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Wireless Sensor Networks in Smart Grid on Demand Management

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Abstract

Now is the applications are using WSN for environmental monitoring and surveillance applications, intelligent transportation systems, monitoring, disaster recovery, and the structure used in the field. Also, the low cost of the communication and control functions can be provided, in particular management of smart grid demand may be used in many applications. In this paper, WSN in smart grid is based on the building blocks of smart grid management system proposed for the fuzzy demand.

Keywords: *iHEM, fuzzy system, EMU*

1. Introduction

In the smart grid, demand management extends beyond controlling the loads on the demand-side. Controlling demand side load is known as Demand Response (DR), and it is already implemented in the traditional power grid for large-scale consumers although it is not fully automated yet. DR directly aims to control the load of the commercial and the industrial consumers during peak hours.

Demand management schemes for the smart grid are grouped as communication-based demand management, incentive-based demand management, real-time demand management, and optimization-based demand management. Firstly, communication-based demand management techniques have been studied in [1][2][3].

In this paper, we represent a broad perspective on the possible utilization of wireless sensor network (WSN) in the smart grid. Then, we focus on in-Home Energy Management (iHEM) among communication-based demand management schemes.

2. in-Home Energy Management

This residential demand management scheme is called in-Home Energy Management (iHEM). iHEM employs a central Energy Management Unit (EMU) and appliances with communication capability. EMU and appliances communicate via wireless links where their packets are relayed by a WSN. According to iHEM, when a consumer turns on an appliance, the appliance generates a START-REQ packet and sends it to EMU. EMU communicates with the smart meter regularly to receive the price updates of the TOU tariff applied by the grid operator.

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3. Takagi-Sugeno fuzzy model

The EMU checks whether locally generated power is adequate for accommodating the demand. If this is the case, the appliance starts operating, otherwise the algorithm checks if the demand has arrived at a peak hour, based on the requested start time of appliance i, S_i. If the demand corresponds to a peak hour, it is either shifted to off-peak hours or mid-peak hours as long as the waiting time does not exceed D_m, i.e. maximum delay. The computed delay of appliance i, d_i is returned to the consumer as the waiting time. D_m parameter limits the delay, hence it guarantees a maximum delay for the consumers, and at the same time it prevents the requests to pile up at certain off-peak periods. StartImmediately() and StartDelayed() functions determine the scheduled time of operation.

The same WSN may also be responsible for other smart home applications such as inhabitant health monitoring since installing a WSN for the sole purpose of iHEM would increase cost. There are stochastic versions of scheduling problems, but they are hard to compute in practice, because some deterministic scheduling problems are already very hard. Resorting to fuzzy set may help building a tradeoff between the expressive power and the computational difficulties of stochastic scheduling techniques while tackling uncertainty and accounting for local specifications of preferences. The fuzzy model proposed by Takagi and Sugeno is described by fuzzy IF-THEN rules, which represents local input-output relations of a nonlinear system. The main feature of a Takagi-Sugeno fuzzy model is to express the local dynamics of each fuzzy rule by a linear system model. The overall fuzzy model of the system is achieved by fuzzy "blending" of the linear system models. In fact, it is proved that Takagi-Sugeno fuzzy models are universal approximates of any smooth nonlinear system.

4. Simulation

Time of Use (TOU) is a natural result of consumer activity. Consumer demands have seasonal, weekly and daily patterns. Morning and evening peaks are visible in the daily load pattern of a typical household on a winter weekday. Also, according to the accumulated loads of a large number of consumers collected by the Australian Independent System Operator (AISO), the peaks become more significant as they are accumulated. Best validation performance is 41.0932 at epoch 6 (see Fig.1). The hours of high consumer activity, i.e. high load durations, is called on-peak periods, while moderate and low load durations are called mid-peak and off-peak periods, respectively.

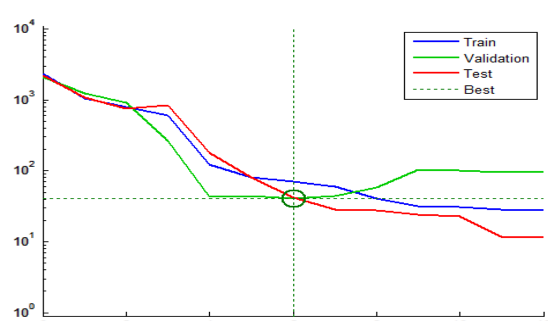

Figure 1. Mean square error vs. Epoch

5. Conclusion

WSN provides promising solutions for efficient integration of intermittent renewable energy resources, low-cost monitoring of traditional power plants and high-resolution monitoring of utility transport assets. Furthermore, WSN offers vast variety of applications in the field of consumer demand management. The ultimate aim of those demand management schemes is to schedule the appliance cycles so that the use of electricity from the grid during peak hours is reduced which consequently reduces the need for the power from the peaked plants and reduces the carbon footprint of the household.

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