

Development and Field Test of Substation Information Network for Facility Maintenance

Background

It is necessary for Japanese electric companies to develop information network for supporting condition-based maintenance. The network collects status information of electrical apparatus with sensors and delivers the information to remote places including a maintenance center efficiently and reliably. Utilizing latest information and communication technologies is effective for constructing the network.

Objectives

To develop substation information network, which delivers maintenance information efficiently and reliably utilizing latest information and communication technologies, and to conduct a field test using an experimental network built in an extremely high voltage substation;

Principal Results

1. Design of substation information network

We need to allocate sensors around electric apparatus easily to collect maintenance information for long duration. It is also necessary to deliver the information to remote places including a maintenance center efficiently and reliably. As Table 1 shows functions of the network and applied technologies, we apply technologies of wireless sensor network and image-processed meter reading for collecting maintenance information. For delivering maintenance information to remote places, we also apply DRNA technologies * 1, which include communication middleware and reliable mobile agent system technologies.

This network is composed of 1) maintenance information collecting network and 2) maintenance information delivering network as shown in Fig.1.

- (1) The maintenance information collecting network: this makes it possible to collect information measured by wireless sensor nodes and meter indicating values which are the result of capturing meter images by network cameras and analyzing these by a collecting computer.
- (2) The maintenance information delivering network: this utilizes mobile agents * 2 based on DRNA technologies to deliver maintenance information from substation servers to a maintenance server. This also ensures reliable communication with management of information delivering status and control of flow and redundant route for traffic of mobile agent.

2. Field test of the substation information network.

We developed an experimental system based on our design in an extremely high voltage substation and collected information for a transformer for fifteen months. Table 2 shows the results of the field test. It is confirmed that the network can collect and deliver the maintenance information effectively and reliably as described below.

- (1) The wireless sensor network technology enables information collection on temperature, sound, brightness, vibration. Communication success rate was 97%.
- (2) The image-processed meter technology enables digitizing meter indicating values and the maximum error rate for all the tested meters was 4.1%.
- (3) DRNA technology enables delivering general-purpose format and variable length data successfully without data loss and monitoring of delivering status by the maintenance server. Plug-in functions for flow and redundant route control work fine.

This research was requested by the Kansai Electric Power Co., Inc.

Future Developments

A communication technology for collecting and delivering multimedia information will be developed to enhance the flexibility of the network.

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Reference

Hiroyuki Yusa, et al., 2007, "Architecture of Information Network System for Substation Facility Maintenance," Joint technical meeting on power engineering and power systems engineering, IEE Japan, PE07-70, PSE-07-85, pp. 25-30 (in Japanese)

* 1 : DRNA means distributed real-time computer network architecture. Y. Serizawa, 2005, "Development of Reliable Communication Architecture Suited to Power System Control in the Liberalized Electric Power Industry," CRIEPI Annual Research Report, pp. 94-95

* 2 : Software component to migrate among computers autonomously.

Table 1 Applying technologies for substation information network

Technology	Summary	Expected result
Wireless sensor network technology	A sensor node cooperates with other nodes, autonomously forming ad-hoc meshed wireless network. The network enables information collection from multiple points.	Automatic collecting maintenance information
Image processed metering reading technology	First a network camera captures images of meters. Second a computer analyzes the images. Then analog meter indications are digitized.	
DRNA technology	Reliable mobile agent system	Assured delivering maintenance information
	Communication middleware	

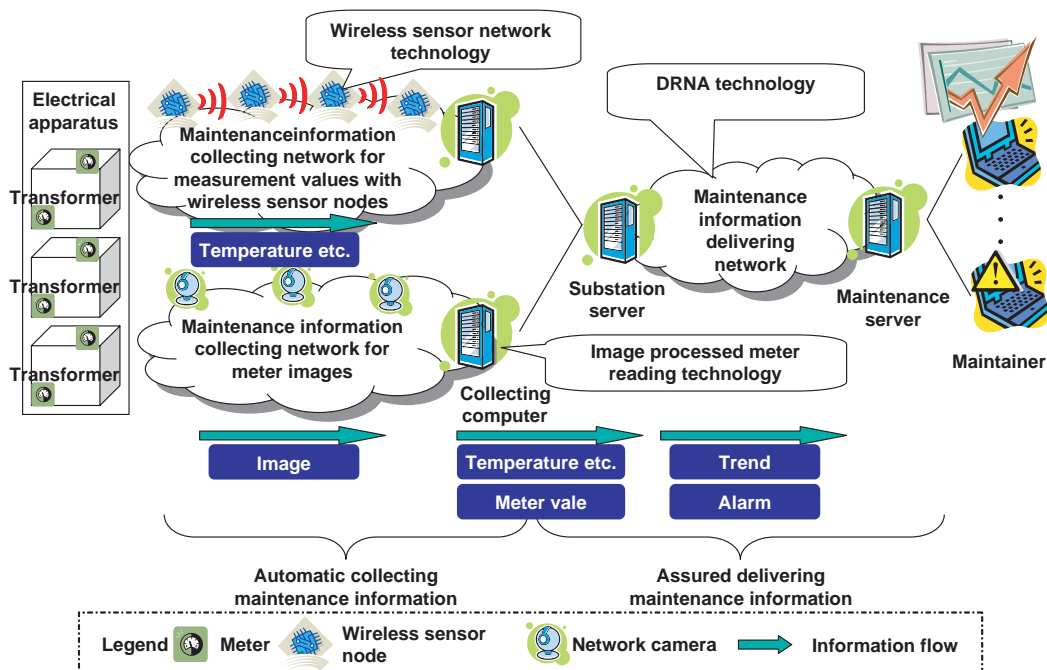


Fig.1 Overview of substation information network and information flow

Table 2 Result of field test in a extremely high voltage substation

Part of system	Applied technology	Item of evaluation	Result of evaluation
Maintenance information collecting network	Wireless sensor network technology	Easiness and possibility to collect maintenance information for long duration	Allocating thirteen wireless sensor nodes around the transformer makes it possible to collect information of temperature, sound, brightness, vibration. Communication success rate was 97%. This rate is enough for trend monitoring whose period is thirty minutes.
	Image processed meter reading technology	Same as above.	The network collected information on oil level, oil temperature, winding temperature. The maximum error rate for all the tested meters was 4.1% on condition that captured images were enough for the image processing. The main reason for the failure of the image processing was the effect of the sun.
Maintenance information delivering network	DRNA technology (Reliable mobile agent system)	Possibility to deliver various types of information.	When a maintainer requested maintenance information, the information was delivered with mobile agent. General-purpose format and variable length data were delivered successfully without data loss.
	DRNA technology (Communication middleware)	Assured information delivery	Remote monitoring of mobile agent enabled to check the delivering status by the maintenance server.
		Assured information delivery	Plug-in functions for flow and redundant route control were enabled according to parameters of the middleware. It was confirmed that these functions work fine.