Smart City Implementation
with “Internet by Design”
- Strategic use of Cloud and Data Center-

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Director, WIDE Project
Director, Green University of Tokyo Project
“Internet by Design”

1. Evidence & Experience Based Research
   Reject: kings, presidents and voting.
   Believe in: rough consensus and running code.

2. Provide “alternatives”, intentionally
   ✓ New component with the same interface
   ✓ Open interface for legacy system

3. Best-Effort (e.g., stupid) Network and Intelligent End-Node
   Does not have any responsibility for end-to-end service

4. Autonomous, distributed, cooperation

5. Transparent
   ✓ Anyone can do anything, with Opt-Out
   ✓ One asset, for multiple purposes
Shared Multi-Purpose Eco System for Sustainable Growth
Contents

1. Strategic use of Cloud & DC
   a. Facility on the net
   b. Computers into the net

2. Yet another strategic use of DC
   a. HVDC
   b. DC for power generating sites
“Strategic use of Cloud & DC”

1. Facility on the Net (Cloud)
2. Computers into the Net (Cloud/DC)
# Energy Saving at The University of Tokyo in Summer of 2011

<table>
<thead>
<tr>
<th>Major 5 campus</th>
<th>Peak (2010) 66 MW ($60M/yr)</th>
<th>Peak (2011) 69% (△31%)</th>
<th>Total (2011) 75%-78% (22%-25%)</th>
<th>RoI less than 1 month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eng. No2 Bldg.</td>
<td>1 MW ($1M/yr)</td>
<td>56% (△44%)</td>
<td>69% (△31%)</td>
<td>2 yrs</td>
</tr>
</tbody>
</table>

## Contributions
1. Multi-Vender for sustainability
2. Global Standards for procurement

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【Contributions】
1. Multi-Vender for sustainability
2. Global Standards for procurement

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12 Fl. EECS & Machinery Dept.
With Smart Phone

Smart Meter

Smart Kiosk

Smart Tap

Receiver

Smart Lights

Smart HVAC
Since 2005 (7th at Kyoto)

DUMBO2006 with AIT

KU+KUS with MIC+JGN2

IIT Hyderabad With IMD

Established FNIC in 2006 (Facility Network Interop)

Building Automation WG in 2003 at IPv6 Promotion Council

Collaboration with Tokyo Gov. since 2004

In 2008

Beijing Olympic

China-Japan Green IT Project funded by MIC in 2009

FIAP in 2009 (Live E! architecture)

IEEE 1888 in Feb.

ISO IEC JTC1 SC6 WP7

with NIST@USA B2G in SGIP (Smart Grid Interoperability Panel) toward CoS
Goal of IEEE1888

1. Smooth migration to open and multi-vendor system
   - Accommodation of legacy and unique systems via GW

2. Changing the business structure of building industry.
   - From “vendor” oriented to “user “oriented
     - User can define the technical specification of smart building, same as happening SDN and cloud in DC

3. New applications/services using common and transparent platform
   - BigData {and OpenData} operation
   - One assets, for multiple use,
     i.e., not only for energy saving but also (1) energy security (i.e., BCP), (2) improvement of productivity (i.e., efficiency) and (3) new functions.
IEEE1888 System Architecture

GW, Storage, APP Binding (Management Plane)

Registry

AAA

TCP/IP Network

HTTP and XML

APP

APP

APP

User Interface
Reporting
Data Analysis
Command Submission

Data Archive
Rendezvous Point for GWs, APPs

Storage

Storage

Virtualization of Input/Output

GW

GW

GW

GW

GW

GW

BACnet

Lonworks

Modbus

ZigBee

Field-Bus

Proprietary Circuits
CSV Files, …
**IEEE1888 System Architecture**

- **User Interface**
- **Reporting**
- **Data Analysis**
- **Command Submission**
- **Data Archive**
- **Rendezvous Point for GWs, APPs**

**Virtualization of Input/Output**
GW, Storage, APP Binding (Management Plane)

**TCP/IP Network**
HTTP and XML

**Proprietary Circuits**
CSV Files, ...

**Data Centric for Transparency**

**Independency from HW, i.e., SDN**

**Integration and Interoperability**
via GW for legacy and {new} unique systems

**Yet, another Wine-Glass Model**
What GUTP provides

1. Technical specification via IEEE-SA and other standardization institutes, e.g., ISO/IEC

2. SDK
   a. Referenced implementation, with Linux VM
   b. OpenADR over IEEE1888
   c. Gateway function, e.g., BACnet, Lonworks, Modbus

3. Testing Environment
   a. Specification and software
   b. Certification / logo
東京電力(株) 2012年7月12日 公開資料
「RFCを踏まえたスマートメータ仕様に関する基本的な考え方」

27 million Smart Meters for residents

Service Providers

MDMS (data repository)
Power company

Residents (Home)

Smart Meter

CIS, MDMS, HE

http://www.tepco.co.jp/corporateinfo/procurerfc/repl/t_pdf/2concept-j.pdf
TEPCO’s Smart Meter System

1. 27 million meters will be connected via IPv6 (e.g., 6LowPAN)

2. Three layer structure,
   i. FAN (Field Area Networks)
   ii. MDMS
      (*) Equal access of data for the third parties (applications), i.e., neutrality of data
   iii. Applications

3. Security against malicious accesses

http://www.tepco.co.jp/corporateinfo/procu...
Tokyo Institute of Technology
Green Hills, No. 1 Bldg

Microsoft Japan
HQ in Tokyo

Otsuka Corp. HQ

Shinryo Reinetsu
HQ and other buildings

Hitachi Info & Tele Eng Ltd.
Nakai Development Center

CANON S Tower
(Canon MJ HQ)
Global Collaboration
Global/International collaboration

1. ISEP/DESSC with UN foundation
2. Beijing team (e.g., Tsinghua Univ., China Telecom) (including Standardization)
3. Chulalongkorn University, Thailand EE Building BEMS, SEIKO Precision Factory Automation
4. NTU (National Taiwan University), Taipei, Taiwan
5. Vietnam with MIC (Japanese gov. support) – Smart industrial park and disaster reaction/protection
6. iDA and NTU in Singapore
7. DoT (Department of Telecomm.), SRM, and IIT Hyderabad
8. UCB with Intel, LoCaL project, in USA
9. SGIP of NIST in USA
10. UMPS/LIP6/CNRS in Paris, France

May want to have shared data-set for Big Data analysis
“Strategic use of Cloud & DC”

1. Facility on the Net (Cloud)
2. Computers into the Net (Cloud/DC)
Private Cloud in our Lab.

**Achievement: Saving 71% (2.52kW)!**

**Before**

- Faculty’s shared servers: 0.647kW
- Web, mail, DNS, group tool (Essential servers...)

**Infra-servers of our Lab.**
- 1.595kW
- web/mail/radius/dns/document/misc
- bld2-guest-gw/mozilla-miror/storage

**Students’ machines**
- 0.700kW
- x10

**Infra-servers in another Lab.**
- 0.623kW

**After**

- Private cloud (stable)
  - Xen
  - 0.794kW
  - VMware
  - ESXi
  - Nexsan SATA Beast
  - No failure since April 11

- Private cloud (experimental)
  - Xen
  - 0.153kW

- Private cloud in another Lab.
  - Xen
  - 0.100kW

- Using inexpensive model: HP ProLiant DL120 G6/G7
Private Cloud in our Lab.

RoI of investment
⇒ 6 months (w/ PUE=2.0)

“True” benefits for us;
1. Manageability of system
2. BCP for power incidents
3. Comfortable environment
Best Current Practice for Commercial Building

1. Facility management control by IEEE1888
2. Servers go to Data Center = No server room in the bldg
What happened on Tokyo Local Government officer?

1. Initial (Spring 2008)
   i. “Hate” Data Center, because of huge power consumption and continuous increase.

2. Beginning 2010
   i. Data Center is ”good” for reduce the power consumption

3. Now
   i. Include the ”exception” for iDC into the “regulation” on the CO₂ carbon footprint reduction
   ii. ”Promoting” to use iDC and cloud platform
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Yet another, Strategic use of “DC”

1. {High Voltage} DC
2. DC for Power Generating Sites

(*) Container Co-Generator and DC for mobility and easier installation
1. Integration of Communication line and Power line (e.g., PoE)
2. Battery operation

Innovation toward “real” infrastructure

1. Reduction of AC-DC transformation, for improvement of efficiency
2. Independent and Autonomous Computer System
3. Applying to Audio Visual system, as well
DC power supply and solar power with container data center by Sakura Internet
1. **Mobility** of infrastructure
2. “Skelton and in-fill” for bldg.
3. Distributed/autonomous power generation
New} Implication of Data Center:

1. Could be carrier neutral
2. Could change from consumer to supplier
3. 72 hour operation, after electric black-out
4. Source of heat, as well
5. Mobility and survivability of computing and power-generator function.

1. Critical Infrastructure for IT/ICT
2. Infrastructure for de-centralized energy source
3. Infrastructure for {short-term} energy security
【Business Scenario】

Energy Saving

- Efficiency (= Productivity)
- Security (= BCP)
- Innovation (= New Services)

RoI by Energy Saving

Energy Saving Platform Delivers BigData for New Functions
“Positive” Eco System

Energy Saving

BCP

New Services

ICT (Cloud & DC)

TQC (Productivity)
Green Univ. of Tokyo Project

• GUTP, established in **June 2008**.
  • 46 private companies and 20 NPOs (as of January 2012)
• **Eng.BUILDING No.2**, in Hongo Campus
  – Targeted reduction; **15% in 2012, 50% in 2030**
  – 12 floor high, R&D and R&E activities
  – Established October 2005
• **5 major campus and new I-REF building**
• More than saving energy
  – Sustainability
  – New functions and business
• Global Standard
  • **IEEE1888**
  • **NIST SGIP CoS**
【Companies】
- Azbil Corporation
- CiMX Corporation.
- Cisco Systems, Inc.
- Citrix Systems Japan K.K.
- ComZeit Inc.,
- Daikin Industries, Ltd.
- DSI, Inc.
- EMC Corporation
- Fujitsu Limited
- Hitachi Co.Ltd.
- INTEC Inc.,
- Intercom Inc.,
- Internet Initiative Japan Inc.,
- KAJIMA Corporation
- Kantokowa Co., Ltd.
- KDDI Corporation
- KDDI R&D Laboratories
- Kyosera Maruzen Systems Integration Co.Ltd.
- Mitsubishi Heavy Industries Ltd.
- Mitsubishi Research Institute Inc.
- Mitsui Fudosan Co.,Ltd
- Murata Manufacturing Co.Ltd.,
- NEC Corporation
- Nippon Steel & Sumikin Engineering Co.Ltd.
- NTT Comware Corp.
- NTT Corporation
- NTT Data Corporation
- NTT Data Customer Service Corporation
- NTT Data Intellink Corporation
- NTT Facilities Inc.
- OSIsoft Japan K.K.
- OTSUKA Corporation
- Panasonic Corporation
- RICHO Co., Ltd.
- Sakura Internet Inc.,
- Sanki Engineering Co., Ltd.
- Schneider Electric Japan Group
- SEIKO PRECISION Inc.,
- SHINRYO Corporation
- Takaoka Electric Mfg. Co.Ltd.,
- Takenaka Corporation
- Toshiba Corporation
- Toyo Denki Seizo K.K.
- Toyo Standard Corporation
- Ubiteq Inc.
- Ubiquitous Corporation

【Organizations/Universities】
- Green IT Promotion Council.
- IPv6 Promotion Council.
- The Institute of Electrical Engineers of Japan
- The Institute of Electrical installation Engineers of Japan
- LONMARK JAPAN
- OKAYAMA IPv6 CONSORTIUM.
- Yamaguchi Prefectural Industrial Technology Institute
- WIDE Project.
- Tokyo Metropolitan Research Institute for Environmental Protection
- Chularonkorn University (Thailland)
- SRM University (India)
- Kanazawa University
- Gifu University
- Keio University.
- Kyushu Institute of Technology
- NAIST (Nara Institute of Science and Technology)
- National Taiwan University (Taiwan)
- Niigata University
- Nagoya University
- Shizuoka University
- Tokyo Metropolitan University
- Yamaguchi University
- Yamagata University
- Yamagata Research Institute of Technology
- The University of Tokyo
System overview Eng.No.2 Building in Hongo Campus, Tokyo, Japan

Legacy system + common I/F gateway
System overview Eng.No.2 Building in Hongo Campus, Tokyo, Japan

**Data Integration among legacy sub-systems**

- **CiMX Server**
  - **Web I/F**
  - **Schedule Server**
  - **Student TE**
  - **Professor TE**
  - **Management TE**
  - **G/W**
  - **Common DB (Live E!)**

- **Electricity**
  - **Management DU**
  - **Electricity (CiMX)**
  - **Data Analysis (Yokogawa)**

- **Action and Control**
  - **Ubiteq/Cisco**
  - **LMJ**
  - **Electricity Sensor**

- **Visualization of data**
  - **Web I/F**
  - **Schedule controller**
  - **Digital signage**

- **Additional system**
  - **Schedule controller**
  - **Digital**

**Legacy system + common I/F gateway**

- **200V Power monitoring, EHP mngmnt and control**
- **GHP mngmnt and control**
- **Lightening control**
- **Electricity and water metering**

**Additional system**

- **BACnet/WS**
- **LON-IP G/W**
- **BACnet/WS**
- **BX-Office**
- **Ubiteq/Cisco/Panasonic**
- **Schedule controller**
- **Digital signage**
- **Electricity Sensor**
- **Energy Sensor**
- **Watanabe**

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- **Energy Sensor**
- **Watanabe**
1. Multi-vendor
   ✓ More than 10 vendors
2. More than 2,000 points
3. Energy saving in 2011
   ✓ 44% (peak), 31% (total)
4. 2 year RoI
Smart Meter

With Smart Phone

Smart Kiosk

Smart Tap

Smart Lights

Smart HVAC
Migrating; from "single screen" to "multiple screens" from "Pull" to "Push"
見える化・見せる化の効果？
気温は違えども、ピーク値は維持。
2011年6月28日＆29日

3.5 ℃
気温は違えども、ピーク値は維持。
2011年7月5日&6日

△30%

△15%

70%+: Only July 12 15:00-16:00 (72%)

44% Peak cut

33% Total Cut
Handling the Current and Historical Data of Building Facilities

10F EHP HVAC Statuses

<table>
<thead>
<tr>
<th>Room</th>
<th>Status</th>
<th>Mode Setting</th>
<th>Temperature Setting</th>
<th>Temperature Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>101B</td>
<td>OFF</td>
<td>冷房</td>
<td>26</td>
<td>28.9</td>
</tr>
<tr>
<td>102B1</td>
<td>ON</td>
<td>冷房</td>
<td>25</td>
<td>25.6</td>
</tr>
<tr>
<td>102B2</td>
<td>OFF</td>
<td>冷房</td>
<td>22</td>
<td>29.3</td>
</tr>
<tr>
<td>101C1</td>
<td>ON</td>
<td>冷房</td>
<td>28</td>
<td>27.6</td>
</tr>
<tr>
<td>101C2</td>
<td>OFF</td>
<td>冷房</td>
<td>27</td>
<td>27.2</td>
</tr>
<tr>
<td>102C1</td>
<td>OFF</td>
<td>冷房</td>
<td>28</td>
<td>29.3</td>
</tr>
<tr>
<td>102C2</td>
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<td>冷房</td>
<td>26</td>
<td>25.6</td>
</tr>
<tr>
<td>103C1</td>
<td>OFF</td>
<td>冷房</td>
<td>27</td>
<td>30.1</td>
</tr>
<tr>
<td>103C2</td>
<td>ON</td>
<td>冷房</td>
<td>27</td>
<td>27.2</td>
</tr>
<tr>
<td>10SV</td>
<td>ON</td>
<td>冷房</td>
<td>23</td>
<td>23.2</td>
</tr>
</tbody>
</table>

Not only energy information!!

(※) 過去180秒以内に更新されていない項目は空欄で表示されます。
A System for Metering Electricity

30,000 kW Substation (66kV → 6600V)

Data Storage (Archive & Rendezvous)

Application 1 (Tool)

Application 2 (Tool)

Gateway

IEEE1888

IEEE1888

IEEE1888

Supply power to the Campus

Supply power to the Campus

※ Important Message

1. IEEE1888 interface is not only designed for the Gateways, but also for Storages and Applications.

2. GW, Storage, APPs come from different vendors.

(Note) This diagram is just a sample, and does not really correspond to the locations above.

6600V power supply areas (23 lines)
Power monitoring for accounting (about 200 points)
Connecting 5 Campuses on the Same Platform

Archive and Share
- IEEE1888 Storage Esaki Lab

Visualization Service Provider
- IEEE1888 App CIMX

IEEE1888 GW
- HITACHI
- MITSUBISHI

IEEE1888 GW
- KINKEI
- PANASONIC

IEEE1888 GW
- ALTER BUILDING
  - TAKAOKA

IEEE1888 GW
- TOSHIBA

IEEE1888 GW
- MEIDENSHI

350 points

Hongo Campus

203 points

Komaba I Campus

32 points

Komaba II Campus

48 points

Kashiwa Campus

22 points

Shirogane Campus

Total: 665 points
66MW, 60 MUSD/year
- 31% peak-cut
- 20-25% total reduction
31% Peak Cut
Smart Tap Integration with IEEE1888

1. Ordinary Smart Tap by Plugwise Inc.
2. Smart Tap for Rack in computer room by RICOH Company Ltd.
IEEE1888 over 3G

• Partners
  – Internet Initiative Japan (IIJ) Inc., <www.iij.ad.jp>
  – 3G Shield Alliance <www.tabrain.jp/newfolder1/a3gsa.html>
  – The University of Tokyo www.u-tokyo.ac.jp

• Feature of the System
  – IIJ GIO Service (Cloud Service)
  – IEEE1888 sensor module with 3G link
IEEE1888 Development Kits
by FUTABA Kikaku
Tokyo Institute of Technology
Green Hills,No.1 Bldg

Microsoft Japan HQ in Tokyo

Otsuka Corp. HQ

Shinryo Reinetsu
HQ and other buildings

Hitachi Info& Tele Eng Ltd.
Nakai Development Center

CANON S Tower
(Canon MJ HQ)
Thang Long Industrial Park  
（Vietnam）

浜松市 （政令指定都市）

城北図書館

中央図書館

浜松市福祉交流センター

北部水泳場
Global/International collaboration

1. ISEP/DESSC with UN foundation
2. Beijing team (e.g., Tsinghua Univ., China Telecom), China (Including Standardization)
3. Chularonkorn University, Thailand
   - EE Building BEMS, SEIKO Factory Automation
4. NTU (National Taiwan University), Taipei, Taiwan
   – MoU with College of EECS
5. MIC/NISCI/HTU/VDC with Japanese MIC, Vietnam
   – Smart Industrial Park, Data Center, Buildings
6. iDA and NTU in Singapore
7. Universiti Teknologi Petronas, Malaysia
8. DoT (Department of Telecomm.), IIT-H and SRM, India
9. UCB with Intel, LoCaL project, in USA
10. SGIP of NIST in USA
11. UMPMS/LIP6/CNRS in Paris, France
12. ISO/IEC JTC1 SC6 WP7
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