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THE PARALLEL STRATEGY OF A LARGE SCALE SIMULATION ABOUT TEN MILLIONS NODES TO RESERVOIR WITH MULTIPLE LAYERS

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Abstract. Aim at large scale fine reservoir numerical simulation application research on Shenwei computer, the multilayer two dimension two phase parallel software transplanted successfully and a large scale integral simulation about ten millions nodes were realized in the environment of Shenwei parallel computer. The whole preconditioning alternating Schward and another many improved algorithm, the parallel optimal methods about coefficient matrix and saturation calculation made the parallel efficiency increased effectively about multilayer two dimension two phase parallel software. Especially the deep research about the communication and load-balanced technology fitting for Shenwei computer make the parallel function of the software to large scale increase. The multilayer two dimension two phase parallel software transplanted and the parallel computer resource of homegrown Shenwei high behavior parallel computer with 112 CPUs was to simulate the production history of 12 sandgroups of the second Shahejian in second block of Shengtuo. The simulation scale is 10 millions nodes and the time exhausted is about 5 hours which satisfies the application requisition of reservoir simulation. This verifies the reliability and stability of the software and makes the whole parallel efficiency to 79%. It is first time to bring out the independent copyright reservoir simulation parallel software with satisfactory back and forth processing function in homegrown Shenwei computer. Especially the application of the whole preconditioning alternating Schward region decomposition algorithm, the deep research of load-balanced technology and the large scale application etc. are all innovative.

Key Words. reservoir simulation, parallel calculation, model, speedup

1. Foreword

High-behavior computer is usually used for large scale parallel calculation in fields of national defence, meteorology and air/space technology, etc. In July, 2000, homegrown Shenwei computer, a huge computer system, came into the world. It is very suitable for such calculation. The key of reservoir numerical simulation is to solve large-scale sparse linear algebraic equation group-formed from large-scale partial differential one, which needs mass of time. But it is a kind of parallel calculation which can be done on various parallel computers. In this paper, parallelization of reservoir numerical simulation and its application has been studied using ShenWei computer and the multilayer two dimension two phase parallel software (developed by ourselves). Also parallel strategy and parallel optimization is probed with good effects. The simulation scale is 10 million blocks and the time exhausted is about 5 hours.

2. Characteristics of Shenwei computer

Shenwei computer is a home-developed, huge computer system used for large scale parallel processing. Considering users' requirements, it is designed to be a super parallel processing system with multiple instruction-flows/data-flows. It is characterized with fast calculation speed, large memory capacity, high efficiency, rich software collocation with completed function and good PFK, friendly interface which is easy to study and use, stable and reliable function which makes maintenance and re-assembling convenient. It is made up of host computer system, front end, disk array and software with main system of isomorphism ,distributing sharing, framework of planar grid- cubicle-net and 384 CPU. The highest calculation speed of this system amounts to 384 billion times per second.

3. Parallelization of multilayer two dimension two phase software

Multilayer two dimension two phase parallel software is adapt to numerical simulation of terrestrial facies, layered, low-saturation, water-flooded sandstone reservoir. According to features of such reservoir, synchronous parallelization of interlayer and intralayer is adopted using region decomposition algorithm on Shenwei computer.

3.1. Parallel strategy. In terms of characteristics of Shenwei computer, the key technical strategy of software parallelization mainly aims to tackle two problems as follows. The first is how to realize large scale simulation and the second is how to make multilayer two dimension two phase software fit to high behavior and huge parallel computer. To solve the former problem, distributing-sharing storage techniques are adopted and for the latter one, multilevel parallelization is used.

3.1.1. Design of distributing-sharing storage manner. Distributing-sharing is one of storage manners usually used by MPP. It can be classified into two categories: Cache or non-Cache. In the former system, one CPU should visit local Cache firstly before visiting other CPU. If local Cache can not be reach, then it can visit a remote CPU. While in latter system, one CPU can visit a remote CPU directly to obtain contents he wants. In terms of contents which are modified frequently by many CPU, the efficiency of Cache distributing-sharing will be higher than that of non-Cache one. In terms of contents which are not modified frequently by many CPU, the efficiency of Cache distributing-sharing will be much more higher. In this study, sharing data should be visited and modified only during major process process, so Cache distributing-sharing will be more effective. Distributing-sharing storage technique is designed and applied.

Without distributing-sharing storage, the largest simulation scale of Shenwei computer with 512M main store capacity will be about 3.5 4 million blocks . If 4 CPU–each with 256M distributing-share capacity-are adopted, totally 1G capacity will be obtained. Then the largest simulation scale will be increased dramatically and amount to 10 11 million nodes. Furthermore, If 16 such CPU are adopted, the largest simulation scale will be above 40 million blocks. The application of distributing-share is an effective method to enlarge storage capacity. Thus, different simulation scales can be realized.

Without distributing-share storage, the largest simulation scale of Shenwei computer with 512M main store capacity will be about 3.5 4 million nodes. If 4 PES–each with 256M distributing-share capacity-are adopted, totally 1G capacity will be obtained. Then the largest simulation scale will be increased dramatically and amount to 10 11 million nodes. Furthermore, If 16 such PES is adopted, the largest