



Chulalongkorn University Building Energy Management System (CU-BEMS)

“IoT Campus-Scale Demo Site”

2102541 IoT Fundamentals (2/2018)
Assoc Prof Dr Chaodit Aswakul
chaodit.a@chula.ac.th



Acknowledgment

- CU-BEMS designed & built by Chula-EE core faculty team members and 30+ BEng/MEng students at Chula-EE since 2013 with various international collaborations and main financial support from Energy Conservation Promotion Fund (ENCON Fund), under the Energy Policy and Planning Office (EPPO), Ministry of Energy
- Materials presented here reflect only some selected parts of those efforts with focus on IoT communication in data cloud aspect.

| | | | |
|----------------------------------------------------------------|--|------------------------------------------|--|
| Project Advisor (Director of Energy Research Institute) | | Sensor and IEEE1888 | |
| Prof. Bundhit Eua-arporn | | Asst Prof Chaiyachet Saivichit | |
| Project Advisor (Head of Department of Electrical Engineering) | | Smart Meter and Equipment Control System | |
| Prof. David Banjerdpongchai | | Asst Prof Wanchalerm Pora | |
| Project Manager | | Renewable Energy Source | |
| Assoc Prof Kulyos Audomvongserree | | Asst Prof Surapong Suwankawin | |
| System Integrator and Demand Response | | Renewable Energy Source | |
| Assoc Prof Naebboon Hoonchareon | | Assoc Prof Surachai Chaitusaney | |
| Sensor and IEEE1888 | | Power Electronics | |
| Assoc Prof Chaodit Aswakul | | Asst Prof Somboon Sangwongwanich | |



Cooperation Acknowledgements @CU-BEMS Initiation

- **IEEE1888 Communication Protocol**
Dr Hideya Ochiai at Prof. Esaki's Lab (Univ. of Tokyo)
- **Smart Meter**
Joint research between ESID (Chula EE) and PEA
- **Renewable Energy Source (PV system – modules and parts of the BOS)**
Supported by Showa Shell Sekiyu K.K. Japan



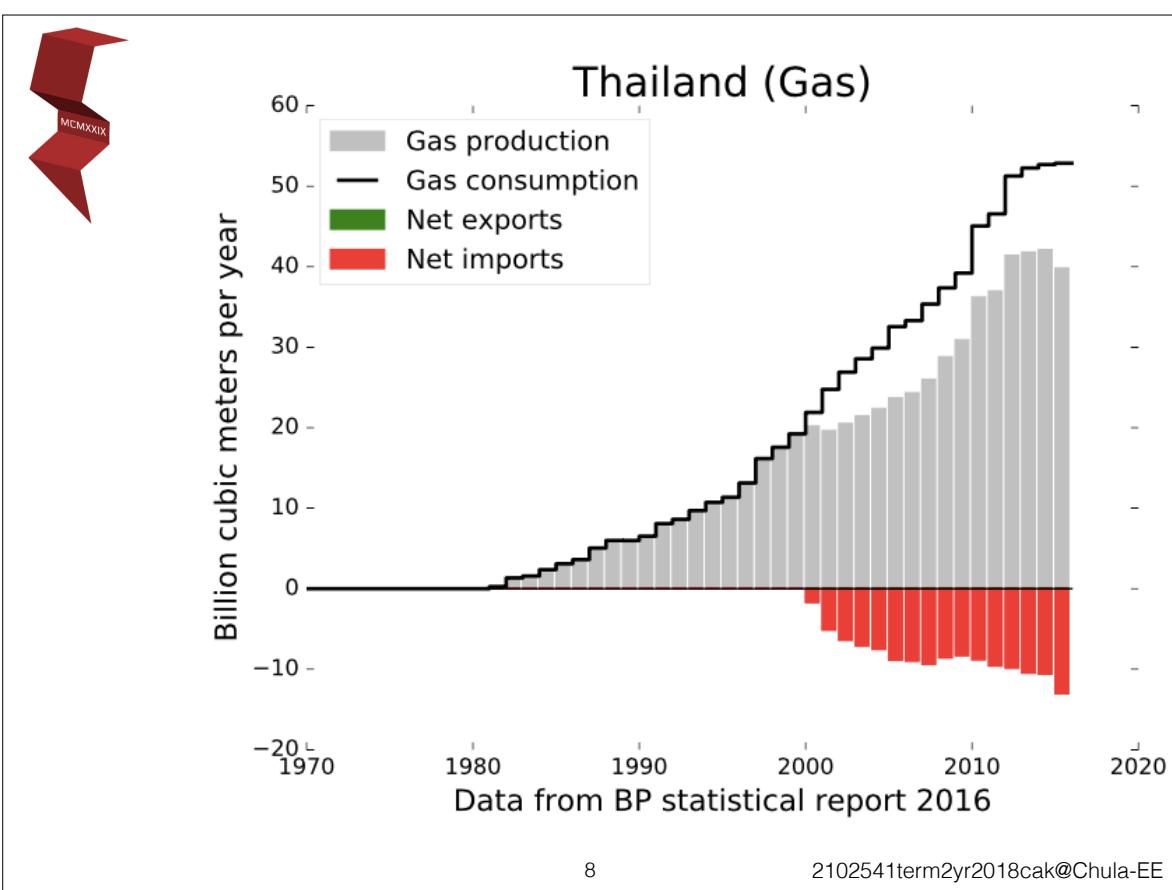
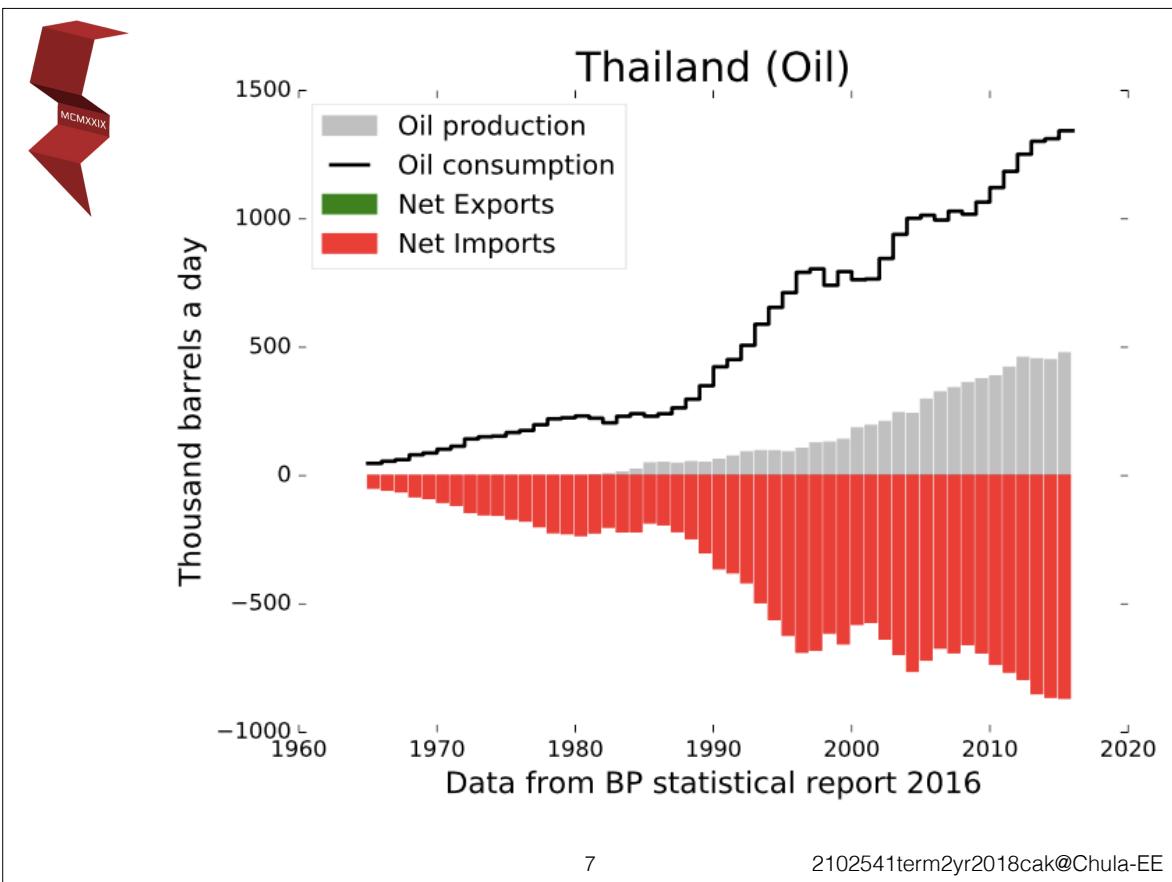
CU-BEMS: Research & Practical IoT Playground @ Chula-EE

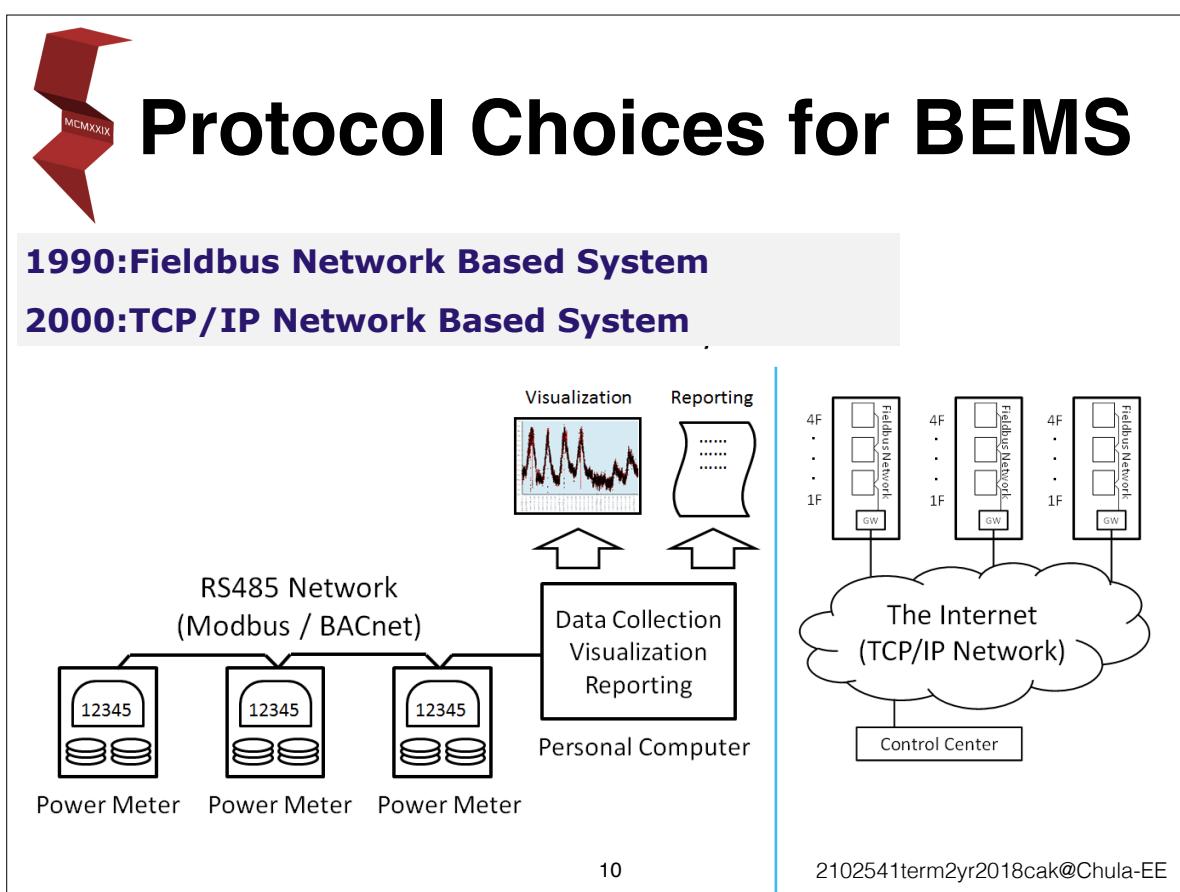
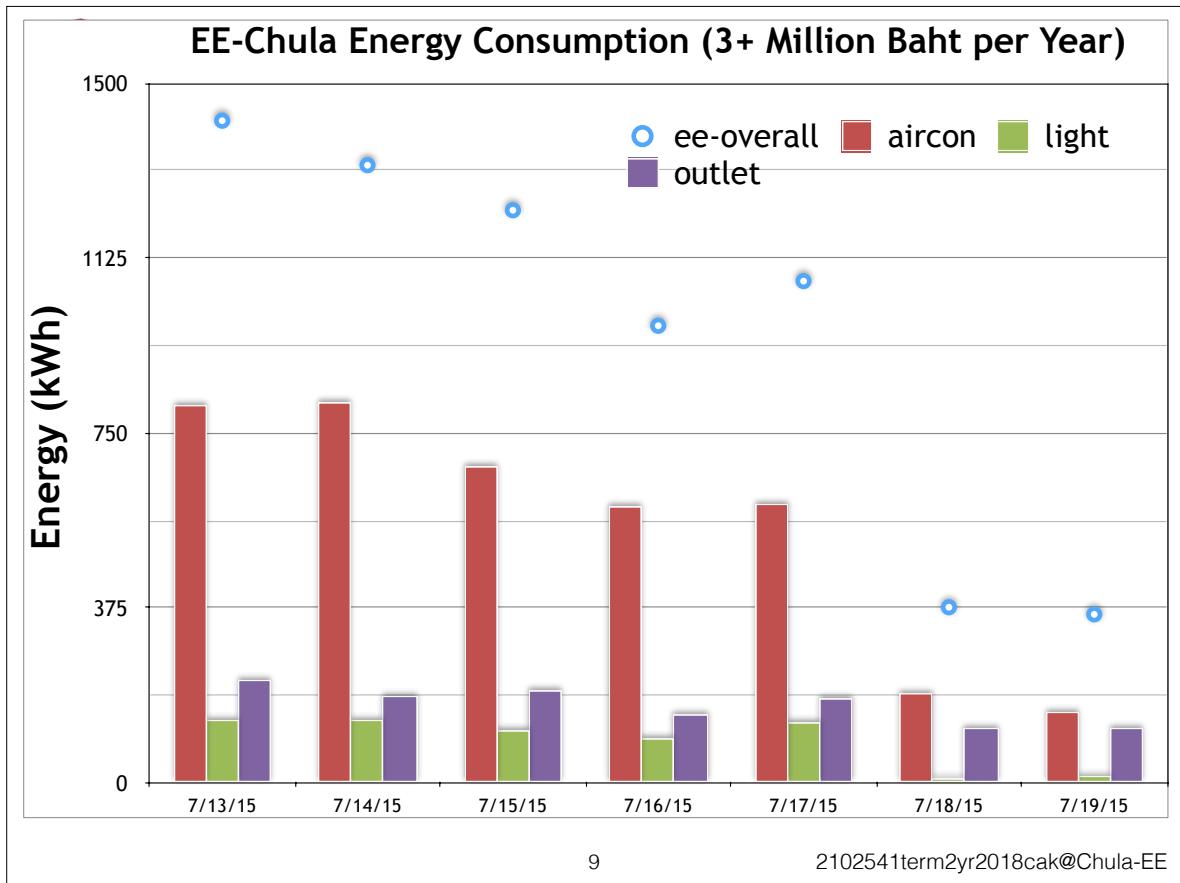
- **Motivation: Energy Situation & Existing Technologies**
- **Addressed Solution Method: IoT Cloud Platform Based on Open Protocol Standards**
- **Demo: CU-BEMS Current Applications**
- **CU-BEMS Implementation towards IoT Cloud**

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Motivation: Energy Situation & Existing Technologies







Addressed Solution Method: IoT Cloud Platform Based on Open Protocol Standards

**IEEE1888, ZigBee, 6LowPAN
(and later extended to
Echonet / ETSI-M2M, MQTT)**

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IEEE1888

- Ubiquitous Green Community Control (UGCC) Network Protocol
- WG started 2008, Standard Approved since 2011
- Open platform & IEEE 1888 gateways to facilitate the management of building/factory/community facilities
- IEEE 1888 targets at the application-layer protocol especially focusing on time-series data exchange.
- Based on SOAP, HTTP, TCP/IP
- 2015: approved by ISO/IEC (ISO/IEC/IEEE 18880)



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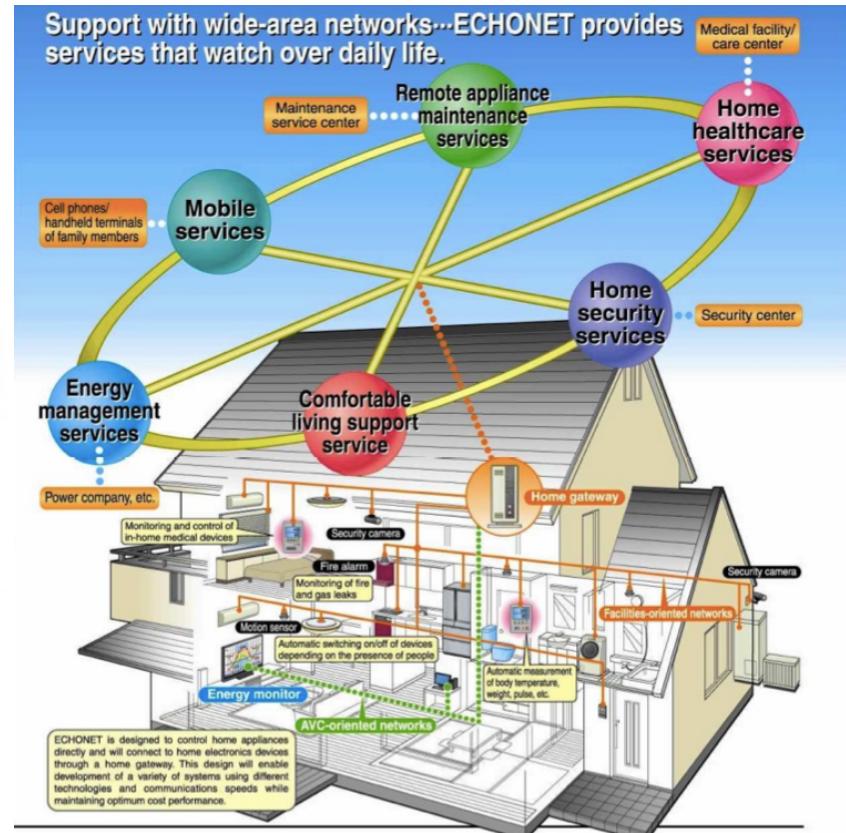
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Hideya Ochiai, Ph.D., The University of Tokyo, JAPAN



[Ref: Masaki Umejima
ECHONET Consortium]





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CHULA ΣENGINEERING
Foundation toward Innovation

100th
100th Anniversary of
Chula Engineering 2013

“Development of real-time interworking between IEEE1888 and ECHONET Lite standards for Building energy management system”

Mr. Chayanon Sangumpai (Master Degree)
Advisor: Assoc. Prof. Dr. Chaodit Aswakul
Chulalongkorn University, Thailand



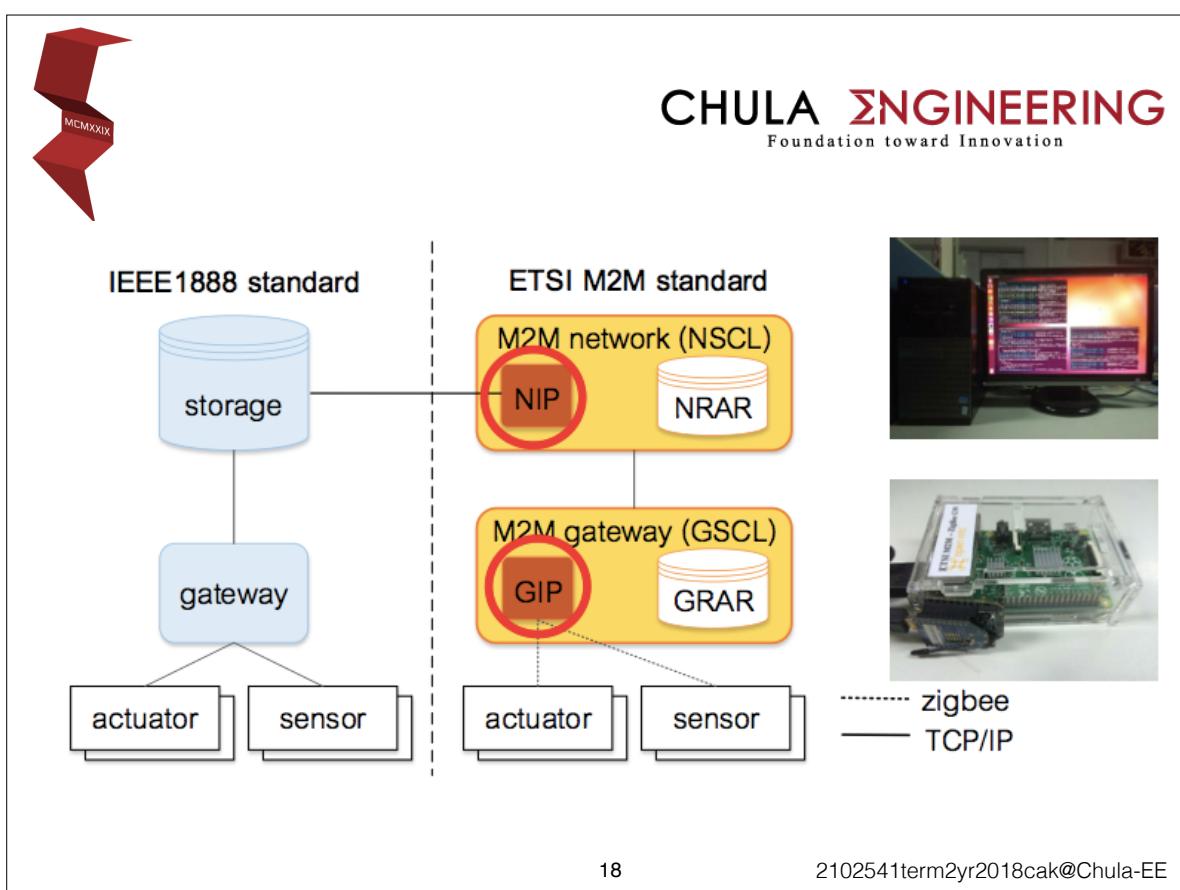
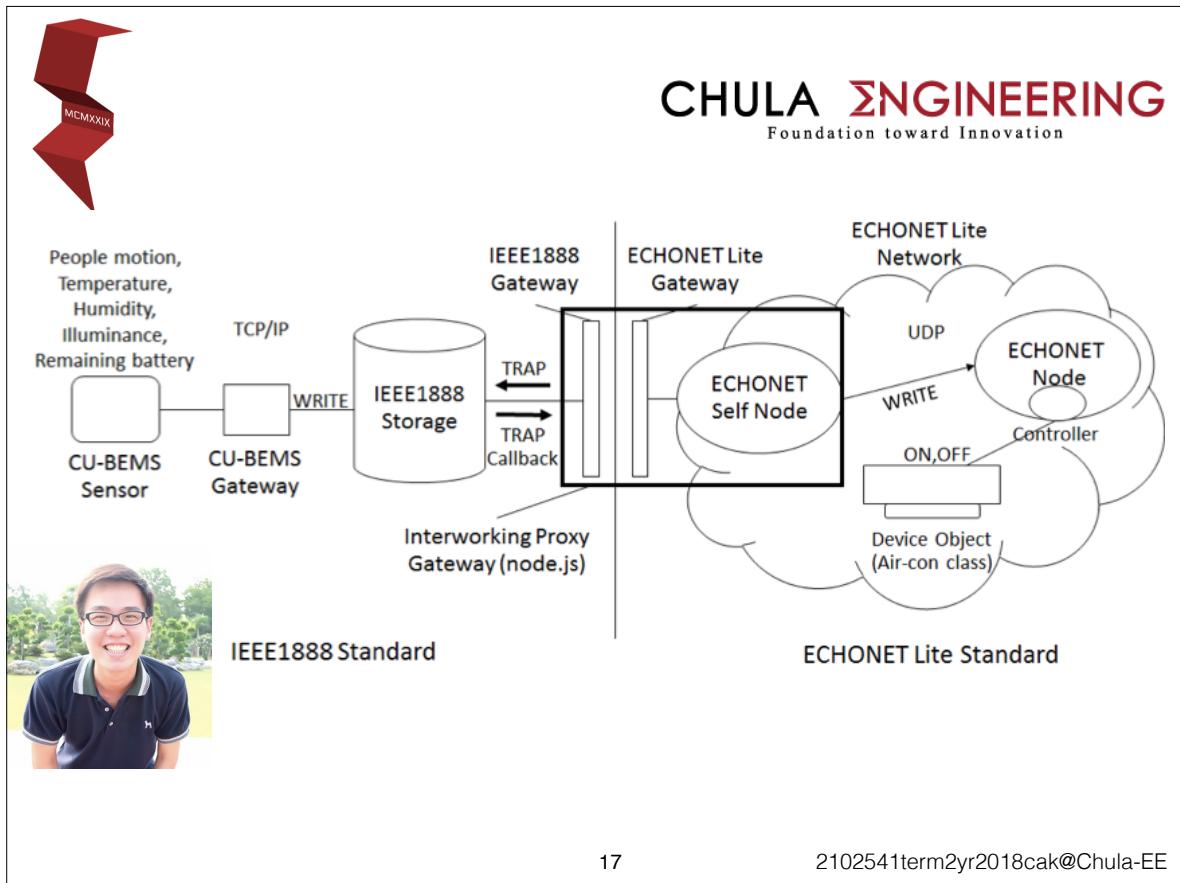
DAAD **unifi**
University Future Internet

1888 READY

CUBEMS

ECHONET

EE





**In this class, we focus only on
IEEE1888-based CU-BEMS**

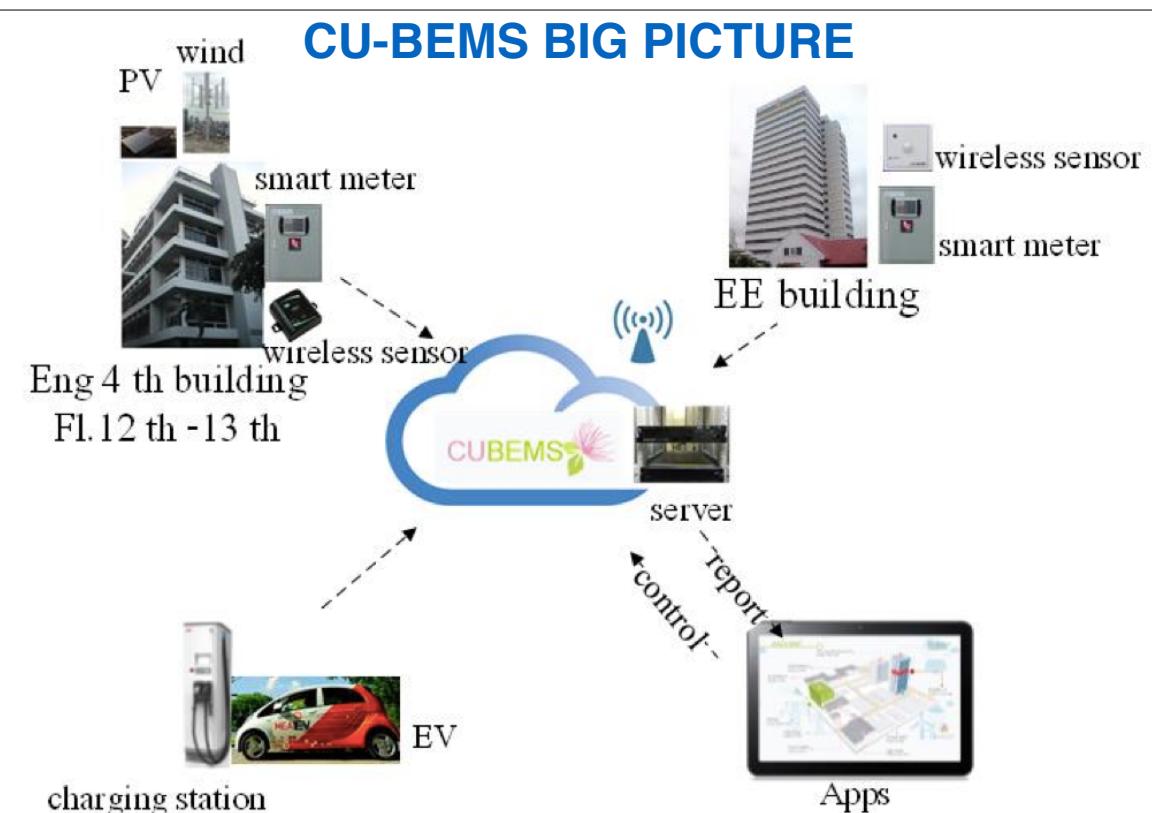


CU-BEMS Pilot Project: OBJECTIVES

- To implement a demonstration site of BEMS at Chula EE
- To develop IT applications on mobile devices
 - to access/monitor energy information
 - to control equipment in smart building
- To study/compare users' behavior before and after BEMS is installed.
- Study demand response to control signals

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CU-BEMS Pilot Project

- Building energy management system (BEMS) implements a system with *sensors and smart meters* to send useful *information to users and to control* electricity consumption through control signals.
- *IEEE1888* plays an important role in communication.
- Project implementation budget **10 MTHB** = 330K USD.
- This project has been *approved by Energy Conservation Promotion Fund (ENCON Fund)*, under the Energy Policy and Planning Office (EPPO), Ministry of Energy.

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CU-BEMS BIG PICTURE

- **EE Building 6 floors:** Staff Offices and Labs
- **Eng 4 Building fl. 12-13:** Labs and Classrooms
- **Loads:** Lighting, air conditioner, computer, and small machines for laboratories, 50-kW electric vehicle charging station
- **Sources:** PV, 1-kW vertical wind turbine, Lithium-Ion 5 kW 10 kWh battery
- **Smart meters:** 80+ for I, V, W
- **Sensors:** 150+ for motion, temperature, humidity, luminance



CU-BEMS DESIGN PRINCIPLES

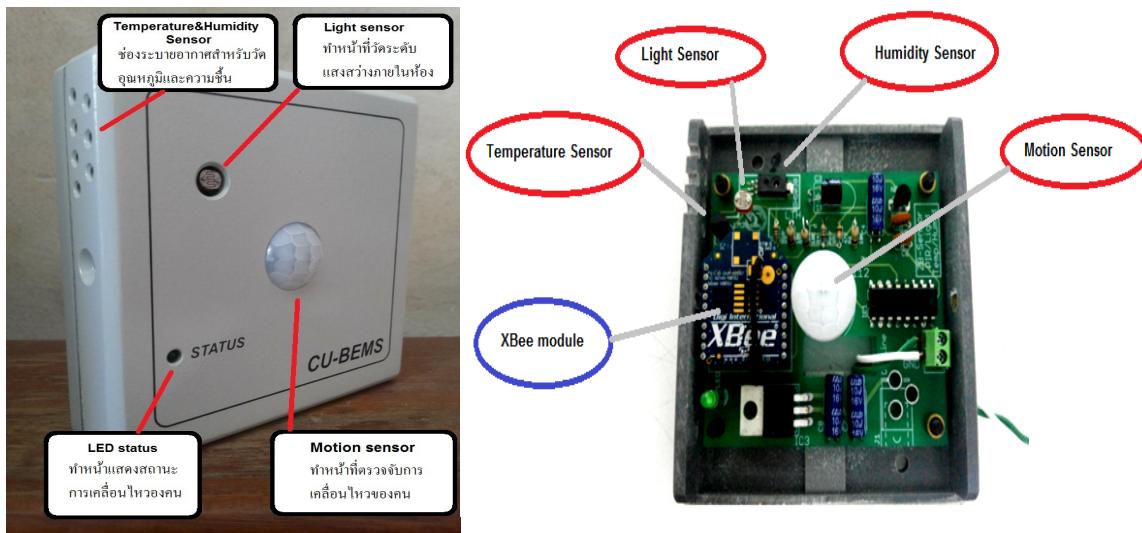
- Protocol/Information: Proprietary/Closed
-----> Open/Sharing
- Information Visualization: Pull Type
-----> Push Type
- Demand Control: Centralized/Top Down
-----> Decentralized/Bottom Up
(Self-Awareness/User Participation)
- Vendor Oriented (Dependency)
-----> User Oriented (Freedom)

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ZigBee Based Wireless CU-BEMS Sensors



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ZigBee Based Wireless CU-BEMS Sensors

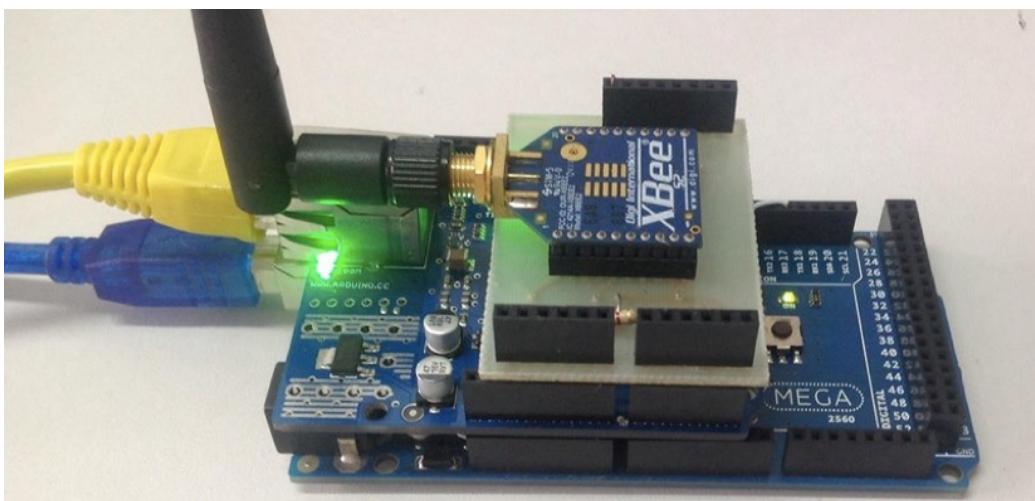


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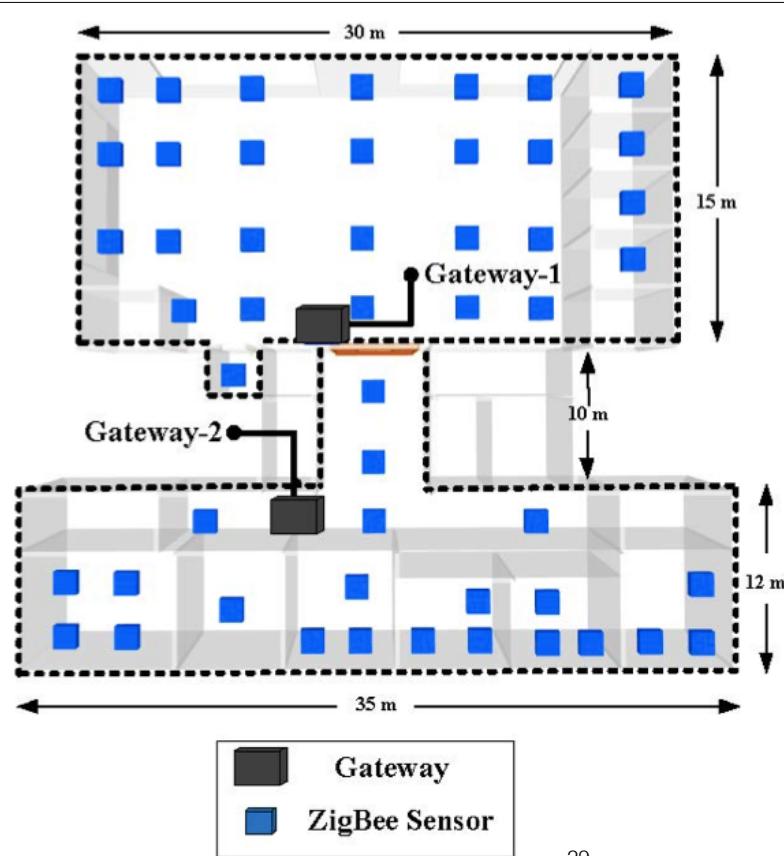
ZigBee Based Wireless CU-BEMS Sensor IEEE1888 Gateway



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Installation of wireless sensors at ENG 4 Building



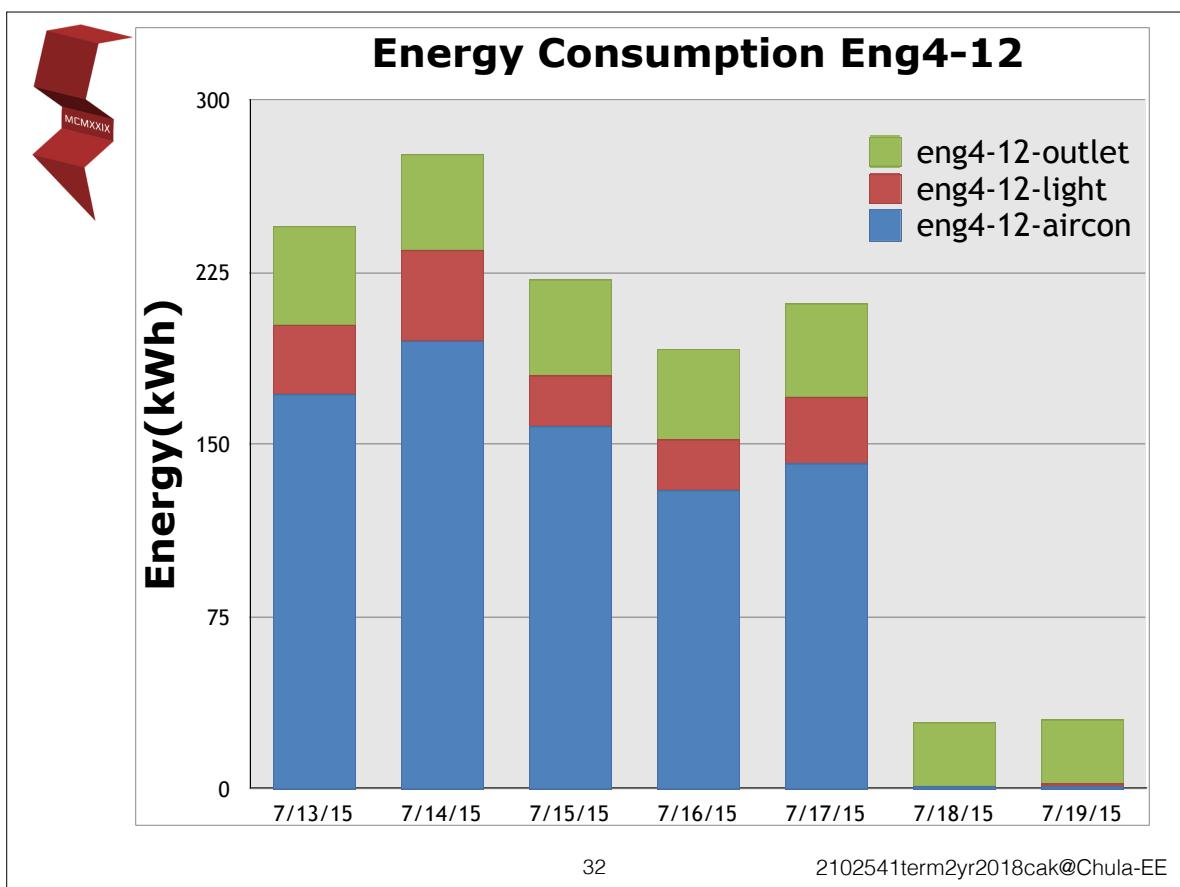
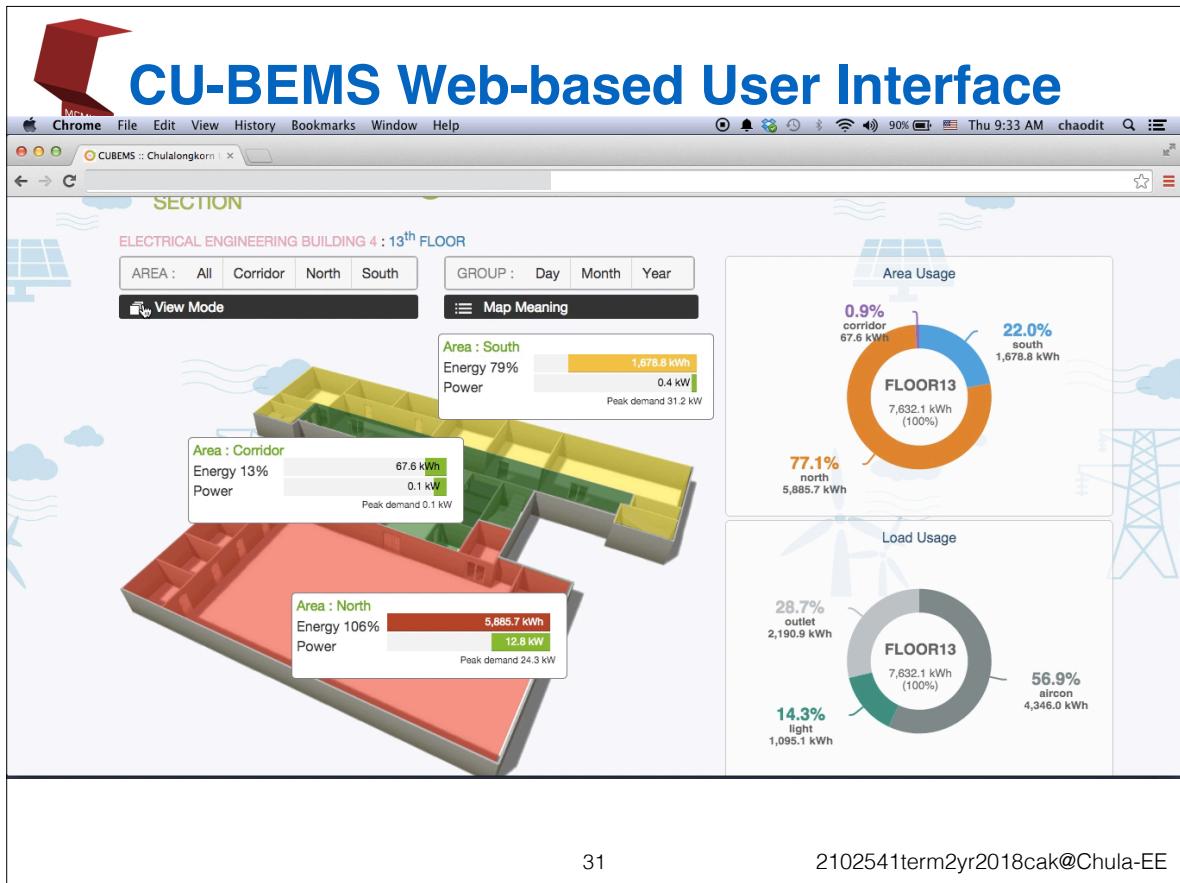
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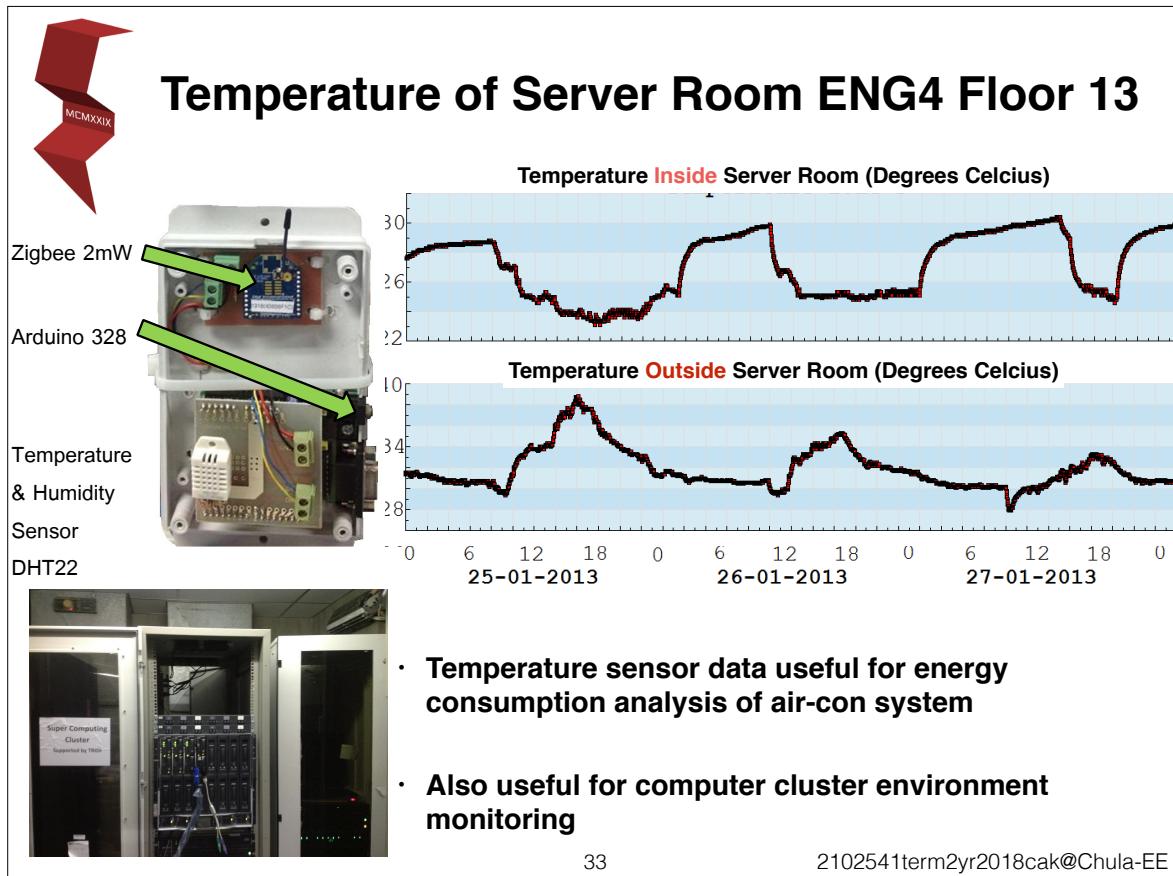
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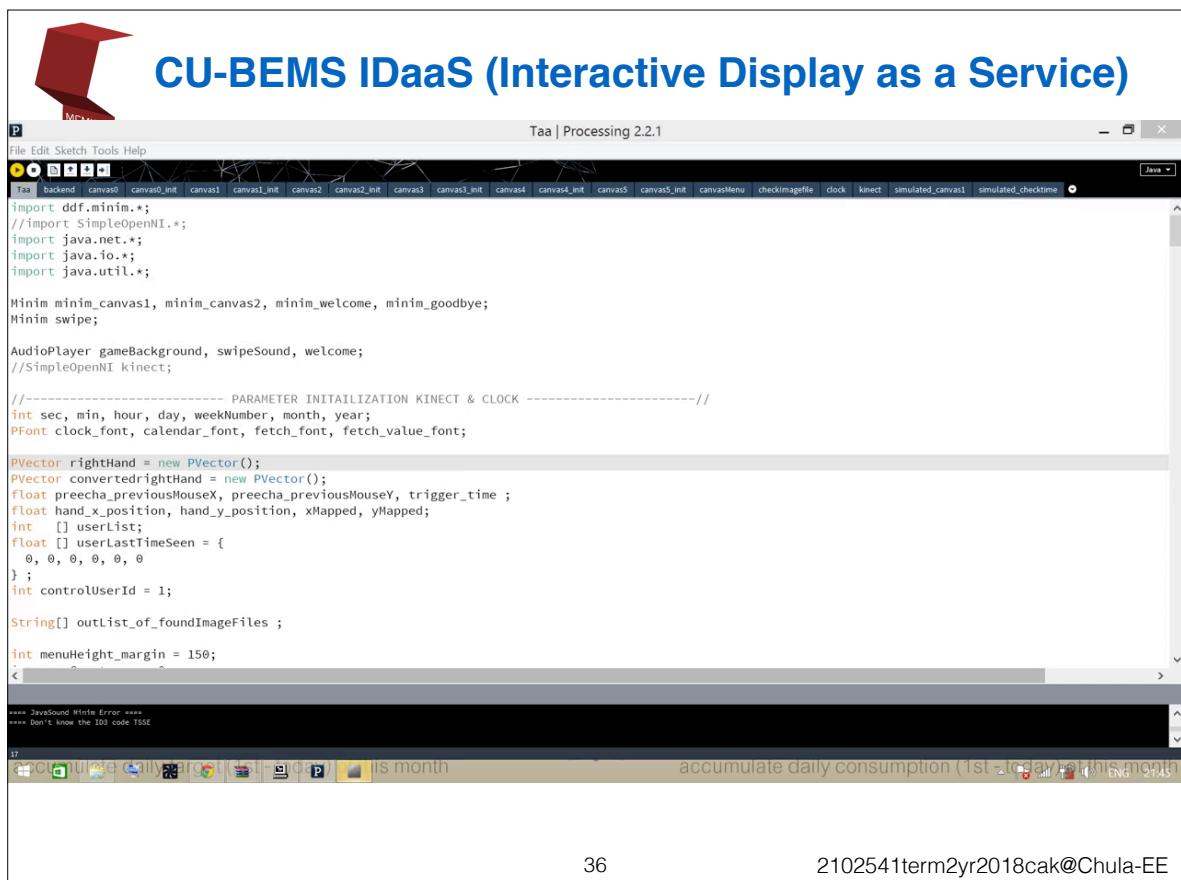
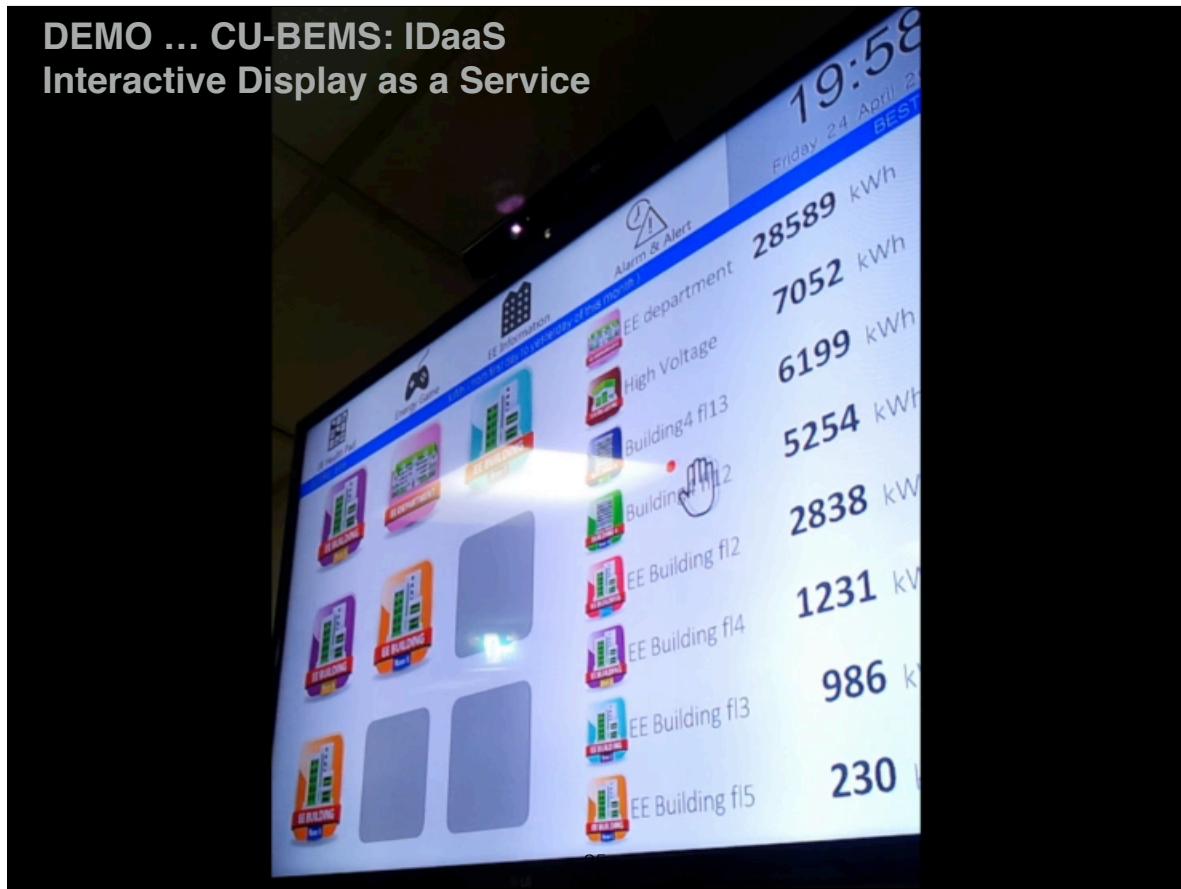
Demo: CU-BEMS Current Applications

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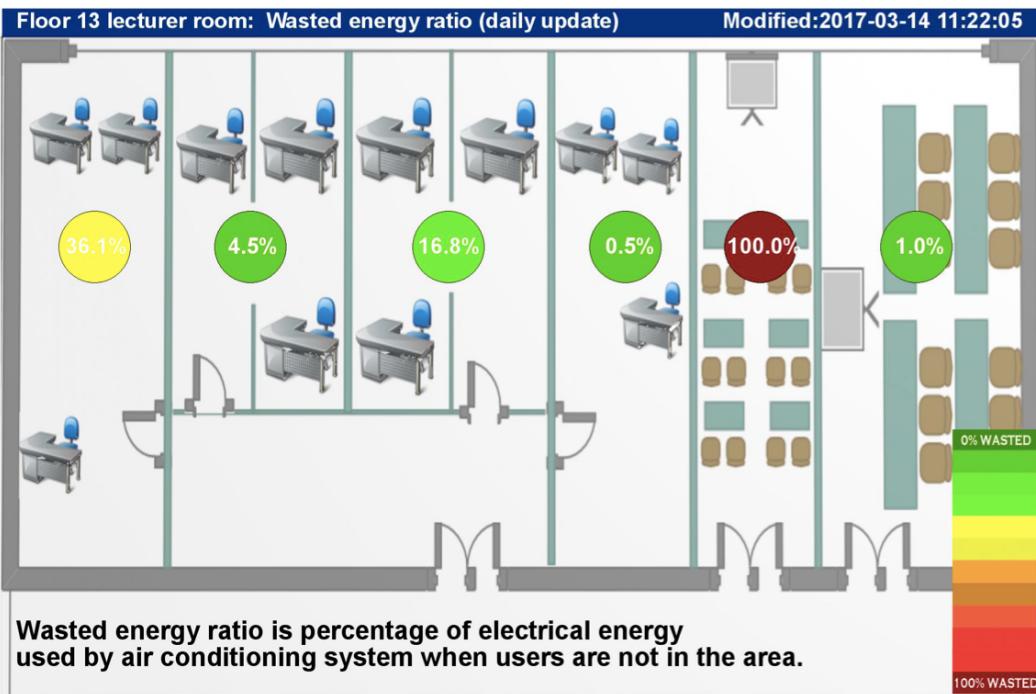








CU-BEMS IDaaS (Interactive Display as a Service)

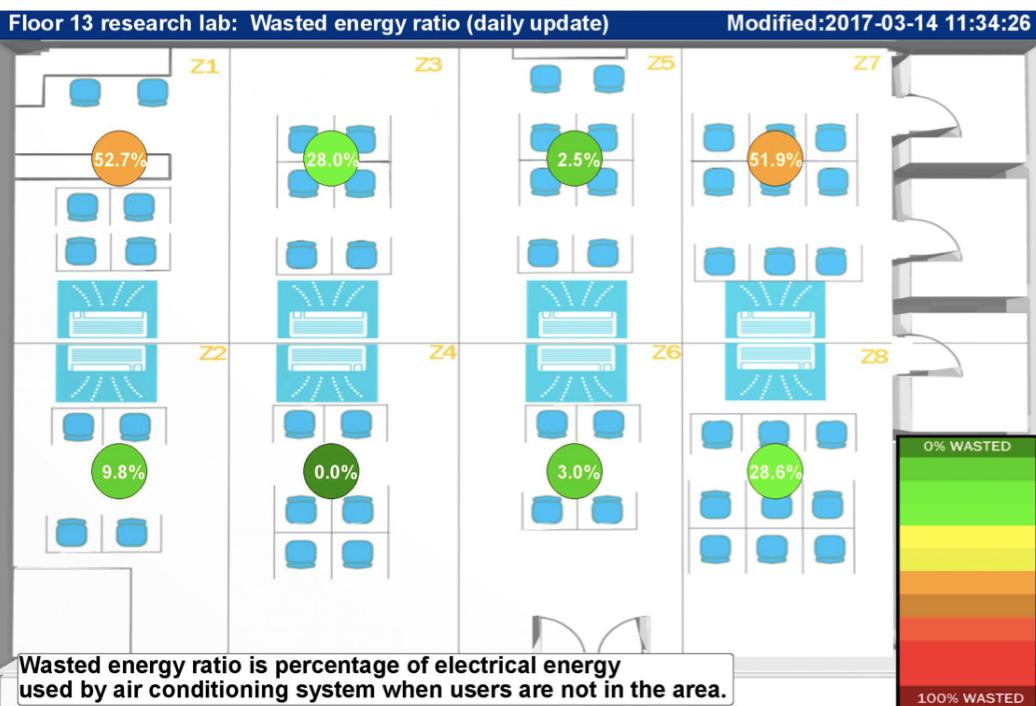


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CU-BEMS IDaaS (Interactive Display as a Service)



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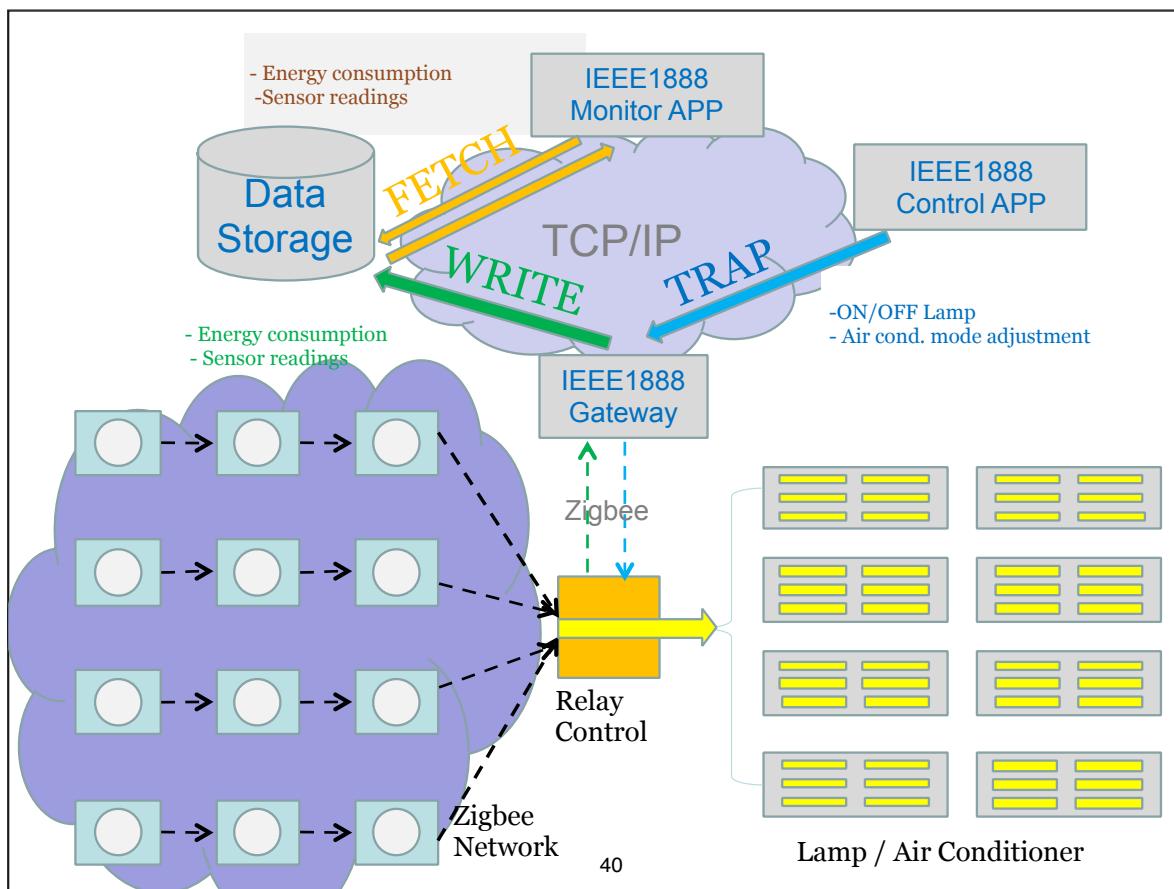
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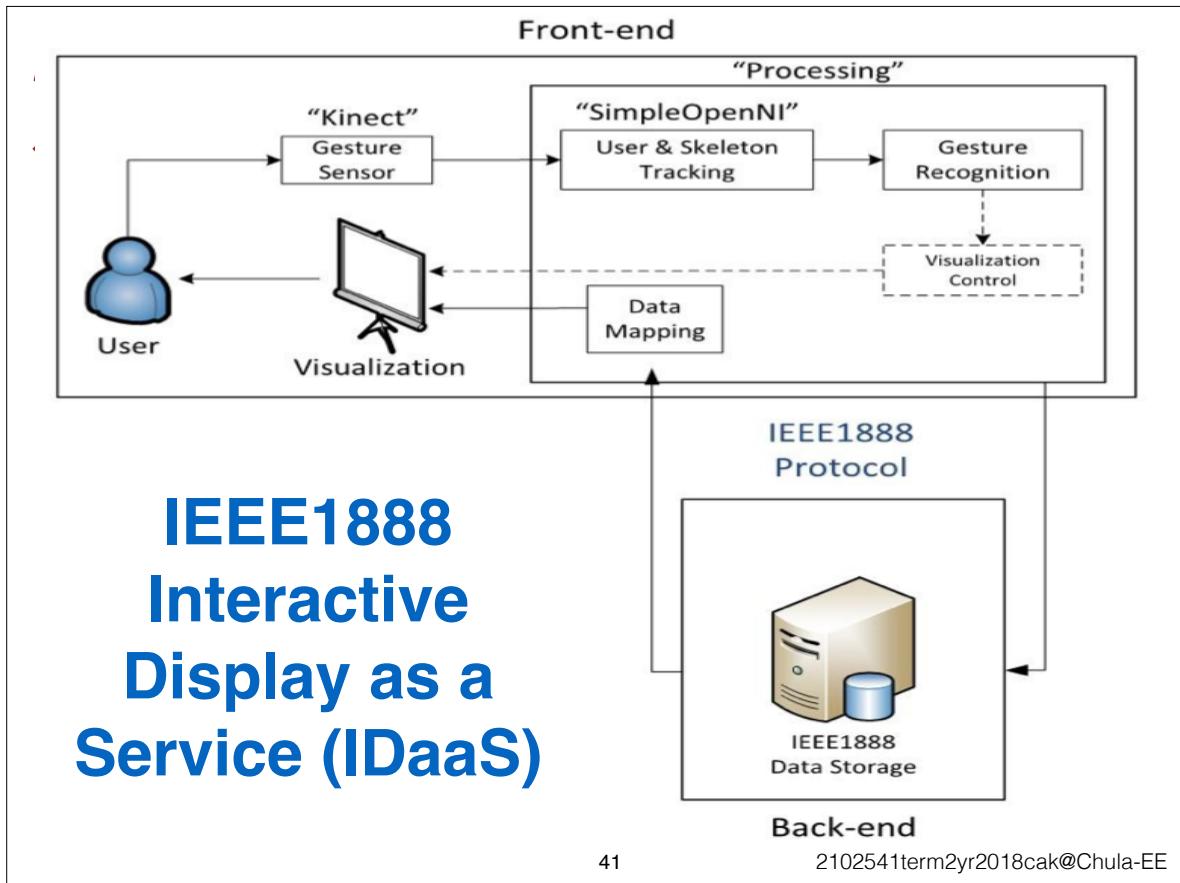


CU-BEMS as Cloud-Based Application

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IEEE1888 Point IDs

Example: IDaaS Effectiveness Measures

Installed at corridor in front of elevators on floor 12 engineering building 4

http://bems.ee.eng.chula.ac.th/eng4/f12/corridor/elevatorfront/kinect/num_swipe

http://bems.ee.eng.chula.ac.th/eng4/f12/corridor/elevatorfront/kinect/canvas_num

http://bems.ee.eng.chula.ac.th/eng4/f12/corridor/elevatorfront/kinect/num_user

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Canvas Numbers Selected By Control User

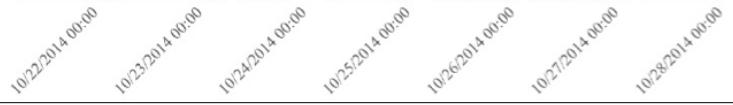
4. Alarm & Alert
(default)

3. EE Information

2. Energy Game

1. EE Health Pad

0. Screen Saver

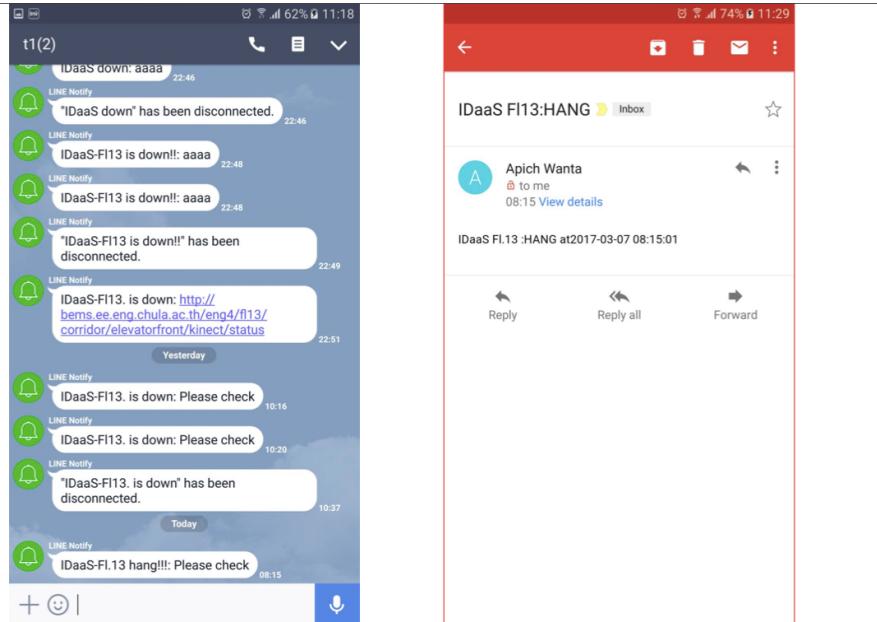


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Total Number of Users Waking-Up IDaaS Displays

| 21-28 Oct. 2015 | floor 12 building 4 | floor 13 building 4 | high voltage engineering building |
|-----------------|---------------------|---------------------|-----------------------------------|
| weekday | 1218 | 1418 | 4367 |
| weekend | 83 | 143 | 583 |

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CU-BEMS Implementations towards IoT Cloud

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Towards IoT Cloud: Resource Sharing

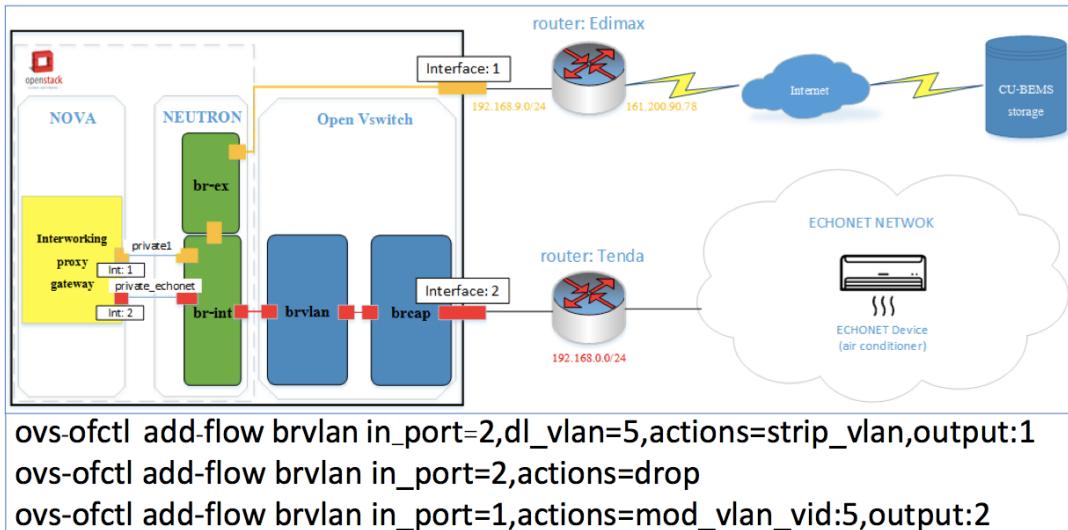
- **Data** Set Usage **Sharing** — Cloud-based Analytics
- **Control** Actuator **Sharing** — User Authorisation / Registry
- **Interoperability** — Interworking Proxy Gateway for Protocol Mapping (ZigBee, ETSI-M2M, Echonet-Lite)
- **Scalability / Security** — Data Concentrator / Encryption

Federated for Multiple Usage/Admin **Stakeholders**
Engined by OpenStack-based Cloud Platform

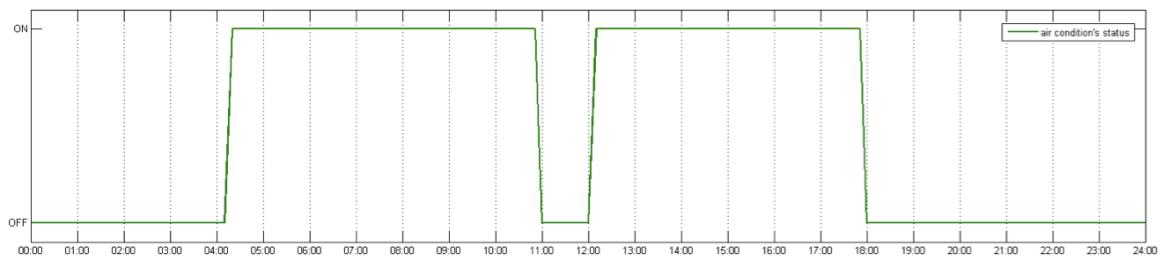
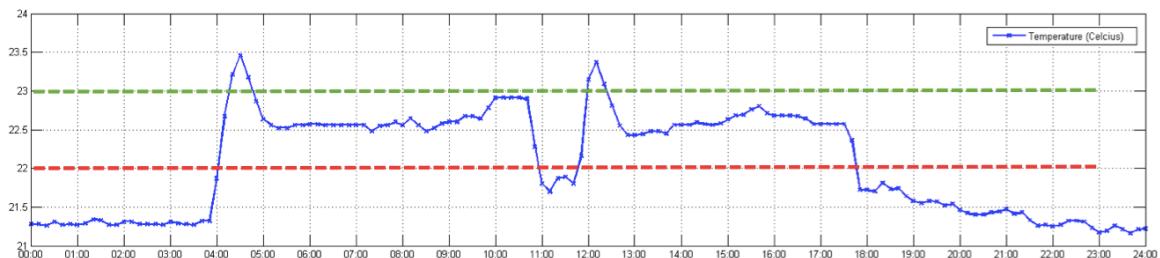
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Virtualised IEEE1888-Echonet Lite Interworking Gateway Function inside OpenStack Cloud



Virtualised IEEE1888-Echonet Lite Interworking Gateway Function inside OpenStack Cloud



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CU-BEMS: Interesting Futures

data concentration
(XML-data compression)

data transfer gateway
(IEEE1888 for
ZigBee, ETSI-M2M,
Echonet-Lite)

IoT-Cloud

intelligence
containerisation
(ongoing)

distributed computing
parallelisation
(currently centralised at
CU-BEMS cluster)

system orchestration
(IEEE1888-registry,
openstack)

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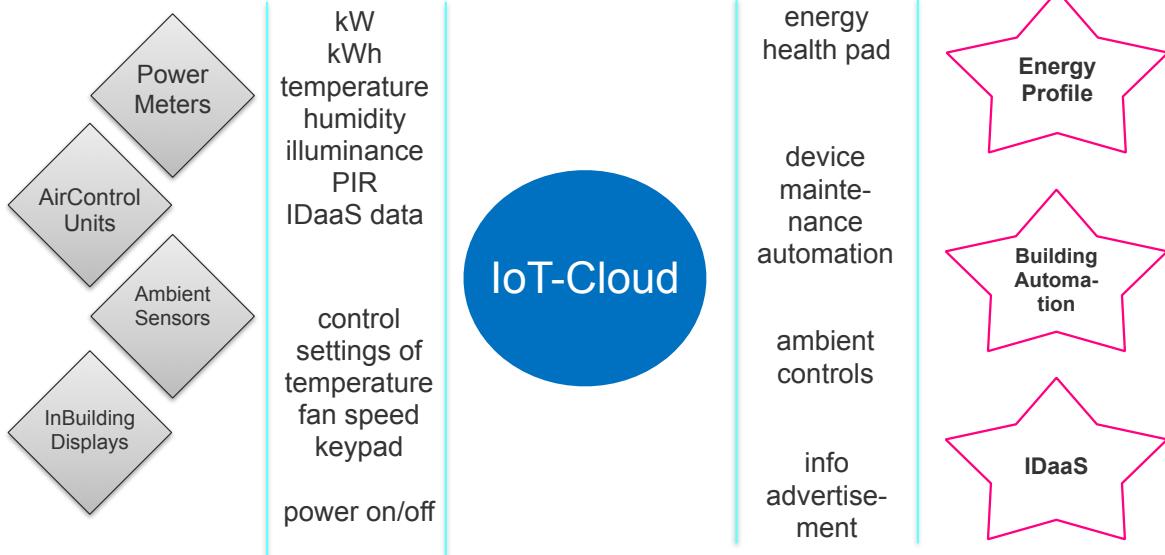
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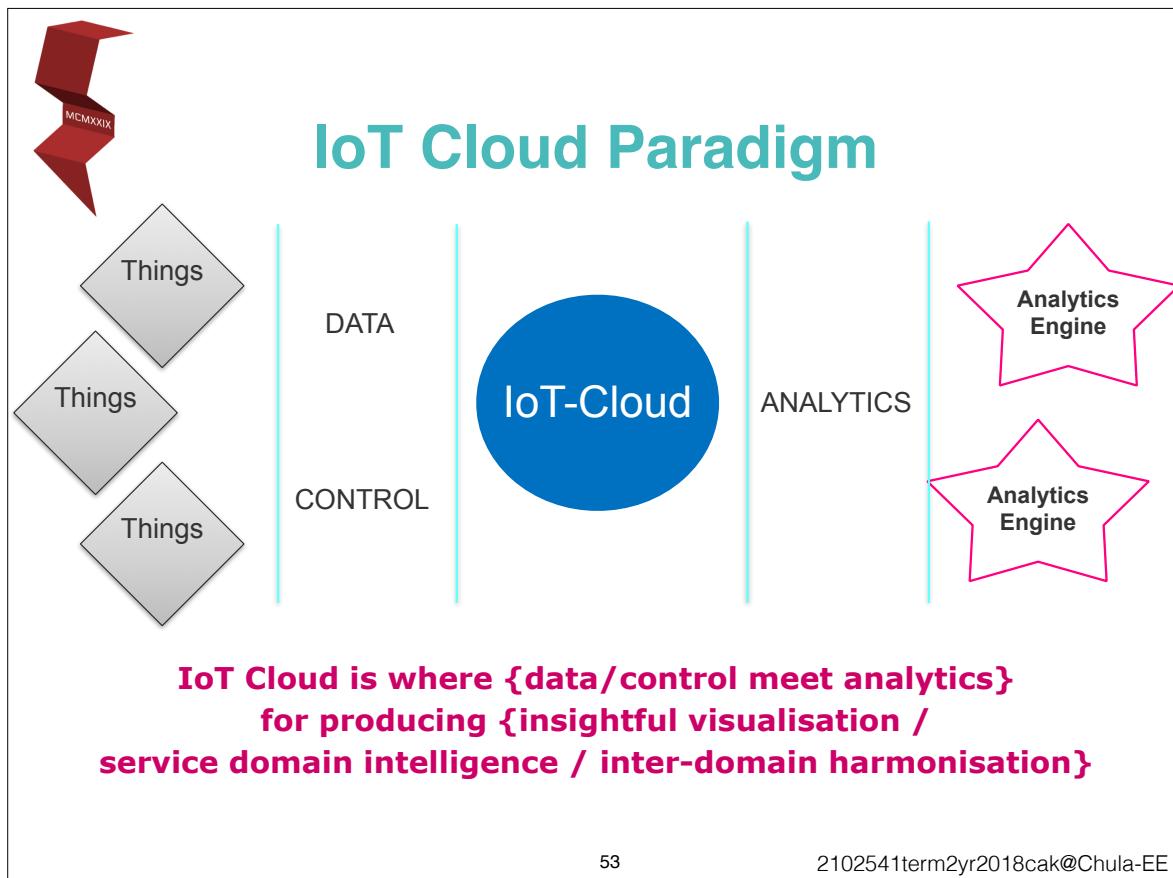


CONCLUSIONS



CU-BEMS in IoT-Cloud Paradigm





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Thank you

Associate Prof Dr Chaodit Aswakul
Wireless Network & Future Internet Research Group
Department of Electrical Engineering
Chulalongkorn University, THAILAND
chaodit.a@chula.ac.th

www.ee.eng.chula.ac.th