Design of a Demand Side Energy Information Management System

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ABSTRACT

In this paper, we design a system for the integrated management of demand side energy information in order to support customer energy management services developed by 3rd party service providers using a dynamic service delivery platform. For this, the DIM describing the demand response characteristics as well as energy resource properties of service participants is proposed. Then, the functional architecture of the designed system based on the DIM is described. Finally, its dynamic service delivery mechanism is explained.

KEYWORDS

Demand Side Management, Demand Response, Customer Energy Management, Smart Grid, DIM

1 INTRODUCTION

For energy saving and efficient energy use, the development of an energy management system for consumer domains such as home, commercial, or industrial buildings has been accelerated. To reflect the characteristics of customer sites, different types of energy management systems are expected to be deployed in customer buildings considering energy usage patterns and energy resource properties managed. With the advent of new energy services such as DR (Demand Response) and VPP (Virtual Power Plant), the integration of demand side information has grown in importance [1-2]. For the efficient energy management of diverse customer facilities including DER (Distributed Energy Resources) and controllable loads, standardized information models and operation methods are needed.

With the rapid increase in energy consumption rate, it is required to build additional bulk power generation facilities. However, the construction of such facilities causes enormous time and cost. It is also difficult to quickly cope with a steep rise in power demand. To mitigate such problems, virtual power plants and demand response services are considered as alternatives. These service applications need the integrated management of information on customer sites where distributed energy resources and controllable loads are placed [3-4].

For this, this paper is to design a system for the integrated management of demand side information that 3rd party service providers consume in order to provide newly developed value-added services through energy management systems owned by their customers. Traditionally, demand side information like metering data can be collected through an AMI (Advanced Metering Infrastructure) comprising MDMS (Meter Data Management System), AMI head-end, and AMI meter. This infrastructure mainly focuses on metering [5]. However, it is a closed system dedicated to utility providers. Therefore, it is difficult for 3rd party service providers who want to deploy new energy services to participate in an energy service market. To solve this problem, we design an open platform for the integrated management of demand side energy information. The platform supports value-added energy services of 3rd party service providers using dynamic service application delivery technics.

2 Overview of a Demand Side Energy Information Management System

Traditionally, customer domains such as home, commercial, or industrial sites are considered as a sort of energy consumer. However, rapid supply of DERs into the sites enables the customers to reduce their peak power demand through DR and DER control. The customers also sell their surplus energy to utility grids. The environmental change in the customer domains also provides various business opportunities to 3rd party service providers. For this, demand side energy information management is needed to exchange energy information between customer domains and 3rd party service providers. Customer domains have different energy consumption patterns and demand response characteristics. Thus, 3rd party service providers require standard information models based on the characteristics of customer sites subscribing to their services. The required information models contribute to efficient use of energy and keeping a balance between energy demand and supply ultimately. Therefore, the designed demand side energy information management system supports standard communication interfaces as well as information models reflecting demand response characteristics and energy resource properties of service participants. With the help of the designed system, customer energy management or demand response service providers can easily decide their operation policy and support various DR programs. It can also lead to market participation of 3rd party service providers.

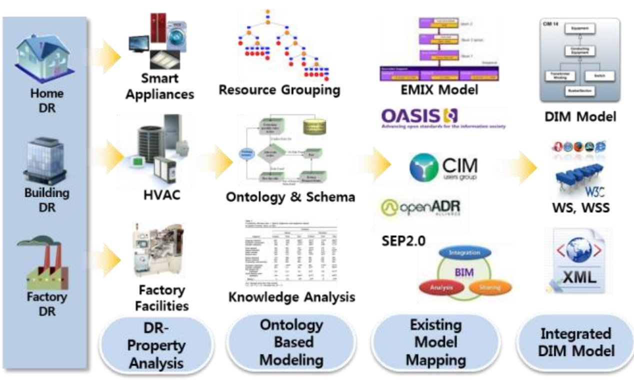

Figure 1. Demand Side Energy Information Modelling

The proposed DIM (Demand Side Information model) improves interoperability between demand side energy management and trading systems such as customer EMS (Energy Management System), DR system, DER management system, and retail energy market system. Figure 1 shows a process of demand side energy information modelling. To develop the integrated model of demand side information reflecting different DR and DER resources placed in customer sites, we need to define the characteristics of different DR resources such as smart appliances, HVAC (Heat, Ventilation, and Air Conditioning), factory facilities, and so on. We also have to find the properties of DERs such as photovoltaic system, ESS (Energy Storage System), fuel cells, and emergency generators. After grouping similar characteristics and properties of DR or DER resources, common properties are classified into the newly defined information model for DR and DER management. The classified information model can be used to create metadata and develop semantic engines for ontology based searching of demand side information. Through mapping the information model on the existing models, it is needed to ensure interoperability with the already standardized information models. Through the comparison analysis of DR or DER information models specified in SEP (Smart Energy Profile) 2.0 [6], OpenADR 2.0 [7], and BACnet object model [8], the specified CIM (Common Information Model) profiles for home, building, and factory EMS can be defined as shown in Figure 2. The defined CIM profiles for DIM is used to design core services of demand side energy information management system

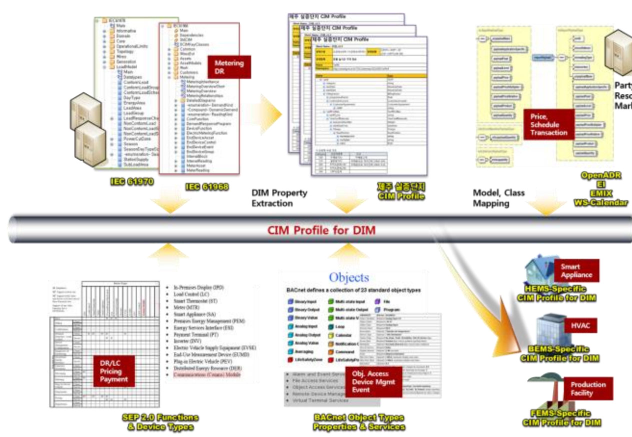

Figure 2. CIM Profiles for DIM

3 Functional Architecture of a Demand Side Energy Information Management System

The functional architecture of demand side energy information management system based on the CIM profiles for DIM is shown in Figure 3. The designed architecture consists of 4 functional layers. The lowest layer includes the IEC 61970/61968 CIM adaptor based on the OPC UA

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(Unified Architecture), OpenADR and SEP 2.0 adapter for processing the already standardized DR and DER models, and the DIM handler responsible for information model mapping and message conversion on top of the three adaptors. The message handlers are placed on top of the DIM handler in order to communicate with customer EMSs, EMS/DMS, energy market, and MDMS. The DR and DER information management engine is placed above the message handlers. It provides core services such as energy resources information gathering and remote control, 3rd party energy service management, energy trading, and customer event/report handling service. The SP adaptor is placed below the information management engine. It performs functions for application advertisement, creation, deployment, and service application life cycle management with the help of the DIM handler. Lastly, the DIM-based information management applications for customer DR and DER analysis, demand prediction, automated DR control, customer EMS operation optimization, and automated energy trading are placed.

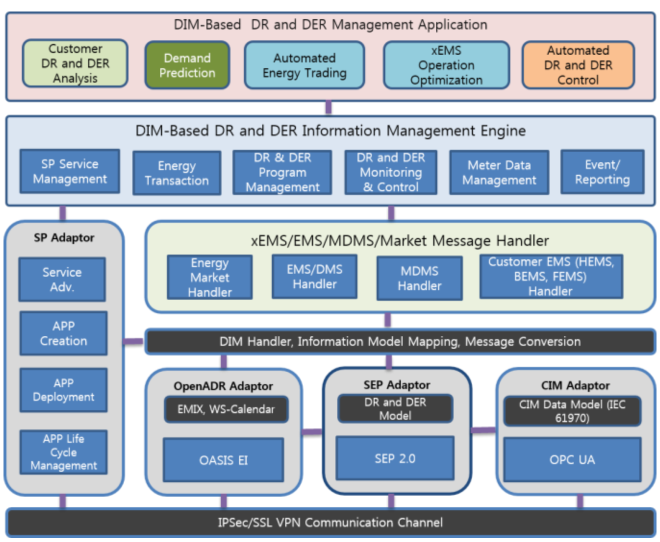

Figure 3. Functional Architecture of Demand Side Energy Information Managemeny System

Existing AMIs for demand side information management collect metering data from AMI meters installed in customer sites. However, they do not provide an open service deployment platform on which 3rd party service providers can easily participate in smart grid service markets. Utility-centric closed service infrastructures could be a sort of barrier hindering the growth of smart grid industry. To mitigate the problem, the proposed system is based on an open and flexible service deployment platform and communication services to securely integrate the information obtained from customer EMSs, 3rd party service providers, and external utility systems distributed on the Internet using a VPN (Virtual Private Network) infrastructure.

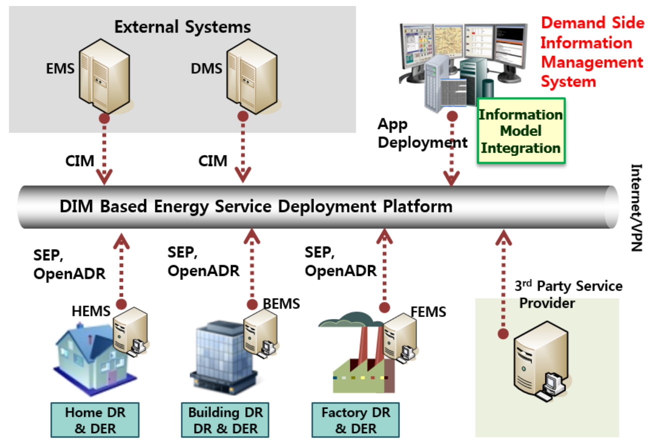

Figure 4. Energy Information Integration based on DIM-based Service Deployment Platform

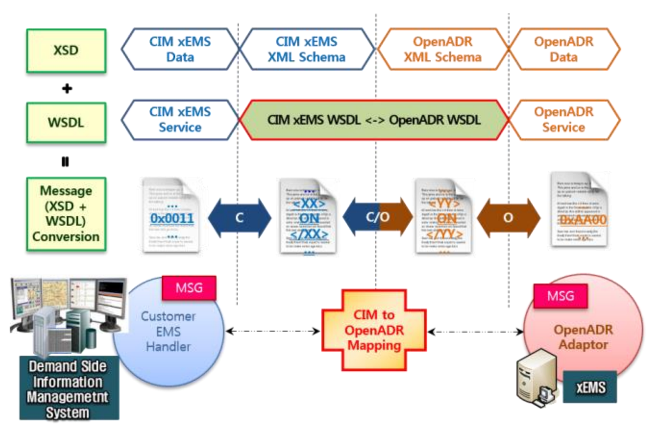

Figure 5. CIM to OpenADR Information Model Mapping Process

Figure 4 shows energy information integration based on the DIM-based service deployment platform. The proposed service deployment platform integrates different demand side information obtained from customer EMSs placed in home, commercial, and industrial buildings. It also provides the interfaces for the deployment of various service applications developed by 3rd party service providers. In addition, the platform ensures interoperability with the existing DR management systems by integrating the OpenADR 2.0

information model into the CIM models for DIM. Figure 5 shows a CIM to OpenADR information model mapping process. Through the process, OpenADR-compliant DR messages sent from customer EMSs are integrated into the CIM models for DIM by the customer EMS handler of designed system.

Traditionally, the price or incentive-based DR programs of existing DR systems are mainly provided by utility providers through offline contract between DR providers and service participants. Under such utility-centric DR infrastructures, it is difficult for 3rd party service providers to participate in energy markets. To solve the problem, the proposed system provides a dynamic application delivery platform as shown in Figure 6. The platform installs energy service applications developed by 3rd party service providers on customer EMSs on-the-fly and updates the installed applications periodically in order to add new functionalities to support varying DR programs.

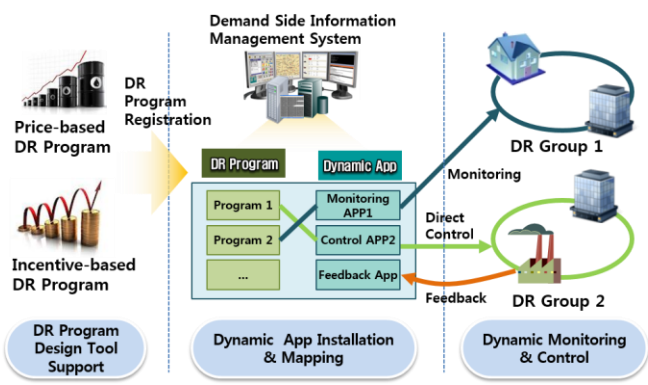

Figure 6. Dynamic Application Delivery Process for DR Services

4 CONCLUSIONS

We design a DIM-based demand side information management system in order to deploy customer energy management services developed by 3rd party service providers using a dynamic service delivery platform. The DIM describing the DR characteristics as well as DER properties of a customer domain is proposed. The functional architecture comprising 4 functional layers is introduced. The main functions of designed system are explained in detail. The DIM-based information management system is based on an open and flexible service deployment platform and communication services to securely integrate energy-related information obtained from customer EMSs. The dynamic service deployment platform helps 3rd party service providers to easily deploy value-added customer energy management services.

5 ACKNOWLEDGEMENT

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