Research Article

Data Processing Method of Distributed Parallel Database System Based on Wireless Network

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With the development of society and the arrival of the information age, data processing has become more and more complex, so people need to manage data systems through wireless communication, and distributed systems can effectively improve data analysis, so this paper is based on wireless communication. Distributed database systems are studied. With the rapid development of database systems, how to effectively obtain useful information about massive data has gradually become an important research problem of the field of data management. The purpose of this paper is to study how to research the data processing of distributed parallel database system based on wireless network. This paper puts forward the basic concepts of wireless network and distributed parallel database system and proposes a clustering analysis algorithm. The preimproved clustering analysis and the improved distributed parallel clustering analysis are described and compared in detail. From the data in the figure in the experimental part of the text, it can be seen that the efficiency of the database system before the improvement is the lowest at 41% and the highest at 58%. The efficiency of the improved distributed database system is at least 65%, and the highest are 95%. It can be seen that the efficiency of the improved distributed database system is much higher than that of the preimproved database system. So it is very feasible to use the distributed database system to process data.

1. Introduction

With the development of computer systems, databases have become synonymous with information management systems. However, the previous database system was based on the previous hardware platform, because the emergence of the new hardware platform will produce many new technology problems, which have not been solved in the existing database. Thus, distributed mobile real-time database technology was born.

Although the network construction of database system has a certain scale, compared with the construction results of network engineering, the construction of database system is far from meeting the needs of statistical business. This is because there is no unified standard for data exchange, which causes difficulties in data storage and application.

The innovation of this paper is as follows: (1) This paper introduces the theoretical knowledge of wireless network and distributed parallel database system and uses the distributed parallel clustering analysis algorithm to analyze how the wireless network plays a role in the data processing of the distributed parallel database system. (2) The traditional database system and the distributed parallel database system are analyzed, and it is found through experiments that the distributed parallel database system can process data more efficiently and accurately.

2. Related Work

With the development of the Internet in recent years, wireless networks have also become more and more important. Wang and Mao first consider the distributed power control problem in a full-duplex (FD) wireless network consisting of multiple pairs of nodes, where each node needs to communicate with its corresponding node. Their goal is to find the optimal transmit power of the
FD transmitter to maximize the capacity of the entire network. Based on high signal-to-interference-to-noise ratio (SINR) approximation and approximation methods for logarithmic functions, they extended their work to general FD network scenarios, which can be decomposed into problems of isolated nodes, paths, and loops. They mentioned that their goal was to find the best transmit power but did not explain how they accomplished the goal, and the simulation results were not supported by experiments [1]. Zheng et al. have witnessed a huge evolution in wireless network design from quality of service (QoS) to quality of experience (QoE) over the past decade, and in many applications, end users are more concerned with the transmission quality of individual tasks than the quality of the link. They propose a new network model that aims to improve user experience by pushing the scheduling problem to the task layer and then achieve application-aware transmission allocation, and the final simulation results show that the scheduling strategy can significantly improve QoE. Although they proposed a new model to improve the user experience, they did not experiment with the model, so the usability of the model is not convincing [2]. Müller et al. found that content caching in small cells or wireless kiosks was considered a suitable method to improve the efficiency of wireless content delivery. Placing the best content in the local cache is critical due to storage constraints, but it requires knowledge of content popularity distribution, which is often not available in advance. Additionally, the popularity of local content fluctuates as mobile users with different interests connect to cached entities over time. Although they found and raised problems, there were no specific measures to solve the problems they found [3]. He et al. found that both caching and interference alignment (IA) are promising technologies for next-generation wireless networks. However, most existing wireless network work assumes that the channel is invariant, which is unrealistic considering the time-varying nature of real wireless environments. They use Google to implement deep reinforcement learning to obtain optimal user selection policies in wireless networks. Although they proposed a specific scheme, there is no specific experimental data and experimental objects to prove the reliability of the scheme [4]. Darsena et al. found ambient backscatter to be an interesting wireless communication paradigm that allows small devices to compute and communicate using only energy harvested from over-the-air radio frequency (RF) signals. Devices reflect RF signals emitted by existing or conventional communication systems designed to transmit information, not for RF energy transfer. After presenting detailed signal models of the relevant communication links, they investigated the effect of physical parameters on the capacity of conventional and backscattered channels by considering different receiver architectures. But they did not describe the effect of physical parameters on the capacity, nor did they compare the traditional channel capacity with the reverse channel capacity [5]. Afshang and Dhillon modeled the locations of nodes as a unified binomial process, and they proposed a general mathematical framework to demonstrate the performance of reference receivers at arbitrary locations in limited wireless networks. A key step in the analysis is the derivation of a new set of distance distributions, which allows easy analysis of not only coverage probabilities but also a wide range of classical and current trending problems in wireless networks. Although they discovered traditional and existing problems in wireless networks, they did not specify what these problems are and how to solve them, nor the concept of diversity loss [6]. Yang et al. found that growing storage in cloud data centers will accommodate most of the internet traffic in the future. Moving massive amounts of data in and out of the cloud wirelessly puts a lot of strain on broadband and can cause unpredictable delays. They advocate extending the cloud to fog computing at the edge of the network, which can effectively ensure low-latency and location-aware service provisioning. They proposed an SDN-enabled cloud-mist interoperability framework aimed at improving quality of experience and optimizing network resource usage. But they did not have a detailed practical case to illustrate the feasibility of this framework [7]. Kadota et al. found that base stations send time-sensitive information to multiple clients over unreliable channels. They formulated a discrete-time decision problem to find a transmission scheduling policy that minimizes the expected weighting of clients in the network. They first showed that in a symmetric network, the greedy strategy of transmitting the current packet with the highest age is optimal. This is the first work to provide performance guarantees for a scheduling strategy that attempts to minimize cost in wireless networks with unreliable channels. But they did not clearly explain the discrete-time decision-making problem, making the discrete-time decision-making problem difficult to understand [8].

3. Concepts of Wireless Networks and Distributed Parallel Database Systems

Mobile computing is a technology set that enables people to access network services at any time and place in any way. It enables computers or other information intelligent terminal devices to realize data transmission and resource sharing in a wireless environment. With the rapid development and use of mobile communication technology, many computing nodes have been able to maintain network connections in the process of free movement, and the concept of mobile computing has emerged. The distributed computing environment has also been further expanded to include a variety of mobile devices and a service network of wireless communication capabilities, evolving into a mobile computing environment [9]. The application of wireless network is shown in Figure 1.

As shown in Figure 1, at present, with the rapid development of Internet-related technologies, management information systems based on computer network and database technology have gradually penetrated into all aspects and fields of social life and people's work. It has become an
important basis for informatization in all walks of life, and it is also an important research branch in the field of computer applications [10]. The database and various application systems built on it are the core issues. Data requirements are distributed over the network, and most accesses are only for "local" data. If the business system it belongs to runs across regions, it is difficult to manage the data [11]. For the application field of the system, users put forward higher requirements for the security and fault tolerance of the database. A schematic diagram of the database is shown in Figure 2.

As shown in Figure 2, as application requirements expand, people are increasingly realizing the limitations of traditional databases. Connecting the information of these subsectors through the network, forming a new database, or rebuilding the database becomes a top priority. There is an urgent desire to build existing departments that process data independently and that can be adapted to a decentralized database system for global applications [12].

In this case, with the development of communication network technology, the concept of "centralization" of centralized database has developed into the concept of "distributed." The birth of distributed database systems has become one of the most active research fields in computer technology. The distributed database system is shown in Figure 3.

As shown in Figure 3, with the increase in the amount of data stored in the database and the amount of user visits, whether it can effectively guarantee and improve the stability and availability of the application system during the operation process, solve the bottleneck problem of the system during the operation process to the greatest extent, and solve the problem of saving the operation cost of the business system, the performance of the database system is the decisive factor [13].

4. Distributed Parallel Clustering Analysis Algorithm

Distributed data storage is to fuse together the data initially detected by sensor nodes, reduce the amount of data sent, then secretly share the fused data, send various shares to various storage nodes, and finally merge the data [14]. In this way, the energy consumed by nodes to send and save data is greatly reduced. The distributed data storage is shown in Figure 4.

As shown in Figure 4, this is an intermediate database application system developed for the actual situation of the company that integrates data management and data services. It includes data retrieval, data management, data service, and data application, and the source of these data is the data in databases distributed in different regions. Therefore, it is necessary to use the distributed database synchronization technology to reasonably plan and layout the data in different places, so that the data can be shared [15].

4.1. Implementation of Distributed Clustering Genetic Allocation Algorithm

With the increasing demand for databases and the rapid development of information technology, distributed database systems will appear as needed because centralized databases are more and more difficult to meet current data storage conditions. In the design of distributed database system, the problem of data allocation is an important part of the design [16]. The convenience and reliability
of the distributed database system are greatly improved. In order to reduce the communication cost and improve the overall performance, this paper proposes a clustering genetic algorithm.

In principle, the selection of the cost formula should consider the database information, application information, site information, and network information as far as possible. However, in practical applications, the main statistical information is considered, such as the communication cost between sites and the frequency of fragments accessed by each application, while the secondary statistical information is ignored. For example, the storage cost can be ignored for distributed databases that do not store massive data [17]. At present, the transaction processing cost and storage cost are used more.

\[
\text{TotalCost} = \sum_a \text{PCost} + \sum_a \text{SCost.} \quad (1)
\]

The storage cost is

\[
\text{TotalCost} = \sum_a \text{PCost.} \quad (2)
\]

Due to the rapid development of hardware, its cost becomes lower and lower, and its cost \( \sum_a \text{PCost} \) can be disregarded relative to other costs \( \sum_a \text{SCost} \). Therefore, the storage cost is ignored, and the transaction processing cost is

**Figure 2:** Schematic diagram of the database.

**Figure 3:** Distributed database system.
mainly considered; that is, the latter is selected as the cost formula \[18\].

The problem of data allocation is mainly to reduce the total cost of the entire system for data fragments. In this paper, two kinds of costs are mainly considered, namely, the local retrieval cost and the remote update cost.

(i) Local retrieval cost: equal to the average retrieval cost in cluster \(C_i\) multiplied by the local average retrieval times and then multiplied by the data segment size \(\text{Size}(F)\):

\[
\text{CLRsum}(T_k, F_j, C_j) = \text{CLR}(T_k, F_j, C_j) \times \text{FREQLR}(T_k, F_j, C_j) \quad (3)
\]

(ii) Remote update cost: equal to the sum of update costs sent from other clusters, where \(\text{CRU}(T_k, F, C_j)\) represents the average update cost per unit of data in cluster \(C_j\), \(T_k\) represents the average number of updates in the cluster \(C_j\), and \(F_j\) represents the size of the fragment:

\[
\text{CRUsum}(T_k, F_j, C_j) = \sum_{i=1}^{n} \sum_{i=1}^{m} \text{CRU}(T_k, F_j, C_j) \quad (4)
\]

In this paper, the problem of data allocation is solved by first clustering and then using genetic algorithm. First, all sites are divided into different “clusters” by the communication cost between sites, and then, the total cost of each data segment allocated to each cluster is evaluated to obtain the distribution of segments on the cluster [19].

(i) Crossover operation: considering the search speed of the algorithm and maintaining excellent genes, this paper adopts an adaptive crossover operator, and the crossover probability \(p_{cl}\) is

\[
p_{cl} = \begin{cases} 
  p_{cl} - \frac{(p_{cl} - p_{cl}) (F - F_{avg})}{F_{max} - F_{avg}}, & F \geq F_{avg} \\
  p_{cl}, F_{cl} > F_{avg}, & \end{cases}
\]

where \(F_{max}\) is the maximum fitness and \(F_{avg}\) is the average fitness in the previous generation group

(ii) Mutation operation: this paper selects each gene locus to calculate according to the adaptive mutation operator, and the mutation probability is

\[
p_m = \frac{(p_{m_1} - p_{m_2}) (F_{max} - F_m)}{F_{max} - F_{avg}},
\]

where \(F_{max}\) and \(F_{avg}\) are the maximum fitness and average fitness in the previous generation population and \(F_m\) is the fitness of mutant individuals.

The main function of wireless sensor network is to provide users with sensory data of interest to users. In fact, according to the survey of sensor hardware, a specific storage node within the sensor network is first selected. After a large amount of detection data is fused, the fused data is stored in various storage nodes in scattered segments to reduce energy consumption [20].

Taking the plane wireless sensor network as an example, firstly, the geographic location of the detection target is represented by a two-dimensional vector as \((a, b)\), and the network coverage is represented as \([-D_a, D_a] \times [-D_b, D_b]\). Assuming that the coordinate of the sink node is at \((0, 0)\), number the sensor nodes as 1, 2, and 3. Select \(n\) sensor node locations within the coverage area for research. The schematic diagram of the selection area of sensor nodes is shown in Figure 5.

As shown in Figure 5, \(P_j(a, b), j = 1, 2, 3 \cdots, q\) is used to represent the data information of the \(j\)th observation target.
into a group. Assuming that the maximum test amount of the data in Table 1 and divide the data of the same target the accuracy of data monitoring also increases. First, classify the observations is shown in Table 1.

As shown in Table 1, as the number of nodes increases, the accuracy of data monitoring also increases. First, classify the observations is shown in Table 1.

observed by the \( i \)-th sensor node, where \( q \) is the total number of observation targets. The detailed table of observation locations is shown in Table 1.

As shown in Table 1, as the number of nodes increases, the accuracy of data monitoring also increases. First, classify the data in Table 1 and divide the data of the same target into a group. Assuming that the maximum test amount of the sensor network is \( \delta_{\text{max}} \), a fixed circle is predetermined as the dividing standard, and the radius of the circle is \( \rho \delta_{\text{max}} \) then the standard of data grouping is

\[
\| P_{ij}(a, b) - P_{aj}(a, b) \| \leq \rho \delta_{\text{max}}, \quad i, a = 1, 2, 3 \ldots , m. \tag{7}
\]

Supposing the measurement variance corresponding to each sensor node is \( \delta_1, \delta_2, \ldots, \delta_r \), perform data fusion on this group, and obtain the latest observation value \( p_j(a, b) \):

\[
P_{ij}(a, b) = \sum_{i=1}^{r} w_i P_{ij}(a, b). \tag{8}
\]

\( w_i \) satisfies the measurement variance function \( \sum_{i=1}^{r} w_i P_{ij}(a, b) \). To determine this formula, define a new function \( H \). \( \lambda \) is the Lagrangian factor to obtain formula (9) after taking the partial derivative of the above \( H \) function:

\[
\begin{aligned}
\frac{\partial H}{\partial w_i} &= 0, \quad i = 1, 2, \ldots, r, \\
\frac{\partial H}{\partial \lambda} &= 0.
\end{aligned} \tag{9}
\]

Solving formula (9), \( w_1, w_2, \ldots, w_r \) can be obtained, the second-order partial derivative of the \( H \) function can be obtained, and the \( w_1, w_2, \ldots, w_r \) obtained after solving is the weight of the data fusion that minimizes the variance of the total function.

4.2. Classical Query Algorithms. If want to query the required data information in the table, it need to compare the expectation of the number of key information in the information input during the query, which is called the query distance average value of the query algorithm when the query is successful [21]. For a table with \( n \) records, the average query distance when the query is successful is

\[
QI = \sum_{i=1}^{n} P_i C_i, \tag{10}
\]

where \( P_i \) represents the probability of the data information of the \( i \)-th row in the query table and \( \sum_{i=1}^{n} P_i = 1, C_i \) represents the number of key information compared with the input information when the key information in the table is queried and the information entered during the query, and the \( i \)-th data information is equal. From the above, it can be concluded that the value of \( C_i \) changes with the query process. Now, assuming that the query probability of each data information is the same, that is,

\[
P_i = \frac{1}{n}. \tag{11}
\]

It can be obtained that when the query probability is the same, the average query distance when the query is successful is

\[
QI_{SS} = \sum_{i=1}^{n} P_i C_i = \frac{n + 1}{2}. \tag{12}
\]

Mobile queries need to be improved and extended based on conventional distributed database query optimization techniques to adapt to the special requirements of wireless networks. The amount of data transferred must be kept to a minimum when operating the query and to satisfy many query problems related to location information. The distributed database query is shown in Figure 6.

As shown in Figure 6, combined with the specific application environment of the system, in order to achieve high availability of the system as a whole, a hybrid data distribution strategy is adopted, that is, between separation and replication. On the premise of maintaining a certain redundancy of data, the locality of data operation applications is maximized, and the redundant copies are kept in the central database server. The following is a performance analysis of the metadata distribution strategy.

Before data distribution, the retrieval frequency \( P \) of a single site to the central database during operation is

\[
P = m \ast (1 + p \ast c + q). \tag{13}
\]
4.3. Parallelized Clustering Algorithms. The central idea of K-means is to split all the data records that need to be analyzed so that each record has its own set of vectors. Usually, the segmentation of vector sets is based on the center distance and data of the vector sets. Before the read-only business data is distributed, the frequency $P_t$ of single-site operations on the central database during the running process is

$$P_t = m \times ((1 - p) + p \times c + q).$$

(14)

The probability of $q$ occurring here is very small, and it is ignored as 0. After distributed shard distribution, the information collection control station does not need to write to the central database server during the operation process:

$$d_{ij} = \lambda \sqrt{\sum_{k=1}^{n} |a_{ik} - a_{jk}|^4}.$$  

(15)

Calculate the average value of the digital vector $\lambda$ transformed by all data records in the set of each vector class $|a_{ik} - a_{jk}|^4$ in turn.

After preprocessing, convert each record into an $n$-dimensional numeric vector:

$$\begin{pmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{pmatrix}.$$  

(16)

By judging whether the positions between the vectors are close enough, each vector can be divided into different subsets $\{A_1, A_2, \cdots, A_m\}$, which satisfies

$$A = A_1 \cup A_2 \cup \cdots \cup A_m.$$  

(17)

This results in a membership function $\mu_{A_i}(a_j)$:

$$\mu_{A_i}(a_j) = \begin{cases} 0, & a_j \in A_i, \\ 1, & a_j \notin A_i. \end{cases}$$  

(18)

Determine whether the clustering operation $J(U, v)$ is completed:

$$J(U, v) = \sum_{k=1}^{K} \sum_{j=1}^{n} (u_{ik})^q \sum_{j=1}^{n} (a_{ij} - v_{kj})^2.$$  

(19)

If there is an optimal solution for the above function $\sum_{j=1}^{n} (a_{ij} - v_{kj})^2$, the clustering iterative step is terminated, and the result of the last iterative operation is output.
The compactness defined in this paper is the distance between each data point and its corresponding cluster center, and all the distances are summed to obtain the average value:

\[
\text{Compact} = \frac{\sum_{i=1}^{n} \left( \sum_{j=1}^{m} \text{disP}_{ij} \right)}{n}.
\]  \hspace{1cm} (20)

Usually, in order to obtain the center vector point set of the best data vector point set, it is necessary to execute the K-means parallelization algorithm multiple times.

5. Distributed Parallel Cluster Analysis

5.1. Clustering Effect of Distributed Parallel. Firstly, three kinds of data satisfying two-dimensional Gaussian distribution are added, and then, the class center is recalculated iteratively, the center point changes, and the best clustering result is obtained. The big circle part is the final iteration position, and the comparison between the initial data distribution map of the cluster analysis and the final clustering result map is obtained, as shown in Figure 7.

As shown in Figure 7, by comparing the initial data distribution graph of the cluster analysis with the final clustering result graph, it can be known that the features of the initial data are messy and unclassified. The final clustering result after clustering analysis not only classifies similar data but also classifies quickly and has high accuracy.

This paper compares the distributed parallel clustering algorithm before improvement and the improved distributed parallel clustering algorithm, as shown in Tables 2 and 3.

As shown in Tables 2 and 3, the improved algorithm requires shorter time, better clustering effect, and higher stability than the ordinary algorithm and has obvious advantages in the stability of clustering results. Therefore, the improved algorithm is better than the ordinary algorithm of K-means. Compared with the existing improved algorithm, the number of clustering results is more stable.

5.2. Features and Advantages of Distributed Database Systems. Databases are the core technology of most information systems. This is an aided management method of data, the study of methods for organizing and preserving data, and methods for obtaining and processing data efficiently and quickly. Study the basic theories of database structure, storage, design, management, and application,
and use these theories to realize the rapid processing, analysis, and understanding of data in the database center. This paper investigates the number of databases from 2015 to 2019, as shown in Table 4.

As shown in Table 4, in the distributed data management, in the sensor network, the data is first fused, and a large amount of data is fused into a detailed data, which can reduce the amount of data transmitted. In terms of data security, the fused data is encrypted, and finally, the data is merged. Thereby, the reliability and security of network data can be improved, and the service quality of wireless sensor network can be improved.

In recent years, the amount of data in the database is increasing day by day, and the data forms are different, but the core data of various applications are still stored in various systems in various forms. More and more users hope to obtain useful data from these large-scale data sources and process them to achieve interoperability between multiple software and hardware systems and different data sources.

This paper analyzes the efficiency and costs of the distributed database system before and after the improvement, as shown in Figure 8.

As shown in Figure 8, the advantages of the improved distributed database system are as follows: the improved distributed database system not only improves the efficiency of work but also saves a lot of costs.

The research of distributed database system began in the mid-1970s. With the expansion of database application requirements and the development of computer hardware environment, distributed database system was born and became the most active research field. Distributed database systems meet the needs of today’s information system applications. In particular, it provides convenience for large enterprises with relatively centralized management. The characteristics and advantages of the distributed database system are shown in Figure 9.

As shown in Figure 9, this paper investigates and analyzes the characteristics and advantages of the distributed database system of the wireless network. It is found that the distributed database system based on wireless network has the characteristics of mobility and location correlation, diversity of network conditions, large scale of the system, and high security and reliability of the system.

6. Discussion

This paper analyzes how to process data in distributed parallel database system based on wireless network. The related concepts of wireless network and distributed parallel database system are expounded, and the related theory of distributed parallel database system is mainly studied, and the data processing method of distributed parallel database system is explored. And through experiments, the significance of distributed parallel database system for data processing was discussed.

This paper also makes reasonable use of the parallel distributed clustering analysis algorithm. As the parallel distributed cluster analysis algorithm is used in more and more fields, it also shows powerful functions in data processing. Clustering analysis itself has the function of clustering, but the traditional clustering analysis cannot be particularly accurate for data classification, so this paper proposes distributed parallel clustering analysis.

Through experimental analysis, this paper shows that in the Internet era, people need to process more and more data, and traditional database systems can no longer bear the load of large amounts of data. Therefore, based on the wireless network, this paper proposes a distributed parallel database
system to process data and finds that the safety and reliability of the distributed parallel database system are high.

7. Conclusions

With the development of Internet technology in recent years, the application of wireless networks has become more and more extensive, and almost every household has applied wireless networks. People can speak freely over a wireless network. However, this also leads to more complex data, which not only becomes larger and larger but also becomes more and more difficult to process. However, traditional database views cannot handle system data well. Therefore, based on wireless network, this paper proposes a distributed parallel database system data processing method. This article provides a comprehensive introduction to distributed and database systems, giving people an understanding of what a database is and what it does. In the method part, the clustering genetic allocation algorithm and the parallel distributed clustering analysis algorithm are proposed. The clustering analysis algorithm is improved, and the improved distributed parallel clustering analysis algorithm is obtained. The improved clustering analysis algorithm not only has a good clustering effect to classify the data but also has a high stability, which makes the data processing less complicated. Finally, in the experiment part, the characteristics and advantages of the distributed database system based on the wireless network are analyzed, and it is found that the distributed database system based on the wireless network not only improves the work efficiency but also saves a lot of costs. It can be seen that the research on the distributed database system based on wireless network is of great significance to the data processing in real life.

Data Availability

The data underlying the results presented in the study are available within the manuscript.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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