Research on High Efficiency IO Control Technology of Seismic Data Based on Data Segmentation

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Abstract. With the development of geophysical prospecting technology, seismic operation processing is terabytes of data in actual production. A seismic operation processing time can be as long as ten days. In order to complete these processing tasks in as short a time as possible, efficient use of node resources is needed. Therefore, it is necessary to segment and decouple the input data in order to improve the computational efficiency when carrying out such large amount of data, intensive calculation and long running time operations. IO control system can decompose such jobs into several sub-jobs for parallel processing, so as to shorten the running time, improve the efficiency of seismic data processing and enhance the computing performance of cluster system.

1. Introduction
With the development of geophysical prospecting technology, seismic operation processing is terabytes of data in actual production. A seismic operation processing time can be as long as ten days. In order to complete these processing tasks in as short a time as possible, efficient use of node resources is needed. Therefore, it is necessary to segment and decouple the input data in order to improve the computational efficiency when carrying out such large amount of data, intensive calculation and long running time operations.

2. Data separable job
Efficient IO control of seismic data is a necessary step in the process of seismic data processing. Job scheduling can allocate available computing resources for submitted jobs and deal with abnormal situations when jobs are running. Job management through the platform can improve the efficiency of computer utilization and the computing performance of cluster system.

Separable jobs refer to jobs that can be divided into a number of sub-jobs, which are independent of each other and have no data dependence and operation dependence. The submission, scheduling, IO control part of this kind of job will implement job parsing, data segmentation, job distribution start-up, data collection, state feedback and other functions. For the operation of data separable jobs, the main control program is needed to complete the operation of data separable jobs. The sub-jobs are sent to the sub-nodes in the form of common job requests, which realizes the decomposition of jobs and parallel batch submission.
2.1. The structure framework of data separable job
Data separable job processing framework receives job requests from server to start job IO control process according to job scheduling system. Job IO control process parses job files, dynamically loads function modules to complete the processing of corresponding jobs, and returns the mode of job execution status to process jobs. Specifically, job scheduler sends jobs to the master node, and other idle computing nodes IP are sent to the master node. The master node starts the master IO control, analyses the data, calculates the number of sub-jobs and the data range of each sub-job according to the segmentation strategy described in the job. The master node partitions the job file. The master node distributes sub-jobs to other idle nodes to run sub-IO control system and perform sub-job processing. The sub-node starts IO to control process to read the data from the master node and send the calculation results back to the master node. The master node merges the temporary data files of the child nodes into the final output data files of the job.

![Figure 1. The structure framework of data separable job](image)

2.2. IO control of data separable job
Data separable job IO control program is the underlying core program that describes, parses and submits operations for processing jobs. Data separable job IO control software provides a control execution software system that can complete job parsing, job IO control and job runtime information output function. It helps to improve the monitoring ability of job operation, enhance job runtime information output ability and exception handling ability.

![Figure 2. IO control design for data separable jobs](image)

The main technologies of data separable job IO control system implementation process are as follows:
(1) Job Parsing Technology: Parsing input and output data file names from job files.
(2) Data Segmentation Technology: According to different segmentation strategies, the file is divided.

(3) Job Distribution Startup Technology: The distribution of sub-jobs is initiated through job scheduling system. Create job run requests and distribute them to each node. The job type in the job run request is set to the normal job type. When a node receives a job execution request, it calls the execution function according to the common job type to start the job execution process.

(4) Dynamic Data Collection Technology
After the sub-job process runs, it feeds back the completion status of job execution to the primary node. According to the temporary file strategy of sub-job data, the master node merges the temporary files output by sub-job into one data file. At the same time, the temporary data file of the sub-job is deleted and the completion status of the job is reported to the server.

(5) State Feedback Technology
In addition to reporting the current status to the server, the sub-job process also reports the current status to the primary node. The master node reports the status of job completion to the server after completing data merging.

3. IO Control System for Data Sepaurable Job
IO control program is an important part of modern geophysical prospecting processing software. It is the core of processing system. IO control system organically links all processing modules in series to form processing flow and complete seismic data processing tasks. The main task of IO control program is to analyze and submit the operation of work flow.

In the process of seismic data processing, the processors may use hundreds of functional modules. These processing function modules need to be integrated into the workflow, run directly on the computing nodes or run in batches. At this time, we need a job IO control system program to describe, translate and control the execution of the jobs defined by the processors, and finally get the seismic data processed by the functional modules. Job IO control system can solve the problems of weak IO control, poor exception handling ability and inconvenience for job management and scheduling in pipeline mode. By strengthening job operation control, information output ability and monitoring ability of job operation are enhanced, and exception handling ability of job operation is improved.

3.1. Structure framework of job IO control program
Operational IO control system consists of four parts (as shown in Figure 3): (1) Job interactive editing software, which mainly completes job editing and submission; (2) Job server and scheduler, complete job status management and scheduling; (3) Calculating the node residence program, completing the resource acquisition and starting the job control process; (4) Job IO control program, realizing the specific operation of the job. The communication platform is responsible for the communication between the above four parts, which is realized by sending messages, in order to control the operation of complex operations and complete seismic data processing.
Job IO control system is the underlying core program that describes, parses and submits operations for processing jobs. Job IO control system software provides a control execution software system that can complete job parsing, job IO control and job runtime information output function. It can improve the monitoring ability of job operation, enhance job runtime information output ability and exception handling ability. The overall framework of job IO control is shown in Figure 4.

3.2. Implementation of job IO control program

Node resident process receives job requests from server to start job IO control process. Job IO control process parses job files, dynamically loads function modules to complete the processing of corresponding jobs, and returns job execution status. Five modules are designed to complete the function of IO control program, including functional module base class, functional module dynamic loading, job parser, data adapter and IO control main program module.

Function module base class provides a unified programming interface for all functional modules, provides thread time-driven, and default processing of various events. At the same time, it provides functions that other functional modules will call (data processing main cycle, function module thread processing, debugging output, etc.).

Job (function module) has its inherent characteristics compared with conventional programming: the name of the executor (dynamic link library) of the function module is known only at runtime; the topological connection mode of the module is known only at runtime; and the parameters of the function module are known only at runtime. The system uses dynamic loading technology and parameters of dynamic configuration function module to solve the above problems.

Job parser can parse all parameters of Xml job file. Job parser is called by IO control program to analyze job steps, function modules, topological connections and parameter information.

Data adapter is mainly used for matching data formats of functional modules, so that seismic data can be read and calculated normally.

IO controls the main program to complete job parsing, module dynamic loading, topological connection, parameter setting, function module thread start, multi-thread running job, waiting for exit of the job process.

At the same time, each part is linked through the operation file, and the coupling degree between them is small, which is easy to maintain. At the same time, the operation IO control system software also has better robustness.

Dynamic loading job IO control technology system has strong IO control power. It can realize complete parameter analysis information output and job operation information output, provide effective exception handling mechanism, and meet the processing requirements of various complex jobs.
3.3. Cooperative operation of modular jobs

The cooperative operation technology of modular jobs driven by seismic data is very suitable for software systems centered on job processing. In seismic data processing, some processing operations are usually taken as a whole, and the input seismic data are output to the next processing step after the same operation. The smallest separable unit of input data is a seismic channel. According to the relationship between seismic traces and operational function modules, input data can be input to the input of functional modules in the way of one seismic traces in turn. In the form of data flow, a topological connection relationship among all functional modules in a job is established. For a functional module, as long as the data (channel) arrives, it can be calculated, which is conducive to improving the efficiency of seismic data processing.

The data between functional modules is mainly realized by input and output port classes, which manage the creation of shared memory. The subsequent function module fetches data from the output port buffer of the previous module through the input port, and the data processed by the operation of this function module is written into the output port buffer of this function module.

![Figure 5. Output port connect to follow-up function modules](image)

The input port reads data from the associated output port. Because each function module reads data at different speeds, the position of each subsequent function module reads is different. But when and only when the data is read by all subsequent functional modules, it can be written to cover. The length of data that can be read by all subsequent functional modules is the data from the reading position of the subsequent functional modules to the starting position of the output port. The read-write (ring buffer) of shared memory is a ring buffer simulated by using a block of memory pointed by a pointer, so when reading and writing data, if the end boundary is involved, it needs to be read or written twice.

![Figure 6. Shared memory design diagram](image)
When the input port reads the data, it notifies the associated output port that the data has been read. When the data is read by all the related input ports, the output port updates the write pointer position, and the data buffer can be covered by the new data.

When the output port writes new data, it notifies the associated input port that new data is readable; when the input port has no data port to read, the output port updates the write pointer position, and the data buffer can be covered by the new data.

When the output port writes new data, it notifies the associated input port that new data is readable; when the input port does not write data, it sets up the data and maintains the read status information of the associated input port data.

Data separable job IO control system forms the cooperative operation technology of modular job, realizes the further research of the cooperative operation program of modular job based on shared memory, expands the type of data interaction, improves the operation efficiency, and enables it to provide more high-quality service for the efficient operation of modular job.

4. Conclusion
When the input port reads the data, it notifies the associated output port that the data has been read. When the data is read by all the related input ports, the output port updates the write pointer position, and the data buffer can be covered by the new data.

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Acknowledgments
The paper was supported by the national project numbered 2016ZX05023-004 and we also appreciate the contributions of our colleagues.

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