Enterprise Integration Implications for Home-Area Network Technologies

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***Abstract* – The interaction of customer network equipment and utility operations is an area of growing interest in the industry. There is significant potential for customers to be able to make energy choices that better suit their needs, both financially and to support societal goals important to them, such as those related to encouraging renewable generation or reducing carbon emissions. Similarly, utilities have potentially significant opportunities to reduce demand, lower emissions, manage local demand restrictions on equipment, and improve facility utilization. Significant effort is being put into defining the requirements (i) for the residential customer's home area network (HAN) and (ii) for market-based quantities, like price and schedule. However, work is just beginning to define how the information flows from the customer and markets will affect information systems in the utility operations enterprise. This paper discusses a potential structure for handling enterprise integration in utility operations and discusses steps that the MultiSpeak® Initiative is taking to develop standardized data objects and services to support these needs.**

I. BACKGROUND

One of the most exciting and promising areas in the evolution towards a smarter grid is the potential for the customers to take actions to enhance utility operations. Customer interactions with grid management have historically been limited to voluntary demand restrictions or direct load control programs that were first popularized in the 1970s and 1980s. Current, innovative directions in customer involvement include:

- Customer response to innovative rates, such as critical peak pricing or real time pricing.
- The ability of the customer to respond to critical peak alerts.
- The optional capability to respond to signals about the availability of renewable resources or carbon-management signals.
- The ability of the customer to offer ancillary services for sale to the utility, including distributed energy resources (DER). Included in DER for this discussion are: plug-in electric vehicles (PEV), distributed storage (DS), and distributed generation (DG) capabilities.

Industry initiatives that envision solutions to support these capabilities are in their infancy. Standards to support customer involvement are few, but rapid progress is being made in: (i) premises area network (PAN) architecture, (ii) price management, (iii) messaging and alerting, and (iv) demand response.

The National Institute of Standards and Technology (NIST) has recently released the draft Release 1.0 of its Framework and Roadmap for Smart Grid Interoperability Standards [1] (NIST Roadmap) that (i) provides a conceptual framework for discussing the needs in this area, (ii) provides a list of existing and developing standards to guide industry deliberations, and (iii) establishes a set of priority action plans to advance industry standards and enhance smart grid interoperability.

Although PAN network messages do not necessarily imply the need for enterprise information flows, implementation of some of the capabilities identified by the available industry documents will require information flows among applications in the utility enterprise. The MultiSpeak® Initiative [2] has begun an analysis of the enterprise implications of PAN communications requirements.

The MultiSpeak Initiative is an industry consortium of software vendors in collaboration with the National Rural Electric Cooperative Association, which has been actively involved in standardizing enterprise integration since 2000. The Initiative has developed a specification [3] for enterprise integration interfaces, based on a data model documented in XML Schema form and a set of web services that utilities and vendors may use to implement the interface definitions. The MultiSpeak Specification includes over 25 mature profiles for interfacing smart grid applications, including AMI, meter data management (MDM), demand response, SCADA, outage management systems, GIS, and work management. MultiSpeak interfaces for AMI and MDM systems are in operations at hundreds of utilities. The MultiSpeak Specification has been included as one of the standards identified for implementation in the NIST Standards Framework.

The reference model in the NIST Roadmap indicates conceptual flows of information between domains, including Customers, Markets, Service Providers,

Operations, Bulk Generation, Transmission, and Distribution. The Customer domain is often divided conceptually into three areas, Home-to-Grid (H2G), industrial/commercial Building–to-Grid (B2G), and electric Vehicle-to-Grid (V2G). This paper will focus on the H2G interactions with the Operations and Service Provider domains, specifically for the purposes of pricing, alerting, and demand response.

II. INDUSTRY VISION FOR CUSTOMER PARTICIPATION

Figure 1 is an illustration of the NIST conceptual reference model [1]. It illustrates, among other things, potential paths for information flows from a customer's PAN to other domains. Since this paper will address only involvement of residential customers, the term home area network (HAN) will be used in the place of the more general term premises area network or simply premises network. Figure 1 shows that there are potentially two paths for information from a customer's HAN into the utility: one directly to the utility, probably through the utility's metering system communications infrastructure, and the other over an Internet link, possibly through a third-party service provider.

The customer's HAN provides a means to connect devices, such as (i) in-home displays (IHDs), (ii) programmable communicating thermostats (PCTs), (iii) smart appliances, and (iv) energy management systems to control loads such as heating ventilation and air conditioning (HVAC), pool pumps, etc. In addition, it is anticipated that DG, PHEV, and DS eventually will be connected to the HAN and be available for communication with the utility operations domain.

Several industry groups are actively working on developing functional requirements for communications with the customer's HAN. The OpenHAN Task Force has issued its System Requirements Specification (SRS) [4] which is perhaps the most comprehensive statement of what functionality the meter-to-HAN communication should include and how a conceptual architecture should support such capabilities. However, the SRS specifically excludes any consideration of information flows on the utility side of the meter and in the HAN itself, except for utility-owned HAN devices. A number of use cases identified in the SRS will require actions to occur in the Operations domain and imply information flows between Operations and other domains.

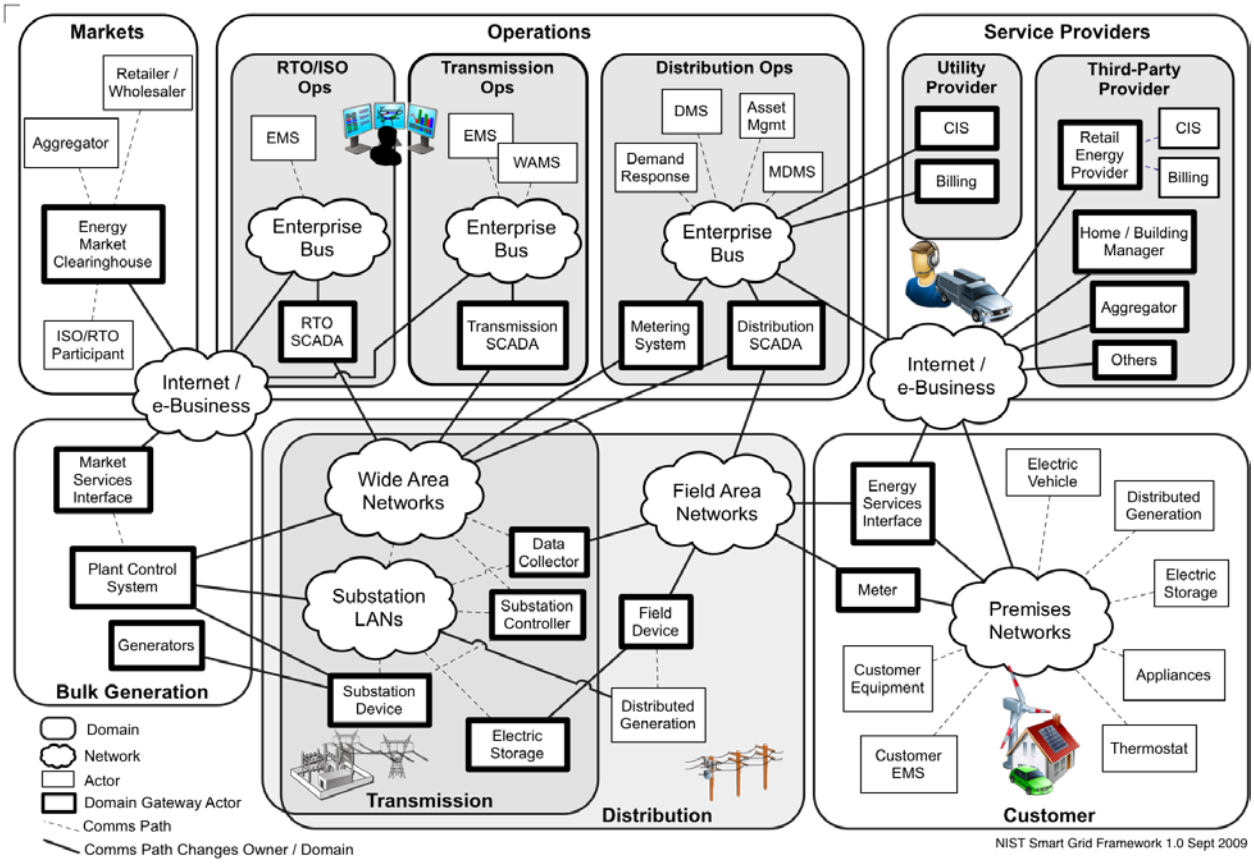

Fig. 1. Conceptual Reference Model [1].

Table 1 lists selected classes of HAN requirements that are likely to require information flows within the enterprise. Although the SRS identified these requirements, it was outside the defined scope of the document to discuss the nature of those information flows.

TABLE I
SELECTED HAN REQUIREMENTS THAT IMPLY ENTERPRISE INFORMATION FLOWS

- Acceptance of utility-directed control actions
- Action based on price signals
- Display of utility-generated messages and alerts
- Monitoring, measurement and reporting of DG, PEV, DS, DR resources
- Commissioning and provisioning of HAN devices
- Security key exchange

The Home-to-Grid Domain Expert Working Group (H2G DEWG) was one of the DEWGs established by NIST and the GridWise Architecture Council in 2008 to help identify smart grid requirements and list appropriate standards to be included in the NIST Roadmap. The H2G DEWG has expanded on some of the HAN requirements identified in the OpenHAN SRS [5].

The identification of the functional requirements for communications between utility-owned meters and customer HANs is a necessary preliminary step in developing detailed information flows in the Operations domain, but has not progressed to the point where detailed enterprise integration requirements can be defined.

III. EMERGING HAN STANDARDS

The other potential source of information that can be used to identify the conceptual requirements for enterprise information flows is the set of potential standards for HAN device communications. Although a number of potential home networking protocol suites have been identified, perhaps the leading candidates are ZigBee® for in-home wireless communications, offered by the ZigBee® Alliance and HomePlug® for in-home power line communications, offered by the HomePlug® Powerline Alliance. The two organizations recently agreed to join efforts and have jointly issued the Smart Energy Profile Marketing Requirements Document [6]. Reference [6] includes utility-defined use cases for HAN communications, including and extending the use cases identified in the SRS [4]. Extensions to the SRS include use cases for prepayment metering, extended messaging and service to plug-in electric vehicles.

The joint ZigBee+HomePlug Smart Energy Profile [7] (SEP) was chosen as the HAN Device Communications and Information Model by NIST in its Smart Grid Interoperability Standards Framework and Roadmap. The SEP outlines detailed message definitions for the exchange of information between (i) meters and network gateway devices called Energy Service Portals (ESPs) and (ii) between ESPs and HAN devices. The SEP groups message capabilities into so-called “clusters”; currently defined clusters include support for price communications, messaging, simple metering and prepayment metering.

IV. PROPOSED ENTERPRISE ARCHITECTURE REQUIRED TO SUPPORT HAN TECHNOLOGIES

The MultiSpeak Initiative Technical Committee has begun studying the impact of the proposed HAN requirements, with a goal of developing an abstract architecture and eventually a set of data objects and supporting service definitions that can be used to implement those requirements. Table II lists the abstract capabilities that the MultiSpeak Technical Committee has identified for inclusion in enterprise integration efforts.

TABLE II
ABSTRACT ENTERPRISE CAPABILITIES NECESSARY TO REALIZE HAN REQUIREMENTS

- Price Management
- Message Management
- Demand Management
- Commissioning and Provisioning
- Demand Response Management
- HAN Communications

Each of these functions might be instantiated by one or more applications in the enterprise. For instance, messages might be generated from a customer billing application, a critical peak alerting system, or another system seeking to get information to the customer. Each such system would need to exhibit the same services that eventually will be defined for a Message Management function. Thus it is important to develop an abstract functional definition that can be concretely implemented in numerous systems at the software design phase. Table III lists the definitions and describes the purpose for each abstract function proposed in Table II.

Each of the proposed abstract functions may affect or be affected by other software applications for which MultiSpeak interfaces already exist. For instance, MultiSpeak Version 4 already includes a Demand Response (DR) Management service to manage and monitor demand response activities that are implemented using traditional load control devices addressed over an AMI system. However that service will need to be enhanced and expanded to incorporate the required HAN messages. As an example, the DR Management service will need to be able to address HAN devices, individually or in groups, so as to issue load control commands, using the HAN Communications function. The existing DR Management service will also need to be expanded to

TABLE III
DEFINITIONS OF PROPOSED ABSTRACT FUNCTIONS

Proposed Function	Definition of Abstract Function
Price Management	This functionality is exhibited by application(s) that prepare price signals and schedules of price applicability. The output of this function is a pricing signal appropriate for communication with the energy service portal in a customer's HAN.
Message Management	This functionality is exhibited by application(s) that prepare messages for display on a customer's HAN device, such as an in-home display.
Demand Management	This functionality is exhibited by application(s) that determine when load control is to go into effect and to what degree. The output of this function is a load control signal appropriate for communication with the Demand Response Management abstract function.
Commissioning and Provisioning	This functionality is exhibited by application(s) that coordinate commissioning and provisioning of new home area networks and HAN devices on those networks. This abstract function also handles security key management.
Demand Response Management	This functionality accepts the load control signal output by the Demand Management function and manages the on-going control of customer loads I order to achieve the targeted demand reductions. The output of this function is a demand control signal appropriate for communication with the energy service portal in a customer's HAN. The DR Management function also communicates with the HAN ESP to obtain feedback on the success, failure, or customer bypass of the load control action; this information is accumulated and returned as a composite value to the Demand Management function.
HAN Communications	This component formats the output of the other functions for proper transmission to the ESP of the customer's HAN. This abstract function is likely exhibited by an AMI head-end system.

incorporate the interactions with the proposed Demand Management and HAN Communications functions.

Furthermore, the meter reading and pre-paid metering services of MultiSpeak already include the capability to send messages, billing information, and price signals to in-home displays for (i) customer notification and (ii) to implement prepayment metering systems. This capability also will need to be expanded to support the new HAN messaging requirements and will need to be modified to support the standard price signals and scheduling mechanisms that are being developed as part of the NIST Roadmap.

Figure 2 illustrates the interfaces that have been proposed by the MultiSpeak Initiative Technical Committee for the various abstract software functions.

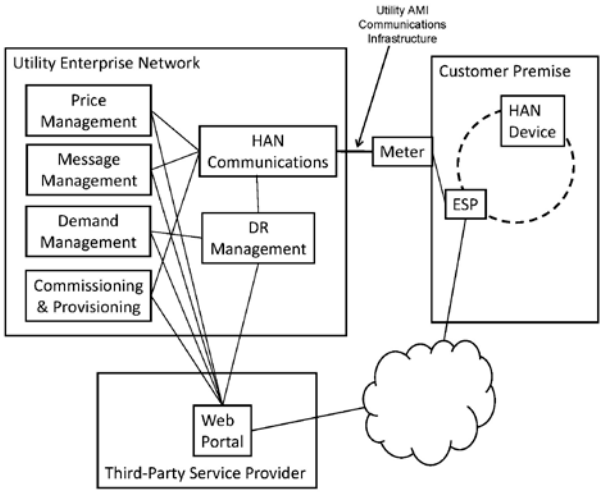

Fig. 2. Abstract Functions to Realize HAN Requirements.

The interfaces shown in Figure 2 indicate that each of the primary functions (Price Management, Message Management, Demand Management, and Commissioning and Provisioning) makes use of the HAN Communications function to provide messaging services across the utility's AMI communications infrastructure.

The Demand Management function also makes use of the DR Management function to act as a proxy and intermediate service prior to delivery to the HAN Communications function.

Whether physical interfaces will exist for all of the abstract interfaces shown in Figure 2 will depend on which software applications exhibit the proposed abstract functions. If one application instantiates several functional blocks then it might encapsulate one more of the interfaces identified.

Figure 2 illustrates the two potential communications paths envisioned in the NIST Conceptual Reference Model (Fig. 1); one through the utility's AMI communications infrastructure and one through an Internet connection. Note that the Internet messaging route might return directly to the utility. In this case, the block entitled "Third-Party Service Provider" would be composed of another instance of utility-managed software exhibiting the services defined for the HAN Communications function. It should also be noted, that the web portal shown in Figure 2 as part of the third-part service provider can itself be created using an implementation of the proposed HAN Communications and DR Management services, exactly as they would be defined for utility implementation.

V. CONCLUSIONS

It will be necessary for the enterprise integration standards - MultiSpeak® and IEC 61968 to adopt concrete interface definitions and messaging specifications to support the requirements and use cases identified by industry groups developing HAN technologies. The MultiSpeak Initiative has begun investigating data model changes and service definitions to implement the proposed

abstract architecture. It is the intention of the MultiSpeak Initiative to coordinate this effort with the Part 9 team of Working Group 14, IEC TC 57 so as to minimize the need for later harmonization efforts.

This paper has provided a survey of industry efforts to define the appropriate interactions with a residential customer HAN and has suggested an abstract architecture for supporting the requirements analyses that have been offered to date.

VII. References

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