Data Integration in Big Data Environment

B. Arputhamary and L. Arockiam

Abstract--- *Data Integration is the process of transferring the data in source format into the destination format. Many data warehousing and data management approaches has been supported by integration tools for data migration and transportation by using Extract-Transform-Load (ETL) approach. These tools are widely fit for handling large volumes of data and not flexible to handle semi or unstructured data. To overcome these challenges in big data world, programmatically driven parallel techniques such as map-reduce models were introduced. Data Integration as a process is highly cumbersome and iterative especially to add new data sources. The process of adding these new data sources are time consuming which results in delay, loss of data and irrelevance of the data and improper utilization of useful information. Traditionally waterfall approach is used in EDW (Enterprise Data Warehouse), where one cannot move to the next phase before completing the earlier one. This approach has its merits to ensure the right data sources are picked and right data integration processes are developed to sustain the usefulness of EDW. In big data environment, the situation is completely different. Therefore the traditional approaches of integration are inefficient in handling the current situation. So people are expected to do something regarding this issue. In this paper the importance of data integration in Big Data world are identified and the open problems of Big Data Integration are outlined to proceed future research in Big Data environment.*

Keywords--- *Big Data, Bid Data Analytics, Data Integration*

I. INTRODUCTION

THE term 'Big Data' basically derived from the big or large volume of data. There is no proper definition for Big Data. It was defined as a situation where the volume, velocity and variety of data exceed an organization's storage or compute capacity for accurate and timely decision making. Storage of these big data can be done by introducing multiple data centers, where as utilizing these data in an effective manner is a tedious one which is to be considered carefully. Today, organizations invest more in data manipulation and most of the time the stored data are unused and they are not retrieved and utilized in a proper way. Enterprises and

organizations are spending more in data processing. Actually big data is not a problem whereas it is a big asset to the organizations. Data are from different sources and integrating such data is very important and available data warehousing tools are used for doing integration. But in big data environment data from different sources are of different formats and existing data warehousing techniques are inefficient to handle such situation. This paper aims at presenting the issues related to data integration in big data environment and techniques available for Big Data Integration.

II. BACKGROUND

Xin Luna Dong et al.,[9], aims at providing the progress by data integration community on the topics of schema mapping, record linkage and data fusion. The authors have tried to identify the challenges of these areas in big data environment. This paper describes how Big Data Integration differs from data integration with respect to 5 V's. Solution for achieving schema mapping is suggested as Hadoop which is in contrast to the traditional approach define the schema after the data has been stored. For record linkage, the authors have identified that Map Reduce model for handling large volume of data. Clustering techniques were suggested to solve the velocity problems. To address the variety aspect, techniques have been proposed that tag and match free text to structured data. Data fusion is a new field which emerged recently due to veracity. Also this paper is very helpful to find the open problems of data integration in Big Data Environment and the problems are, Integrating Crowd sourcing data, Integrating Data from data markets and providing an exploration tool for data sources. Nikhil Debbarma et al.,[10] made study on the issues related to Data Warehouse in the quality perspective. Data quality plays an important role in Data Warehousing and Data Warehouse plays a vital role to extract right information from the right place at the right time with the right cost, in order to take right decision. This paper has outlined the impacts of poor quality data in decision making and the cost of erroneous data. Completeness, Consistency, Validity, Integrity, Conformity, Accuracy are the important parameters to be considered in data quality. The authors have worked towards the steps on data warehouse extraction, transformation and load they have also identified the quality related problems on ETL process. Data Profiling is the mechanism that has been suggested as a future scope in data warehousing to ensure data quality. Jin Zhou et al.,[12] has considered Internet of Things (IOT) to generate large amounts of multisource, heterogeneous, dynamic and sparse data. To acquire an acceptable quality of intelligence, the authors have decided to combine diverse and voluminous data. The authors have proposed multidimensional fusion algorithm for IOT data,

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based on partitioning. To achieve the main objective, three mechanisms such as finding the core attributes, determining global core attributes from the core attributes and finally attribute reduction based on rule extraction are proposed. Mian Wang et al.,[13], proposed a framework for set similarity join. This approach improves the efficiency by reducing candidate pairs and load balance. The authors have proposed an algorithm to reduce the amount of candidate pairs. Multiple filtering principles such as length filter, Prefix filter and Position filter are used. Load balancing techniques are also used to address the skew data and decrease the replication transfer volume. They proposed a filter framework that combines multiple filter algorithms and uses Map Reduce to process similarity join tasks in parallel. Rashmi Ranjan et al.,[20] have proposed a systematic time series based scheme to assess the demand of the product by tracking its behavior and predict the future response of customers depending on the present dataset as well as historical dataset using Hadoop framework and Holt-Winter prediction function in the R environment. In future by the capturing the sentiments of users about a given product from different social networks, the performance of predictive and sentiment analytics can be improved. The main objective of this research [21] is extracting web content with high volume and heterogeneous information which continues to expand in size and complexity. Existing approaches are proposed based on automatic extraction and hand crafted rule generation. In this research work a hybrid approach is proposed to extract main content from the web pages. Decision tree classification and Naïve Bayes Classification machine learning methods are used for rules generation. The performance of machine learning methods is compared with metrics like precision, recall, f-measure and accuracy. In this paper the authors Umeshwar Dayal et al.,[22] discussed the objectives of Business Intelligence in Data Integration. The objectives are, reducing the latency, Extracting Information from a wider variety of data sources and extending the serial ETL to more general data flows. The research mainly concentrate on proposing a framework by identifying the current requirements of Data Integration, Limitations in current technologies and research challenges in meeting all these requirements. The authors also identified and outlined the future demand on data integration flows.

III. OVERVIEW OF DATA INTEGRATION

The World Wide Web has rich source of voluminous and heterogeneous information which continuous to expand in size and complexity. Many web pages are unstructured and semi structured. Information extraction is first and an important task in data integration process. Data Extraction takes data from source systems and makes it available to the data warehouse. Main objective of this extraction process is to extract right information from the right place at the right time with the right cost to support right decision. Traditionally, data warehouses were used as multidimensional databases to store large amounts of data. The downsides of the data warehouses are ensuring quality of arriving data. Poor data quality results in poor decision making which ultimately results in poor

performance. Completeness, Consistency and Correctness of data supports organizations and is the cornerstone of decision making systems in organizations. Good functioning and efficiency of an organization depends on the quality of the data. Poor data quality decreases customers satisfaction and automatically degrades the performance and decision making ability[4][16].

A. Extract, Transform and Load Process

ETL comes from Data Warehousing and stands for Extract-Transform-Load. ETL performs the process of loading data from the source system to target system. It is converting data of same type or different types to centralized Data Warehouse which is having standard format for all data[5]-[7].

i. Extract

The “Extract” task involves gathering data from external sources that needs to be brought to the required systems and databases. The data might be found in stand-alone databases or spreadsheets that aren’t integrated with any master database. The data might even be hard-copy or could be data that have been purchased from a data provider. The goal of this task is to understand the format of data, assess the overall quality of the data and to extract the data from its source so that it can be manipulated in next task.

ii. Transform

In the “transform” step a variety of software tools and even custom programming are used to manipulate the data so that it integrates with data that is already present.

iii. Load

After the successfully transformation of the source data it is required to physically load it into the target system or database. Before loading the data, it is required to make sure that there is a backup of the current system so that roll back or undo can be initiated in case of failure of the Load process. After loading the data, it’s common to run audit reports so that there can be review of the results of the merged databases and systems to make sure the new data hasn’t caused any errors. The following diagram describes the general steps in traditional data warehousing process[10].

Figure 1: The General Process of ETL

Table I: Data Quality in ETL

Issues in Data Quality during data integration process		
Extract	Transform	Load
Heterogeneous data sources having own storage methods.	Insufficient source data analysis.	Lack of Periodical refreshment of integrated data cause for data quality problems.
Imperfect schema level definition.	Undocumented alterations.	Wrong mapping of data leading to data being erroneous.
Imperfect Instance data.	Unhandled null values in ETL process.	Misinterpreting / wrong implementation of the Slowly Changing Dimensions (SCD) strategy in ETL phase.
Insufficient source data analysis.	Inaccurate conditional statements force the valid data to move to the invalid tables.	Lack of error reporting, validation and metadata updates in ETL process.
Undocumented alterations.		Inappropriate handling of return strategies during ETL process.

IV. QOX METRICS IN DATA INTEGRATION

The followings are the some of the QOX (Quality of Service, Quality of Data, Quality of Information etc.,) metrics in data integration[21],[22].

Reliability: The probability that the ETL process will perform its intended operation during specified time period under given conditions. Any reason for not performing the intended operation is considered to be a failure.

Maintainability: The ability of an ETL process to be operated at the design cost and with service level agreements.

Freshness: The ability of the system to provide the desired latency in updating the data warehouse.

Recoverability: The ability to restore an ETL process to the point at which a failure occurred within a specified time window.

Scalability: The ability of an ETL process to handle higher volumes of data.

Availability: The probability that the ETL process is operational during a specific time period.

Flexibility: The ability to accommodate previously unknown, new or changing requirements.

Robustness: The ability of an ETL process to continue operating well or with minimal harm.

Affordability: The ability to maintain or scale the cost of an ETL process appropriately.

Consistency: The extent to which the data populating the data warehouse is correct and complete.

Traceability: the ability of an ETL process to track the lineage of data and data changes.

Auditability: The ability of an ETL process to protect data privacy and security, and to provide data and business rule transparency.

V. BIG DATA AND ITS CHARACTERISTICS

Big Data means datasets which could not be captured, managed and processes by general computers within an acceptable scope, Apache Hadoop,2014. According to Gartner[18], Big data is defined as high-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision making. The three V's of Big Data are - Volume, Velocity, and Variety. When most people hear the term Big Data, they assume it to be a massive transactional data set. However, volume is only the first dimension of Big Data, and is potentially the least important among all three dimensions [1][15]-[20].

Figure 2: Characteristics of Big Data

- Volume - Volume derives the amount of data from terabytes to Peta bytes.
- Velocity – Velocity represents speed (ie.) Velocity means the rate of change in the data and how fast it must be processed to gain business value.
- Variety - Big Data means much more than traditional RDBMS data. It includes unstructured text, sound and movie files, images, documents, geo-location data, web logs, etc.

Now two V's are added namely Veracity and Variability

- Veracity – Data in doubt or unpredictable data.
- Variability - Semantics or the variability in language [2].

VI. OVERVIEW OF BIG DATA INTEGRATION

Big data integration (BDI) means linking or fusing large volumes of heterogeneous data from many dynamic data sources. The main differences of BDI from traditional Data Integration are [9],

- The number of data sources even for a single domain has grown to be in the tens of thousands.
- Many of the data sources are dynamic.
- The data sources are extremely heterogeneous in their structure.
- The data sources are of widely differing qualities with significant differences in the coverage, accuracy and timeliness of data provided.

The schema mapping, record linkage and data fusion are challenging areas of data integration in Big Data environment. The following figure describes integration techniques in meeting the big data challenges with respect to the 5 V's.

Figure 3: Big Data Integration Challenges and Techniques

The following section describes analysis of different platforms and its advantages in Big Data environment.

VII. PLATFORMS OF BIG DATA ANALYTICS

Big Data analytics means identifying hidden patterns and business information from large amounts of data, to make the business more agile. This data comes from everywhere: social network activity, web server logs, sensors used to gather climate information, stock market data, e-mails, transaction records, web click streams, etc. Analytics is an important task to take right decisions in order to improve the businesses. This section outlines the importance of scalability to extract and analyze data in high volume with heterogeneity. The following table summarizes the platforms for Big Data Analytics under horizontal and vertical scaling [23],[24].

Table II: Big Data Analytics Platforms

Scaling (Ability to extend based on increased demand in terms of information processing)	
Horizontal Scaling / Scale Out	Vertical Scaling / Scale In
<p>(1) Peer-to-Peer Networks:</p> <ul style="list-style-type: none"> Distributed Networks Message Passing Interface (MPI) programming is used to ensure communication. Hierarchical Master / Slave Paradigm Efficient for running Iterative Programs <p>Drawbacks:</p> <ul style="list-style-type: none"> No fault tolerance mechanisms. <p>(2) Apache Hadoop</p> <ul style="list-style-type: none"> Opensource Framework Highly fault tolerant MapReduce Programming model is used Hadoop Distributed File Systems(HDFS), HIVE, HBASE, YARN are important components in Hadoop <p>Drawbacks:</p> <ul style="list-style-type: none"> Inefficient in handling iterative programs <p>(3) Spark</p> <ul style="list-style-type: none"> Next Generation Paradigm Developed by researchers at University of California at Berkley Ability to perform in-memory computations faster than Hadoop MapReduce 	<p>(1) Graphics Processing Units(GPU)</p> <ul style="list-style-type: none"> GPC have more than 2500 processing cores Maximum Memory:12GB Not suitable to handle terabytes of data <p>(2) High Performance Clusters(HPC)</p> <ul style="list-style-type: none"> Machines with thousands of cores. Powerful hardware Optimized for throughput and speed Top quality high end hardware Fault tolerant Deployment cost is very high MPI is the communication scheme <p>(3) Field Programmable Gate Arrays (FPGA)</p> <ul style="list-style-type: none"> One machine having dozens of processing cores <p>(4) Multicore CPU</p> <ul style="list-style-type: none"> One machine having dozens of processing cores Parallelism is the key idea which is achieved through multithreading

VIII. OPEN ISSUES IN BIG DATA TECHNOLOGY

This section describes the possible research directions of big data[1]-[3],[25].

- Format conversion mechanisms are required due to its heterogeneity
- Improving the transfer efficiency (data migration process)
- Computing models to be built to improve the real time performance of Big Data
- Mechanisms are required to process high volumes of data with huge velocity and wide variety.
- Big Data Privacy and Data Quality must be improved at security level
- Mechanisms to integrate different data sources

IX. CONCLUSION

Today data are being generated, collected and analyzed at an unprecedented scale which creates problems in management and manipulation of data. Big Data Integration is the major challenge in Big Data Environment due to its heterogeneity nature. This paper aims at giving the outline of challenges of data integration related to Big Data environment. From the study of Big Data Integration, it is identified as the existing techniques and approaches are inefficient to handle the problems. Therefore a new framework, technique or algorithms can be proposed in future. And also this paper identifies some open problems in big data integration for future research.

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