The Research on Data-Intensive Resource Scheduling in Intelligence Processing

Cui Yun-fei, Li Yi, Liu Dong, Li Kang, Lv Peng

***Abstract*—Based on the requirements and process of data processing, this paper contrives a multi-evel and multi-stage resource scheduling model in information processing, which will implement unified resource management and dynamic resource scheduling. This paper researches information processing resource scheduling from user-level resource allocation and task-level resource scheduling. It comparative analysis different scheduling needs of pre-processing stage and data sharing stage. And then, this paper presents data processing models for each stage and introduces scheduling algorithms, which are suitable for different stages. *Abstract*—Based on the requirements and process of data processing, this paper contrives a multi-level and multi-stage resource scheduling model in intelligence processing, which implements unified resource management and dynamic resource scheduling. This paper researches resource scheduling of intelligence processing from both user-level resource allocation and task-level resource scheduling. On contrast of different scheduling needs of pre-processing stage and data sharing stage, this paper presents data processing models for both stages as well as scheduling algorithms, which are suitable for different stages.**

***Index Terms*—intelligence and reconnaissance systems; multi-level; multi-stage; data processing; resource scheduling**

I. INTRODUCTION

In the era of information warfare, the one who can catch the necessary information quicker and more effective, as well as process massive information more efficient, transform information superiority into decision superiority, will grasp the dominance of information warfare. In recent years, intelligence data gradually emerges characteristics such as massive growth, polymorphism, dynamic and data intensive. Thus, it is necessary to build a data-intensive intelligence processing system, which is integrative, high scalable and high available. It is the key to transform information superiority into decision superiority on battlefield of information warfare. Methods designed for system-level resource allocation will improve the operating efficiency of the entire intelligence processing system. And resource scheduling algorithms which are designed for specific intelligence processing tasks, can reduce execution time.

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II. INFORMATION PROCESSING OF INTELLIGENCE AND RECONNAISSANCE SYSTEMS

Intelligence processing system can provide valuable intelligence, which is useful to make decisions on battlefield, to commanders by coordinating, analyzing, picking-up, and compositing the original information obtained by sensors. To process information timely, efficient and accurate is very important for effective use of intelligence information, and is a key factor to transform information superiority into decision superiority. Intelligence process includes data pre-processing (format conversion), information storage, processing, logistic analysis and output [1,2]. Fig. 1 shows the basic flow of information processing.

As for intelligence data gradually emerges characteristics such as massive growth, polymorphism, dynamic and data intensive, this paper researches data-intensive resource scheduling in intelligence processing.

At present methods for data-intensive scheduling are mainly improved Algorithms, based on Map-reduce [3] and Dryad [4]. These Algorithms try to improve operational efficiency, on the basic of fairness and data locality. Researches on data-intensive scheduling methods mostly concentrated on the scheduling algorithm improvements. The typical scheduling methods are FIFO scheduling, HOD scheduling [5], fair scheduling, delay scheduling [6], minimum cost flow scheduling [7], as well as improvements to these scheduling algorithms.

These scheduling algorithms mentioned above all focus on job-level scheduling for entire system. However data-intensive resource scheduling systems faces several challenges as follows. ①Global synchronization for entire system is costly, which makes single-point scheduling a bottleneck. ②Resources in data-intensive system are heterogeneous, and the ability of different resources to handle different jobs is different. ③Failure becomes normal, and how to solve the scheduling problems brought by the failed node becomes a problem. ④Data-intensive environment is dynamic, which needs dynamic resource scheduling to improve the utilization of system resources.

In response to these challenges, Gunho Lee proposed a dynamic resource allocation and scheduling model for data-intensive environments [8], and researched allocation methods and scheduling algorithms. However, this model only introduced multi-level scheduling for data-intensive applications, which cannot meet the demand of data processing and sharing of intelligence and reconnaissance system, cannot achieve unified dynamic management for overall resources. LI proposed a multi-level scheduling algorithm based on fuzzy clustering [9]. It used fuzzy clustering method to cluster resources according to their capabilities and computed tasks' resource bias coefficient according to their parameters. Thus tasks with different resource preference were able to choose different capability resources in the corresponding clusters. The new algorithm reduces the scale of resource choice, reflects cloud tasks' service requirements better. It aims at achieving low-cost on-demand services for public cloud which has many service providers. Ali cloud designed flying large-scale distributed computing systems [10], achieving resource hierarchical scheduling through "wholesale and retail" and "the planned economy in the form of the market economy ". The methods above are designed data-intensive resource scheduling methods from the view of heterogeneous resources and hierarchical scheduling. And the resource allocation and scheduling are in allusion to data which is already distributed storage. However, these methods don't consider user needs, system resource utilization rate and task execution time enough.

Intelligence process of intelligence and reconnaissance systems includes data pre-processing (format conversion), information storage, processing, logistic analysis and output. The pre-processing stage is compute-intensive, aimed at data format conversion and data storage. Other four steps are data-intensive, aimed at data analysis, data mining and data sharing. This paper researches how to achieve unified and dynamic scheduling of heterogeneous resources on the basic of avoiding single point bottleneck. According to demand mentioned above, a multi-level and multi-stage resource scheduling model in information processing is brought forward.

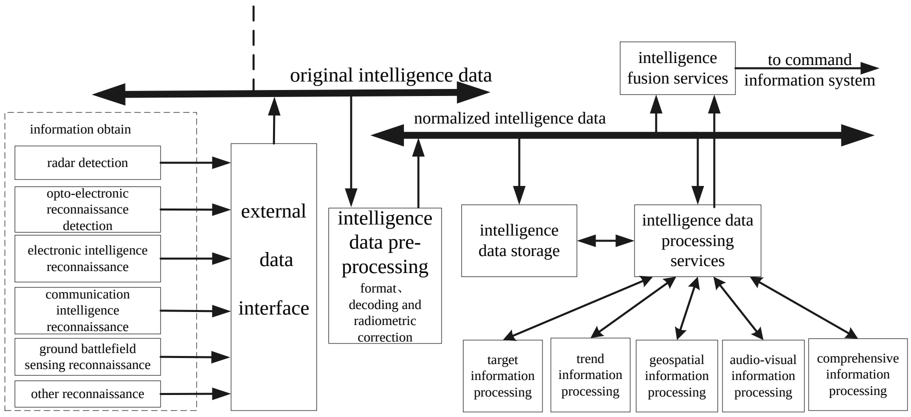

Fig. 1 the data processing workflow of intelligence and reconnaissance systems

III. MULTI-LEVEL AND MULTI-STAGE RESOURCE SCHEDULING MODEL ON INFORMATION PROCESSING

A. Multi-level and Multi-stage Resource Scheduling Model

According to data processing flow of intelligence and reconnaissance systems, a multi-level and multi-stage resource scheduling model is designed, as Fig. 2

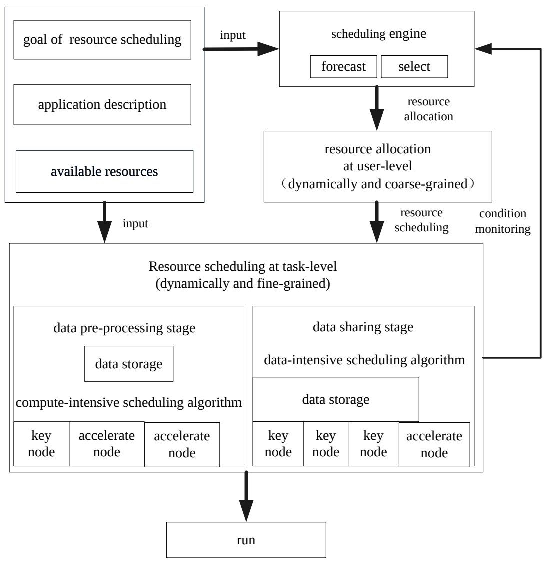

Fig.2 the multi-level and multi-stage resource scheduling model on data-intensive information processing

The scheduling model shows multi-level and multi-stage resource scheduling workflow. Input information includes: the goal of the resource scheduling (minimum completion time and system proceeds), application description (application characteristics, application demand for resources, etc.) and available resources (the type of available resource, resource topology, etc.). Based on input information, the scheduling engine allocates available resources to applications (user-level resource allocation), and dynamically increases or recycles resources to achieve dynamic scheduling. The task-level resource scheduling matches tasks and processing resources. Corresponding to the flow of intelligence information processing, task-level resource scheduling includes scheduling for data pre-processing stage (compute-intensive scheduling) and scheduling for data sharing stage (data-intensive scheduling).

The multi-level dynamical resource scheduler is divided into multi-layers, each one answers for its own platform to implement scheduling. When the platform resources are insufficient to complete the work of information processing, the scheduler will request higher level scheduler for other resources. Of course, if there are remaining resources, then the higher level scheduler will take initiative to recycle excess resources. The multi-level scheduling model implements overall-scheduling at user-level and micro-scheduling at task-level at the same time. This can help to reduce the size of the problem, reduce the scheduling pressure of the central node to avoid single point failure. According to characteristics of resources and users' preferences, selecting appropriate resources can reduce resource selection overhead, avoid blindness, and easy to implement extensions, fault tolerance and co-allocation.

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The multi-stage scheduling, according to data processing flow, can adopt different methods for different stages of data processing. At data pre-processing stage, the scheduler should schedule data to application, while scheduler application to data at data sharing stage. Scheduling data to application for pre-processing tasks can select computing power node to focus on calculation. Scheduling application to data for data sharing tasks can use data locality to reduce the data transmission as to avoid network transmission bottlenecks, in order to improve resource utilization.

B. The Key Technologies in Multi-level and Multi-stage Resource Scheduling Model

The goal of multi-level and multi-stage resource scheduling model is to achieve information processing resources unified management and dynamic scheduling. User-level resource scheduler allocates resources to user-level applications, and dynamically increases or recycles resources. Task-level resource scheduler adopts different scheduling methods, according to the difference between compute-intensive tasks and data-intensive tasks, to improve the efficiency of task execution and resource utilization.

a Resource Scheduling at Data Pre-processing Stage

At data pre-processing stage, data storages centrally on the data receiving apparatus, and needs for format conversion. The data processing flow shows in Fig. 3.

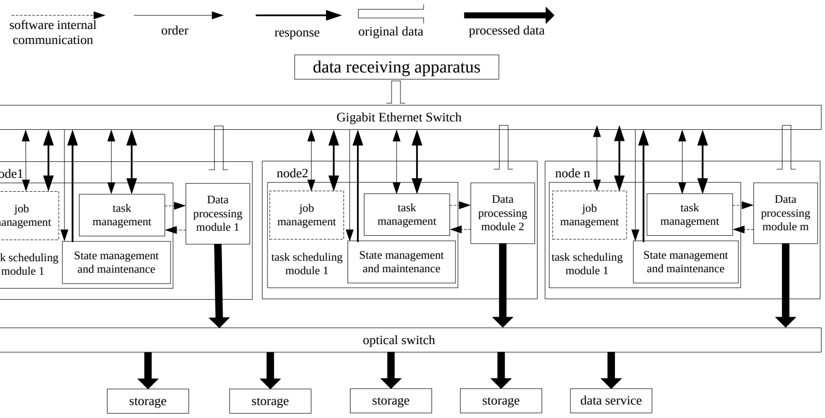

Fig. 3 the data processing workflow at data pre-processing stage

At data pre-processing stage, only one job management module is started to be responsible for scheduling of data processing resources. The task management module is responsible for resource monitoring, task monitoring and interacting with job management module. Compute node read the original data from the data receiving device via network, and process it. The main task of data preprocessing stage is data format conversion. After conversion the data will be distributed stored in the information processing system for data sharing stage. At the same time, a part of the data after format conversion can be directly provided to users as service.

The resource scheduling at data preprocessing stage mainly considers computing capacity of the computing nodes, and schedule data to nodes for processing. And mature scheduling algorithms can be adopt, such as random load balancing algorithm, minimum execution time scheduling algorithm, minimum completion time scheduling algorithm, Min-min algorithm, Max-min algorithm, genetic algorithm (GA), simulated annealing algorithm (SA), genetic simulated annealing algorithm (GSA), neural networks, ant algorithm, taboo scheduling algorithm (Tabu) algorithm and etc.

b Resource Scheduling at Data Sharing Stage

At Intelligence information sharing stage, the data for processing has already been distributed stored in the system, and the nodes storing data have a certain amount of computing capacity. The data processing flow shows in Fig. 4

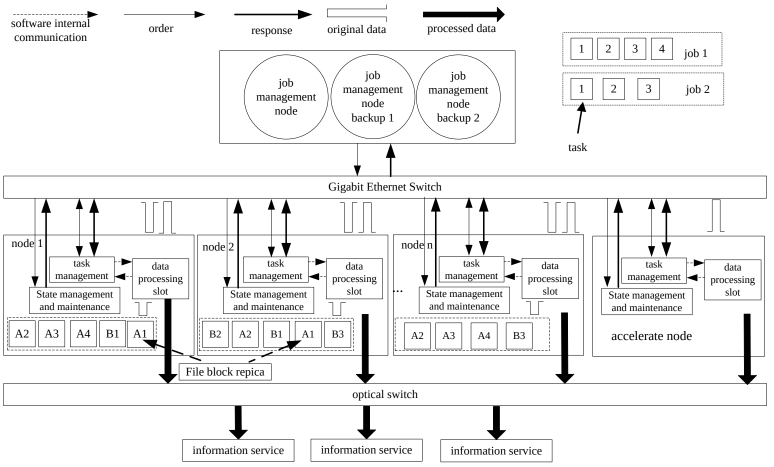

Fig. 4 the data processing workflow at data sharing stage

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Data processing at data sharing stage is a data-intensive data processing, and data files are managed by Distributed File System. Each file is divided into a number of equivalent file blocks, which are distributed at compute nodes in the data center. In order to ensure the reliability of the file, there are some replicas for every block. When processing a file, the management node will divide data processing the job into several independent tasks (such as Map-Reduce, one job consist s many tasks). Each task is responsible for a block of input data file. The job isn't completed until all tasks are complete. As shown in Figure 4, file A will be processed by job 1 while file A will be processed by job 2. Because file A consists four file blocks, job 1 is divided into four tasks, empathy, job 2 is divided into three tasks. [5-8, 11]

The differences between information sharing stage and data pre-processing stage are different storage location of original data and different amount of calculation of tasks. At data pre-processing stage, original data is stored in data receiving apparatus, and the tasks are mainly format conversion. At information sharing stage, original data is distributed in computing nodes in the system, and the tasks are mainly data comparison. Therefore, data locality, fairness, and node computing capability should be synthetically considered at information sharing stage, especially data locality. If data locality is difficult to meet, accelerate nodes will be adopt to increase processing speed, sacrificing data locality. Data-intensive resource scheduling methods are required, such as FIFO, fair scheduling, delay scheduling, minimum cost flow scheduling.

IV. Conclusion

The workflow of information processing of intelligence and reconnaissance systems can be divided into two stages: data pre-processing stage and data sharing stage. The tasks in pre-processing stage are compute-intensive, while the tasks in sharing stage are data-intensive. The multi-level and multi-stage resource scheduling model can achieve unified resource management and dynamic resource scheduling, while avoiding single point of failure. Adopting different scheduling methods, according to different workflow in different stage, will improve the efficiency of system operation.

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