NEC's Approach towards Advanced Metering Infrastructure (AMI)

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Abstract

Since 2006, NEC has been a participant in a project reviewing the possible automation of meter reading by power utility companies, aimed at developing and validating a communication method for so-called smart meters. Automated meter reading started out as a way of improving the power utility company's meter reading efficiency, however together with heightened interest in smart grids today, expectations are high for its future potential applications.

This paper discusses the scope of NEC support in regards to the validation project until now, as well as efforts toward utilization of smart meters in the future.

Keywords

smart meter, AMI, smart grid, multi-hop communication
wireless communication technology

1. Introduction

Even before the worldwide smart grid boom in 2009, Japanese power utility companies had been formulating a framework for automated meter reading as a way to increase their meter reading efficiency and provide a higher level of service to their customers.

There are two major challenges to achieving automated meter reading. First there is the operational challenge of how to renovate the various procedures in accordance with power meter automation. Then there is the challenge of communication technology, specifically how to achieve a network for the purpose of gathering meter readings. Naturally these two challenges are closely interrelated, and an ideal path for communication network development needs to keep in mind the aforementioned operational challenge as our business requirements.

And now, with the emphasis on energy saving and renewable energy ensuant to the Great Tohoku Earthquake of March 2011, the role of electricity meters is beginning to change. Expectations are high for implementation of the "smart meter," which acts as an information tool to encourage energy saving by the utility customer, in addition to automatic meter reading. Due to this role change, the technological aspects required of the data gathering communication network are also starting to change.

From 2006, NEC has been a full participant in the AMI (Advanced Metering Infrastructure) validation project, working to solve mainly issues in communication technology. In this paper, we will use our validation project activities thus far as a case study to introduce an outline of the AMI system and the scope of NEC's support. Also covered will be the evolving role of automated meter reading in the future, and the communication technologies required to achieve it, reflecting the changing conditions of present-day society.

2. Overview of AMI System

NEC has been a full participant in the AMI validation project undertaken by Kansai Electric Power Co., Inc. since 2006 has actively contributed to the development of their AMI system called the "New Meter Reading System." Subsequently, we have been involved in various automatic meter reading validation projects throughout the country.

Kansai Electric Power Co. has worked over many years in research and development for the realization of an automatic meter reading system, aiming to address two objectives, namely an improvement in customer service as well as streamlining meter reading procedural efficiency. As a precursor to full-scale automatic meter reading validation study in Japan, in 2008 a field test involving some 3,000 units was done, which has since led to more massive scale studies.

This section will provide an outline of the AMI system based on the case study of Kansai Electric Power Co.

2.1 AMI System Functions and Characteristics

The basic functions that would be required of an advanced metering infrastructure (AMI) system are as follows:

- **Scheduled meter reading function (Collection)**
  Function that acquires meter reading data at 30 min. intervals and sends it to the power utility company.
- **On-demand meter reading, Remote stop/release functions (Control)**
  Function that sends commands to a specified electricity meter to acquire meter reading data for a specified time span, and to change the status of circuit breakers.
- **Maintenance function (Distribution)**
  Function that updates the terminal's firmware and revises the time information.

Aside from these are other functions such as registration management at the time of terminal installation, however when looking at basic functionality, they do not differ much from the sensing system for periodic observation. However, the AMI system features two major characteristics. The first that sets it apart from other systems is its enormity. In order to install this functionality on the tens of millions of electricity meters throughout the country, an access network equivalent to a gargantuan communication carrier would ultimately be required. And since new electricity meters capable of automatic meter reading would be installed in phases over time, the system architecture would need to take scalability into account.

The second unique aspect is the level of quality that is required. In Japan, the replacement of electricity meters that are in use is mandated by law once every 10 years by the Measurement Act. In other words, unless an electricity meter breaks down, the opportunity to replace it arises only once in a decade. So electricity meters equipped with communication functions will likewise be required to offer sufficient quality enabling them to provide stable performance for 10 years installed outdoors. And as mentioned earlier, due to the enormity of scale, it is necessary to keep the cost per unit as low as possible and also minimize replacement due to initial malfunctions in order to attain cost-effective installation.

2.2 Multi–hop Communication Method

As for the validation tests done in conjunction with Kansai Electric Power Co., we applied the multi-hop communication method using wireless technology as our principal means of communication.

A number of power utility companies have already been individually applying remote meter reading via mobile phone carriers, etc., in cases where physical meter reading was problematic. However, unless mobile phone carrier rates can be set relatively low, connecting all households using these carriers becomes very unrealistic from a financial standpoint. For this reason, we have selected the multi-hop communication method in which terminals autonomously communicate with each other to create a tree topology communication network, sending terminal data wirelessly to the telephone pole-mounted metering data collection unit which then connects to the power utility company's network. This method, which allows development of an in-house access network while minimizing communication line costs, is currently the mainstream at other power utility companies as well (**Fig. 1**).

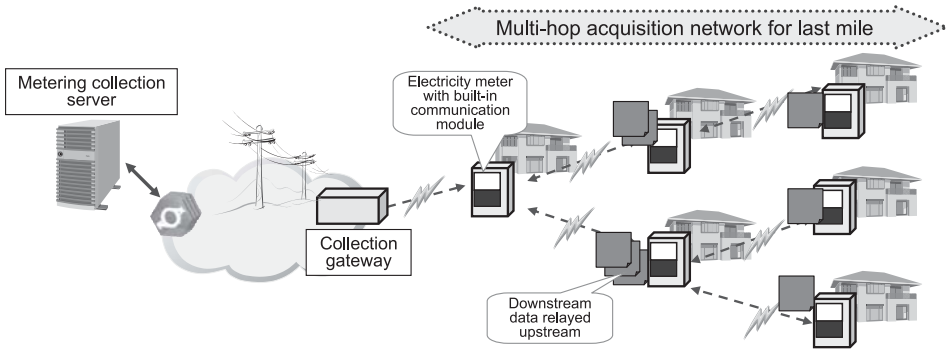


Fig. 1 Multi-hop communication method.

One of the merits of the multi-hop method is that, since a terminal can communicate via other terminals even if it cannot send a clear signal directly to the metering data collection unit, a detailed communication line plan is not necessary. Other advantages include high access reliability since communications are automatically rerouted in the case of a metering data collection unit malfunction, as well as superior cost-efficiency of communication lines due to multiple terminals being able to share traffic.

On the other hand, one of the disadvantages is, since it relies on multistage connection, there may be cases where an electricity meter installed in a location where direct communication with the metering data collection unit is not possible, finds itself unable to connect with any terminal and becomes stranded. In order to enlarge the coverage area per one metering data collection unit, it is necessary for communication capable electricity meters to be installed at a certain density. Furthermore, since multiple terminals share traffic, if a low-capacity transmission media is used, it may cause severe limitations on real-time performance (increasing latency) and transmission capacity.

2.3 Scope of NEC Support

As a participant in the validation project, NEC was involved in the development and manufacture of communication equipment including the communication unit of the electricity meter and metering data collection unit, as well as development of the routing function that optimizes the communication route (**Fig. 2**).

As mentioned earlier, one of the characteristics of multi-hop communication is the autonomous configuration of a network without requiring a line plan. The multi-hop communication method requires not only that the initial topology be configured automatically, but also for the route to be periodically updated for optimization in case there are any disruptions in the surrounding environment or temporarily interrupted connections. These functions are called "routing functions."

Route information is compiled based on a variety of environmental information that is sent along with the meter reading data to the terminal. In order to improve the collection efficiency of the network, we fine-tuned our settings a number of times to see which information (parameters) among those collected should be used to configure the most efficient communication route.

And since multiple terminals share traffic in the multi-hop communication method, there are cases, such as after a power outage, where multiple terminals attempt to communicate all at once causing a convergence. To avoid this, we implemented a system where the timing of communication resumption would be dispersed, and were able to verify positive results.

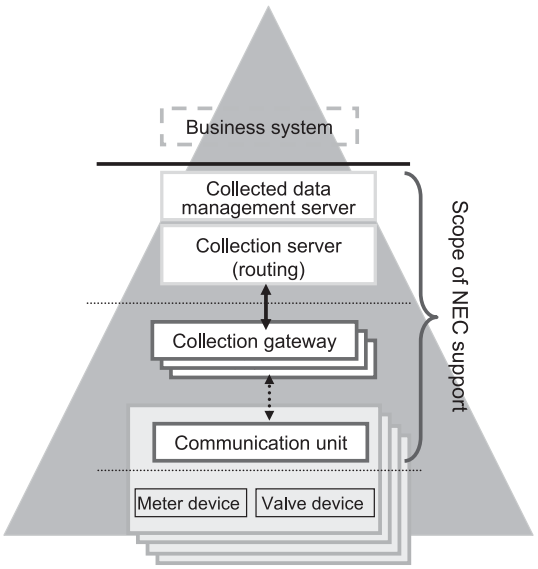


Fig. 2 Scope of NEC support.

3. Challenges for the Future

Participating in the validation project gave us the know-how on realizing a large-scale network that is necessary for advanced metering infrastructure. Also, people's thoughts on electricity usage have changed after the Great Tohoku Earthquake, and the role that smart meters are expected to play has also changed.

This section will discuss the role expected of smart meters, and the requirements of the communication network in accordance with it.

3.1 Changing Role of Smart Meter

The "Conference on Energy and the Environment" which was set up under the Japanese Government's National Policy Unit (NPU) announced on November 1, 2011 their "Energy Supply-and-Demand Stabilization Action Plan." This plan

outlines the actions to be taken over a 3 year period to counteract the shortage of electrical energy since the Tohoku quake, with one of those actions is the promotion of smart meter implementation by power utility companies.

In the plan, smart meters are defined as "infrastructure that would allow price plan setting to encourage reduced peak-hour usage by utility customers." In other words, the idea is to use smart meters to provide a clear understanding of electricity usage by time range, thereby enabling flexible price plans that would encourage reduced electricity usage during specific time ranges (peak hours), eventually leading power utility customers to save energy of their own accord.

Before the Great Tohoku Earthquake, the meter reading information acquired through automatic meter reading was meant to play a role in improving customer service. However, with this plan, the smart meter is positioned as a tool to encourage a rethinking of the way people use electricity through the implementation of flexible price plans, and is indicative of the changing role of electricity meters (smart meters) after the quake.

3.2 Achieving "Visualization" (Visual Representation)

In order to link the supply and demand of electrical power to the electrical usage activities of power utility customers, it is necessary to provide more meaningful information to the customer.

Therefore, we are considering the need for a means of communication on both the meter and in the home, to allow data held at the smart meter to be transferred directly to the household "visualization" terminal.

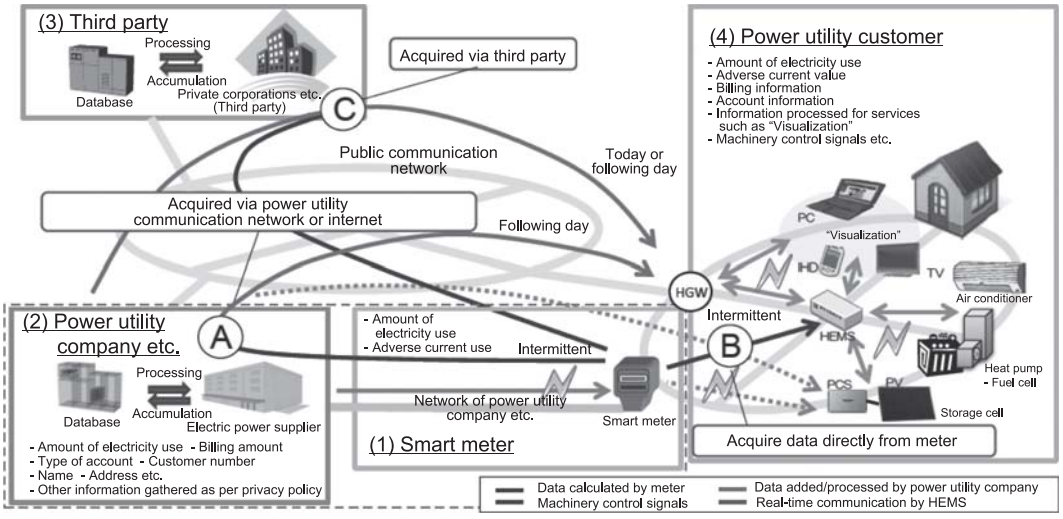
The need for a "visualization" route that allows data to be acquired directly from the meter has already been discussed during the Smart Meter System Review Committee of 2011, which acknowledged the necessity of standardizing the data format to be used between the meter and in-home terminal (**Fig. 3**).

Smart meters that can communication with in-home terminals have already been implemented in North America, and it is expected that similar smart meters with in-home terminal communication capabilities will become the mainstream in Japan also.

3.3 Features Required of Future Communication Networks

Pursuant to the changes in role of the smart meter as mentioned previously, the need to also change the role of the smart meter's communication function is apparent.

By connecting with the in-home terminal, or in this case, a HEMS terminal, the smart meter takes on the role as part of the



Source: Smart Meter System Review Committee Report (METI) Feb. 2011

Fig. 3 Communication route between smart meter and in-home terminal.

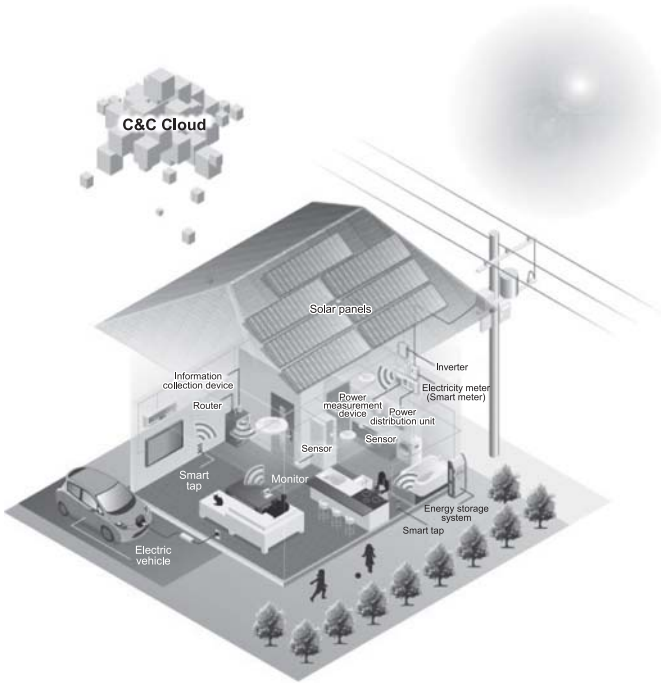


Fig. 4 Smart house image.

Smart House (**Fig. 4**).

By attaining such a role, the usage applications of smart meter are expected to expand further on a mid to long term basis. Accordingly, it is reasonable to assume that traffic on the smart meter network will increase in stages as well.

In order to prepare for such future possibilities and provide alternatives for the smart meter network communication method, NEC is assessing whether mobile carriers such as WiMAX can be adapted to the smart meter network. As already mentioned, using a communication carrier service has its issues in terms of communication cost and operation, however since it is possible to implement only in areas where it is needed, it is well suited for bringing smart meter services to specified areas as quickly as possible.

It is our intention to consider the operational feasibility along with technological implementation issues in our smart meter validation study.

4. Conclusion

Prior to the AMI validation project, for many years NEC has been involved in developing the internal communication networks of power utility companies. By combining this cumulative expertise with our mobile carrier communication technology, we intend to propose the ideal smart meter network capable of meeting the changing capabilities required of it.

*WiMax is a trademark and/or a registered trademark of WiMax Forum.

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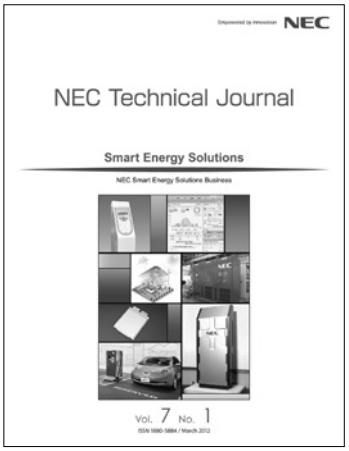

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