

Smart Meter Data Analytics using Hadoop

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ABSTRACT

Smart meter data analytics contain 15-minute meter data sets that are used to identify possible values comes from the data. A Smart meter records the information that contains the consumption of electric energy in intervals of a short time period. To collect and process the voluminous data is difficult with traditional database system so to solve big data problem Hadoop used. Energy distribution companies can reduce the cost because Hadoop runs on commodity hardware. Meter data analytics helps to detect the missed values in the dataset so predict the accurate result in data set, identify the peak and off peak patterns, and also identify the energy consumption patterns per day, weekly and monthly. All these analyses are done on the dataset that present by the visualization method.

Keywords- Hadoop, Meter Data Analytics, Meter Data Management, Smart Grid, Smart Meter

I. INTRODUCTION

Government and the private sector are investing millions of rupees to build the smart grid infrastructure that saves energy, reduce a cost of the system, and also increase the system reliability [1]. In the year 2012, Ministry of power, government of India selected the 14 smart grid pilot projects. These projects implemented by half of funding done by Ministry of power and other half would be collected from various state utilities [11]. The major advancement in the power system invents the smart grid. In smart grid smart meter play a major role to achieve good efficiency. In the traditional system, old meter collects the data monthly basis but a new smart meter collects the data by the interval of 15 minutes [2]. This short interval data provide more granular detail of energy consumption that's helps to design better planning for a future system. Meter data is used for the monitoring and billing process. Meter data is generated in the type of time series data. The time series data contain the few features [2]:

- The collection of data is in the huge amount of timestamp/ value pair data.
- Time series data is recorded once which is rarely changed and follows the append mode only.
- Data aggregation is provided greater view level of data and according to the requirement of a system. It follows the drill down a process to give a more granular view of data.

As conventional power grids turn into the smart grids, same as traditional electricity consumption measurement done by meter are replaced by smart meters [6]. The benefits of a smart meter are an ability to automatically collect the fine grained consumption data. This help to doing the accurate billing work without sending workers to customer premises to manually read the meters. The data generated by a group of smart meters can be huge because data can be recorded and sent at very small time interval e.g-15 minutes or 30 minutes. Smart meter

data analytics process collected the time series data and processing done on data for taking useful conclusion. Smart meter analytics helps to understand electricity consumption patterns, helping governments and utilities plan for future and reduce the energy consumption bills. Performing analytics on smart meter data by the conventional database is not possible because of voluminous of data and aggregation of data creates a hurdle to processing on it.

The following are the benefits of using smart meter data analytics by the different people [4, 8].

- Electricity providers: According to electricity providers they will identify different types of the consumer and predict future consumption.
- Electricity consultants: According to electricity consultants they will perform virtual audits to understand consumption patterns and finds the ways to save the electricity.
- Electricity consumers: According to electricity consumers they will see the electricity usage information around a small interval and they also obtain the advice how to change the consumption habits to reduce their bills [9].

1.1 BACKGROUND STUDY

As traditional simple analog electro-mechanical meters turn into the smart meters. In a conventional way, the recording, as well as the generation of the electricity bill was done by the manual system. On that time only a final bill at end of certain time period was handled over to the customers and that bill has no details related to usage with respect to time interval but it only carries initial reading and final reading of meter on specific time with the billed amount.

But after the coming of the smart meter in the industry, the way of doing a work is amazingly changed. Traditional database system could not handle such a huge volume of data because smart meter generates the time series data that grows in the direction of horizontal. The data grows rapidly it almost becomes impossible to use the traditional data base to store and process such a data. Traditional system has limitation not only to store the vast amount of data but also not a feature of distributed fault tolerant of the time series data.

1.2 SMART METER DATA ANALYTICS

In India when ever ask for the electricity generation process than their only non-renewable sources come in mind because it fundamentally depends on these resources. In term of these resources India is rich but with the passage of time or by used largely according to demand will depleting these resources at an alarming rate. Some other reasons that also affect on these like a poor metering system, power stealing, not proper planning of usage of energy will not only make poor power grid but also affect largely on the resources. To resolve these issues the government of India has taken many steps to resolve the situation and provide the better and improve the Grid system and also work on Smart Meter concept [1]. The government should try and involves the various IT companies into this problem so that experts from these companies can give the major amendments in this field so that provides valuable insights.

II. IMPLEMENTATION

The system that implemented on smart meter data is providing a result for an electricity provider. Smart meter generates a huge amount of data on a small interval basis. To handle a large amount of data by the traditional system is the difficult task so the solution of this problem solved by the Hadoop [2, 5] concept. Hadoop is open source and works on the distributed computing platform and it runs on commodity hardware. In the implementation phase, Hadoop distributed file system (HDFS) is used for storing the electricity consumption data which includes Date, Time, Active, Reactive, Apparent power, Meter number, voltage level and etc. Map Reduce programming is done on this dataset that generates a key/value pair. In this data format, key/ values are generated from hours and date basis. The results are shown in the form of visualization. NetBeans IDE 8.2 is used and Java language is used for this work.

2.1 HADOOP

We live in the age of big data, where the data volumes arise beyond the storage and processing capabilities of a single host so there are required to work with on a day-to-day basis to solve this problem. Big data comes with facing the two fundamental challenges that are how to store and work with the voluminous amount of data, and how to understand data and turn it into an actionable result. Hadoop provides a solution of the effectively storing and providing computational capabilities for substantial amounts of data. It's a distributed system made up of a distributed file system, and it works on the cluster of machines to parallelize and execute the programs. Most of the areas used Hadoop to address the big data needs like Yahoo!, Facebook, and Twitter.

2.2 A DIFFERENCE BETWEEN TRADITIONAL RDBMS AND HADOOP

After studying the Hadoop than in the mind one question always arises that if there is already traditional system then why to choose this. Sometimes there is confusion that when to choose the traditionally and when to choose Hadoop so all these questions solve by studying the comparison between these two terminologies [2, 10]. Following Table 1 show the comparison between traditional RDBMS and Hadoop system.

Table 1 Comparison of Traditional RDBMS and Hadoop Framework

| Parameters | Traditional RDBMS | Hadoop |
|-----------------|------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Structure | Relational database management | Node based flat structure |
| Access | Used for OLTP processing | Used for analytical and big data processing |
| Storage concept | It is row column database | Hadoop store the data in the file system |
| Storage cost | It is costly to store and process | Hadoop is less costly compared to Traditional system |
| Data size | Deals with the gigabytes | Deals with the petabytes |
| Scalability | RDBMS has scalability issue. Because scale by adding lots of RAM and CPU to a single or set of database servers. | Solve this problem here by adding lower power machines that work in parallel. |

| | | |
|----------------------------|---------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Best situation to used | RDBMS will be more useful when looking for one record from big data | Hadoop will be useful in a case when wanting big data in one short and perform analysis on that later. |
| Deals with | RDBMS used for the transactional system to report and archive the data | Hadoop deals with storage and process a huge volume of data in distributed file system. |
| Language supported | Structured query language (SQL) will be used to extract data that stored in these tables. | Hadoop framework is written in Java |
| Latency | RDBMS can give a very fast response when the data size is ideal | Hadoop is following batch processing and results are only available after a large amount of data has been processed. So Hadoop is not ideal platform when expected for immediate result |
| Throughput | It refers to the amount of the data is processed in the period of time. RDBMS throughput is less. | Hadoop throughput higher than the RDBMS |
| ACID property | It follows ACID property | Hadoop nothing like ACID property exist |
| Manufacturers | Sql Server, MySql, Oracle etc. | Hadoop implementation by Cloudera, Intel, IBM, Amazon, Hortonworks |
| Updates | Read and write many times | Write once and read many times |
| Model Data | It always model the data | It not model the data |
| Storage deployment concept | It follows the centralized concept | It spread data across the servers |
| Velocity | Handles the data that coming in low velocity | Handles the data that coming in high velocity |
| Sources of the data | Data is arriving from 1 or few locations | Data is arriving from the multiple locations |
| Deployment of structure | Deploy in the vertical fashion | Deploy in horizontal fashion |
| Nature of the data | Deals with structured data | Deals with all variety of the data |

III. RESULTS

In this section, it shows the results when applying the Hadoop concept on the database. When runs the smart meter data analytics project than front view of the project is shown in Figure 1. In this view first select the path where the file exists and after select, the file goes to the upload file button. That is automatically uploading the selected file for the system. After this various analysis performs on the dataset that is [3]:

- Missed Status
- Peak-Off Peak Patterns
- Energy Consumption per Day
- Energy Consumption Weekly
- Energy Consumption Monthly

Figure 1 Front end of meter data analytics

3.1 Missed Status

An abnormal or the missing data create a big problem in analytics to perform on the meter data. So it is the first step of analytics is to require the fine grained estimation and validation of the meter data. At this phase identifies those parameters which go wrong at meter cause to reflect the actual usage. It evaluates the quality of the data and generates the estimate that at which instance of time errors, overlaps, redundancies and gaps are exists. Missed status will be calculated by checking the status of the pole in data. To get the result select the range in terms of date and then go to get result button. This status represents in the excel sheet with respect to the Date and hours basis. Figure 2 shows the missed read of the meter on a particular date and hourly basis.

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y |
|----|------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 1 | Date/Hours | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 2 | 06-01-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3 | 13-01-2017 | - | - | - | F | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 4 | 14-01-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 5 | 15-01-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 6 | 16-01-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 7 | 17-01-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 8 | 18-01-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 9 | 19-01-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 10 | 20-01-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 11 | 21-01-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 12 | 22-01-2017 | F | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 13 | 23-01-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 14 | 24-01-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 15 | 25-01-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 16 | 26-01-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 17 | 27-01-2017 | - | - | - | - | - | - | - | - | F | F | F | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 18 | 28-01-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 19 | 29-01-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 20 | 30-01-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 21 | 31-01-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 22 | 01-02-2017 | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F |
| 23 | 02-02-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 24 | 03-02-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 25 | 04-02-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 26 | 05-02-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 27 | 06-02-2017 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 28 | 07-02-2017 | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F |
| 29 | 08-02-2017 | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F |
| 30 | 09-02-2017 | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F | F |

In the excel sheet, 'F' means fail status of poll and '-' shows the ok status of poll

Figure 2 Missed Read on a Particular Day

3.2 Peak-Off Peak Patterns

For making smart grid it is the critical requirement is to flatten the load curve. The benefits to flatten the load curve are cost saving on infrastructure, energy savings due to reducing the grid losses. The consumption pattern of electricity usage has enabled the utility to design the time of the tariff. To get the result select the range according to date after this step it shows the result. Figure 3 shows the peak and off peak patterns of the grid. From a consumer point of view, this study helps to predict at what hour of time energy usages is high. The energy usage is high in the tariff of the day then it will increase the bill to manage this problem by applying fewer loads on that time interval.

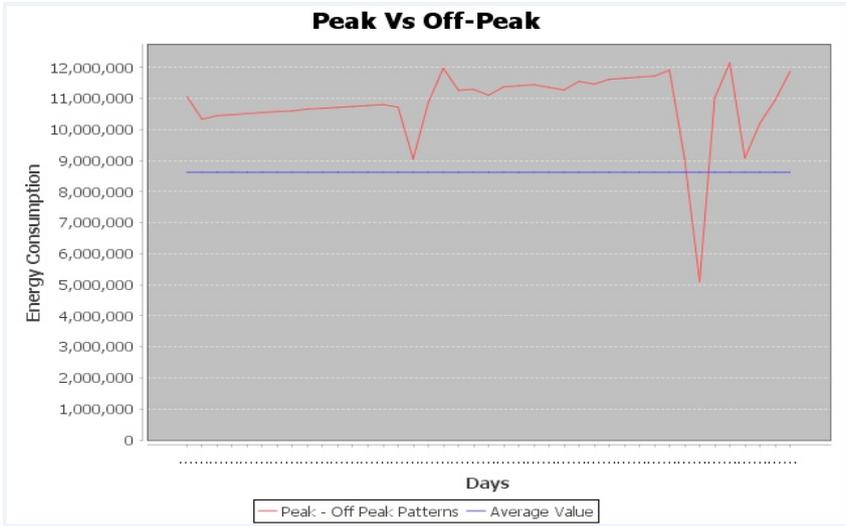


Figure 3 Peak Vs off Peak patterns

3.3 Energy Consumption per Day

The daily energy consumption pattern yields the information such as minimum, average, and maximum energy consumption as well as the change in daily energy usage.

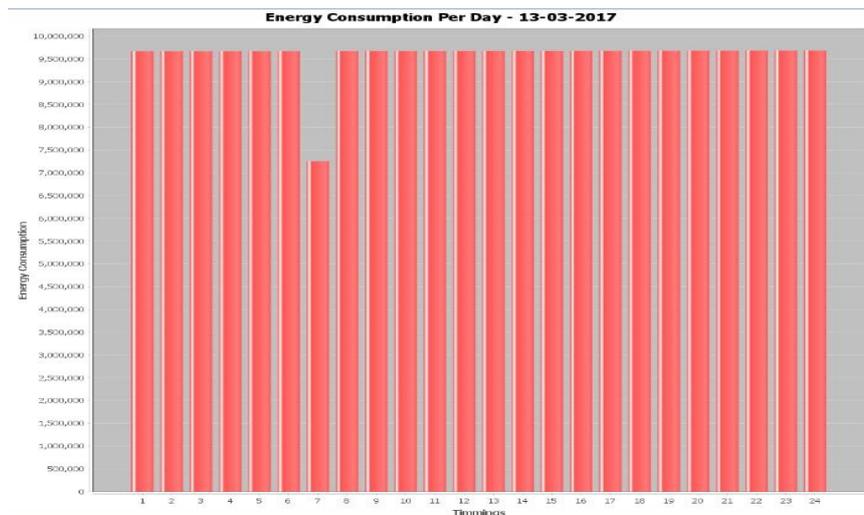


Figure 4 snapshot of daily energy consumption on a day basis

For better energy management this information helps to consumers. To get the result select the date from drop down list. A typical consumption pattern of a consumer on a particular day collected through smart meter shown in below Figure 4. Energy consumption varies daily due to certain reasons like weather changes, occupancy, and different consumer’s consumption behavior toward electricity use [7]. For the customer’s point of view to see the energy consumption on daily basis helps for increasing the security and decreases the energy consumption bill. Daily monitoring helps to consumers have exclusive information about their electricity usage behavior. An abnormal change in consumption pattern will alert to take serious action.

3.4 Energy Consumption Weekly

Further, weekly and monthly analysis of consumer consumption behavior has helped to utilities to identifies the consumption pattern in normal working days and non-working (weekend) and accordingly plan energy requirement for working days and holidays. Figure 5 shows consumption pattern of consumers in that grid during weekly.

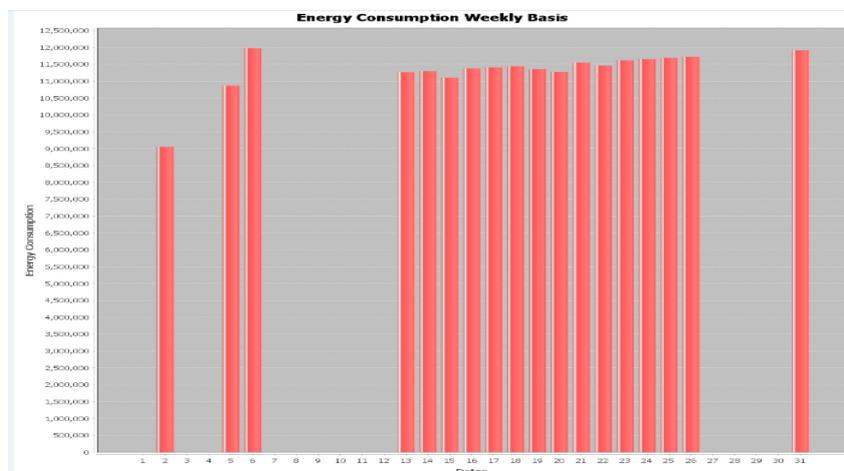


Figure 5 Snapshot of energy consumption on weekly basis

1.5 Energy Consumption Monthly

Traditionally energy meter recorded the energy usage by real power consumption only that means a number in terms of units read at the end of each month for the record of energy consumed

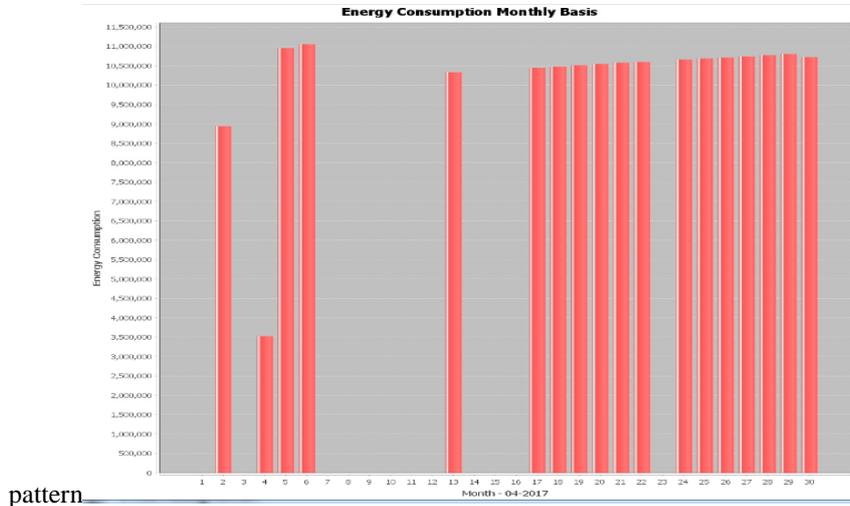


Figure 6 Snapshot of Energy consumption on the monthly basis

This process meter was not read the grained interval data so monthly energy consumption data was provided the few details on consumption [1]. With the advent of the smart meter, it records each type (Real, Active, Apparent Energy/Power) of data at the interval of minutes. Figure 6 represents the energy consumption pattern on monthly basis.

IV. CONCLUSION

Smart grid provides taking control of the electricity used by the consumer will present the new dimensions in the entire electricity system. Smart meter sends the consumption data of individual meter at the small interval of time that is generating big data at the end. To process and store this amount of data is difficult with the traditional database system. A large amount of data is required for accurate results and to process more granular data is required and to overcome the big data problems Hadoop concept is used. The Smart meter helps for planning and meeting the energy requirement of the different users. Data analytics on smart meter data helps the consumers to view their electricity consumption behavior pattern. This process helps to control their energy consumption and optimize to reduce the electricity bill by shifting the load from the day of the tariff to non-peak interval of time.

V. FUTURE WORK

The analysis is performing on the 6-month basis data. The temperature data is also added in the system than it shows the better result to predicting the load profile of the consumers. For the forecasting of the load consumption temperature data will play the important role. The energy consumption is more in summer as compared to winter. So according to usage pattern generate the electricity because energy cannot store or the role of grid operator here is to detect energy demand in advance because if not done the analysis than Blackout

condition will be occurring. In India main problem is to install the smart meter all over the country phase's two problems, first to update the previous meter with smart meter takes a cost and then second internet facility is still not present in most of the rural area.

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