THE POSSIBILITIES ARE INFINITE FUJITSU

Smart Grid: Japan and US

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Fujitsu Laboratories of America, Inc.
January 21, 2010

Energy Source: Japan and US

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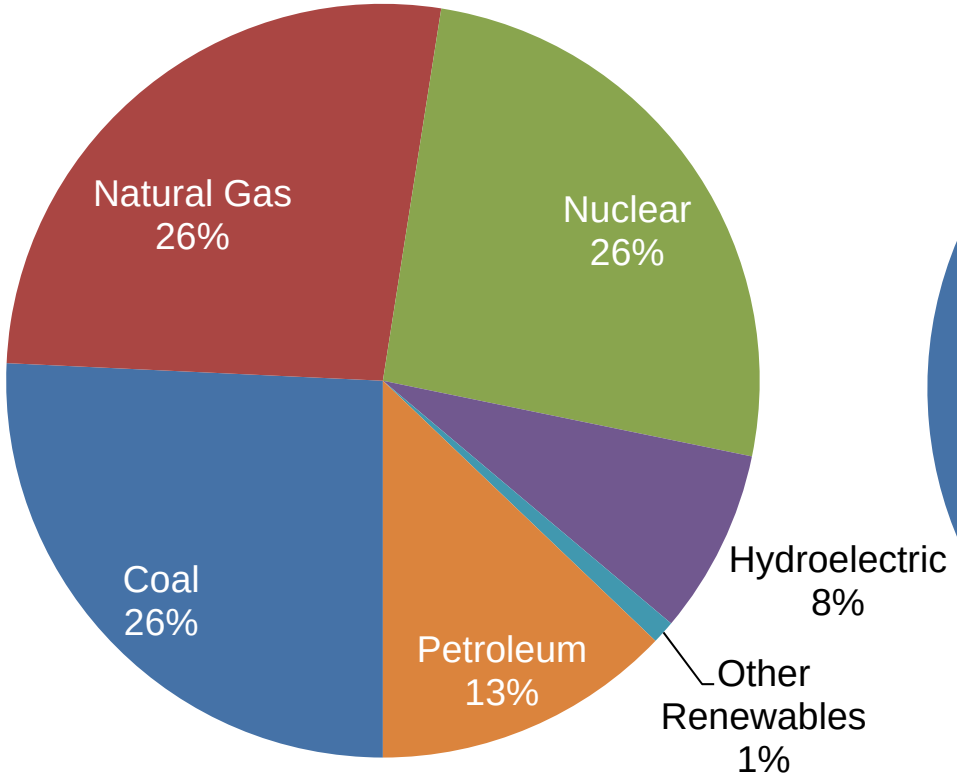
2007

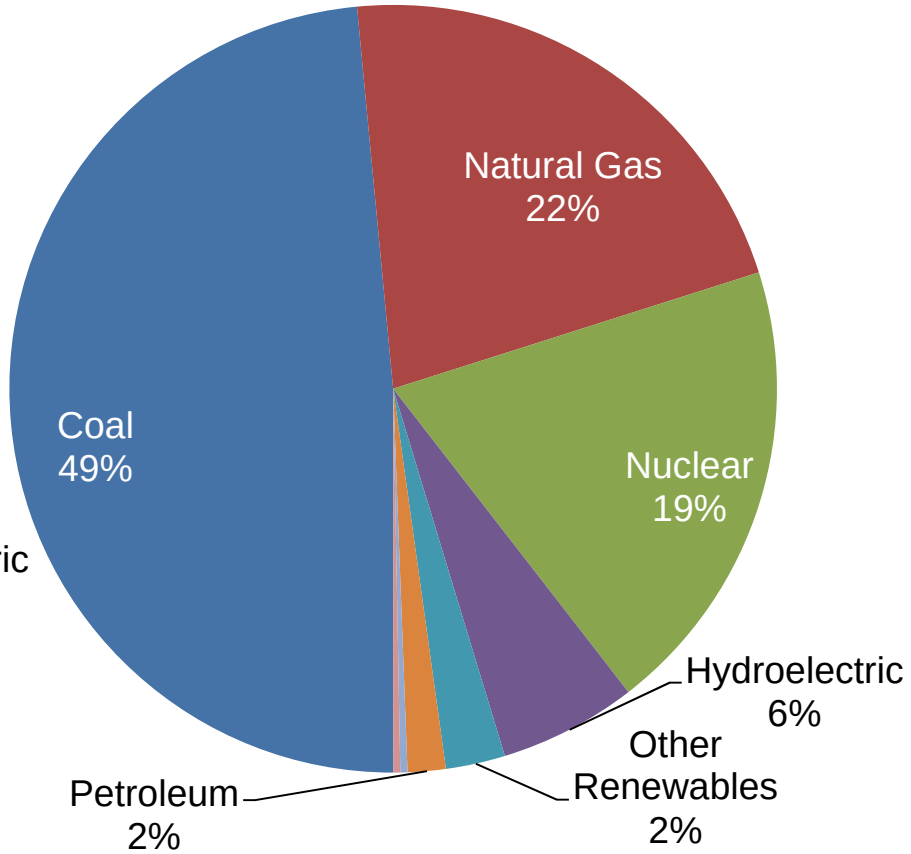
Japan

1,030 B kWh



US

4,157 B kWh



Electric Utilities: Japan and US

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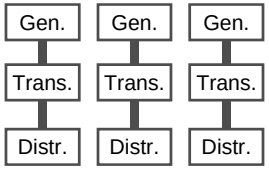
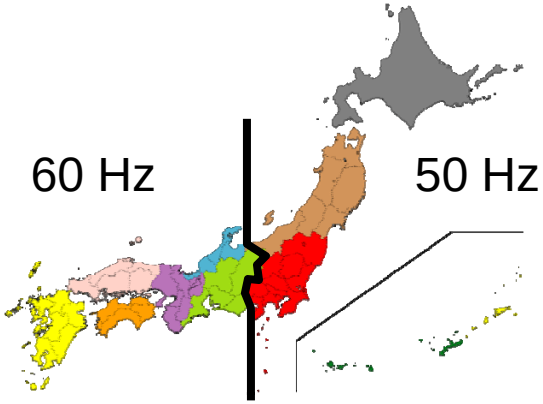
Japan

- 10 electric power companies
  - All IOUs
- Vertically integrated for each region

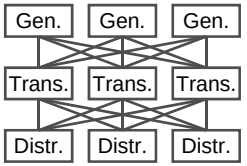


- 0.7 M to 25 M customers

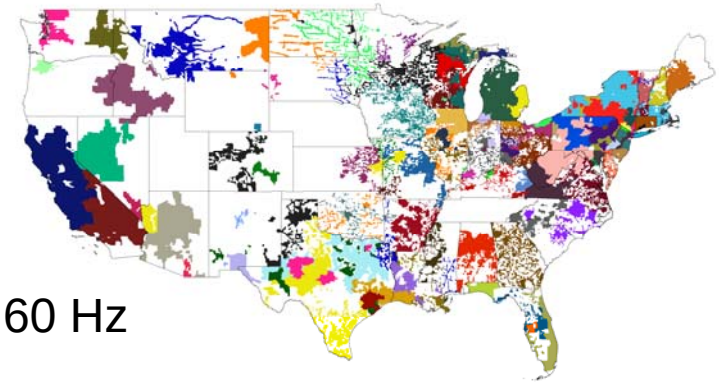


US

- Over 3,000 traditional electric utilities
  - IOUs (210), Public (2,009), Co-ops (883), Federal (9)
- Interdependent infrastructure



- A few K to over 5 M customers



Toward Smart Grid: Japan and US

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Japan: Move toward Low Carbon Emission Society

Jul. 2008: G8 Toyako Summit Agreement

Greenhouse gas reduction
50% by 2050

Jul. 2008: "Low Carbon Emission Society Action Plan" approved by the Cabinet

Apr. 2009: Subsidy for Home Solar Panels begins

Solar Panel Generation:
28 MkW by 2020

Sep. 2009: Greenhouse gas reduction announcement by Democratic Party

25% greenhouse gas reduction
from 1990 by 2020

Jan. 2010: Bill submitted by Government

Greenhouse gas reduction from 1990, 25%
by 2020 and 80% by 2050, 10% Renewable by 2020

US: Focus on Businesses and Infrastructure

CA Energy Crisis (early 2000s)
Northeast blackout (2003)
Wake-up Calls

Financial Crisis (2007-2010)
originated from US
Stimulus for slow economy

EISA (2007)

- Smart grid: modernization of the electricity grid to improve reliability and efficiency
- Tasked NIST for Coordinating Smart Grid Interoperability

ARRA (2009)
(a.k.a. Stimulus Package)

- $4.3B for smart-grid
- $10M for NIST to coordinate smart grid standards

Smart Grid Boom with US IT Vendors

EISA: Energy Independence and Security Act of 2007
ARRA: American Recovery and Reinvestment Act of 2009

Japan: Increasing the Speed of Solar Power Adoption

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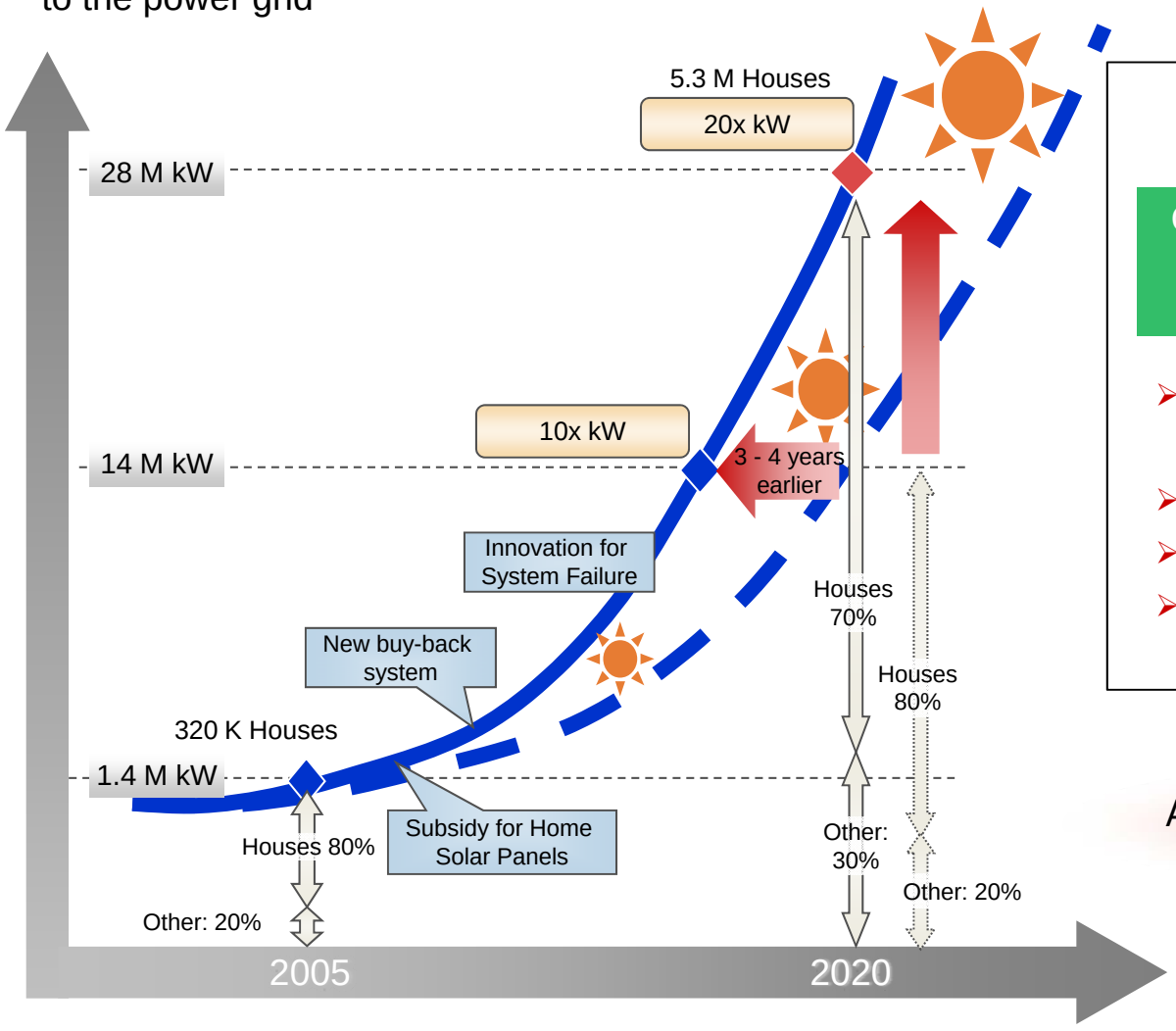
- 28 M kW by 2020 (20x 2005's, 12% of total generation) as government goal
- Researches have started to address challenges caused by large unstable solar power generation connected to the power grid



Study on Low Carbon Emission
Electric Power Distribution (July 2009)

Challenges caused by large unstable solar power generation connected to the power grid

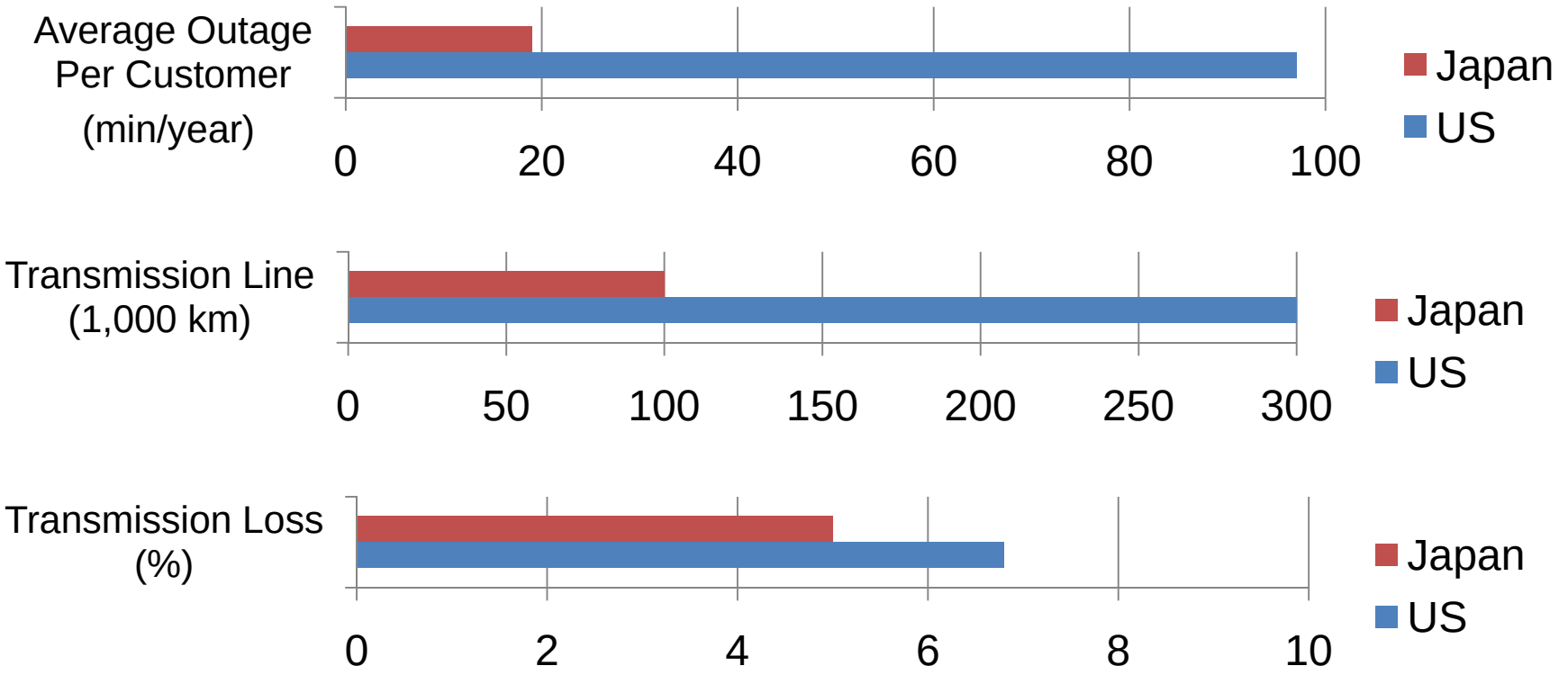
- Deviation from voltage range by voltage rise of distribution grid
- AC frequency regulation
- Excessive power generation
- Anti-islanding control and fault ride through

Activities for Japanese Smart Grid

[Legend]
Current Plan
May 2008 Plan

Source: Agency for Natural Resources and Energy

Reliability: Japan and US



Japan

- Japan already has highly reliable grid
- Going for advanced integrated control including demand-side to accommodate unstable renewable power

US

- Need for highly reliable transmission and distribution networks
- Need for demand/response for peak shaving and to avoid additional infrastructure

Smart Grid Focus: Japan and US

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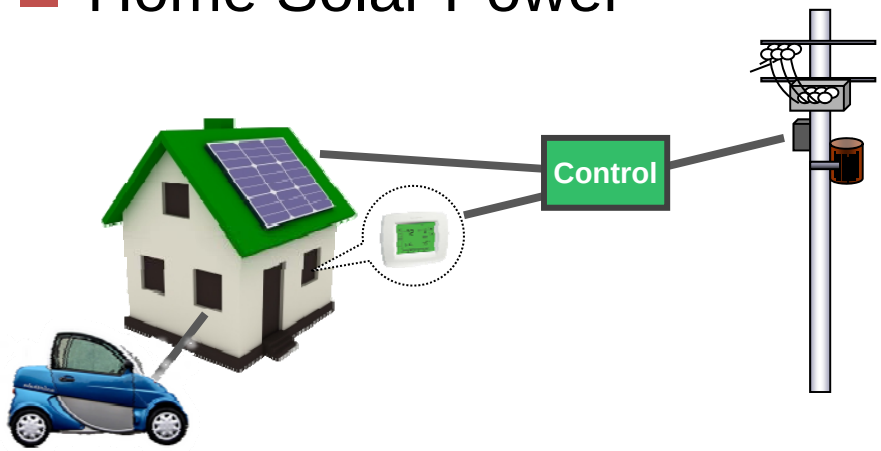
Japan

- More than $100 Billion investment during 90s to upgrade generation, transmission, and SCADA network
- Last mile and demand-side management (DSM)
- Home Solar Power



US

- Little investment (~$30B) in 90s into grid
- Now working across entire grid for enhancements
- Last mile and DSM are also hot

Japanese Smart Grid: Focus on Last Mile

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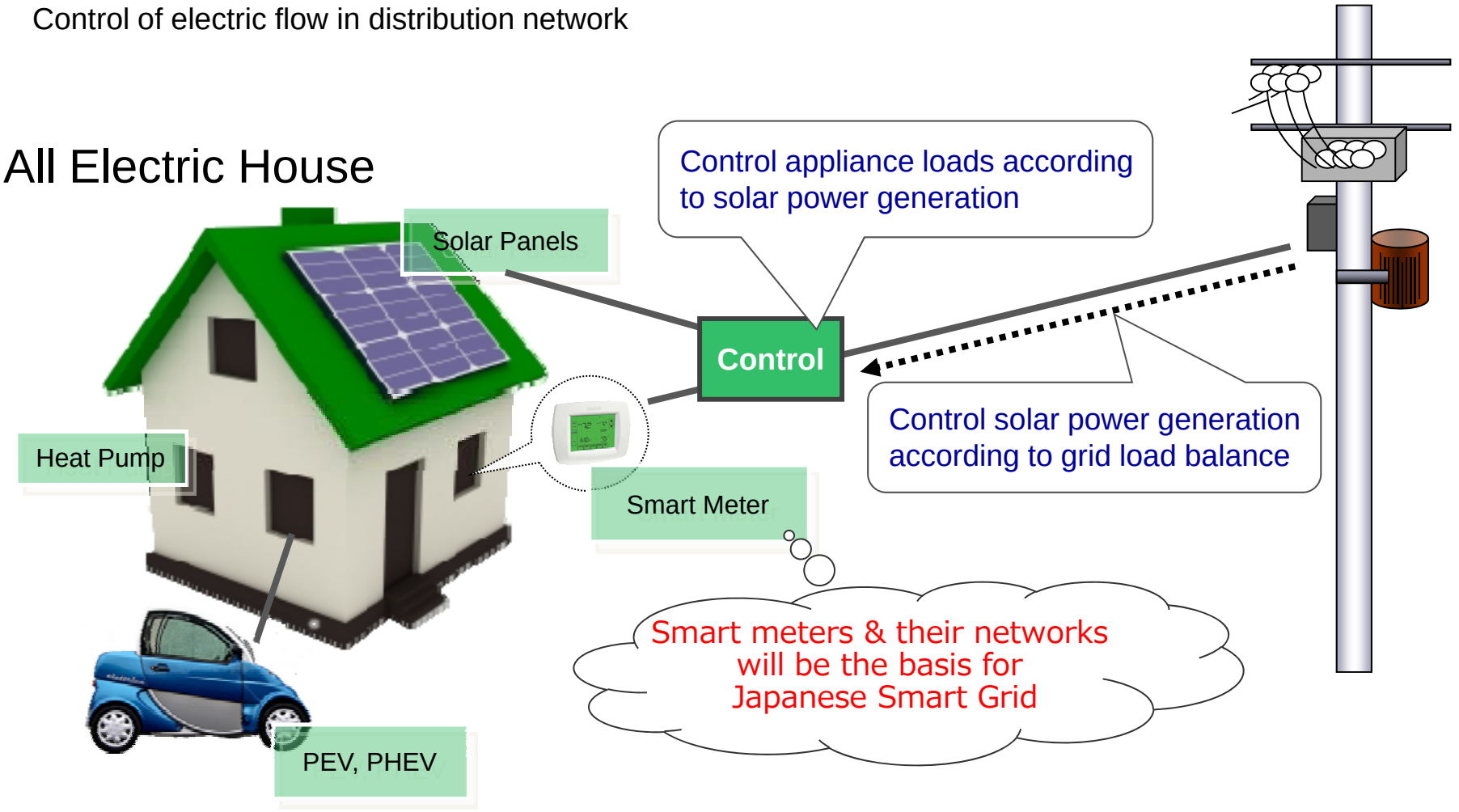
- Collaborative control of storage batteries and power plants according to fluctuating solar power generation
- Moving toward all electric house to leverage heat storage by heat pump, power storage by PEV's, etc.
- Autonomous control of solar power generation and heat pump loads according to the load of the grid
- Control of electric flow in distribution network



Source: Agency for Natural Resources and Energy

One Common Problem: Large Metering Networks

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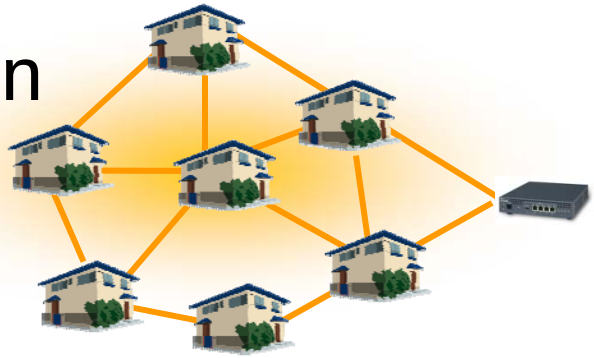
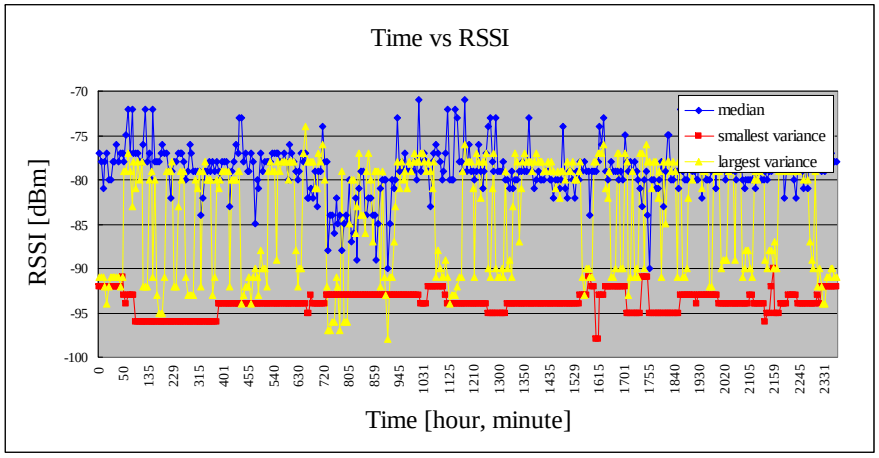
- Scalability, deployment, configuration
- Dynamic and unstable nature of wireless communication
- Monitoring
- Security
- Long life cycle



Large # of nodes per GW



Fujitsu's *"Smart Network"*

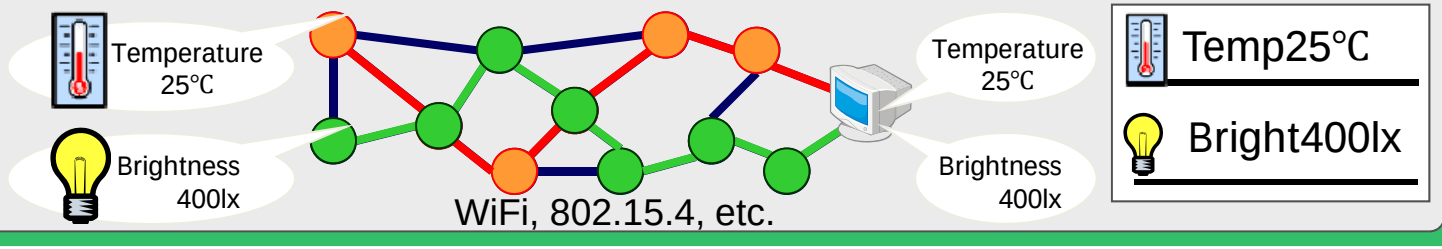
FUJITSU

- Fujitsu's new technologies to overcome the challenges of large metering/sensor networks

Ad Hoc Communication Technology

Network (Collect and Communicate)

Meters/sensors self-configure a large-scale mesh network



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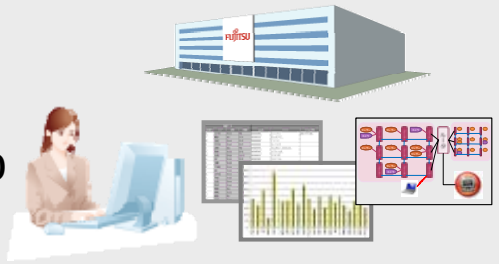
Sensor Middleware Technology

Data Center (Operate and Utilize)

- Collect and utilize vast amount of sensor data efficiently
- Monitor equipment and network status to enable reliable operation



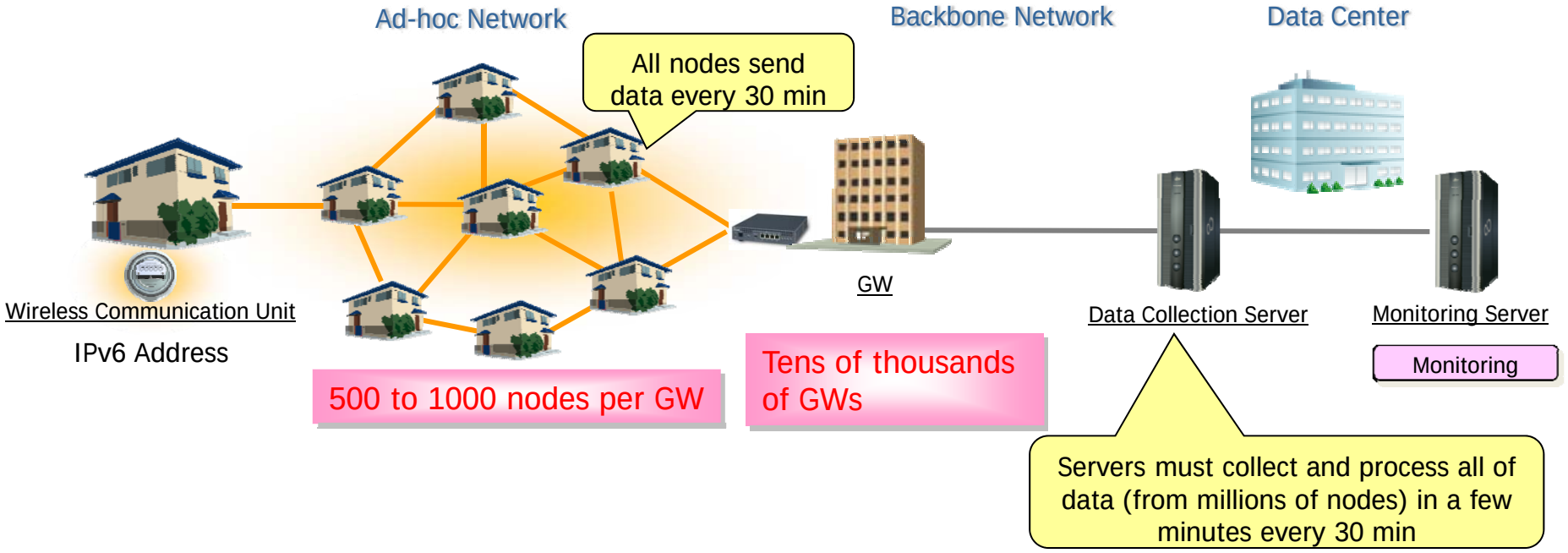
Cybersecurity: End-to-end security and privacy

Use of Fujitsu's Smart Network

Fujitsu has deployed large scale wireless networks using ad hoc communication technology

- Construct a very large scale network autonomously and guarantee data reachability
- Security and interference proof tested
- Real time monitoring and operation of network conditions
- Can provide IP communication for network services

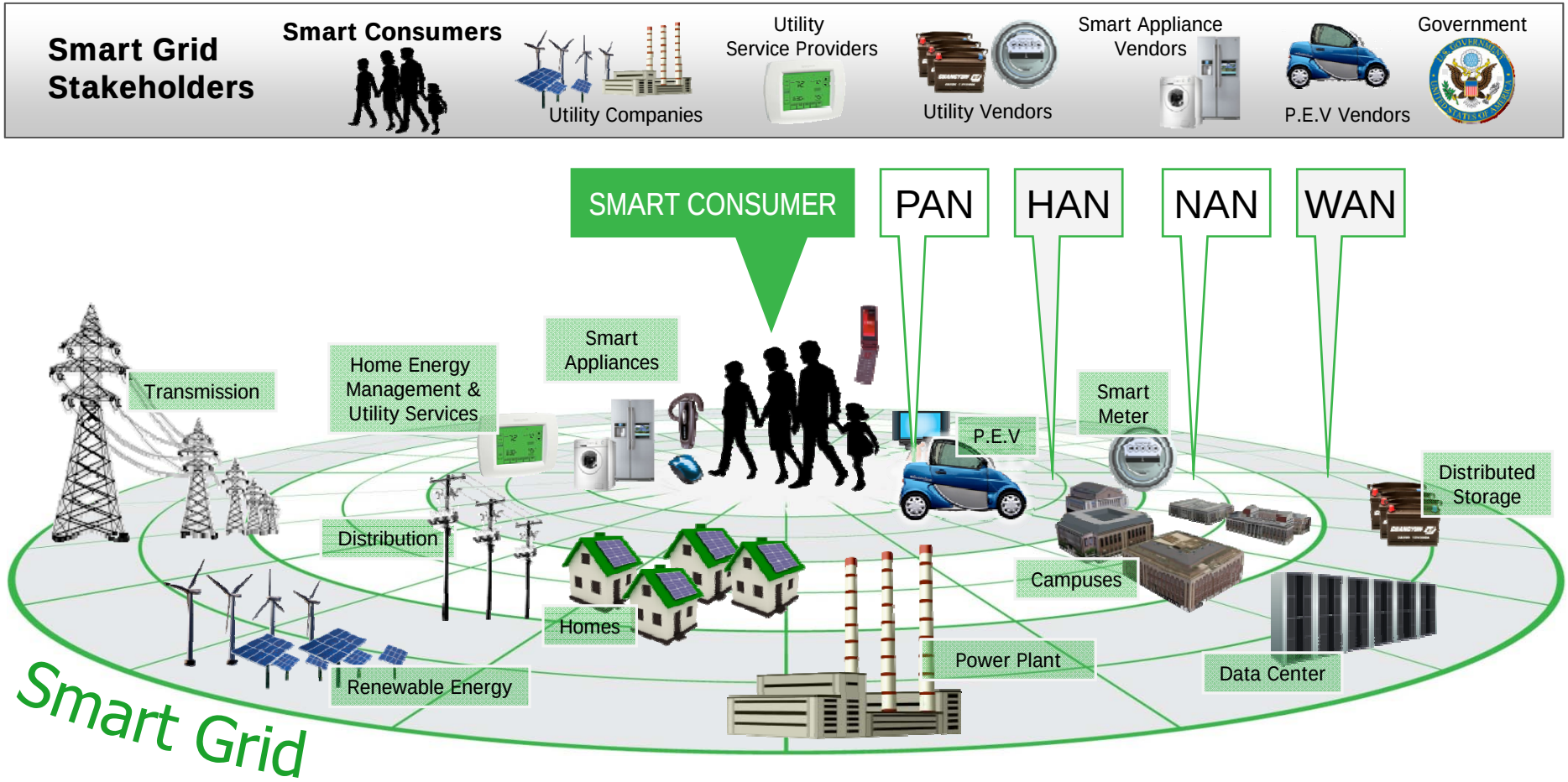
Succeeded in an ad hoc field test using over 1,400 wireless (WiFi) nodes in an urban environment



Vision: Unleashing the Smart Consumer within

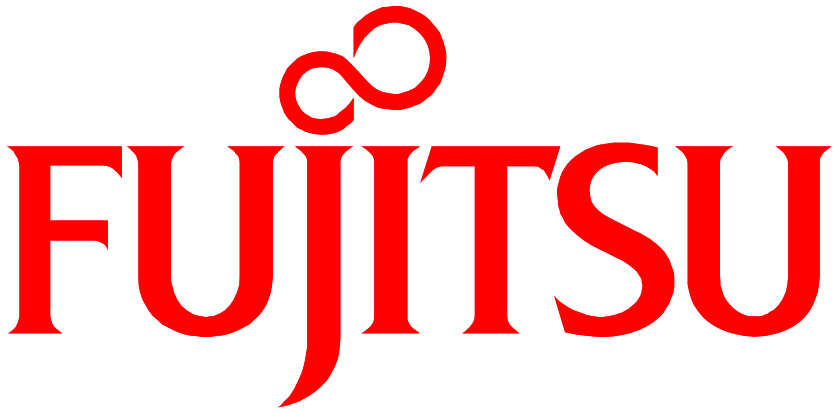
FUJITSU

- Utilize technology to bring behavioral changes (smart decisions & smart actions)
- These will lead to sustainable future & social wellness



Infrastructure for Smart Action

Information for Smart Decision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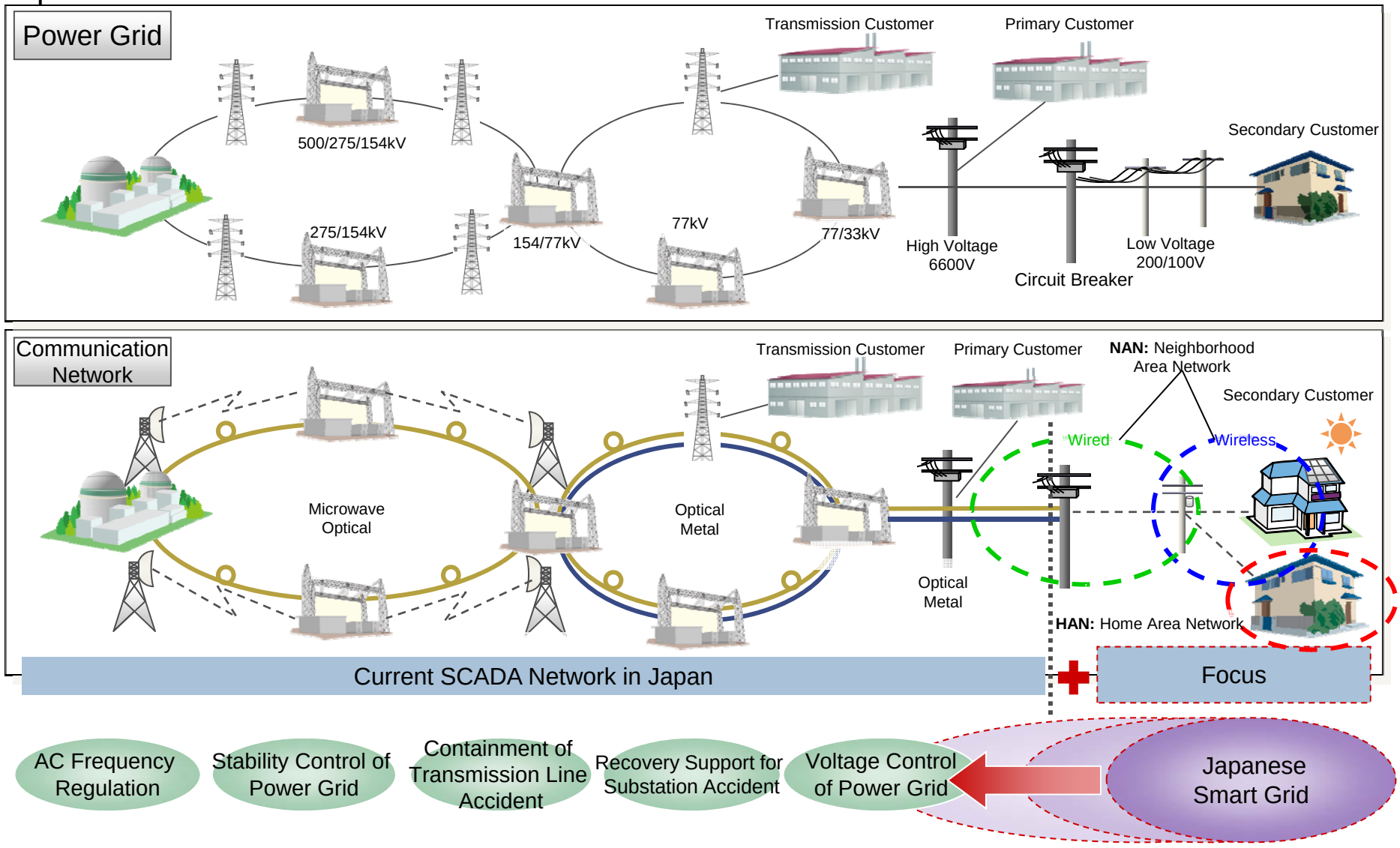
Appendix

Japan: Current Power Company SCADA Network and NAN/HAN

FUJITSU

- New networks (NAN and HAN) combined with existing SCADA network will be the basis for Japanese Smart Grid



US: Neighborhood Area Networks (NAN)

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Proprietary protocols of meter companies
Unlicensed spectrum

RF Mesh

Tower-based

Proprietary protocol
Licensed spectrum
One hop to meter

wimax

Open standard 802.16
Licensed spectrum

Cellular Networks

External network
One hop to meter

US: Home Area Networks (HAN)

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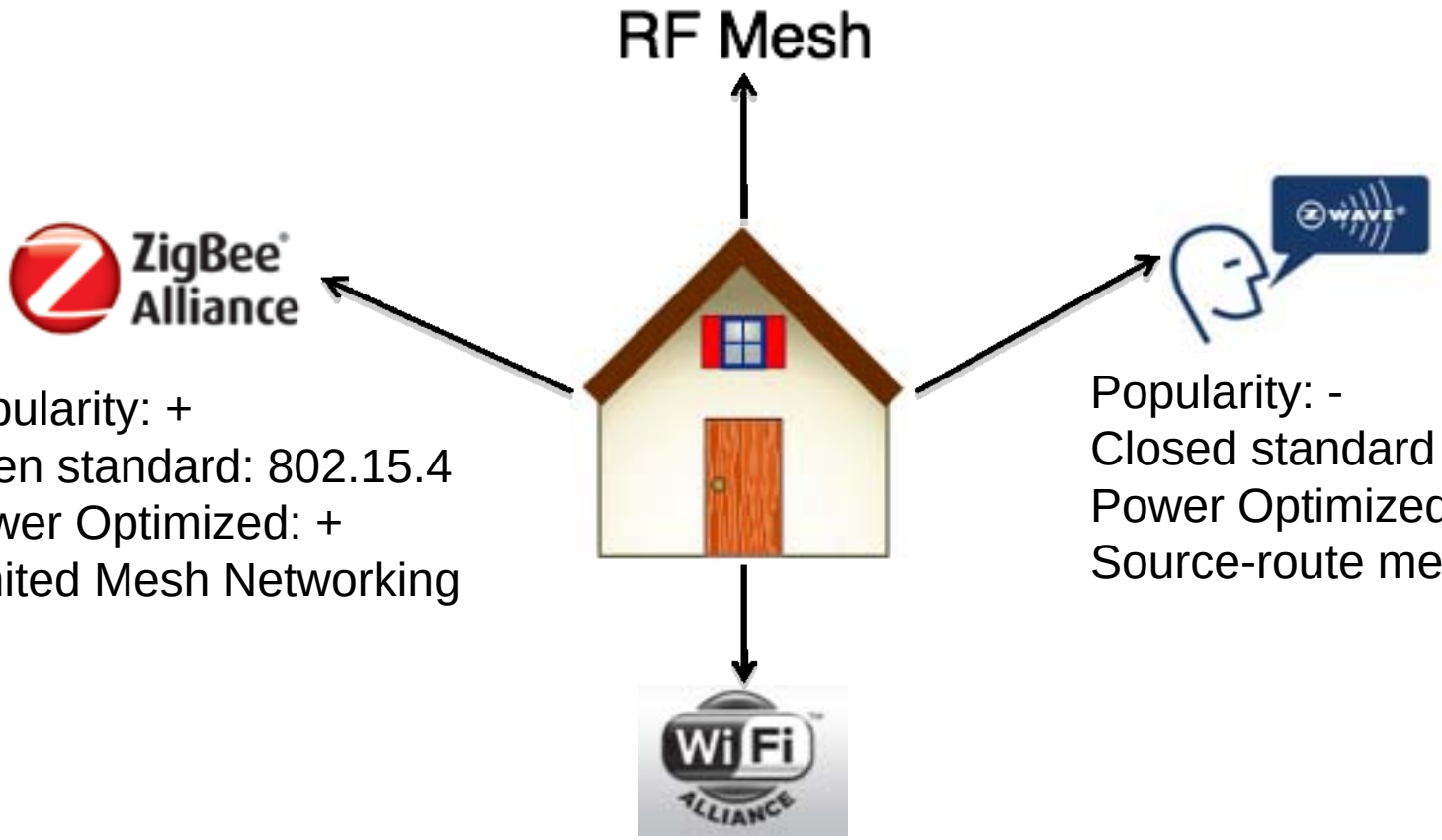
Proprietary protocols of meter companies



Popularity: +
Open standard: 802.15.4
Power Optimized: +
Limited Mesh Networking

Popularity: -
Closed standard
Power Optimized: ++
Source-route mesh network

Popularity: ++
Open standard: 802.11
Power Optimized: --
One hop wireless network

Routing Methods for Ad Hoc Communications

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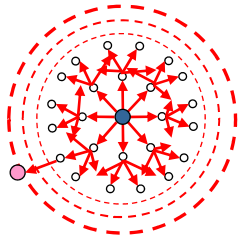
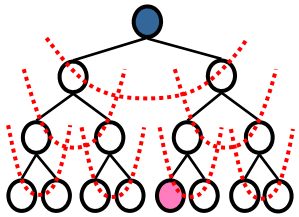
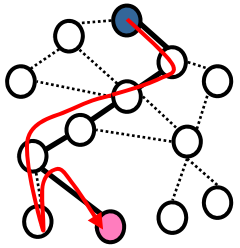
- In ad hoc routing method, there are AODV, OLSR and Fujitsu's DADR (used in WisReed). IETF MANET WG is discussing AODV and OLSR.

AODV : Ad hoc On Demand Distance Vector OLSR : Optimized Link State Routing DADR : Distributed Autonomous Depth-first Routing

	Routing Method	Path finding method		Applications
AODV	"Reactive type" Finds the path each time when sending a packet (When a link in the path is down, node tries to find a path again)	"Breadth first method" Transmits a control packet to the whole NW concentrically and search it. Not suitable for large-scale NW		This method is suitable for a small network such as 10 mobile nodes (250,000 control packets for 500 nodes)
OLSR	"Proactive type" Finds the path before sending a packet (When a link is down, node tries to find a path again)	"Modified Breadth first method" Avoids sending the same message to the same node		Suitable for a mid-size network of 50 nodes (25,000 control packets for 500 nodes)
Fujitsu's Method (DADR)	"Modified proactive" Learns possible paths before sending packets and picks the path dynamically when sending a packet (When a link is down, tries alternative links)	"Depth first method" Picks the path by going for depth first when sending a packet. Much less control packet required		Suitable for a large scale network up to 1,000 nodes (5,000 control packets for 500 nodes)

AODV and OLSR: Not practical for large scale networks because of packet losses and flooding
Fujitsu's Method (DADR) is designed for large scale networks

Sensor Middleware for Cloud Computing

FUJITSU

Issues of *Smart Network* :

- ✓ System must process large amount of data from sensors efficiently
- ✓ Administrators want to analyze the data from various angles
- ✓ Administrators cannot determine where the bottleneck is or which node is at fault in the network

Fujitsu's sensor middleware technology can handle vast amount of sensor data and present APIs easy for applications to be built on. It also provides ad hoc network monitoring which has been difficult with existing technologies

Sensor Management

- ➢ Process sensor data efficiently and exposes essential APIs to application
- ➢ Communicate with sensors by just connecting them to the network, without any settings

Network Monitoring

- ➢ Monitor Ad-Hoc network which covers wide area and changes its communication paths frequently
- ➢ Detect bottlenecks and failures in the network and automatically notify them to the administrator

Service Configuration

- ➢ Determines the context from sensor data history
- ➢ Invoke actions according to the context

Sensor management

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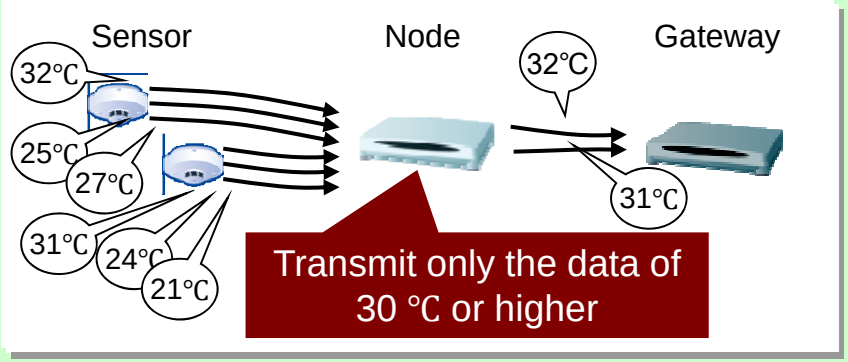
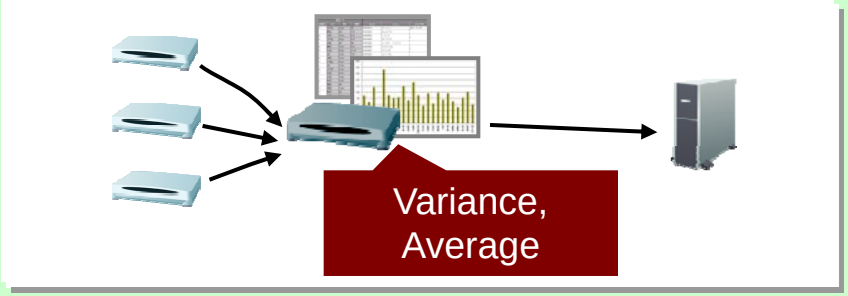
Processes large amount of data from sensors so that the load of applications becomes low.

Filtering

Selects data that is necessary and transmits them

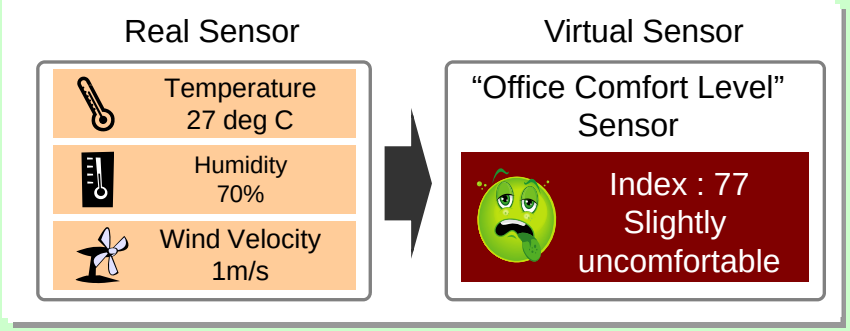


Converts data into required form (variance, average, etc.) and transmits them

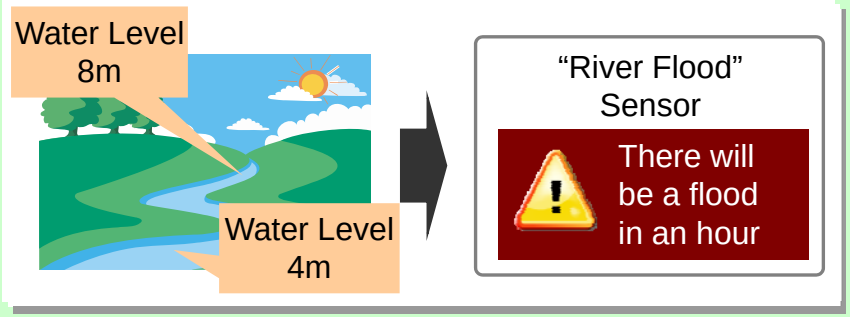


Virtual sensor

Combines different kinds of sensors to treat them as a single virtual sensor



Combines sensors in different areas to treat them as a single virtual sensor



Relieves the application from complexity of sensor data processing

Network monitoring

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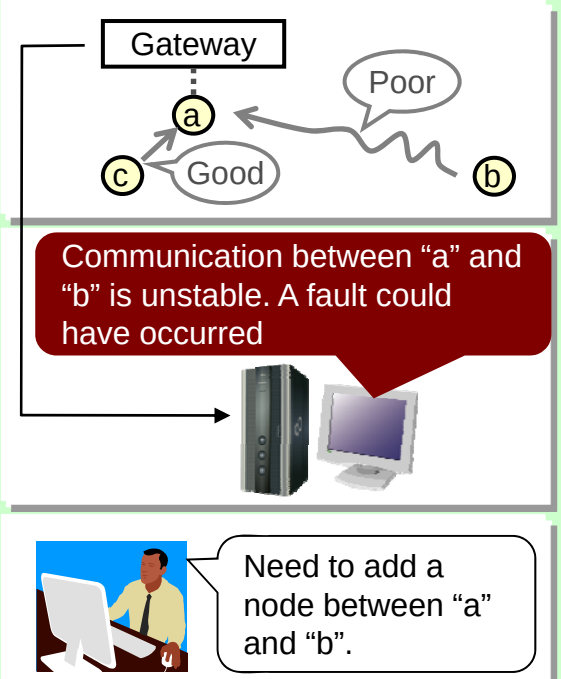
Visualizes configuration and communication status of networks
Monitors faults and notify the administrator

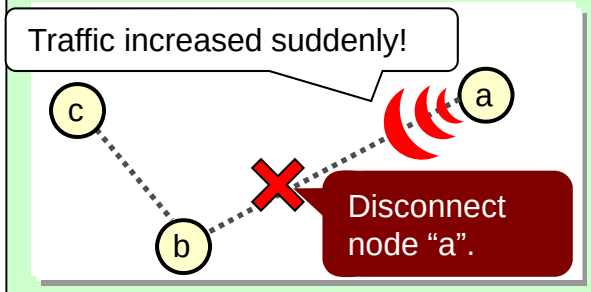
Network predictors of faults monitoring

Monitors communication quality and notifies bottlenecks to the administrator.

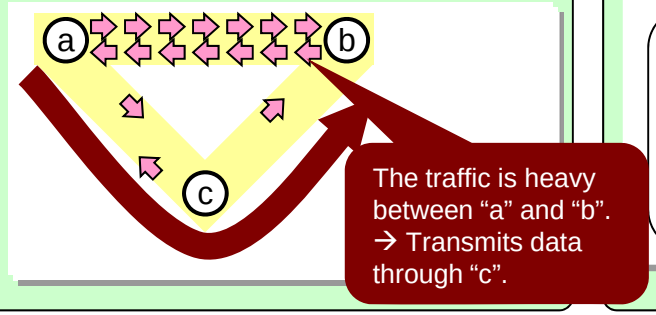


Traffic monitoring

Detects rapid increase of packets due to packet loop or virus, then disconnects suspicious node

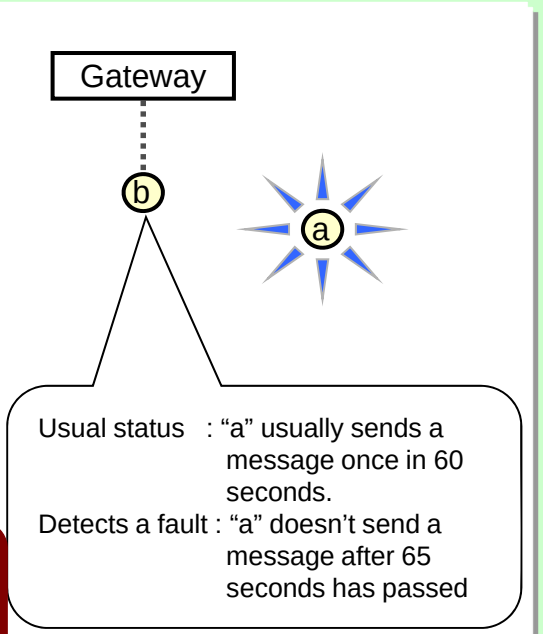


Transmits data through alternative route to avoid heavy traffics



Status monitoring

Nodes monitor each other’s status. If a node detects any faults, it notifies them to the administrator.



Makes it easy to manage and maintain complicated Ad-Hoc network

Service configuration

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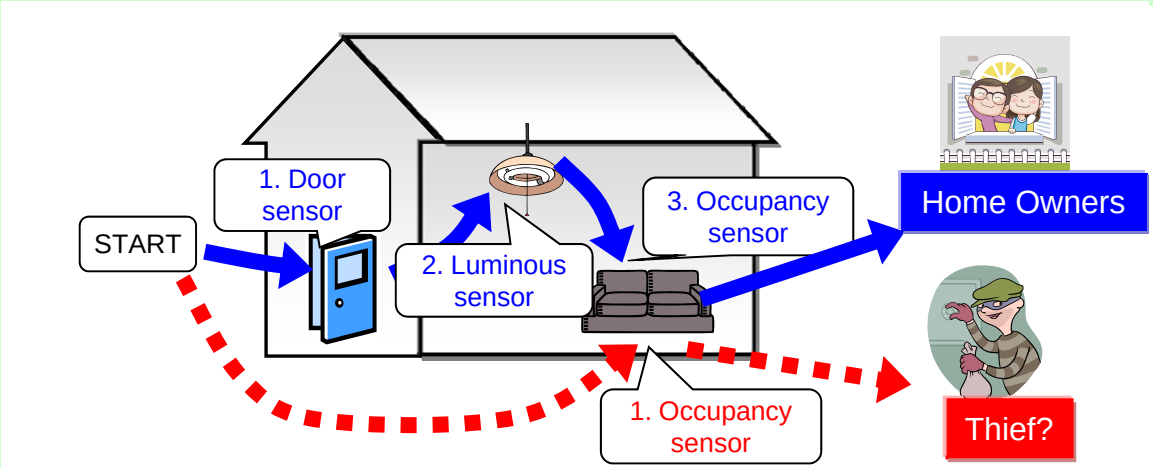
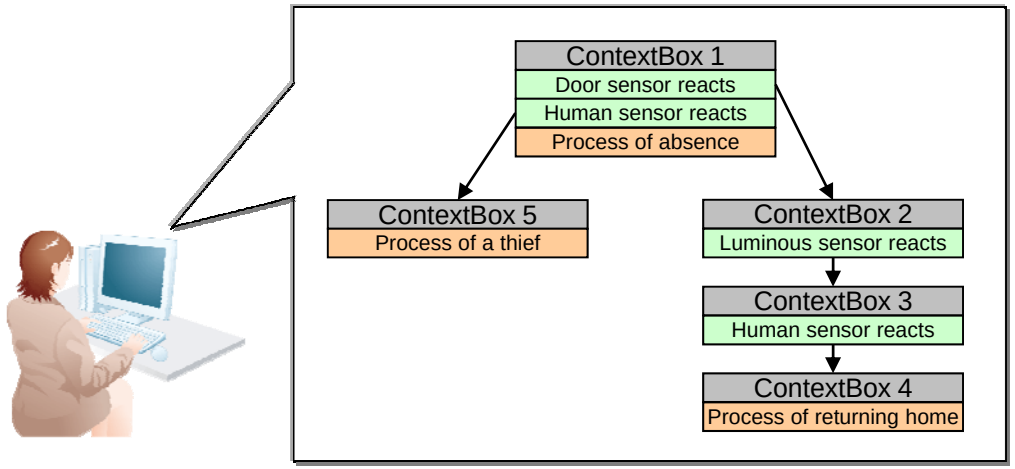
Provides services according to the context of sensor data history

Context processing

- When occupancy sensor reacts, different services run depending on sensor data history



- Administrators can specify procedures by drag and drop using a GUI tool
- Sensor data history specification separated from programming. Administrators do not have to program again when sensors are added or removed



Cybersecuirty Research at Fujitsu

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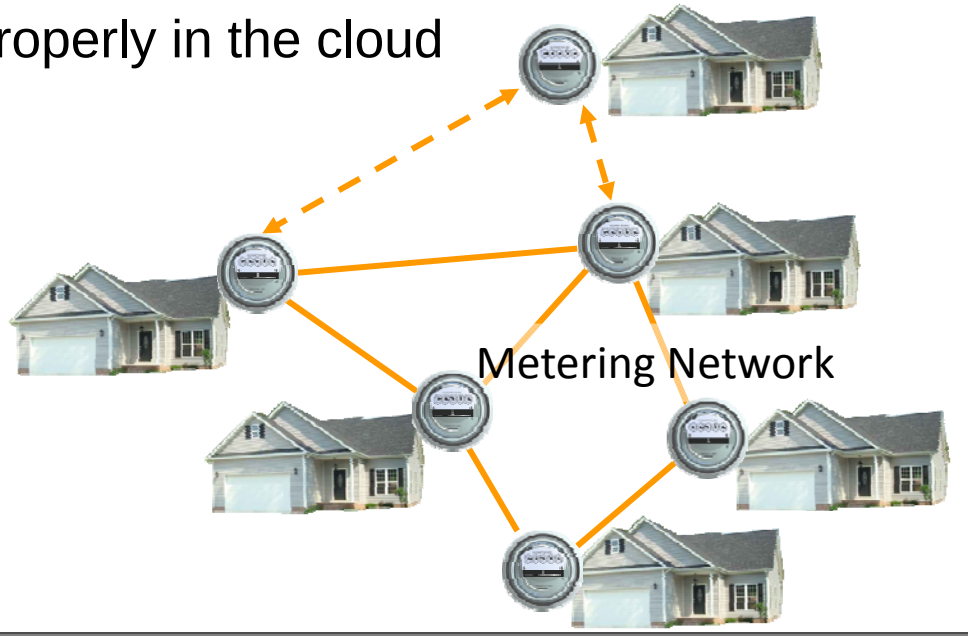
- While you lose your *money* on Internet, you can lose your *life* in the Smart Grid
- Protect smart meters
  - Physical tamper-resistance is there, but not enough
  - Can be stepping stones into the Smart Grid
  - Mutual monitoring
- Security and privacy into the cloud
  - Make sure your data is handled properly in the cloud

Cloud Computing



Cycle Enabled by IT

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