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# Time Orient Utility Pattern Based Voltage Regulation Model for Power Stations Using Data Mining and Power Flow Factor

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**ABSTRACT**

The growing usage of electric devices increases the scarcity of electric power at each fraction of modern days. The usability of electric devices and the consumption level differs related to many factors and there are few approaches to utilize the power units in efficient manner. They suffer with the problem of voltage loss by conduction as well as excess units, where there is no need of power supply at maximum level. We propose a novel time orient utility pattern based regulation model to increase the efficiency of power supply to reduce the conduction losses as well as the unused losses. The method monitors the consumption of electric volts in each region at regular interval and maintains data set. Each electric meter has attached with the wireless transmitter which transmits the consumption of electric units at each time window which is received by the proposed model and stores them in the data base. Using the data set available, the method computes the time orient utility factor for each region and based on the utility factor the voltage regulation will be performed. The method computes the utility factor using different features like personal, commercial, industrial connections. Also the source of power station is selected based on power flow factor of each power station. The proposed method increases the power utilization and reduces the conduction losses.



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## INTRODUCTION

Data Mining is the process of extracting useful information from large data set or knowledge base. We name the huge volume of customer utility information as electric log which has more information about the usage parameters of electricity. There may be number of area or region under a power station or power generation units. Also there may be number of power generation units around the substation or power regulation station.

The geographic region of any country can be classified into number of categories based on different factors like population, residential units, commercial units and industrial units. Also the power consumption varies between the regions of any country. The power consumption of different regions varies according to the type of region and it varies with time to time.

The power flow factor is the value which represents the consumption of power in volts, which is consumed by any of the region. This can be also named as utility factor of the region which is calculated based on the above mentioned factors of electricity distribution.

The problem of electric conduction is the loss introduced by conduction and switching. The conduction loss is produced by the distance and the conduction material, where the switching loss is produced by inductors and capacitors or any form of electric circuit. The conduction loss is the most affecting factor in electricity distribution where 10 percent of the power supply, has been deprecated by the conduction loss which has to be removed. Basically, this conduction loss is introduced by transferring the power units from longer distance generation units to for away distribution center. In some times, the excess power directed to any particular region will not be utilized and it will be simply conducted through the devices. The consumer does not consume much of the electricity from the large power energy.

In general phenomenon, the usage of electricity varies according to the region, based on the number of residential units, or commercial and industrial units. The residential units can be categorized as three classes like township, village, metropolitan. The usage value of the township residential unit will be less than the other two

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where the metropolitan unit has more usage value. Also based on number of residential points can be used to compute the power flow factor and utility factor. Similarly, the commercial unit of any region has more consumption than the residential units and the same for the industrial sectors. By identifying the most dominating type of units and their number and consumption rate, the utility factor can be generated.

The power utility pattern is one which represents the features of power consumption and shows details about the units consumed, number of each type units, the time value and so on. By generating such pattern, we can identify the most dominating or most consuming region and the time when they consume more and so on.

In this paper the voltage regulation model is discussed which regulates the generated power units to different regions and for each region, the power regulation or source of station is selected using the power flow factor. The proposed model regulates the power supply in such a way to reduce the conduction loss produced by the electric devices.

***Related Works:***

There are few approaches has been discussed for the support of power distribution centers and we discuss few of them here in this section.

Data Mining and Analysis of Tree-Caused Faults in Power Distribution Systems (Le Xu, 2006), four different measures: actual measure, normalized measure, relative measure, and likelihood measure are used to data mine the Duke Energy Distribution Outage Database for meaningful data features and to analyze the characteristics of tree-caused distribution faults.

Data mining techniques application in power distribution utilities (Ramos, S., 2008), presents an electricity medium voltage (MV) consumer characterization framework supported on the data base knowledge discovery process (KDD). Data Mining (DM) techniques are used to discover a set of a MV consumer typical load profile and, therefore, to extract knowledge concerning to the electric energy consumption patterns. In order to form the different customers' classes a hierarchical clustering algorithm is used.

Power Distribution System Fault Diagnosis Using Hybrid Algorithm of Fuzzy Classification and Artificial Immune Systems (Le Xu, Mo-Yuen Chow, 2008), discusses a vital lifeline of the modern society for maintaining adequate and reliable flows of energy, power distribution systems deliver the electricity from high voltage transmission circuits to customers.

Application of Log-Normal Distribution and Data Mining Method in Component Repair Time Calculation of Power System Operation Risk Assessment (Zelei Zhu, Jingyang Zhou, Lijie Chen, 2012), propose a novel probability distribution named‘ log-normal distribution’ for component fault repair time. The shape of probability density of log-normal distribution can describe the distribution characteristics of component fault repair times well. When the history data is limited, it can be used to calculate the instantaneous state probability, the method is simple and easy to use.

Data processing of high-rate low-voltage distribution grid recordings for smart grid monitoring and analysis (Heiko Maaß *et al*., 2015), describe a data processing network for the in-house developed low-voltage, high-rate measurement devices called electrical data recorder (EDR). These capture units are capable of sending the full high-rate acquisition data for permanent storage in a large-scale database. The EDR network is specifically designed to serve for reliable and secured transport of large data, live performance monitoring, and deep data mining.

The above discussed approach suffers with the accuracy of voltage regulation and conduction losses which needs to be improved. By concerning the above mentioned problems, an time orient utility pattern based voltage regulation model has been presented in this paper.

***Time Orient Utility Pattern Based:***
***Voltage Regulation Model:***

The time orient utility pattern based voltage regulation model monitors and collects the power usage at each meter using the transmitter attached with the electric meter. The collected details area stored in the utility log, and from the log the method generates the time orient utility pattern and classifies the customer region into different classes and computes power utility factor and utility pattern to compute the time orient utility factor to regulate the input voltage to different regions of the station. The proposed model has different functional components namely Time orient utility pattern generation, Time orient Utility factor computation, Voltage regulation. We discuss each of the functional components in detail in this section.

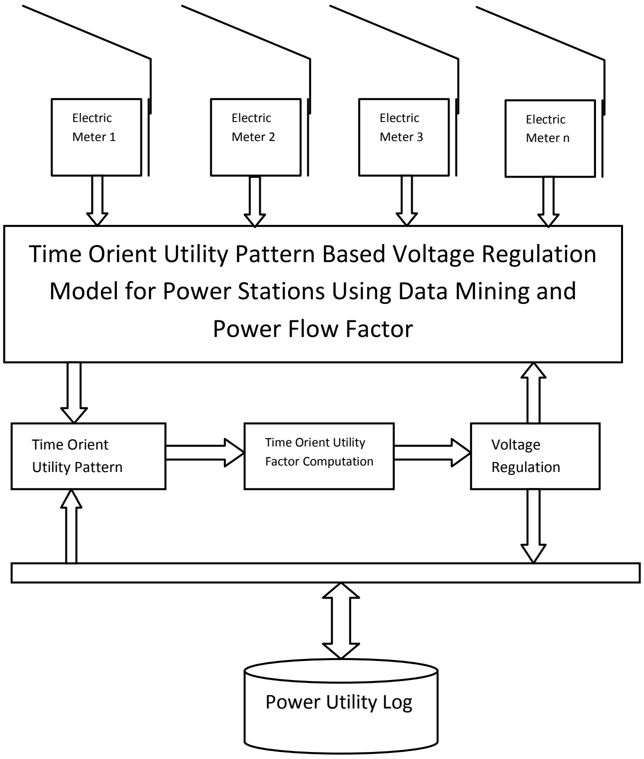



**Fig. 1:** Proposed System Architecture

The Figure 1, shows the architecture of the proposed time orient utility pattern based voltage regulation model and its functional components.

***Time Orient Utility Pattern Generation:***

The method retrieves the utility log from the data base and splits the log into number of time window. Here the time window can be assumed to be an hour, day, month and so on. We consider it by hourly basis time window. The method splits the whole hours into 24 time window and splits the utility log into different time window. For each time window based log Tl, the method identifies the set of all meter id and their type, number of units consumed, the voltage flow at that time through the electric channel. The method extracts the above mentioned features from the log , the method generates the pattern which represent the utility pattern of the particular meter.

Procedure:
Input: Utility Log Ul
Output: Time Orient Utility Pattern set TUPS.
Start
Initialize Utility pattern set TUPS.
Split the time widow Tw into number of small time window $T_i$

$$Ts = f(\sum_{n=1}^{24} Tn)$$

For each time window $T_i$ from Ts
Identify logs generated at time window $T_i$.

$$Tl = \sum_{k=0}^{size(Ul)} \binom{Ti}{k} Ul(k)$$

Identify unique meters from the log Tl
For each log l from Tl
Generate Pattern Pi.
Identify meter id = Tl(i).MeterId
Identify Meter type MT = Tl(i).MType
Number of units consumed Nc = Tl(i).units
Identify voltage flow vf = Tl(i).volts

Pi = {Ti, id, Mt, Nc, vf}.
Add to the pattern set TUPS.
TUPS = ∑(Pk©TUPS)ÚPi
End
End
Stop

The above discussed algorithm generates the time orient utility pattern for each of the consumer meters from the utility log. The generated pattern set will be used to compute the utility factor.

***Time Orient Utility Factor Computation:***

The method computes the utility factor from the pattern set generated in the previous stage. The method computes the total number of meters at each type considered, then the total unit of current consumed is computed. Similarly the same is computed for each type of meters and based on the usage and number of meters of each type of meters, the method computes the utility factor and based on the utility factor, the method classifies the region as residential, commercial, or industrial region. This represents the type of consumer who consumed the power in maximum level at any time window.

Procedure:
Input: Time orient utility pattern set TUPS.
Output: Utility factor set UFS.
Start
For each time window Ti from Tw
Pattern set ps = ∑Pi(TUPS).Tn==Ti
Compute Number of house meters Hm = $\sum_{k=0}^{size(Ps)} Ps(k).metertype == H$
Compute number of units consumed NHUC.
NHUC==
$\sum_{k=0}^{size(Ps)} Ps(k).units \ll (Ps(k).metertype == H)$

Compute Number of commercial meters Cm = $\sum_{k=0}^{size(Ps)} Ps(k).metertype == C$
Compute number of units consumed by commercial units NCUC.
NCUC==
$\sum_{k=0}^{size(Ps)} Ps(k).units \ll (Ps(k).metertype == C)$

Compute Number of Industrial meters Im = $\sum_{k=0}^{size(Ps)} Ps(k).metertype == I$
Compute number of units consumed by industrial meters NIUC.
NIUC==
$\sum_{k=0}^{size(Ps)} Ps(k).units \ll (Ps(k).metertype == I)$

Compute House Utility Factor HUF = $\frac{NHUC}{Hm} \times Ti.volts$
Compute Commercial utility factor CUF = $\frac{NCUC}{Cm} \times Ti.volts$
Compute Industrial Utility Factor IUF = $\frac{NIUC}{Im} \times Ti.volts$
Generate utility factor pattern UFP = {Ti,HUF,CUF,IUF}
Add to utility factor set UFS = $\sum(UFP_i$@UFS)+UFP.
End
Stop

The above discussed algorithm generates the utility factor set which has the set of utility factor values at each time window which is computed using the utility pattern generated in the earlier stage.

***Voltage Regulation:***

The voltage regulation is performed at different times by the controlling stations of power generation units. The power generated from different location has reached set of sub station from where the power supply is exchanged and supplied to different region of the state. In this stage, the method monitors the volts generated by the power units and if there are many power units from where the supply is being received then, it computes the overall power units produced. Once the power units available are computed then, the method computes the power utility factor set and identifies the power utility factor for the current time window. According to the input power supply, the voltage regulator computes the voltage to be regulated to the region using the power flow factor. The power flow factor is higher than any threshold, then the method intimates the other controlling station, to regulate to the region at the particular time window.

```
Procedure:
Input: Utility Log Ul.
Output: null;
Start
While(True)
TUPS = compute time orient utility pattern generation (UL)
UFS = compute time orient utility factor set(TUPS)
Identify the utility factor set belongs to the current time window.
UFI = UFS (Ti).
Read current power flow Cv = Current Voltage.
Compute power flow factor PFF = CV-(Distance×Conduction Loss).
Compute voltage utility Vu = UFI (H) + UFI(C) + UFI (I).
If UFI(H) > (UFI© && UFI(I)) then
Regulated Voltage Supply RVs = UFI (H) +PFF.
If RVS > CV then
Send Vu to neighbor controlling stations.
    end
Elseif UFI© > (UFI(H) && UFI(I)) then
Rvs = UFI©+PFF.
If RVS > CV then
Send Vu to neighbor controlling stations.
    end

Elseif UFI(I) > (UFI(H)  && UFI©) then
Rvs = UFI(I)+PFF.
If RVS > CV then
Send Vu to neighbor controlling stations.
    end
    End
Wait for the next time window Tk.
    End
Stop
```

The above discussed algorithm computes the required voltage supply to the concern region at particular time window and based on that the controller performs voltage regulation. If there is excess voltage that will be redirected to some other power station, which will be used by other station.

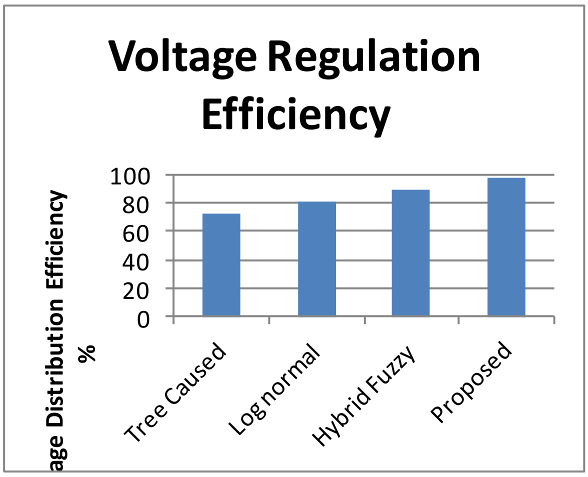
## RESULTS AND DISCUSSION

The proposed voltage regulation model has been implemented and designed to evaluate the performance of the proposed approach. The method has been evaluated with different number of connections and varying number of type of connections. The proposed voltage regulation model has produced efficient results in power utilization and reduces the voltage distribution losses.

**Table 1:** Details of simulation parameters

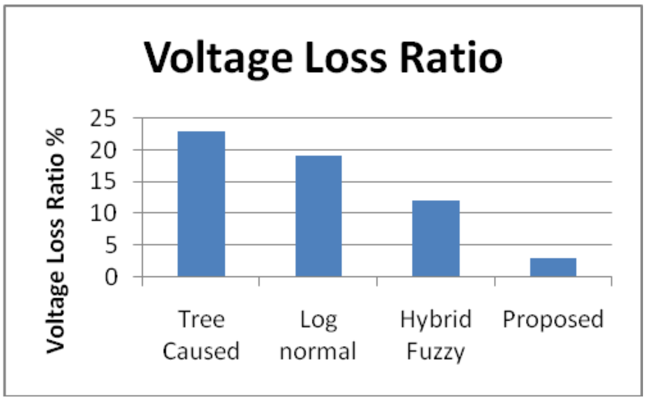
| Parameter Name | Value |
|---|---|
| Number of power generation units | 10 |
| Number of distribution centers | 10 |
| Number of connections | 50000 |
| Type of connections | 3 |

The Table 1, shows the details of parameters used in evaluating the performance of the proposed voltage regulation model.




**Graph 1:** Comparison of voltage regulation efficiency

The Graph1, shows the comparison of voltage regulation efficiency produced by different methods and it shows clearly that the proposed method has produced more voltage distribution efficiency.




**Graph 2:** Comparison of voltage loss ratio

The Graph 2, shows the comparison of voltage loss ratio produced by different methods and it shows clearly that the proposed method has produced less voltage loss than other methods.

***Conclusion:***

We proposed a time orient utility pattern based voltage regulation model which maintains the utility logs of electricity consumers. The method splits the log into different time domain and for each time domain it generates the time orient utility pattern using the details of consumer meter and the number of units being consumed and the overall voltage supply in that channel. Using the utility pattern generated, the method computes the utility factor value for each of the time domain an using the value of utility factor, the voltage regulator computes the regulated voltage supply values using the power flow factor in the channel. The method distributes the voltage in efficient manner and reduces the conduction losses introduced by other methods efficiently.

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