ICTs for innovative sensing and networking toward sustainable society

Hiroshi Kumagai, Tetsuya Miyazaki, Tatsuya Yamazaki, and Motoaki Yasui

NICT (National Institute of Information and Communications Technology)

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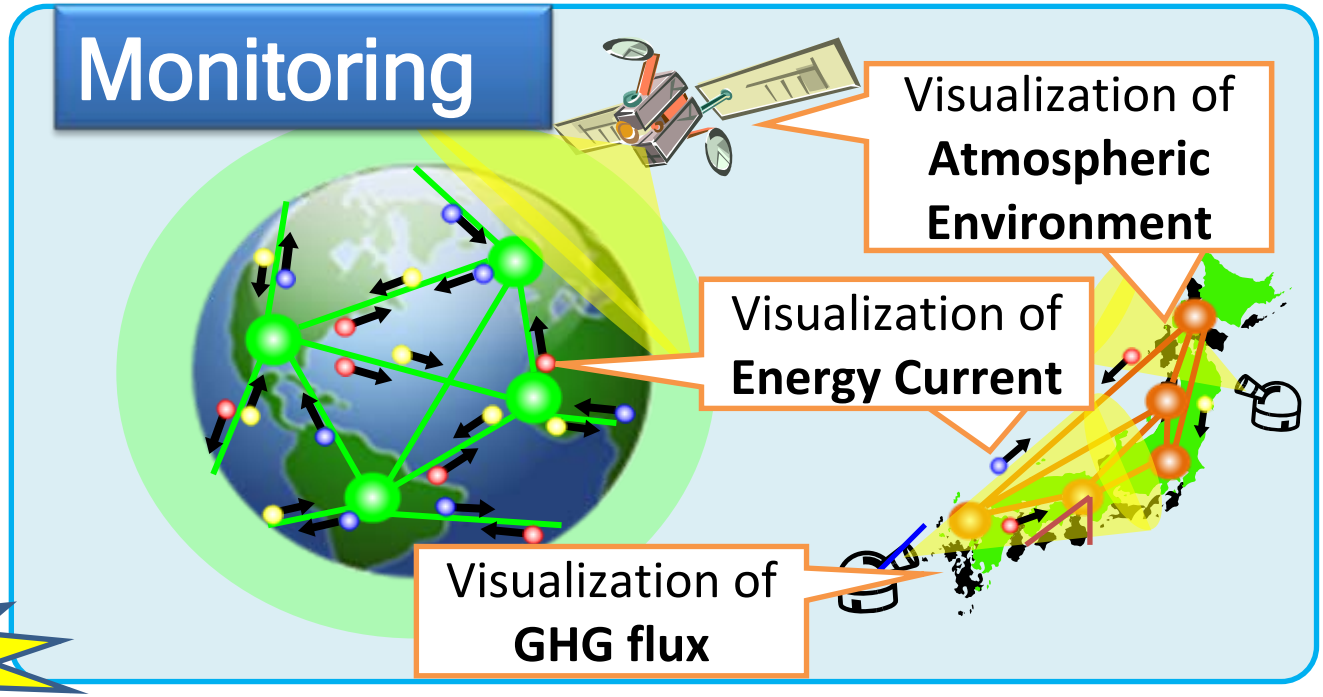
Contents

- Several activities in ICTs to tackle global warming issue

1. Novel remote sensing techniques as the monitoring tools;
   - 1-1 CO_2 laser sensing techniques
   - 1-2 Global monitoring of cloud and aerosol with millimeter radar
2. R&Ds for energy efficient ICTs
   - 2-1 Photonics approach toward highly efficient broadband NW
   - 2-2Ubiquitous sensor network approach: Smart proactive HEMS and BEMS
3. Combining monitoring and controlling helps optimize the measures

Optimization of Energy Management by ICTs



Optimized Measures!

Control

Feed Back

Optimum Management of Energy Consumption

Ultrafast, Low power consumption

Proactive HEMS&BEMS

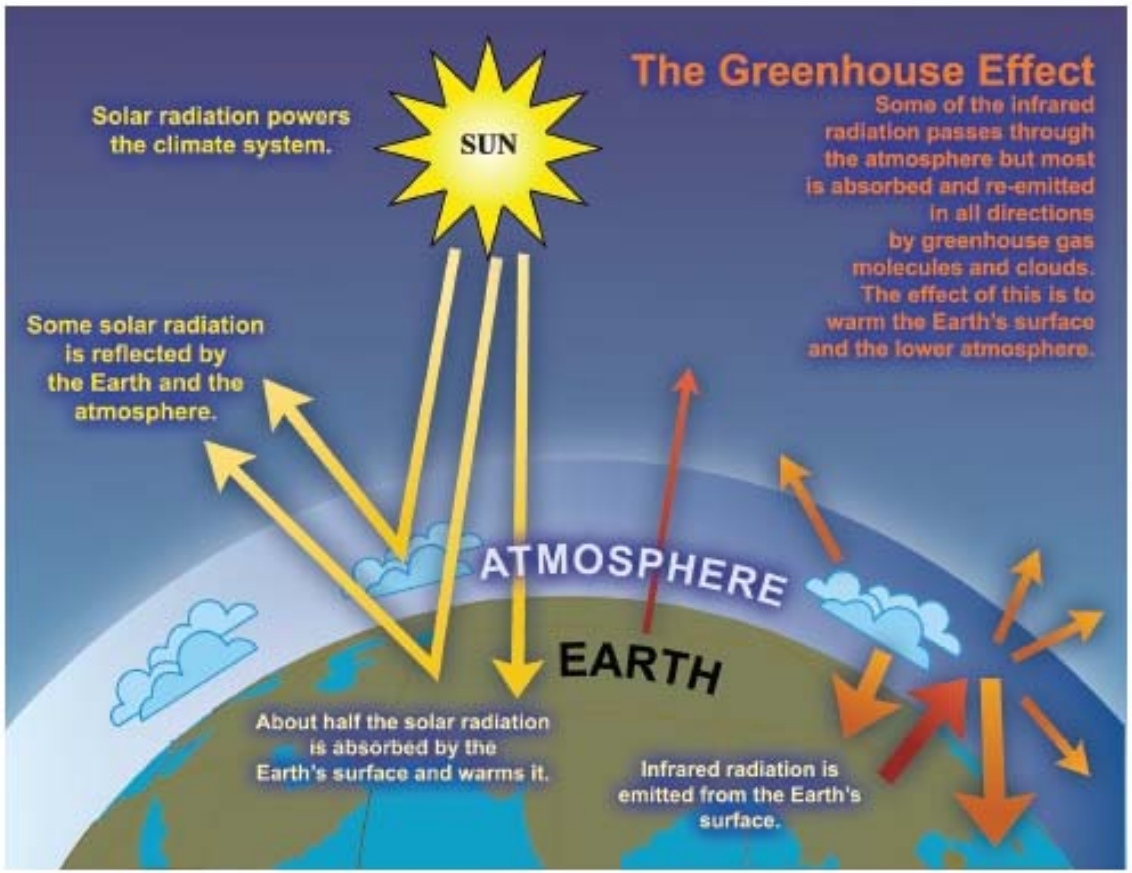
Photonic Network

I. Monitoring technologies: Remote sensing

NICT conducts remote sensing R&D:

I-1. Laser sensing of CO2

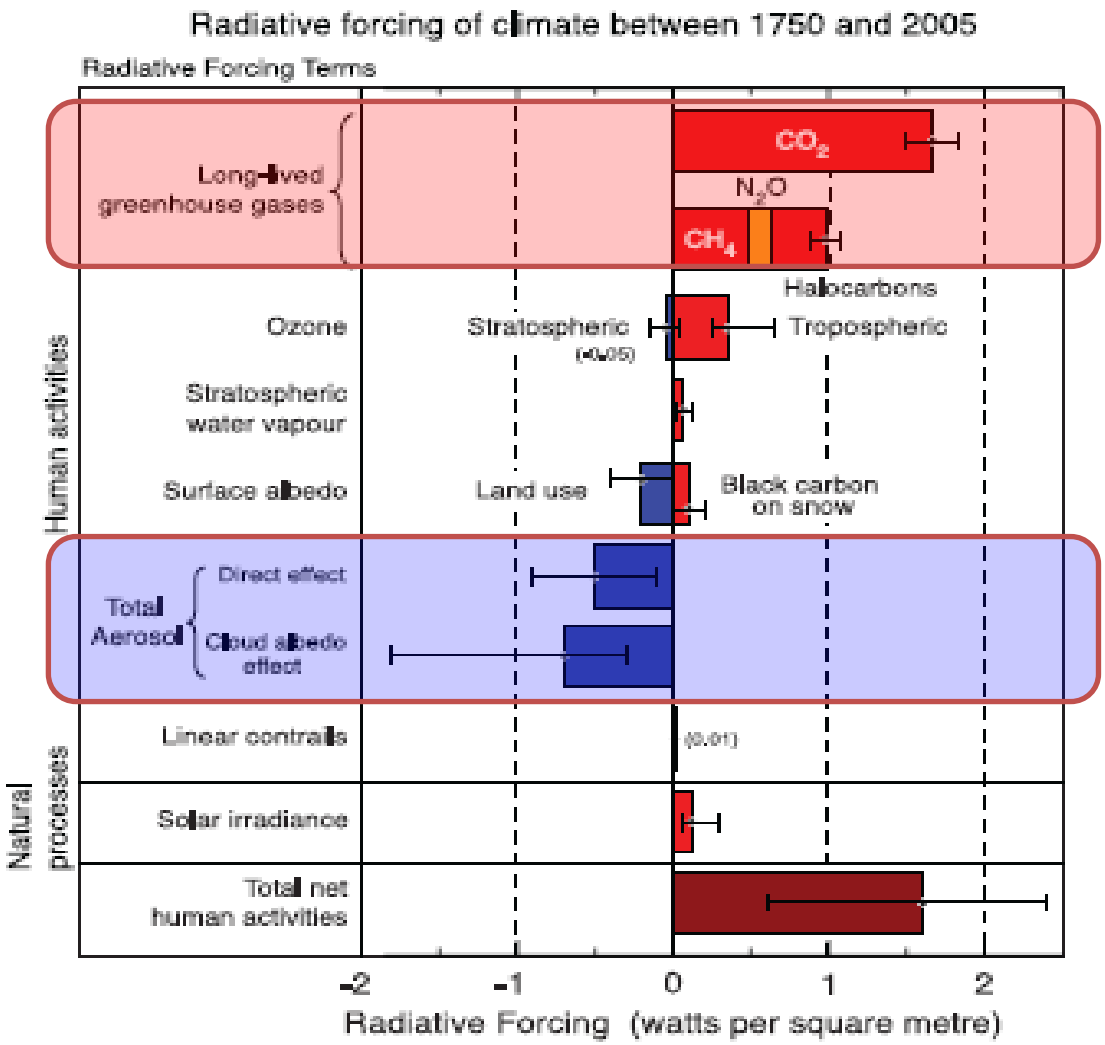
I-2. Global monitoring of cloud with millimeter radar



Greenhouse Gases:
CO2 and other GHG absorb outgoing long waves; resulting In warming

Cloud and Aerosol: direct and indirect (cloud- albedo) effect of aerosol cause cooling with biggest uncertainty

Radiative forcing Elements



IPCC AR4

- CO2 is the largest positive Element with small uncertainty
- Cloud albedo is the largest Negative element with biggest Uncertainty;
- Monitoring of these two elements Is available by remote sensing developed by NICT

NICT developed a CO_2 laser sensor

- DIAL (Differential absorption Lidar) technique applied;
- High power 2 μm wavelength laser is used with coherent detection;
- Test measurement system performs good coincidence with an in-situ sensor

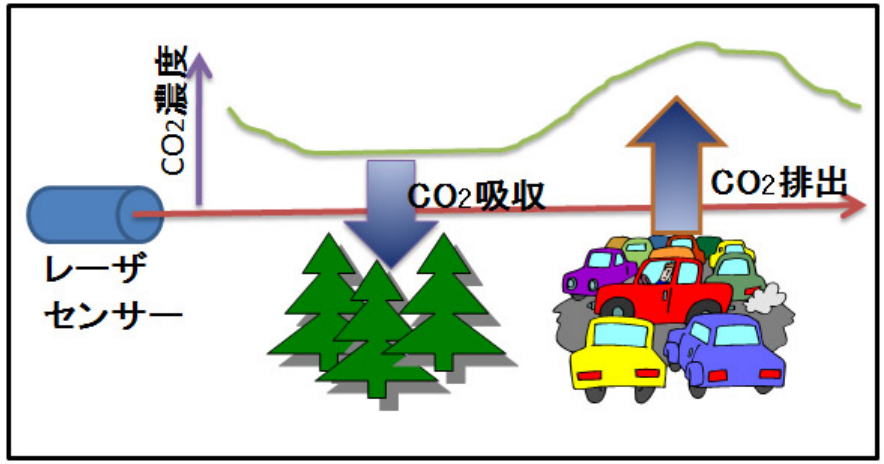
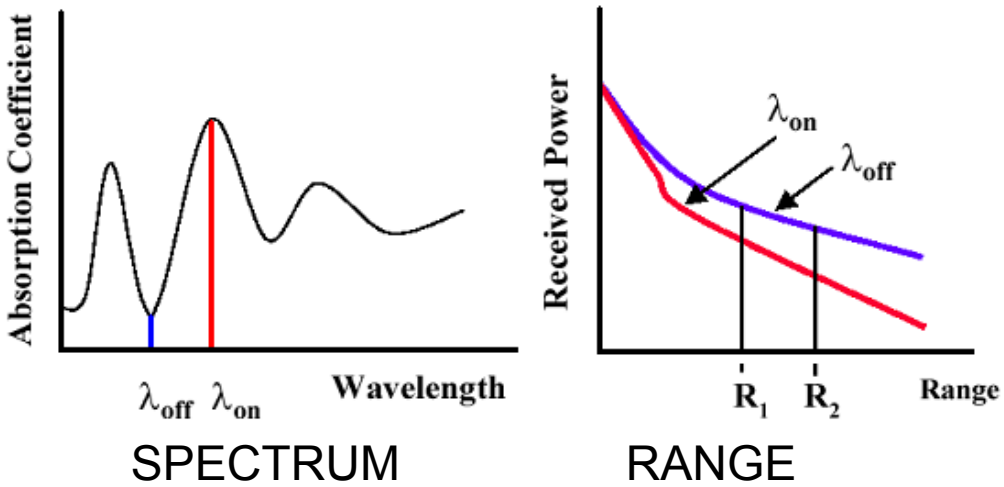


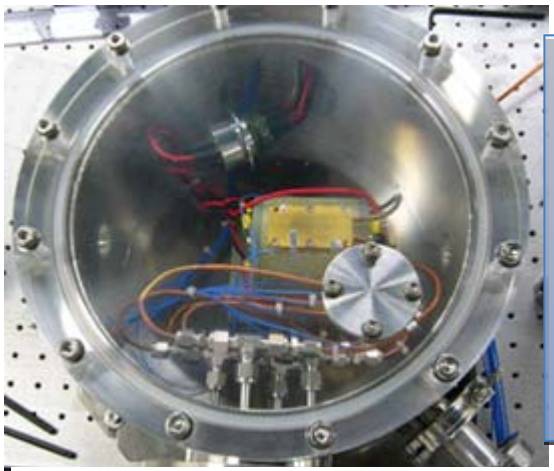
Image of local CO2 measurement



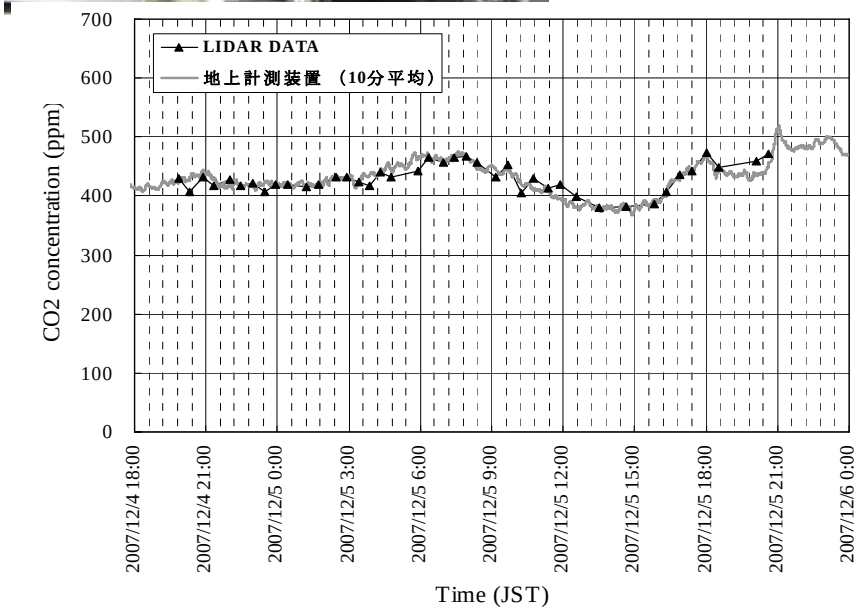
Differential absorption lidar operates at two wavelength, one with large absorption and the other with small absorption with a gas, enabling us to estimate gas content

Principle of DIAL measurement

Characteristics and test measurement of NICT CO_2 DIAL



◆Tm,Ho:YLF laser with 12 LD packages;
◆Rod cooling down to –80C LD controlled to 20C



Diurnal variation of CO_2 content visible

Special feature of NICT 2 μm coherent DIAL

- Eye-safe laser can be used horizontal and downward emission
- Spatial resolved capability
- Both daytime and nighttime usable
- Wind speed is measured as well;
- Solid state conductive cooling laser is used (good for mobile and satellite application);

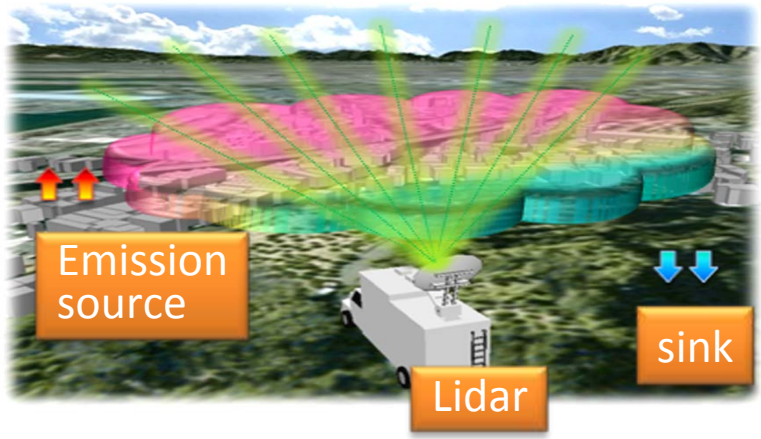
Plan for development of mobile system and field measurements

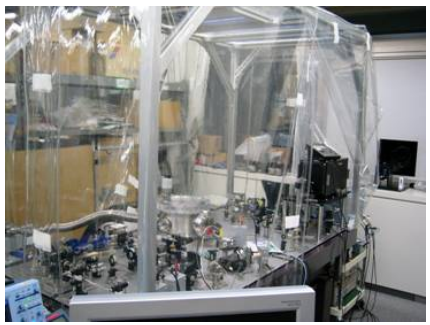
Present

2008-2010

2011-
Field measurement

Mobile system



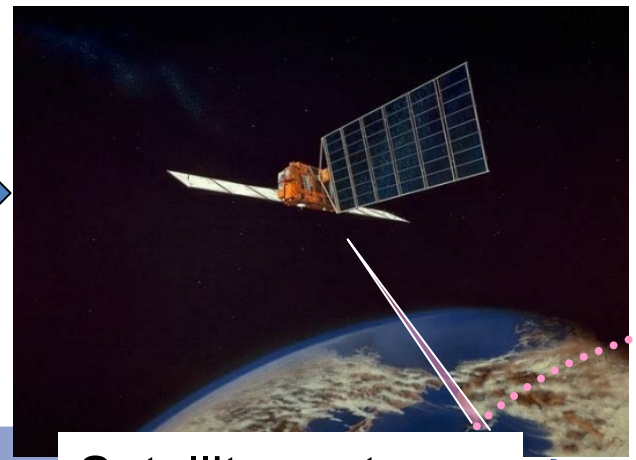


Laboratory system

Satellite validation

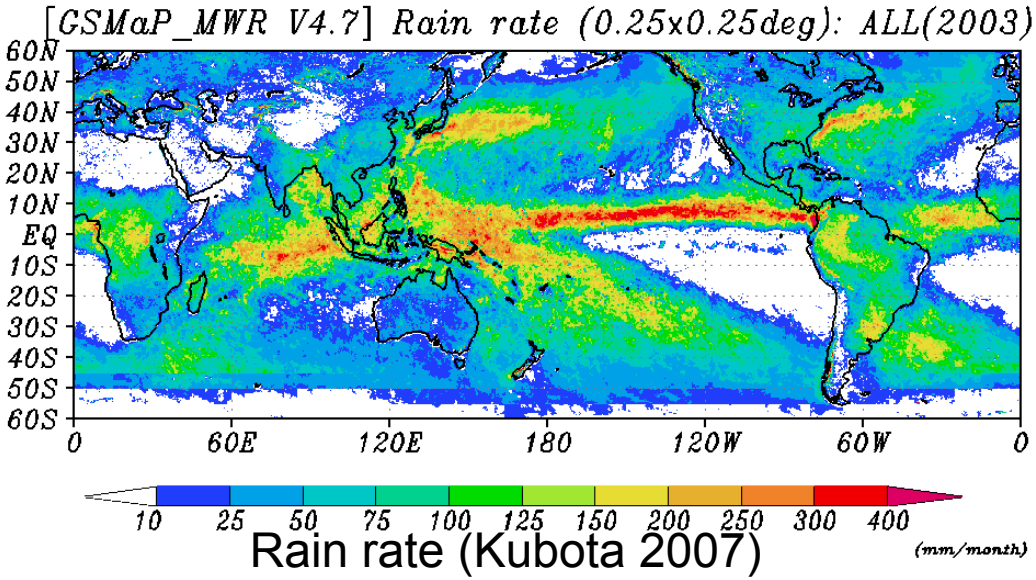
Global emission distribution

Airborne system

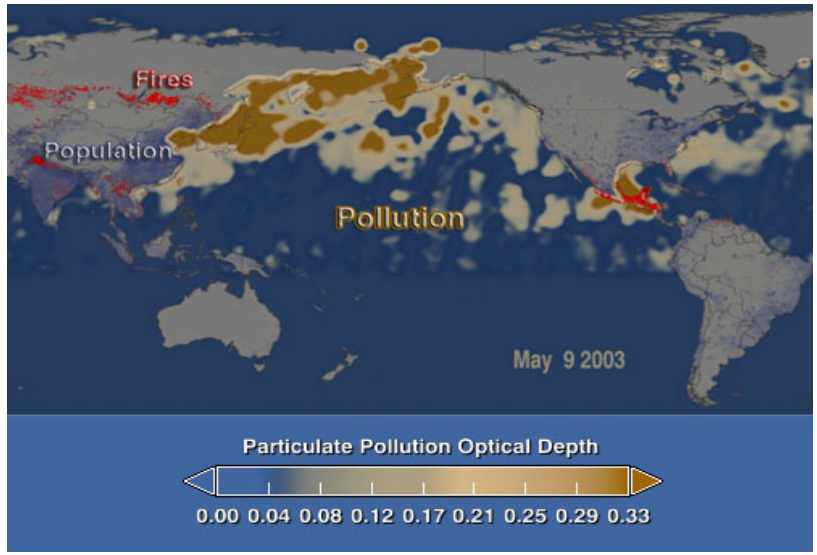


Satellite system

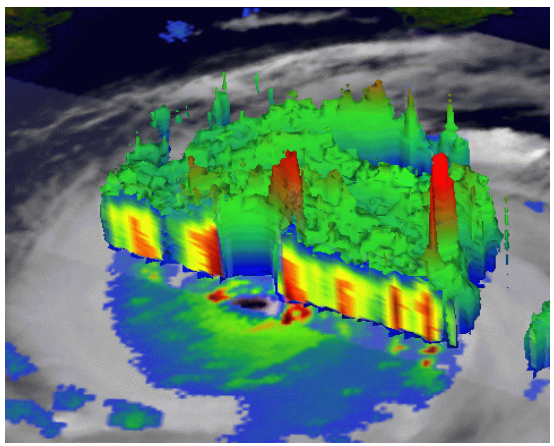
Cloud, Rain and Aerosol play significant role in the climate change



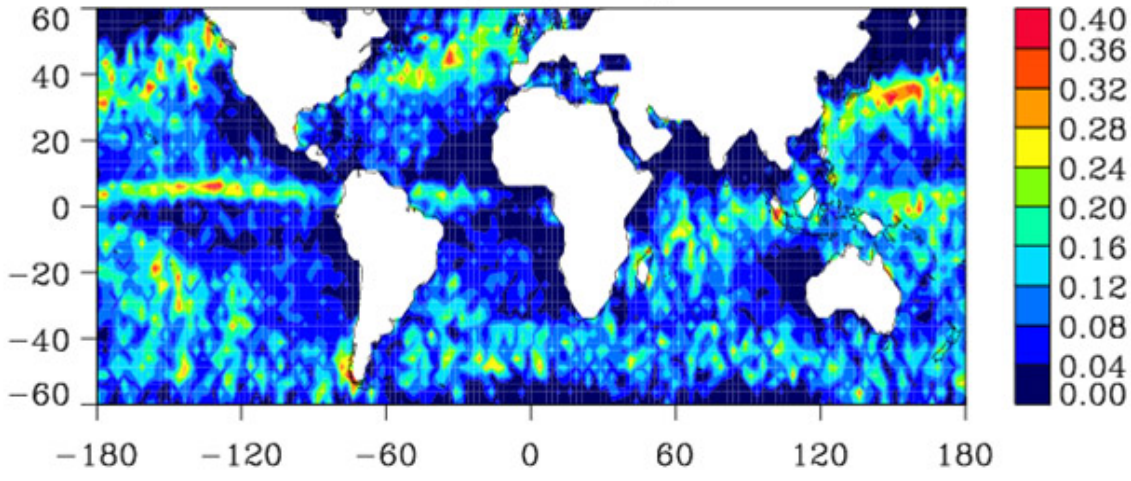
Rain rate (Kubota 2007)



Air pollution (NASA 08)



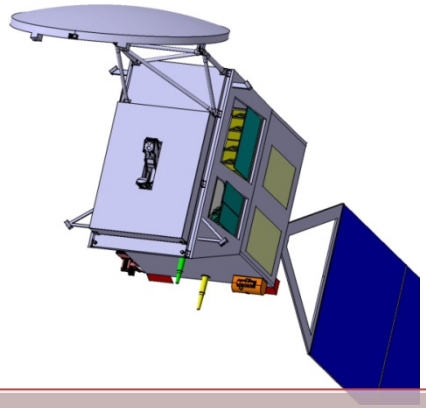
Hurricane Katrina 3D rain map taken by TRMM PR(2005 Aug)

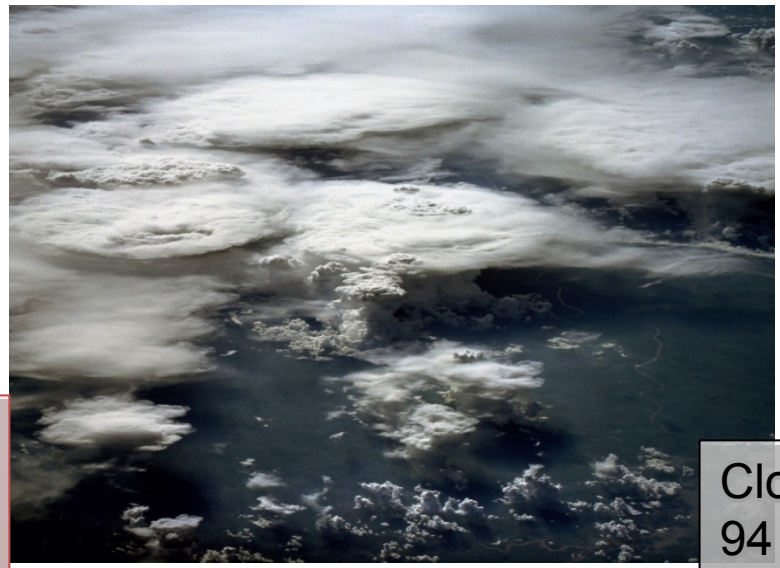


Rain production ratio over cloud occurrence (NASA 08)

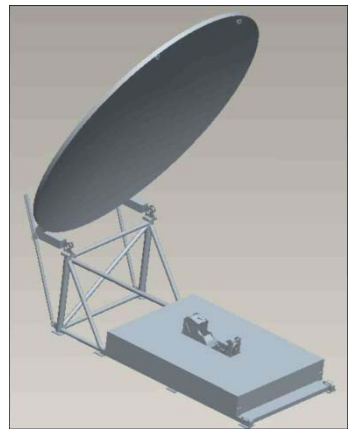
EarthCARE Mission

http://www.esa.int/esaLP/ASESMYNW9SC_LPearthcare_0.html





Tropical Cumulonimbus seen from space shuttle



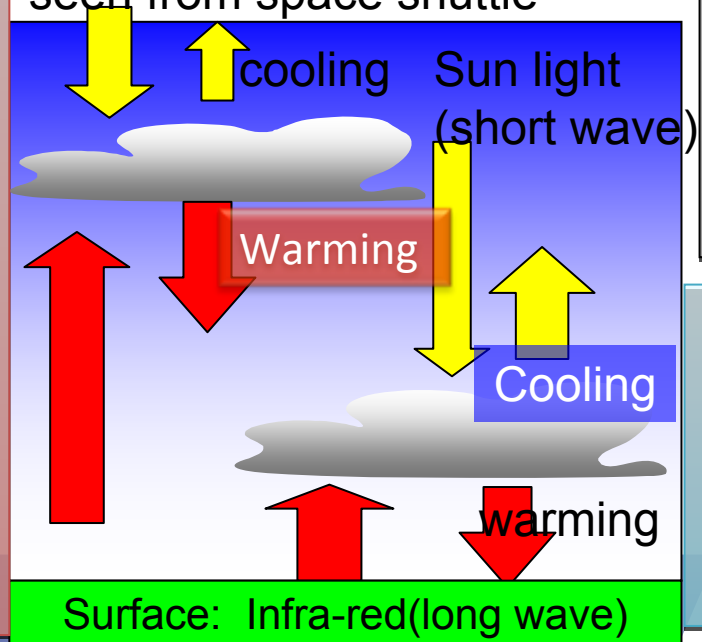
EarthCARE (Cloud, Aerosol and Radiation Explorer) Mission

To study interactions between cloud, radiative and aerosol processes that play a role in climate regulation;

Payload sensors

- Cloud profiling radar
- Atmospheric lidar
- Multi spectral imager
- Wideband radiomete

Launch date 2013



Cloud Profiling Radar
94 GHz with Doppler capability
Sensitivity -35 dBZ
Vertical resolution 500m
Doppler accuracy 1m/s

NICT and JAXA develop

Cloud height information is an important parameter for radiation budget, which is only obtained from Cloud radar;

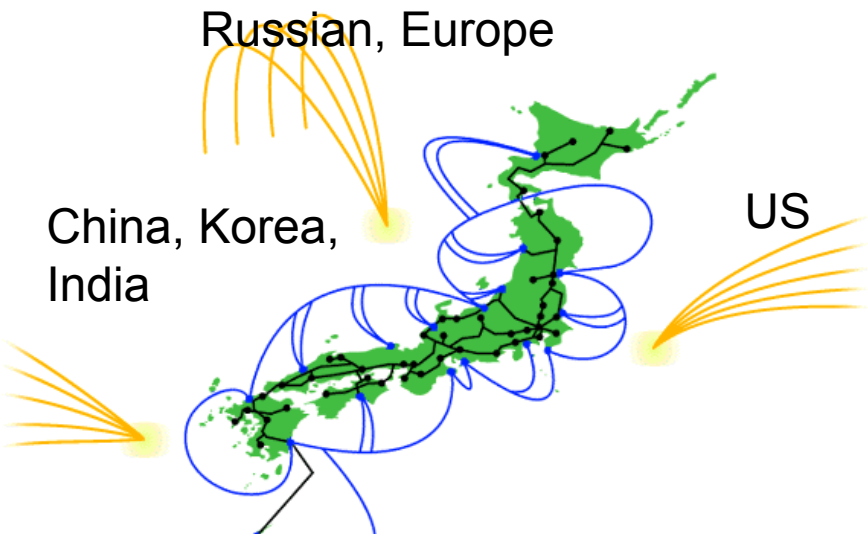
2. R&Ds for energy efficient ICTs
2-1 Photonics approach: for highly efficient broadband NW

Growing Demands of Internet Traffic in Japan

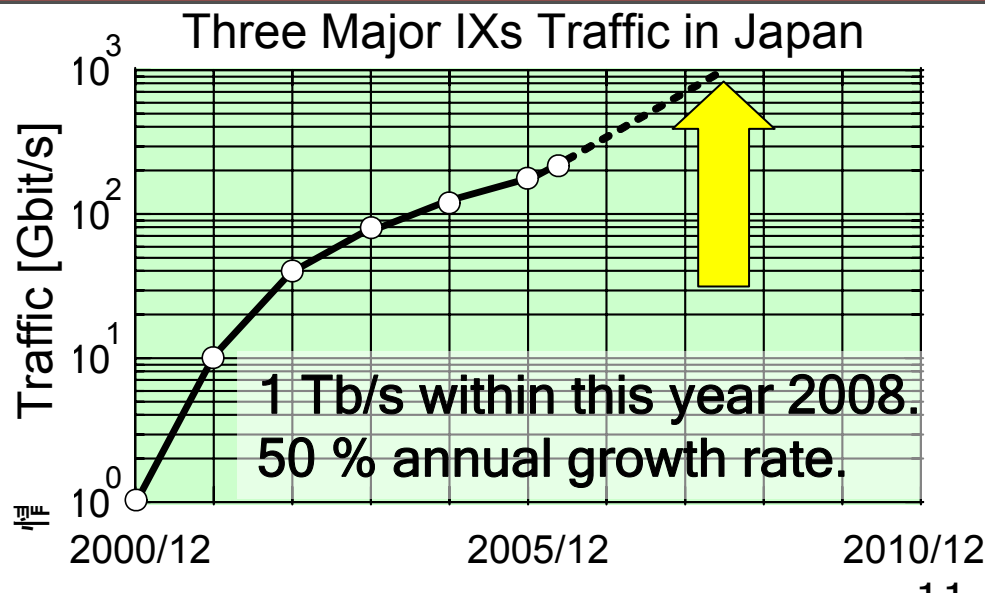
Annual growth rate of internet traffic in Japan has been ~ 50 %
（It was estimated by summation of traffic among major three IXs in Japan.）

Total traffic amount will reach 1 Tbit/s (1000 Gbit/s) within the year 2008;
1 Peta bit/s will be realistic in 2030th.

Can current technologies sustain Peta bit/s networks?



Current Backbone Optical Network

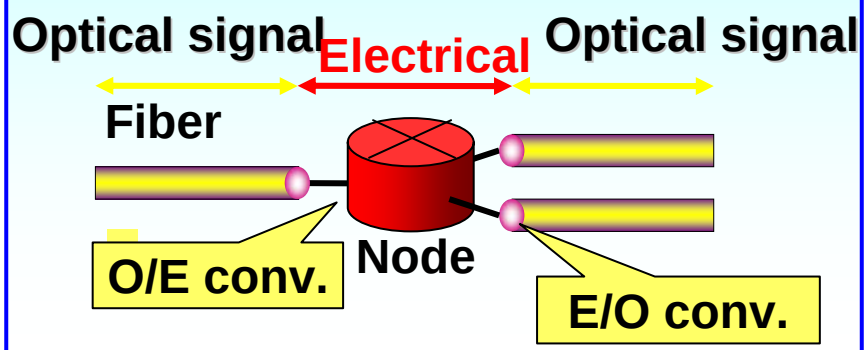


http://www.soumu.go.jp/s-news/2006/060310_8.html
http://www.soumu.go.jp/joho_tsusin/policyreports/chousa/jise_ip/

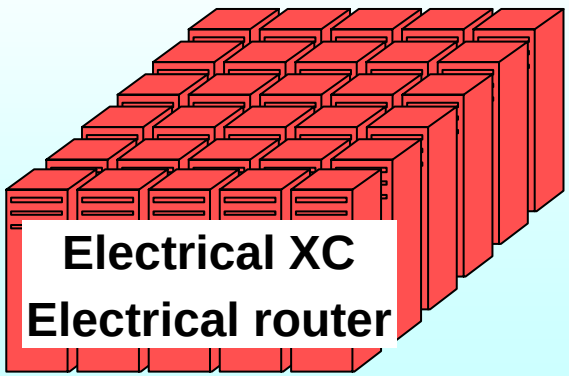
Why Optical Packet Switching ?

Current Optical Network

- Opaque electrical network
- Many Opt. ←→ Elec. conversion

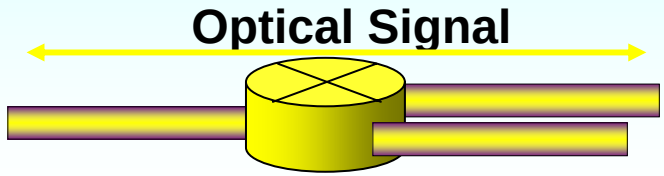


- Electrical processing << 100 Gb/s
- Huge power consumption
  > MW @ 100Tb/s

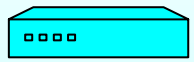


Future Optical Network

- Transparent throughout network
- Less Opt. ←→ Elec. Conversion

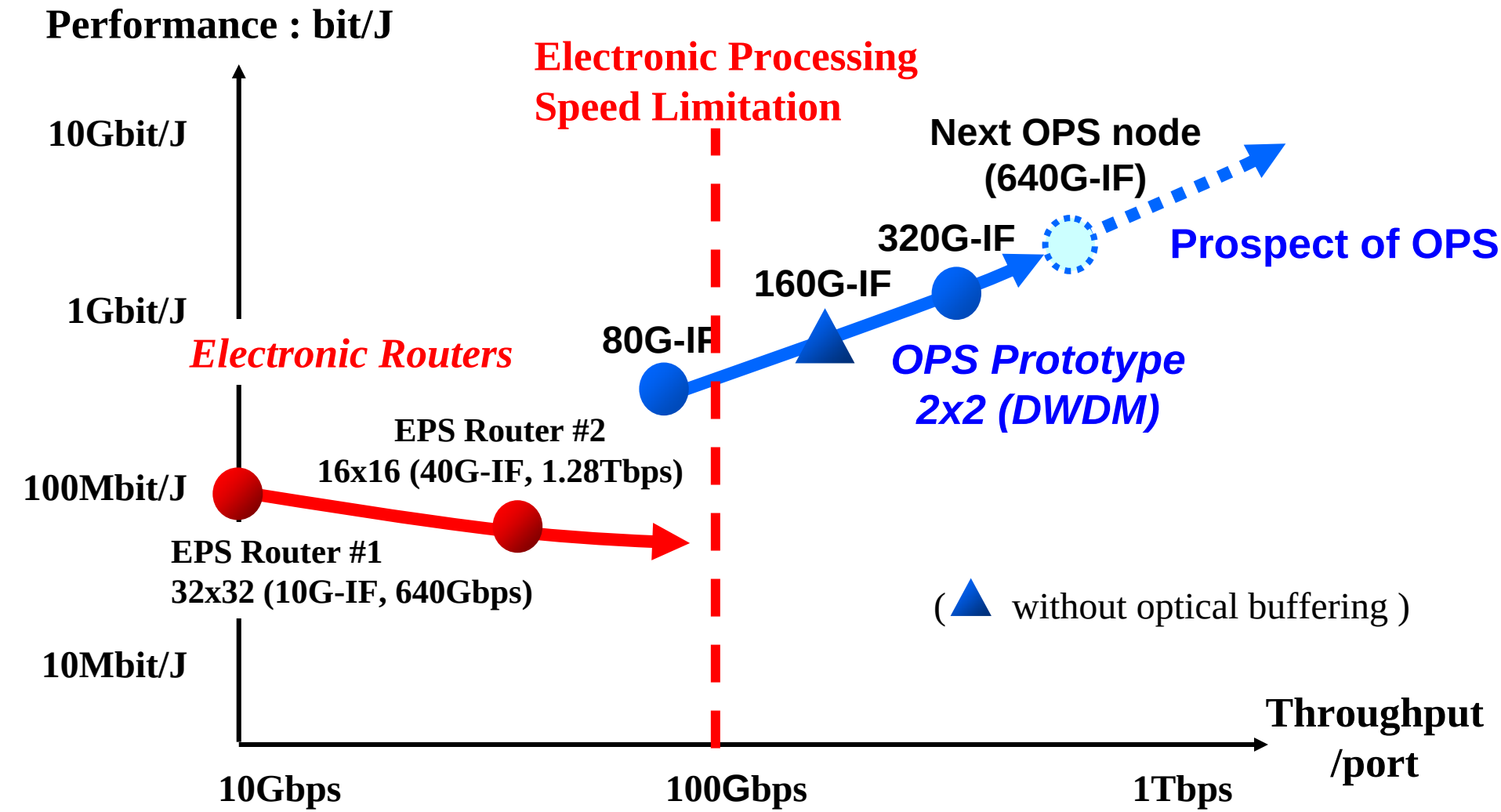


- Ultrafast optical processing
- Low power consumption
- Small footprint



Optical Packet Switch for Peta bit/s network

A solution to high speed node with low power consumption



EPS: Electronic Packet Switch
OPS: Optical Packet Switch

OPS Prototype Development by NICT

1.28T
(10G x 128λ)

160G
(10G x 16λ)

80G
(10G x 8λ)

40G

160G

WDM packet

TDM packet

Throughput / port (bit/s)

1.28T
640G
320G
160G
80G
40G
20G
10G

2001 2002 2003 2004 2005 2006 2007 2008

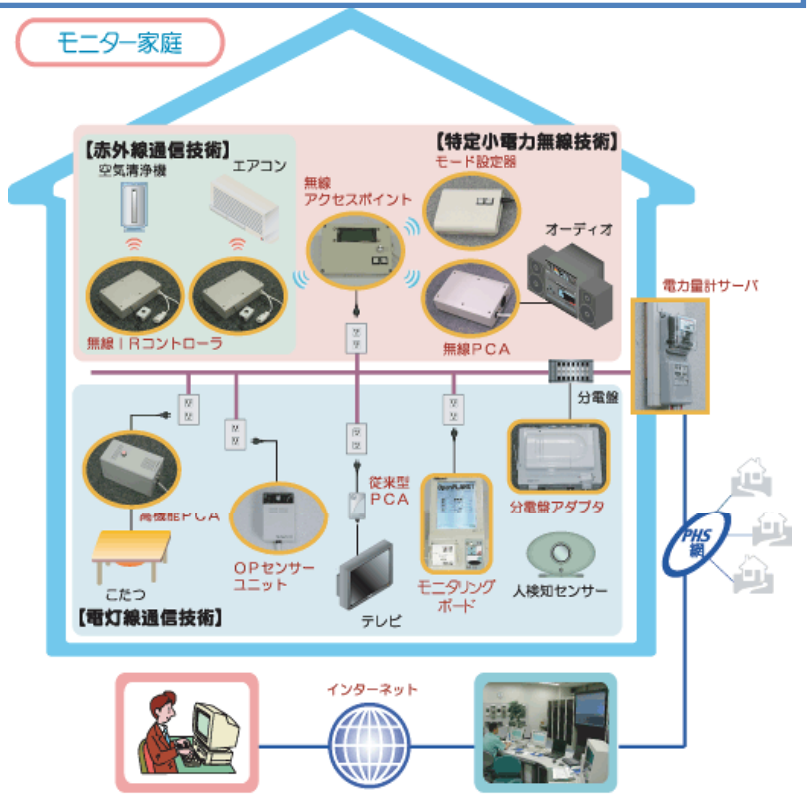
Year

(▲ without optical buffering)

2-2Ubiquitous sensor network approach:
Proposed Proactive HEMS and BEMS

Conventional HEMS and BEMS

To optimize operation and control of home appliances or office equipments with techniques as real time monitoring and data visualization;



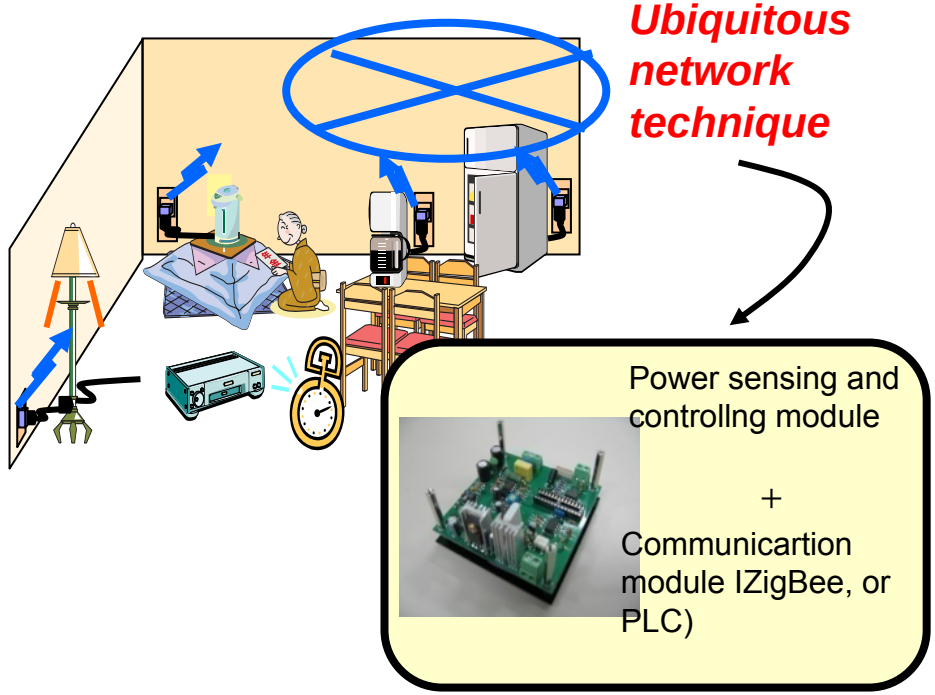
四国電力
データセンターを通じて、さまざまな省エネルギーサービスをエージェントプログラムの形で各家庭へ配信

データセンター
電力の通信／データの蓄積、管理

出典:四国電力(株)
OpenPLANETのHPより

Proactive HEMS and BEMS

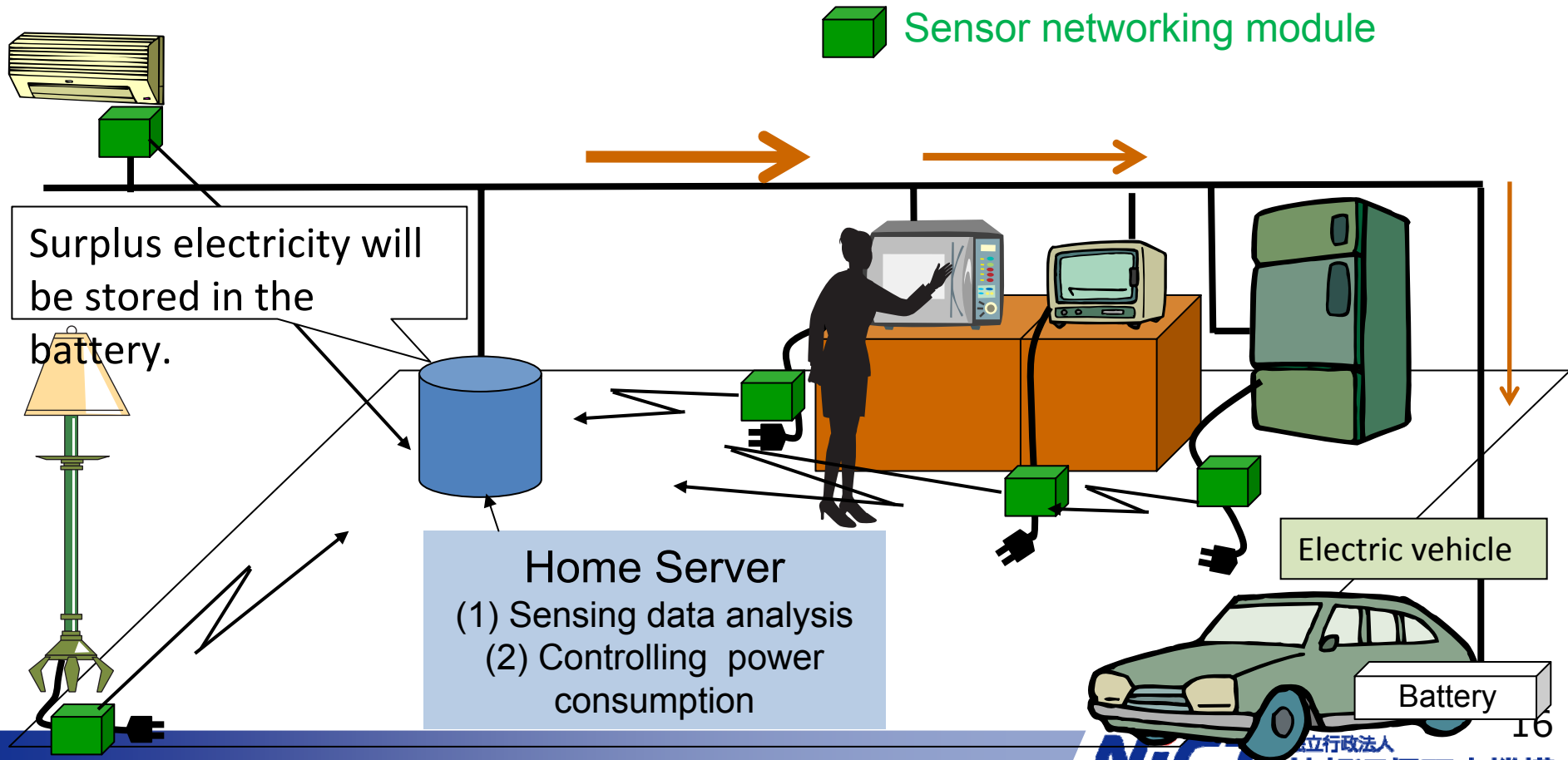
Status and power consumption data are collected from all electric instruments and network-based coordinated control is applied to them; maximum energy saving with maximum comfort achieved;



HEMS: Home Energy Management System
BEMS: Building and Energy Management System

Ubiquitous Sensor Network in Home

Sensing modules attached to all electric instruments form a home ubiquitous sensor network. The modules also control the power consumption of the electric instruments.



Summary and conclusion

- A novel ICT approach proposed to combine sensing and controlling to find optimized measures for climate change;

- Monitoring with ICT:
  - A new laser remote sensor to measure CO_2 distribution is established, which enables us to estimate CO_2 flux in both global and local scales.
  - Satelliteborne cloud profiling radar to monitor global 3D cloud field for joint Europe and Japan program of EarthCARE is under development, for better understanding of cloud aerosol process, thereby improving global warming prediction;

- Improve efficiency in network and energy systems:
  - Optical packet switching has been developed for future target of terabit/s speed with reasonable power consumption.
  - Ubiquitous sensor network technique is proposed to realize smarter proactive HEMS and BEMS;