

# The Research and Application of a Big Data Storage Model

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## Abstract

*In the big data environment, there are many new demands with data storage, the traditional data storage mode which based on relational database cannot meet these needs, many application systems tend to use NoSQL to solve the problem of big data storage. However, NoSQL gave up on the relationship between operation support, so that part of existing application system is difficult to use the simple way of transplantation. This thesis with reference to some typical existing big data storage scheme, we presents a big data compatible with relational storage model storage scheme, this scheme can not only meet the big data storage requirements, but also can support the most relational operation, so that the original system based on relational database can easily be ported to new storage schemes in.*

**Keywords:** Database, Big Data, Relational Data Storage Model, Object-Oriented

## 1. Introduction

With the development of information technology and personal computing devices, the whole world of data showing explosive growth, the huge amount of data, available from a variety of sources, different forms, the rapid growth of the data, it puts forward new requirements to the data capture, storage, query, sharing, analysis, display etc.. Since the global well-known consulting company McKinsey released in 2011 big data report, big data become a hot topic in computer science research.

Big data refers to the rapid growth and is difficult to be ordinary data management software to capture, store, query, sharing, analysis, display data sets within the tolerable range of time. Big data is a concept of qualitative, need to be analysed from its characteristics, generally big data with a big amount of data, complex structure, high real-time performance, low density of four characteristic value, which can be concluded as "four V", namely Volume, Variety, Velocity, Value.

According to McKinsey estimates, in 2010, the global enterprise CO produced and 7EB data storage, and individual users through personal computing devices to store 6EB data, the IDC of the digital universe report more is expected in the next ten years, global data usage will increase 44 times, up to 35.2ZB. The sensor, the transaction log, navigation every moment to produce large amounts of data, the data quantity of the data up to the number of TB is the number of EB. It is worth noting that a large amount of data is a relative concept, with time, field and hardware conditions, its size will be different, as defined in the Mike2.0 on big data, even a small amount of data presented big scene.

The diversity of data sources leads to the complexity of its structure, network log, video, pictures, geographical location can be as big data sources, most of them are semi-structured or unstructured data. Big data is generated in real time, the requirements of data management tools for real-time analysis of the data, and get the conclusion in real time. IBM survey of global CIO from the side to show that an

important aspect of today's enterprise competitiveness is the ability to perform real-time analysis of a large number of data collection, and gain enlightenment.

The fourth characteristic of big data is its value density is low. Compared with the traditional business data, the magnitude of value of unit of large volume data is often low, can create value data are often only a small part of all the data in. To find useful information in the data and use them, it is an important aspect of big data processing.

The value generally of big data is relatively low, because compared to the traditional data, big data processing is more concerned in the traditional data management methods easy to be ignored or cannot process the portion of the data, this does not mean that the high value of data quantity is low, when there is enough data, big data will be the competitiveness of enterprises an important part, and create great value.

Based on big data, enterprises can gain on the product, user behavior, trends and other aspects of a more complete, accurate view, so as to provide decision support to improve the quality and efficiency of its products or services, and even generate new business model. Big data is not provided by the data itself, but rather a through the existing business more thoroughly and more accurate understanding, get more potential value opportunity.

McKinsey pointed out that data as an important aspect of the production factors in research report, and it has penetrated into every industry and related fields, attention and active use of massive data, it indicates that the productivity of enterprise and user amount of consumption will be a qualitative growth. According to McKinsey estimates that only the United States medical and health field, the potential value of each year brought by big data up to \$three hundred billion. In the age of big data, data is the capital.

Although big data contains great value, but value of the data density, resulted only in the presence of enough data, and capable of handling of these data, we can really find and exploit the value. The door to embrace big data mainly from two aspects, from the business perspective, the need for adequate amount of data, from a technical point of view, there is need to analyze these data tools and talent. The traditional data management model to relational data as the representative of the big data management has been unable to meet the demand, and thus requires the use of more flexible, more efficient data storage model and processing method.

## 2. Related Research

Since the IBM researcher Edgar Frank Codd (article collectively referred to as Codd) has been proposed in 1970 the relational model relational database, relational database has become the leading database system. Although in the data environment to show its limitations, but the relationship database still showed a strong vitality, plays an irreplaceable role in data engineering.

In fact, most of today's relational database management systems are not fully support the Codd rules, such as the vast majority of relational database can not realize the logic layer and application layer independent (Rule 9). The database relations mentioned in this thesis, is not required to meet completely the rules of Codd, and the attention and base on satisfying most relational operations, to achieve compatibility of the existing system.

Along with the research and application of large data constantly, NoSQL is gradually emerging from the relational database can not match advantage. NoSQL as a solution of large data problems, widely used.

NoSQL as a mainstream solution for large data storage and processing, research and Study on a deeper, have important reference significance to the design of the scheme. There is a big difference in different storage model of NoSQL treatment on

large data, simply discusses the principle of NoSQL has no meaning, and respond to specific targeted research on NoSQL database.

NoSQL is often classified according to the storage model, the existence of multiple partition granularity.

## 2.1 Generalized Column Model: BigTable

BigTable is a distributed database Google began a applicable time-consuming eight months developed widely, scalable, high performance and high availability since 2004, published since 2006 Google classic paper "Bigtable: A Distributed Storage System for Structured Data", the thought of designing the database was quickly recognized the industry, and the emergence of a plurality of derivative version, such as HBase, Cassandra, HyperTable etc..

Look from the concept, BigTable is a extremely sparse 3D table, which is why the BigTable name. Among them, the column is organized according to column family way, column free extensions allow family, tribe and the column name column combination, as the column labeled (Column Key).

In fact, the BigTable data is stored in sparse mode, the data can be labeled as three element mapping: (Row Key, Column Key, Timestamp) -> Data, which Row Key and Column Key are capable of sorting strings, byte sequence data with can't segmentation view. BigTable data can be configured according to keep multiple versions of history, taking Timestamp as the distinction.

BigTable data segmentation according to Row Key, line sequence similar Row Key bytes into a group, called the tablet. Tablet segmentation (metadata) according to the three dimensional index structure to organize, store and GFS. The Table data stored in the form of SSTable file in GFS. SSTable is a mapping file is not variable format, according to Row Key and Column Key, to index data.

In data storage, BigTable into the group of columns, each column group comprises one or a plurality of column families, different group of columns of data are stored in different SSTable files, visible BigTable data is stored in a group of columns, BigTable compression algorithm allows the user to configure each column groups, so as to improve the compression efficiency.

BigTable uses a client server architecture, the existence of a master with multiple tablet server. The master is responsible for the tablet server state maintenance, tablet distribution, load balancing, garbage collection work, tablet server is responsible for tablet read and write work. Tablet and tablet server are among the many to one relationship, the distribution of work done by master.

The working process of Tablet server master is not needed for management, master can automatically collect tablet server information, and according to the metadata reduction of tablet distribution state, so the master can be closed at any time to restart. This makes the availability of the BigTable not reduced because of its use of single master master-slave structure. At the same time, because the log and SSTable were present in GFS, the tablet server state is recoverable, making the system operation process can directly add or remove tablet server. Master according to the tablet server state redistribution of tablet, and to achieve load balancing.

The BigTable client can automatically according to metadata positioning tablet, and directly with the tablet server communications, the process is hardly interact with the master, so the master load is very low, will not become a performance bottleneck, tablet and server clusters can be amplified, can achieve high concurrent read and write operations.

## 2.2 Key-Value Model: Amazon Dynamo

Amazon Dynamo is a fully managed, it can provide fast, and its performance can be expected, seamless extension of database services, it uses the Key-Value memory model, all data is represented in the Key -> Value mapping, in which Value was used as a binary sequence, support any format, the size of the data. Amazon Dynamo only provides for a single key data read and write operations, for a plurality of key value of the data operation is not supported, so it does not support the relational operation.

The premise of the Dynamo using this model, the majority of the Amazon service, only using the primary key of the data read and write operations. Because the data model of the database is simple, almost do not need to carry on modeling to data before use, simplifies the design process, Value support large data storage, can use a tool to deserialize for other structured data, enhancing the using range of database.

Simple data model to the Dynamo database engine is simple, the design and implementation of Dynamo on the primary goal is to achieve high availability, performance and scalability can be expected, the key technologies including data segmentation technology, copying technology, version control technology, error handling technique etc..

Dynamo MD5 algorithm to calculate the 128 mark in the mapping of Key-Value Key, as the basis of data segmentation. In the data segmentation process, in order to ensure seamless expansion capacity of distributed systems, Dynamo uses consistent hashing as segmentation algorithm. Consistent hashing enables the add or remove a single node, keep the mapping relationship between most of the nodes and data nodes, so that the impact of change on the segmentation process as low as possible, is the foundation of Dynamo system performance can be expected expansion.

Dynamo preclude the use of a special replication technology will be several copies of each data replication, the replication process is also based on the results of consistent hashing, each node only needs to store data which they are responsible, even before the data storage nodes K (K configurable). The main objective is to achieve Dynamo replication availability rather than consistency, the data read operation only on a subset of nodes is completed, the quantity can be configured to allow users to make a trade-off between usability and consistency.

In the system architecture, Dynamo preclude the use of P2P architecture, all nodes are equal, each node is connected to other nodes through a certain way, the calculated data storage location. Because all nodes can receive all the key of read and write operations, the user read and write requests may go through the transfer.

## 2.3 Document Storage Model: MongoDB

MongoDB is IOgen developed a document data storage system in 2007, which preclude the use of the data structure is very loose.

In MongoDB, use the collection (collection) instead of the table, called the document element of the collection, use BSON (Binary Serialized dOCUMENT Format) document structure format. BSON is a JSON document structure similar to a BSON object is some combination of key-value mapping, which is a string key, value can be of any type, including BSON object itself, so BSON document is a tree structure, MongoDB, this tree does not require a pre-defined data model, you can freely bifurcation, it is possible to support flexible complex data types.

MongoDB supports a powerful query language, query results returned to the BSON document, but the query conditions can be accurate to every part of the document tree. In order to improve the query efficiency, MongoDB can be indexed for any key in the document tree. MongoDB also support the establishment of a unique index, and achieve the integrity constraints.

MongoDB supports master-slave replication read and write separate, providing high availability and reliability for. At the same time, MongoDB supports data segmentation scheme is transparent, the user (application developer) can choose any key as the segmentation standard, segmentation according to the sections, and distributed storage in different host, in order to achieve parallel processing and balanced load.

In order to improve write performance, isolation of MongoDB by default does not provide the transaction, in order to realize the process of atomic transaction, you need to explicitly configure, MongoDB provides a special update mode, in the update execution before check whether the data has changed, if the change is not to perform the update operation, the application can achieve a simple by the way of transaction control.

### 3. Proposed Scheme

#### 3.1 Sub-problem I Research and Design: Unstructured Data Storage

Unstructured data refers to no formal predefined structure data, such as text, image, sound, video and etc.. Unstructured data is a kind of very important data, the survey shows that the data in the universe, 95% data belongs to a non structured data, more than 80% of the data belongs to a non structured data and organization.

For the non structure data, need to understand from a deeper level. In fact, unstructured data purely is not exist, which is the basis of computer processing unstructured data.

First of all, may contain parts of structured information in non-structured data. If an article is usually considered to be non-structured data, but may include forms with the format information data.

Secondly, non-structured data in a suitable interpreter, can be transformed into structured data. A relational database for storing the data file is usually a binary file stored on disk, if no database management system to carry on the translation, the data is unstructured. Similarly, a JSON code is as plain text is unstructured data, but after the JSON interpreter to explain, is converted into structured data.

Finally, non-structured data can be extracted from the structured information element, such as storage, data producers and data communication way, even the data itself.

To sum up, the definition of non-structured must be in combination with the storage requirements is discussed the significance, in this paper, non-relational data all were considered as non-structured data, because this paper is concerned with the process to achieve this kind of data storage using relational database.

Big data is not completely belongs to a non-structured data, a large part of which still has the relationship between the structure specific, or can be converted directly into the relationship between the structure, main problems of large data storage is the data structure to the data storage before completely determined, but may have. The difficulty of the relational database to store such data is to extend its ability to the data model, the relational data model need to determine the data model in advance of data storage, contrary to the characteristics of such data, although the relational database can be used in the process to change the data type, the price is very great. This thesis focus on not only for non structured data storage itself, but rather through simple improvement on the relational data model, database enhanced expansion ability, making changes to the data model can be used to complete.

### 3.2 Sub-problem II Research and Design: Mass Data Storage

Existing relational database systems, there are four main levels of mainstream data segmentation segment.

The first kind is divided in accordance with section, this way will be divided into key range is divided into a plurality of sections; the tuple is stored in different sections in different sections. If according to section partition of integer types of ID, the ID value in the storage and section 10000 below 1, and the ID value is greater than the tuple storage 10000 to section 2. The way to facilitate the data version management, if known ID larger data more new, some new ID small data may not be the regular operation, and can be removed from the system. Often need to segment data operations according to this segmentation methods require operations less slice, so its efficiency is high.

The second way is partitioned according to the list, this approach requires segmentation is the key enumeration type enumeration segmentation, according to the key value was classified, for example according to the region of the field is divided into the data of Beijing and Shanghai, this way can be a special case as section method, in this section way, each section contains only one value. The way to facilitate modular management system, such as different regions and departments use machines, different data processing system.

The third way is partitioned according to the hash value, the hash algorithm can have many kinds of, the benefit of this approach is the slice position data fast calculation speed, do not need to look up tables, and the data distribution, not easy to cause the slice data overflow problem, the disadvantage is that it is difficult to SQL statements for the range of operation optimization.

The fourth way is to combine the front way, provide multidimensional segmentation methods, such as first according to region segmentation, segmentation and in accordance with section.

The above four methods are usually required to complete in accordance with the logic of the system, and it is difficult to form a unified scheme. The segmentation scheme cannot be confined to large data business logic in the system, so it is necessary to adopt segmentation scheme is feasible.

### 3.3 Sub-problems III Research and Design: Parallel Processing

Data processing speed, high real time requirement is the one big characteristic of data processing, and it is also the difficulty of this thesis, a large amount of data data greatly, this almost decided the large data processing need to be adopted to realize the parallel processing technology in the distributed environment.

This paper uses a three-dimensional storage model, because the data are segmentation according to the type, and each section is stored in different physical database, summary the realization of parallel computing is in fact the query distribution process and results.

The scheme proposed in this paper, to improve the efficiency of relation operation in a query sentence level, one hand to achieve the compatibility of relational database, on the other hand can meet the real time requirement of large data in a certain extent.

For large data simple read operation, the scheme uses a special internal connection processing way, through every part of parallel to read the data, improve the data read-write ability, meet the large data and high concurrent read and write requirements. Compared with the NoSQL database, the efficiency of the program to read and write in the simple data not inferior, and statistics and mining relational data operation of this scheme support for many large data is also very necessary, NoSQL usually need a lot of extra code, in MapReduce in the realization of the

scheme is equivalent to some common integration to the database, save the cost of application development.

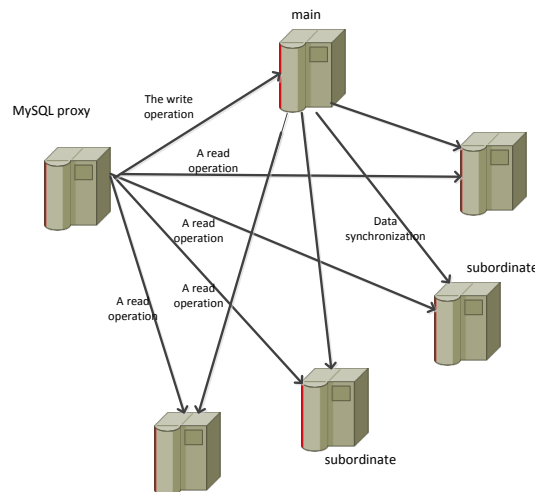
The program also has many disadvantages, one of which is the realization of the process is more complex, and the scheme based on large computer clusters, requires a large amount of hardware resources support. On the other hand, the scheme is in the process of distributed transaction, is used to compare the simple way, its efficiency may be low, and need to be further improved.

### 3.4 Applications of the Scheme

1) the final outcome of this dissertation will be applied to the project of national health examination pre Natal, solve the problem of data storage module projects in the actual operation of the system appeared in the process of large amount of data, complex structure, rapid growth. The current data storage scheme of the project has been in accordance with the earlier research results to a certain degree of improvement, performance improved contrast this section mainly describes the storage scheme of the process, before and after the improvement of performance and comparing with using NoSQL method.

Health examination program of free pre pregnancy state consists of six subsystems: the doctor work system, clinical laboratory systems, medical imaging systems, follow-up management system, report generation and decision support system, the system administrator. The six subsystems are connected to the same data center, using the same data model.

Due to the single data center using, at the same time, the data center will face from across the country thousands of connection requests, the requirements of data center adopts a distributed architecture to meet the demand of high concurrent read and write. The system was initially MySQL master-slave synchronization mode, cluster includes a primary server and four units from the server, the main server from the server through MySQL and between Proxy realize the read and write separate and load balancing, as shown in figure 1.



**Figure 1. Schematic Diagram of the Database Cluster System**

First of all, to system of relation data model using response data structure's changing needs. The data model of the actual complexity of the data structure is not complicated, mainly from three aspects: in the system operation process, once many times of revision, data structure of some change, leading to the old and the new data in the database system of hybridity, resulting in data structure complexity increases; some bug system operation process in there, leading to bad data in the database, the

old and the new version of data and bad data, eventually leading to complexity increases, the system software structure stability decreases, and further increase the bad data can; along with the function of the system gradually strong, non structured data management system need more types, including medical imaging, log data etc..

Secondly, MySQL master-slave replication is used in asynchronous replication mode, inconsistency, may lead to a transaction processing system, the database of some write operation is the current state of the database based on the serial number, such as the generation, it needs real-time database is read from the database information, and of the main database synchronization exists a certain delay. The resulting database information read operation obtained not new.

Thirdly, to copy the way of full backup based database, wasted a lot of storage space.

Finally, the parallel processing of database is to query for particle size, with the increase of data quantity, some complex query relation operation to complete, in an acceptable time based on the contrary, the query will occupy a lot of resources, efficiency further reduce other query operations, resulting in vicious spiral.

#### 2) The improved data storage scheme

Due to various defects of original data storage system, health examination program of free pre pregnancy state according to the research results of this thesis, the database system has been improved a full range of. Data storage system is improved to meet the following characteristics:

1 From the original data model for smoothing improvement, the original data can be simply transplant;

2 Compatible with the original application;

3 The horizontal expansion of 3 support data table;

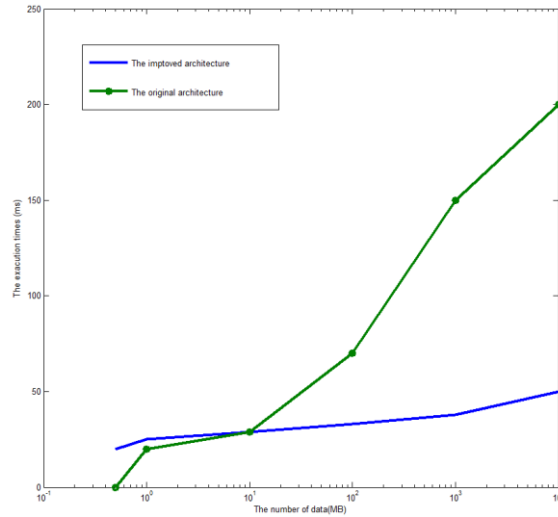
4 It can be performed efficiently query complex relationship;

## 4. Experimental Results and Analysis

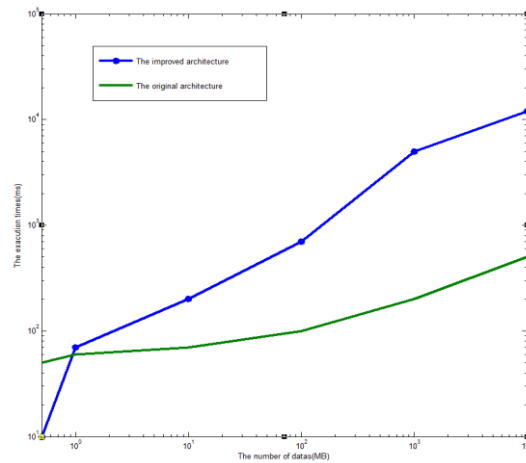
After the application of the improved scheme, data operation efficiency of the national free checkups system significantly, figure 2 and figure 3 is part of the operating system time comparison before and after improvement.

As can be seen, in the case of small amount of data, high efficiency of data management of the original storage scheme, because of the improved scheme will result in certain time overhead in query parsing and forwarding process, it is reasonable. With the increase of the amount of data, data query, especially used in the retrieval operation data connection and sorting capabilities, increased rapidly, its execution time compared to the execution time of data storage scheme, the improved rise speed is relatively slow.





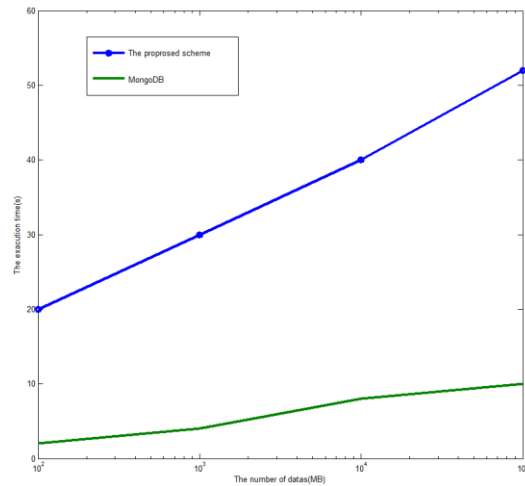
**Figure 2. Data Object Reading**



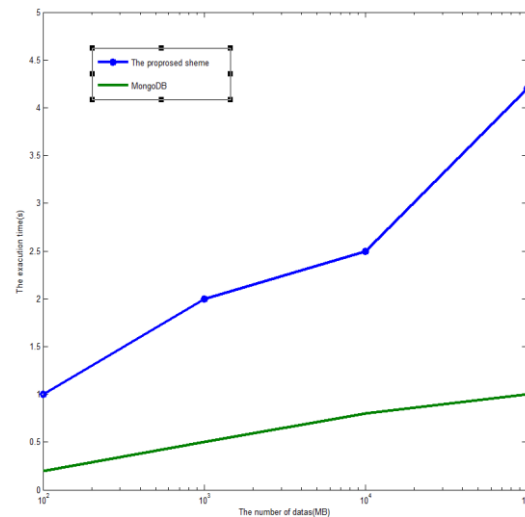
**Figure 3. Data Retrieval and Ranking**

Compared with the original storage scheme, the lateral expansion storage scheme improved also support data model, to solve the multi version data coexist, unstructured data management problems.

NoSQL is not suitable for the national free pre pregnancy health examination items, here only in the case of MongoDB, some test data extraction system, and based on these data comparison this paper scheme and the NoSQL scheme to read and write performance in the process of data, use efficiency to verify this paper storage scheme.



**Figure 4. Data Object Reading**



**Figure 4. Data Object Writing**

Compared with the NoSQL database, the performance of the program is low, but the NoSQL performance improvement is at the expense of the compatibility, this paper does not seek more than the NoSQL database in the performance, but is committed to based on compatibility relation data model, as far as possible to meet the needs of large data storage. At the same time, and the difference of the efficiency of the NoSQL shows that this scheme can be optimized in many exists in front of the space, which provides the direction for the next step in the development of the work.

## 5. Conclusion

With the further development of the research on large data, NoSQL almost has become standard processing large data solutions, but NoSQL needs to change the original system data model, which makes the system transplantation cannot simply finish, or even impossible in many cases.

The main goal of this thesis is to find a can meet storage model of large data storage requirements and compatibility requirements. The model can not only realize the large data storage requirements, and can support the operation of most of the relationship, so as to realize the compatibility of the existing system.

This paper is based on the relational data model, and specifically for the relationship between operation optimized operation relations, can support most, which is compatible with the existing application system based on relational database.

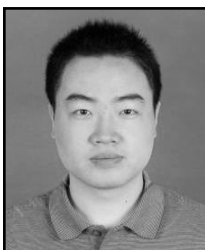
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