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# Framework of energy saving for Future Networks

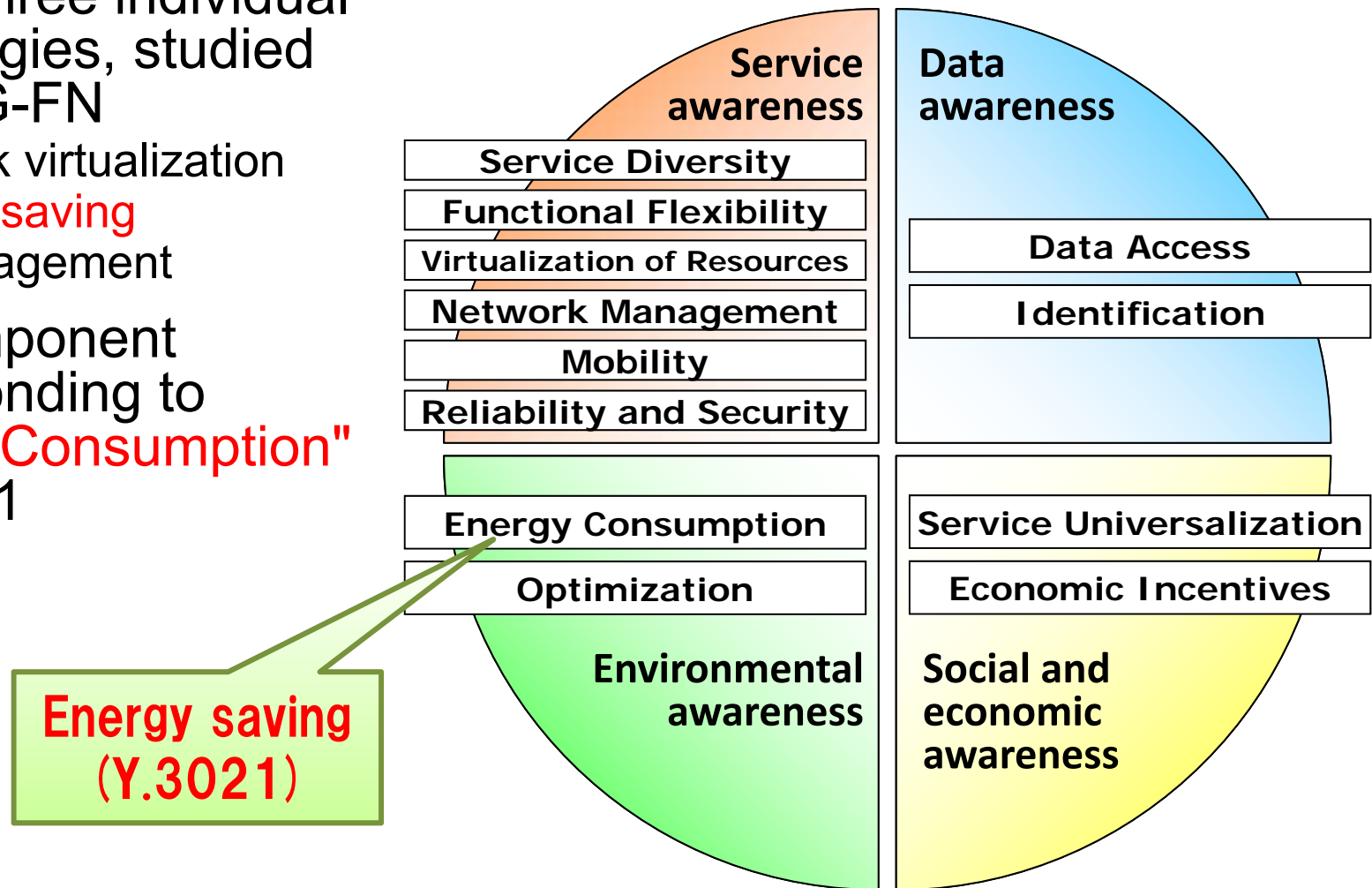## - ITU-T Recommendation Y.3021 -

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Dec. 5, 2011

# Position of energy saving in FN

- **One of three individual technologies, studied since FG-FN**
  - Network virtualization
  - Energy saving
  - ID management

- **Key component corresponding to "Energy Consumption" in Y.3001**

Energy saving
(Y.3021)

| Service awareness | Data awareness |
|---|---|
| Service Diversity | |
| Functional Flexibility | |
| Virtualization of Resources | Data Access |
| Network Management | Identification |
| Mobility | |
| Reliability and Security | |

| Environmental awareness | Social and economic awareness |
|---|---|
| Energy Consumption | Service Universalization |
| Optimization | Economic Incentives |

**4 Objectives and 12 Design Goals in FN（Y.3001）**

# Scope

■ Scope of Y.3021

- ■ Describe the necessity for energy saving

- ■ Review potential technologies

- ■ Identify multiple viewpoints to be considered

- ■ Identify major functions and their cyclic interactions

- ■ Analyze possible impacts by introducing the technologies

- ■ Itemize high-level requirements

Reference： TD-241(PLEN/13)
Newly consented in SG13 Oct. Meeting

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# Background

- ■ **Definition of "Energy-saving of Networks"**

  - ■ <u>Network capabilities and their operations</u> where the total energy for network equipment is systematically used in an efficient manner and, as a consequence, <u>the energy consumption is reduced</u> compared with networks without those capabilities and operations.

- ■ **Why needed ?**

  - ■ Reasoning
    - • **Individual benefits:** reduction of energy costs and heat
    - • **Social perspective:** reduction of environmental impact, e.g., GHG emission

  - ■ Two aspects from network
    - • Green by Future Networks → Energy saving of non-ICTs using FNs
    - • Green of Future Networks → Energy saving of FNs themselves

  - ■ Y.3021 focuses on **"Green of Future Networks"**

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# Prediction of network energy consumption

- In global environment, IP traffic is estimated to increase by 34% every year

  → IP traffic of 2025 will be 350 times that of 2005

- Accordingly, network energy consumption in 2025 is predicted to be 6.2 times the 2005 level

  → The share among all industries' energy consumption will also increase

**Energy saving of networks is becoming more important**



Prediction in global environment

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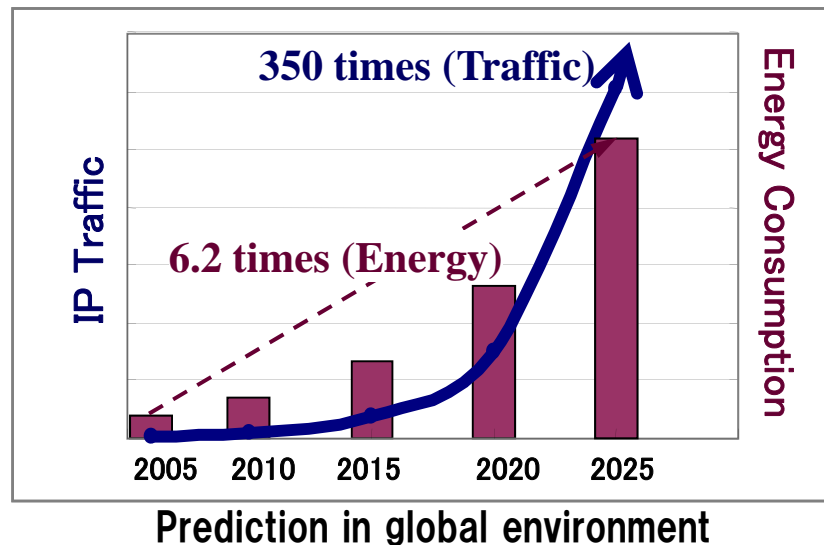
# Technology levels to be considered

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- ## Device level
  - Technologies which are applied to electronics devices such as LSI and memory

- ## Equipment level
  - Technologies which are applied to one piece of equipment (a set of devices) such as a router or switch, etc.

- ## Network level
  - Technologies which are applied to equipment within the whole network (e.g., routing protocol applied to multiple routers)

# List of technologies
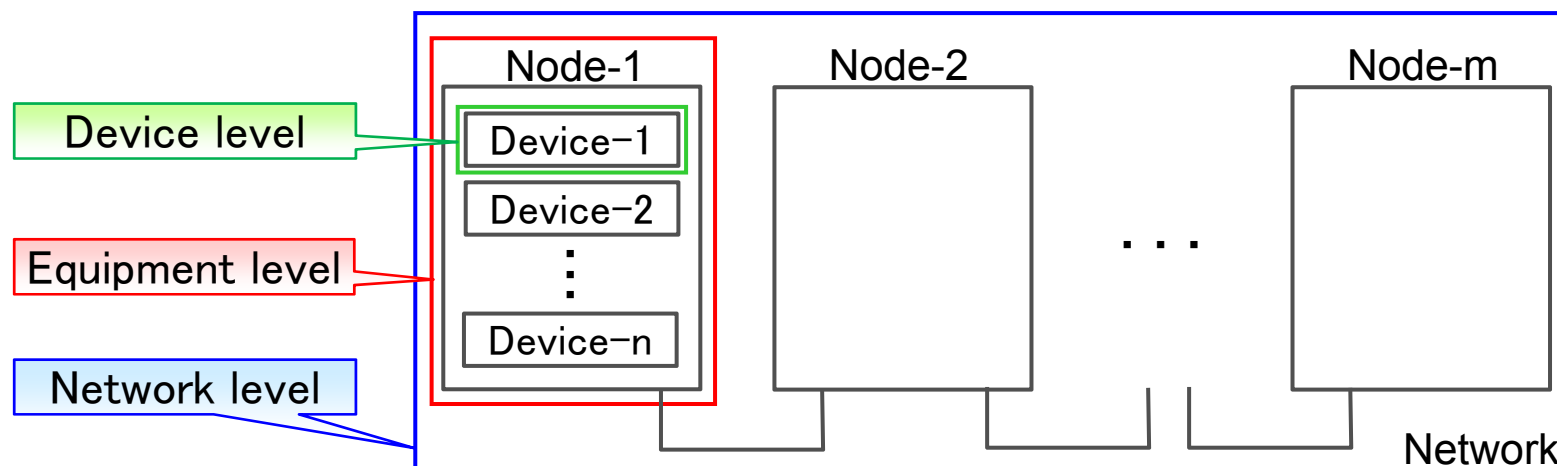
- **Device-level technology**
  - LSI micro fabrication, Multi-core CPU, Clock gating, Power-aware virtual memory, Advanced Power Amplifier (PA)

- **Equipment-level technology**
  - Optical network node, Sleep mode control, ALR/DVS, Thermal design, Cache server, Filtering, Sorry server, Shaping, Compact base transceiver stations (BTSs), Smart Antenna Technologies, Relay station

- **Network-level technology**
  - Circuit/burst switching, Energy Consumption-based routing/traffic engineering, Lightweight protocol, Transmission scheduling, CDN, Traffic peak shifting, Small-cell design, Energy Consumption-aware network planning

Rivew these technologies → Identify essential approaches and functions

# Target area of this Recommendation

- **"Green of FN" or "Green by FN"**

  → "Green of FN"

- **Stages in a lifecycle**

  → The use stage, which includes pre-operation and operation phases

- **Levels of technologies**

  → Three levels of technologies (device-, equipment-, and network level)

- **Type of methods for energy saving**

  → Technical methods

# Approaches for energy saving

**1) Reduction of required network capacity**
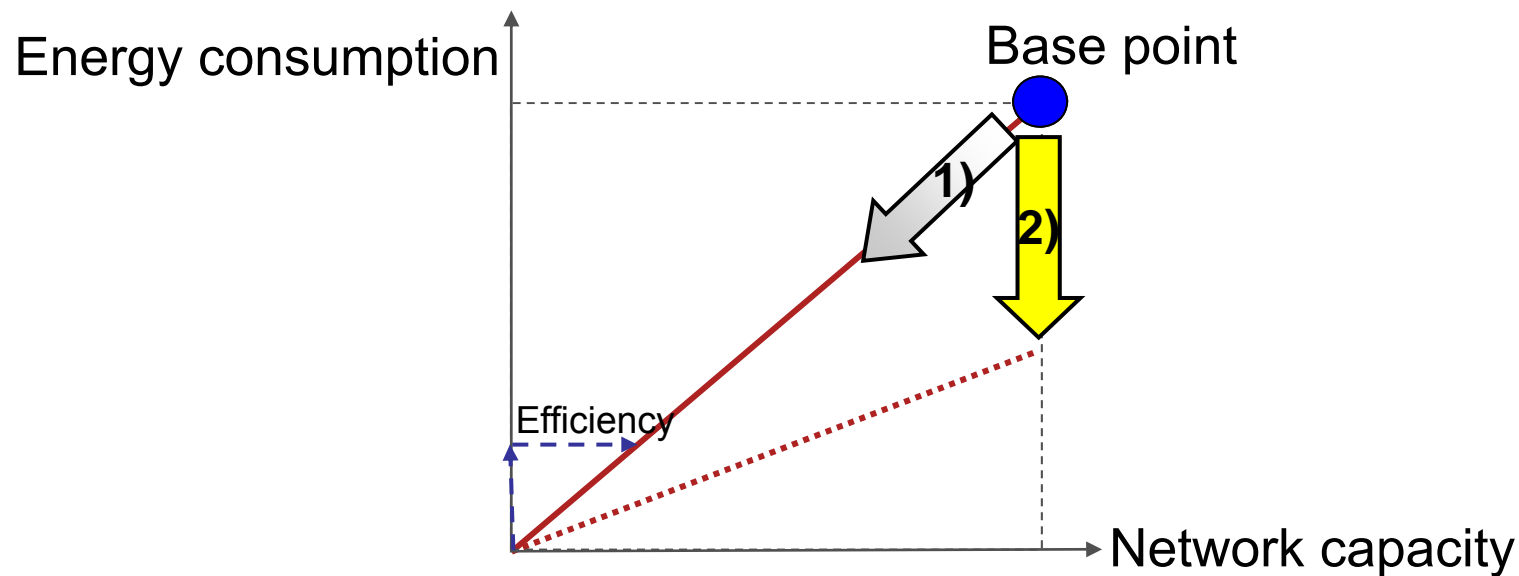
1-1) Reduce the volume of traffic as a whole network

1-2) Shift the traffic at peak time, which reduces the maximum capacity

**2) Improvement of efficiency**

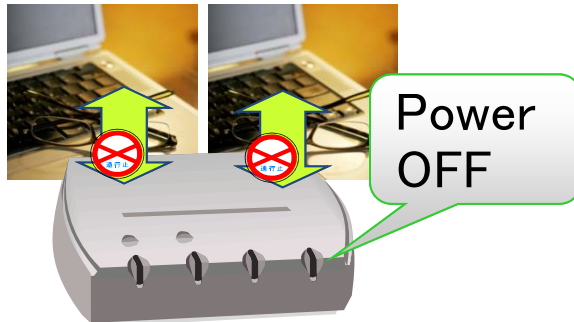2-1) Control device/equipment operation according to traffic dynamics

2-2) Forward traffic with less power

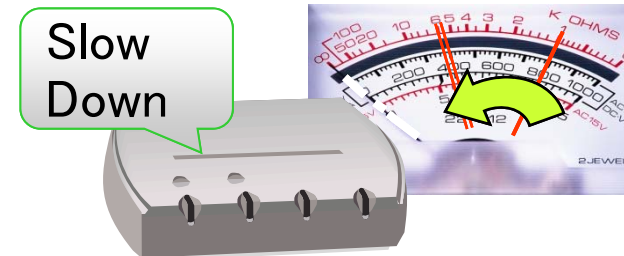→ Includes more potential network technologies



cf) **Network energy efficiency:** Throughput of the network divided by the power consumed. It is usually expressed in bps/W.

# Control operation to traffic dynamics

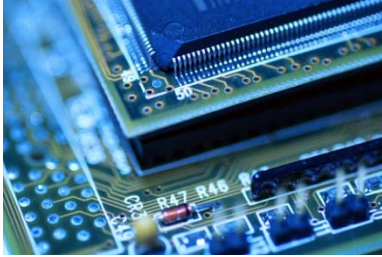■ **Example**



Power OFF

Slow Down

■Sleep mode control

■Dynamic Voltage Scaling (DVS)

■ **Method**

■ Putting a device to "sleep mode" when it is not in use

■ Reducing the traffic-forwarding capacity of a device when traffic volume is low

⇔ Current devices are always on, and always at full capacity

# Forward traffic with less power

## ■ Example



■LSI micro fabrication



■Optical network node

## ■ Method

- ■ Reduce the necessary power for the given throughput

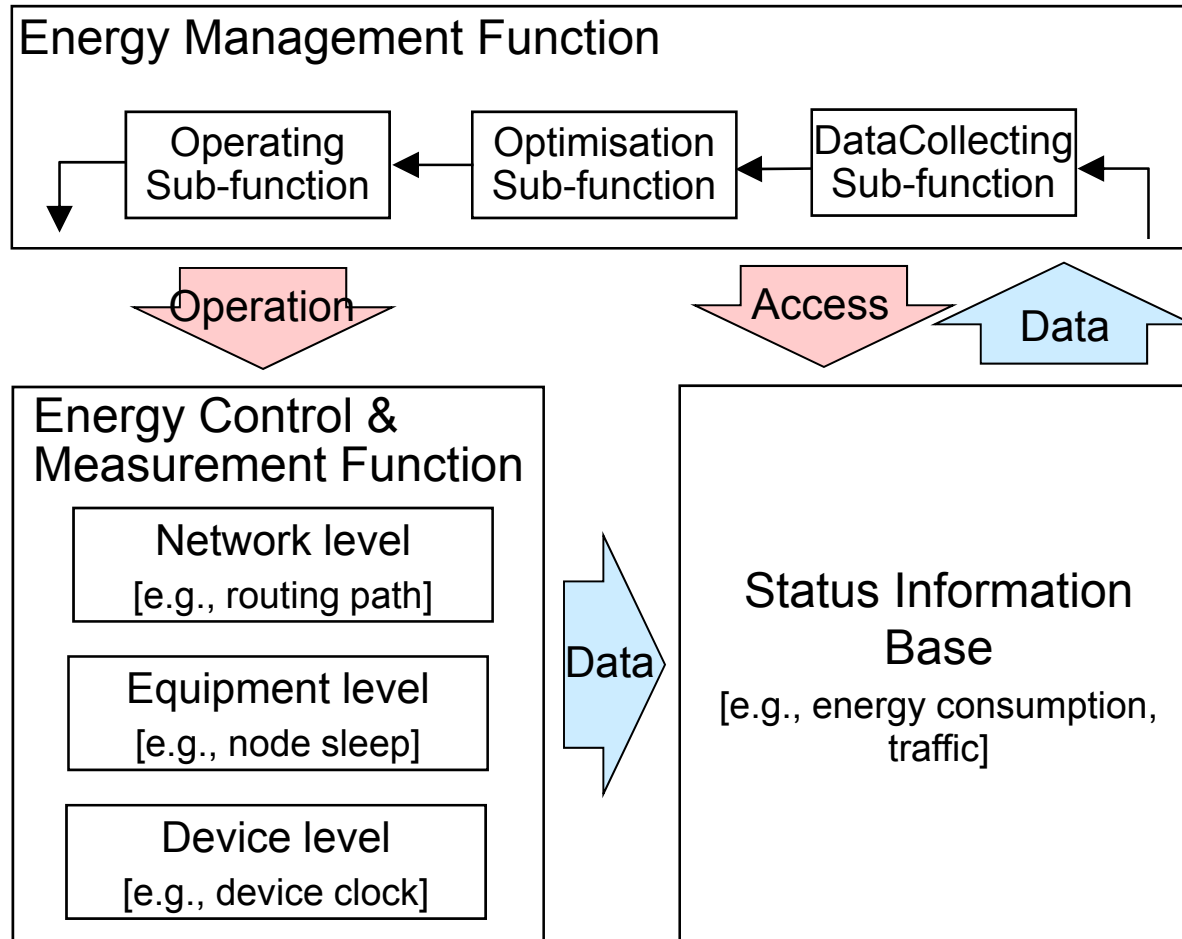$$\text{Network energy efficiency} = \frac{\boxed{Throughput} \; : \textbf{\textit{given}}}{\boxed{Power} \; : \downarrow\textbf{\textit{reduce}}}$$

- ■ Not only device-level technologies, but also equipment- and network-level technologies are important

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# Classification of technologies

| Approach / Tech. level | 1) Reduction of capacity | | 2) Improvement of efficiency | |
|---|---|---|---|---|
| | 1-1) Reduce traffic | 1-2) Peak-shift | 2-1) Dynamic ctl. | 2-2) Less power |
| Device | | | - Multi-core CPU<br>- Clock gating<br>- Power aware virtual memory | - LSI fabrication<br>- Advanced Power Amplifier |
| Equipment | - Cache server<br>- Filtering | - Sorry server<br>- Shaping | - Sleep mode control<br>- ALR/DVS | - Optical node<br>- Thermal design<br>- Compact BTSs<br>- Smart Antenna Technologies<br>- Relay station |
| Network | - CDN | - Traffic peak shifting | - Routing/traffic engineering<br>- Energy-aware network planning (dynamic) | - Circuit/burst switching<br>- Light protocol<br>- Txt. scheduling<br>- Small-cell design<br>- Energy-aware network planning (static) |

# Possible functions and their interactions

**Energy Management Function**

Operating Sub-function ← Optimisation Sub-function ← DataCollecting Sub-function

Operation

Access     Data

**Energy Control & Measurement Function**

Network level
[e.g., routing path]

Equipment level
[e.g., node sleep]

Device level
[e.g., device clock]

Data →

**Status Information Base**
[e.g., energy consumption, traffic]

- Energy Control & Measurement Function
  - Includes a set of various energy saving technologies and energy measurement technologies

- Energy Management Function
  - Collects basic information, calculates the optimum case of operation, and issues operation commands

- Status information Base
  - Is a database which includes a set of energy-related information

# Energy Management Function

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- ■ **Includes three sub-functions:**
  - ■ **DataCollecting Sub-function:** Collects the necessary status information about network nodes from the Status Information Base
  - ■ **Optimisation Sub-function:** Decides which management operation should be performed on which network node to minimise total power consumption
  - ■ **Operating Sub-function:** Sends an operation request to the Energy Control & Measurement Function of a network node

# Combination models of functions

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**Network Management Server**

Energy Management Function (Global)

**Network node**

Energy Management Function (Local)

Energy Control & Measurement Function
- Network level
- Equipment level
- Device level

Status Information Base

**Network Management Server**

Energy Management Function

**Network node**

Energy Control & Measurement Function
- Network level
- Equipment level
- Device level

Status Information Base

**Network node**

Energy Management Function

Energy Control & Measurement Function
- Network level
- Equipment level
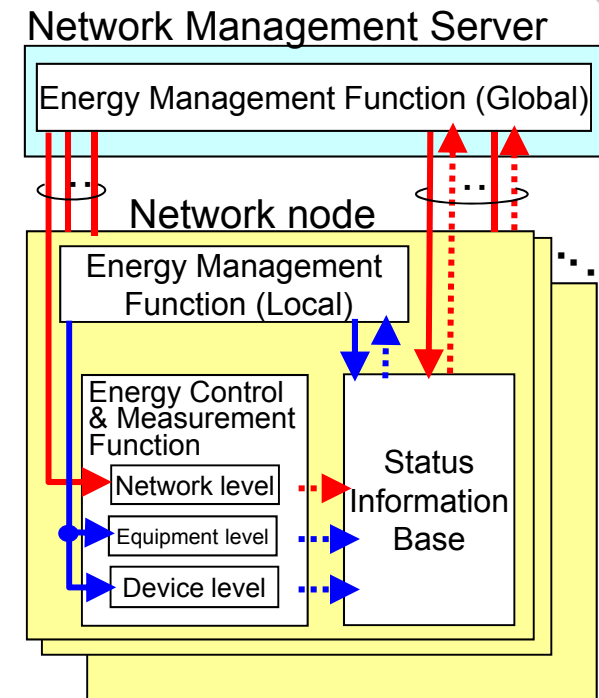- Device level

Status Information Base

(A) Local loop model

e.g., to control device clock according to the traffic
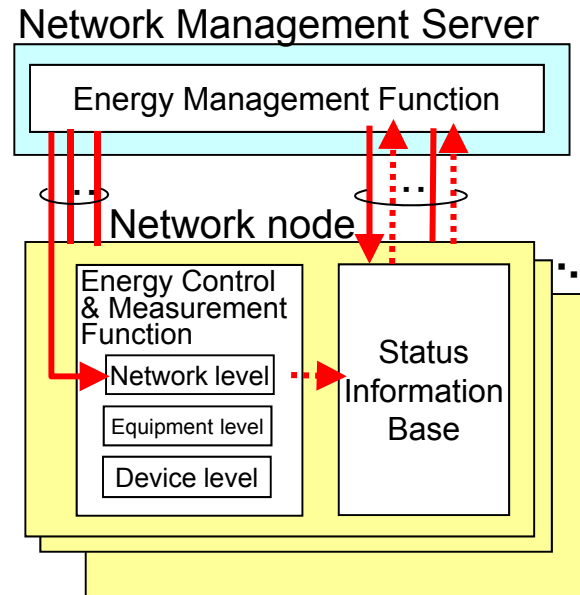
(B) Global loop model

e.g., the routing which assigns least power consumption route

(C) Combined loop model

e.g., energy-based routing, where global loop aggregates the traffic routes, and local loop puts the node to sleep in case of no traffic

# Impact analysis of energy-saving

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- **Influence on network performance**
  - **Issue:** Introducing energy saving technologies may change network performance such as the QoS, and may also influence security
  - **Requirement:** energy saving technologies should be applied so that the degradation of network performance, which is caused by the introduction of energy saving technologies, would fall within the acceptable range for specific services

- **Influence on service provisioning**
  - **Issue:** Provisioning of a certain new service, which usually requires extra capabilities and resources, could result in increased energy consumption
  - **Requirement:** on service provisioning, Energy saving technologies should be applied so that the increased consumption, which is caused by multiple simultaneous service provisioning, would fall within the acceptable range in order that individual service requirements are maintained (e.g., delay, loss, etc.)

# High level requirements (1/3)

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## ■Approaches

- ■ Reducing the volume of traffic to be forwarded by device or equipment
- ■ Shifting the traffic at peak time, which reduces the maximum capability
- ■ Controlling device/equipment operation according to traffic fluctuations
- ■ Forwarding traffic with less power by transmitting data on simplified mechanism

# High level requirements (2/3)

## ■ Functions
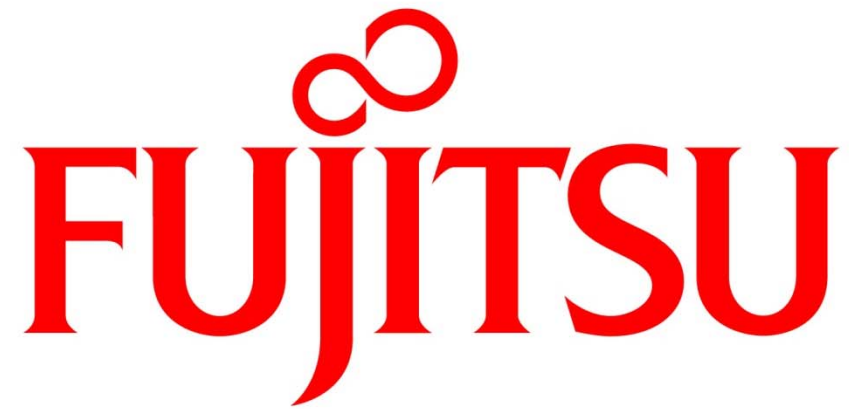
- Supporting Energy Control & Measurement Function, Energy Management Function, and Status Information Base

- Energy Control & Measurement Function performing control actions to reduce the energy consumption, and performing measurement of energy consumption

- Energy Management Function collecting basic information, calculating optimum case of operation, and issuing operation commands

- Status Information Base gathering basic information of the current mode

# High level requirements (3/3)

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■ **Influence to network performance**

- On introducing energy saving technologies, they are applied so that the degradation of network performance would fall within the acceptable range for the service

- On service provisioning, energy saving technologies are applied so that the increased consumption would fall within the acceptable range in order that individual service requirements are maintained

# Current status and next steps

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- Y.3021 has been newly consented in SG13 Oct. Meeting

- As the contents are high-level descriptions, more considerations and detailed documents are required in next step

  - Energy measurement, Sleep control, Energy-based routing, etc.

- Cooperation with other SDOs may be necessary

  - ITU-T SG5, ISO/IEC JTC1, IETF, etc.

# Related trends

**FUJITSU**

- **ITU-T FG-Smart Grid**
  - Studies energy saving in home network, and is working on baseline documents

- **ISO/IEC JTC1 SG-Green by ICT**
  - Was established in last Nov., and studies standardization on energy saving by using ICT

- **IEEE - Energy Efficient Ethernet (802.3az)**
  - Is a standard of energy saving in the Ethernet, which uses sleep mode control, etc.

- **IETF eman(Energy Management)-WG**
  - Studies standardization on energy saving from network management perspective, which includes monitoring and controlling of network equipment

- **GreenTouch Consortium**
  - Is international consortium to study technologies on energy saving of networks, in which Alcatel-Lucent etc. have participated

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