The Overview of Big Data Storage and Management

Jie Li[3, 1], Zheng Xu[1, 2], Yayun Jiang[1], and Rui Zhang[3]
[1]The Third Research Institute of the Ministry of Public Security
[2]Tsinghua University, Beijing, China
[3]Shanghai University, Shanghai, China
The corresponding author: Zheng Xu, xuzheng@shu.edu.cn

Abstract— **Recent years, data amount is increasing rapidly, indicating that we are in the era of big data, which brings opportunities and challenges. In this paper, we illustrate the big data storage and management status, analyze the problems and finally propose solutions.**

Keywords—big data; storage; management

I. INTRODUCTION (*Heading 1*)

Today, big data is abstracting more and more attentions. With the high development speed of information technology, huge amount of data is producing every minute. Data comes from all industries: internet, network communication, financial, biological and so on, it has become a new and essential factor of production. Along with many opportunities, big data brings new challenges in technology and revolution in many subjects.

Data comes from many sources including mobile devices, network, and cameras and so on. Since 1980, the storage of data doubled every 40 months [1]. As of 2012, every day 2.5 exabytes (2.5×1018) bytes of data were created [2]. And it is predicted that the amount of traffic flowing over the internet will reach 667 exabytes (6.67 ×1020) annually by 2013 [3, 4].

A. Big data

Big data is a broad concept. It is first proposed by the well-known consulting company McKinsey. In 2001, big data is described by META Group (now Gartner) analyst Doug Laney, he defined it as being three-dimensional: Volume (amount of data), Velocity (speed of data in and out), and Variety (range of data types and sources) [5]. The "3V" definition was wildly used by many companies. And then Gartner updated it as "Big data is high volume, high velocity, and/or high variety information assets that require new forms of processing to enable enhanced decision making, insight discovery and process optimization."[6] And later, a new character named "Veracity" was added to it [5].

These days, researches on big data have already covered nearly every area, such as economic productivity, genomics, and biological researches. The processing system of big data can be divided into six parts: Acquisition and pre-processing, storage and management, computing, analyzing and data mining, visualization, privacy and security. In this paper, we mainly discuss the storage and management part.

B. Storage and management of big data

With new technology wildly used in daily life, for example, mobile internet and cameras [11-17], huge amount of data make the traditional data storage and management system collapse. And thus it has driven the storage industry and data management industry to take a new approach to scalable data storage. The new function should be necessary to meet the emerging requirements associated with the growing data volumes and data with all kinds, such as image, text and video.

II. THE DEVELOPMENT OF BIG DATA IN STORAGE AND MANAGEMENT

According to the difference in interfaces and functions, data storage and management applications divide into two main parts: file system and database. As we are in the big data era, the most applicable technologies are: distributed file system, distributed database, access interface and query language.

A. distributed file system

Distributed file system store the data in distributed nodes and devices, the nodes connect by network. Nowadays, the technology of using distributed file system [7,8] to store and manage big data mainly involve following key points:

- High performance management of metadata. In the big data era, there are huge scale of metadata. The storage performance of metadata is the key in the whole distributed file system. Common metadata management can be divided into centralized and distributed management architecture [9]. Centralized management use single metadata server, the advantage is easy to realize, but there exist the possibility that the single node may failure. On the contrary, the distributed metadata server store the data in several nodes, in this way, the bottleneck of the metadata server is solved, and it is scalable, however, it is hard to realize, and raised another problem: how to keep the metadata consistency.

Proc. 2014 IEEE 13th Int'l Conf. on Cognitive Informatics & Cognitive Computing (ICCI*CC'14)
S. Patel, Y. Wang, W. Kinsner, D. Patel, G. Fariello, & L.A. Zadeh (Eds.)
978-1-4799-6081-1/14/$31.00 ©2014 IEEE

- Flexible system expansion. In the big data era, the scale and complexity of data are increasing heavily and quickly. So it is quite essential to expand the system flexible according to the real need. To realize the technology, two problems have to be solved first: how to assign the metadata and migrate it transparent. Besides, the big data storage system is in large scale, node failure rate is high, so the system must be self-management, that is if given data and computing amount, the system must have the ability to estimates the number of nodes needed, and migrate the data between nodes dynamically. Meanwhile, if some nodes are failure, the system can transfer the duplicate data from other node to ensure the system can work normal.
- Optimize storage techniques. While building storage system, based on cost and performance, storage system usually use different classes of memory devices to build it. Because of the large amount of data, storage system which are efficient and reasonable cost will reduce costs while ensuring the performance. For example, if some data are less of use, transferring them to cheap memory devices can leave more space for top data and improve performance.
- Optimization about application and load. Large scale, dynamic and fast processing are characters of big data. Thus, big data require storage system to be high performance and ignore the versatility.
- Optimization on memory devices. With the development of new memory device, devices like flash and PCM are playing a more and more important role in storage devices.

B. Distributed database

In big data era, the changing needs of industry in data management, query and analysis promotes many new technologies. The changing needs mainly include data size growth, increase in throughput, data types increasing and application diversity. The increasing in data types and throughput brings more challenges to the tradition relational database, such as to be more efficient in parallel computing, interconnection agreements, resource management and fault tolerance. What's more, diversity in data types and application accelerate the data systems individuation.

- Relational database.

  This type of database contains NoSQL and NewSQL. NoSQL system tends to increase performance and scalability by reducing the difficulty of ACID transaction semantics approach.

  It usually has several characters: (1) Non-relational data model, for example: key-value storage model. (2) Simple operations such as key-value query scalability, which often does not support complete SQL works. (3) The ability of splitting and coping data in multiple nodes. (4) Making full use of distributed index and memory.

- Analytical database.

  As MapReduce is proposed and popular of Hadoop, several SQL analysis engines focusing on Hadoop has been proposed, the representative system are Hive, HAWQ, Impala and Hadapt.

  Hive is a SQL engine which is based on MapReduce. The basic principle is accepting SQL sentences and analyzing SQL at first. And then transform these SQL sentences into several MapReduce tasks, and realize basic SQL operations through MapReduce. The advantage of Hive is simple and easy to implement, as it use MapReduce frame to handle fault tolerance, resource management and execution. However, it also has some inevitable shortcomings, including lack of support in standard SQL and real-time query and hard to optimize, which makes the resources cannot be fully used and low concurrent throughput.

- HAWQ is a large scale data analysis engine combining Hadoop and SQL. It combines the advantages of Hadoop and MPP large scale database analysis engine, and achieves the combination of HDFS distributed storage and MPP engine. It is well compatible with many BI tools, and support real-time query.
- Impala and Hadapt are both based on Hadoop. Their aim is also to lead MPP technology into Hadoop. However, the technology is not immature.

C. access interface and query language

The access interfaces and query language are dependent on the storage model of the system. Traditional MPP database usually use relational model, and the query language is standard SQL. However, map database has its' own query language, and realizes route query. Based on Hadoop, class database system supply the query language and access interface to their storage model. For example, HBASE uses its' own API to query and modify table which is in the key-value term. HiveQL is the query language of Hive, it is similar to SQL servers for the relational table. Besides, there is pig which is a programing platform for MapReduce.

III. PROBLEMS AND CHALLENGES

These years, the big data industry developed rapidly. It helps people to get more evaluate information and knows better about the world. Although the big data industry has many achievements, problems and challenges still exist.

As for data storage and management, big data brings following three main issues.

- Huge scale storage, usually reaches PB grade (1000TB) ,sometimes even EB grade (1000PB) .
- Complex in management, the data are usually in different types, structured data, unstructured data and semistructured data, so it is hard to manage the data.
- Data services call for high level data storage management.

Applications have high requirement on data storage management performance and reliability. These challenge are not new problems in data storage, however the features of big data is large scale and high complexity make it more difficult to reach the technical level.

Big data storage and management software needs to provide high performance data access interface, because the data scale is PB grade and even EB grade, besides it need to complete the data access in short response time, and ensure the correctness and availability of the data. For the underlying devices, the software should manage the data resources adequately and efficiently. Under the challenges that the big data brings, there need to be more research on big data storage and management technology [10].

IV. SOLUTION

As for the problems and challenges proposed, there are several solutions.

A. Imporve index of the big data and query technology in distributed system

Index and query technology is the most important entrance of the data processing system. With the rapid growth of data volume, velocity and variety, to use index and query technology as a main entrance of big data becomes very essential.

The significant challenge that big data bring is huge scale of data, a single node cannot handle this order of magnitude data efficiently. Besides, the amount of data is growing fast, which requires the system to handle not only the existing data but also the newly generated data. These features promote us to develop new index and query language in distributed system in the big data era.

(1) Break through the bottle neck before.

Distribution is a basic method to handle big data. Distributed index is to split all index data to several nodes. There are two advantages, on the one hand, this function make it possible to store huge index data, while one node cannot. On the other hand, it can break through the bottle neck of one single node and be more efficient.

(2) Easy to expand to fulfill the huge scale of data in the future.

The greatest feature of a distributed system is easy to expand. When the amount of data increase and the storage system is over load, only need to add more nodes into the system. For the whole system, there is little to modify. However, for the single node, if over load, the only way to fix it is to replace hard disk to hold the data which is limited.

(3) Security.

For single node, if there it is down, the data may lost and the system cannot operate. This problem is fixed in the distributed system, there are more than one node, and it usually use mirror to save multiple copy on other node, so if one node is down, the system can migrate the task of the node to other node and use the copy to compute to keep itself operate normal.

B. Storage and process of real-time and streaming big data

With the increase in the amount of data, more attention are driven by the velocity of big data. Questions and problems that are needed to solve several days before, now the expected time is minutes even seconds. In this case, real time data stream storage and management technology become a hot issue. Besides many similarities with distributed system in principle, it does has some unique requires.

Real-time data stream process system include real-time storage and real-time computation. Data stream storage means to store data stream to database and data repository. And the computation is to compute and analyze the data stream fast.

Real-time data stream process contains four features.

(1) Load the data stream. In real-time data stream system, data are usually in the form of data streams when enter into the system. How to load the data into the storage system efficiently and reliable is the foundation of reducing the delay.

(2) Complex Event Processing. The data sources and the data types are in all kinds, and data format, filtering and processing logic different a lot, thus a flexible and stable complex event process engine is needed to fit all kinds of scenes.

(3) Stable. In the process, data stream may need to come across many complex calculation and nodes. Mistake may make in any step, so in order to keep the data stream stable and move normal, the system need to be able to handle fault tolerant.

(4) Data stream control and cache. The system has multiple process modules. The process ability and throughout capacity are different greatly among modules. So as to achieve efficient data process, the system need to have the ability to control stream, add and delete nodes dynamically. Besides, when the speed data stream flow into the system is greater than the data stream flow off the system, then the system is required to be able to cache data.

Nowadays, some real-time process technology have already realized, their focus is different from each other. For example, Flume, Scribe, Kafka and Sqoop are mainly focus on data transfer technology. On the other hand, storm, S4, Spark are computing frame. However, there is still many problems of big data real-time storage and process need to research.

CONCLUTION

In the big data era, people are facing many opportunities and challenges. In this paper, we analyze the storage and management problem in the era of big data, and proposed some solutions.

Acknowledgment: This work was supported in part by the National Science and Technology Major Project under Grant 2013ZX01033002-003, in part by the National High Technology Research and Development Program of China (863 Program) under Grant 2013AA014601, 2013AA014603, in part by National Key Technology Support Program under Grant 2012BAH07B01, in part by the National Science Foundation of China under Grant 61300202, and in part by the Science Foundation of Shanghai under Grant 13ZR1452900.

REFERENCES

[1] Hilbert, Martin; López, Priscila. "The World's Technological Capacity to Store", Communicate, and Compute Information. Science.2011, 332(6025):60-65.

[2] "IBM What is big data? — Bringing big data to the enterprise". www.ibm.com.

[3] Spence D. Data, data everywhere[J]. BMJ (Clinical research ed.), 2012, 346: f725-f725.

[4] Jacobs A. The pathologies of big data[J]. Communications of the ACM, 2009, 52(8): 36-44.

[5] http://en.wikipedia.org/wiki/Big_data

[6] Manyika, James, Big Data: The next frontier for innovation, competition, and productivity. McKinsey Global Institute, 2011.

[7] Sagiroglu S, Sinanc D. Big data: A review[C]//Collaboration Technologies and Systems (CTS), 2013 International Conference on. IEEE, 2013: 42-47.

[8] Song Y, Alatorre G, Mandagere N, et al. Storage Mining: Where IT Management Meets Big Data Analytics[C]//Big Data (BigData Congress), 2013 IEEE International Congress on. IEEE, 2013: 421-422.

[9] YuanZhuo Wang, XiaoLong Jin. "Network big data: Present and future".Chines Journal of Computers[J] . 2013,36(6):1-15.

[10] Weil, S.A., Brandt, S.A., Miller, E.L., Long, D.D.E., Maltzahn, C.. Ceph: A scalable, high-performance distributed file system. In Proceedings of the 7th Symp.on Operating Systems Design and Implementation(OSDI). 2006:307-320.

[11] D. Yuan, Y. Yang, X. Liu, W. Li, L. Cui, M. Xu, and J. Chen. A highly practical approach towards achieving minimum datasets storage cost in the cloud. IEEE Transactions on Parallel and Distributed Systems, 24(6):1234-1244, 2013.

[12] Y. Liu, M. Ni, and C. Hu. A Generalized Probabilistic Topology Control for Wireless Sensor Networks. IEEE Journal on Selected Areas in Communications, 30(9): 1780-1788, 2012.

[13] C. Hu, Z. Xu et al. Semantic Link Network based Model for Organizing Multimedia Big Data. IEEE Transactions on Emerging Topics in Computing, DOI:10.1109/TETC.2014.2316525.

[14] Y. Liu, Y. Zhu, Lionel M. Ni, and G. Xue. A Reliability-Oriented Transmission Service in Wireless Sensor Networks. IEEE Transactions on Parallel and Distributed Systems, 22(12): 2100-2107, 2011.

[15] Y. Liu, Q. Zhang, and Lionel M. Ni. Opportunity-Based Topology Control in Wireless Sensor Networks. IEEE Transactions on Parallel and Distributed Systems, 21(3): 405-416, 2010.

[16] Z. Xu, et al. Knowle: a Semantic Link Network based System for Organizing Large Scale Online News Events. Future Generation Computer Systems, DOI:10.1016/j.future.2014.04.002.

[17] [23] Z. Xu, X. Luo, S. Zhang, X. Wei, L. Mei, and C. Hu. Mining Temporal Explicit and Implicit Semantic Relations between Entities using Web Search Engines. Future Generation Computer Systems, DOI:10.1016/J.future.2013.9.027.