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The Smart International Hellenic University project 'Smart I.H.U'

Applied Research on Green ICT and Smart Grids

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Mr. Thanos Stavropoulos (Web services)

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The Smart IHU

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❑***Smart IHU Scope***→ Based on the ‘’Smartgrid/Smartbuilding’’ model

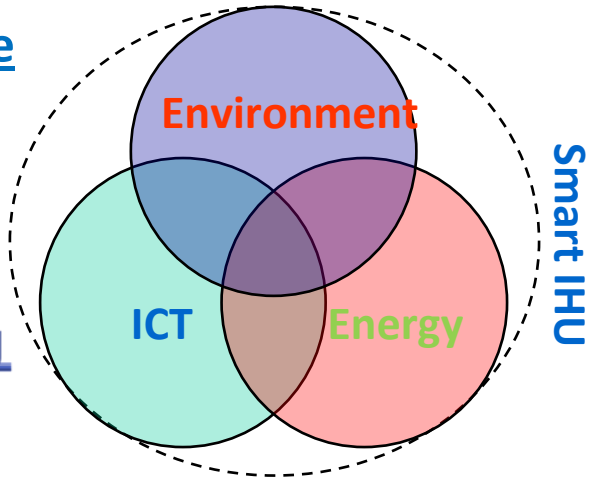
✓interdisciplinary research project in the field of ICT for Sustainable Growth and Green ICT (combines ICT, Energy and Environment)

✓Use of ICT for smartgrid applications, automation, demand response (**ICT for Energy Efficiency**)

✓Use environmental Sensors for **better Quality of Life**

✓Funded by International Hellenic University!

✓We are member of FP7 European Project Trend

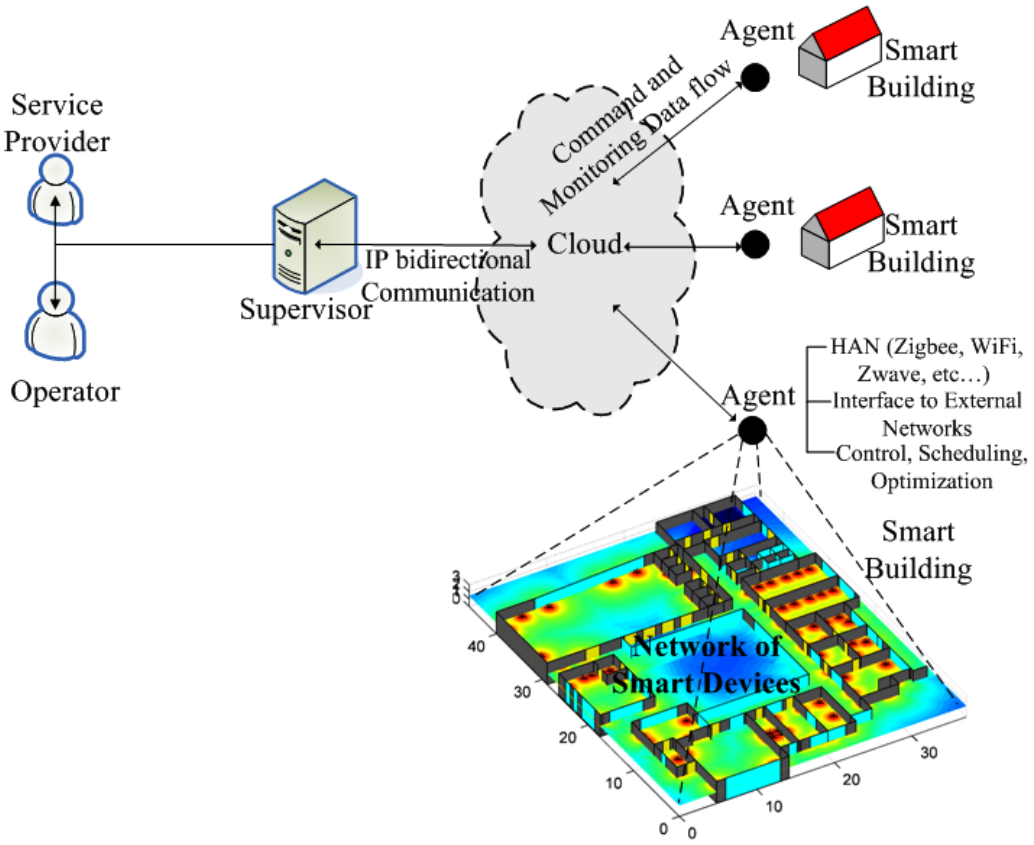


The Internet of Energy

The Smart Grid Concept

❑ *Smart Grid Functionalities*

- ✓ Supply Load Control
  - ➢ Adapt energy production to demand
- ✓ Demand Response
  - ➢ Shut down part of demand
  - ➢ Transfer non emergency tasks to off peak hour
  - ➢ Dynamic Pricing



❑ *Smart Grid Elements*

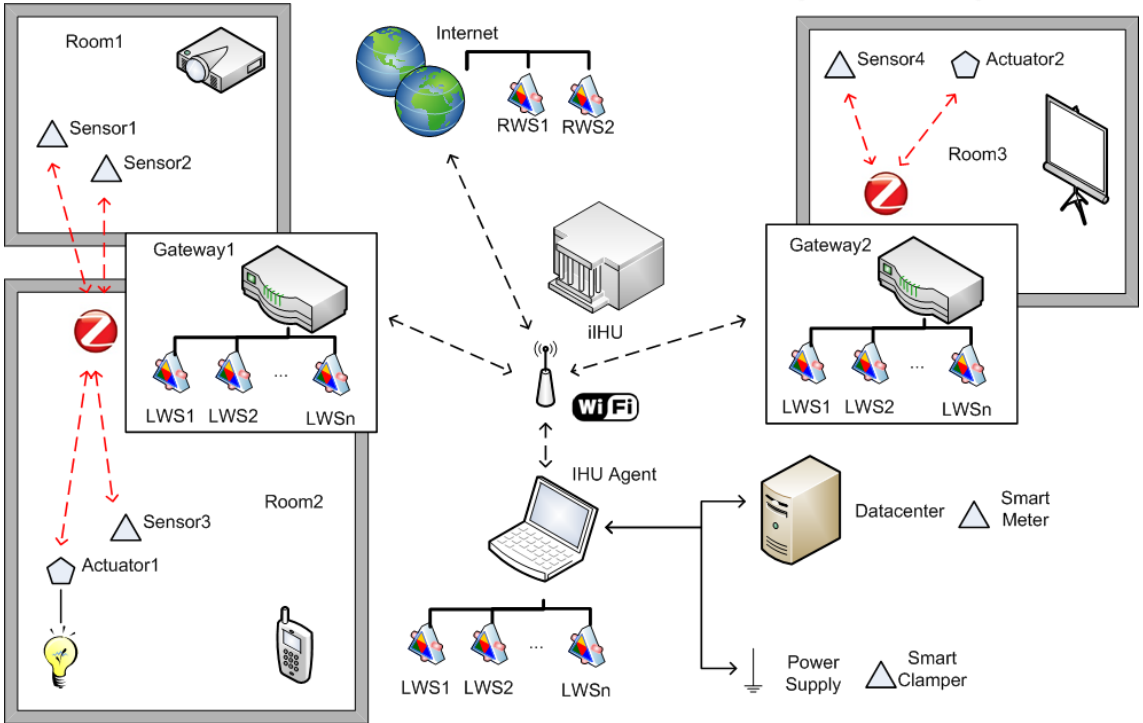
- ✓ Smart Buildings
- ✓ Communication infrastructure
- ✓ Supervisor
- ✓ Service and Energy Provider

G. Koutitas, 'Control of Flexible Smart Devices in the SmartGrid', IEEE Trans. Smart Grids, 2012 (in Press)

The Smart IHU Architecture

The basic components of the smart IHU building are:

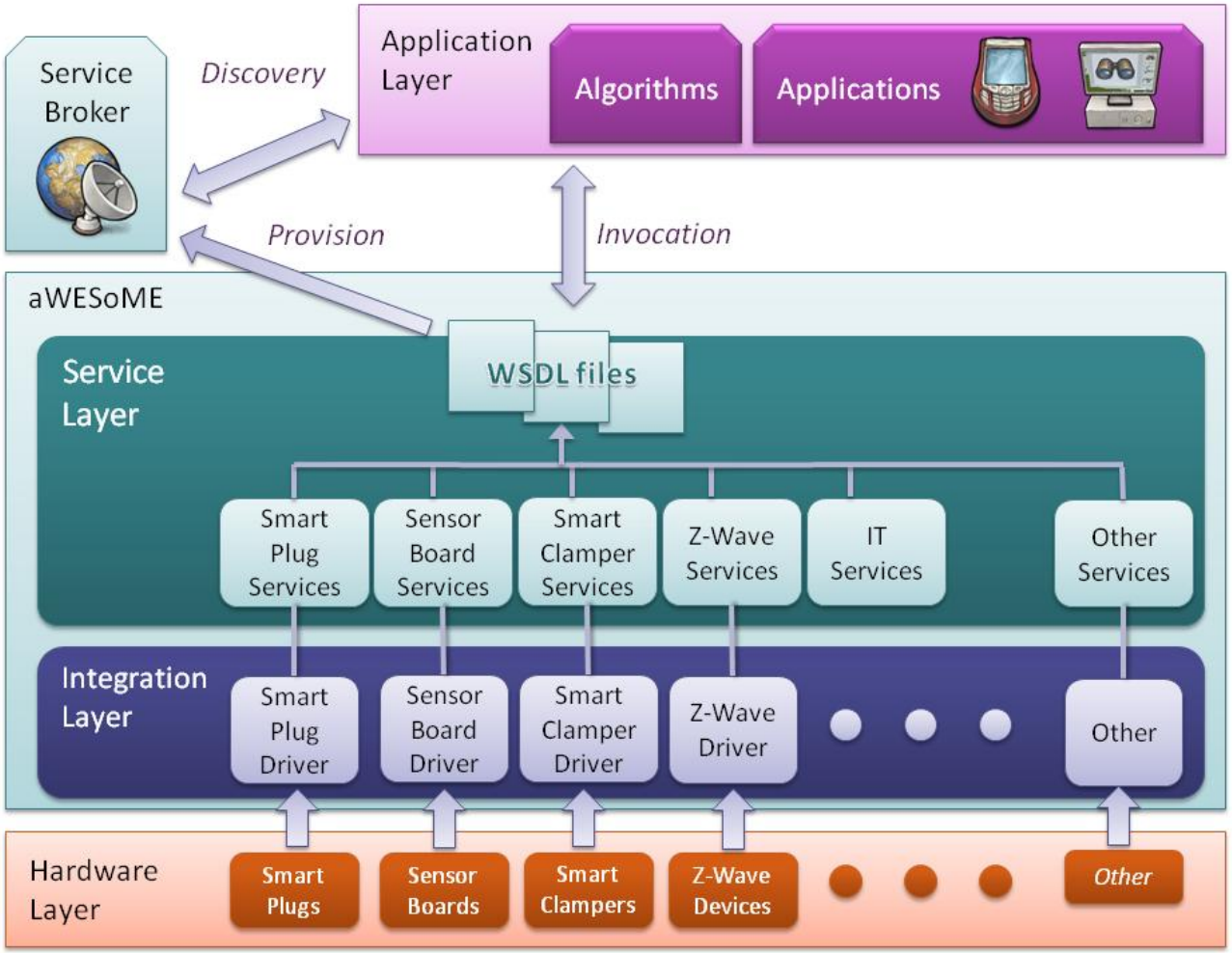
- **The IHU Agent**
  - ✓Central CPU unit →aggregates data and manages the network
  - ✓Software →processes data, interface to users, enable command flow to the smart devices under certain criteria (energy/environment)
- **The IHU sensor network of smart meters/actuator**
  - ✓A dense network of smart meters/ sensors/ actuators under the agent



Th. Stavropoulos, A. Tsioliaridou, G. Koutitas, D. Vrakas and I. Vlahavas, "System Architecture for a Smart University Building", in Proc. ICANN 2010

The Smart IHU Architecture

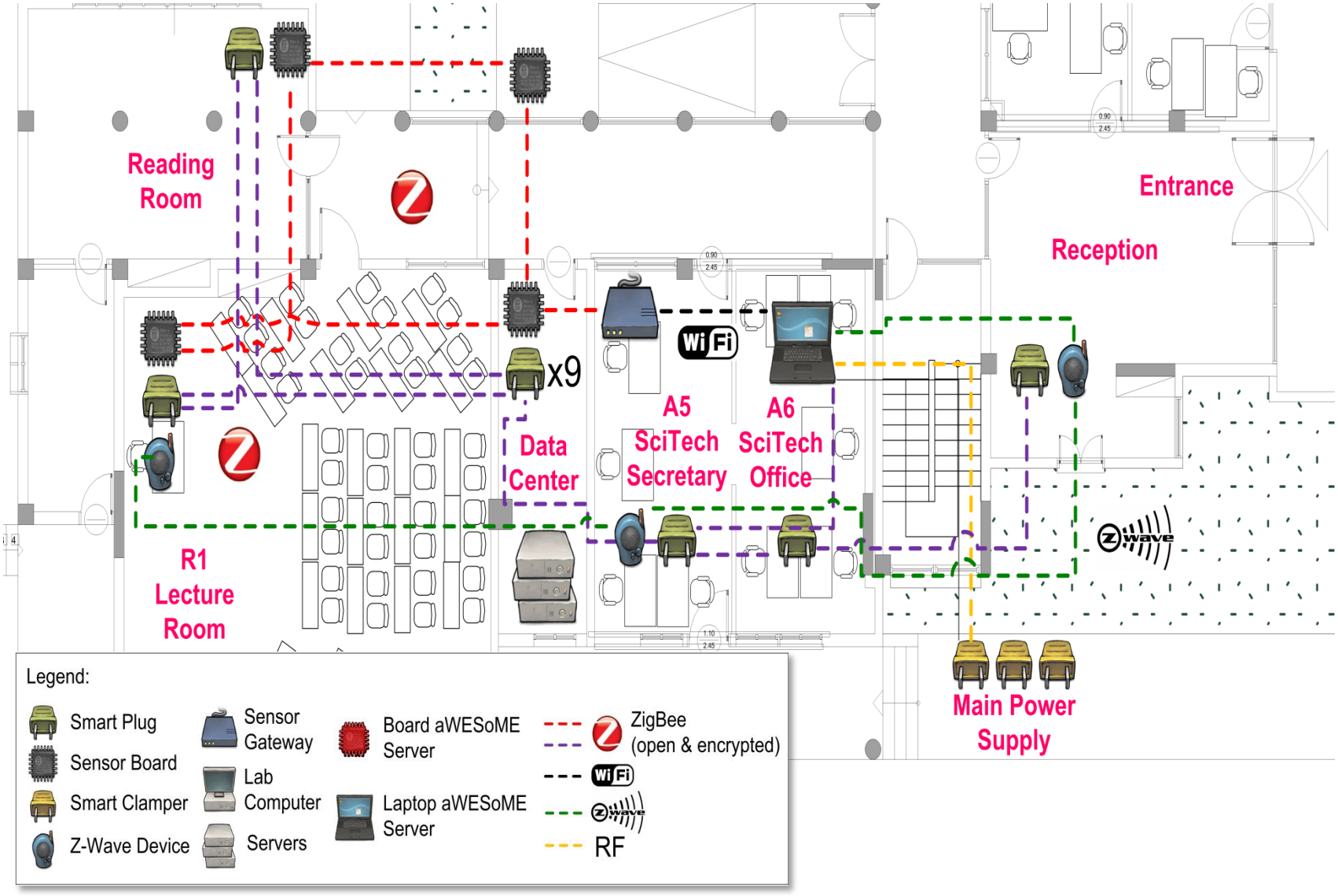
- AI planning
- Decision making (Demand Response)
- Energy Analytics
- Ontologies



- Integrates heterogeneous sensor networks
- overlaps commercial software.

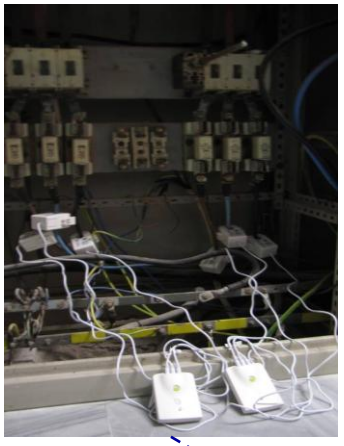
- WSN deployment
- Energy Efficient networking of sensors

The Smart IHU Architecture



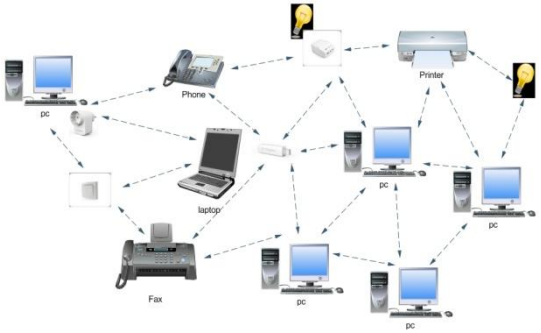
Sensor Layer – Energy Monitoring

Energy is monitored in two ways (using low cost commodity sensors)



- **Large scale** energy consumption (University's Building) is monitored with a wireless star network topology of Smart ***Clamp Meters*** (RF 434MHz star network)

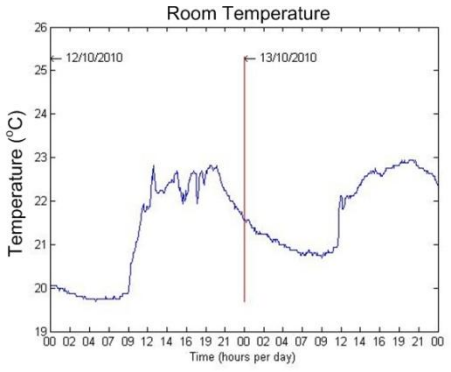
- **Small scale** energy consumption (individual appliances) is monitored with a wireless mesh IEEE 802.15.4 ZigBee network topology of ***Smart Plugs/Actuators***

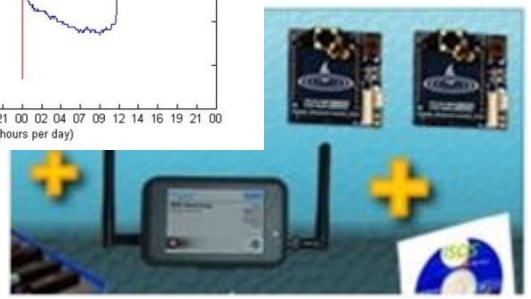


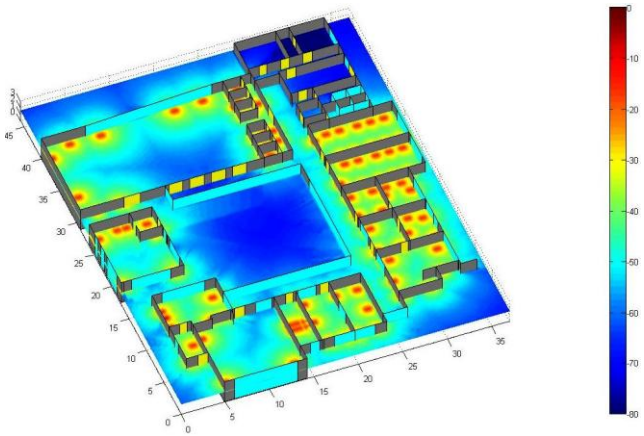
Sensor Layer – Environmental Monitoring

Environmental parameters are monitored through a mesh ZigBee wireless network. Parameters that are considered now are

- ✓ Luminance
- ✓ Humidity
- ✓ Temperature
- ✓ **CO_2 concentration** at IHU classes to be added..



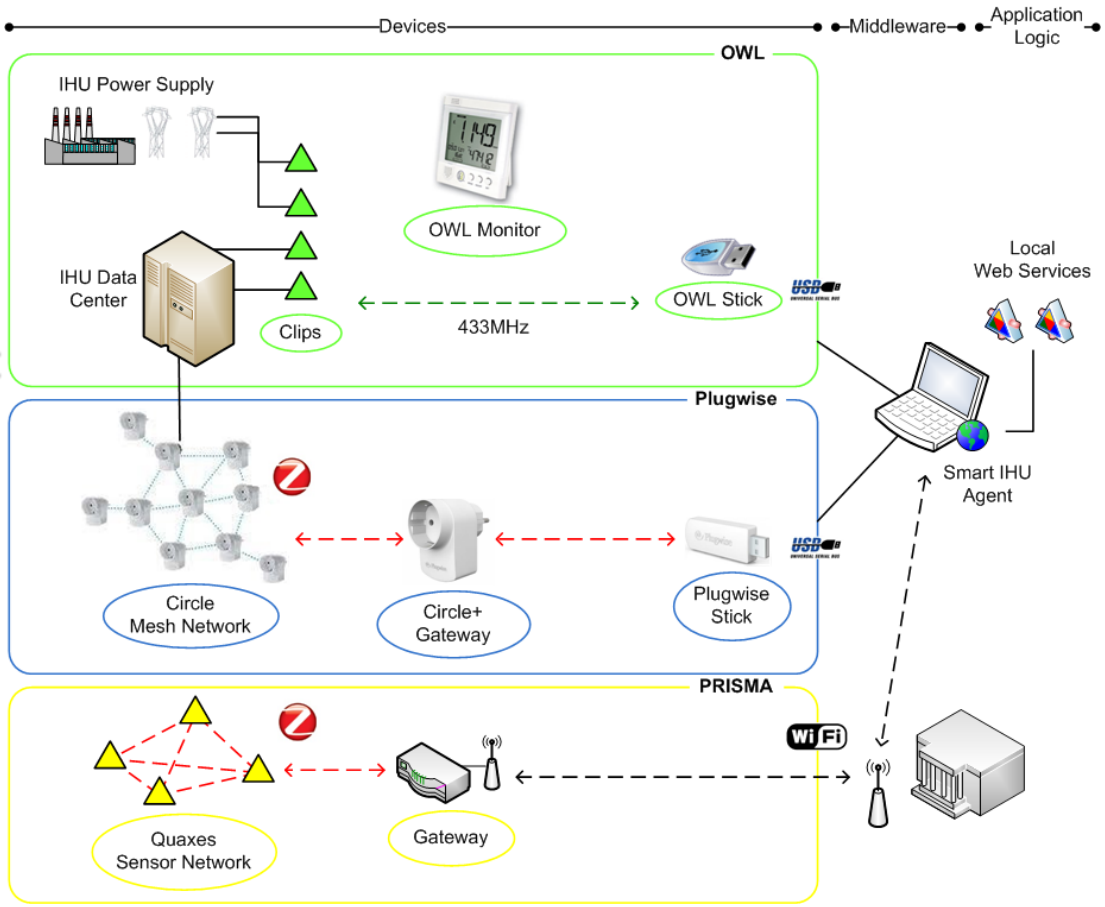




For the deployment of the sensor networks we perform theoretical simulations based on real IHU digital maps (Wireless sensor network in ground floor of IHU - scale in dBm).

Middleware Layer- Web Service

- ✓Provide universal remote access to heterogeneous data, OS - independent
  - e.g. sensor values, status data
- ✓Carry out *atomic* tasks
  - read values, control actuators, switch devices on/off
- ✓Deployed at the Smart IHU Agent and on local Gateways
- ✓Develop "Drivers" that store data
  - any platform (Java)
  - no company software
  - easy deployment



Th. Stavropoulos, D. Vrakas, A. Arvanitidis and I. Vlahavas, "A System for Energy Savings in an Ambient Intelligence Environment", in Proc. of ICT-GLOW 2011

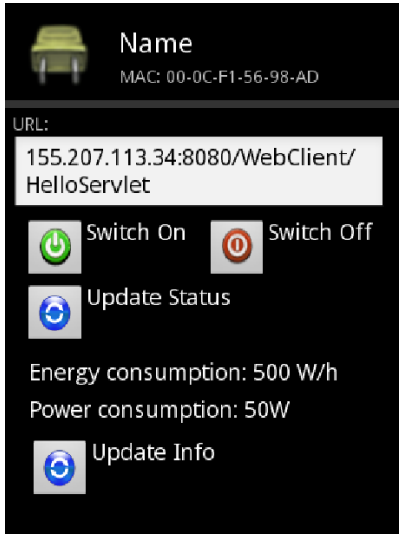
Application Layer – Desktop, Web and Mobile App (Analytics)

Development of web, desktop and mobile applications to create an interface between the user and the smartbuilding/smartgrid

Desktop/Web Platform

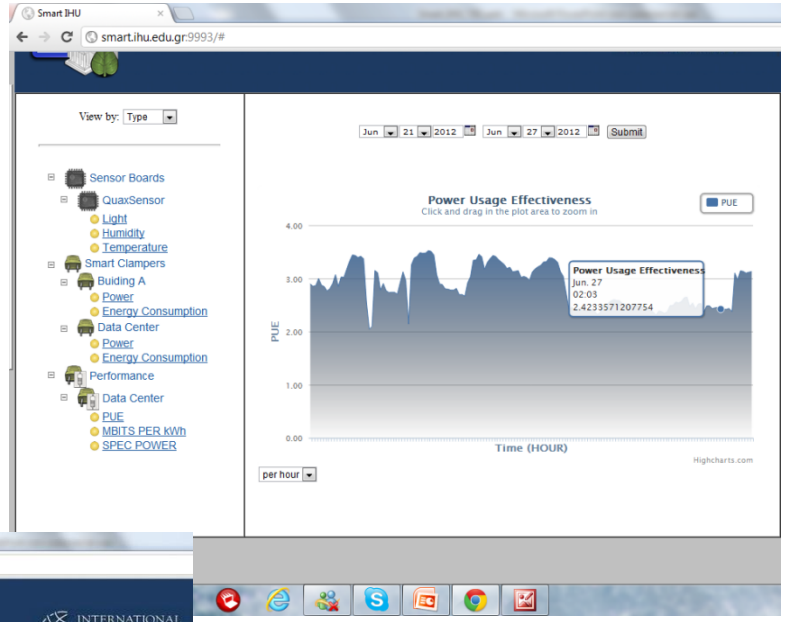
PlugDroid (Smartphone)

✓Historical and real time data, Function support, GUI, local and Web mode, Energy savings, Environmental Mng.



Application Layer – Web Analytics

Building Power

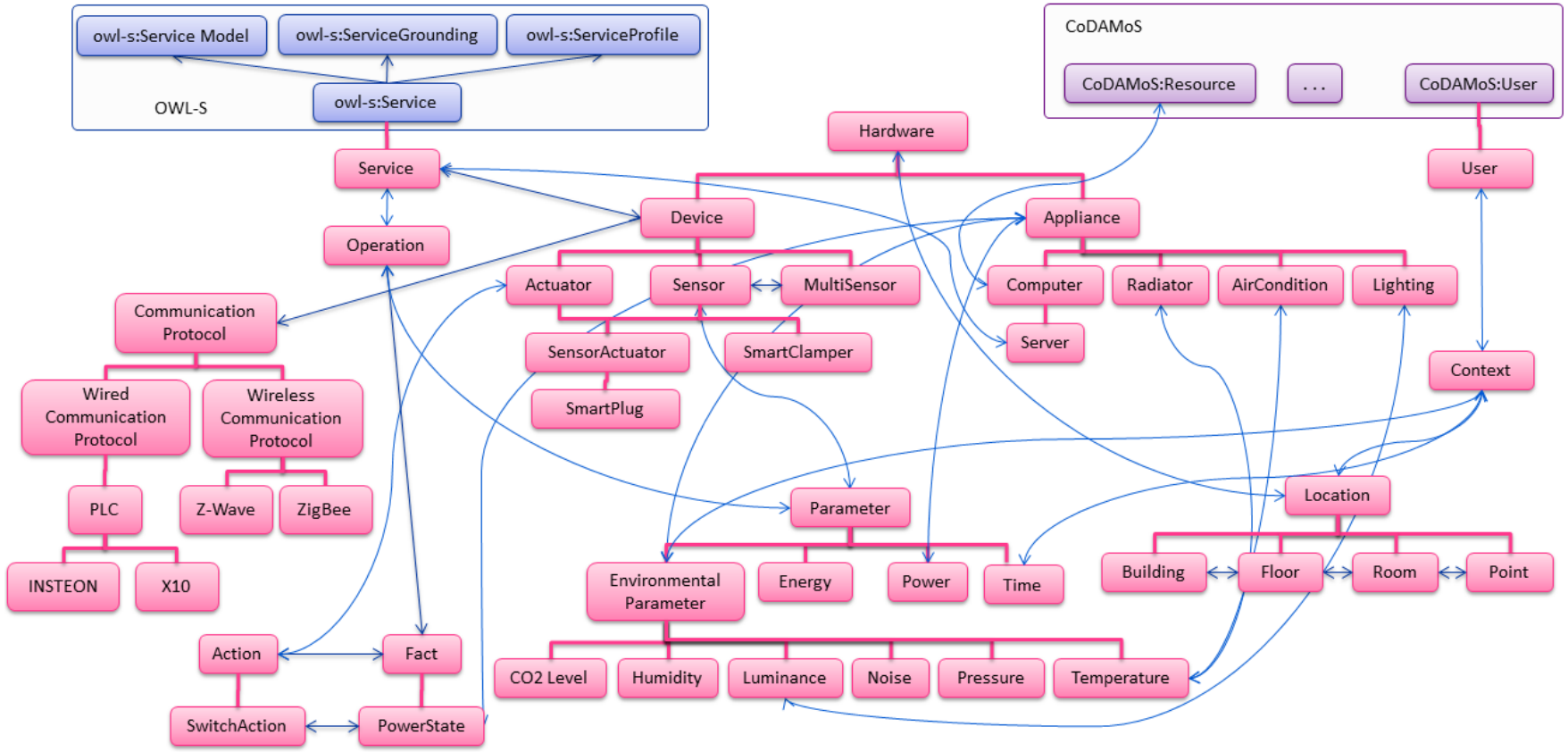


Datacenter PUE

Datacenter IT Energy Efficiency

Application Layer – Smart Grid Ontologies

- Ontology Smart IHU (BOnSAI)



Thanos G. Stavropoulos, Dimitris Vrakas, Danai Vlachava, and Nick Bassiliades, *"BOnSAI: a Smart Building Ontology for Ambient Intelligence"*, in the proc. of WIMS 2012, Craiova, Romania

Application Layer – Energy Management

- Investigate **on/off** management schemes of flexible loads for demand response and load control.
- Change binary (0-1) state of operation of flexible loads externally.
- **Objectives**

1. Threshold Capacity

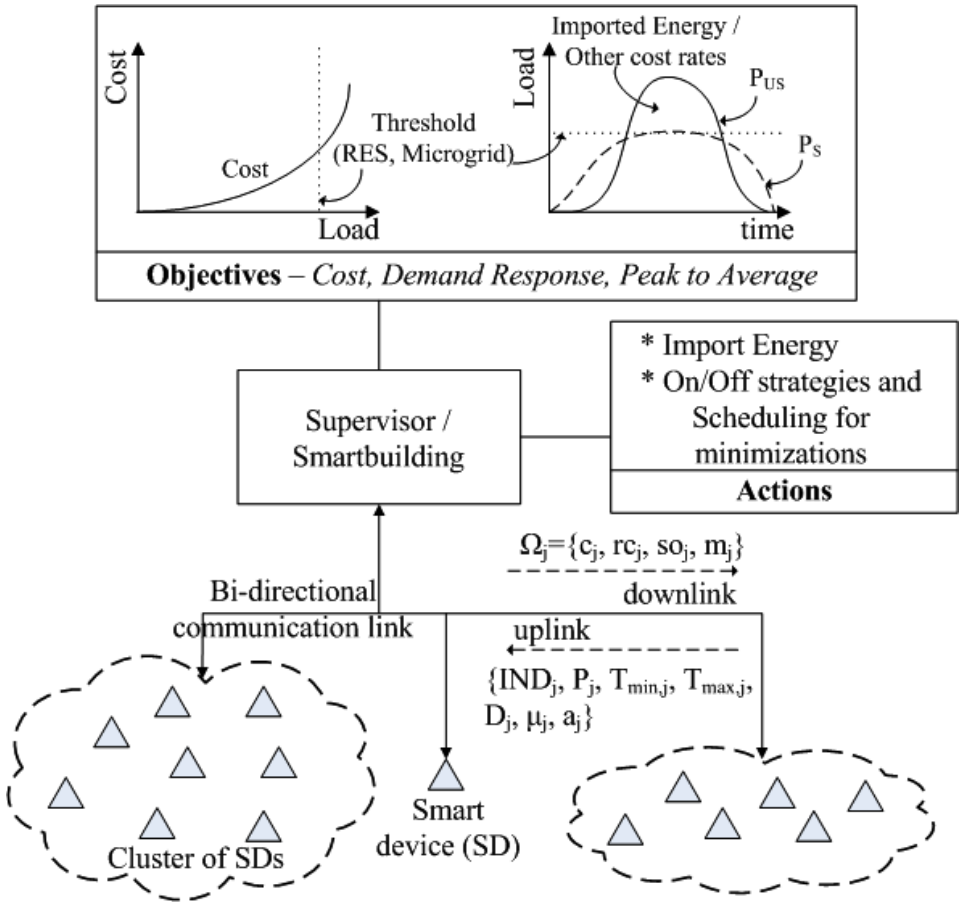
$$P_p(t) = \sum_{j=1}^{N<M} \left[P_j(t)\right] \leq B_p(t), \quad \forall t$$

2. Energy Reduction

$$\min \int_0^{T_{sim}} \sum_{j=1}^{M} \left[P_j(t)\right] \cdot dt$$

3. Cost Reduction

$$\min \int_0^{T_{sim}} \sum_{j=1}^{M} \left[C_j(t)\right] \cdot dt, \quad C_j(t) = P_j{}^n(t)$$

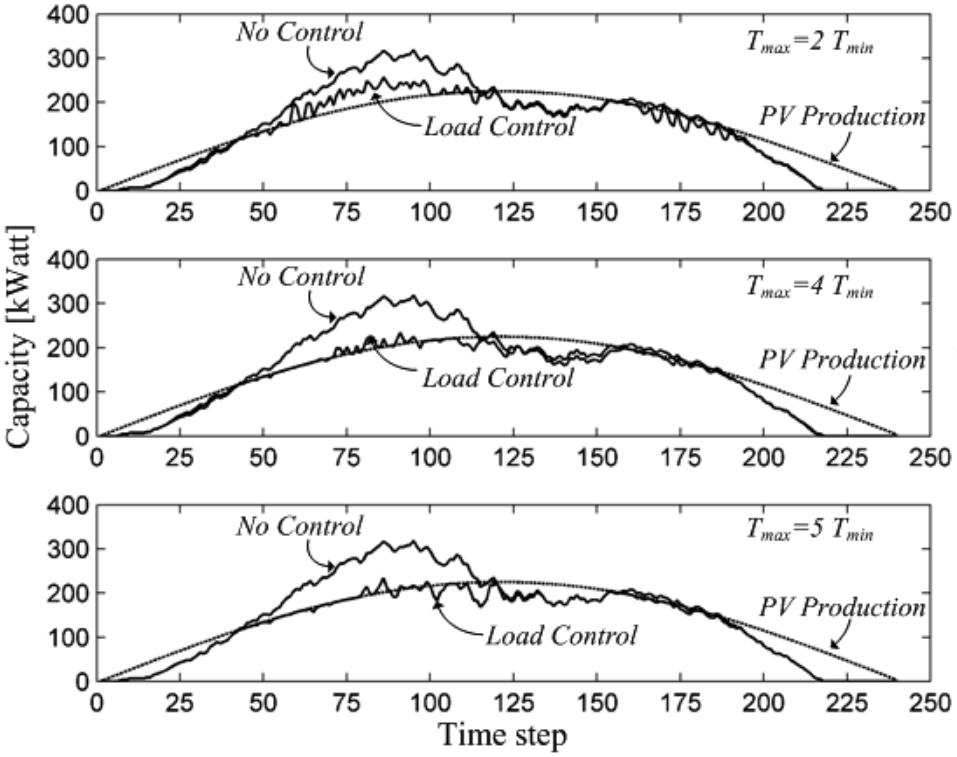


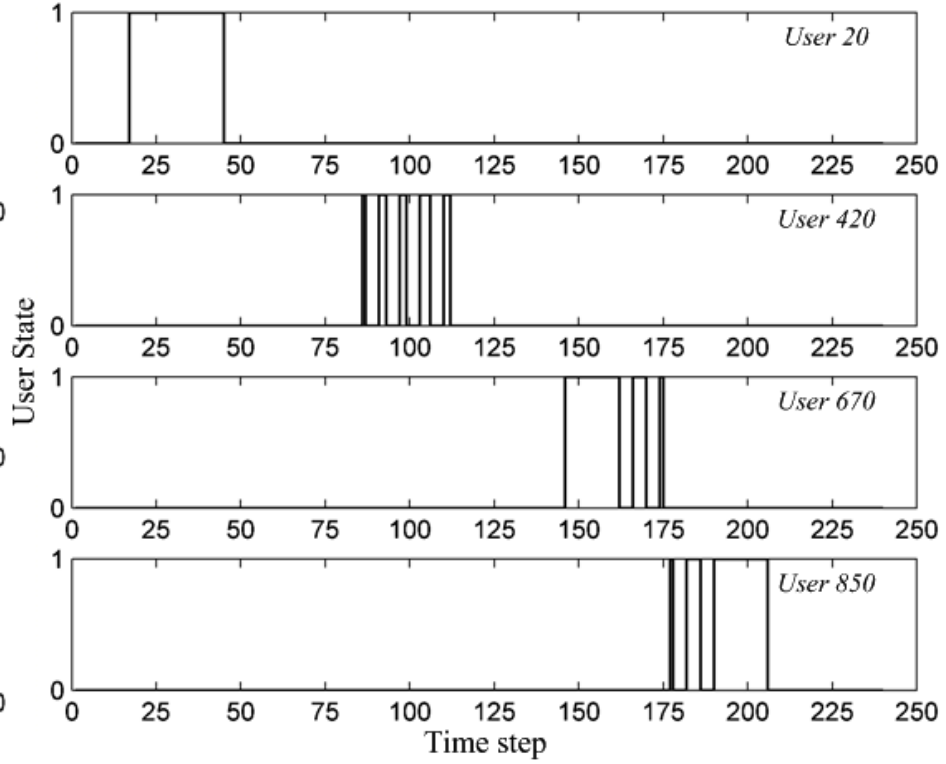
G. Koutitas, 'Control of Flexible Smart Devices in the SmartGrid', IEEE Trans. Smart Grids, 2012 (in Press)

G. Koutitas and L. Tassiulas, 'A delay based optimization scheme for peak load reduction in the smart grid', e-Energy, Madrid, 201

Application Layer – Energy Management

- ✓ We try to provide load control without affecting users' comfort and taking into account fairness issues (scheduling policies)





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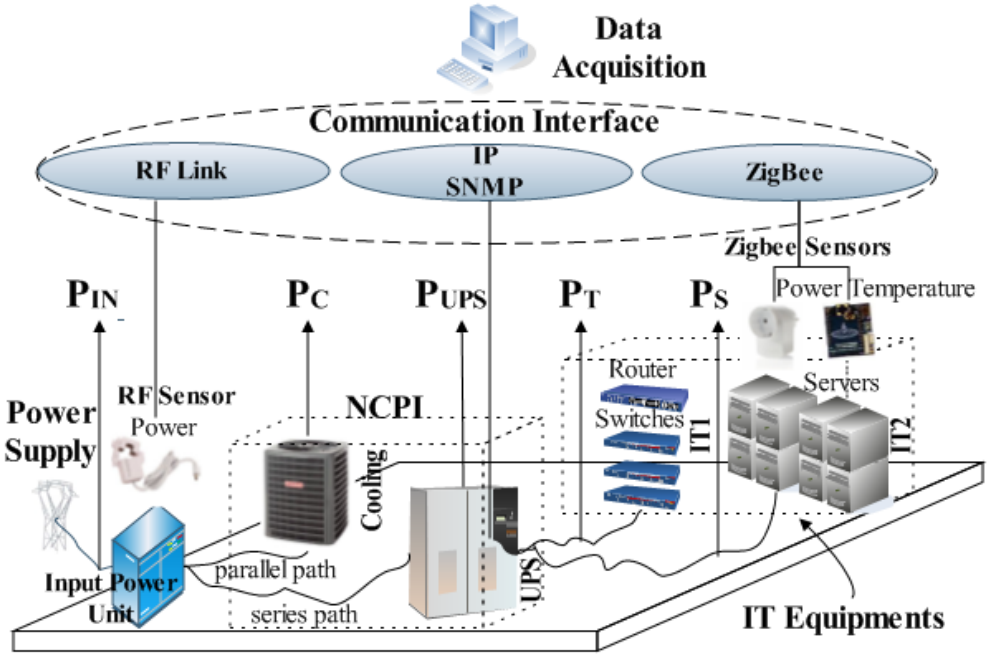
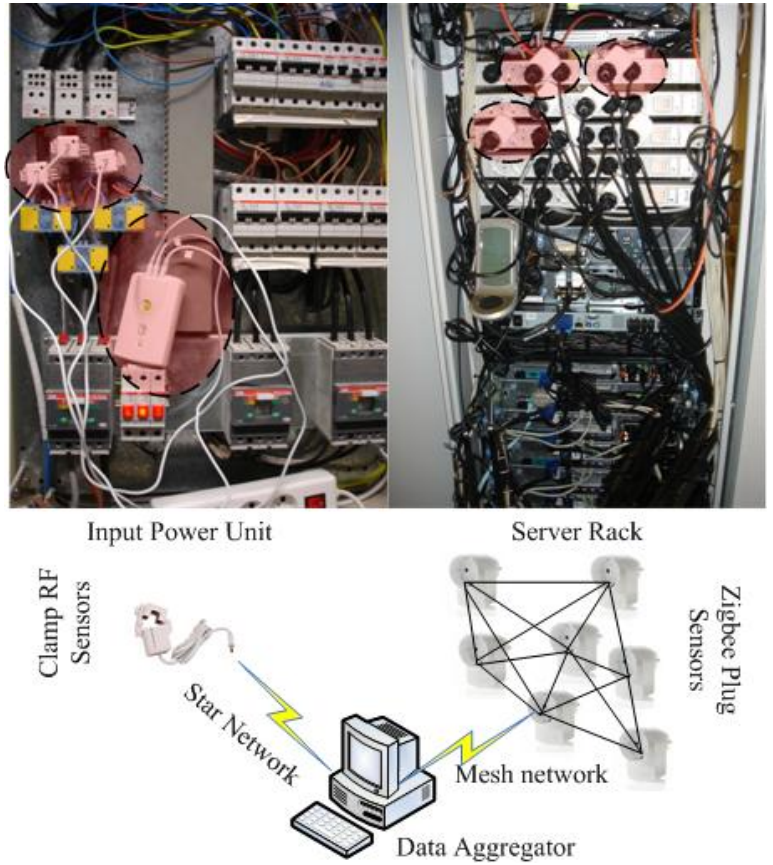
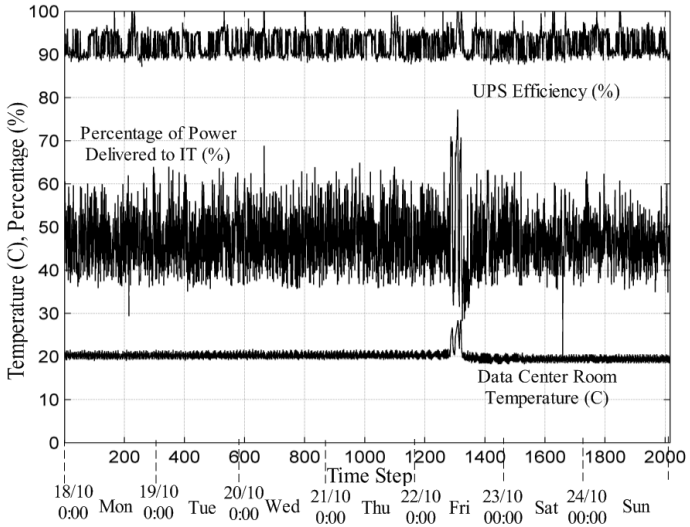
Smart IHU and Green ICT

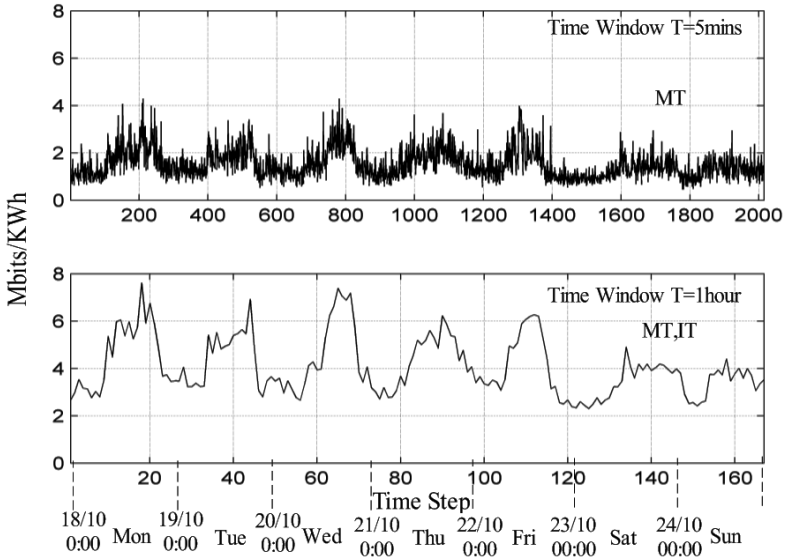
- Monitor Green Grid Metrics like PUE, MBits/KWh, Useful work/KWh
- Obtained by real time measurements using WSNs and SNMP requests from IT equip.



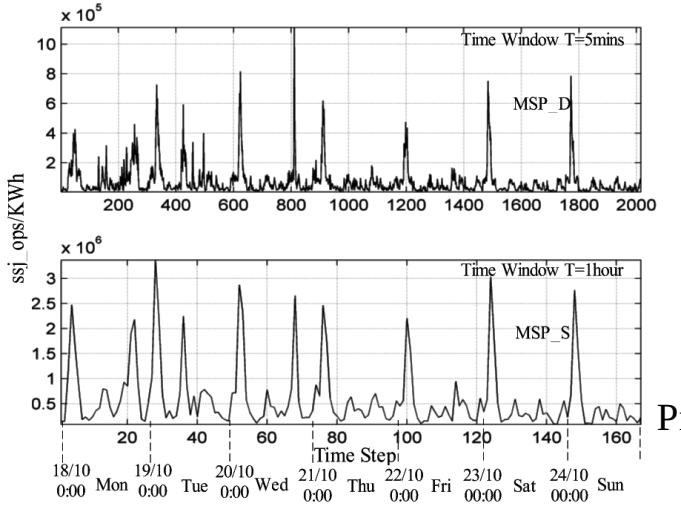


Smart IHU and Green ICT





$$PUE = \frac{P_{IN}}{P_{IT}} 1 < PUE < \infty$$



$$\mathrm{Proxy}_{\#4(bkWh)} = \frac{\sum_{i=1}^{k} b_i}{E_{DC}}$$

$$\mathrm{Proxy}_{<\#5(\mathrm{int\_rate})\ \#6(power)>} = \frac{T \cdot \sum_{i=1}^{n} \left[U_i \cdot < \frac{B_i}{S_i} > \cdot \left(\frac{CC_i}{CB_i} \right) \right]}{E_{DC}}$$

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  - *Smart Grids*
  - *Energy Savings*

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