Demonstration of Remote Storage Battery Control Using Standard Procedure

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Abstract

The introduction of storage batteries has begun to be used generally in households. When batteries of a certain size are bundled and controlled together, they can be used to balance supply and demand in areas other than for general consumers. At the EMS Shinjuku Demonstration Center, Waseda University, NEC has recently succeeded in building a system for the automated control of storage batteries of consumers from a remote location. This was done by combining ECHONET Lite, which is the standard procedure for equipment control, and OpenADR, which is the procedure for Demand Response (DR) signal interchange. Using the developed environment, NEC demonstrated the remote charging/discharging control of storage batteries at consumer premises, the results of which are reported below.

Keywords

ECHONET Lite, OpenADR2, storage battery, direct load control (DLC)

1. Introduction

The spread of installations of photovoltaic power generation systems among general consumers has been supporting the creation of energy by the consumers themselves. With regard to the systems for storing energy, heat pumps utilizing thermal energy are already widely distributed, and market growth for smart energy management using storage batteries is recently much anticipated.

The storage battery is introduced in order to optimize energy usage by charging while the demand is low and discharging in the high-demand period. When batteries with certain levels of charging/discharging capability are bundled and subjected to external control, they can be used to secure demand/supply balance in fields that are no longer limited to general consumers.

We have recently developed a system packaged featuring a standard procedure for the remote control of storage batteries and have demonstrated the remote charging/discharging performance. We report on this experiment in this paper.

2. System Configuration

Fig. 1 shows the system configuration adopted in the present demonstration. The higher-order system that features the OpenADR VTN (Virtual Top Node) function transmits the signal for the direct load control (DLC), which is one of the Demand Response (DR) usage cases. The aggregator system is an intermediate system that

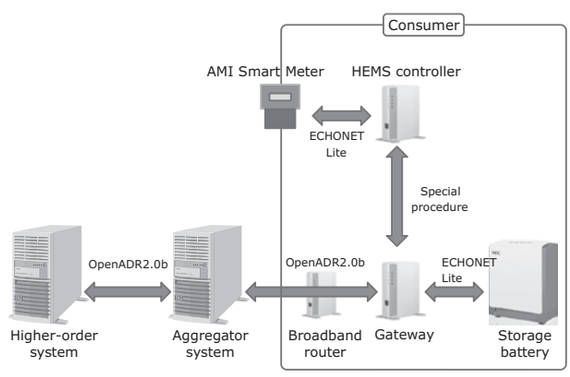


Fig. 1 Configuration of demonstration system.

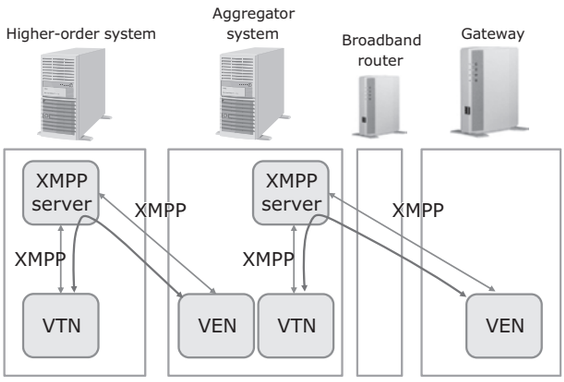


Fig. 2 Configuration of XMPP connection.

assumes installation in an organization in charge of DR aggregation. It has the OpenADR VEN (Virtual End Node) function with respect to the higher-order system and the VTN function with respect to consumers (**Fig. 2**).

A compact household storage battery (charging/discharging 2 kW, capacity 5.53 kWh), an aggregator system and a gateway device for connecting the storage battery are installed at the consumer premises. In addition, the consumer uses a broadband router to separate the home network and the broadband communications network. An HEMS-gateway communication facility is provided so that the higher-order DR system can be notified of the data held by the HEMS. The aggregator system, gateway and storage battery are provided by NEC and they incorporate the requisite functions for the demonstration. The higher-order system, HEMS controller and the AMI Smart Meter are the property of the EMS Shinjuku Demonstration Center.

3. Communication Protocol

The section between the higher-order system and aggregator system and that between the aggregator system and the consumer gateway are connected with OpenADR 2.0b. The usage cases adopt direct load control (DLC).

The XMPP is adopted as the OpenADR transport protocol. Although the simple HTTP is mandatory for OpenADR and the XMPP is optional, we selected the push distribution using the XMPP considering that short-period operation at 1-minute intervals is to be demonstrated. The XMPP connection from the gateway enables push distribution using the XMPP across the broadband router. With the demonstration herein, XMPP servers are packaged in the higher-order system and aggregator system. **Fig. 2** shows the configuration of the XMPP connection.

The connection between the gateway and storage battery employs ECHONET Lite. A device object for storage battery class is packaged to allow the gateway to give the storage battery a charging/discharging indication of a specified charging/discharging amount. The required instantaneous charging/discharging electric energy amount is also obtained from the storage battery.

The gateway is also connected to the HEMS controller. This function is provided so that the data held by the HEMS controller can be sent to the aggregator system and to the higher-order system.

4. Demonstrated Usage Cases

Fig. 3 shows the usage cases of the demonstration.

(1) Charging/discharging indications (1-minute intervals)

In this usage case, indications for charging or discharging are given to the storage battery at the consumer premises. The amount of charging or discharging can be specified in kW. The minimum charging or discharging interval is set to 1 minute. Detailed specifications can be made from the higher-order system. To reduce the event transmission count, the event information interval specification facility is available to transmit multiple charging/discharging amount specifications at 1-minute intervals simultaneously for a single piece of event information. If the charging/discharging amounts are unknown until immediately before giving an indication, a single piece of 1-minute interval information should be transmitted per piece of event information. However, when the charging/discharging amount is decided for tens of minutes, the charging/discharging amounts of multiple 1-minute intervals can be specified in order to reduce the

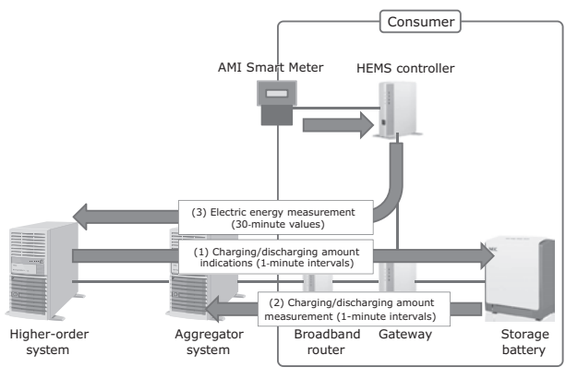


Fig. 3 Demonstrated use cases.

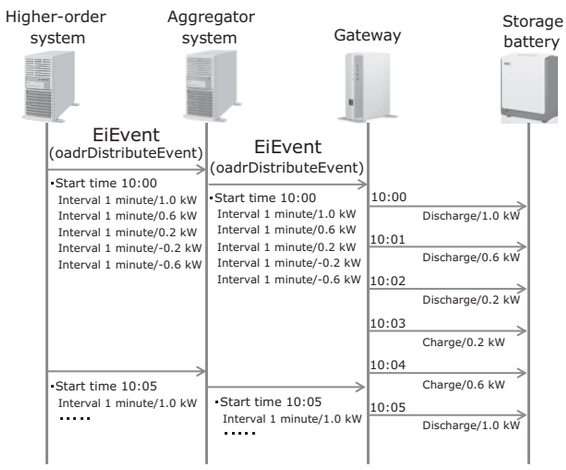


Fig. 4 Charging/discharging indication procedure.

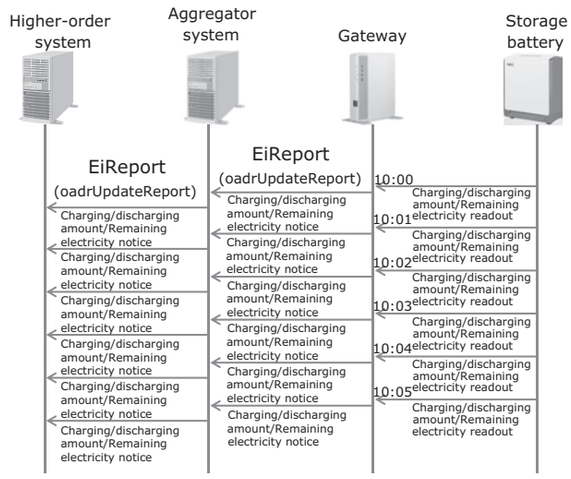


Fig. 5 Charging/discharging amount measurement procedure.

event transmission count.

Fig. 4 shows the charging/discharging indication procedure.

With OpenADR 2.0b, the charging/discharging indications use the oadrDistributeEvent payload of the EiEvent service.

For the signal, we used signalName=LOAD_DISPATCH and represent the discharging amount (load decreasing kW) with a positive value and the charging amount (load increasing kW9 with a negative value. For the indications from the gateway to the storage battery, charging or discharging is specified by means of the "Operation mode setting" property of the storage battery class of ECHONET Lite. In the case of charging, the amount is specified in the "Charging electric energy setting." In the case of discharging, the amount is specified in the "Discharging electric energy setting."

(2) Charging/discharging amount measurement (1-minute intervals)

This usage case is intended to confirm the charging/discharging indication enforcement status by reporting the actual operating status of the storage battery when its charging or discharging is indicated for one-minute interval. The aggregator system collects the report on the actual charging/discharging amount every minute. The report on the collected information can be sent to the higher-order system as required.

Fig. 5 shows the charging/discharging amount measurement procedure.

The gateway reads the charging/discharging amount and the remaining stored electricity every

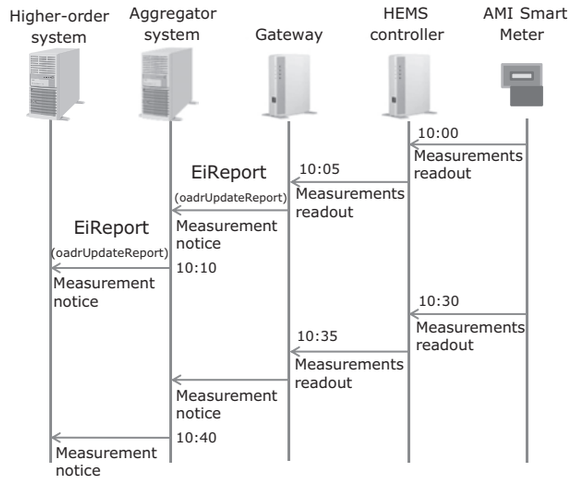


Fig. 6 Electric energy measurement procedure.

minute from the storage battery. The charging/discharging amount is read using the "Measured instantaneous charging/discharging electric energy" property of the Storage battery class of ECHONET, and the remaining stored electricity by using the "Remaining stored electricity 1 (Wh)" property. The aggregator system is notified of the read-out measurements every minute using the oadrUpdateReport payload of the EiReport service of OpenADR.

(3) Electric energy measurement (30-minute value)

This usage case measures values of the cumulative amounts of the electric energy, which are measured by the AMI Smart Meter at 0 min. and 30 min. of every hour, and notifies them to the aggregator

system and higher-order system. It is intended to confirm the result of a charging/discharging instruction by measuring the electric energy amount at the power receiving point. With the present demonstration, we set it to report on measurements every 30 minutes in order to identify them.

Fig. 6 shows the electric energy measurement procedure.

The HEMS controller reads the "Cumulative amount of electric energy measured at fixed time (normal direction)" and the "Cumulative amount of electric energy measured at fixed time (reverse direction)" properties of the low-voltage smart electric energy meter class of ECHONET and holds them.

The gateway inquires of the HEMS controller, the measured values at 5 min. and 35 min. of every hour, which are 5 minutes after the 0 min. and 30 min. points of every hour. Upon acquiring the measured values, the gateway notifies the aggregator system about them using the oadrUpdateReport payload of the EiReport service of OpenADR.

Considering that the aggregator system may receive reports from several gateways installed at different consumers, it reports to the higher-order system about the sum of the measured values at 10 min. and 40 min. of every hour using the oadrUpdateReport payload of the EiReport service.

5. Results of the Demonstration

We confirmed the operations activated by the charging/discharging indication from the higher-order system to the storage battery based on the data obtained with the charging/discharging amount measurement (1-minute intervals). The data about which the higher-order system was notified is shown in **Fig. 7**.

We indicated a change by 0.4 kW to occur every minute, and the measured values certify that the intended operations are actually performed.

Fig. 8 shows the result of the electric energy measurement notification in comparison with the data collected via route A of the AMI smart electric energy meter. The figure confirms that the data of route B sent to the higher-order system by means of OpenADR is identical to that collected via route A.

6. Conclusion

We applied the direct load control (DLC), which is one of the DR use cases of a storage battery by means of OpenADR that is a procedure for DR implementation and by ECHONET that is an equipment control procedure, and succeeded in obtaining favorable results. We expect that, in the future, the application of standard open procedures will advance via systems such as a group control system for handling the storage battery as one of the distributed power sources.

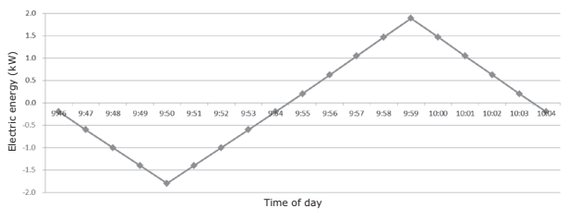
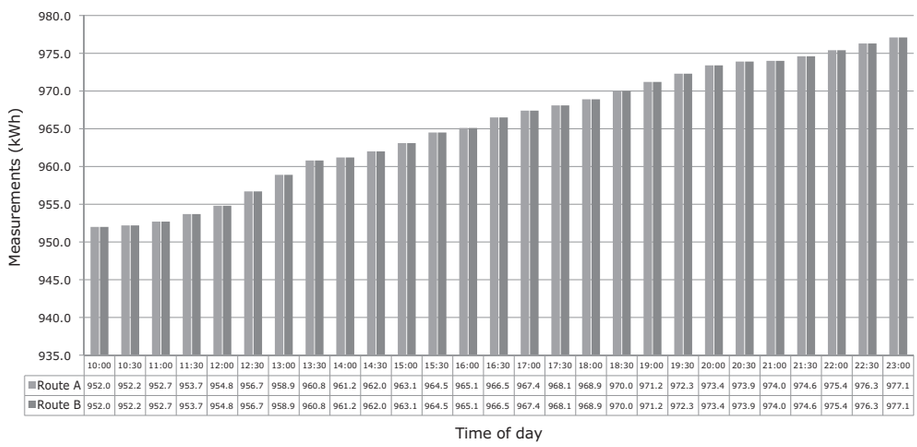


Fig. 7 Instantaneous charging/discharging electric energy amount measured on storage battery.



	10:00	10:30	11:00	11:30	12:00	12:30	13:00	13:30	14:00	14:30	15:00	15:30	16:00	16:30	17:00	17:30	18:00	18:30	19:00	19:30	20:00	20:30	21:00	21:30	22:00	22:30	23:00
Route A	952.0	952.2	952.7	953.7	954.8	956.7	958.9	960.8	961.2	962.0	963.1	964.5	965.1	966.5	967.4	968.1	968.9	970.0	971.2	972.3	973.4	973.9	974.0	974.6	975.4	976.3	977.1
Route B	952.0	952.2	952.7	953.7	954.8	956.7	958.9	960.8	961.2	962.0	963.1	964.5	965.1	966.5	967.4	968.1	968.9	970.0	971.2	972.3	973.4	973.9	974.0	974.6	975.4	976.3	977.1

Fig. 8 Comparison of electric energy measured via route B and that obtained via route A.

7. Acknowledgement

The present demonstration was conducted at the EMS Shinjuku Demonstration Center, Waseda University. We would like to express our gratitude to Waseda University, for their invaluable support during our demonstration.

* ECHONET Lite is a registered trademark of the ECHONET Consortium.

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