Convergence of Advanced Information and Control Technology in Advanced Metering Infrastructure (AMI) Solution

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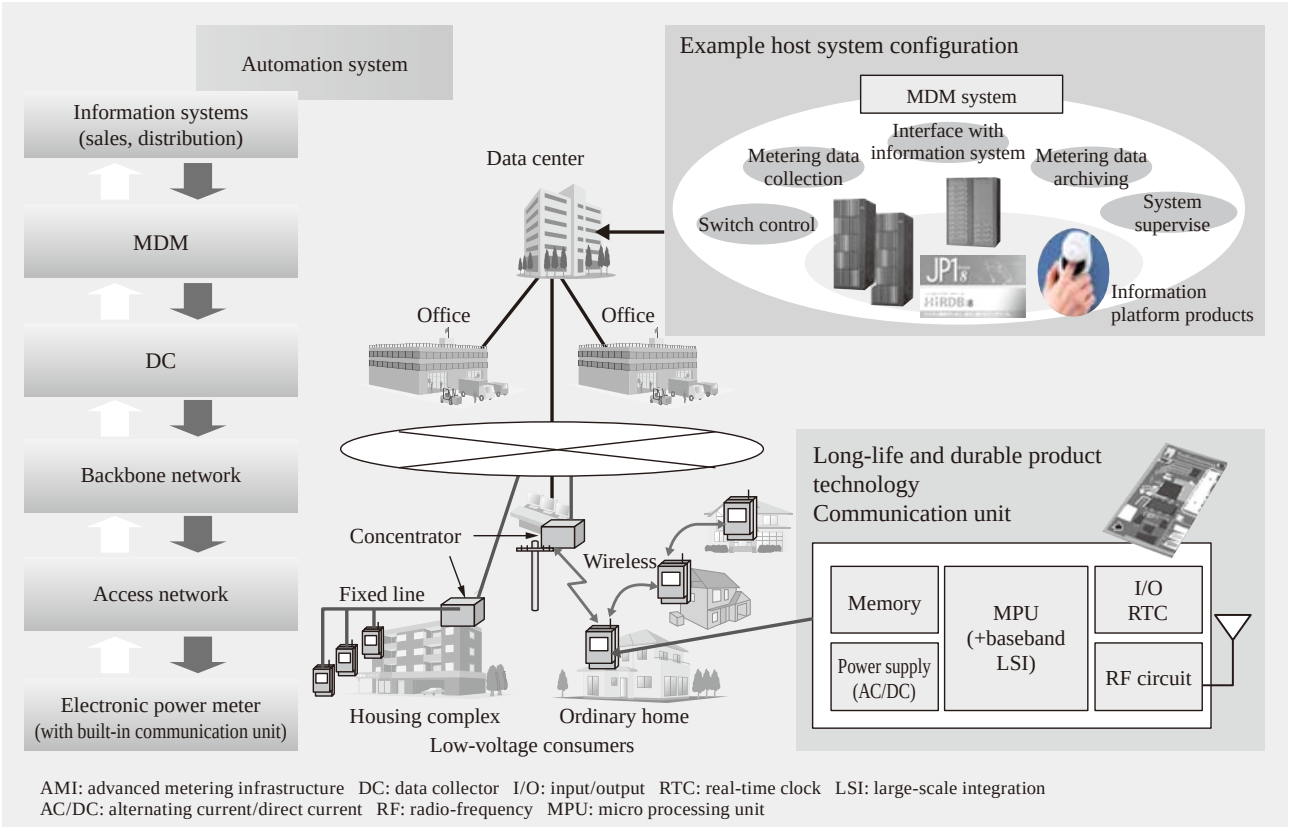
OVERVIEW: Power utilities have started investigations and actual implementation of AMI automatic metering systems for monitoring and control that involve installing an electronic power meter with a communications function at each low-voltage customer premises and collecting power consumption and other data on a meter data management system via a backbone and access network. It is anticipated that use of AMI will allow not only conventional power metering but also improvements to customer service and various other applications that utilize the collected data, communications infrastructure, and other resources made available by the system. Therefore, large-scale installation of AMI smart meter systems is already underway in EU and USA. As an integrated business with enhanced information and control technology, Hitachi is a one-stop supplier of total AMI solutions from embedded communication unit for electronic power meter to meter data management system.

INTRODUCTION

ACHIEVING a low-carbon society requires that measures such as smoothing energy use and improving energy efficiency also be adopted by ordinary households. This has created a new need for power utilities as well as households and other consumers



AMI: advanced metering infrastructure DC: data collector I/O: input/output RTC: real-time clock LSI: large-scale integration
AC/DC: alternating current/direct current RF: radio-frequency MPU: micro processing unit

Fig. 1—Hitachi's Total AMI Solution.
Hitachi is a one-stop supplier offering everything from the communication unit in the power meter to the MDM (meter data management) system.

to acquire data on their respective electric power consumption from both the supply side and demand side to allow an intelligent service to power demand.

This trend has provided a chance for the introduction of AMI (advanced metering infrastructure) in Japan. Progress on introducing AMI is more advanced in European Union (EU) and USA where the energy situation and other background factors are different to those in Japan where the intention is to boost the efficiency of existing metering and improve customer service. Some power utilities have already carried out field tests and proceeded with full-scale implementation. To meet the needs of such utilities, Hitachi is working on developments based on solutions that converge the information and control technology required for AMI system architecture.

This article describes a convergence of information and control technology in total AMI solution.

OVERVIEW OF AUTOMATIC METERING SYSTEM

AMI systems use electronic power meters fitted with a wireless or fixed-line communication unit and installed at each low-voltage customer premises (house or housing complex, etc.) to collect power consumption and other data and send it via the communication unit to a MDM (meter data management) system. Because the AMI system is so large and covers such a wide area, the data collection mechanism uses a hierarchical structure with intermediate equipment such as concentrators mounted on power pole and data collector systems. Also, data collection is performed efficiently by adopting practices such as routing functions that use multi-hop wireless communications to transmit the data from each household.

The MDM system performs tasks such as managing data collection and handling coordination with other systems. The AMI communications infrastructure provides not only upstream transmission from electronic power meter to MDM system but also allows downstream data transmission to customer premises for functions such as controlling switches (see Fig. 1).

Hitachi is a one-stop supplier able to provide everything from access networks, backbone networks, DC (data collector), and MDM system made up of communication units for the meters and data collection units through to information systems. Hitachi's various information and control technologies have a strong reputation and are being utilized in the development of AMI system by those power utilities that have already commenced work or are proceeding with actual implementation.

Access Network Technologies

Power consumption and other data obtained from the electronic power meters are sent to the MDM system via the communication units built into the meters. This is called an "access network." Potential media for access networks include PLC (power line carrier) and other fixed-line communication media and wireless communications using public or private networks. It is also possible for AMI implementations to use different communication media depending on the local characteristics (urban area, mountainous area, etc.) and type of premises (house, housing complex, etc.).

Also, for the communication unit in each meter to operate autonomously and reliably, it needs to implement applications such as routing control, metering, switch control, and maintenance functions such as firmware updating.

Hitachi supplies solutions that support multiple communications media based on the experience it has built up over many years in various technologies including semiconductor devices, wireless communications, and embedded software.

Routing Control Technology

The limited range of wireless communications is an issue for access networks that use privately-owned wireless bands. The likely communications range for low-power radios that can be used in the communication unit without licensing is only between several tens to several hundreds of meters. If this method is used for electronic power meters installed in the home, concentrators mounted on power poles or similar locations would not necessarily be able to communicate directly with every meter. One solution is to use multi-hop communications whereby data is relayed to the concentrator via a number of communication units using a bucket relay configuration.

To implement routing control for multi-hop communications, it is necessary to select the routing topology (mesh or tree) and routing method (determined by communication units or determined by a routing control unit) taking account of the system requirements and the characteristics of the radio band being used.

As AMI communications run from a concentrator at one end to the electronic power meter communication

units at the other, the network has a tree topology with the concentrator as the root. It is also desirable for the topology to have backup routes available to deal with changes such as radio transmission conditions.

One potential routing method is for each communication unit to determine autonomously the route to the concentrator (or more correctly, determine which communication unit is to become the next hop on the route) based on information about its ability to receive messages and signals from other communication units. Another alternative is for a route control unit to collect information periodically from each communication unit about their ability to receive from other communication units. The route control unit then generates route information specifying the tree structure as well as backup routes and sends this to all of the electronic power meter communication units which use the information as the basis for their communications with the concentrator. One version of this latter method is to incorporate the route control unit function into the concentrator and another is to perform the function on a higher level server. The best option needs to be selected based on the development time and how the network operates.

By introducing AMI, power utilities are able to send power consumption data to the host system at, for example, 30-m intervals instead of once a month under the previous method. This allows them to improve both customer service and the efficiency of their business by utilizing the collected data to offer billing schemes in which rates vary depending on the time of day or as analysis data for distribution equipment management system. This means that the data carried over the access network will include traffic from the host system for functions such as remote control of switches as well as the traffic associated with the frequent transmission of power consumption data from the communication units. Accordingly, depending on the wireless transmission speed, how to avoid communication congestion may become an issue.

To resolve this issue it is necessary to adopt measures that make effective use of the available bandwidth and prevent congestion before it happens. Example methods include the channel search technique whereby multiple channels are used to allow multiple pairs of communication units to send data simultaneously and the transmission timing control technique which prevents communication units that are within range of each other from attempting to transmit at the same time by having the communication units at the outermost points on the tree initiate communications. In this latter case, the data is accumulated progressively at each hop to the next communication unit along the chain. If routing is performed by the route control units as described earlier, the transmission timings can be controlled in a way that is closely tied to the route topology (see Fig. 2).

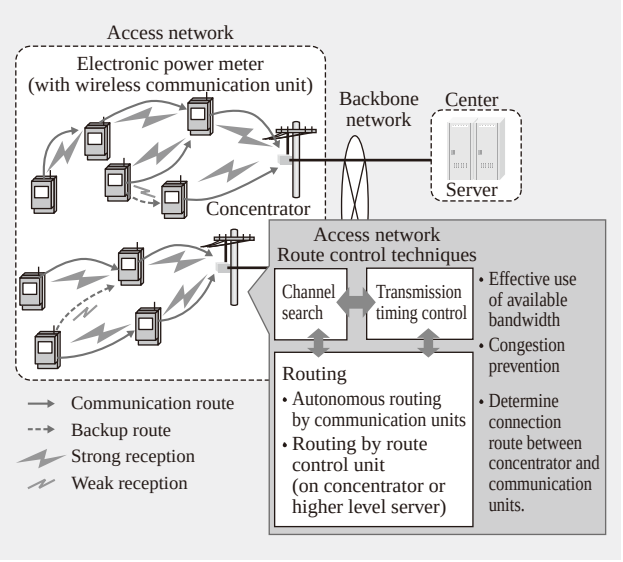


Fig. 2—Route Control Techniques for Access Networks. To provide efficient multi-hop communications, the optimum routing control method is implemented based on the system requirements and the characteristics of the radio band being used.

HOST SYSTEM (MDM SYSTEM)

Overview of MDM System

The purpose of the MDM host system is to provide a reliable way to collect the metering data sent via the access network and send it to the information systems, and also to accept requests to read individual meters remotely, forward the requests to the access network, and pass the results to the information systems. This requires the following functions.

(1) Functions for monitoring and administering data collection

(2) Functions for improving the data collection ratio for automatic metering (automatic recovery and routing)

(3) Functions for installing or replacing meters and for ensuring the consistency of automatic metering

(4) Functions for collecting coordination data from meters, editing it, and coordinating with information systems

(5) Functions for collecting recovery data from meters, editing it, and coordinating with information systems

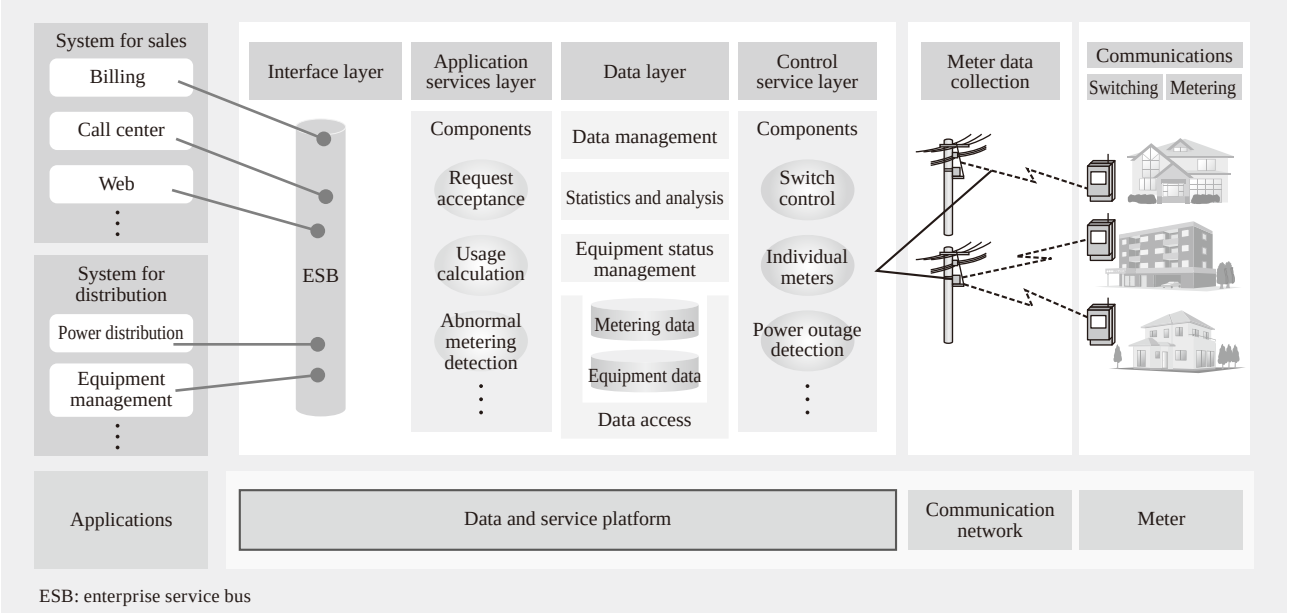


Fig. 3—Overview of MDM System.
The MDM system provides a reliable means of collecting metering data sent via the access network along with other functions such as coordination with information systems.

(6) Individual meter reading (accepting requests, controlling request execution, and returning the result)

MDM system also requires basic functions such as system for sales and the acquisition and reporting of fault information. The main system design and configuration techniques required are basic information system design skills in database design and transaction control along with techniques for the functional design of overall systems that take account of coordination with information systems (see Fig. 3).

Interface with Information Systems

Because introducing AMI allows power consumption data to be collected at, for example, 30-m intervals instead of once a month using previous methods, it makes possible major improvements in information system functions. In particular, it allows the progressive reorganization of customer information systems and power distribution systems. In addition to automating the meter reading process required for customer information system, the AMI network can be used to perform remote control of the switches built into electronic power meters. This remote switch control allows power to be cut off or restored promptly after events such as requests to disconnect or reconnect the power when moving home or on reception of payment details.

Performing meter reading automatically and remotely also provides a range of indirect benefits including eliminating meter reading errors, safeguarding customer privacy, preventing information disclosures or leaks, and the utilization of accurate consumption data to prevent problems.

Numerous potential uses can also be found in the area of power distribution, most of which involve the optimization of distribution equipment. Examples include the acquisition of load data, efficient equipment design, acquisition of information about power generation by distributed power sources, improvements in power quality, determining the scope of power outages or ground faults (fault locations), faster fault recovery, distribution equipment maintenance, and efficient ways of smoothing inspection workloads by monitoring equipment status (condition-based management).

Other anticipated improvements in power utilities' customer operations include providing visual representations of metering data and better customer service.

Specific examples include providing detailed information showing power consumption and CO_2 (carbon dioxide) emissions, providing customers with appropriate advice on saving energy, offering a variety of different billing schemes, and acquiring information about power outages and notifying customers.

The SOA (service-oriented architecture) design concept provides an information framework that allows the overall system to be constructed in stages and with flexibility, and given the expectation that MDM will be integrated with a wide range of different information systems including system for distribution and system for sales, its adoption is seen as an important planning consideration.

CONCLUSIONS

This article has described a total AMI solution that converges information and control technology.

The adoption of AMI not only helps improve the efficiency of conventional meter reading, the infrastructure and data it provides can also be a source of new value such as improving customer service and boosting the business efficiency of power utility operations such as customer information system and power distribution system.

Hitachi intends to act as a one-stop supplier for AMI by offering total solutions that converge the control technologies used in power distribution automation systems and elsewhere with the various information system technologies that Hitachi has built up over many years working with power utilities on billing and other information systems.

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