Demand Response Systems: Neighborhood Aggregator Design

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Introduction

One of the biggest problems that our society is facing today is the huge demand and large consumption of energy. The utilities' need to take generators on and off over the course of the day, because of the uneven demand distribution, is making the use energy more expensive for utilities and at the same time for consumers. Looking for an efficient solution to this serious problem is where Demand Response Systems start to appear in this research project. Dr. Stephen Wicker and his colleagues have being doing researches and experiments with demand respond systems, in order to develop a system that could bring potential savings in energy.

According to Dr. Wicker, demand response systems balance daily power consumption patterns by showing consumers the cost of electricity at different times throughout the day. The basic idea, according to Dr. Wicker and his colleagues, is that by showing consumers the cost of their consumption behavior, they'll be more likely to perform electricity-intensive domestic tasks during off-peak hours [2]. This consumption behavior would result in a more uniform demand distribution and demand will then level out, alleviating the utilities' need to take generators on and off line over the course of the day. Giving an example, to do laundry is an electricity-intense domestic task that people can move to off-peak hours without seriously altering human habits.

In order to develop this demand response concept, Dr. Wicker and his colleagues proposed to use what they call Advanced Metering Infrastructure or AMI. They described the AMI as a metering system that records customer consumption on a minute-by-minute basis, as opposed to the once-a-month meter readings of the past, and that provides for daily or more frequent transmittal of measurements over a communication network to a central collection [2].

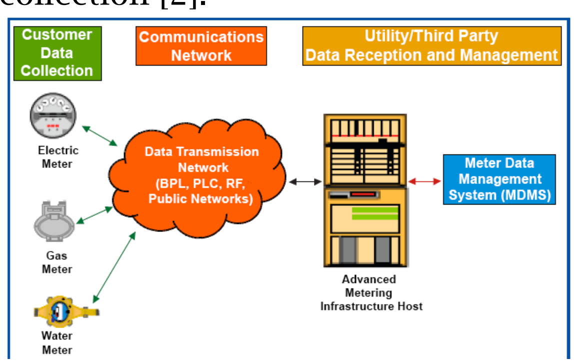

Figure 1. Advanced Metering Infrastructure [1]

Everything seems to be right until it is demonstrated that if people use the AMI in that way, it can create a seriously privacy concern. Dr. Wicker conducted an experiment in a standard student residence in which he demonstrated that data collected by Advanced Metering Infrastructure reveals detailed information about behavior within the home. They described their experiment as follows: "A Brultech EML energy usage monitor was attached to the residence's breaker panel to collect real-time power consumption data" [2]. "The data, obtained at intervals of 15 seconds with a resolution of 1 watt, was transferred to a non-intrusive load monitor application running on a workstation" [2]. "A behavior extraction algorithm was then run on the workstation in an attempt to predict behavior based solely on power consumption and video data was used to establish a control for the experiment" [2]. The results of this experiment showed that using the AMI to process data directly from the home to the utility creates a serious privacy concern.

Using a "Privacy-Aware design", Dr. Wicker developed an idea to minimize the privacy concerns of users and the public at large, which is the research's main objective during this summer. His idea is to use a Neighborhood Aggregator in order to anonymize the data of multiple households in a surrounding geographical region. A Neighborhood Aggregator can be used to combine and anonymize data so that the desired temporal data is provided without providing information about individual behavior. Aggregator contractual obligations to the utility will provide the utility with sufficient information to determine how much of the predicted demand can be mitigated through pricing mechanisms [2].

Basically, the principal goal of this project is to develop a theoretical software design about how a Neighborhood Aggregator would capture the data from the AMI, process that data, and send the data to its utility.

Solving Privacy Issues

Demand response systems call for 3 different data flows and for each of them, a privacy-aware approach can be adopted [2]:

1. First flow – In order to make consumption decisions, pricing data must be presented to the consumer. This doesn't present a privacy concern, as the utility can simply broadcast the pricing to the residential meter.
2. Second flow- Utilities would need customer's specific consumption data for **billing** purposes. One cannot stream consumption data to the utility without creating privacy issues. However, consumption data could be accumulated at the residence and the aggregate cost could be send to the utility on monthly or weekly basis, avoiding privacy issues. This means that consumption data for billing purposes doesn't

have to be in the neighborhood aggregator. The residence's meter will have two different lines to transfer data: the first one is going to be from the meter to the neighborhood aggregator, and the other one will be from the meter directly to the utility just for billing purposes.

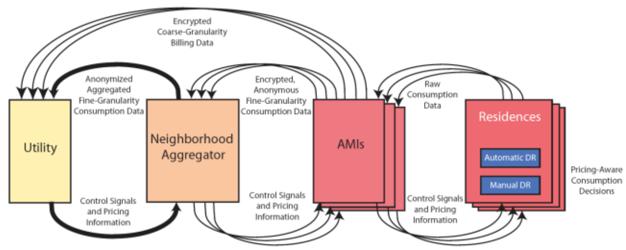

Figure 2. Demand Response Design including the Neighborhood Aggregator [2]

3. Third flow – In order to predict demand and maintain a price model, the utility needs precise consumption data aggregated at the level of the consumer. A neighborhood aggregator can be designed to sum the power consumption data of sufficient number of costumers in a neighborhood so that a single customer's data cannot be isolated. This information will be sufficient for the utility to predict demand and maintain a price model and, also, it will avoid privacy issues.

Software Design of the Neighborhood Aggregator

In order to simulate the power consumption data transfer between the neighborhood aggregator and the utility, the researcher developed a computer program, using MATLAB programming tool, to simulate the behavior of a neighborhood aggregator that has 15 customers participating in this demand response initiative. The program was called "Ithaca Neighborhood Aggregator Design".

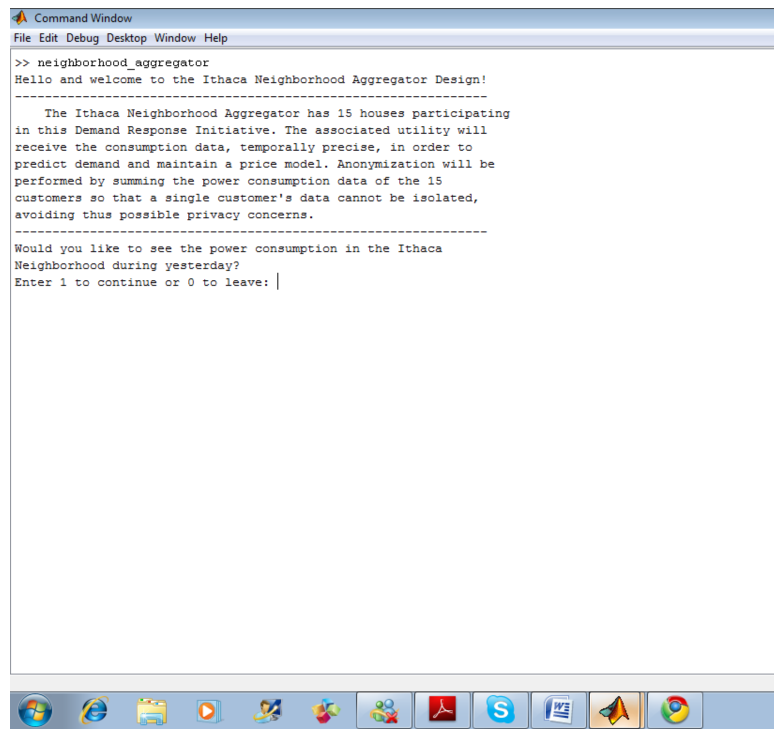

Figure 3. Simulation of a Neighborhood Aggregator (Part 1)

The program asks the user (the utility in this case) if he or she wants to see the neighborhood's power consumption during the last day (yesterday). If the user agrees, the program calculates the power consumption of each house in an hour-by-hour basis. Then, it sums the power consumption of all houses every hour and shows the user a table with detailed information about the energy consumed in the neighborhood (Kb/h), hour-by-hour during the last day.

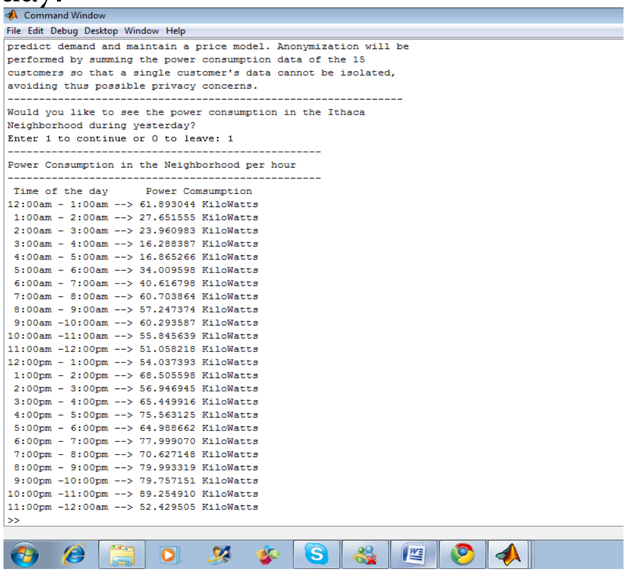

Figure 4. Simulation of a Neighborhood Aggregator (Part 2)

At the same time, the program shows the user a bar graph of the power consumption pattern during the day, just to visualize better the results.

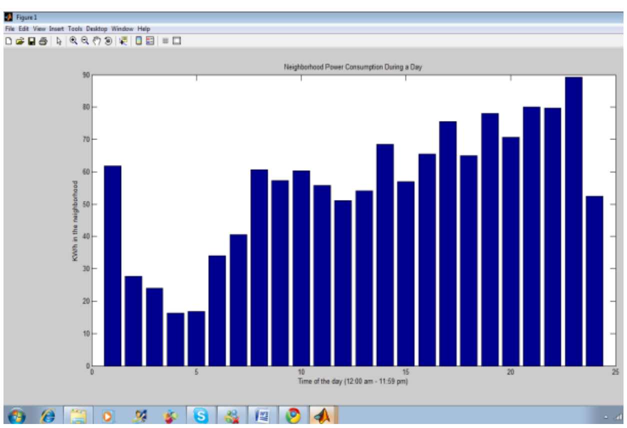

Figure 5. Simulation of a Neighborhood Aggregator (Part 3): This bar graph shows the power consumption from the first hour of the day (12am) to the last one (11pm)

It is very important to mention that every "house" in the "Ithaca Neighborhood Aggregator Design" program has its own consumption data. However, the utility has no access to that information to avoid privacy issues.

Conclusions

The "Ithaca Neighborhood Aggregator Design" program shows a general idea about the possible interaction between a Neighborhood Aggregator and its utility. In addition, it displays just the kind of information to which the utility would have access, in order to avoid privacy problems.

To provide ideas like this one on how to save power and, at the same time to avoid privacy issues is important in order to progress in the Demand Response Systems initiative.

References

[1] "Advanced Metering Infrastructure," Engineering Power Research Institute, Available at http://www.ferc.gov/eventcalendar/Files/20070423091846-EPRI%20-%20Advanced%20Metering.pdf

[2] Stephen. B. Wicker and Robert J. Thomas, "A Privacy-Aware Architecture for Demand Response Systems", Submitted 2010

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