Infrastructure of Grid-based Distributed Remotely Sensed Images Processing Environment and its Parallel Intelligence Algorithms

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Abstract: There is a growing demand on remotely sensed and GIS data services in modern society. However, conventional WEB applications based on client/server pattern can not meet the criteria in the future. Grid computing provides a promising resolution for establishing spatial information system toward future applications. Here, a new architecture of the distributed environment for remotely sensed data processing based on the middleware technology was proposed. In addition, in order to utilize the new environment, a problem had to be algorithmically expressed as comprising a set of concurrently executing sub-problems or tasks. Experiment of the algorithm was implemented, and the results show that the new environmental can achieve high speedups for applications compared with conventional implementation.
KEY WORDS: Grid Computing, Parallel Computing, Distributed Environment, Clustering, Speedup, Remote Sensing.

1. Introduction

With the development of the earth observation technique, a data acquisition system by remote sensing with multi-temporal, multi-resolution, multi-sensor, and multi-band is coming into being, which can take us vast amount of remotely sensed data every day. However, although with huge volume of reserved data, valuable information is very few to practical applications for the lack of processing methods which are fast and effective.

In remote sensing fields, image with high spatial resolution has being applied by users more and more widely, especially on applications related to geo-object recognition and geo-information extraction. Toward those applications, image segmentation and classification are measures indispensable. Although with thorough study for years, the time complexity of computation has always been as a difficulty, such as texture feature, which is more serious toward applications on high spatial resolution remotely sensed images. Parallel computation has been a topic of general interest on high performance computation for years, with quite limited applications on remote sensing up to now, especially to complicated tasks, such as image segmentation, for the expensiveness high performance parallel computing system, as well as its low availability in distributed WEB environment.

The incoming grid computation takes ways to those problems, which can reduce the difficulty on utilizing the character of high performance computation through parallel system such as cluster.

In this paper, framework of parallel processing system of remote sensing data in grid environment is presented firstly, and then, parallel algorithm for parallel texture segmentation of remote sensing image was implemented, with detailed experiment shown at last.

2. Grid-Based Distributed Remotely Sensed Images Processing Environment

Parallel computing has being developed for years with the increasing need of high performance computation. However, it has not been full of used for its high price. In recent year, cluster computation, which was characterized by its high ratio of performance with price, has been paid great attention by researchers. Anyway, it is also hard to be integrated with the common applications based on WEB for public.

Grid computation, as an advanced idea for establishing a uni-model which can provide the mechanism of sharing all kinds of resource included in the distributed network environment toward common WEB-based applications easily.

In order to utilize grid computation for remotely sensed data processing, it is necessary to establish the software architecture for parallel remotely sensed data processing toward grid computation environment, which can be outlined as follow:

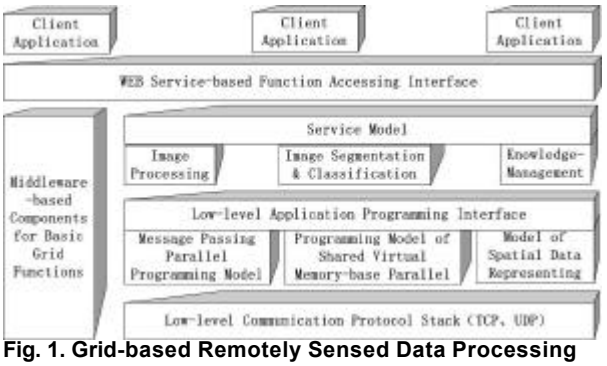

Fig. 1. Grid-based Remotely Sensed Data Processing Environment.

The architecture is composed of six parts:

- Low-level Communication Protocol Stack, such as TCP and UDP, whose function is mainly to provide basic communication facility for implementation of upper-level distributed applications.
- Middleware-based components for Basic Gird Functions, which provide the basic operation mechanism following the grid computing definition.
- Low-level Application Programming Interface, which provides the basic implementation facilities for parallel processing environment of remotely sensed data beyond distributed network environment.
- Service Model, which provides basic domain regardless functions for image-related processing with unified software design pattern.
- WEB Service-based Function Accessing Interface, which provides system services of remotely sensed data processing to client applications with unified web service interface standard defined by OGSA.
- Client Applications, which can be all kinds of those related to remotely sensed data application, for example, geo-object extraction and recognition, Landover change detection, etc.

3. Experiment of Parallel Texture segmentation of Remotely Sensed Images

Texture-based image Segmentation is indispensable for applications of high spatial resolution remotely sensed images, which is high time-complexity in most cases. Therefore, it is necessary to introduce parallel computation, which is also an advantage provided by grid computing. Here, parallel texture segmentation experiment based on concurrent matrix is introduced as an example for this problem.

3.1 Texture Segmentation Based on Concurrent Matrix

Gray scale concurrent matrix is a common method for texture segmentation of images, which has been full of used in image segmentation. However, the algorithm to compute the matrix and its derivate is of high complexity on time.

Here, parallel processing was introduced to the task. Texture feature is composed of five statistical variables computed from the matrix, which are:

$$\mathrm{ASM} = \sum_{i=1}^{N}\sum_{j=1}^{N} P_d(i,j)^2 \qquad (1)$$

$$\mathrm{ENT} = \sum_{i=1}^{N}\sum_{j=1}^{N} P_d(i,j)\cdot \log P_d(i,j) \qquad (2)$$

$$\mathrm{HOM} = \sum_{i=1}^{N}\sum_{j=1}^{N} P_d(i,j)/[1+(i-j)^2] \qquad (3)$$

$$\mathrm{DIS} = \sum_{i=1}^{N}\sum_{j=1}^{N} |i-j|\cdot P_d(i,j) \qquad (4)$$

In addition, mean value of the textured area was also utilized as an index for image segmentation. Based on the extraction of texture feature, image segmentation was implemented by unsupervised spatial clustering process.

3.2 Result

Parallel processing was implemented by separating data of image into several parts for feature extraction with multi-processes on different computers. Result of the experiment is shown as follow.

Table 1. Experiment Result Table.

Image Size	Node Num	Time(s)	Speed Up Ratio	Efficiency
128*256	1	6.600	1	1
	2	3.600	1.83	0.92
	4	1.900	3.47	0.87
256*256	1	13.900	1	1
	2	7.410	1.88	0.94
	4	4.100	3.39	0.85
512*512	1	52.800	1	1
	2	29.600	1.78	0.89
	4	16.000	3.30	0.83
1024*1024	1	215.000	1	1
	2	122.000	1.76	0.88
	4	64.500	3.33	0.83
2048*2048	1	870.000	1	1
	2	499.000	1.74	0.87
	4	265.000	3.28	0.82

4. Conclusion

Architecture of Grid-based parallel remotely sensing image processing environment was proposed, which was proper for intensive computation task and easy for WEB integration. Next step is to develop middleware-based components for the real gird-based implementation of this architecture.

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