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CLUSTERING OF CUSTOMERS ON THE BASIS OF VARIABLE POWER CONSUMPTION BEHAVIOR TO FACILITATE DEMAND RESPONSE TARGETING

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Abstract- As present day grid is transferring to the smart grid, the major part to be emphasis is on demand side management. This was the only thing missing in contemporary power system. In the demand side management the major role is played by demand response. The demand response has the capabilities to flatten the load curve and peak reduction, valley filling, etc. But the bottleneck in implementation of demand response i.e. participation of customers in demand response is very low. As the demand response involves the methodology in which customers have to change the pattern and time of consumption of the electrical power. But there are many rigid customers who are not ready to change their consumption pattern. So to identify the flexible consumer the variability of each customer is studied in this thesis. And a technique for targeting the consumer based on their flexibility has been presented in this thesis.

Keywords:loadprofiles,clusters,centroids

I INTRODUCTION

After pre-processing of data, it has been modelled for clustering algorithm. The clustering phase of this cycle has gained a significant amount of observation in recent years and different methodologies have arisen to tackle this problem. A recent observes identified five different collect methods. A recent look over identified five different gather methods for load profiling: partitioning based methods, hierarchical methods, density-based methods, grid-based methods and model-based methods. There are a lot of methods for clustering but they are broadly classified into the following:

1) Partitioning process: This clustering process classifies the information into many groups based on the characteristics and similarity of the data. It is the data analysts to prescribe the number of clusters that has to be generated for the clustering methods. There are many algorithms that come under split process some of the popular ones are K-Mean, PAM, K-routine etc.

2) Hierarchical method: A Hierarchical gather method collects via grouping data into a tree of clusters. Hierarchical clustering begins by treating every data point as a separate cluster. Then, it repeatedly perform the subsequent steps:

Identify the 2 clump which can be adjacent together, and

Merge the 2 maximum comparable clusters.

We need to pick up these steps until all the clusters are join forces together.

3) Density based type: Density-Based collect refers to unsupervised learning system that identify distinctive groups/clusters in the data, based on the idea that a cluster in a data space is a adjacent

region of high point density, isolate from other such clusters by proximate regions of low point density

4) Grid-based type: proposed a Statistical Information Grid-based clustering method (STING) to cluster spatial databases. The algorithm can be used to facilitate several strains of spatial queries. The spatial area is sculpt up into rectangle cells, which are speck for by a hierarchical structure.

5) Model-based clustering: In the family of version-based totally clustering algorithms, one makes uses certain models for clusters and attempts to optimize the fit between the statistics and the models. In the model-based collect approach, the statistics are estimate as coming from a mixture of probability distributions, every of which represents a extraordinary collect.

There are various methods for calculating the distance between two different sets or clusters or within clusters. Like Euclidean, cosine, chi square and Murkowski but the most used method is Euclidean. In the authors compares the effect of different distances on K-NN clustering method and suggests chi square distance for K-NN.

Impacts of DR on DSM Power Systems

The impact of DR on DSM power systems is evaluated from the perspectives of the electricity market, environment and power system working and reliability.

1.2 Voltage Stability

Voltage safety refers to the capacity of power systems to keep going allowed voltages at all buses under normal operating conditions and after disturbances. The proven ability of DSM to help execute voltage stability in power systems is important for alleviating transmission congestions that are otherwise limited by bus-voltage violations. On the other hand, DR can keep going frequency balance as well.

1.3 Transmission Congestion

As the Demand Side Management seeks to level the load profile and decrease the time of peak load duration, the needed transmission capability decrement and this affect indirectly leaves transmission congestion. Best power flow has been obtained to maximize system welfare through the analytics of the best problem of demand-side resources.

1.4 Preventive Maintenance

Preventive maintenance is required maintenance and is a response that is direct and planned in advance; it is put off if require and includes component withdrawal. Pre-emptive maintenance must be performed when system components approach the end of their useful lifespan or when failures are anticipated. Preventive maintenance is periodically scheduled for give rise up units, transmission lines and distribution networks to reduce the risk of being out of service.

The various types of clustering

1.Connectivity-based Clustering (Hierarchical clustering)
2.Cancroids-based Clustering (Partitioning methods)
3.Distribution-based Clustering
4.Density-based Clustering (Model-based methods)
5.Fuzzy Clustering
6.Constraint-based (Supervised Clustering)

II.PROBEM FORMULATION

As the bottleneck of implementing demand response is the diversity of consumption behavior of consumers. A lot of money has been wasted on a vast number of consumers, if some customers to be selected and targeted for demand response, there could be a huge amount of savings. As the rigid customers are not willing to change the consumption pattern of the electrical energy, so it is required to find out a technique to target the customers who are flexible enough to participate in demand response.

2.2 Impact of DR On DSM

The terminology can be taken into considered a reason that makes the literature review on Demand Side Management a serious trouble. Demand side management is probably the maximum diffuse time period used to describe the changes of the user demand as a way to meet a few necessities or attain specific desires. Demand side management (DSM) consider all the measures acting at demand tier, aimed at dropping the consumption/emissions or enlarge the income from the energy sales, including the technique to upgrade energy efficiency of the buildings. Some other very diffuse name is demand response (DR). Regarding demand response, this is a subset of demand side control, best which only including the non-everlasting movements done on the demand.

Each the names are born in the electricity discipline. In this zone, the goal is editing the electricity loads of the very last users such that the general demand is extra convenient for the supply side

2.3 Different Techniques to Targeting Consumers

Techniques of attractive customers in demand reaction efforts consists of providing time-based rates such as time-of-use rates, serious peak pricing, changeable peak rates, real time rates, and critical top rebates. It also considers direct load control package which give the capability for power companies to cycle air conditioners and water warmers on and off during periods of peak demand in change for a monetary incentive and lower electric payments.

	0	1	2	3	...	21	22
H 1	691.7	-1450	-80.6	-10.46	...	-2365	2595.81
H 2	24.32	1329.87	760.39	-1476.4	...	1864.61	2666.18
H 3	-2876.6	-2141.34	-626.83	827.55	...	-1861.2	3229.21
H 4	-736.11	-766.37	-6	-733.76	...	-800.58	1487.79
H 5	2769.65	107.98	675.23	-660.28	...	-2675	4170
...	...	...	...	...	...	...	...
H196	722.81	-1373.48	1360.29	-2224.7	...	2222.75	1012.33
H197	-1465.5	725	-2193.9	2898.81	...	-725.34	711.1
H198	-3318.4	13320.28	2877.5	-853.67	...	-1846.7	1952.6
H199	-408.71	-899.97	961.77	718.33	...	-1744.7	1389.3
H200	-725.86	-1430.25	2149.23	-745.61	...	3260.26	-335.26

III. OBJECTIVES

1.To study and analyze impact of demand response on demand side management.
2.To study and analyze different techniques to targeting consumers for demand response.
3.To study and analyze different techniques clustering customers referring to various basis.
4.To study and analyze the various techniques for clustering customers referring variability of their load profiles to facilitate demand response.

IVResearch Methodology

To find the variability in load consumption of the households and to figure out flexible consumers, the change in every hour consumption of every consumer is to be noted for a particular day of particular months. The months are chosen such that they include the effect of weather conditions and the change of equipment due to weather change.
After forming a separate data frame which includes the change of energy consumption for each hour. The standard deviation of each household is to be calculated using the formula given below.

$$\partial = \sqrt{\frac{\sum(x_i - u)^2}{N}}$$

Where,
$\partial$is the standard deviation
x_i is the ith hour change in power consumption for the particular customer
u is the means change in consumption for that consumer
N is the total number of events in the sample space
Therefore using this formula a new table of standard deviation is to be formed for every consumer. A range is to be decided for flexible consumer and rigid consumers. Then to figure out customers it should be observed for at least three different months of the year.
For the demand response aggregator, the most important thing required by the aggregator is the flexibility. The flexibility is the how much power is there to change or shift.

V. Result &Discussion A dataset of 200 households has been taken and resample it to hourly consumption. After this the data frame is created which contains the hourly change in consumption as shown in table 1.

The above shown table is formulated by taking the change in power consumption of each hour of all the 200 customers. As the 0^{th} column contains the change of electricity consumption from 12 at night to 1 o'clock at night and so on.
Using this data frame the standard deviation is calculated using the formula above mentioned :

Table 2: Standard deviation of different households

House	STD	House	STD
House 1	0.516136	……	……
House 2	0.378227	House16	0.375756
House 3	0.275747	House17	0.417181
House 4	0.335127	House18	0.513502
House 5	0.471657	House19	0.407416
…..	……	House20	0.438967

After getting the data frame of different household's standard deviation the visualization of data is important. Therefore, similar data frames for all 200 households should be made for four different months. The below shown figure shows the difference in standard deviation of these 200 households.

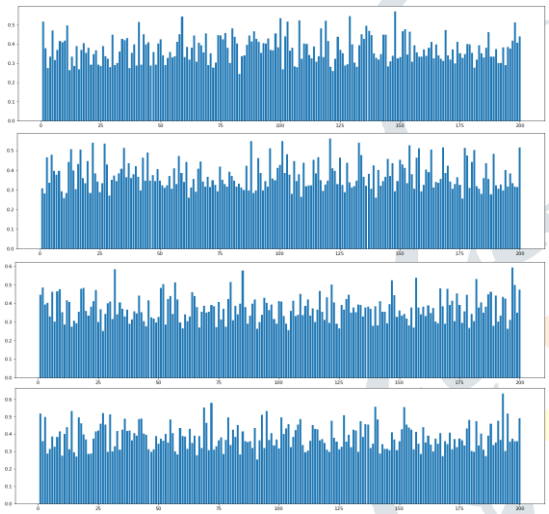

Figure 1 The standard deviations of 200 different households for January, April, July, October

As observing the above figure1 it can be concluded that for all the four months there exists a range in which the standard deviation is low medium and high. And the range is same for all the four months.

Therefore, the range is less than 0.3 which are the rigid customers and then the medium range which is between 0.3 to 0.5. These consumers are moderately rigid or flexible. Then comes the highest flexible consumers which have standard deviation of more than 0.5.

After this the consistence performing customers are identified. Like house 43 and 23 are consistently having low standard deviation, therefore they are rigid consumers. House 1 and 78 are consistently having medium standard deviation; therefore they are moderately rigid or flexible consumers. Highly flexible consumer is household number 2 and 7.

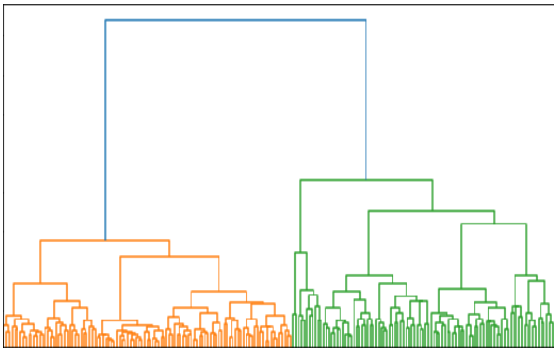

Fig 3: Dendrogram of the 200 households

According to the dendrogram the number of optimal clusters will be 4. Therefore, the clusters of different customers will be formed according to the hierarchical clustering. As shown in the figure below.

V.Conclusion & Future Scope

In this the paper demand response targeting has been performed and the most rigid and flexible consumers has been identified. The major money is being wasted on the consumers which are not willing to participate in demand response. Therefore, a customer targeting technique is been proposed in this thesis. A data set of 200 households are taken and analyzed. It was the target to separate the rigid customers who are not willing to participate in demand response, from more flexible consumers who are flexible enough to change their consumption pattern according to demand response signal.

In this paper the hourly change of power consumption of each consumer is calculated and accordingly the standard deviation chart is been prepared.It has been noticed that there were three ranges of standard deviation i.e. less than 0.3 which are to be considered as most rigid consumers, than moderate rigid or flexible who are in the segment of 0.3 to 0.5 standard deviation, than there exits the most flexible consumers who are having standard deviation above 0.5. From the analysis of four months the consistence performing customers are identified. Like house 43 and 23 are consistently having low standard deviation, therefore they are rigid consumers. House 1 and 78 are consistently having medium standard deviation, therefore they are moderately rigid or flexible consumers. Highly flexible consumer are household number 2 and 7.

Future scope of this work is vast, as it is an emerging technology and attracting a lot

researcher. It is a multidisciplinary research work which has a large scope. The demand response targeting using variation can also in co-operate various other factors like sensitivity of the consumers to weather, climate, working day or holiday etc. to enhance the performance of the targeting mode.

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