MPSoC2017

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An Architecture Design for Integrated Traffic Control System

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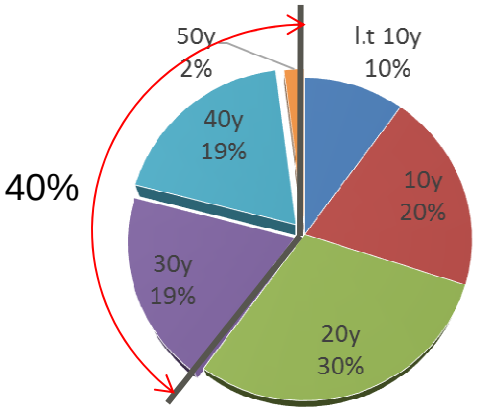
Background

- Sensing device of automotive and advanced intelligence is progressing.
- On the other hand, management system of the road itself is considered.
  - Aging problem (30~50 years after construction)
    40% of road infrastructure (bridge, tunnel, slope…) of freeway
  - Disaster problem
    70,000 areas (freeway), 1,050,000 areas (other local roads) must be monitored continuously

* Only in Japan



Age of road infrastructure (freeway)*

Profile

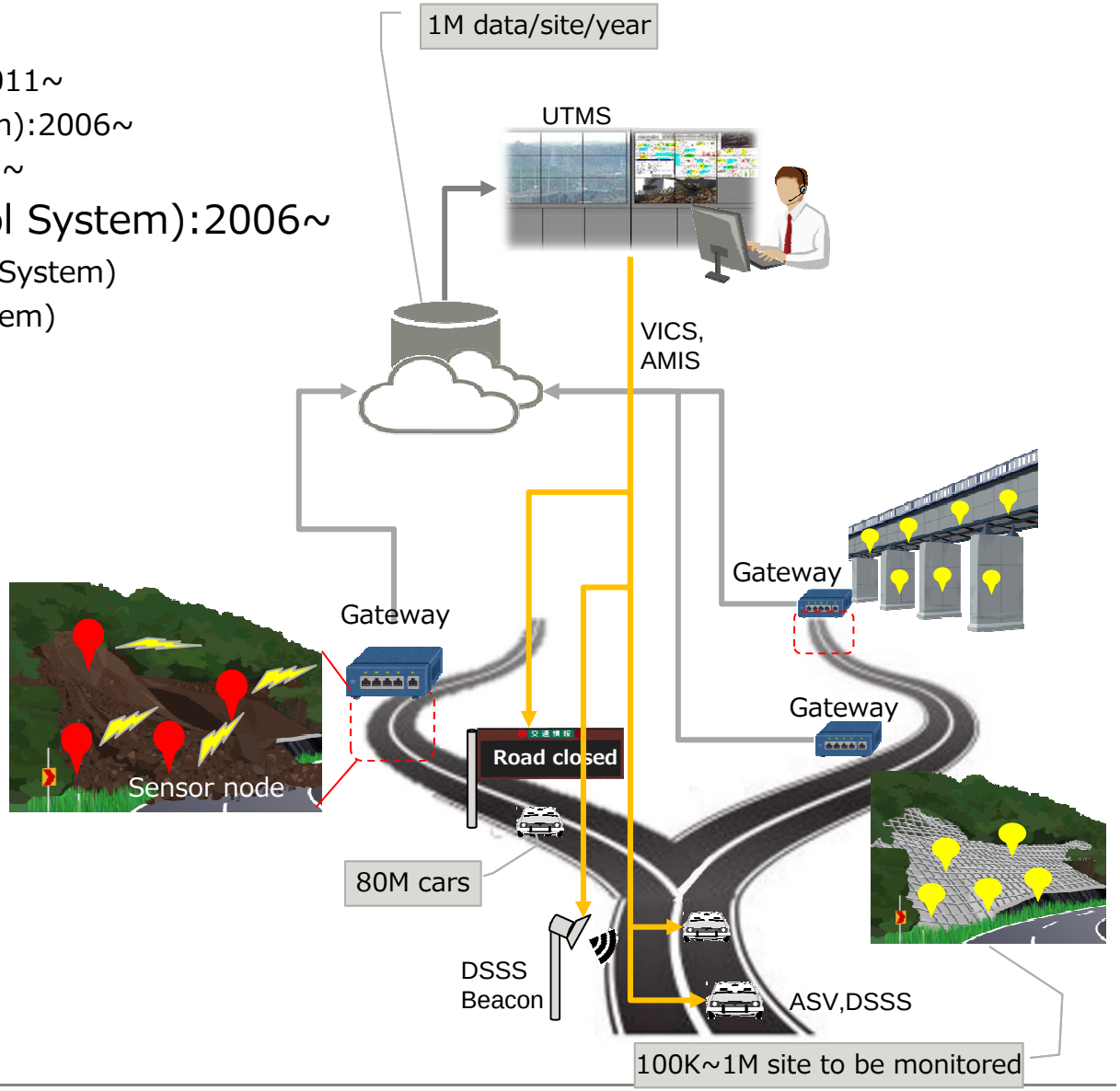
	Length[km]	Monitoring target
Freeway	10,000	70,000 areas*
National highway	54,000	1,050,000 areas**
Prefectural road	129,000	
Others	1,000,000	

Along with the evolution of automobiles, remote monitoring of road infrastructure has been integrating as an advanced IoT system

* Fujitsu and partners examined
**Ministry of Land, Infrastructure and Transport, Japan 2007

Intelligent Transport System

- Navigation System ,VICS, ETC: 2001~
- Safety Driving:2006~
  - AHS(Advanced Highway System):2011~
  - DSSS(Driving Safety Support System):2006~
  - ASV(Advanced Safety Vehicle):2011~
- UTMS(Universal Traffic Control System):2006~
  - AMIS(Advanced Mobile Information System)
  - ITCS(Integrated Traffic Control System)



Conditions and Challenges

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- Huge data collection, sustainability and robustness
  - Problems:
    - The bottleneck of the system is not disclosed
    - It doesn't work properly with a simple implementation
  - Proposal:
    Dynamic vertical migration control for distributed processing between gateway (edge) and cloud.
- Fluctuation in wireless communication and power model due to the environmental disturbance
  - Problems:
    - The deployment environment is severe
    - No power supply, no wired network line
  - Proposal:
    1. Power scheduling method considering solar-power generation variation via weather and temperature (MPSoC2015,2016)
    2. **Wireless node deployment simulation :** transmission rate becomes symmetric under the environment of varying signal strength

Dynamic vertical migration control

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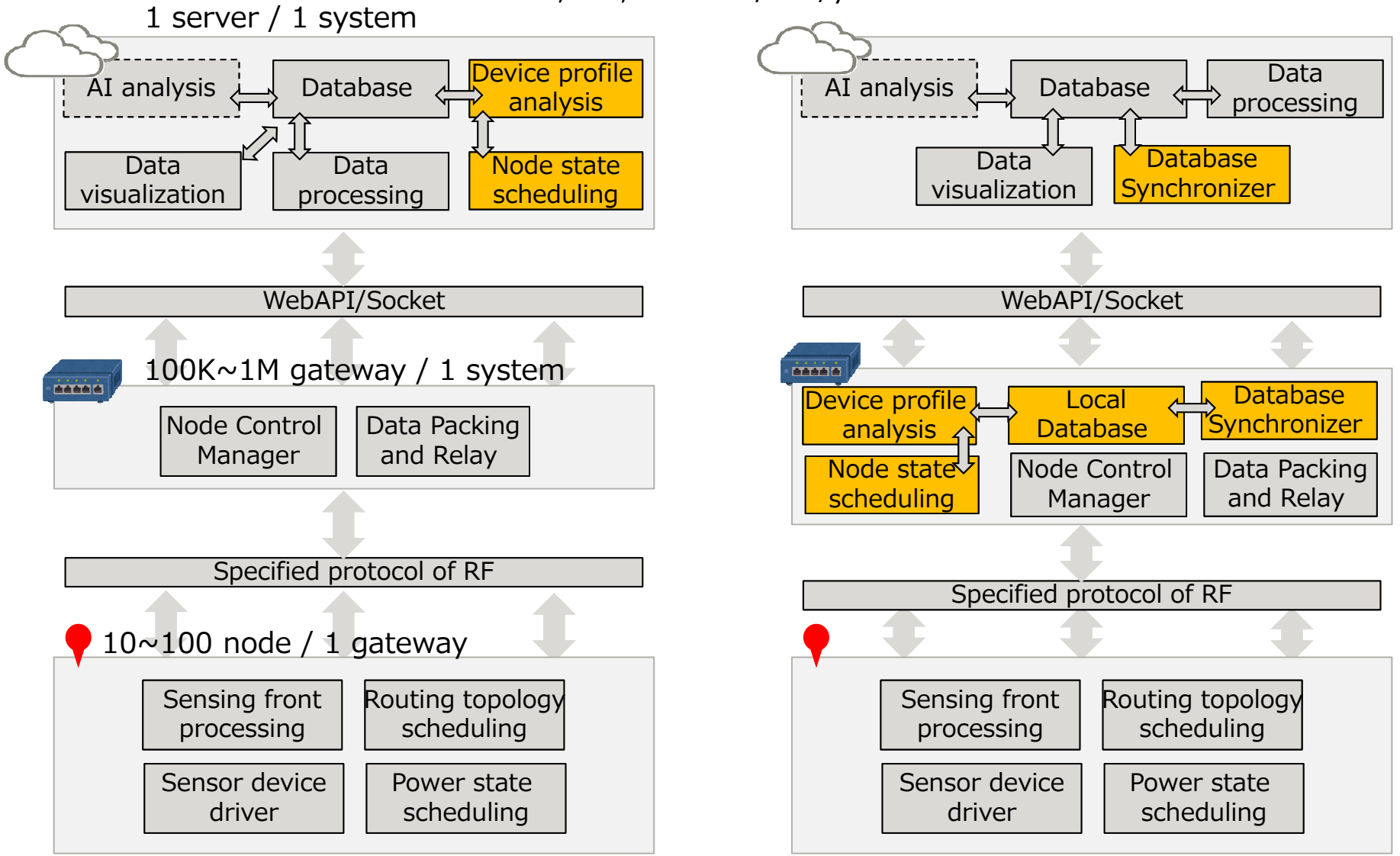
Which is better ?

✓ About 1,000,000 data/site/year are collected



Trade-off

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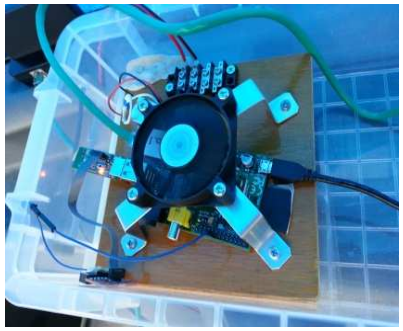
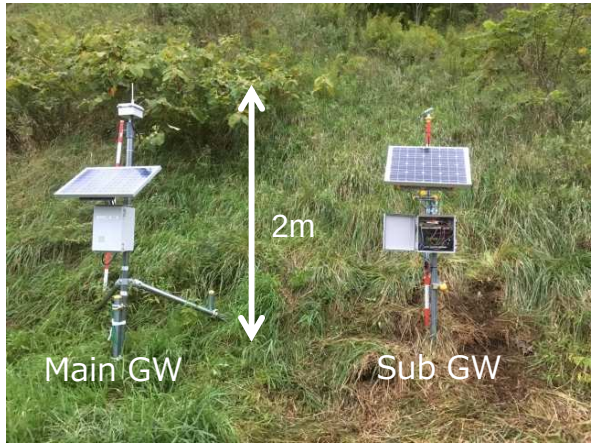
	Cloud centralized	Gateway (Edge) centralized
Advantage	➢ Real time performance of all global data analysis (Comprehensive observation and analysis of all data) ➢ Miniaturization of gateway architecture (GW only relays data)	➢ **Data flow between cloud server** (compressed and arranged DB data) ➢ **Robustness against backbone network** (local DB becomes backup when backbone network is disconnected) ➢ **Real time performance for sensor device control**
Disadvantage	➢ Real time performance for sensor device control ➢ **Robustness against backbone network** (data loss during failure of base station of cellular network)	➢ Real time performance of all global data analysis (It's necessary to judge with only local data or to wait for feedback from the center) ➢ Calculation load and the size of gateway

Gateway size comparison

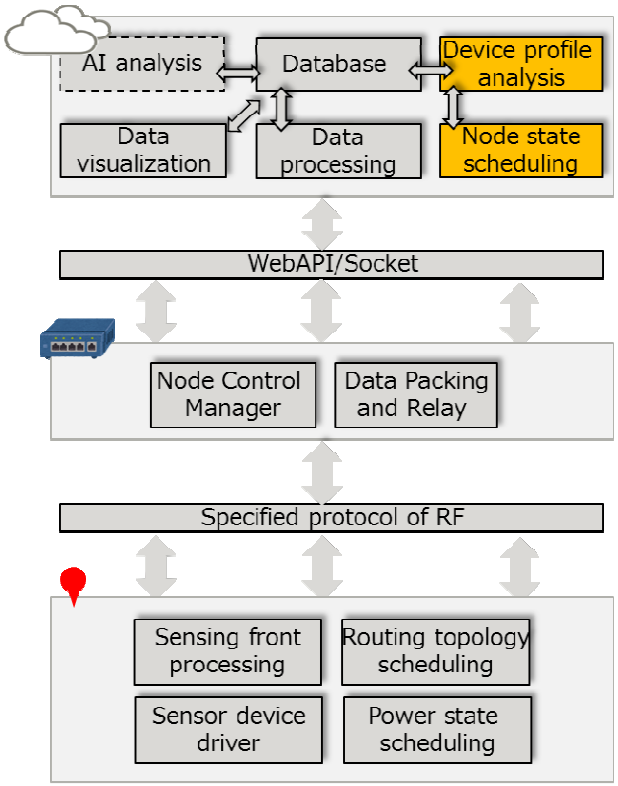


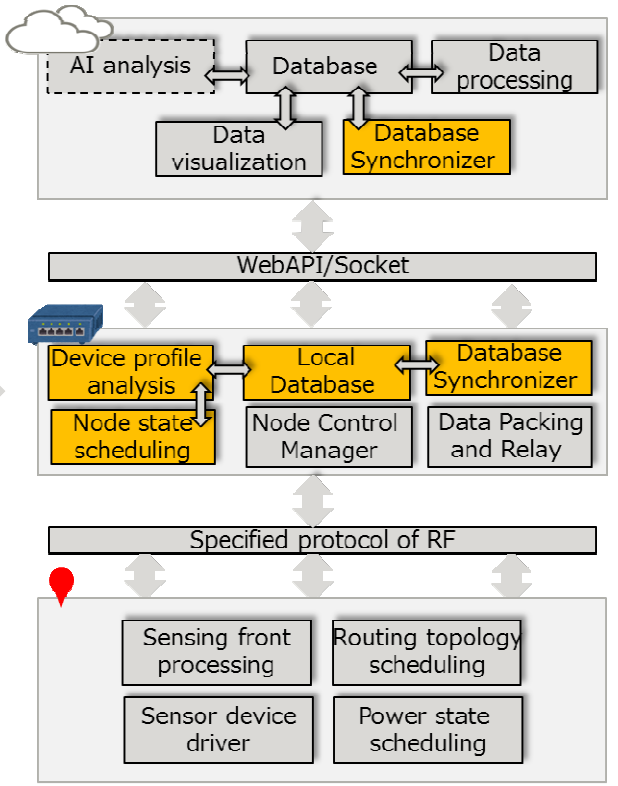
Minimum : lunch box size
ease to install everywhere



Full function with full autonomous power supply

Dynamic vertical migration control





Trigger of migration

- Trouble of backbone network (disconnect, security anomaly)
- Trouble of power state of GW
- Trouble of sensor network
  - Unstable link quality and topology change
  - Power scheduling of sensor nodes
  - :

Frequent migration causes unstable system

Frequency of Trigger of migration

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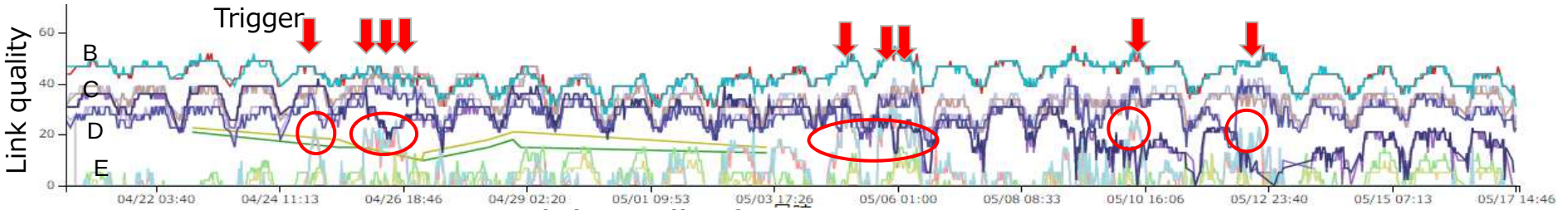
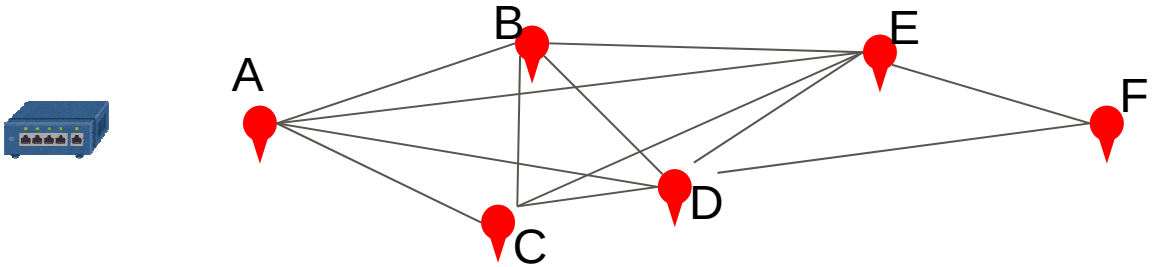
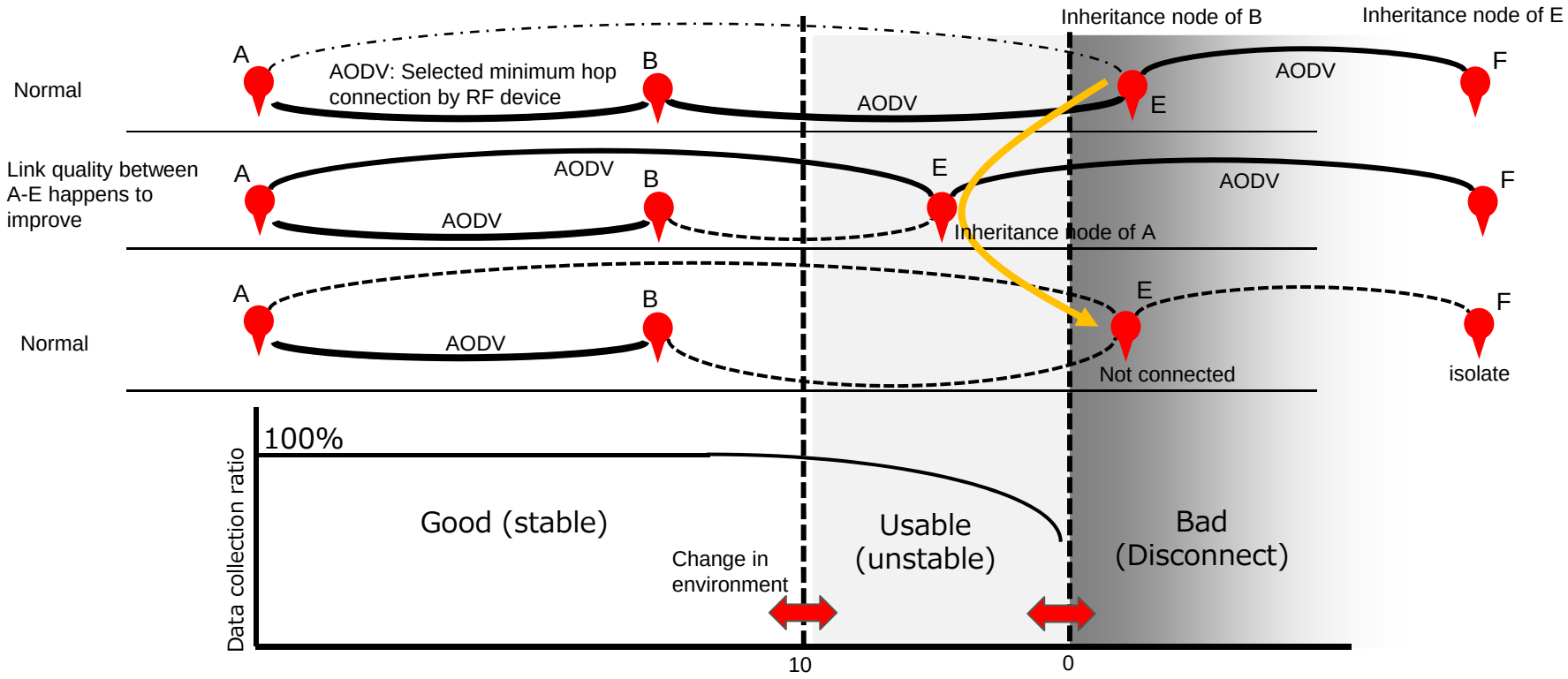
Trigger	Freq.	Cause	Countermeasure
Backbone network	Several times a year	Backbone maintenance DDoS attack	
Power state of GW	-	Battery running out	Correct estimation
Power state of sensor	Several times a month	Fluctuation of sunshine	Power scheduling (MPSoC2015,2016)
Link quality	Several times a month Several times a day	Weather, vegetation, moving obstacle, **Optimized routing of RF device**	Deployment plan considering environment and characteristics of RF device





What happened

- Optimal path search algorithm like AODV(Ad-hoc On-Demand Distance Vector) is affected by environmental change and reduces data collection ratio. → **cause of system instability**



Link quality (ex. Stable=-80dBm~, Usable=-80~-85dBm, Bad=-85dBm)

Nodes must not be deployed at physical distance that transit the “usable-bad” state

Proper deployment

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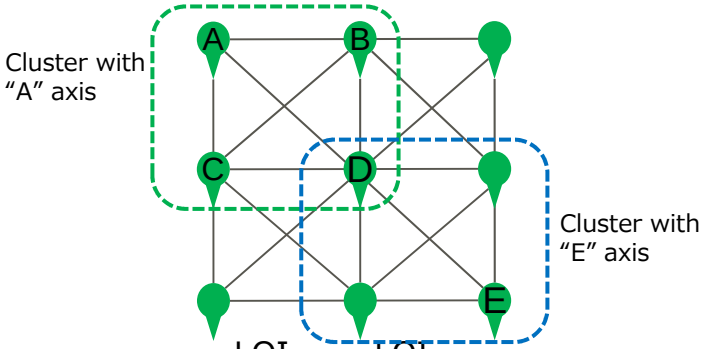
Ideal relationship of nodes



$LQI_{A-B} = LQI_{A-C} = LQI_{A-D} = LQI_{D-E} \cdots$

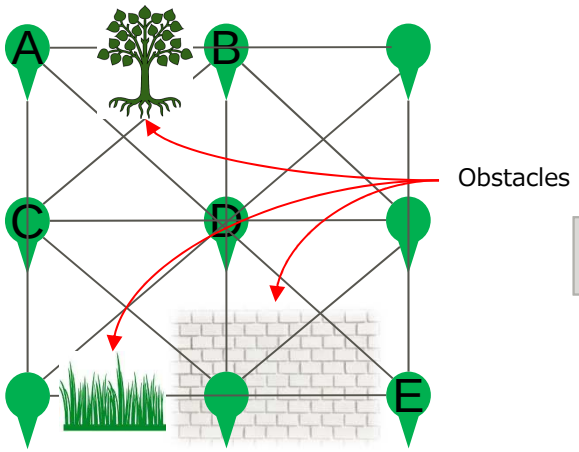
Data calibration operation with neighbor nodes
Reliable data transfer (ad-hoc network)

Symmetric topology

- Equivalent architecture
- Equivalent transmission path throughput
  (Stable link quality and stable data transmission makes easy scheduling for control)

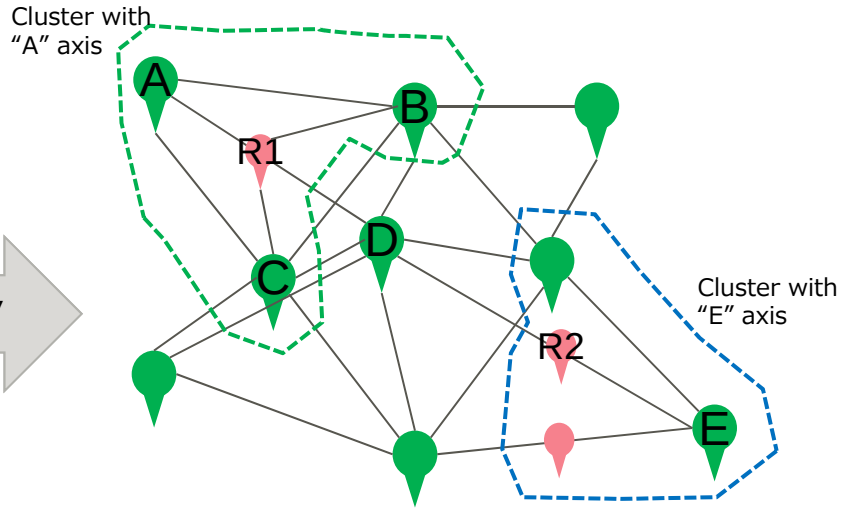
LQI=Link Quality Indicator (≒ RSSI)

Actual relationship of nodes



$LQI_{A-B} \neq LQI_{A-C} \neq LQI_{A-D} \neq LQI_{D-E} \cdots$

Appropriate placement, additional relay node



$LQI_{A-B} = LQI_{A-R1} = LQI_{R1-D} = LQI_{D-R2} \cdots$

Even though the physical distance is symmetric,
it will not be symmetric in terms of wireless communication

Proposed simulation

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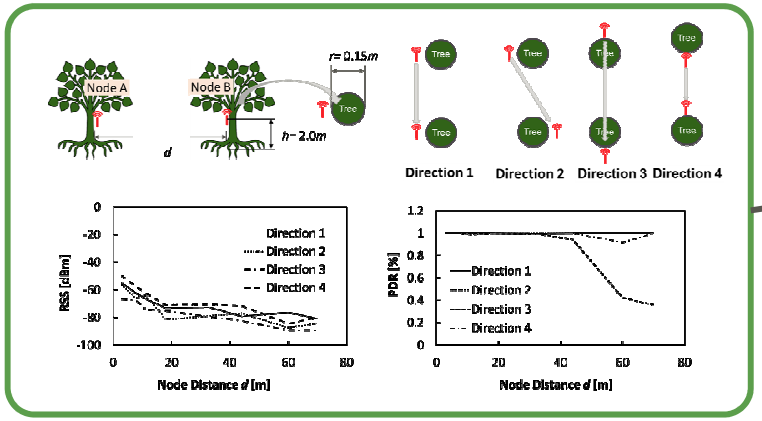
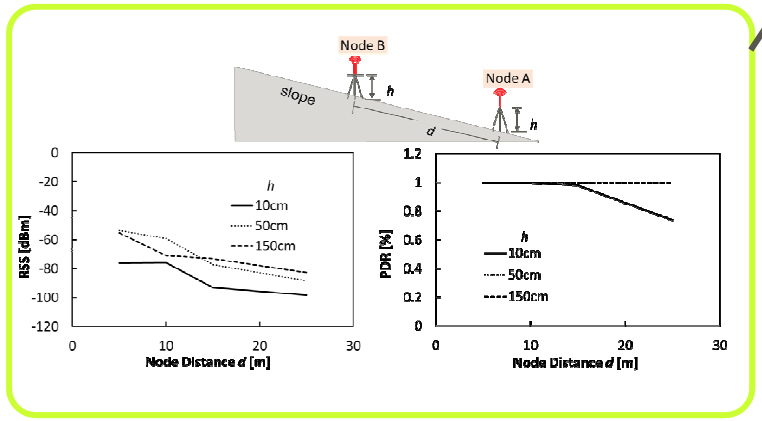
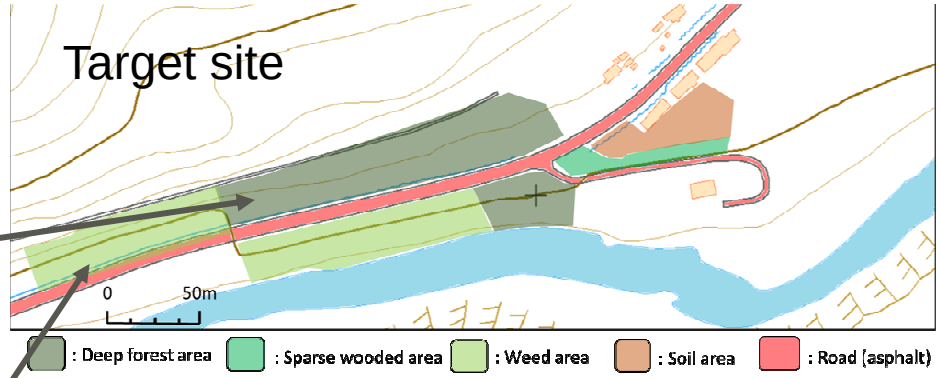
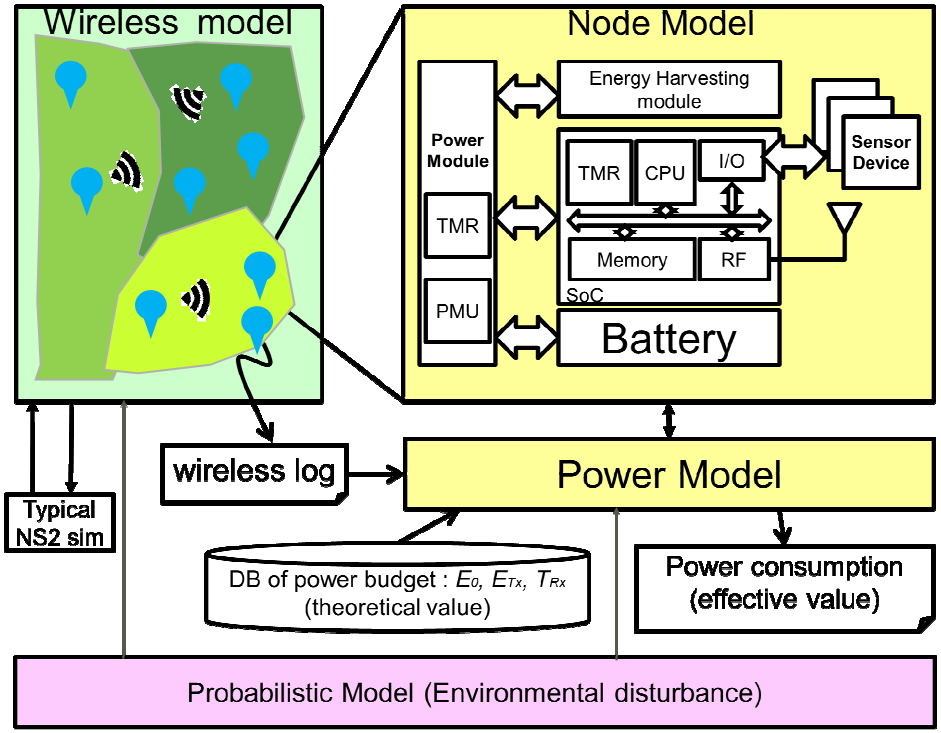
Example of region



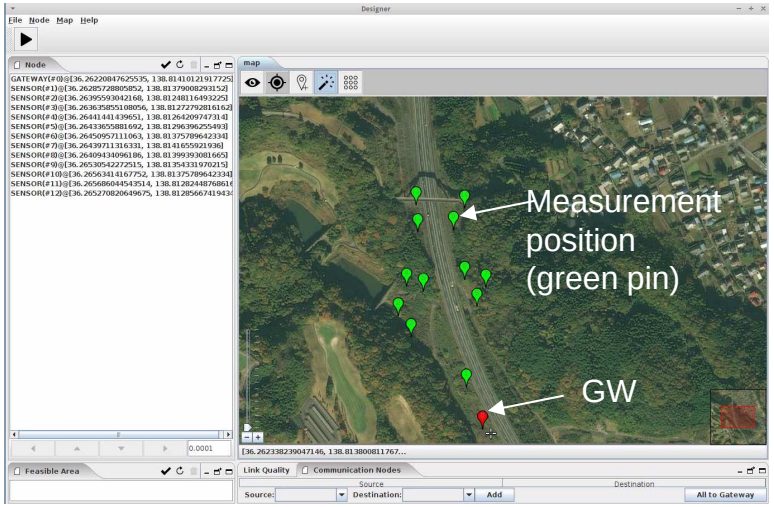




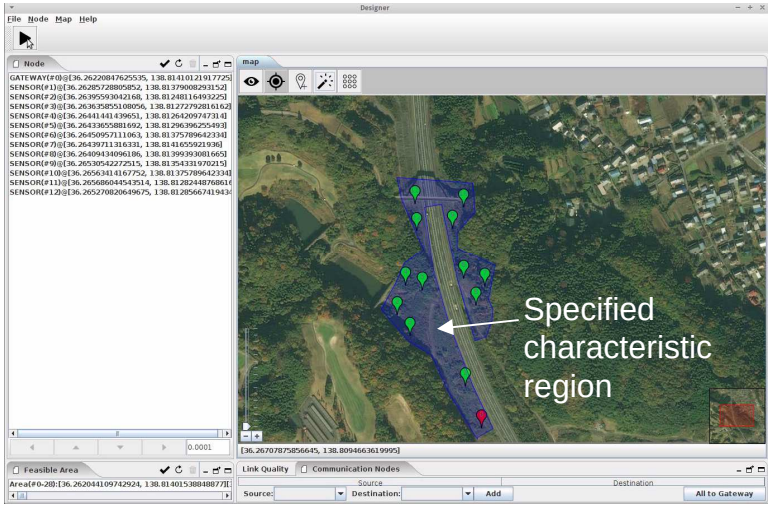


Proposed simulation

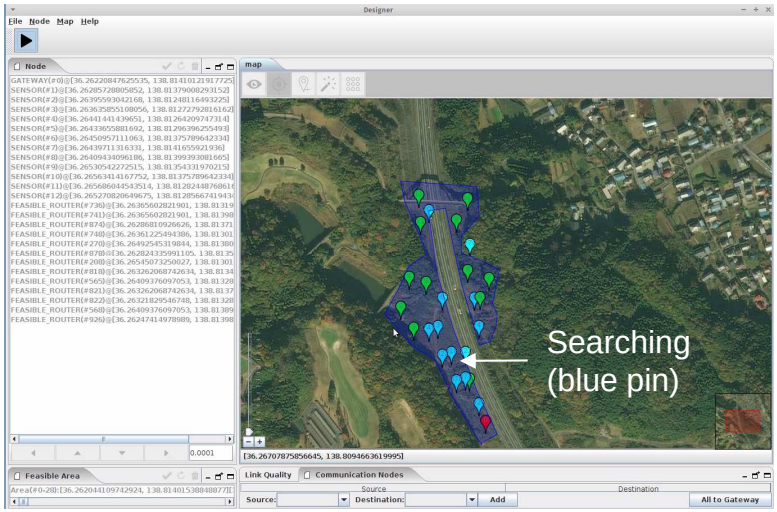
① Specify GW and measurement position



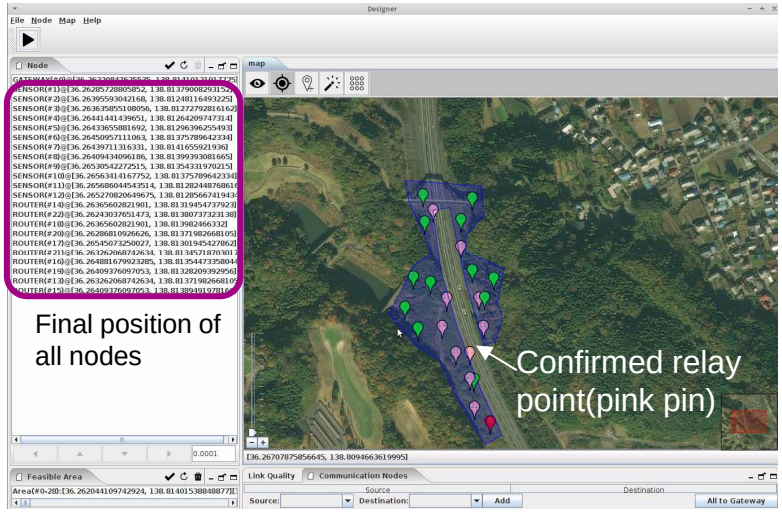
② Enter communication characteristic template



③Searching for relay points (automatic)



④Determination



Result

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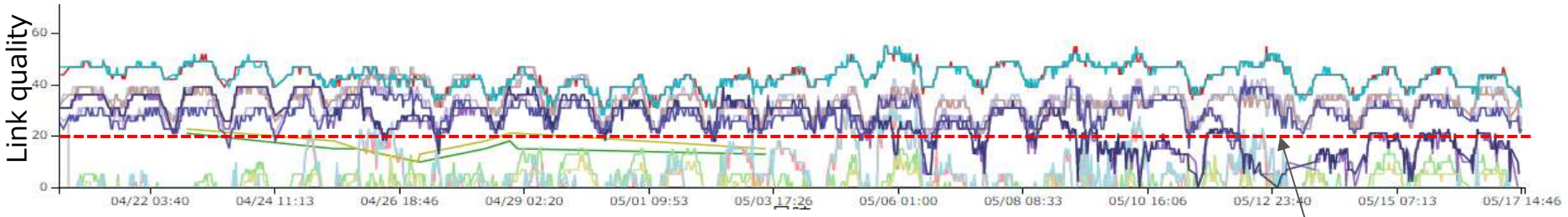
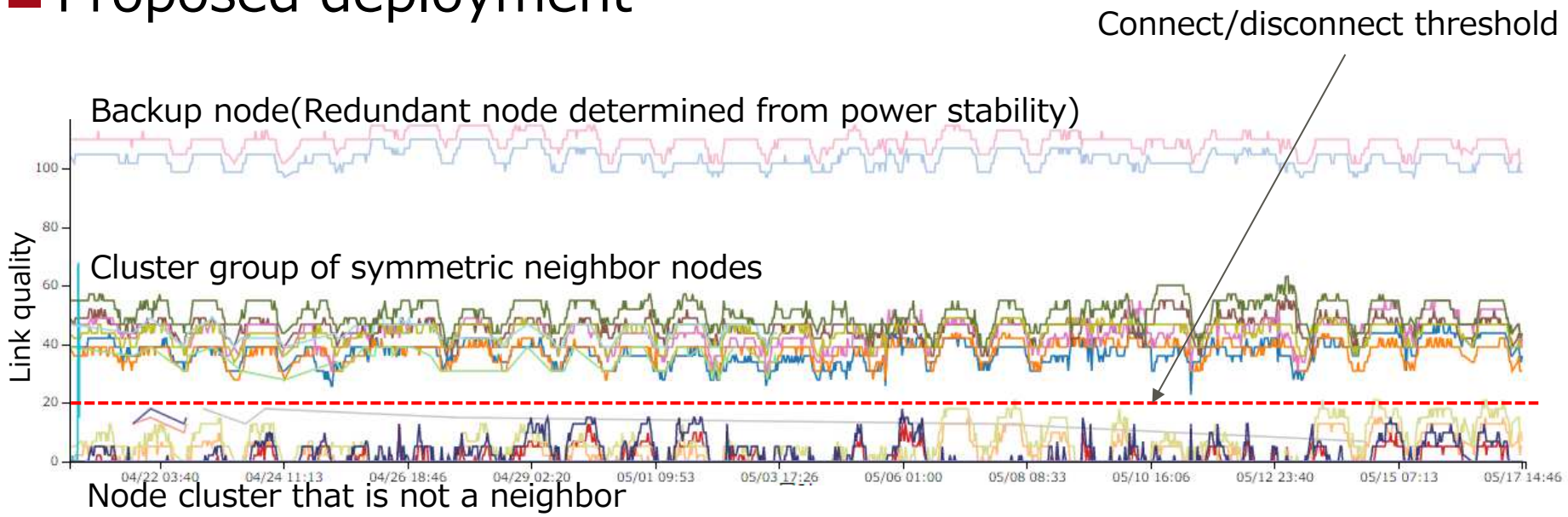
Simple deployment



Proposed deployment



Conclusion

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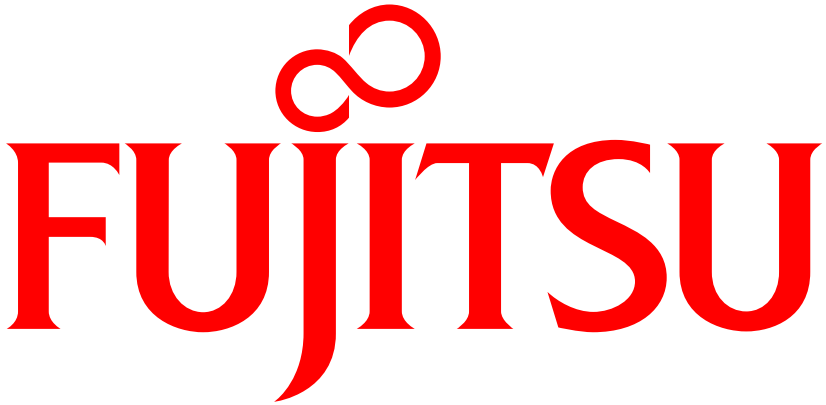
- Advancement of automobile and road operation system is progressing.
- Although, research and development of advanced control systems for automobiles is in progress, the road monitoring and control systems to be cooperated into ICT has been delayed.
- There are problems between server cloud and gateway edge loads and system robustness and stability. Implementation is not simple and not easy.
- We made two proposals and verified the effect.
  - Dynamic vertical migration control for distributed processing between gateway (edge) and cloud
  - Wireless node deployment simulation



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