

Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [PHY and MAC Proposals for low-power consumption SUN]

Date Submitted: [2 May, 2009]

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Re: [In response to TG4g Call for Proposals]

Abstract: [Proposal of PHY and MAC for low-power consumption SUN]

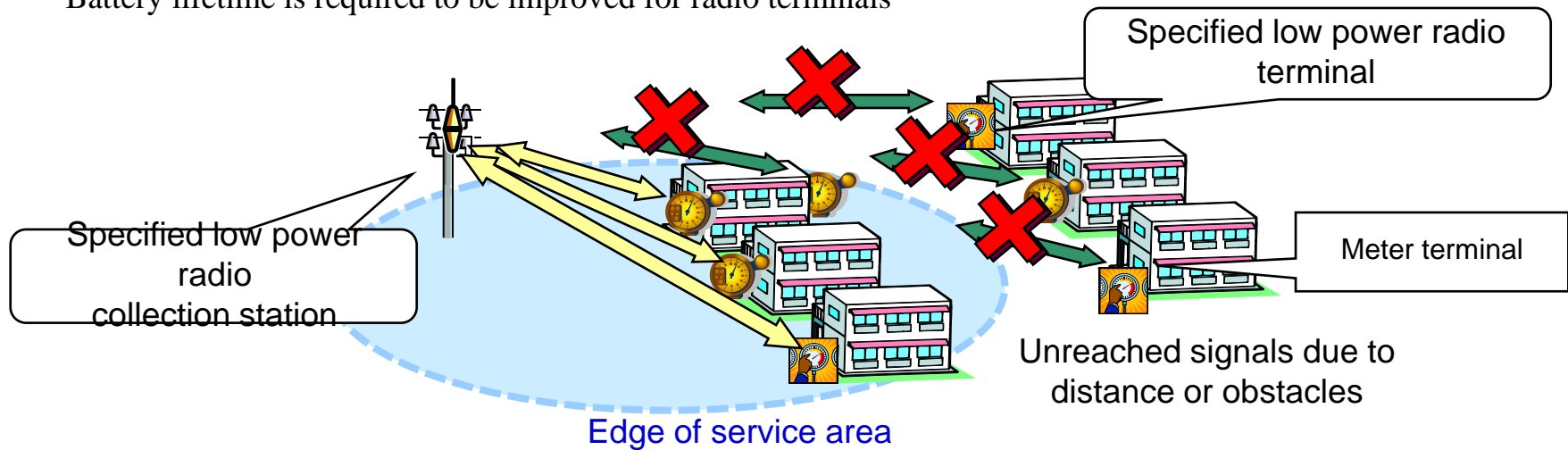
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System image of the assumed specified low power radio system

Automatic meter for gas, electricity and water is considered one of very attractive usage of specified low power radio on 400MHz band that realizes rational management and advanced customer services, while the following issues are considered before practice and diffusion.

- **Small transmission power restricts the service area**
- Advanced transmission scheme is required with coexistence with the other systems
- Battery lifetime is required to be improved for radio terminals

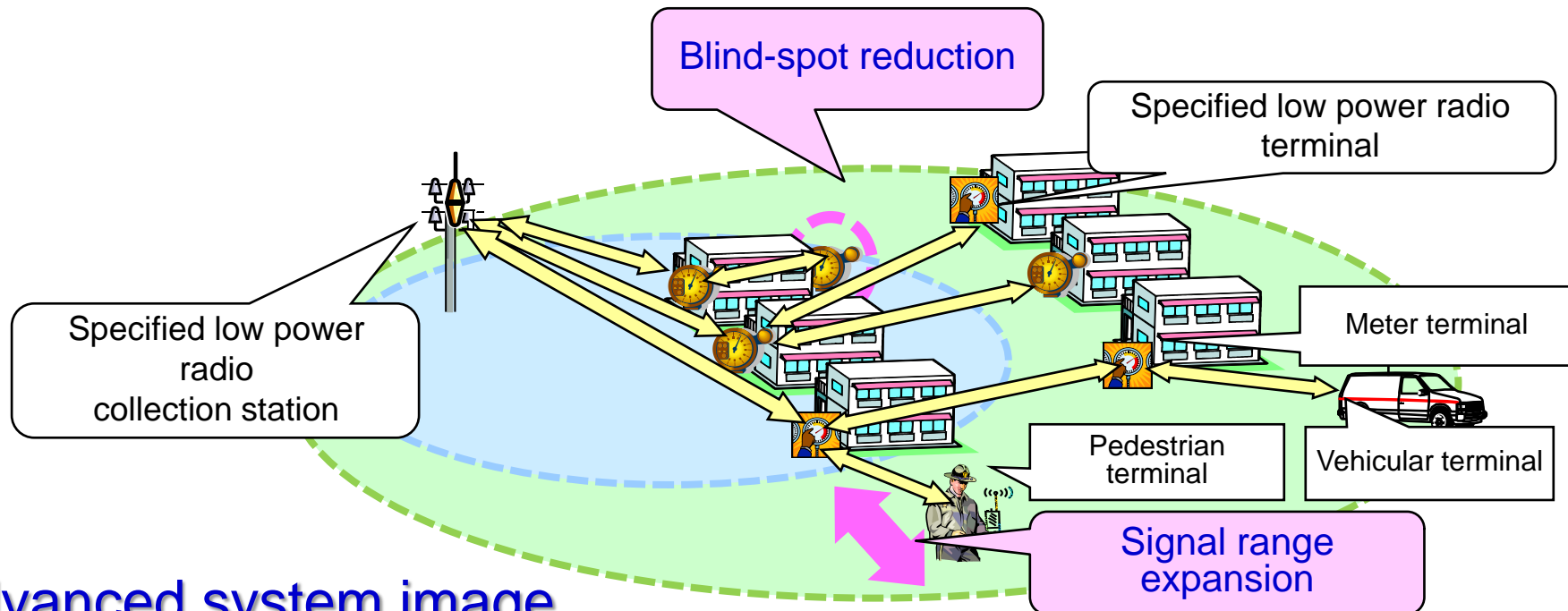


Current system image

Improvement by multi-hop transmission employment

Multi-hop transmission enables service area expansion by the following functions

- Signal range expansion
- Blind-spot reduction



Advanced system image

Proposed PHY and MAC

Center frequency band	400 MHz and lower
Transmission power	Max 10dBm (antenna input power)
Modulation scheme	FSK
Signal bandwidth	30 kHz (Min) – 150 kHz (Max)
Data rate	20 kbps – 160 kbps
MAC scheme	CSMA/CA with sleeping period
Routing scheme	Based on autonomous TREE topology construction

- This proposal is decided on the basis of the following evaluation
 - ✓ Measurement of propagation characteristic
 - ✓ Computer simulation
 - ✓ Evaluation by experimental prototype
 - ✓ Evaluation by pre-commercialized prototype

Propagation characteristics evaluation experiments

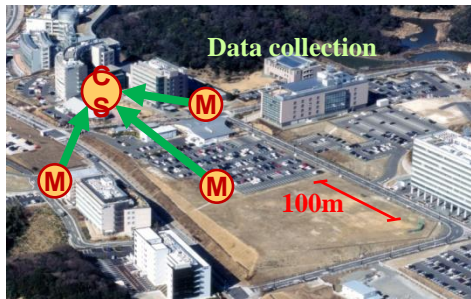
Propagation characteristics have been evaluated according to service area conditions, and meter located situations, thereby obtaining suitable models for several degradations.

Consideration of area conditions

Two different areas are defined each of which has further different profiles as for LOS/NLOS conditions. Such areas are used as parameters to evaluate the propagation characteristics.

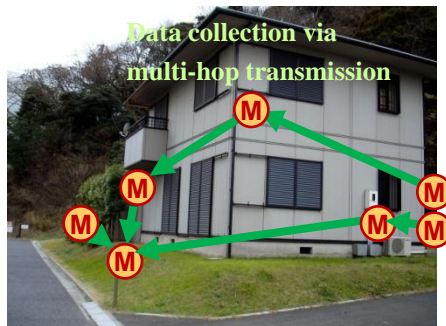
Wide area

Area for collection station having higher located antenna and meter communication

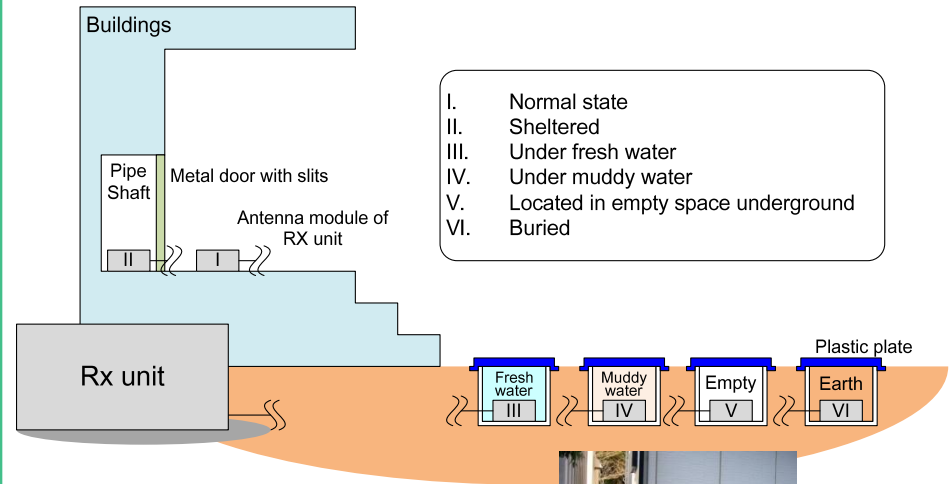


Meter located area

Area for meter and meter communication with multi-hop transmission



Degradation evaluation due to meter location



Antenna conditions assuming meter locations



Under fresh water

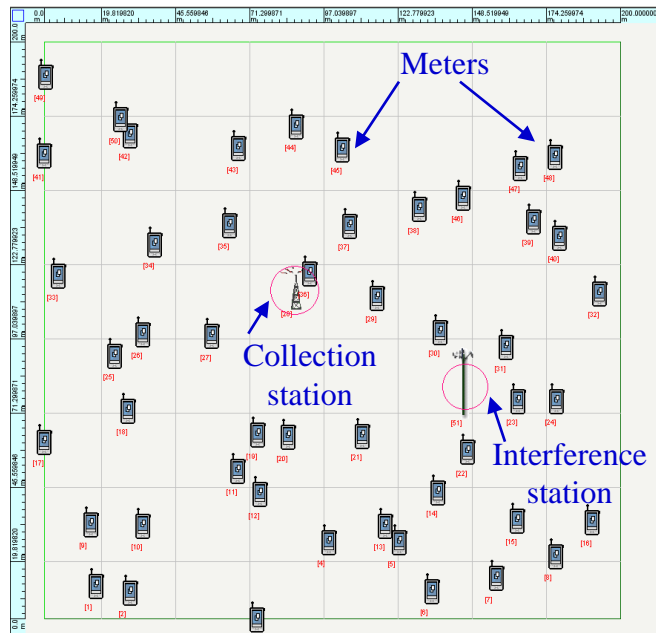
Under muddy water

Buried

Evaluation by computer simulation

Computer simulation results confirmed that system parameters should be suitably configured in order to cope with real usage model such as crowded terminal situation or interference situation.

Simulator interface



Simulator activation image including 50 meters with an interference station

Parameter introduction

Four parameter categories are employed to simulate strict usage models

Computer simulation parameter	Detailed parameter	Input Examples
Collection station and meter location parameters	Simulation area size	200m x 200m based on assumed service area
	Number of meters	50 - 1000
Propagation parameters	Shadowing	6.5dB as in land mobile communication
	Path loss factor	2.0 as in land mobile communication
	Center frequency	426MHz as for existing telemeter system
	Antenna setting	Collection height 5m, meters: 1m
	Degradation for each meter #1: Building penetration loss	Based on propagation experiment results
	Degradation for each meter #2: Meter location (PS; Pipe shaft)	-20dB, assuming propagation experiment results
	Degradation for each meter #3: Meter location (Other than PS)	Based on propagation experiment results
	Degradation for each meter #4: Interference suffering condition	Existing telemeter system model
Traffic parameters	Traffic model	Periodical arrival
Protocol parameters	Radio communication scheme	FSK, B(Q)PSK, GMSK, 802.15.4PHY
	MAC	General MAC, 802.15.4MAC
	Routing scheme	AODV, OLSR, Direct transmission, Tree topology

Prototype terminal for experimental evaluation

NICT has proposed a prototype terminal with the following features

1. A variety of modulation schemes and data rates
2. Low power MAC with suitable sleeping periods
3. Autonomous routing scheme based on tree topology construction

Outline

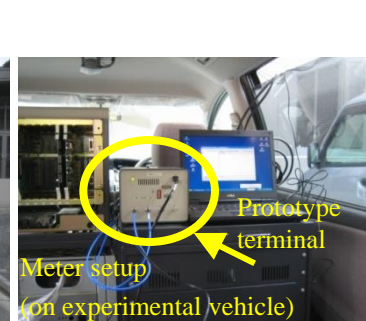
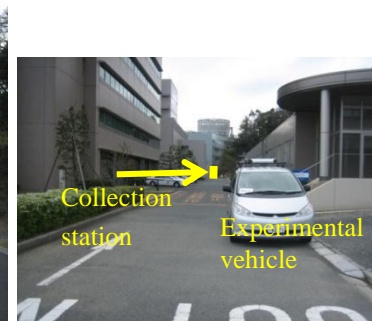
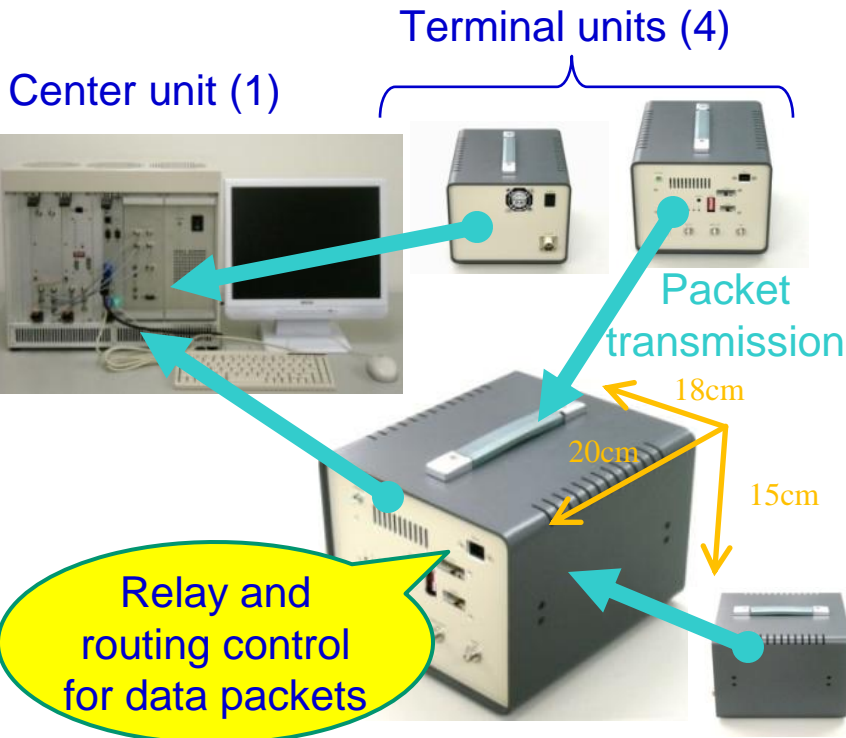
After power-on, each terminal unit establishes route to the center unit by examining units around.

Specifications

Size and weight	W18cm x H15cm x D20cm, 2.5kg			
Center frequency	426.0375MHz			
Transmission power	10dBm			
Antenna gain	2.15dBi /9dBi			
Modulation scheme	ASK	FSK	BPSK	QPSK
Signal bandwidth	150kHz	300kHz	150kHz	150kHz
Data rate	80kbps	80kbps	80kbps	160kbps
MAC scheme	CSMA/CA with sleeping period			
Routing scheme	Based on autonomous TREE topology construction			

Experiments

Multi-hop packet transmissions are confirmed to improve system performance

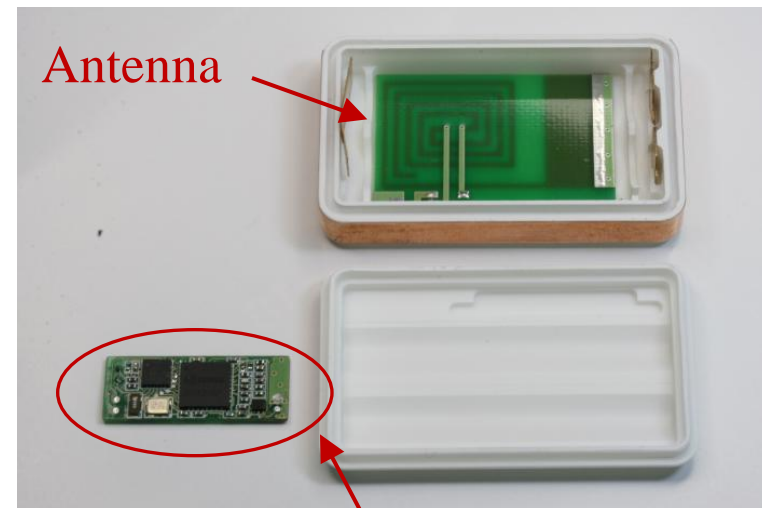


Small sized and low power prototype terminals

NICT has also developed **small sized and low power prototype terminals** with reduction of several functions from the previous prototype. This “customized” terminals could be used in order to evaluate performances under the strict situations for concrete use cases in the future.



Operation with AAA batteries



Radio circuit board

Specification of Small sized and low power prototype terminals

Center frequency band	400 MHz and lower
Transmission power	Max 10dBm (antenna input power)
Modulation scheme	FSK
Signal bandwidth	30 kHz
Data rate	19.2 kbps
MAC scheme	CSMA/CA with sleeping period
Routing scheme	Based on autonomous TREE topology construction