Demand Response Systems: Neighborhood Aggregator Design

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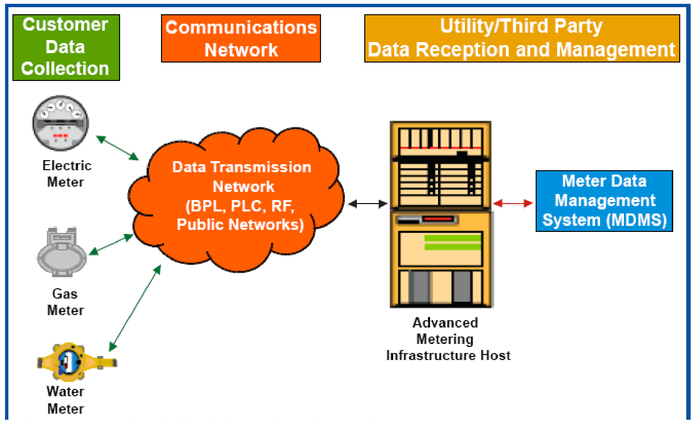
Introduction

• One of the biggest problems that our society is facing today is the huge demand and large consumption of energy. 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. Dr. Stephen Wicker and his colleagues have being doing researches and experiments with demand respond systems, in order to develop a system that promotes a more uniform demand distribution and power savings.

• 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. Demand will then level out, alleviating the utilities' need to take generators on and off line over the course of the day.

• 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 recorded customer consumption on a minute-by-minute basis, as opposed to the once-a-month meter readings of the past, and that provided for daily or more frequent transmittal of measurements over a communication network to a central collection.



•Figure 1. AMI Building Blocks [1]

•Unfortunately, if people use the AMI in that way, it can create a seriously privacy concern. Dr. Wicker, with the help of his colleagues, 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.

• Using a "Privacy-Aware design", Dr. Wicker developed an idea to minimize the privacy concerns of users and the public at large, in which this work focused on. His idea was to use a Neighborhood Aggregator to anonymize the data of multiple households in a surrounding geographical region.

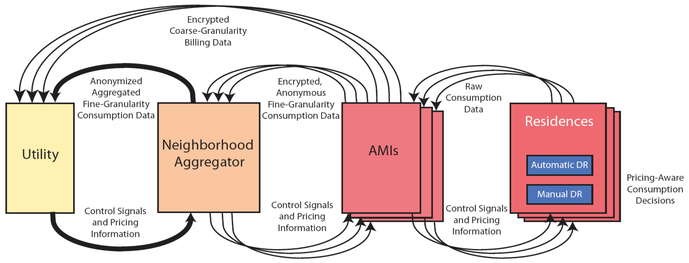


Figure 2. Demand Response Design including the Neighborhood Aggregator [2]

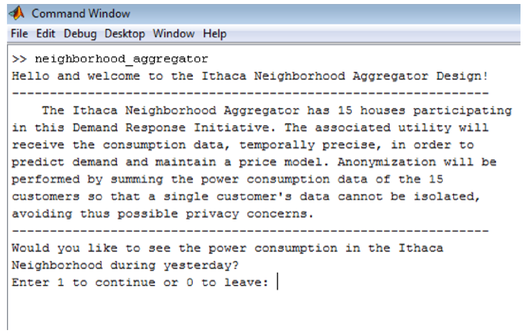
• The principal goal of the project was to develop a theoretical software design about how a Neighborhood Aggregator would capture the data from the AMI, process the data, and send the data to its utility.

Solving Privacy Issues

Demand Response Systems call for 3 different data flows and for each of them, a privacy-aware approach can be adopted:

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.
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**.

Software Design



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Command Window
File Edit Debug Desktop Window Help
>> neighborhood_aggregator
Hello and welcome to the Ithaca Neighborhood Aggregator Design!
-----------------------------------------------------------------
    The Ithaca Neighborhood Aggregator has 15 houses participating
in this Demand Response Initiative. The associated utility will
receive the consumption data, temporally precise, in order to
predict demand and maintain a price model. Anonymization will be
performed by summing the power consumption data of the 15
customers so that a single customer's data cannot be isolated,
avoiding thus possible privacy concerns.
-----------------------------------------------------------------
Would you like to see the power consumption in the Ithaca
Neighborhood during yesterday?
Enter 1 to continue or 0 to leave:
```

Figure 3. Simulation of a 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". 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).

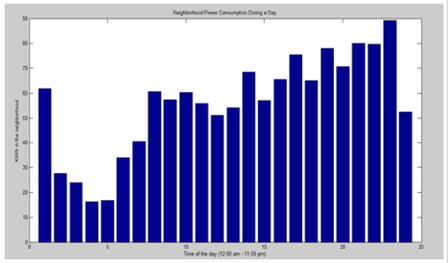
• If the user agrees, the program calculates the power consumption of each house in an hour-by-hour basis. Then, it sums the power consumption of all houses every hour and shows the user a table and a bar graph with detailed information about the energy consumed in the neighborhood (Kb/h), hour-by-hour during the last day. 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.

```
Command Window
File Edit Debug Desktop Window Help
predict demand and maintain a price model. Anonymization will be
performed by summing the power consumption data of the 15
customers so that a single customer's data cannot be isolated,
avoiding thus possible privacy concerns.
-----------------------------------------------------------------
Would you like to see the power consumption in the Ithaca
Neighborhood during yesterday?
Enter 1 to continue or 0 to leave: 1
-----------------------------------------------------------------
Power Consumption in the Neighborhood per hour
-----------------------------------------------------------------
 Time of the day       Power Consumption
12:00am - 1:00am --> 61.893044 KiloWatts
 1:00am - 2:00am --> 27.651555 KiloWatts
 2:00am - 3:00am --> 23.960983 KiloWatts
 3:00am - 4:00am --> 16.288387 KiloWatts
 4:00am - 5:00am --> 16.865266 KiloWatts
 5:00am - 6:00am --> 34.009598 KiloWatts
 6:00am - 7:00am --> 40.616798 KiloWatts
 7:00am - 8:00am --> 60.703864 KiloWatts
 8:00am - 9:00am --> 57.247374 KiloWatts
 9:00am -10:00am --> 60.293587 KiloWatts
10:00am -11:00am --> 55.845639 KiloWatts
11:00am -12:00pm --> 51.058218 KiloWatts
12:00pm - 1:00pm --> 54.037393 KiloWatts
 1:00pm - 2:00pm --> 68.505598 KiloWatts
 2:00pm - 3:00pm --> 56.946945 KiloWatts
 3:00pm - 4:00pm --> 65.449916 KiloWatts
 4:00pm - 5:00pm --> 75.563125 KiloWatts
 5:00pm - 6:00pm --> 64.988662 KiloWatts
 6:00pm - 7:00pm --> 77.999070 KiloWatts
 7:00pm - 8:00pm --> 70.627148 KiloWatts
 8:00pm - 9:00pm --> 79.993319 KiloWatts
 9:00pm -10:00pm --> 79.757151 KiloWatts
10:00pm -11:00pm --> 89.254910 KiloWatts
11:00pm -12:00am --> 52.429505 KiloWatts
>>
```

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

Conclusions

• The "Ithaca Neighborhood Aggregator Software Design" 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.



• Providing ideas 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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