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# Implementation of Power Management System by Using Data Clustering Method

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**Abstract**

This paper proposes a way to alert large number of users to current power consumption status to prevent over uses of power. For this, the system makes use of methods of data collecting, storing and processing, which also includes some BigData processing from some periods. In order to efficiently use electric power, it needs to drive a predicted value of existing data from the history data. So, we introduce some schemes related to data clustering and analysis mechanism and implementation results. In the simulation results, we confirm the power efficiency of about 14% increase compared with the simple usage of the power.

**Keywords**: Clustering Analysis, Peak Management, MQTT

## I. Introduction

In the recent, a power grid has developed for intelligent through a smart grid which is electricity and information and communication technology convergence to provide high quality service and maximize energy efficiency in the power industry. The smart grid has collected BigData by smart meter, intelligent sensor and has supplied diffusion of renewable energy.

Accordingly, on the efficient management based on BigData, it is increasing interest to create new value added from a large amount of data. It is difficult to store/analysis the data because it is increased with collected data and smart grid supply. In order to efficiently use electric power amount, it is required to predict the target exiting data [1]. So, we need an analysis scheme with exiting data and prediction algorithm [2].

In this paper, we propose a way to store and analyse the power data by using the BigData system. We use these system that alerts and control for a large number of users. An analysis of data by utilizing clustering technique proposes the load control method to prevent the peak load. The exiting collected history data predicts the power consumption and is managed through the clustering analysis. Notification and control method of analysis that takes into account the user by using the MQTT [5] (Message Queuing Telemetry Transport) which is related the hierarchical management about multiple users through the structure of the 'topic'.

This paper is organized as follows. Section II describes the proposed architecture of system and the analysis method by using the clustering analysis with saved the power data. Also, Management method of a large number of users is described with MQTT. Section III describes an Implementation result through the proposed method. Section IV is conclusion.

## II. Algorithm of clustering prediction method

### A. System Structure

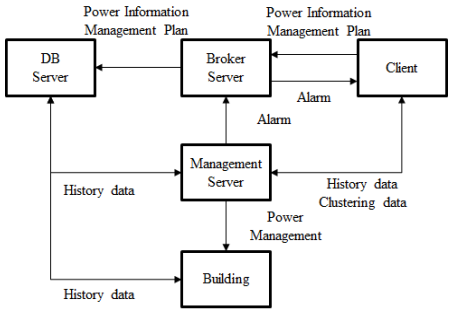


Figure. 1 The proposed system architecture

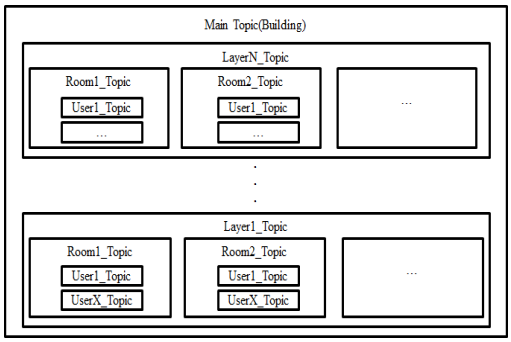


Figure. 2 F The proposed 'topic' architecture

This paper has a system architecture like Fig1. Table 1 describes the explanation and connectivity of each component. The contents of Table 1 can be mainly stored in DB server and partly in Broker Server in Figure 1 respectively.

Classification information (or subject) for example Room No. from history data and clustering data is presented as 'topic' in MQTT scheme. The 'topic' structure can be a framework for managing classification of data in the building, which can be gathered at the Broker Server. User can create a 'topic' in each room. Actually, if User 1 is in Room1 at first floor of a building, the 'topic' in DB server can be created like "/Main (building) / Layer1 / Room1 / User1". If anyone wants to broadcast specific power data in a Layer N, he can use a message /Main Topic/LayerN/ and then all users in Layer N can receive the message. If anyone wants to join at Layer N and tries to receive all data in the Layer N, he can subscribe with a message, Multi-level wildcard using "/Main Topic/LayerN/#".

Table.1 Element-specific features

| Element | Function |
|---|---|
| DB Server | ▪ Collected history data management in the building<br>▪ To manage the information of the building and users and recording<br>▪ Clustering value of Management Server recording |
| Management Server | ▪ history data analyzing<br>▪ If applicable to Alarm Policy, request the Alarm.<br>▪ Event-based power management |
| Broker Server | ▪ User Topics management<br>▪ Issue a message to a specific 'topic' (building, User) |
| Building | ▪ power usage and control target |
| Client | ▪ It subscribes to messages that are delivered in a Broker<br>▪ Change and peak control of peak management policy |

## B. Algorithm and Method

In this paper, we propose the algorithm to utilize Gaussian distribution and partitioning clustering for analyzing the energy consumption pattern [3], [4], [7]. This method is clustered in the desired time period history data. The clustering data obtains the mean and variance values. It predicts power consumption by using the analysis data when selected. The existing methods are considered based on the average of a couple of history data because an error may occur for the consideration of a specific value (ex. The value of the period resulting abnormally power demand). In the proposed system, it utilizes the clustering method to solve the problems of the existing method. The clustering process should take into account the number of the best class and the nearest class data in a given.

In this paper, we derive each cluster based on a Gaussian Mixture. Also, it performs the alarm system and control policies through variance and average of the results. The following table2 shows the history data clustering process by the date on the Management Server to the pseudo code form.

Table.2 Power management algorithm using the Cluster

```
<1>: if(min_var ≤day_GD ≤max_var){
<2>:   if(CP_consumption ≥ min_var){
<3>:     if(Clinet_'topic'_Count ≥ 'topic'_Count){
            pub message(Client 'topic', message(CP_consumption, day_mean,
'topic'_Count))
            'topic'_Count++
<4>:     }else if(Clinet_'topic'_Count < 'topic'_Count){
           pub message(Client 'topic', message(CP_consumption, day_mean, 'topic'_Count))
           'topic'_Count++
<5>:       if(Client_Peak_Policy == true){
             random drop appliance --;}}
<6>:   }else if(CP_consumption ≥ day_mean){
         pub message(Client 'topic', message(CP_consumption, day_mean)
         random drop appliance --;}}
```

The management Server brings the needed data values for the algorithm to request the DB Server. The request data is data that is input of the algorithm. The data is shown in the following Table 3.

Table.3 Data used in the Algorithm Parameter

| Read Data | Function |
|---|---|
| History Data (Client) | ▪ The collected data<br>▪ Client data requester |
| Search Range [year/month/day] | ▪ Information requested period Search<br>▪ Used for the classification period |
| Client_'topic' | ▪ Client 'topic's |
| Client_'topic'_Count | ▪ min_var criteria notification the number of times of the Client |
| Client_Peak_Policy | ▪ Applied state control |

Table.4 Data Calculation used in the Algorithm Parameter

| Parameter | Function |
|---|---|
| day_mean | ▪ The average for Search Range |
| day_var | ▪ The variance for Search Range |
| day_GD | ▪ Probability density function of a Gaussian distribution[3] |
| min_var | ▪ The largest value of power consumption values in the cluster |
| max_var | ▪ The smallest value of power consumption values in the cluster |

The algorithm calculates the average, dispersion and Gaussian distribution with the requested data. The following Table3 is a description of the parameters in the algorithm. The algorithms are created to calculate the average value the date using the history data. The following table4 is a description of the parameters in the algorithm. In the formula, it selects the range with the time because it prevents the different data collecting time problem by each meter. And then, it obtains the variance and Gaussian distribution values. The min_var is obtained through the variance and Gaussian distribution values. The min_var is the lowest value of the density value date. The alarm policy is performed on the basis of the min_var. Conversely the max_var value is the highest value of the density value date. It will check the value belongs in the Gaussian distribution. In the above algorithm controls the power using the dropped appliance and alarm policy. The table shows the description of the operation position of the algorithm. In the description, < > represents the operating position.

Table.5 Operation position of the Algorithm

| Marker | Explanation |
|---|---|
| <1> | ▪ The algorithm checks the range of distribution of the power value through min_var ≤ day_GD ≤ max_var |
| <2> | ▪ The notification is performed with the power control based on the current power value (CP_consumption).<br>▪ The CP_consumption ≥≥ min_var is the condition when the lowest value of the current power density date value |
| <3> | ▪ At this time, the notification policy is performed and the Clinet_'topic'_Count gives the notification as number of times user want. |

Table.5 (Continued): Operation position of the Algorithm

| | |
|---|---|
| <4> | ▪ If it is over a number of times notifications condition, it confims the Client_Peak_Policy by the customized power policy. |
| <5> | ▪ If policy is true, it terminates the dropped appliance one by one |
| <6> | ▪ If it does not set to the Client_Peak_Poilicy or is over the power consumption value, the power consumption value occurs the case of reaching day_mean value<br>▪ If it applies the above condition, it terminates the dropped appliance one by one regardless of the power policy |

The algorithm uses the method about avoiding the maximum peak load through the dropped appliance and does not consider to use controllable appliance.

## III. Implementation Result

In the result, it shows the results of a cluster analysis using the history data. The results were assumed below.

1. The drop appliance [3] does not account for more than 15% of the overall power consumption.
2. The client sets the peak policy to true

The result is confirmed in Fig. 4. history data to generate about five years. The generated data is generated based on the existing data (about 1 years). The Fig. 3 shows the clustering results of one month. The value of the result, the average of the total annual power consumption has a 107.086(kwh/$m^2a$).

The result is a power consumption of the apartment which can correspond to in downtown area [6]. In the Fig. 3, it is result graph of the cluster with an average power consumption of 8.92 (kwh/$m^2a$).x is the time and y is confirmed the range of the average, variance of the cluster. The graph is expressed through the High-charts API [8]. Fig. 4 is the sum of each power consumption in cluster. The shown values are power consumption, average power consumption, and power consumption using the algorithms. The power consume is 7.839kwh when the algorithm applied. In addition, it came out the average value(8.923kwh) and value(9.13kwh) ratio low. The result shows the efficiency of about 14%.

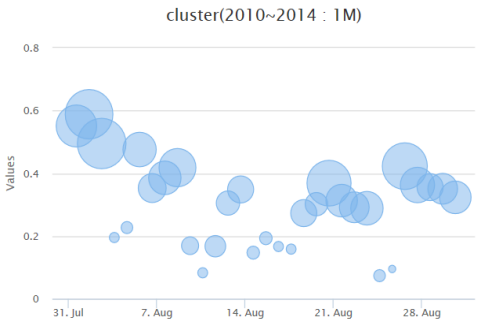


Figure 3. Cluster with an average power consumption

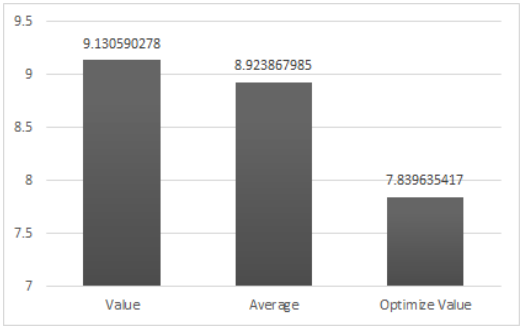


Figure 4. The sum of each Power consumption in Cluster

## IV. Conclusion

In this paper, we store and analyse the data using a power big data system. And then, we propose a method to control notifications and number of users. In a proposed method, the Gaussian distribution and partitioning clustering are used to analyse the pattern of power consumption. The MQTT is utilized to control the power and user notification. The reference operation of the proposed method is used based on the analysis result. It can cause errors that is analysis using only the average history data value. The average history data value do not consider the value of the period of abnormal power demand caused insufficient. So, we could take advantage of the clustering method. As a result, we confirmed the increase of about 14% of power consumption efficiency

In further study, we will study the increase of power efficiency targets IoT appliance as a whole, not just dropped appliance.

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