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A way to improve the performance of integrated real-time monitoring system in power grid by Distributed Shared Memory technology

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Abstract. Data processing in integrated real-time monitoring system in power grid is becoming a performance issue with the rapid development of power grid. This paper proposes a way to improve the data processing efficiency in the real-time monitoring situation by the application of distributed memory sharing technology. By this method, the data will be stored into different machines' memory as Physical-distributed and the data access in a Logically-unified way. Compared with the original solution in real-time monitoring system, the new solution with Distributed Shared Memory technology has obvious advantages in the performance of data processing performance.

1. Introduction

With the rapid development of China's economy, state grid launched its smart grid development strategy in 2009, as the country's electricity demand grew rapidly. Smart grid dispatch and control system (D5000) has developed rapidly and achieved significant technological breakthrough, which has been widely used in the dispatch center [1-12].

With the development of UHV construction, smart grid dispatch and control system (D5000) develops rapidly. Secondary device monitoring, power network operation analysis and evaluation, mixed simulation decision and power network and equipment failure pre-evaluation are developed on the basis of four traditional applications of power system. The load forecasting and investment evaluation of distribution network are studied. In this case, the size of the monitoring data and the processing pressure increase rapidly, making the system run under a high pressure and making the secondary support and decision system more and more complex, the data of the grid monitoring system with data acquisition frequency become higher, and the behind-the-scenes access to grid data will become more and more complex [13-14].

The improvement of complexity means the improvement of management cost and the reduction of reliability. In order to facilitate the integration of real-time monitoring system data acquisition and improve the convenience and reliability of monitoring data management, the power system needs higher data processing and management expectations.

Based on the research of integrated real-time monitoring system, this paper applies the third part of Distributed Shared Memory products to the project. Compared with the traditional solutions, the processing efficiency of real-time monitoring data of the power grid has been greatly improved.

2. The distributed shared memory technologies

2.1. The introduce of distributed shared memory

Using Distributed Shared Memory (DSM), data can be shared by processes on different machines without using shared physical memory. Distributed Shared memory is a kind of program model of memory sharing, which is superior to message-based model in some aspects.

In the application of Distributed Shared Memory. How to avoid high communication cost in Distributed Shared Memory requests and how to keep the system consistent when so many customers are connected to the DSM is a big problem.

Using DSM, different machines can request to share data without physically sharing memory, DSM requests are like local machine requests, DSM has a grantee that informs processes on different machines when data is modified. Logically, each process requests the same Shared memory, but physically the memory is distributed.

2.2. Implementation of distributed memory

DSM is mainly used for parallel or distributed applications or group applications that can access each Shared data directly. Because there is no physical Shared memory, the DSM needs to notify other nodes via messaging when making changes. There is data replication in the DSM, and in order to speed up data access, each node has a copy of the Shared data.

There are three main ways of implementing DSM; it is implemented through special physical devices, virtual memory, and libraries. (1)By special hardware: in a multiprocessor architecture, DSM is based on special hardware to load and store instructions to complete DSM addressing and node communication for remote memory. In these systems, the processor group is connected to the memory node group via a high-speed network, which is mainly designed to allow the number of processors to break the 10 limit or to enable communication to be completed on a public bus line. (2) By virtual paging: in the applications based on virtual paging, the address range for each process is the same, in these systems, the kernel of operation system is in charge of the maintenance of the data consistency and the error handling of the paging. (3) Support DSM through libraries: some programming languages or language extensions (such as Orea and Linda).In these applications, sharing is achieved not through a virtual memory system, but through communication in the runtime language. Library call completes data access and information sending and receiving of DSM; Library methods can access local data or maintain data consistency.

2.3. The data consistency of distributed memory

In a distributed environment, the data is usually divided into several parts and then stored in different nodes to guarantee the reliability of the data. When one node in the system and the data of other nodes can be obtained, feature is very important non-volatile memory. Traditional segmented control, synchronous control and asynchronous control are effective methods to ensure data consistency. (1) The traditional segmented control method is transaction based. All transactions are atomic, all transactions involve data commit and non-commit in only two states, and all data replicas are in the same state to ensure data consistency, which is achieved through lock. A common solution is a protocol called the two-phase commit protocol, which applies to distributed systems with small amounts of data and transactions for very low time costs, but when the data increases significantly or the complexity increases high, the solution will have a high concurrency performance that affects the entire system. Defects based on two-phase commit, some scholars put forward the three phases, four phases, as well as the dynamic adaptive piecewise transaction model, but the harmony that node lock and transaction completion status needs at each stage of process, the communication between the nodes will be more frequent, can make the transaction response speed decreases, the overall performance will not be able to guarantee. (2) The synchronization control method.

The synchronous method means that when modifying one data and having more replica data, the modification must be done in all copies, and it must be done in the atomic transaction, which means the modification must fail or succeed in all nodes, other nodes fail and the success of nodes is not allowed. In the course of a transaction, all involved replication must be locked (locking on a replica basis rather than on a file) to prevent any read and write from being performed by other users or processes, and then all users and processes have the same data. (3) The asynchronous control method.

The key point of the asynchronous control method is that when data modification operation occurs, only one or several copies of the data should be modified, rather than all copies of the data, and then the data version should be set according to the update time. But when the data read occurs, the system integrates all the copy information and then merges it into a uniform version. The main idea of this approach is to hand over the complexity of synchronous data replication step version integrated data read operations, and then make the time cost data write operations less complex, so this approach is much less applicable to case data writes and then reads.

3. The architecture of integrated real-time monitoring system

3.1. The hardware architecture

The provincial and above monitoring system control center contains data collection cluster server, SCADA cluster server, WAMS cluster server, AGC cluster server, AVC cluster server and distributed storage[15]. Regional monitoring system contains data collection cluster server, SCADA cluster server and AVC cluster server, as shows in figure 1. The state-area-provincial monitoring system is built in a dual alive mode, and regional monitoring system is recommended in a dual alive mode too[16].

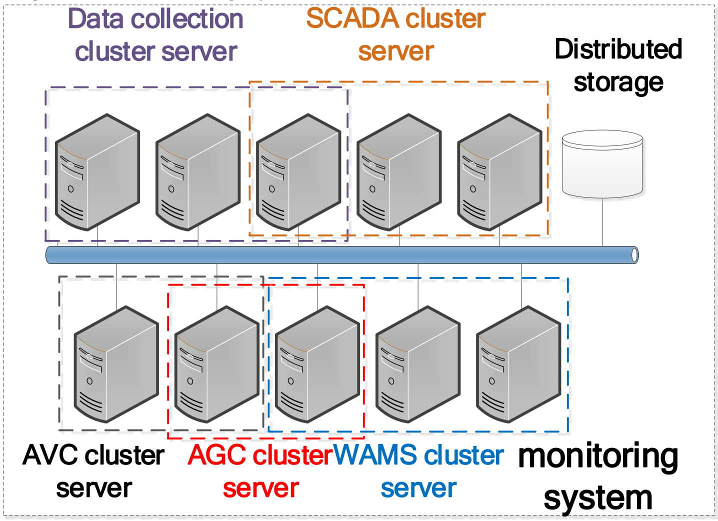

Figure 1. The hardware architecture.

3.2. The software architecture

The supporting platform for integrated real-time monitoring system software consist of common components such as dynamic resource management and distributed service management. The application part for the integrated real-time monitoring system at the provincial level and above consist of the distributed data collection software (FES), which realizes the efficient and highly scalable data collection of the power network under its jurisdiction. The data processing unit of SCADA and WAMS supplies data for the grid analytical decision control by the implements the data requirement of high-speed parallel processing for the dispatch system by data flow processing and time scale data processing. After analysing the decision center will generate the economic operating domain that meets the security constraints, the auto generate unit control (AGC) and auto voltage unit control (AVC) application unit will combining the real-time power market transaction situation and local control strategy to adjust the generation unite of the power network under its jurisdiction and adjust the local voltage after obtaining the optimization adjustment result of the analysis decision center. Regional real-time monitoring systems contain platform common components and public services, FES, SCADA and AVC, but generally do not contain WAMS and AGC. The monitoring system can still run normally under the failure of the analysis decision center[17].

3.3. The typical data flow

The typical data flow of the monitoring system is divided into three parts. 1) grid model data flow, including grid model maintenance data flow, grid model data synchronous flow and grid model data release flow. 2) grid monitoring real-time data flow, including real-time data sharing and real-time data collection flow;3) analyze and decision flow, including the trigger calculation instruction of each monitoring system to the analysis decision center flow and the analysis decision result of each data acquisition flow monitoring system to the analysis decision center flow. As shows in figure 2:

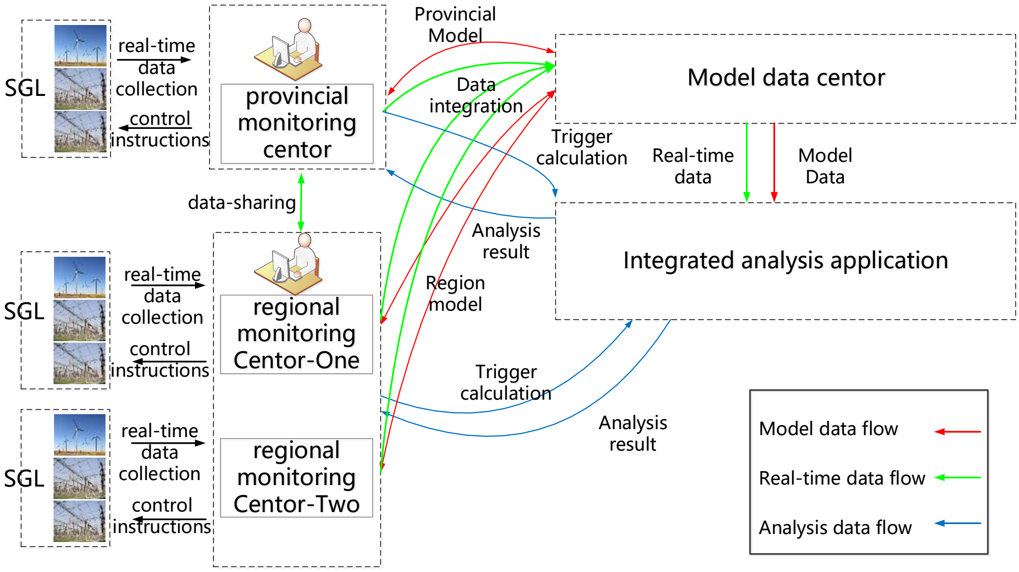

Figure 2. The typical data flow.

3.4. The application method of DSM

3.4.1. The storage of monitoring data. This chapter studies the monitoring data storage and access method based on the existing wide-area distributed memory product Redis, a memory database that stores data in the form of key-value pairs. The key-value storage type is appropriate to divide the same type of data into a single point for operation, the consequence of which makes the data management complicated. For simple data management, the storage of data is stored in a hash structure. A hash table corresponds to an entity table, the primary key of the hash table corresponds to the primary key of the entity table, and the value of the hash table corresponds to the whole row record of the entity table record. As the monitoring data contains a property of time, so the primary key has a suffix of the record time, as shows in figure 3.

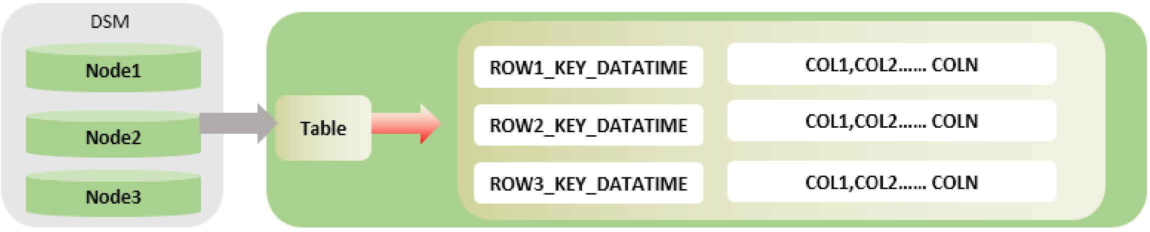

Figure 3. The typical data flow.

3.4.2. The data access architecture. When the monitoring application write data into the storage, the data is firstly saved fast into the memory database, then send a message to the message queue, and the synchronous application will write the data to the hard disk storage slowly. In the data read situation, the analysis application just need the recently data in most calculation case, so the data storage is divided into two parts, the hard disk part and the memory part, the recently data is stored in memory, and the old data is stored in hard disk. By this design, most of the data access case is against the memory, so the performance of data acquisition is improved a lot, the structure is showed in figure 4.

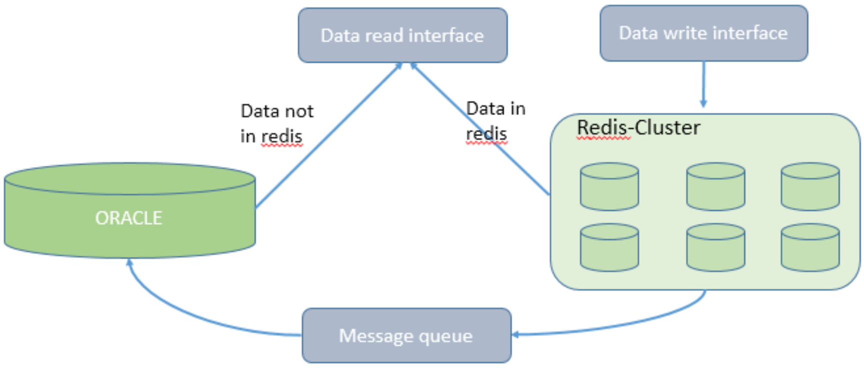

Figure 4. The typical data flow.

3.4.3. The disaster fault method. When the data is in the memory database, but has not written to the hard disk yet, if the memory cluster master node is shut down, the slave of master will take a replacement of the master to supply data access, as shows in figure 5.

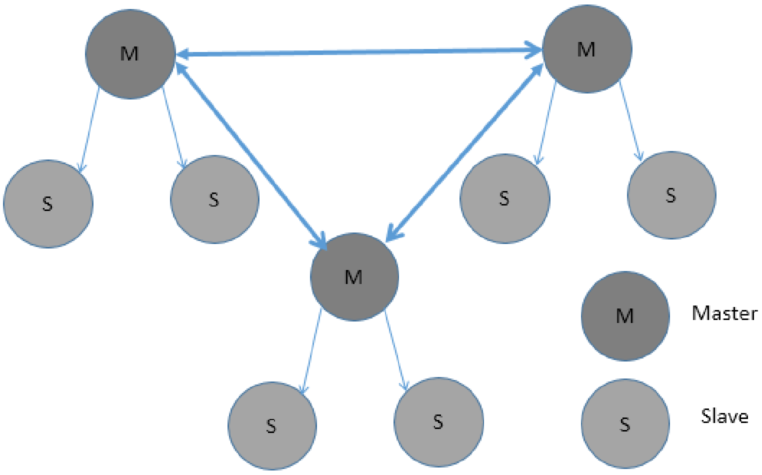

Figure 5. The typical data flow.

4. The contrast test on data access

4.1. The test environment.

The test is based on the wide-area distributed storage product Redis. The following figure shows the storage design of the model data. The key is the same as defined in the D5000 scheduling system. This value is stored as a string through serialization, as shown in figure 6:

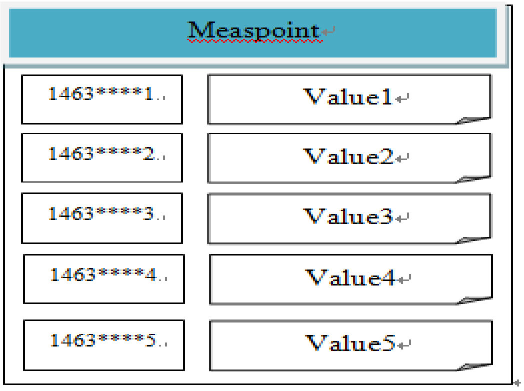

Figure 6. The typical data flow.

The data sample of the test is based on the power model of JIANGSU province, and the test client is on the same machine and in the same WLAN to make the test result is fair in the test environment. The following test result in the diagram is an average result of the test, this paper recorded the test result of each test, and calculate the average result by the following formula:

Time(s) = Sum(Ti)/N

4.2. Table 1 shows the test result and analysis.

Table 1. The test result.

Test Case(N=20)	Redis(s)	RTDB(s)
Table read (300000 records)	4.5	7
Single record read (100000 times)	10	147
Single record write (100000 times)	10	141
Single record read(100000 times)*10 threads	34	770

From the test result above, the test situation with the Distributed Shared Memory product Redis is much faster in the data access process than the traditional RTDB.

5. Conclusions

In this paper, we clarify the background of the data access pressure of the current power integrated real-time monitoring system, introduced the concept of Distributed Shared Memory technology, then proposed a method based on distributed memory for the monitoring data access process, by this method the data access process in the project is optimized, after that we made a comparison test of data access between the new method and the traditional RTDB, we found that the data access process is much faster than the traditional RTDB in the integrated real-time monitoring system in power grid.

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