Integrating Smart Houses with the Smart Grid Through Web Services for Increasing Energy Efficiency

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Overview

Treating homes, offices and commercial buildings as intelligently networked collaborations can contribute to enhancing the efficienct use of energy. When smart houses are able to communicate, interact and negotiate with both customers and energy devices in the local grid, the energy consumption can be better adapted to the available energy supply, especially when the proportion of variable renewable generation is high. Through sending price signals or comparative information / incentives to the smart house, it can optimize the utilization of the household appliances and shift them to times when the overall load is low or the availability of electricity from renewable sources in the grid is high.

A key issue for realizing such concepts is the integration of devices, the communication between devices, and the integration and communication of the devices with enterprise systems run by utilities or other service providers. Information generated at the point of action (device level) is used by other devices, by higher level systems that aggregate and process them, as well as by global services. In that sense, there is an "information bus" where the meaningful information is made available for entities to consume. As this information dissemination and exploitation has to be done in an open and interoperable way, Internet-based technologies and especially web services are considered to be the best candidates to glue the components of the system together. Furthermore, several other technologies can be used beyond basic communication technologies in order to simulate and predict behaviour of such systems, or to provide further system capabilities [Karnouskos/Terzidis 2007].

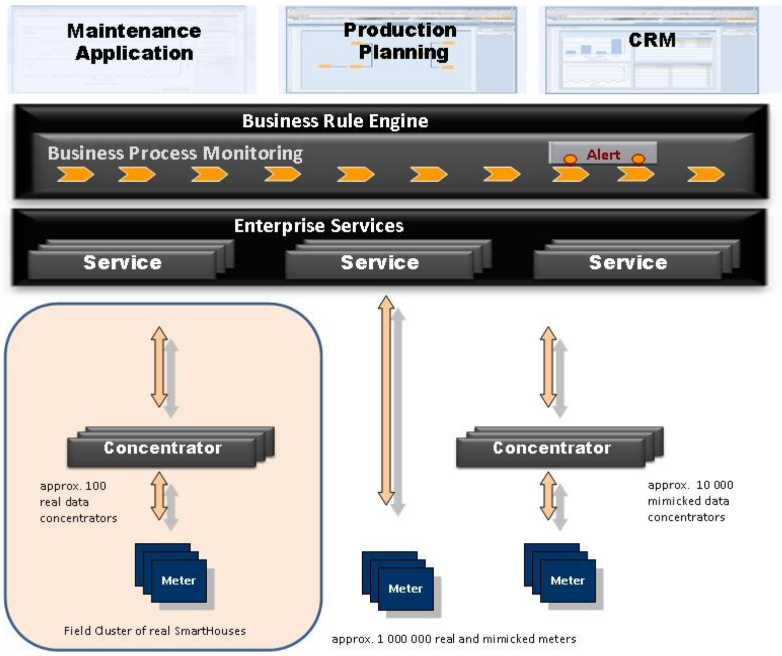
Methods

The joint management of a collection of houses and commercial sites can be done in two ways. The aggregator might directly control one or several participating devices (e.g. deep freezers, air conditioning); this would require the end-users to allow direct access to the control of these appliances. Another way is that an aggregator can only provide incentives to the participating devices, so that they will behave in the desired way with a high probability, but not with certainty. The second option leaves the power of control to the end-user, i.e. the owner of the appliances, and might thus be more acceptable, and also easier to implement from a legal perspective.

The concept of service-oriented architectures is well suited for integrating a large number of flexible and intelligent devices to one scalable overall system [Karnouskos/Tariq 2008]. Services could be delivered directly by smart meters, or by other devices that process information. A house energy management system for example could both use and offer web services. The idea behind a service-oriented approach within collaborations of smart houses is that data is processed at the place where it is needed, and all devices can subscribe to those services that they actually need. For example, a billing process does not need to have to-the-minute information of energy consumption, nor does it need to know exactly which devices consumed how much electricity. It only needs aggregate data, coupled with the applicable tariff at the time of consumption, which could be provided by an according service. A consumer who wants to compare his consumption pattern with that of similar households would be interested in the distribution of consumption among different appliances, but maybe wouldn't care for the availability of electricity from renewable sources at the times of his consumption. So he could subscribe to a service which offers him exactly this information, without transmitting further data that is not necessary for this information. In such a scenario, services can be seen as tradable goods, and the service providers can generate income from offering the service to other parties.

Results

This contribution will demonstrate how device-level services can be integrated with enterprise systems through the application of web services. This requires the definition of new integration concepts taking into account the emerging requirements of business applications and the explosion of available information from the device level. Of particular interest is the availability of real-time event information, which will be used to specify new enterprise integration approaches for applications such as business activity monitoring, overall equipment effectiveness optimisation, maintenance optimisation, and others. A basic overview of the system's components is provided in the subsequent figure.



The next generation of metering and data exchange technologies is known as Advanced Metering Infrastructure (AMI) technologies. With abilities to support bi-directional flows of information, AMI enables far more responsive sales and service departments and allows customers to make more informed energy-consumption decisions in response to different price signals. All processes and systems involved – both within and beyond company boundaries – can be linked through composite application technologies that consume enterprise services exposed by a process-centric data exchange infrastructure. This, in turn, enables two-way communication between metering systems and enterprise applications so that utilities can build innovative sales and customer service processes.

The first step in the process of the metering infrastructure communicating with the back-end system involves the collection and consolidation of relevant consumption and meter-reading data from the customers' meters. The meter infrastructure must then transfer this data to a raw database for storage, but not before executing consistency checks and replacement-value procedures for data quality purposes. The information and billing systems can perform these activities – as it might be required when the back-end system of the utility is receiving implausible values from the AMI system, which would prevent a further processing of the data in energy settlement and billing.

Conclusions

The collaboration of intelligently networked smart houses with the smart grid can increase the overall energy system's efficiency. The concepts presented in the paper will demonstrate how energy suppliers or other service providers can integrate functionalities provided by the smart meter situated in the smart house into its own business processes through web services. With an overall infrastructure that enables smart houses to collaborate based on web services, the existing generating capacity and the available power from renewable sources can be utilized more efficiently as in the current energy system in which (smart) houses are treated as isolated and passive individual units.

The results presented in the paper are currently developed within the framework of the EC co-funded research project SmartHouse/SmartGrid [Kok et al., http://www.smarthouse-smartgrid.eu].

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