INVESTIGATION OF AVAILABILITY BASED TARIFF- REAL TIME ELECTRICAL GRID PARAMETERS THROUGH DATA MINING METHODOLOGY

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ABSTRACT

Grid indiscipline is the biggest concerns of Power Engineers universally. In the last decade, there was no respect for schedule by generating stations as well as beneficiary SEBs. This gave rise to Poor Frequency regime Low frequency during peak periods, high frequency during off-peak periods. This got rectified with implementation of Availability Based Tariff (ABT) and Deviation Settlement Mechanism (DSM). This paper details study on the real time data of one of the Regional Electrical Grid for the complete data for each time block for the whole year, With the amount of data and analysis parameters involved in actual operation, the is necessity of an automated data mining tool and effectiveness of Weka for assessing improvement by ABT is being assessed. Overall improvement in Grid behavior in terms of maintained frequency and reduced unscheduled power flows is being established.

Keyword: - *Availability Based Tariff, Frequency, Regional Grid, Data Mining, Weka, Pre-processing*

1. INTRODUCTION

In the previous times, India has a huge power shortage (unmet electricity demand), which was retarding the nation's progress. Hence, the nation had to work simultaneously on all fronts to increase the availability of power. The mechanism of Unscheduled Interchange (U.I.), was properly deployed, and helped in bringing more power into the electricity grids, enabling the utilities to meet additional consumer load, both short-term and long-term.

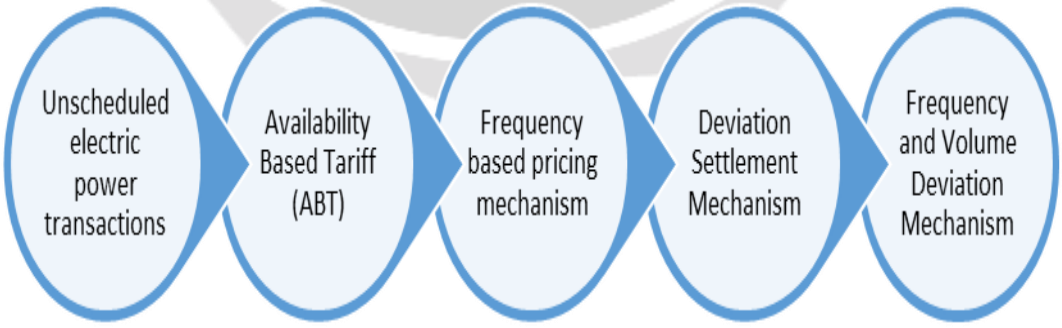


Figure 1: Development of Concept of Availability Based Tariff (ABT) and DSM

Availability Based Tariff (ABT) is a frequency based pricing mechanism applicable in India for unscheduled electric power transactions. The ABT falls under electricity market mechanisms to charge and regulate power to achieve

short term and long term network stability as well as incentives and dis-incentives to grid participants against deviations in committed supplies as the case may be.
UI has generally been known as the third component of the so-called Availability Based Tariff (ABT), which was introduced in India at the regional level in 2002-03. Many have perceived UI only as a disciplining mechanism, whereas it is actually a multi-purpose tool for tackling many of the pressing problems of system operation. Later the same concept was revised to Deviation Settlement Mechanism (DSM). [2], [3]

2. SIGNIFICANCE OF DATA MINING INVESTIGATION

Grid indiscipline is the biggest concerns of Power Engineers universally. In the last decade, there was no respect for schedule by generating stations as well as beneficiary SEBs. This gave rise to Poor Frequency regime Low frequency during peak periods, high frequency during off-peak periods. Perverted incentives in the tariff regime at that time – Recover of capacity charges based on PLF and no differential payment for deviations from schedule. So the analysis of grid becomes very important for evaluation performance. With the amount of data involved in actual operation, there is necessity of an automated tool for analysis. One of such software applications Weka is used here to apply the data mining approach. [1]

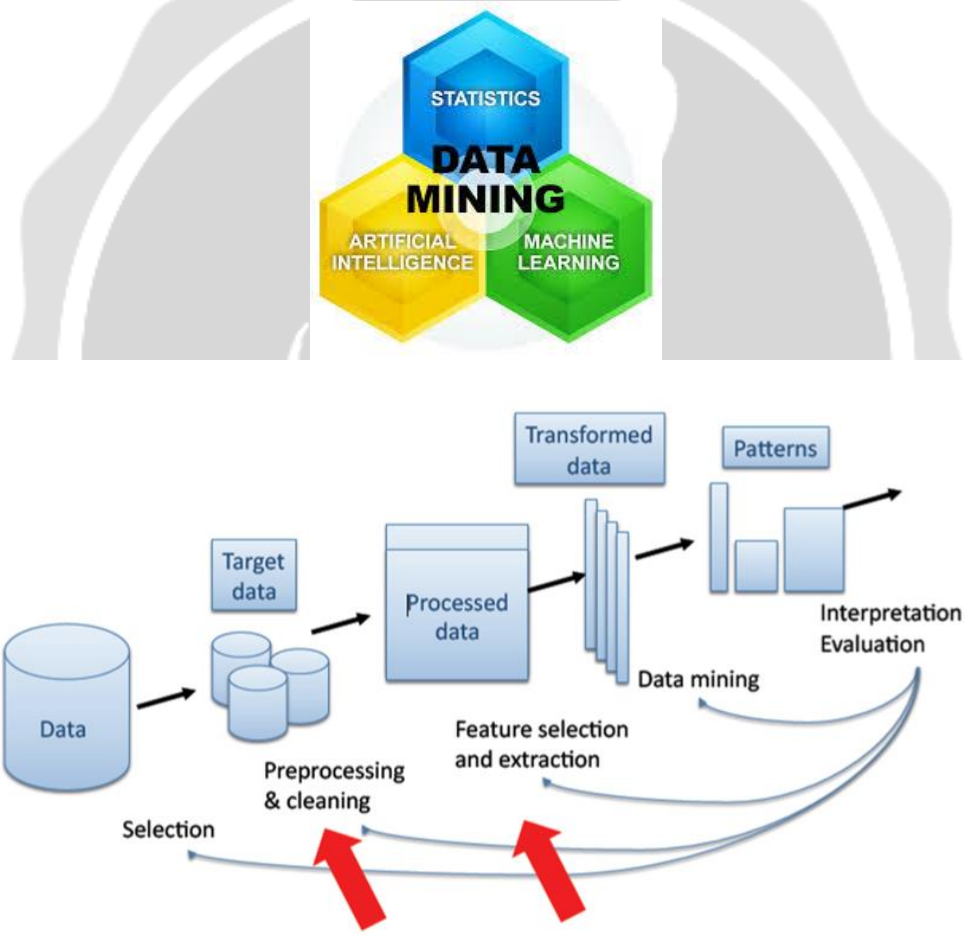


Figure 2: Data Mining Methodology

Weka is a collection of machine learning algorithms for data mining tasks. The algorithms can either be applied directly to a dataset or called from your own Java code. Weka contains tools for data pre-processing, classification, regression, clustering, association rules, and visualization. It is also well-suited for developing new machine learning schemes.

3. TEST MODEL

Here the Western Region of the Indian Electrical Grid network is being taken as the test model.

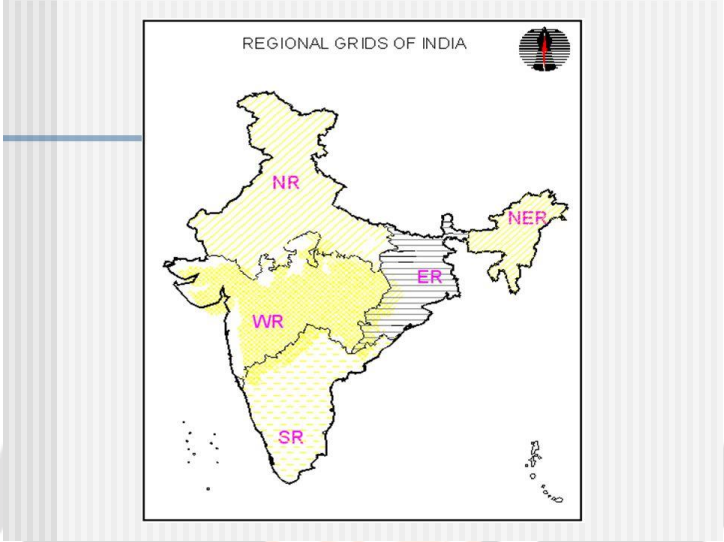
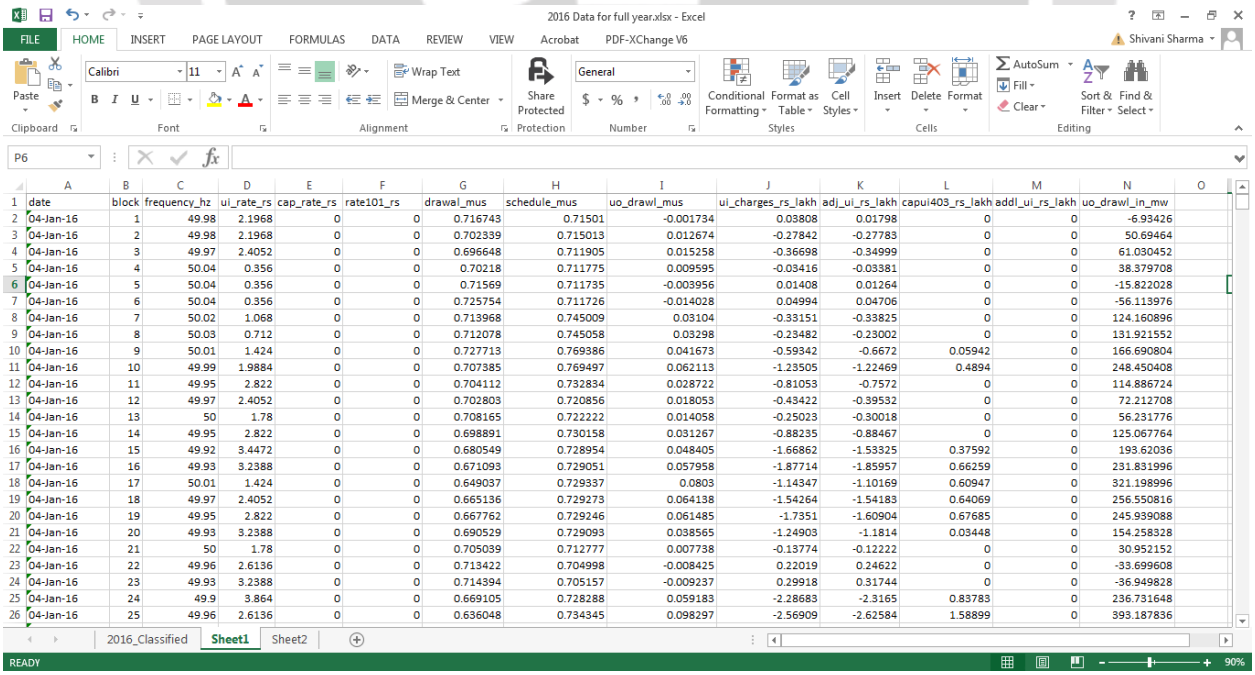


Figure 3: Regional Grids of India

The complete data for the whole year of 2016 is being taken for the analysis. Details like Year, Month, Hour, Frequency (Hz), UI Rate Rs, Cap Rate Rs, Rate101 Rs, Drawal mus, Schedule mus, UO drawl mus, UI charges rs lakh, Adj ui rs lakh, capUI403 rs lakh, addl UI rs lakh, uo drawl in mw, etc is being taken. This has to be converted to a compatible format to analyse in data mining tool Weka. Source of data is from the Regional Pwer flows official database for the bulk import and export of Power and the grid system parameters. Reference as mentioned in [4].



2016 Data for full year.xlsx - Excel

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	date	block	frequency_hz	ui_rate_rs	cap_rate_rs	rate101_rs	drawal_mus	schedule_mus	uo_drawl_mus	ui_charges_rs_lakh	adj_ui_rs_lakh	capui403_rs_lakh	addl_ui_rs_lakh	uo_drawl_in_mw
2	04-Jan-16	1	49.98	2.1968	0	0	0.716743	0.71501	-0.001734	0.03808	0.01798	0	0	-6.93426
3	04-Jan-16	2	49.98	2.1968	0	0	0.702339	0.715013	0.012674	-0.27842	-0.27783	0	0	50.69464
4	04-Jan-16	3	49.97	2.4052	0	0	0.696648	0.711905	0.015258	-0.36698	-0.34999	0	0	61.030452
5	04-Jan-16	4	50.04	0.356	0	0	0.70218	0.711775	0.009595	-0.03416	-0.03381	0	0	38.379708
6	04-Jan-16	5	50.04	0.356	0	0	0.71569	0.711735	-0.003956	0.01408	0.01264	0	0	-15.822028
7	04-Jan-16	6	50.04	0.356	0	0	0.725754	0.711726	-0.014028	0.04994	0.04706	0	0	-56.113976
8	04-Jan-16	7	50.02	1.068	0	0	0.713968	0.745009	0.03104	-0.33151	-0.33825	0	0	124.160896
9	04-Jan-16	8	50.03	0.712	0	0	0.712078	0.745058	0.03298	-0.23482	-0.23002	0	0	131.921552
10	04-Jan-16	9	50.01	1.424	0	0	0.727713	0.769386	0.041673	-0.59342	-0.6672	0.05942	0	166.690804
11	04-Jan-16	10	49.99	1.9884	0	0	0.707385	0.769497	0.062113	-1.23505	-1.22469	0.4894	0	248.450408
12	04-Jan-16	11	49.95	2.822	0	0	0.704112	0.732834	0.028722	-0.81053	-0.7572	0	0	114.886724
13	04-Jan-16	12	49.97	2.4052	0	0	0.702803	0.720856	0.018053	-0.43422	-0.39532	0	0	72.212708
14	04-Jan-16	13	50	1.78	0	0	0.708165	0.722222	0.014058	-0.25023	-0.30018	0	0	56.231776
15	04-Jan-16	14	49.95	2.822	0	0	0.698891	0.730158	0.031267	-0.88235	-0.88467	0	0	125.067764
16	04-Jan-16	15	49.92	3.4472	0	0	0.680549	0.728954	0.048405	-1.66862	-1.53325	0.37592	0	193.62036
17	04-Jan-16	16	49.93	3.2388	0	0	0.671093	0.729051	0.057958	-1.87714	-1.85957	0.66259	0	231.831996
18	04-Jan-16	17	50.01	1.424	0	0	0.649037	0.729337	0.0803	-1.14347	-1.10169	0.60947	0	321.198996
19	04-Jan-16	18	49.97	2.4052	0	0	0.665136	0.729273	0.064138	-1.54264	-1.54183	0.64069	0	256.550816
20	04-Jan-16	19	49.95	2.822	0	0	0.667762	0.729246	0.061485	-1.7351	-1.60904	0.67685	0	245.939088
21	04-Jan-16	20	49.93	3.2388	0	0	0.690529	0.729093	0.038565	-1.24903	-1.1814	0.03448	0	154.258328
22	04-Jan-16	21	50	1.78	0	0	0.705039	0.712777	0.007738	-0.13774	-0.12222	0	0	30.952152
23	04-Jan-16	22	49.96	2.6136	0	0	0.713422	0.704998	-0.008425	0.22019	0.24622	0	0	-33.699608
24	04-Jan-16	23	49.93	3.2388	0	0	0.714394	0.705157	-0.009237	0.29918	0.31744	0	0	-36.949828
25	04-Jan-16	24	49.9	3.864	0	0	0.669105	0.728288	0.059183	-2.28683	-2.3165	0.83783	0	236.731648
26	04-Jan-16	25	49.96	2.6136	0	0	0.636048	0.734345	0.098297	-2.56909	-2.62584	1.58899	0	393.187836

Figure 4: Data for year 2016 selected Regional Grid of India

4. RESULTS AND DISCUSSION

The Data is first extensively processed and cleaned in order to feed it to the Data Mining Software. The results of Classifier output and the various processed data are as in figures below:

```
=== Run information ===

Scheme:       weka.classifiers.bayes.NaiveBayes
Relation:     2016 Data for full year Phase 3
Instances:    8065
Attributes:   15
              Year
              Month
              Hour
              Frequency (Hz)
              UI Rate Rs
              Cap Rate Rs
              Rate101 Rs
              Drawal mus
              Schedule mus
              UO drawl mus
              UI charges rs lakh
              Adj ui rs lakh
              capUI403 rs lakh
              addl UI rs lakh
              uo drawl in mw
Test mode:    10-fold cross-validation

=== Classifier model (full training set) ===

Naive Bayes Classifier
Time taken to build model: 0.04 seconds

=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances        7795               96.6522 %
Incorrectly Classified Instances       270                3.3478 %
Kappa statistic                          0.9334
Mean absolute error                      0.0222
Root mean squared error                  0.1097
Relative absolute error                 10.802  %
Root relative squared error             34.2771 %
Total Number of Instances             8065

=== Detailed Accuracy By Class ===

               TP Rate   FP Rate   Precision   Recall  F-Measure  MCC      ROC Area  PRC Area  Class
               1.000    0.000    1.000      1.000    1.000      1.000    1.000     1.000     0-2.06:1, 2.07-4.12:2, 4.13-6.18:3,
```

```
6.19-11:4
                0.993   0.048   0.927     0.993   0.959     0.934   0.985   0.964   2
                1.000   0.000   1.000     1.000   1.000     1.000   1.000   1.000   1
                0.114   0.004   0.525     0.114   0.187     0.234   0.891   0.220   3
                0.000   0.000   0.000     0.000   0.000    -0.000   0.996   0.158   4
Weighted Avg.   0.967   0.018   0.955     0.967   0.956     0.948   0.991   0.959

=== Confusion Matrix ===

   a    b    c    d    e   <-- classified as
   1    0    0    0    0 |    a = 0-2.06:1, 2.07-4.12:2, 4.13-6.18:3, 6.19-11:4
   0 3050    0   19    1 |    b = 2
   0    0 4713    0    0 |    c = 1
   0  241    0   31    0 |    d = 3
   0    0    0    9    0 |    e = 4
```

Figure 5: Classifier Output information of Weka for test model using Naives Bayes Algorithm

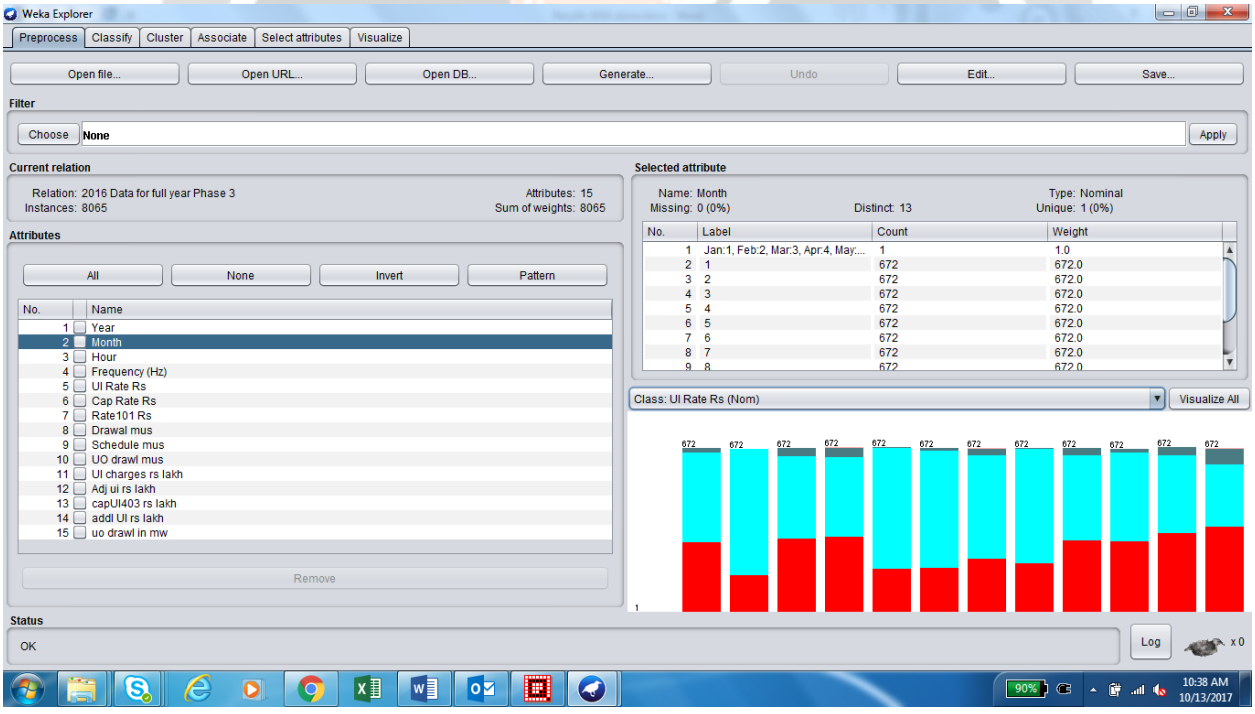


Figure 6: Monthwise variation of UI Rate

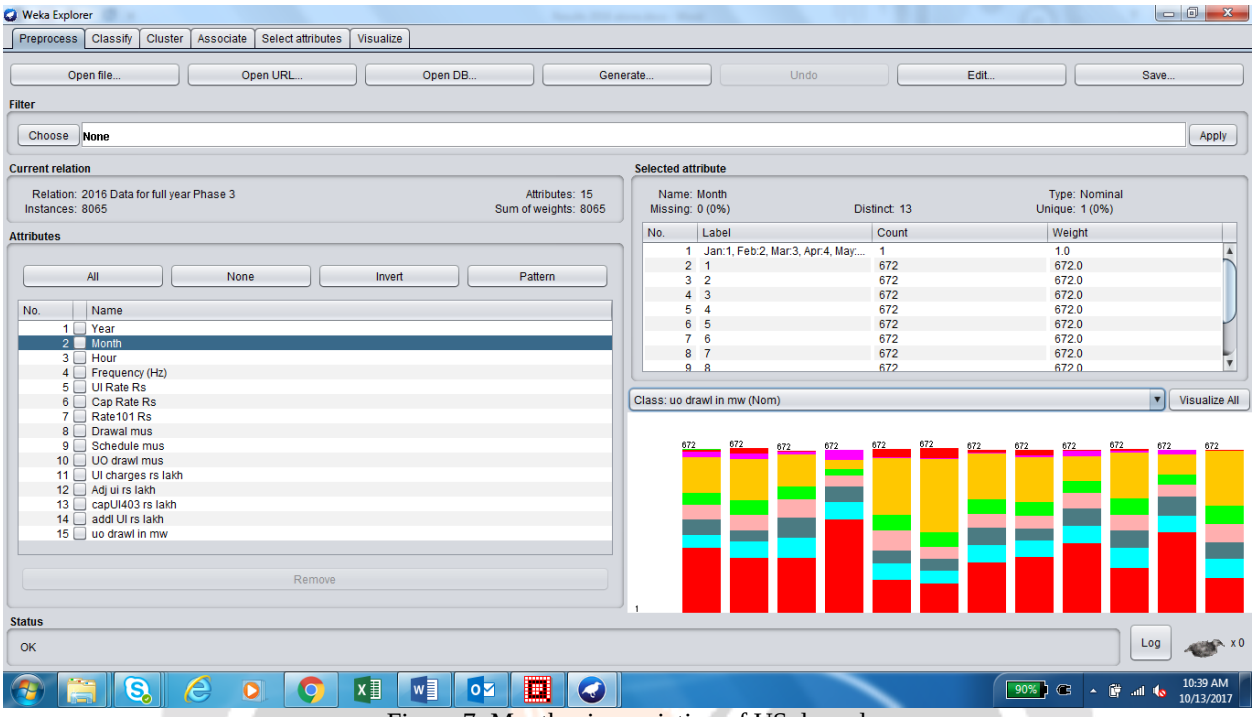


Figure 7: Month wise variation of US drawal

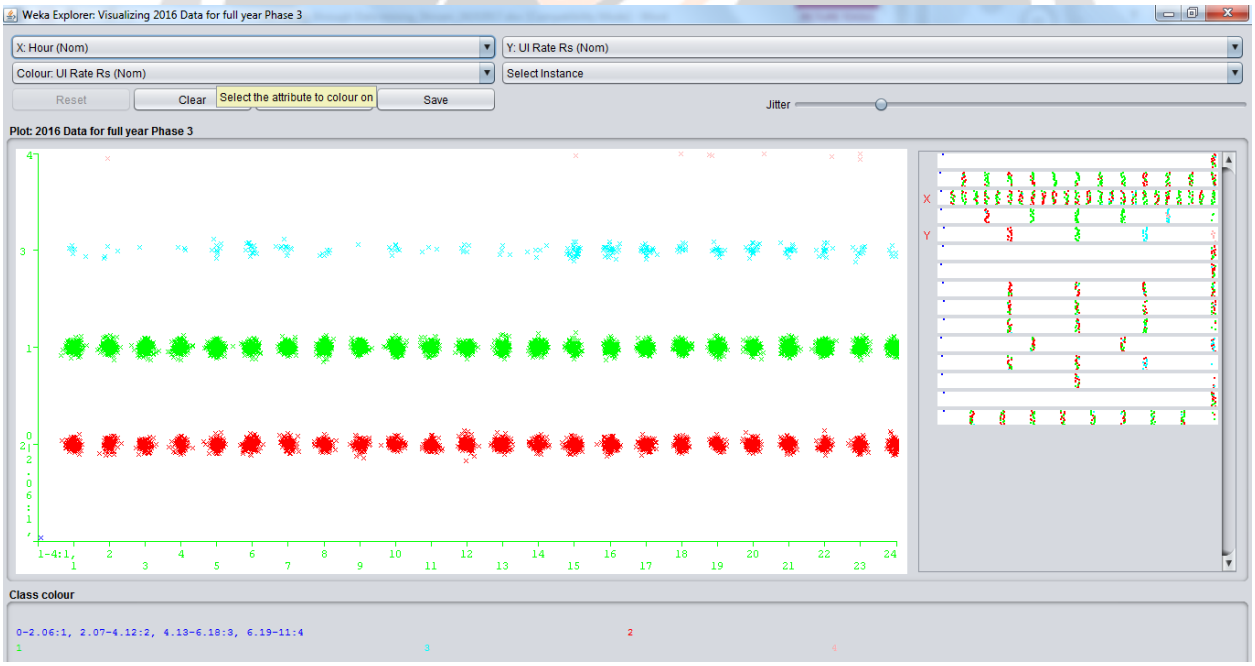


Figure 8: Visualisation of Hourly variation in UI Rate

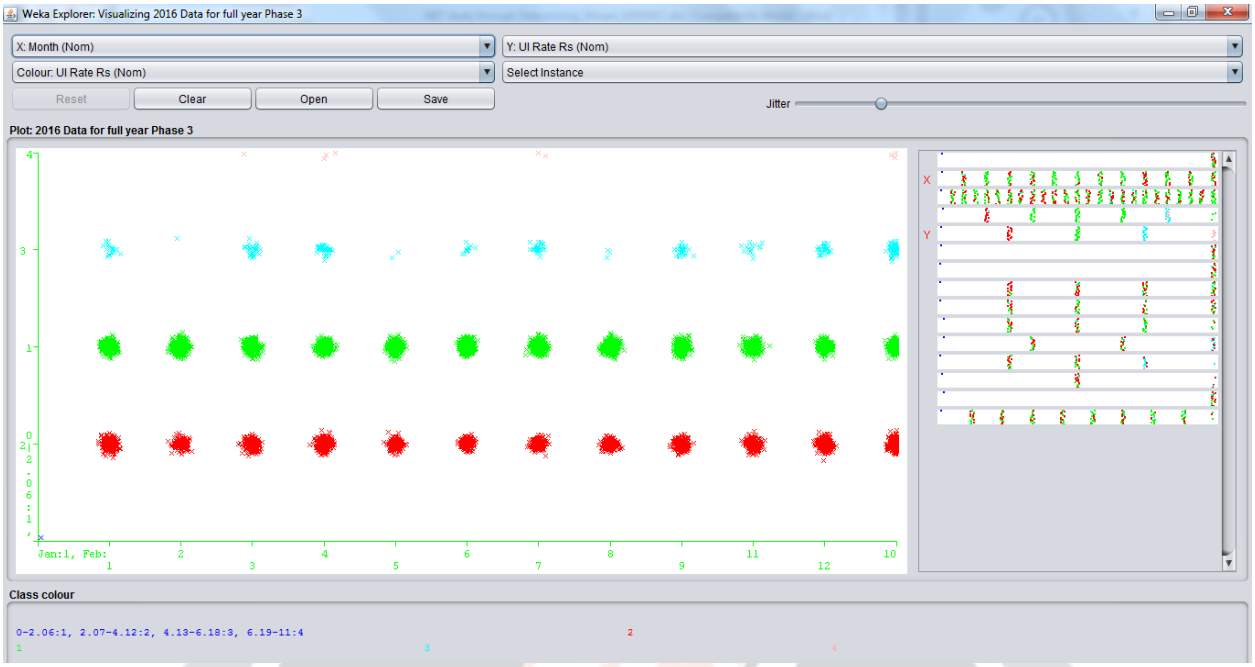


Figure 9: Visualisation of Monthly variation in UI Rate

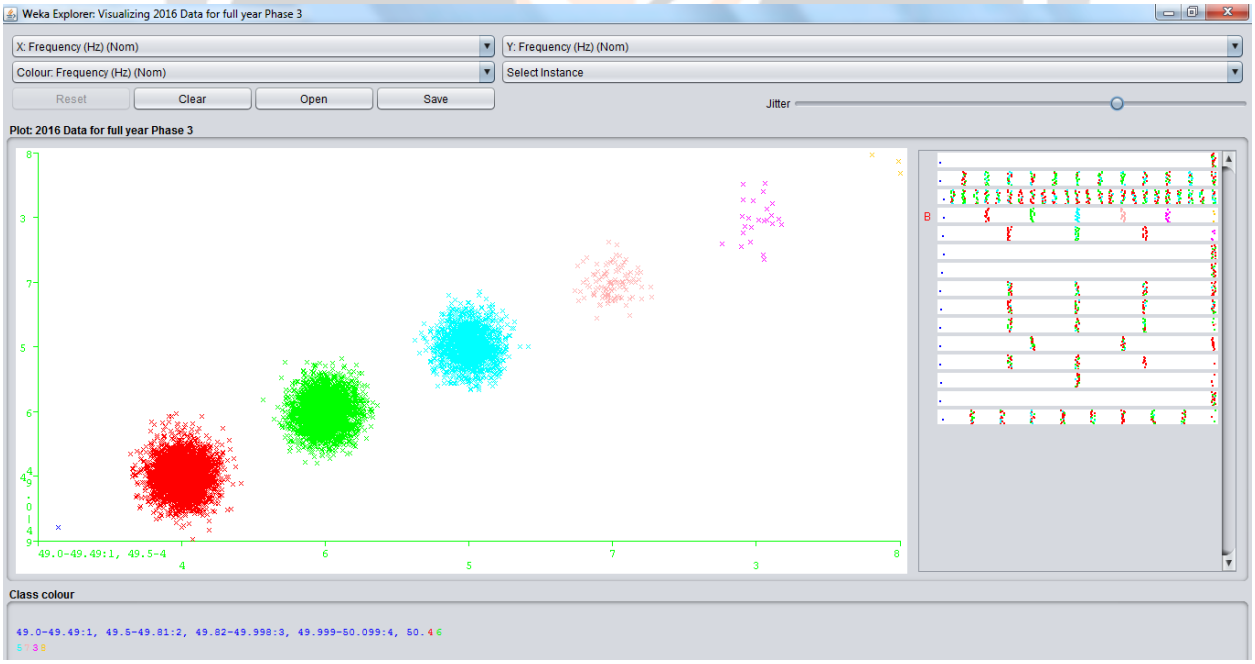


Figure 10: Visualisation of Monthly variation in UI Rate

The self-learning Algorithm Navies Bayes is used for classification. The variation of UI rate and US drawl month wise is as seen from the figure 5. Similarly all other parameters can be studied in details. The seasonal month wise variation results can also be observed from the graph. It can be seen that as the load changes, proportionately the UI rate and the US drawl also changes.

5. CONCLUSION

The analysis shows the investigation of various parameters involved. Especially with the massive data involved, which is for each time block and each hour, of each day of each month, Data mining tool becomes a necessity. All the real time data for 2016 was being classified as per the Naives Bayes Algorithm and the results show the variation of various important parameters like the grid UI rate and US drawal. At the same time Weka data mining helped to converge the solution with excellent speed and accuracy. The algorithm performance is excellent in terms of speed, correctly classified instances and the overall analysis. It can be seen that the unscheduled drawal and UI rate are directly inter related. The last figure shows that the maximum instances i.e. each time block actual readings are in the range near to 50 Hz. Hence, the ability of ABT to control the deviations and hence improve overall availability and stability of Grid is being established.

6. REFERENCES

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