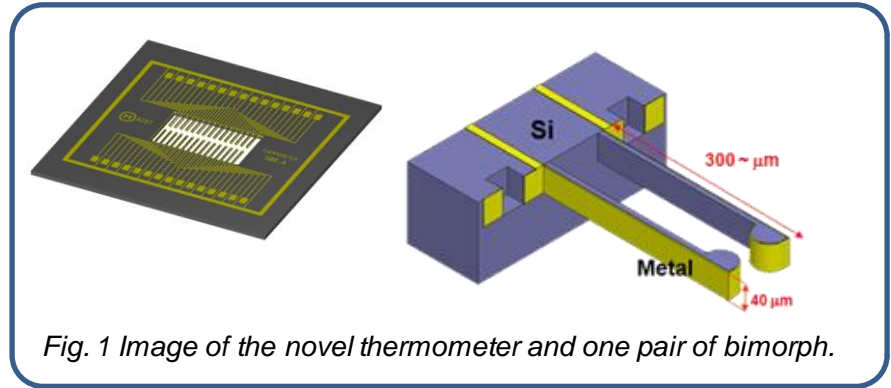
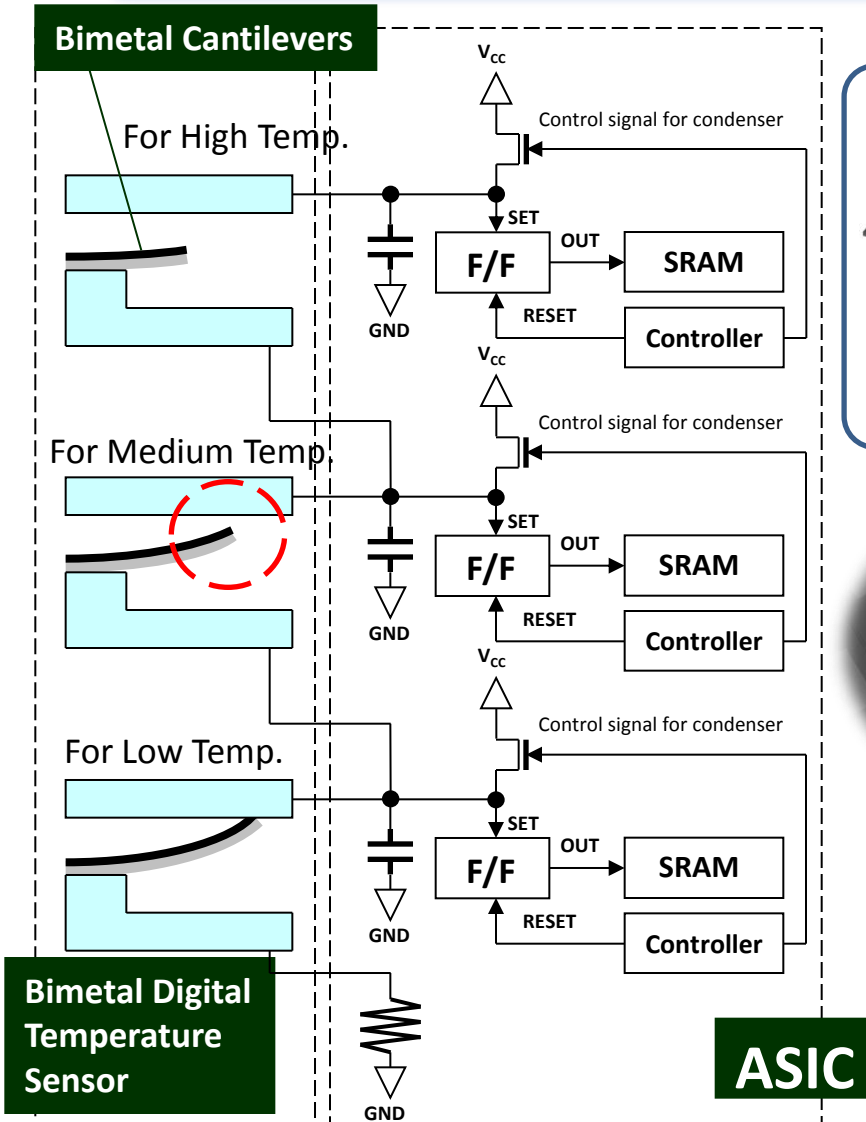
} 高信頼性を求めている

課題：高信頼性が不要なセンサネットでは消費電力が大きい

グリーンセンサでは電力や塵埃量などを送信

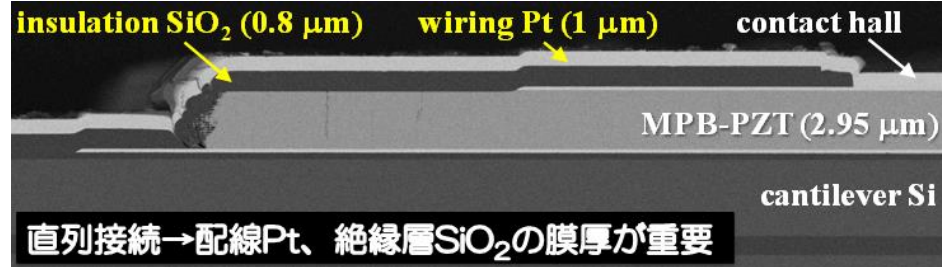
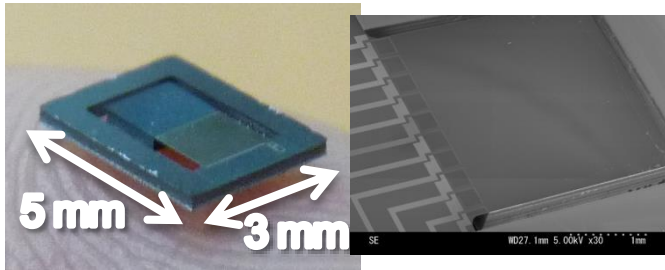
→ 必ずしも100%の通信信頼性を必要としない

# New Idea :LPC “Digital Temperature Switch

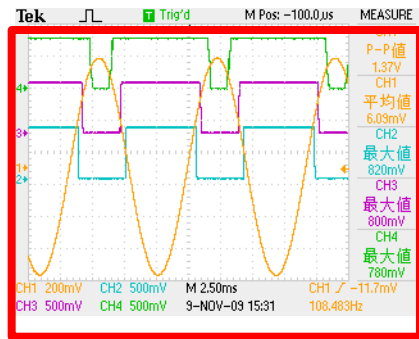
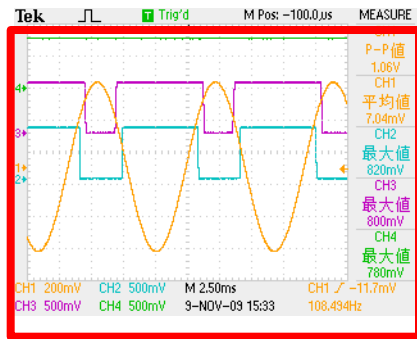
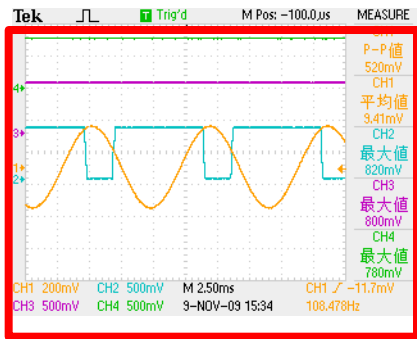
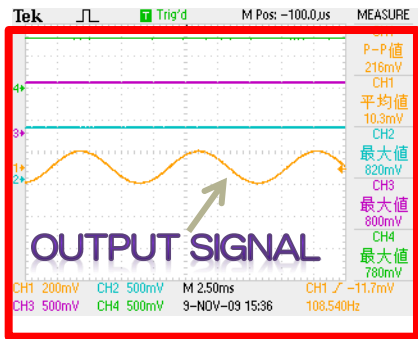




# New Idea :LPC“Piezoelectric Accelerometers



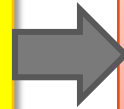
## PIEZO-CANTILEVER+CMOS INVERTER → DIGITAL ACCELEROMETER



Acc. [m/s <sup>2</sup> ]	<1.0	1.0 2.5	2.5 5.0	>5
<b>CMOS1</b>	off	off	off	<b>ON</b>
<b>CMOS2</b>	off	off	<b>ON</b>	<b>ON</b>
<b>CMOS3</b>	off	<b>ON</b>	<b>ON</b>	<b>ON</b>
<b>Dig. Acc.</b>	<b>000</b>	<b>001</b>	<b>011</b>	<b>111</b>

## New Idea 2 : LPC communication

Ordinary tele-communication:  
Reliability is important  
WSN  
data transmission error  
acceptable.



### Strategy for LPC

- One directional data transmission
- Data volume deduction

### Conventional data transmission



**PC decrease**

CRC : 巡回冗長検査

## New Idea for LPC: Event driven sensor)

To wake up sensors only on sensing time

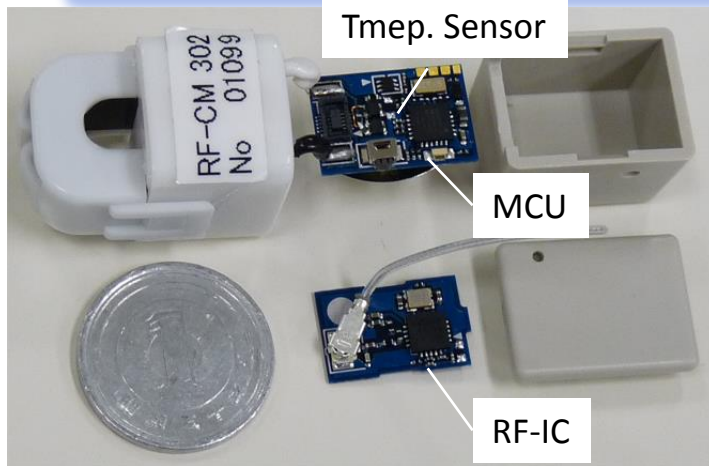
⇒ Decrease of average PC of Sensor Nodes



▪ Development of Particle sensor triggered by event driven Piezo-electric switch (average PC =  $95 \mu W$ )

# Prototype of Wireless Power Sensor

ULP  
CREST



**Average Power Consumption: 10  $\mu$ W (10 sec sampling)**

## Specifications

### -Sensing

Power : 0~1000 W  
Temperature: -10°C~+65°C

### -Wireless Communication

Frequency: 2404 MHz ~ 2420 MHz  
Transmission Power: 1 mW  
Data Communication: Packet-type

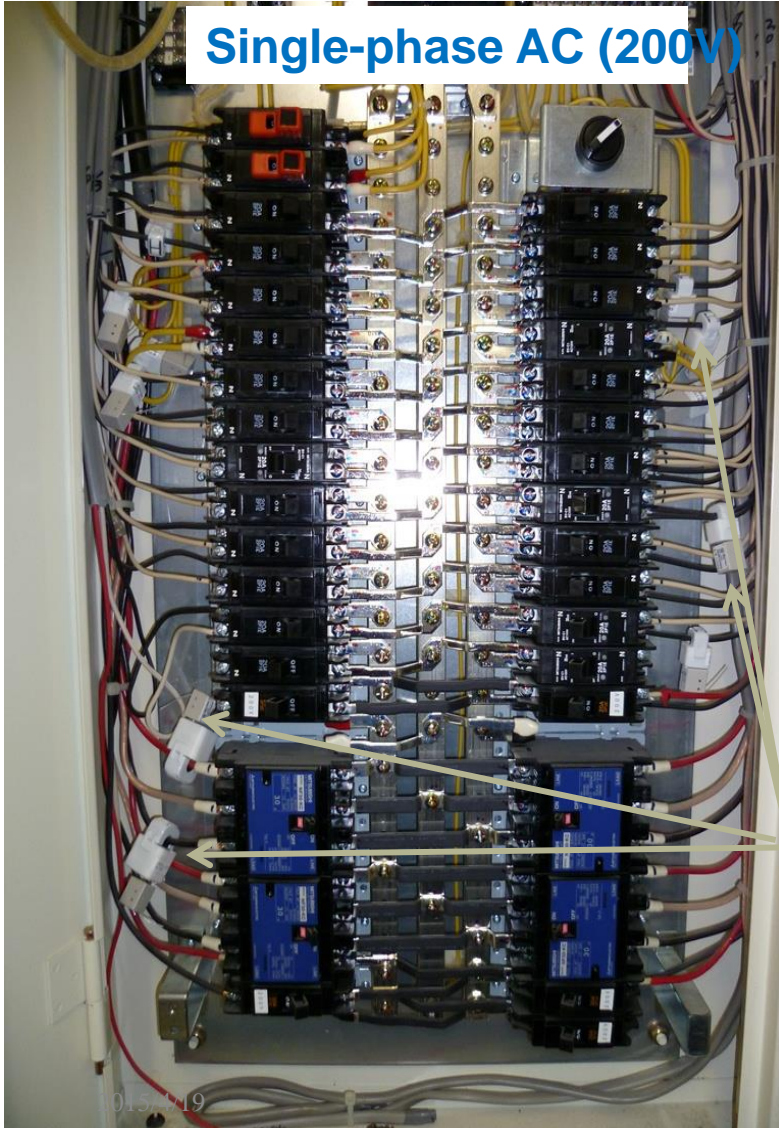
### -Powering

Battery: 1.5 V, Button-type  
(LR44, SR44, SR48, etc)  
Life-time: 60 days (LR44, 0.5 sec sampling)

<b>Clamp-on Type AC Current Sensor</b> CTL-6-S32-8F-CL [1]	- Dimensions (mm): 18W x 25H x 18t - Windng (Turn): 800 - Current Range (Recommended): 10 mA – 15 A
<b>MCU</b> C8051F930 [2]	- Supply Voltage: 0.9 – 1.8 V (One-cell mode operation) - Built-in dc-dc converter with 1.8 – 3.3 V output (65 mW max) - Typical sleep mode current < 0.1 $\mu$ A - 10-Bit Analog to Digital Converter
<b>Transceiver IC</b> nRF24L01 [3]	- 2.4-2.5 GHz ISM band - Minimum supply voltage: 1.9 V - Supply current in TX mode @ 0dBm output power: 11.3 mA - Supply current in Power Down mode: 900 nA

# Sensor Installation

Single-phase AC (200V)



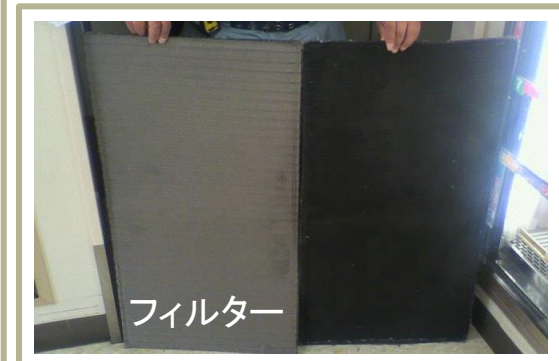
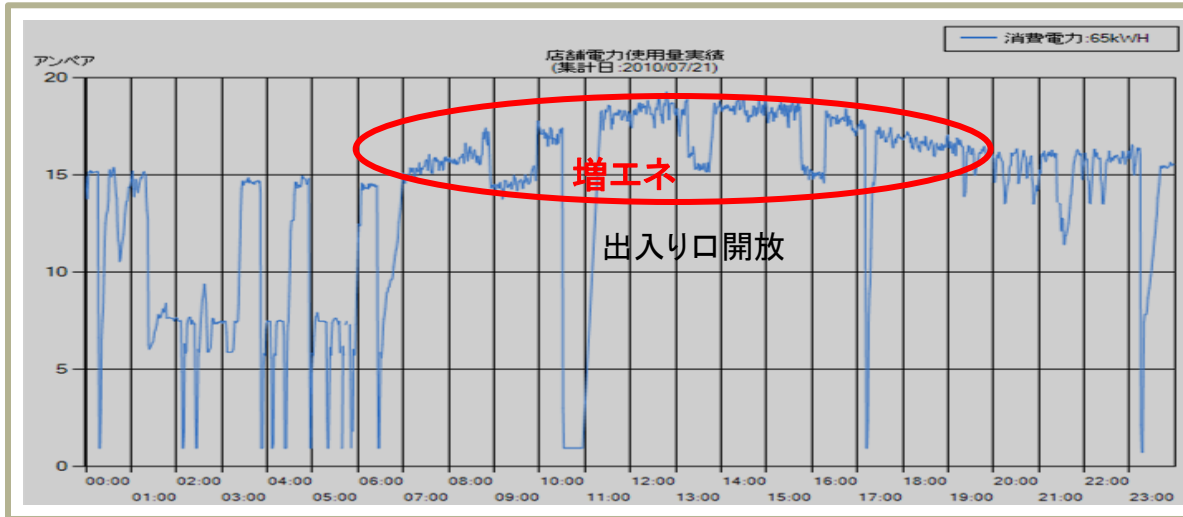
Three-phase AC (200V)



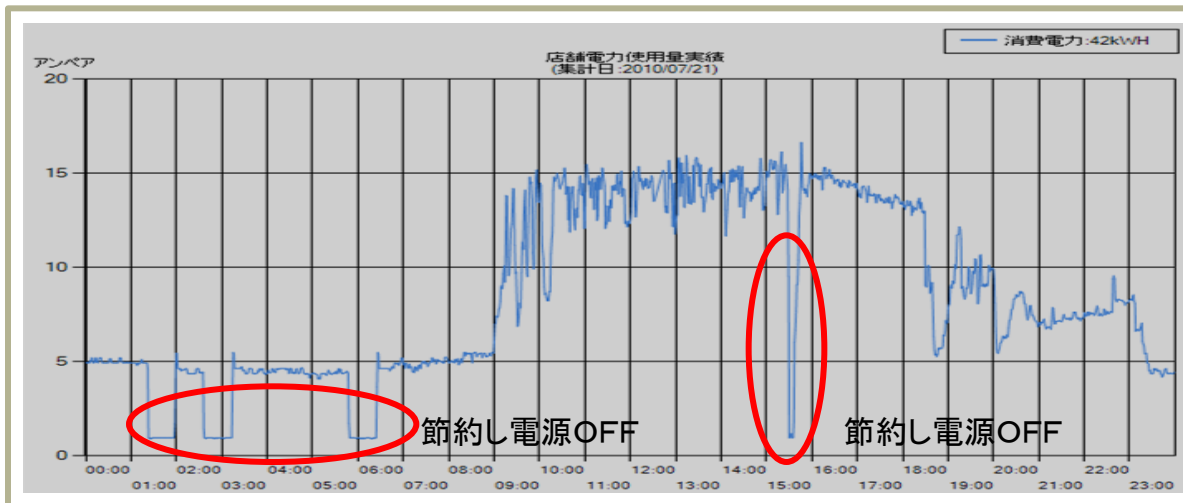
Wireless  
Sensor Nodes

# Employment of WSN to convenience store

## Air conditioning

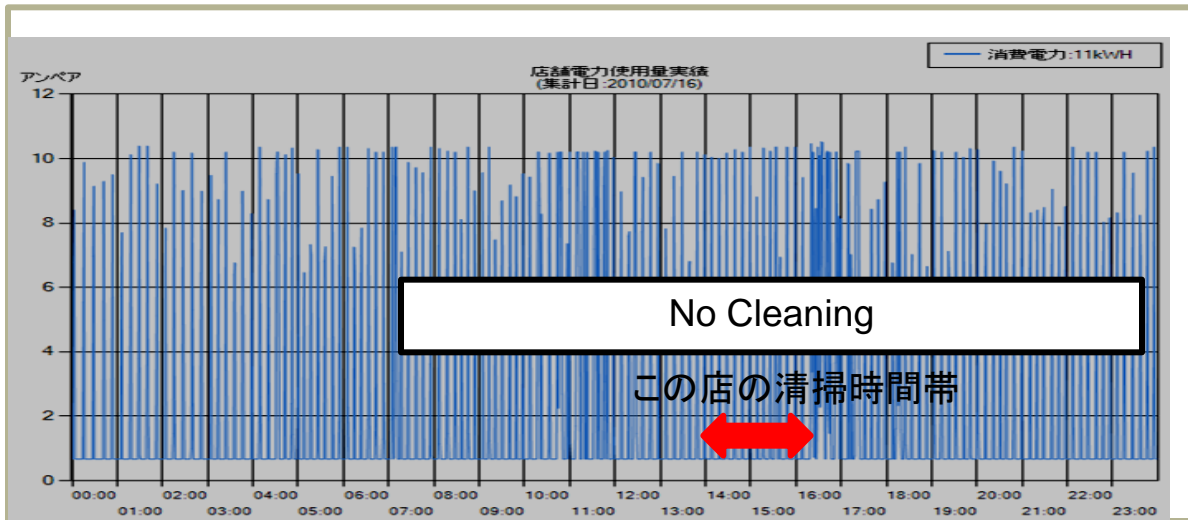


Good operation

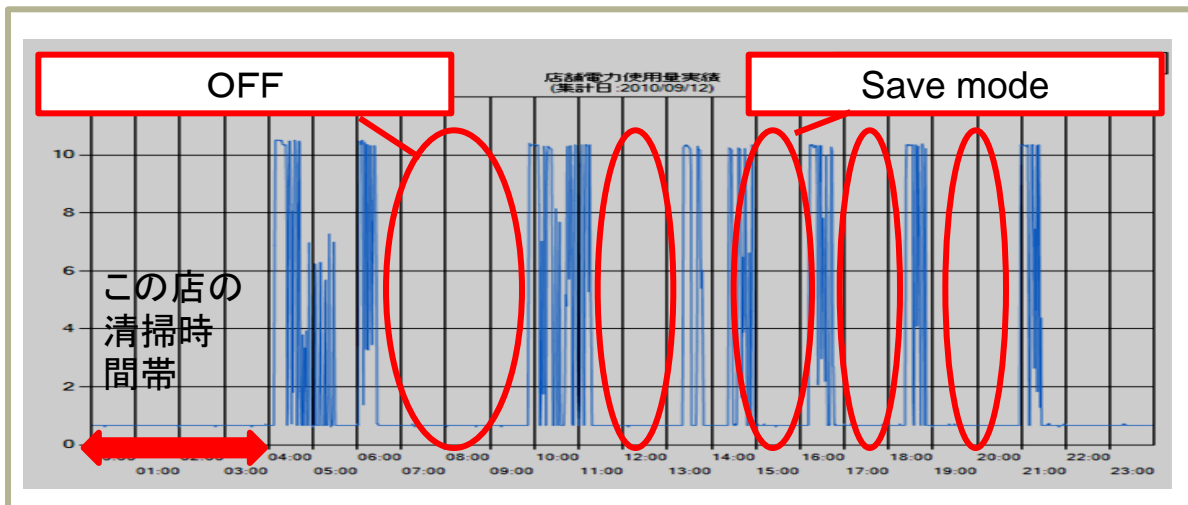


# Employment of WSN to convenience store

## Fryer system

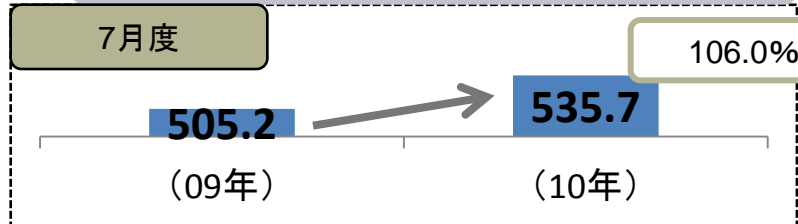


Good operation

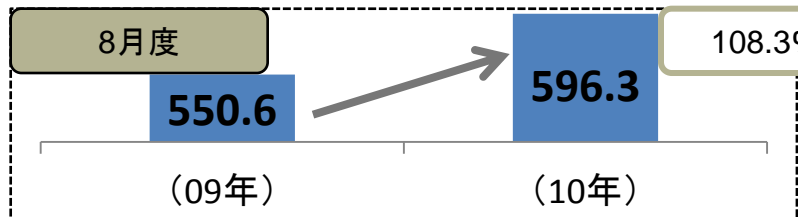


# EPC REDUCTION AT TOKYO AREA CVS

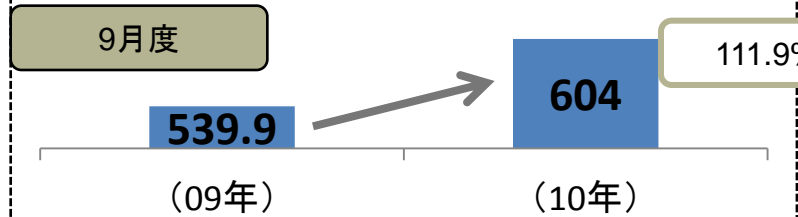
## ◆ Without GSN



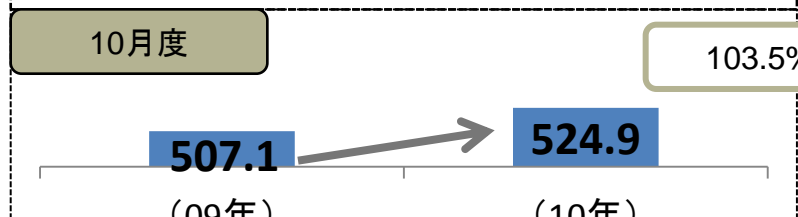
▲5.8%



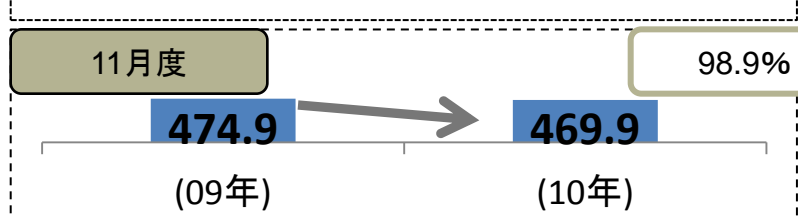
▲8%



▲8.1%

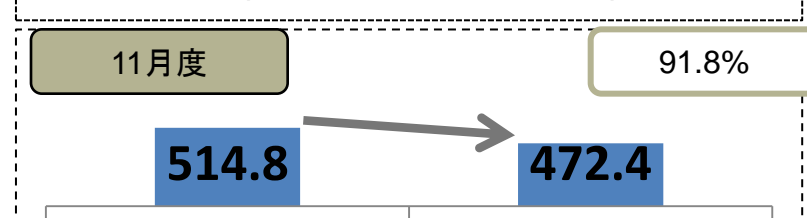
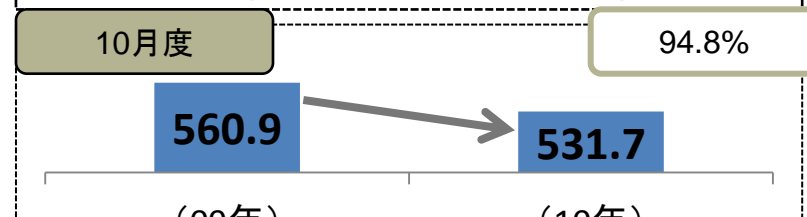
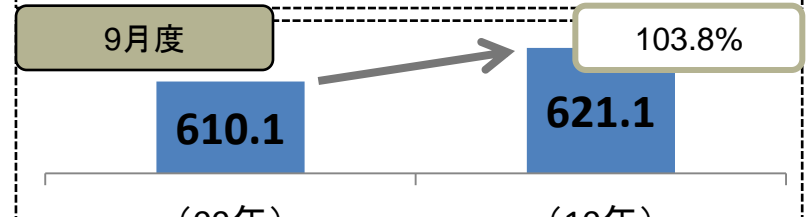
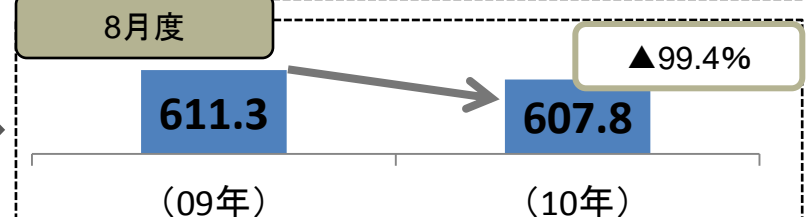
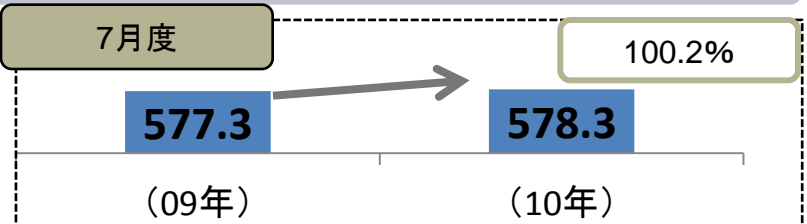


▲8.7%



▲7.1%

## ◆ With GSN

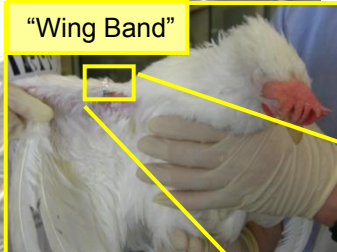
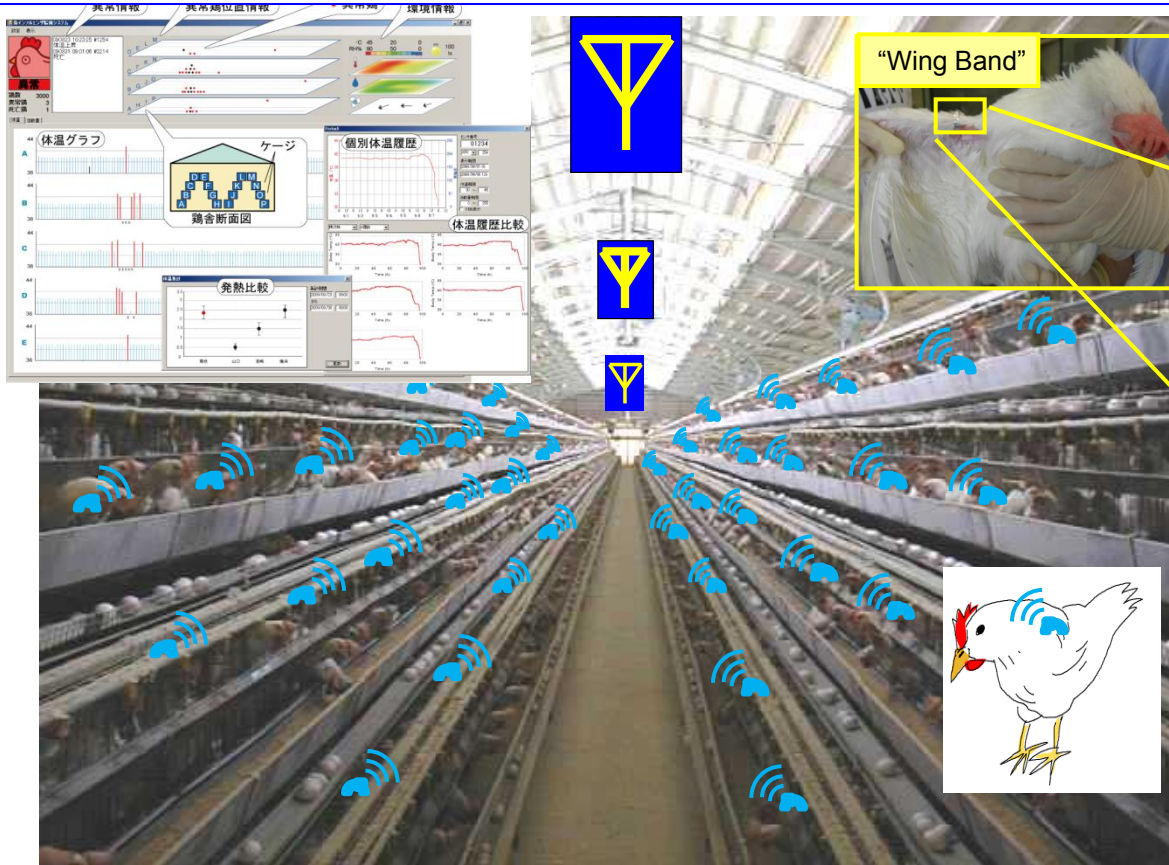




# Health Monitoring System for Chickens



## Health Monitoring and Management System in Poultry Farms



“Wing Band”

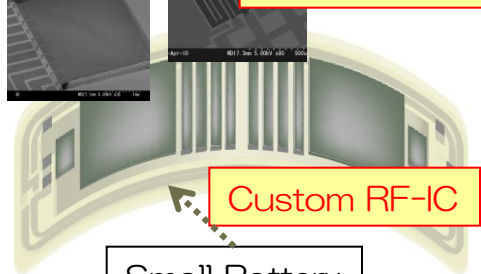
### <Miniaturized Flexible Node>

Wing-Band 6 x 30 x 0.1 mm<sup>3</sup>, 1 g  
maintenance-free (2 years)  
315MHz, 10 m  
Average < 5 μW  
(Target 1 μW)



Piezoelectric  
Activity Sensor

Digital Temp.  
Sensor



Custom RF-IC

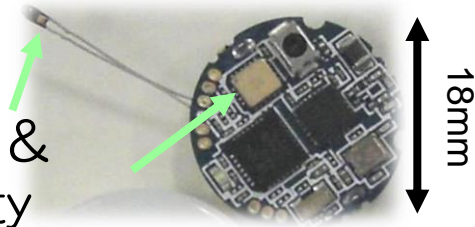
Small Battery

# WIRELESS SENSOR FOR BIRD FLU

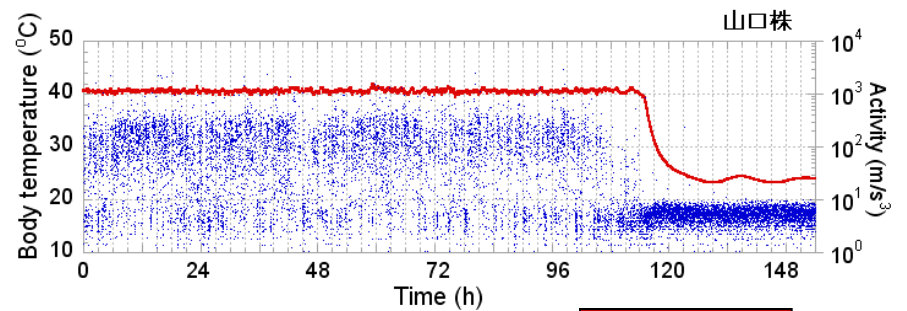
Prototype  
Sensor node

Data  
transmission  
of 20s  
interval  
Life time > 1  
year!

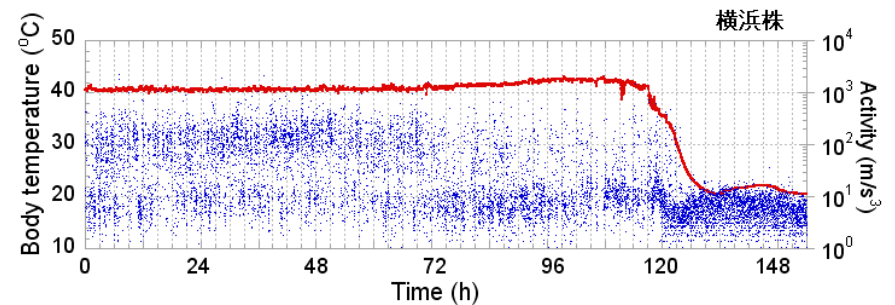
Temp &  
Activity



山口株



横浜株



Type  
Yamaguchi

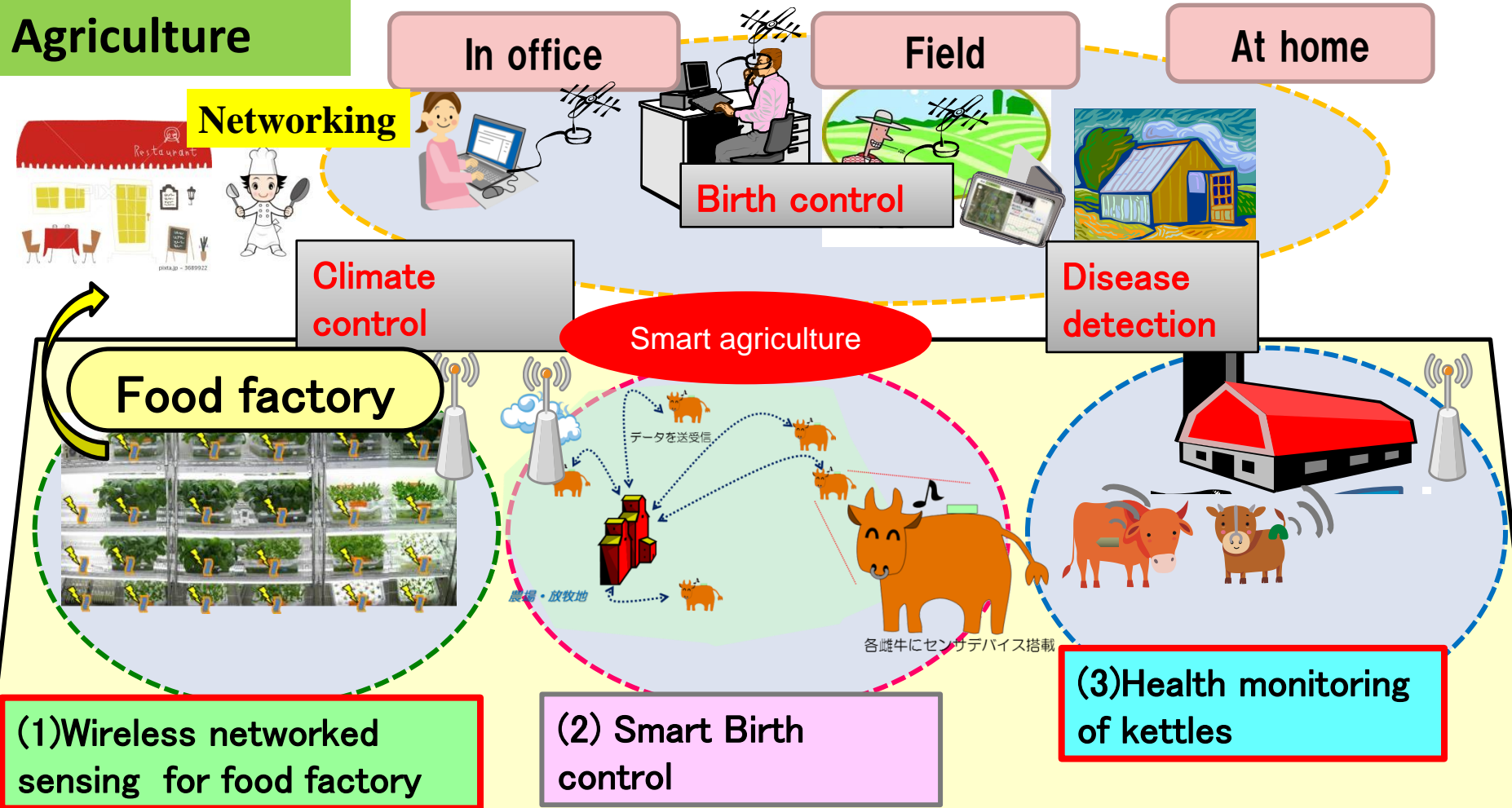


Type  
Yokohama



Detection of virus is  
possible by activity  
monitoring

# Application for Agriculture



# CONCLUSION AND ACKNOWLEDGEMENTS

**Down sizing, cost reduction and LPC are important issues for industrialization of WSN.**

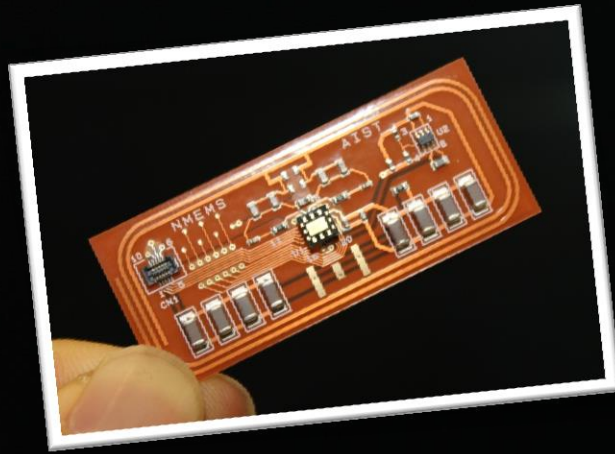
## **Green sensors**

- **Energy saving of 5-to 10 % by power monitoring of Equipment**
- **Installed a system of 10 battery-less sensor nodes + receiver to 2,000 / 14,000 CVSs**
- **Further cost reduction is needed (Integration test, PKG)**

## **Smart agri WSN**

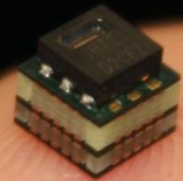
- **Chicken monitoring**
- **Birth control of cows**

**Special thanks for NEDO & JST for their financial supports**



# Thank you for your attention!

**Currently** *One of the world  
smallest wireless  
sensor node*



**Future**

- More functions*
- Higher sensitivity*
- Much cheaper*
- Much smaller*
- Less power consumption*
- ...*
- ...*