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Residential Power Load Forecasting

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Abstract

The prepaid electric power metering market is being driven in large part by advancements in and the adoption of Smart Grid technology. Advanced smart meters facilitate the deployment of prepaid systems with smart prepaid meters. A successful program hinges on the ability to accurately predict the amount of energy consumed on a daily basis for each end user. This method of forecasting is called Residential Power Load Forecasting (RPLF). This paper describes the systems engineering (SE) processes and tools that were used to develop a recommended load prediction model for the project sponsor, SmartGridCIS. The basic concept is that power is treated similar to a prepaid telephone in a “pay as you go” fashion. Modeling techniques explored in the analysis of alternatives (AoA) include Fuzzy Logic, Time Series Moving Average, and Artificial Neural Networks (ANN). SE tools such as prioritization and Pugh matrices were used to choose the best-fit model, which ended up being the ANN. Cognitive systems engineering was used in conjunction with the task analysis. Requirements were developed using the commercial tool IBM Rational DOORS®.

Keywords: Energy Load Forecasting; Short-Term Forecasting; Long-Term Forecasting, Smart Grid

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1. Introduction

The exponential growth of the Smart Grid and the rapid deployment of software-enabled meters provide utility companies and consumers alike new opportunities in the way that energy delivered and consumed. The global growth of prepaid electricity programs has been steady and gradual in recent years, but now, thanks to the Smart Grid, the prepaid metering market is now poised to take off on a larger scale. The prepaid energy market is similar to the pre-paid cellular phone concept. Energy consumers are able to pay for energy usage in advance, making an account deposit and having the daily energy usage cost debited from the account. This system provides utilities a way to service customers with poor credit rating or who have a delinquent payment history because Smart Meters allow real-time monitoring of individual customer usage. In order to provide the end user with sufficient notice and accurate account balance status, an accurate individual-customer forecasting method is needed. Residential Power Load Forecasting (RPLF) is a method to predict power usage for individual consumers based on both historical energy use and weather data.

The purpose of this paper is to show how Systems Engineering can be used to determine the most appropriate forecasting model for RPLF. The remainder of the paper is outlined as follows:

- Section 2 - background information on energy forecasting & cognitive systems engineering
- Section 3 - literature review of individual load forecasting
- Sections 4&5 - discussion of design and architecture considerations respectively
- Section 6 - outline of the proposed forecasting model
- Section 7 - outline of future work
- Section 8 - conclusion

1.1. System characterization

Figure 1 depicts an overview of the Prepaid Smart Meter System of Systems (SoS), which describes information flow between the operational elements of the system in order to set a frame of reference for this work.

The customer's home residence is equipped with a specially designed prepaid smart meter rather than a standard Radio Frequency (RF) communications enabled smart meter or electromechanical meter. The process that the customer goes through to add more available energy to their account involves a swipe of a prepaid reloadable chip card on the card slot of the prepaid smart meter. The balance of the chip card is monitored and added to by using various customer interaction methods, such as smartphone/tablet applications, SMS, web applications, email, kiosks, etc. These interaction methods inform the customer how long their prepayment will provide available energy at their meter, and add energy (via adding credit) to their account as needed.

The smart meter installed at the customer location is monitored and controlled by a connection to the utility company's Advanced Metering Infrastructure (AMI). Examples of the type of energy consumption statistics that are collected from customer smart meters include kilowatt usage per various time intervals, smart appliance usage details, and so forth. These data are fed into the Meter Data Management System (MDMS) at the utility company, where it is stored and analyzed. Not shown in the diagram is the input of weather data to the utility company third-party sources, used as a factor in the calculations of energy forecasts.

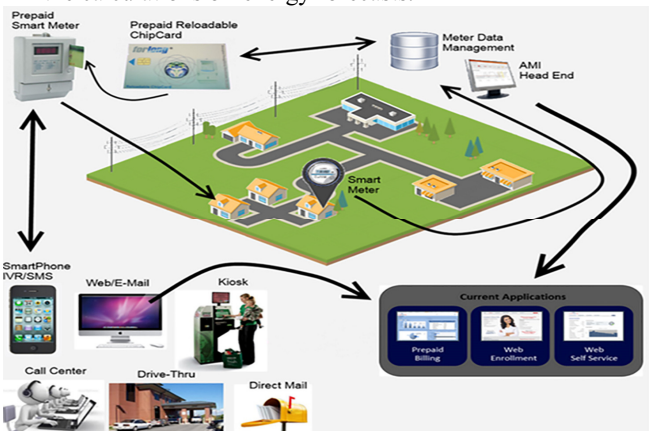

Fig. 1. System Characterization