MPSoC2015

FUJITSU
shaping tomorrow with you

Control System for Large-Scale Sensor Network

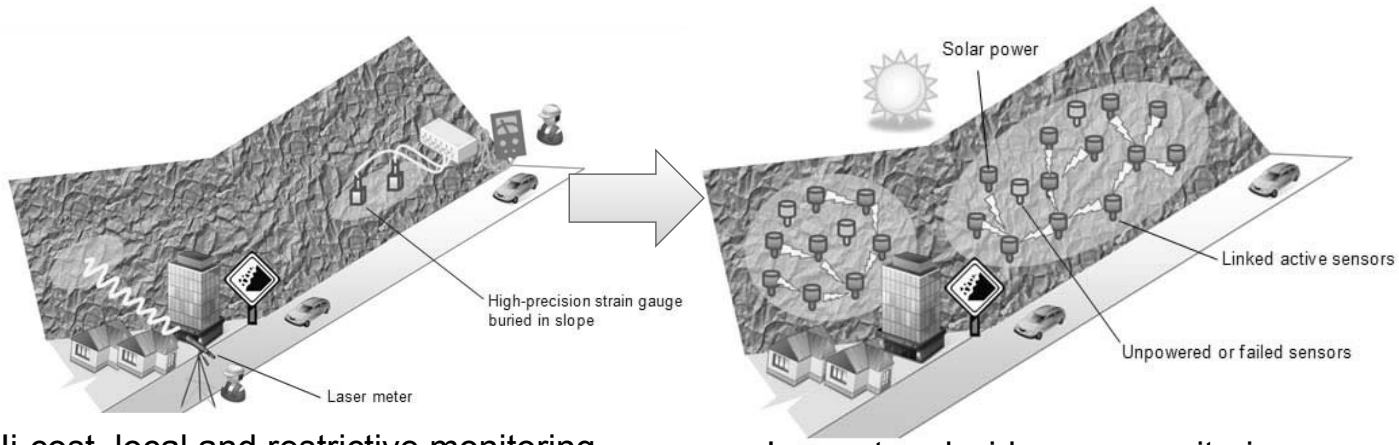
Koichiro Yamashita
Fujitsu Labs.

Background ~ Our mission

FUJITSU

Existing technologies for environmental monitoring have not spread to here and there… difficulty of installing, running cables, replacing batteries, and cost.

They have only been deployed over small areas, and the promise of effectively collecting data in a grid over a wide area has not yet been realized.



Hi-cost, local and restrictive monitoring

Lo-cost and wide area monitoring

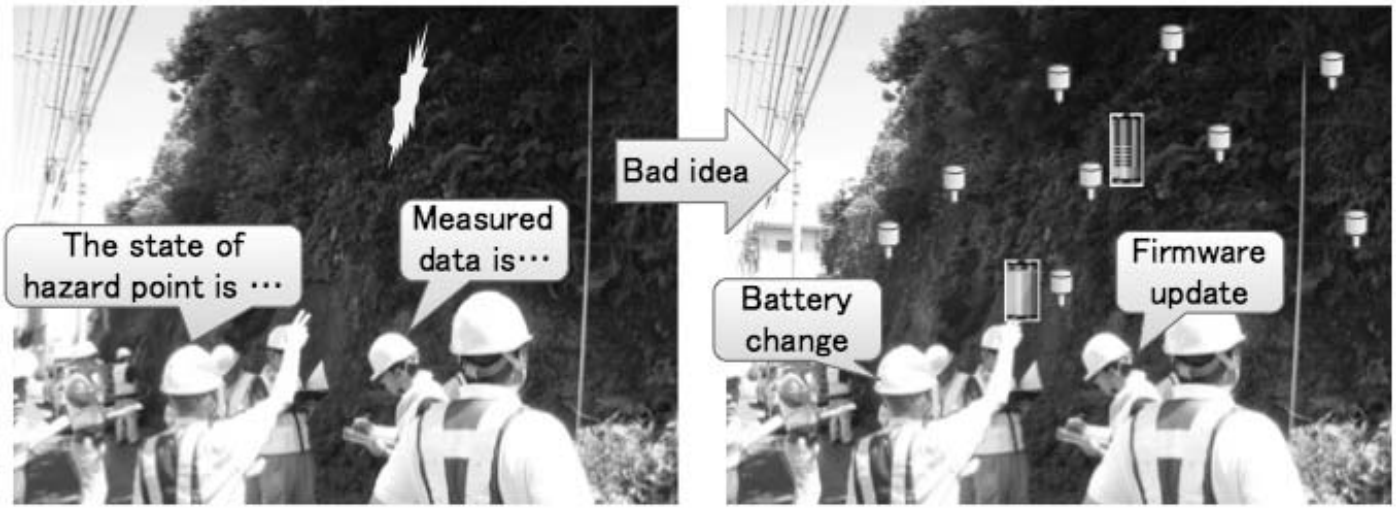
Challenges

FUJITSU

- Distributed control system for large number of sensors
  - Wireless communication and topology between sensors
  - Low power consumption control of sensor
- Flexibly corresponding scheduling method
  - Power scheduler : Variations in the environment power harvesting
  - Network scheduler : Data aggregation and communication quality
- System architecture design and implementation
  - Lo-cost sensor : Compact and small hardware devices
  - Maintenance-free sensor : Minimization of software implementation

Challenges

FUJITSU



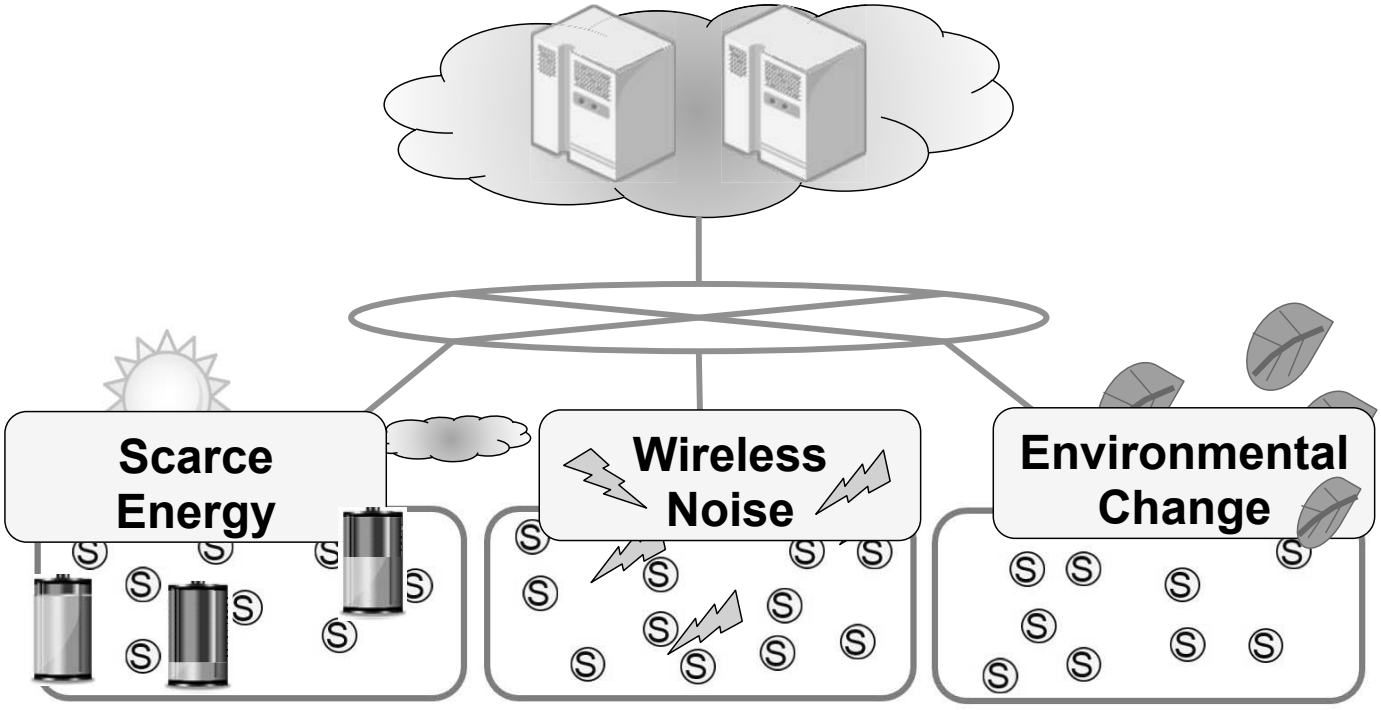
Visual confirmation.
The field measurement by luxurious measuring instrument.

~~Inspection of the installed sensor.~~
~~Battery exchange.~~

Challenges

FUJITSU

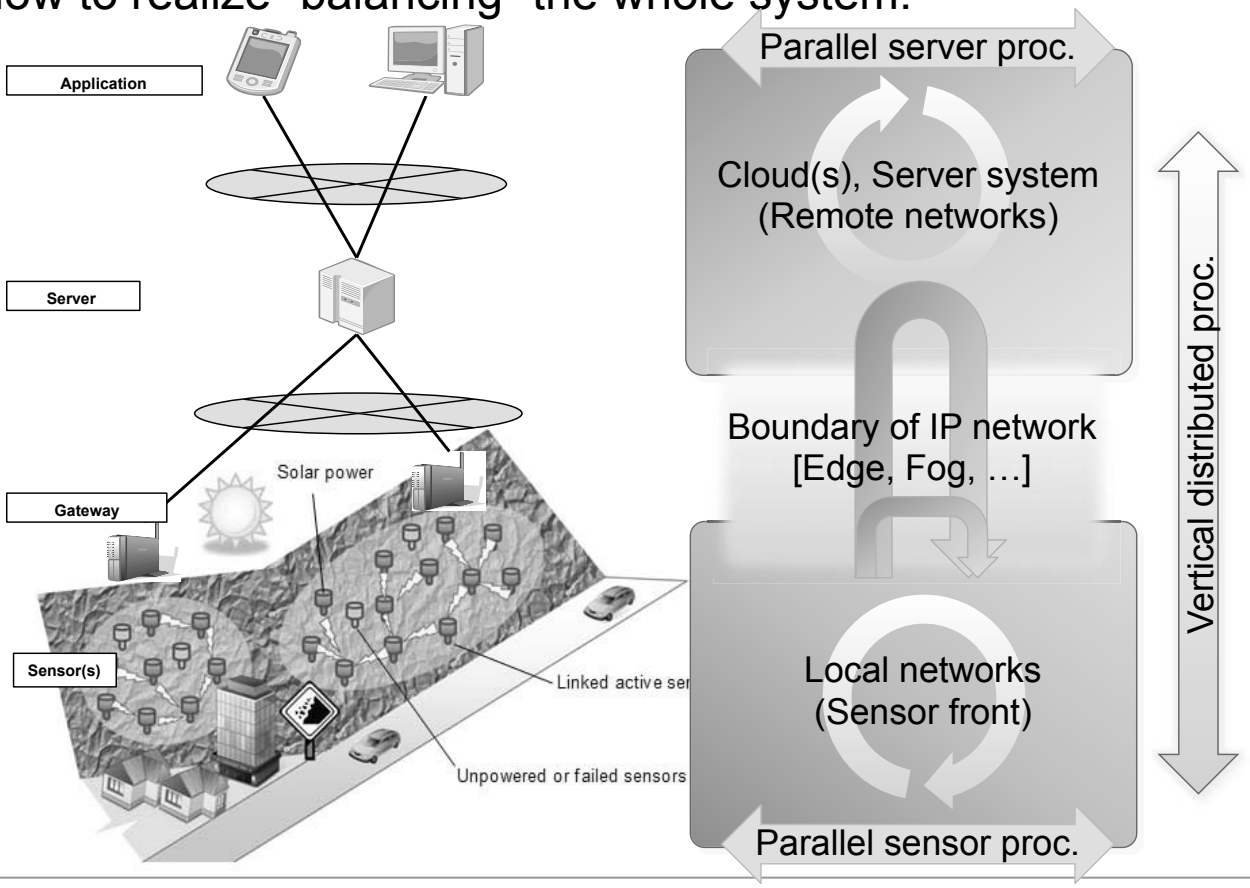
Even if hardware is fully optimized, a sensor network undergoes influence of a natural environment.



Proposed system

FUJITSU

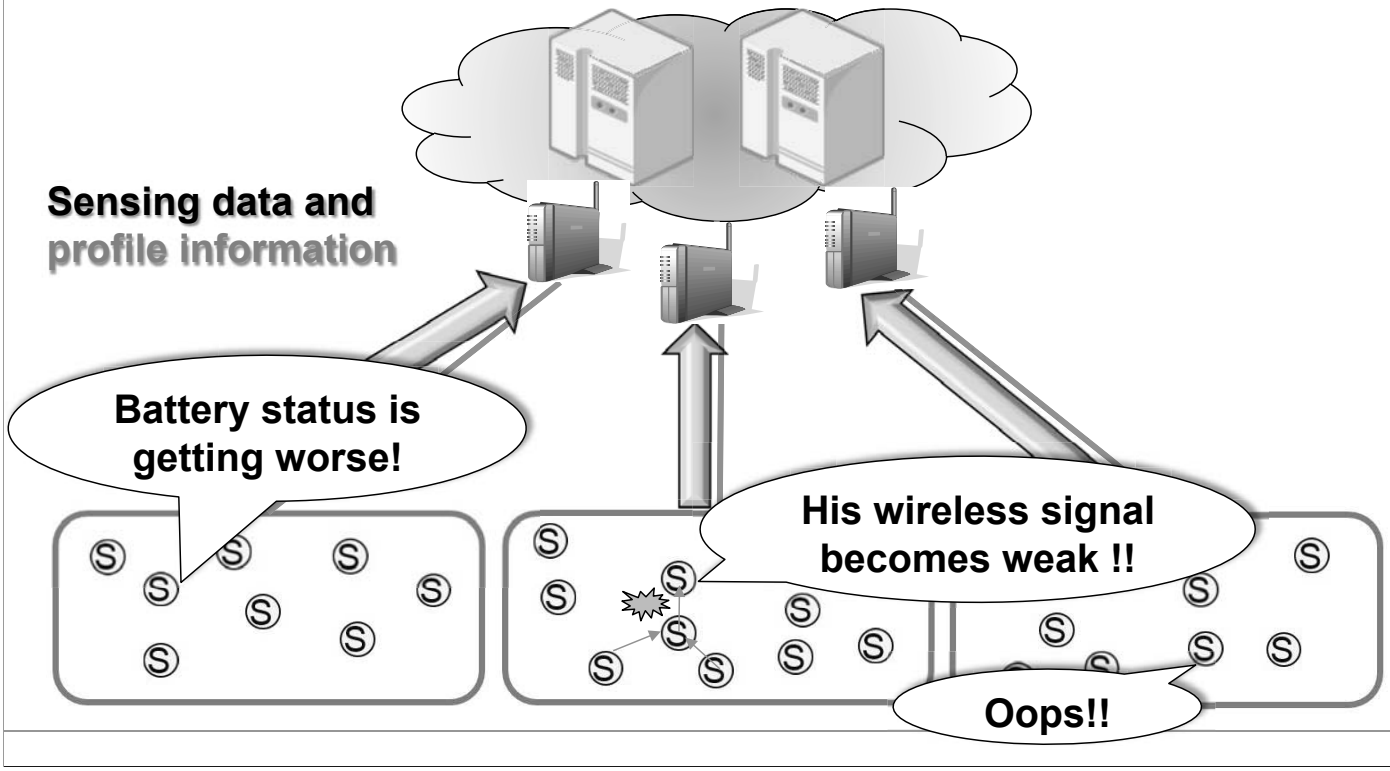
■ How to realize “balancing” the whole system.



Proposed software

FUJITSU

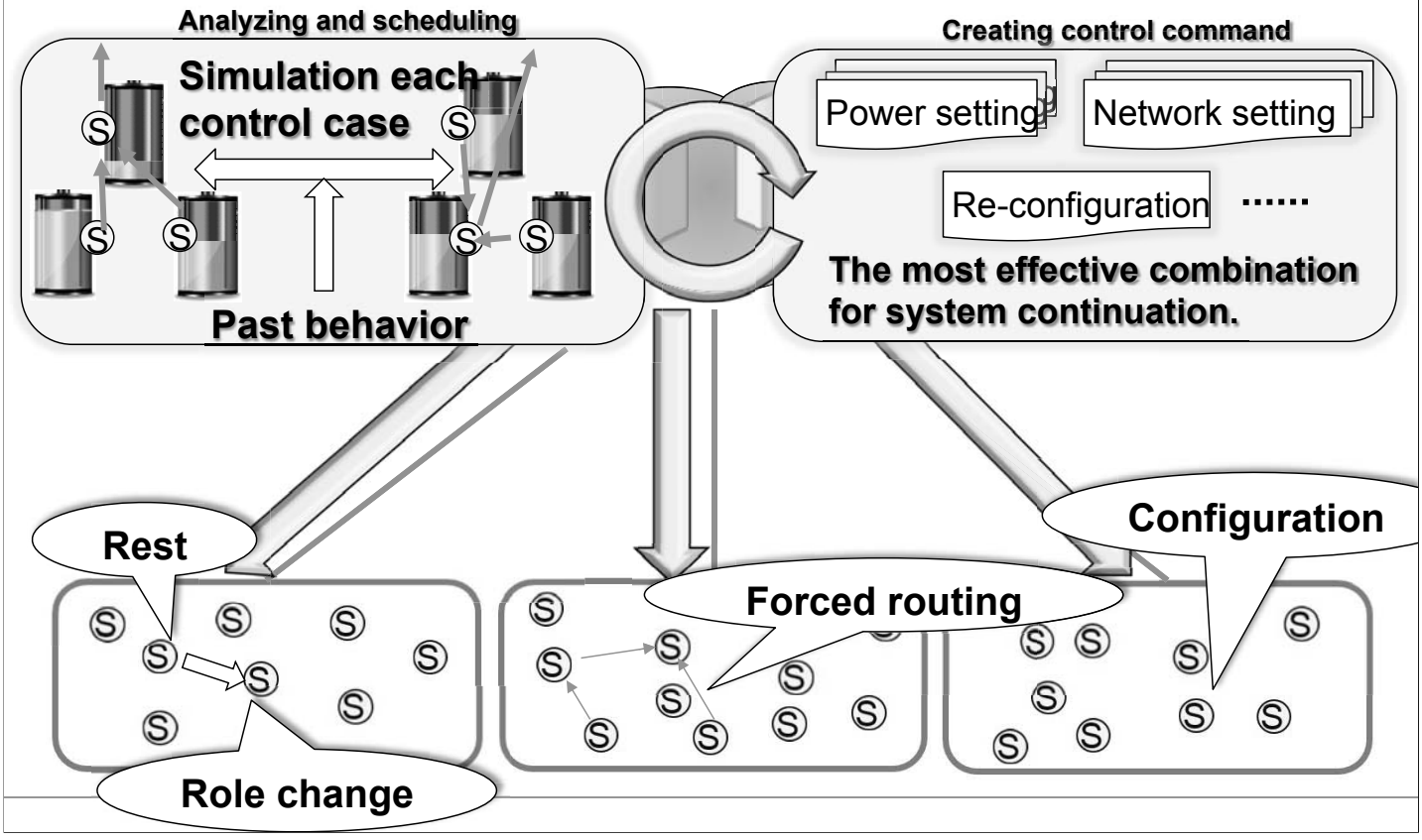
A system collects not only sensed data, but also profiling information of sensor hardware.



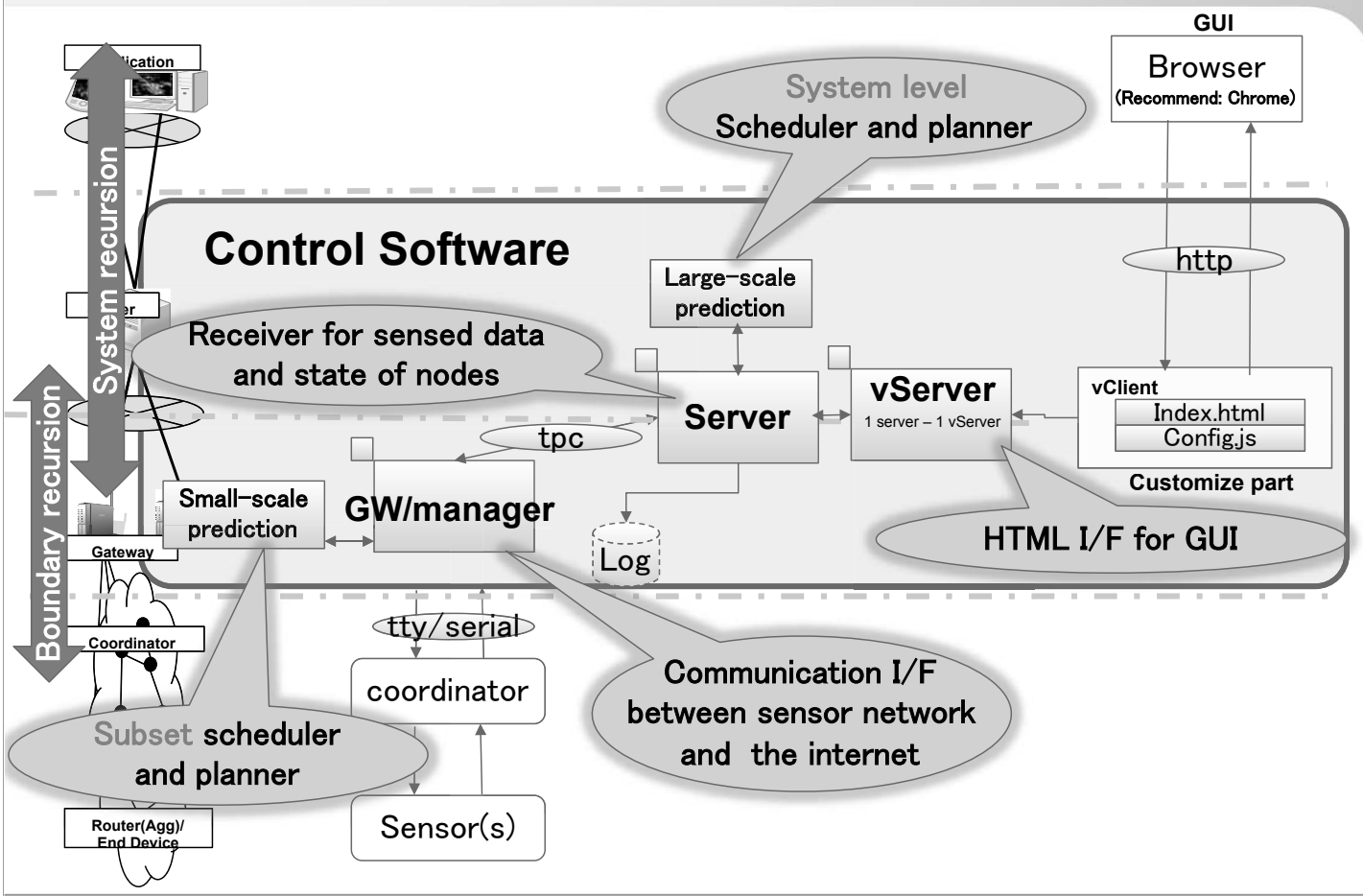
Proposed software

FUJITSU

A system compares the past information with profile information and schedules a sensor.

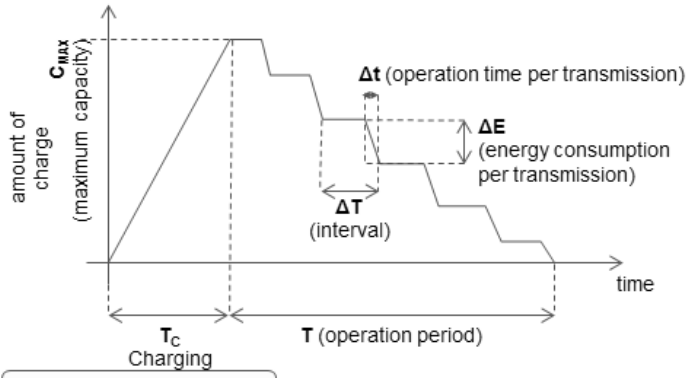


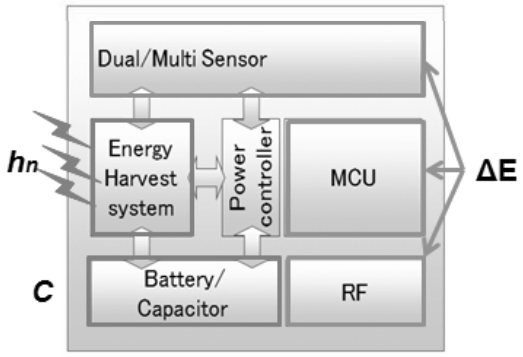
Implementation (System overview)



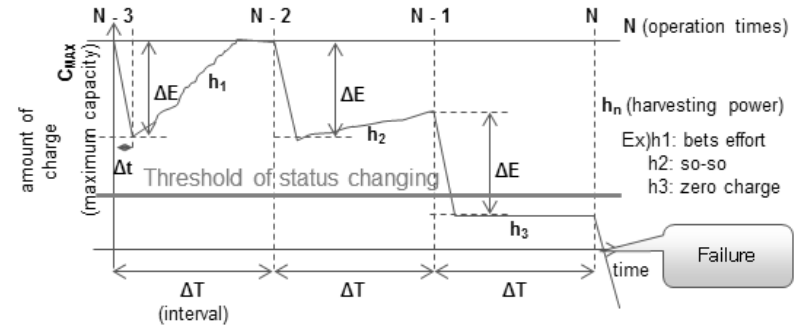
Ex. Probabilistic model power scheduler(MPSoC2014)

Theoretical model





Actual model



Consideration on the Large scale prediction

$p = 100\%$ is not necessary.
Value of "p" or "N" is most important.

It is less than C_{MAX}.

$$E_{xpectation}(h_1, h_2, h_3, \dots)$$

$$P_{ossibility}\left[\left\{\sum_{n=0}^{N}\int_0^{\Delta T} h_n dt\right\} - (N\Delta E) > 0\right] \geq (p\%)$$

$$h_n = H(x, y, z, \dots)$$

: Function of harvesting power

Uncertain parameters Depend on environments.

Default threshold is 25% remaining power amount to the inflection point.

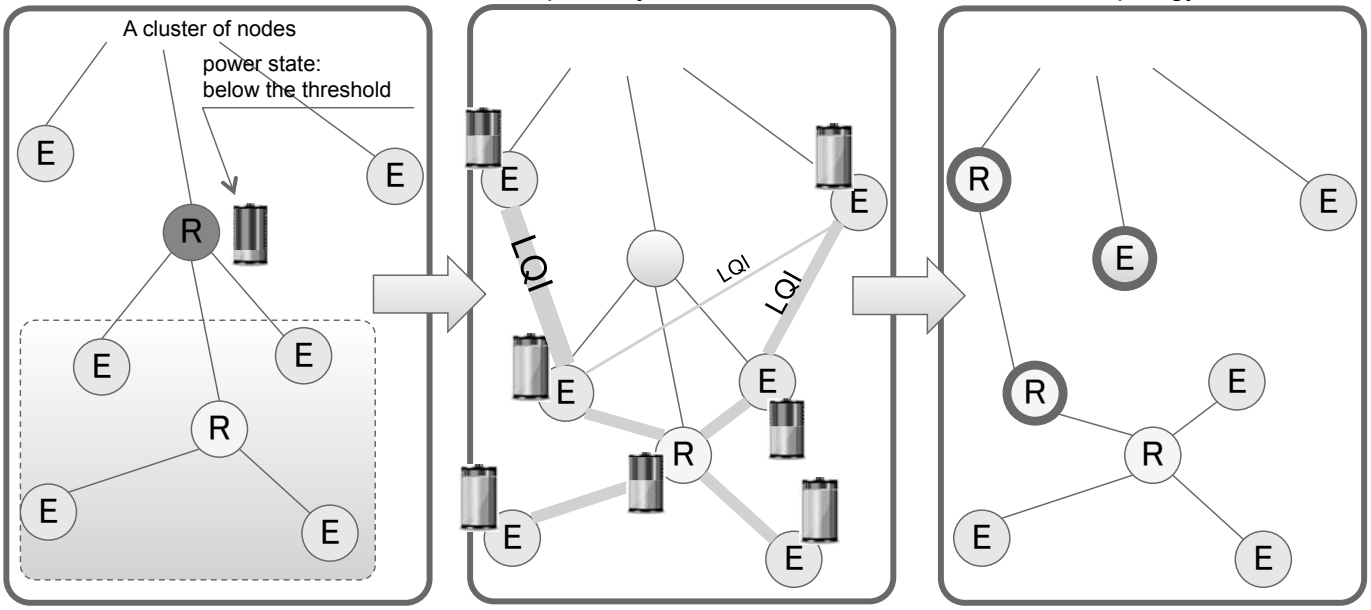
Ex. Network and power scheduler

FUJITSU

Children and grandchildren will disconnect when “R” becomes power off.

Search surrounded node’s power status and LQI value.
System refers to the movement situation of the past and relocate the appropriate "Router" which has no partiality.

The system only changes the role of “R” and “E”. The system layer DO NOT specify the concrete network. After “Construct” operation, local system (Zigbee) autonomously construct the topology.

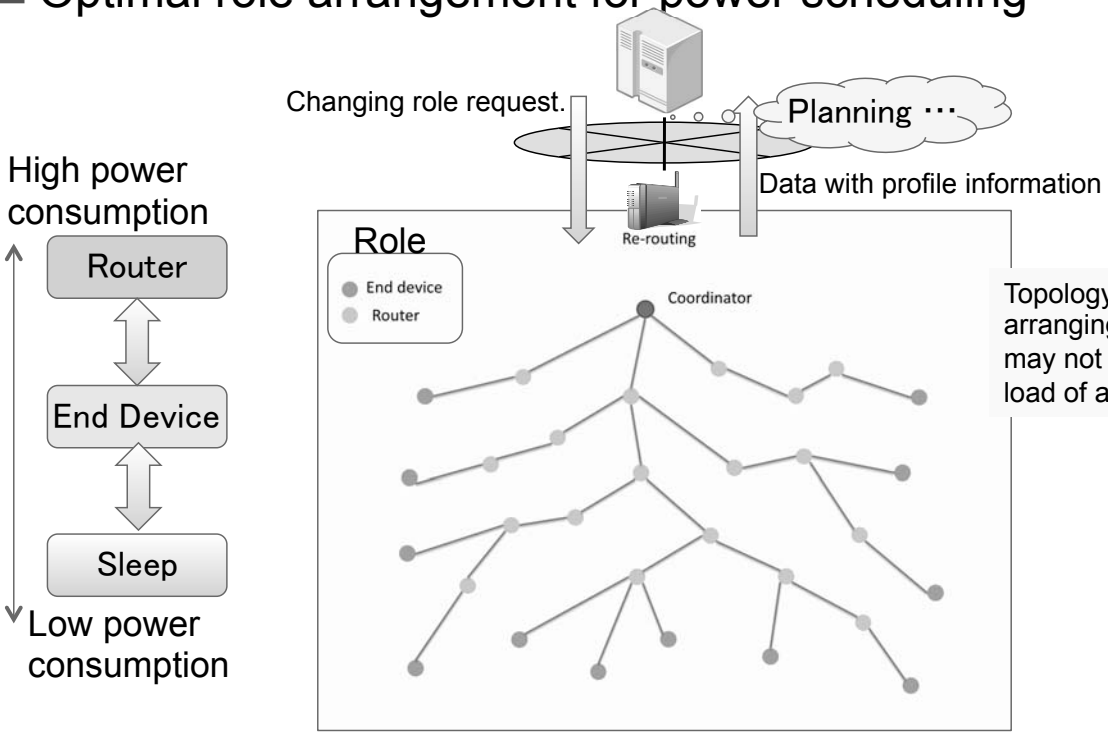


GUI has I/F which operates role change manually to control safety and certainly.

Ex. An image of sensor network status

FUJITSU

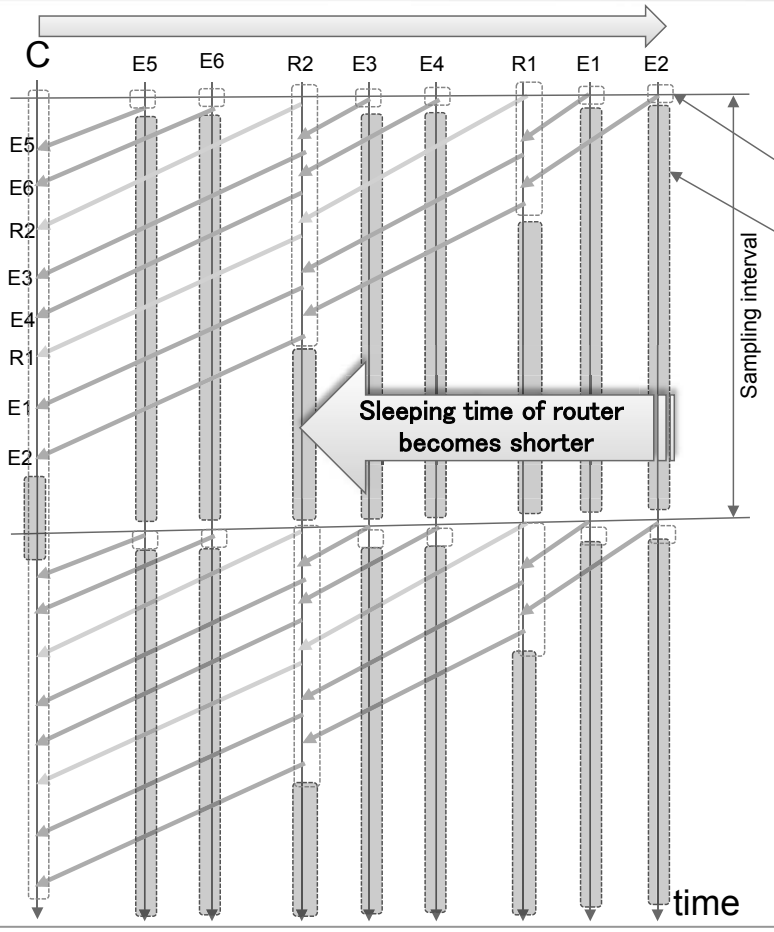
■ Optimal role arrangement for power scheduling

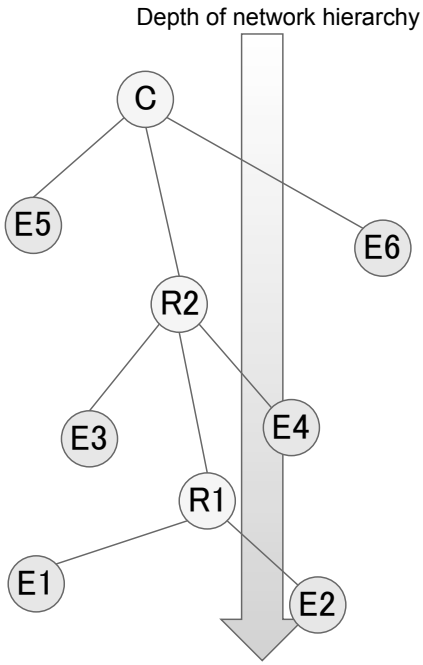


Topology is changed by arranging a "role" so that it may not become the heavy load of a specific node.

When the power of the “End Device” is exhausted, it sleeps, but even a few days darkness it acts continuously by low-power designed hardware and a optimal battery capacity.

Ex. Subset scheduler (Periodic control)





When the system want to reduce the power more, Periodic-mode is implemented as a concept of "Normally-Off"

Specs of the prototype sensor

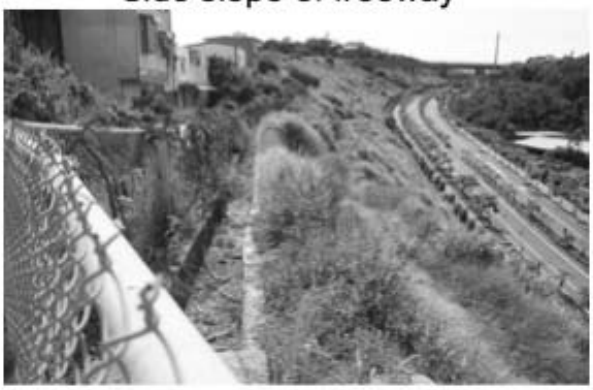
	Spec.	Note
Wireless	IEEE802.15.4 (Zigbee)	Emission range :Max 100m
Solar panel	200mW	5cm x 10cm
Battery	3.7V 3200mAh	Li-ion
Sensor	Pressure 3 axis gravity Temperature	Underground water pressure Angle and vibration
Monitoring	Sampling: Every 3-10min Distance :30-50m	
Node software	Footprint : 8KByte ROM 2K/RAM 6K	(10MHz CPU) Command interpreter Iterative processing Sequential processing Sleep
Power consumption	Peak: 130mW Idle : 3mW	

In the comparison study, requiring battery replacement every 13-15 month at three times the battery capacity.

Field experiment

FUJITSU

Side slope of freeway



Pre-construction field

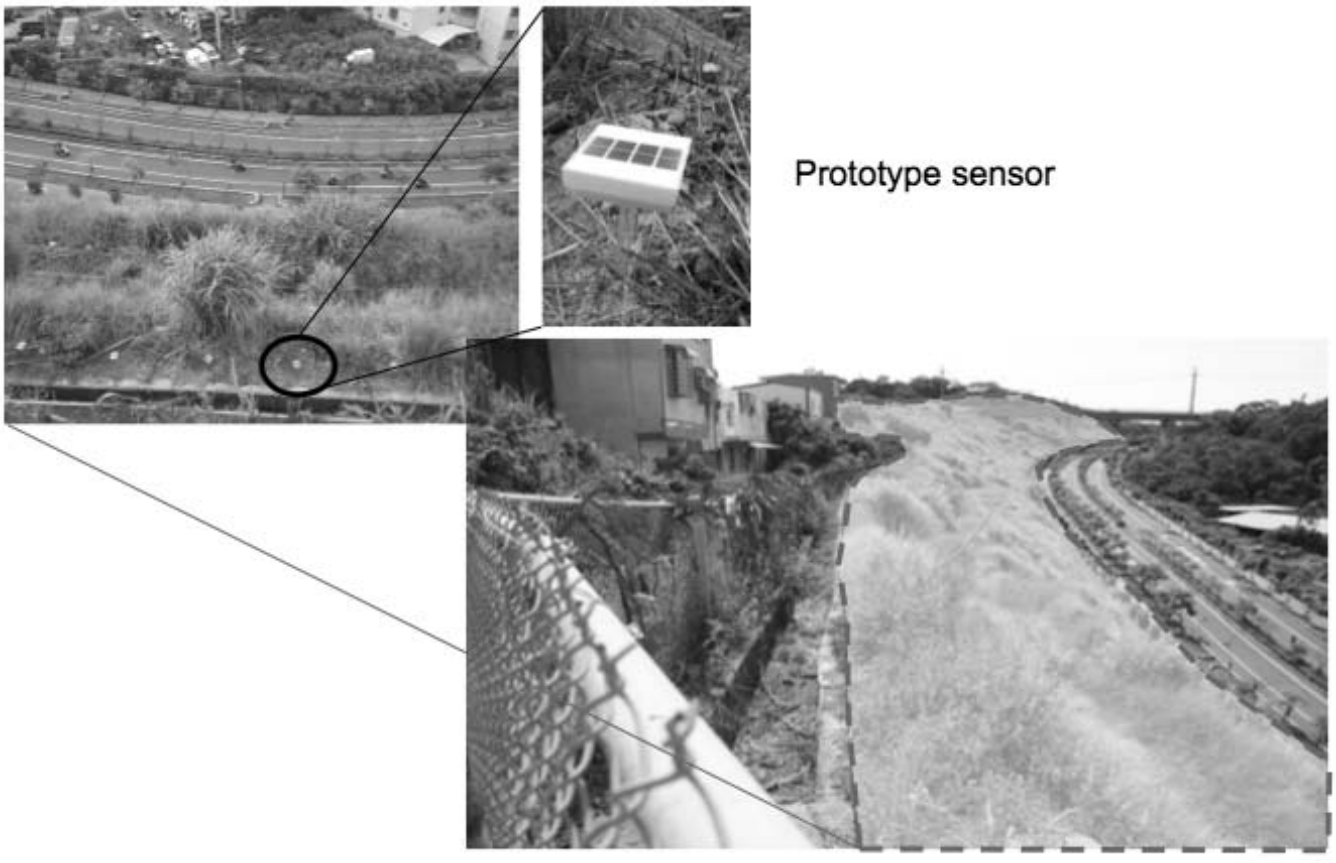
Deep mountain area

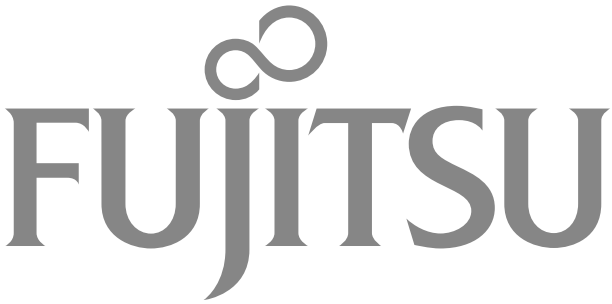
Old stone wall

Hundreds of nodes have been running over one year without maintenance.

Field experiment

FUJITSU





shaping tomorrow with you