GEO-BASED IMAGE PROCESSING ON MOBILE CLOUD COMPUTING ENVIRONMENT

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KEY WORDS: Cloud Computing Service, Mobile Device, Geo-based Image, Image Processing, Open Source

Abstract: It is known that cloud computing service shows many advantages such as economic cost, flexible scalability, improved security, sharing and excellent accessibility. Accordingly, it is growing very fast in the information communication technology (ICT) fields, and will be expected to be used in various real world problems. Among several application models with cloud concept, mobile cloud computing service is one of cloud computing services, which mean combination of cloud computing with the mobile services. In terms of the ripple effect, applicability and development possibility, mobile cloud computing is highly evaluated, because of popularity of mobile devices. Another keyword in this study is a geo-based image. This is used to various applications for remote sensing processing, and especially using to useful source for visualization in the map services by many web portal service providers through mobile or desktop web browser. Although the result of geo-based image processing by certain analysis algorithms is significant to interpret surficial phenomena, most map services are focused on geo-based image visualization, so that image processing or analysis functions and their results is not provided in current map services applications yet. It is expected that mobile cloud computing service and geo-based image processing service can be generating synergy effect. This study is design and implementation of the mobile app for geo-based image processing and visualization based on mobile cloud computing service and open source concept. Considerations to mobile app development in cloud computing environment are describing in this study such as image processing core module, processing or analysis speed and multi device user interface. In conclusion, this study is the first approach to provide analysis function services with respect to geo-based image in mobile cloud environment.

INTRODUCTION

The mobile devices and cloud computing services are regarded as important keywords in global industries and ICT fields, and recently mobile cloud computing services combined cloud computing services and mobile environments are receiving attention. One of keywords in this study is cloud computing services that are divided into private cloud, public cloud, and hybrid cloud according to operating type, or are divided into IaaS (Infrastructure as a Service), PaaS (Platform as a Service) and SaaS (Software as a Service) according to service type. These cloud computing services have advantages such as economic cost, flexible scalability of hardware resources, convenient parallel processing environment, and excellent accessibility through various devices or web browsers, and is being gradually expanding in the industrial world. Another one of keywords in this study is mobile devices, and smartphone and tablet pc are typical examples. These mobile devices can be used various apps for information search, social network, game, utility, etc., and are thereby providing high value to users, and also many users are experienced mobile devices. Recently, companies and general users are wanted to use mobile apps that are professional information processing functions and business assistance. Hardware specs of mobile device have steadily grown; nevertheless mobile apps are limited to users since the mobile devices have resource lack aspects and mobility problem. But mobile apps can be providing information processing functions of high level through mobile cloud computing services. However, the study and product development in remote sensing fields based on mobile cloud service are the beginning stage still.

The information processing of remote sensing fields on mobile devices is not easy, because the remote sensing domain are generally used to large scale dataset, and required a lot of time in information processing. But geo-based image processing and large scale dataset processing on mobile will be possible through mobile cloud computing service. The mobile app for geo-based image processing used mobile cloud computing service was developed in this study based on Kang and Lee (2010 and 2012), and applied parallel programming for improving speed of geo-based image processing. Also measured time how long takes to information processing. The developed mobile app in this study was tested on the cloud computing environment of three types. The cloud computing environments were configured unlike previous study Kang and Lee (2012), and also image processing module was using different

algorithm with previous study. This study is an example using IaaS of cloud computing services in remote sensing fields. As the previous research related to this, Armbrust *et al*. (2009) analyzed cloud computing in economics aspect, new application opportunities aspect, and obstacle aspect. Zhang *et al*. (2012) summarized key technologies of cloud computing such as virtualization, storage, parallel programming model and data management. Sriram and Ali (2010) classified researches of cloud computing into six categories. Fernando *et al.* (2013) survey related to mobile cloud computing research. Lee (2012) suggested that cloud computing paradigm provides a new pattern for deploying a geo-spatial application. Kim and Lee (2012) developed mobile web for 3D geo-based image visualization using AWS (Amazon Web Service) EC2 (Elastic Compute Cloud).

MOBILE CLOUD COMPUTING SERVICE

For mobile cloud computing services, there are many definitions, but the mobile cloud computing services in this study were used to mean that it is information processing and visualization of result using cloud computing environment resources in mobile devices. Thus, it is possible to use advantages of cloud computing service in mobile. The mobile cloud computing services can be providing the following synergies for developers and users. First, the developer can be easily constructed that parallel processing computing environment through cloud computing service. The developed mobile apps based on parallel processing environment and cloud computing services are able to do providing very fast information processing service and large scale dataset to users, because information processing modules or functions of the mobile app is processed from cloud computing environment. Second, the mobile apps based on cloud computing services can be smoothly provided to service when the users are very quickly increasing at the same time, because the cloud computing services are possible to flexible scalability of hardware resources, and AWS ELB (Elastic Load Balancing) is a good example. Third, the mobile cloud computing service is possible to overcome the limitations of mobile devices storage through data management based on cloud computing services. Also data in various devices without relation to time or location is available as sharing and using. Fourth, the maintenance management costs of cloud computing services are inexpensive in comparison with generally data warehouse. Fifth, mobile cloud computing services can be able to do bug patch and function upgrade without redistribution of mobile app. This point is important in the user convenience aspects. Thus, mobile cloud computing services are economical, and have potential and vision. Because of these points, mobile cloud computing services can be providing high value to users and companies.

GEO-BASED IMAGE PROCESSING USING CLOUD COMPUTING ENVIRONMENT

It is possible to get the useful information from geo-based image through various information processing algorithms. But mobile apps based on geo-based images have been mostly focused on visualization of original images until now. Kang and Lee (2010 and 2011) were developed the mobile app for the geo-based image processing function, and implemented mobile app using cloud computing services in this study. Many considerations for the mobile app developments of providing geo-based image processing are existed. The information processing speed is very important consideration based on mobile. Generally, the parallel programming techniques are good in order to improve the processing speed, and the cloud computing environments are easy to apply parallel programming techniques. Therefore, this study was developed mobile app using parallel programming and cloud computing service, and developed mobile app can be possible to provide fast service of geo-based image processing to users. The source codes for parallel programming were coded using Python Parallel (PP). Parallel programming languages, models, and interface are very varied. In this study, selected PP as parallel programming, because PP is supporting various computing environment such as SMP (Systems with multiple processors or cores), clusters, cross platform, and cross architecture, and is providing convenient programming methods based on Python. Also image tiling can be improved the processing speed and image visualization speed. Another consideration is the image processing core module. This is essential to the image processing procedures in mobile app, and is related to the performance of mobile app for image processing. OTB (Orfeo Tool Box) is one of various image processing core modules, and is providing various algorithms and programming language, and also has continually updated stability until now. Therefore, OTB as core modules of the image processing was selected. Also the multi device user interfaces is one of the consideration for mobile app developments. It is possible through using of HTML5 and Media Query.

Cloud computing environments for geo-based image processing mobile app form three types, and Table 1 represents specification of the configured cloud computing servers. The configured AWS EC2 - Single Server has a single ECU, and not applied parallel processing. This server was used to compare with other configured servers. Meanwhile, AWS EC2 - Quadruple Server is consisting of quadruple t1.micro instance that can be basically created free from EC2 service, and the t1.micro instance can be expanding CPU capacity during short time. And AWS EC2 - Quadruple Server and AWS EC2 - Cluster Server were applied parallel processing through PP. Figure 1 represents tiled images of geo-rectified KOMPSAT-2. The tiled images were used to test performance for developed mobile app testing, and the size of each tiled image is 256 x 256.

Table 1: Testing hardware specification of cloud computing servers in this study

Server / Environment	AWS EC2 - Single Server (Micro Instance : t1.micro)	AWS EC2 - Quadruple Server (Micro Instance : t1.micro x 4)	AWS EC2 - Single Server (Extra Large Instance : m2.4xlarge)
CPU clock	One ECU (EC2 Compute Unit) provides the equivalent CPU capacity of a 1.0-1.2 GHz.		
CPU core	One EC2 Compute Units	One EC2 Compute Units x 4	8 Core (Each core has 2.5 EC2 Compute Units)
Memory	613 MB	613 MB x 4	7 GB
Operating System	Amazon Linux AMI	Amazon Linux AMI	Amazon Linux AMI
Platform	32-bit	32-bit x 2, 64-bit x 2	64-bit
Used Major Open Source Library	OTB (ver. 3.8), GDAL (ver.1.8.1)	OTB (ver. 3.8), GDAL (ver.1.8.1), PP (ver. 1.6.2)	OTB (ver. 3.8), GDAL (ver.1.8.1), PP (ver. 1.6.2)
Parallel Processing	Not used parallel processing	Used parallel processing	Used parallel processing

Figure 1: Tiled geo-based image of KOMPSAT-2.

Figure 2 shows parallel processing procedure of AWS EC2 - quadruple server from the configured cloud computing servers in this study, and represents system layout composed of open sources such as OTB, GDAL (Geospatial Data Abstraction Library), and PP. The configured AWS EC2 - quadruple server was divided in the main server and sub servers. The main server is managing the parallel processing, and stored for the processed image results. And parallel processing is processed by all servers. The users can be using developed system by the main server connection through mobile app. The procedures shown in Figure 2 are executing when the geo-based image processing through the mobile app requests to cloud computing server, and the procedures of (2)~(4) are executing by parallel processing, meanwhile the procedure of (3) is executed using OTB and GDAL. In this study, tested canny edge detection as image processing, the algorithm is used for normal edge detection in remote sensing fields (OTB Development Team, 2010). Table 2 represents the CPU time to execute the canny edge detection processing on quadruple configured servers, in this study. The measured CPU time using time stamp is representing procedures time during the step (2) ~ (4) in Figure 2, and the procedures of (1), (5), (6) in Figure 2 were excluded

due to the effect on the Internet speed. Figure 3 shows average CPU time of Table 2 with the number of CPU core of the configured cloud computing servers. As shown from Figure 3, the configured server shows as higher the number of CPU core higher performance. But the configured server using four instances has lower CPU capacity and fewer CPU cores in comparison with AWS EC2 - Single Server (m2.xlarge).

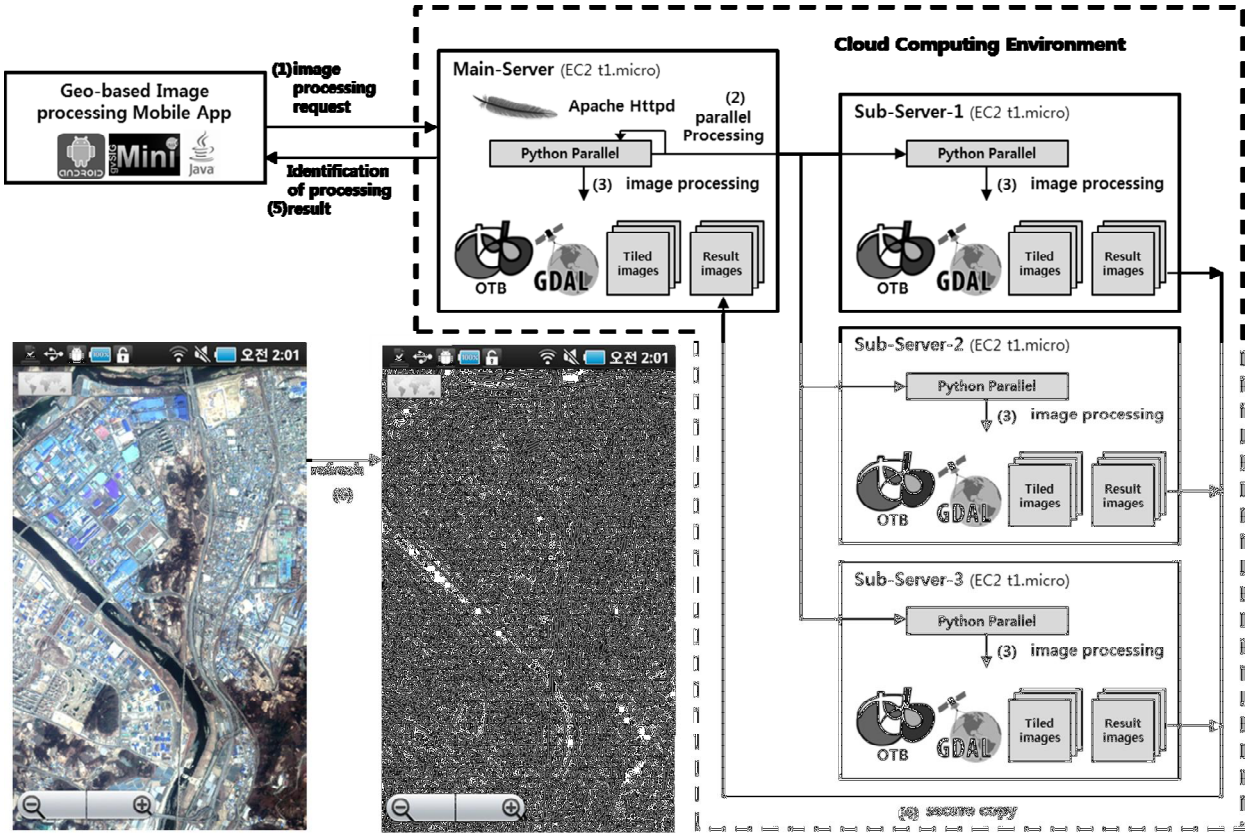

Figure 2: Parallel processing procedure and system layout using the quadruple EC2 Server (t1.micro x 4) and open sources, added and modified from Kang and Lee (2012).

Table 2: The result of CPU time measures in seconds

Server Type / Trial	AWS EC2 - Single Server (t1.micro)	AWS EC2 - Quadruple Server(t1.micro x 4)	AWS EC2 - Single Server (m2.4xlarge)
1st	3.31830216	2.22968102	1.39167404
2nd	3.26867199	2.07620502	1.38238621
3rd	3.17776084	2.17421293	1.38318300
4th	3.31339002	2.19702196	1.41910195
5th	3.43047595	2.13648295	1.39782214
6th	3.35494399	2.17220902	1.38623214
7th	3.25607109	2.08358884	1.38369393
8th	3.44322920	2.15977311	1.42000484
9th	3.15846181	2.13354397	1.38616800
10th	3.22467613	2.23273897	1.38997102
Average	**3.294598**	**2.159546**	**1.394024**

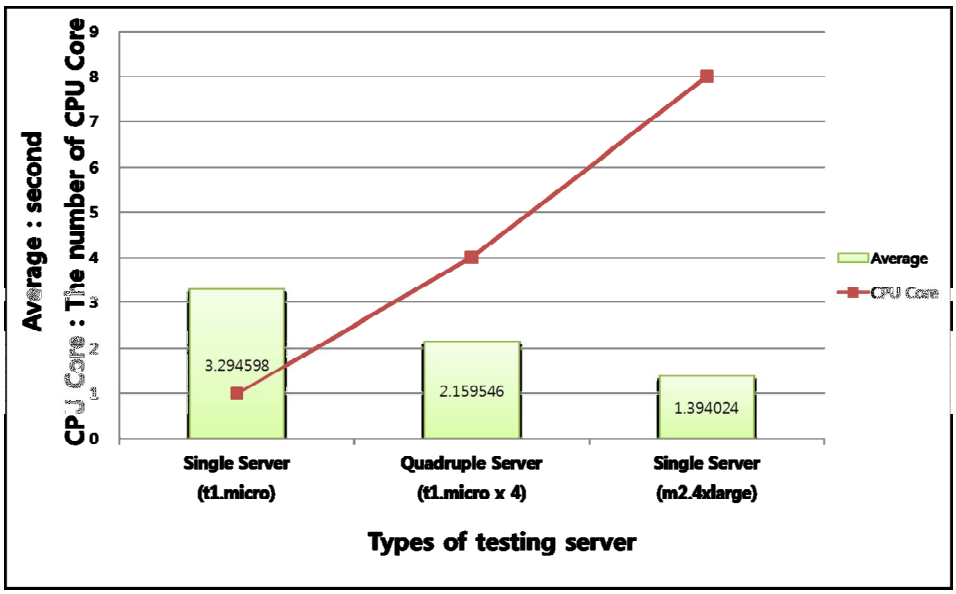

Figure 3: Average CPU time according to testing server types and the number of CPU core.

CONCLUDING REMARKS

Mobile cloud computing services provide various opportunities for mobile apps for both sides form developers and users. Therefore, mobile cloud computing services are regarded as the most promising and cited trend in the mobile business. Although the result of geo-based image processing by certain analysis algorithms is significant to interpret surficial phenomena, most map services are focused on geo-based image visualization, so that image processing or analysis functions and their results is not provided in current map services yet. It is the motivation of this work that mobile cloud computing service and geo-based image processing service can be generating synergy effect. In this study, a mobile app using the mobile cloud computing services based on open sources was developed as the revision from the previous achievement in Kang and Lee (2010 and 2012), and the mobile app was carried out a performance testing on a satellite image processing module. For this testing task, the servers were configured in three types, and the part of configured server was applied parallel processing for geo-based image processing. As the result of this testing study in a given condition, it is shown that the higher the number of CPU core, the higher performance. In conclusion, this study is the first approach to provide analysis function services with respect to geo-based image in mobile cloud environment.

ACKNOWLEDGEMENTS

This research was supported by a grant by Satellite Information Application Supporting Program of Satellite Information Research Institute in Korean Aerospace Research Institute in 2012.

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