DEVELOPMENT OF NOAA AND LANDSAT IMAGE SERVER USING FOSS

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1 Introduction

Web Map Service (WMS) is an online access to, or integration and exploitation of geo-spatial information. Access to multiple servers simultaneously, which is also one of the core procedure for enhancing data sharing, can be done easily as the normal URL linkage of Internet reference. The data will be more valuable by the easier procedures and physical requirement for sharing data.

GMS stands for Greater Mekong Subregion, which consists of Thailand, Laos, Vietnam, Cambodia and part of China and Myanmar. In GMS countries, the use of Remote Sensing data for environment management, agriculture, forestry, fisheries and other various fields is quite important. We have formed a "IT-Agriculture Forum" which is to utilize IT to agriculture with Thailand and International organizations. This forum has been discussing how to demonstrate the usefulness of IT to agriculture.

In this regards, the prototype development of a Web Map Server in GMS countries showcases the benefits of sharing of remote sensing data among forum members. Satellite image Map Server will be the main feature of the linkage with other GIS data from various organizations using WMS technology. The GIS data overlaid on satellite image, which act as background image, will leads more efficient visualization of information. Multiple Web Map Service has a multiple server function. One server can obtain GIS data or Image data from other servers simultaneously to serve to users. Users may not realize that they are accessing to multiple servers. For example, one organization who has GIS data may setup a link to another server such as our prototype server to obtain remote sensing image as a background, and serve GIS data overlaid on remote sensing images to users. This will reduce the cost of copying or maintaining huge images at their server site.

Three type of satellite image are provided by this remote sensing image server. The Mosaic image of GMS countries using Landsat 5 images at spatial resolution 28.5 m. x 28.5 m. is the highest spatial resolution available in this prototype. Also Low resolution satellite image NOAA/AVHRR NDVI 30-days composite and NOAA/AVHRR 30-days composite shown as FCC (False color composite) 121 are available.

2 Methodology

2.1 Development of Satellite Image Server

The WMS map server was setup on Linux, which is an open source system and a free operating system. In this case, the Minnesota mapserver was used for Satellite image

server, which supported WMS technology. It is also an open development environment for building spatially enabled Internet applications. Thus, updating new features and detecting bugs were done very frequently by users around the world. This mapserver is not a full-featured GIS system; however it provides enough core functionality to support a wide variety of web application. Other popular open source and free software such as Shapelib, FreeType, Proj.4, libTIFF, Perl were integrated with the Minnesota mapserver for more efficient tool. The Mapserver is an open source system, thus, customized configuration can be done during compiling. This system was configured to support various type of image file format such as PNG, GIF, JPEG and TIFF using GDAL and GD capabilities. The integration of different map projection data can be solved by Proj.4 with "on the fly projection" capabilities. The OGR library was included to support various types of vector file format, thus even different data source can be integrated together. [2]

The emergence of WMS was a breakthrough in interoperable Web mapping technology. The interoperability is a standard interface between client and server via WWW by requesting map across the Internet to a Web map service without having to know the underlying GIS format, or even the type of software that is in use. Many vendors now include WMS capabilities in their products such as ArcIMS, MapXtreme and UMN mapserver. The prototype has also one important service and that is the WMS (Web Map Service). A Web Map Service produces maps of georeferenced data, which are visual representations of geodata. These maps are rendered in normal image formats such as PNG, GIF or JPEG. [3]

One of the advantages of implementing Satellite image server is that the potential of Geoinformatics can be fully utilized and developed contributing significant benefits to the society in general. Remote sensing process is in need of specialist people and system. After opening the dataset, society can benefit more from space technology which at present lees people utilize. The realization of data sharing through Open GIS and Web GIS will showcase the potential of the technology in achieving the goals. After that linked integrated data from participating will be increase because people can get benefit much more than their share.

The main interface of this mapserver was divided into two parts. The system process step is shown in Figure 1. First, the direct user interface allows users to surf for satellite images and other GIS data from this server system directly, which provide basic functions such as selecting images, zooming and panning. Functions to identify some databases related to GIS data can be done also. The second interface is the WMS interface, which enables another mapserver to get the map data through Internet and integrate with their own data or data from other WMS mapserver and show on their display screens. The customized function and interface can be done with the client side by specifying layer data from the multiple layers provided in the WMS server.

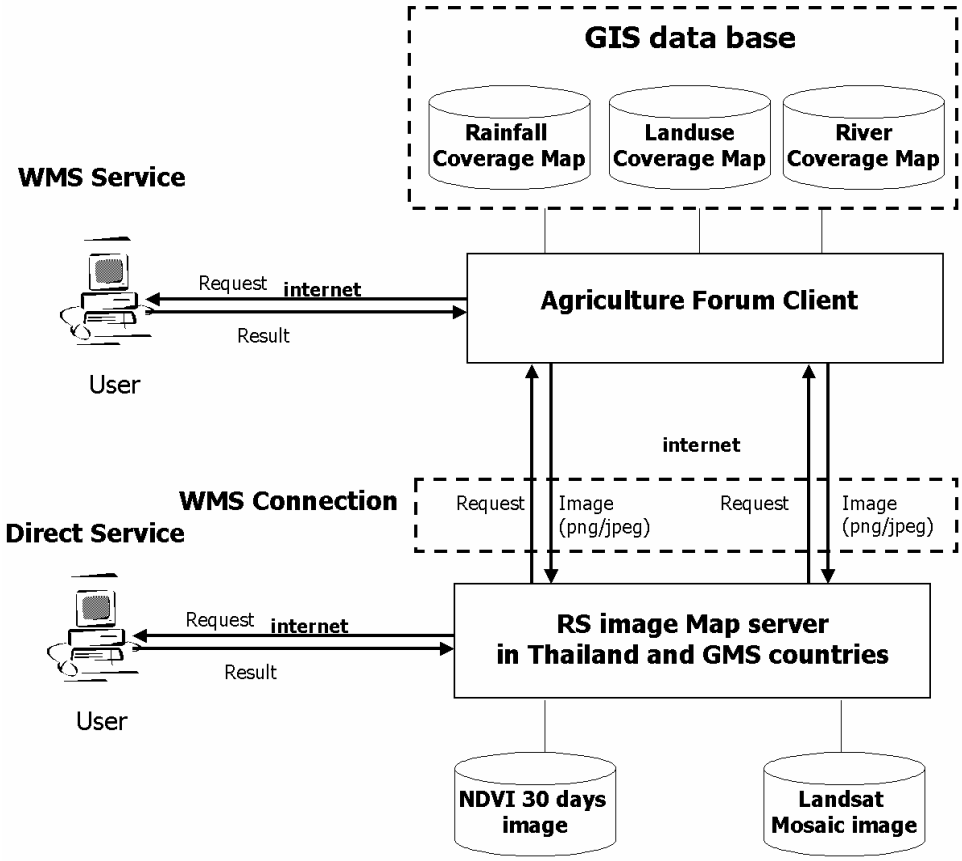

Figure 1: Overview of process steps

All data provided are free in this prototype. All Landsat 5 data were downloaded from Global land cover facility of university of Maryland. One hundred and five Landsat 5 scenes were downloaded from the site. This dataset covers 5.4 million square kilometers. Eight scenes of data were unavailable from this system. The original projection data is UTM with datum WGS84. The GMS countries fall into four UTM zones, with most area in the 47 and 48 North zones. Before generates the mosaic image, all Landsat 5 images were converted to Latitude-Longitude system with datum WGS84. This procedure solves the problem of mosaicing images in different UTM zones. The mosaic image is composed of band spectral blue, green, red and near infrared. The service thus provides multi spectral images.

The data amount of the mosaic image from 105 Landsat scenes is huge. This service allows multiple users to browse data at the same time. The speed of data processing has to be fast enough to serve multiple users over internet connection. Thus, tile index and multi resolution images were applied in the prototype. The big mosaiced image was divided into a number of smaller images and saved as separate files. Each file is a tile of the larger image available for display. Only tile image files overlapping to the current display will be requested and opened. The processing time of Input and Output file can be reduced by this algorithm. The process of tile indexing was created by gdaltindex, which forms a shapefile with polygons representing the footprint of each file, and name of the files. However, displaying the whole image was still a problem, requiring all tiles be opened. This problem was solved by reducing the original pixel size, and thus the file size of the whole image. Then the selected suitable resolution image was controlled by current map scale to display.

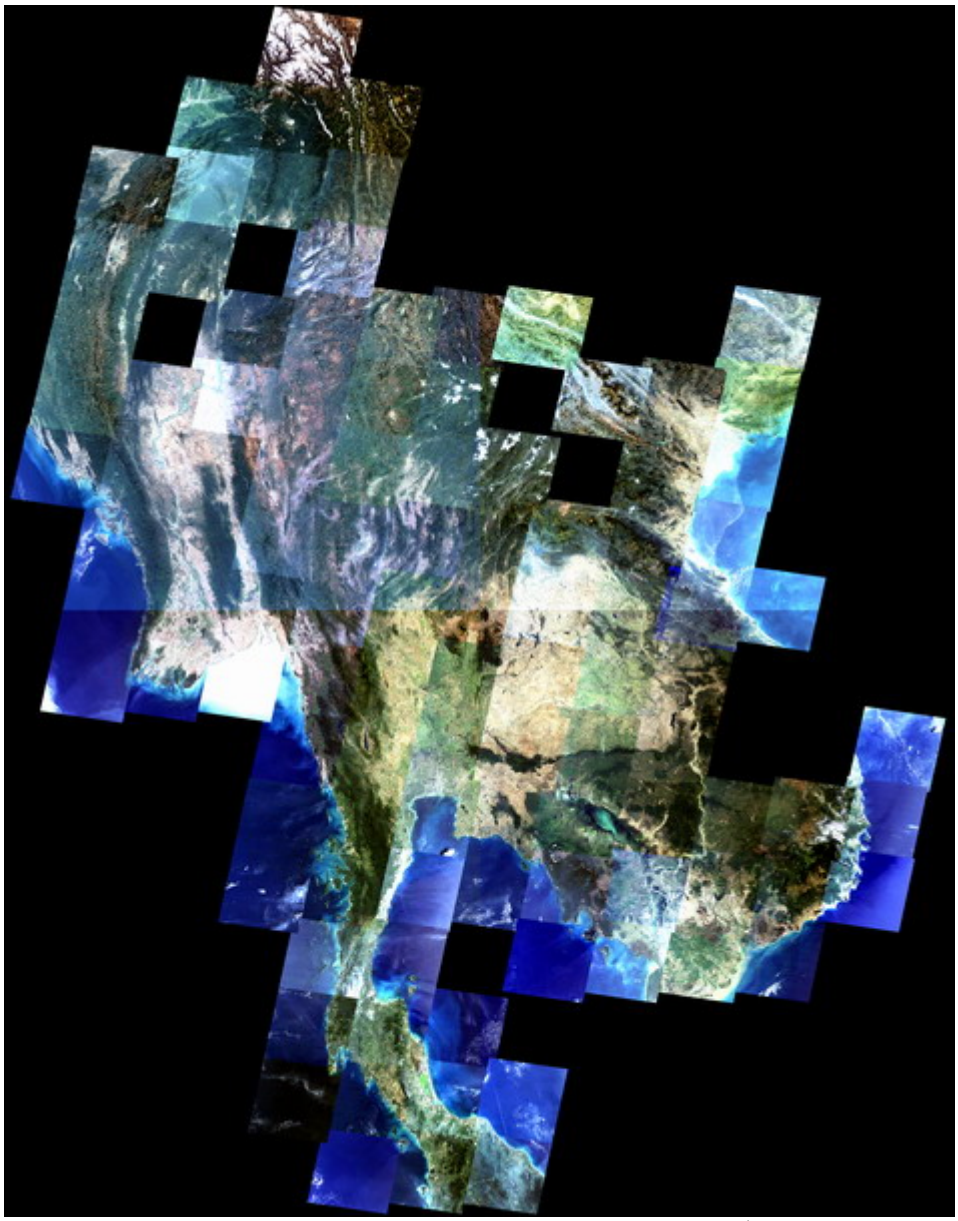

Figure 2: Landsat 5 mosaic image of GMS countries (True color composite)

UTM zone	Number of Scenes
46	17
47	51
48	33
49	4
Total	105

Table 1: Number of Landsat scenes in each UTM zone

The test multiple Web Map Service environment was established mutual links between the WMS server. The satellite image map server provides remote sensing images for linked clients. User can access client's web site to get various GIS data and overlay on remote sensing image which can be provided by satellite image map server. Otherwise users can access the satellite image map server directly to browse images. In this study, one additional server was setup in AIT to simulate the multiple server environment, which is called client WMS hereafter. The linked client WMS was setup in Windows 2000 operating system, while the satellite image map server was setup in Linux operating

system. The configurations of both sites are the same even with different system environments.

3. Result and Discussion

3.1 Satellite Image Server

After setting up the WMS map server prototype, it was first tested with GIS data before integrating with remote sensing data. The mosaic image of GMS countries was done using Landsat 5 images at spatial resolution 28.5 m. x 28.5 m. The Mosaic data was divided into two parts; the east side of GMS and the west side around Myanmar, because it is very huge remote sensing dataset. It covers 105 of Landsat 5 scenes. The total mosaic image has 76,000 samples and 101,300 lines of pixels. The maximum capacity size of input image data for GDAL library and most graphic program without pyramid algorithm is less than 2 Gigabyte. However the entire size of the dataset is around 31 Gigabyte. The reading of this huge dataset needs much memory and processing time on server side. The solution to this problem is a tile indexing. When handling very large amount of raster layer it is often convenient, and with higher performance to split the raster image into a number of smaller images. Each file is a tile of the larger raster mosaic available for display. The list of file forming a layer can be stored in a shapefile with polygons representing the footprint of each file. Mapserver will first scan the tile index and ensure that only raster file overlapping the current display request will be opened.

Part	Filename	Dimension (Sample x line)	File size (Byte)
West Side	west_gms.img	38,000x101,300	15,397,600,000
East Side	east_gms.img	38,000x101,300	15,397,600,000
Total	all_gms.img	76,000x101,300	30,795,200,000

Table 2: Part of GMS mosaic image

However only with tile indexing, the speed is still slow especially when users zoom to the entire area. For this reason, the full resolution dataset at 28.5 meters was resampled into three different pixel sizes (57, 228 and 1,824 meters), which have been selected from a set of double resolution images to increase the speed to serve images at various resolution requested. And scale control was integrated to select a suitable pixel size dataset in for map scale as show in Figure 3. For example, when scale is grater than 600,001 and smaller than 5,500,000 then 288 meters resolution image overlapping the current display request is used. This criterion was decided based on the ground size (in terns of meter) of 1 dot on screen as shown in Figure 3. With this 228 meters pixel size data set at less map scale, all the feature are shown as same as full resolution pixel size but it is very less physical data size when compared with full resolution pixel size data set. The integration of both algorithms is an important key to improve the speed of this kind of service.

Meters per pixel (MPP) (meters/pixel)	No. of Sample tile	No. of Row tile	Tile file size of the tile images (KB)	Number of tile image	Total File Size (MB)
28.5	80	120	3,300	9,600	30,937
57	40	60	3,300	2,400	7,734
228	20	30	870	600	509
1824	6	8	170	48	8
Total	-	-	-	3,162	39,188

Table 3: Number of sample and row tile

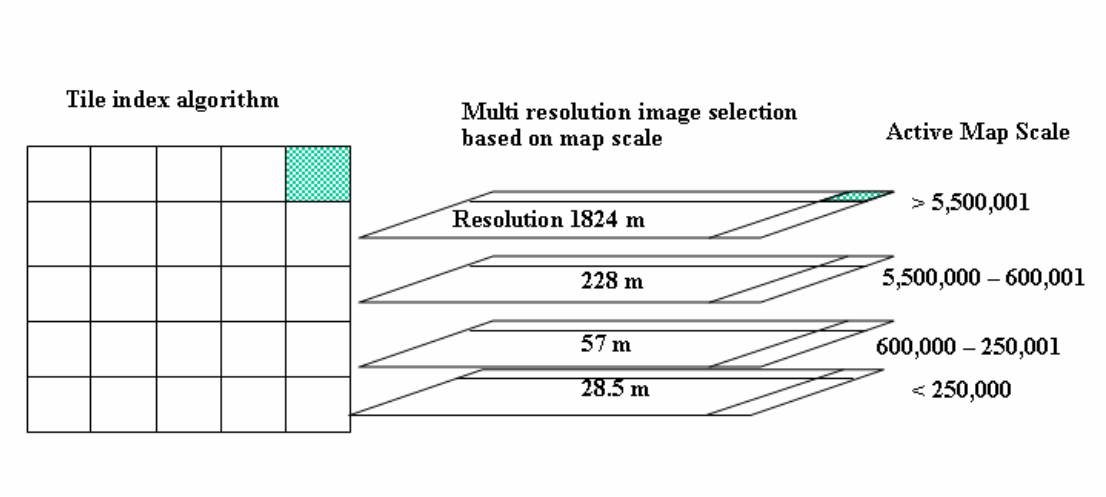

Figure 3: Improvement algorithms for Satellite image map server

Prior to improvement made in the algorithms, the speed of response time is very slow and sometimes. Connection is lost while waiting a resample process on the server side. With the improvements, the return response time becomes acceptable at around 3 or 4 seconds even loading the entire area. The main objective of the improvements is to speed up the response time while preserving the data quality. As a result, a user can clearly distinguish around the area of interest from RS data incorporated with GIS data to zooming into actual pixel size of remote sensing data.

Not only speed improvement was done and also many user interface functions were implemented. The PHP mapscript module is a PHP dynamically loadable module that makes mapserver's mapscript functions and classes available in PHP environment that is a main environment for web development functions. A function to make it sure that user has selected only one remote sensing image, is necessary, because if two image were shown at same and same area, mix data image was generated and users will not be able to see proper images. On the other hand, multiple GIS vector layers can be selected at the same time. Three type of display image size (400x300, 600x450 and 800x600) were available for user requirement. And also grid line layer can be generated dynamically on the service. The unit of grid line is in Decimal and minute (DD.MM).

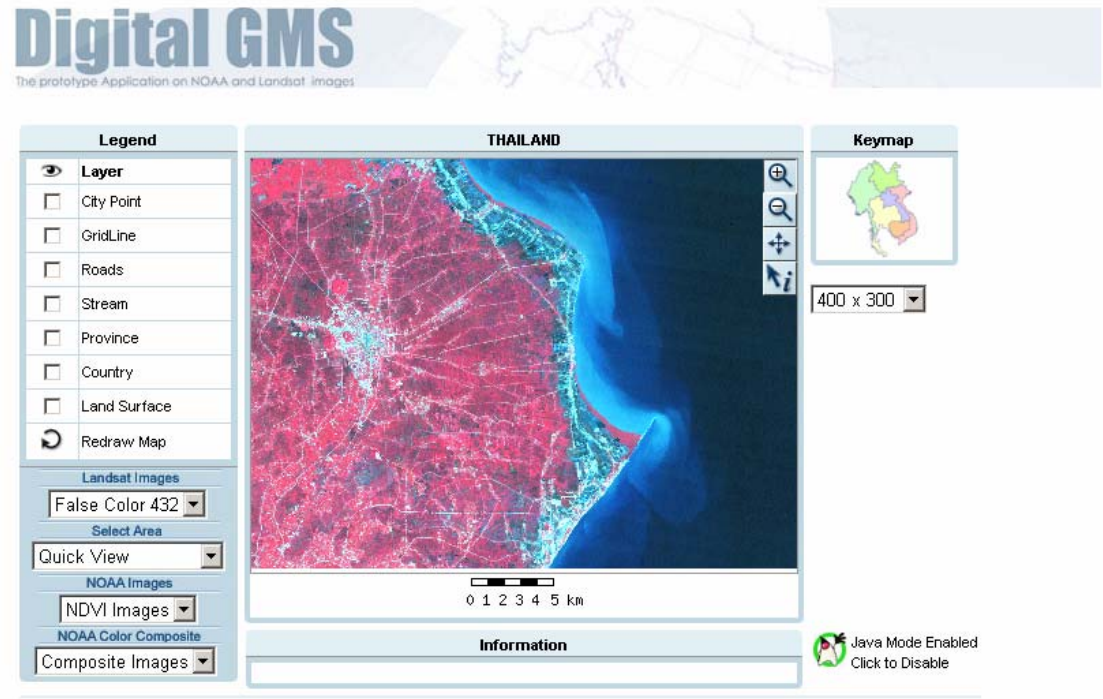

Figure 4: Direct interface to mosaic of Landsat 5 image

3.2 Display map image quality

The display map generated from mapserver is an image file that can be saved as a specific type of output. Basically, mapserver overlays all active layers and makes only one display map image. The communication between user and server come as a request, with input text data and result output in image. The linkages of WMS also use this method for connection. On the client side the output image can be overlaid with own layer and generate new result output image. This satellite image server used png24 bit image format because the Landsat image is a 24 bit image for true color and false color composite. Previous version of mapserver support only 8 bit image output, thus the display map was not good enough. However the file sizes of png24 bit image format is bigger than 8 bits png image 3 times. With an output image of 400x300 pixels, the file size is around 360,000 bytes without any file compression for png24 bit file format. The png file format uses the LZ77 compression algorithm instead, which was created in 1977 by Lemper and Ziv (without Welch), and revised in 1978. LZ77 compression also takes advantage of repeating data, replacing repetitions with references to pervious occurrences. Since some images can not be compressed well with the LZ77 algorithm alone, PNG offers filtering options to organize the pixel data before it gets compressed. These filters take advantage of the fact that neighboring pixels are often similar in value. Filtering does not compress data in any way; it just makes the data more suitable for compression[4]. After the compression, minimum file size for vector based images was 5,649 bytes by our experiment, but for Landsat display images, average file size was around 320,000 because less repeating data by image property. Comparing to popular zip which is also lossless compression, the performance of the compression seems not so efficient. The png24 does not support loosy compression; big compression rate cannot be expected. 400x300 is the minimum size for this service. User can request two bigger sizes, 600x450 and 800x600. For high quality print resolution an 8.5 inch by 11 inch 300-dpi image, that is 2550 pixels (8.5 x 300) by 3300 pixels (11 x 300) is possible.

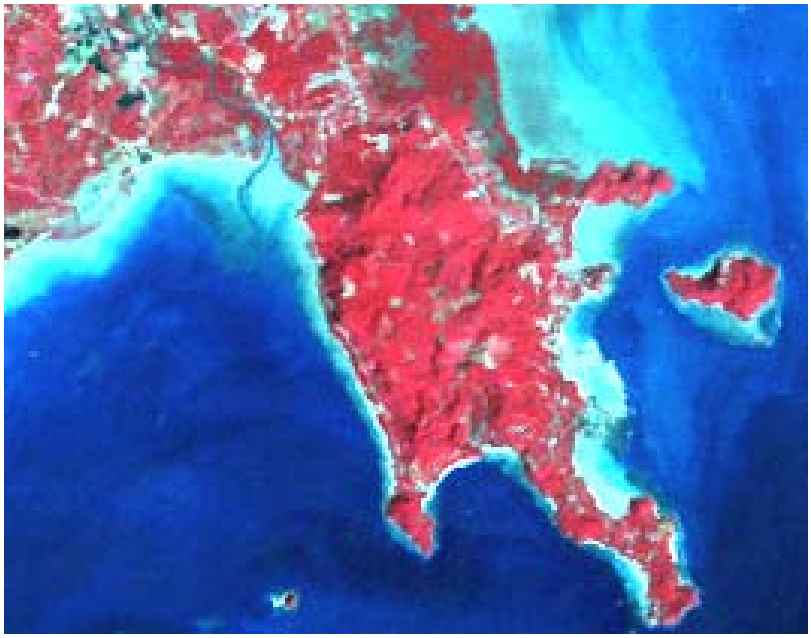

Figure 5: Original image from Landsat 5 image actual size is 266x209

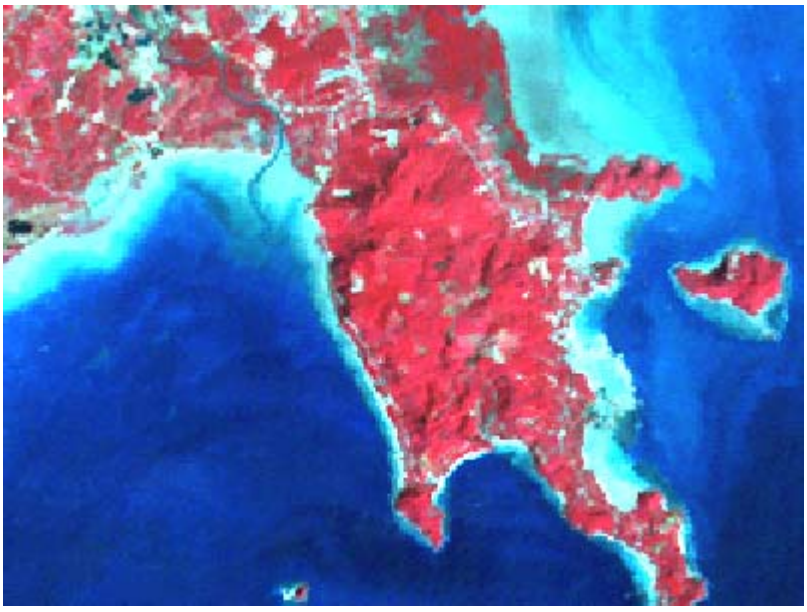

Figure 6: Png 24 bit image generated from mapserver at 400x300 size

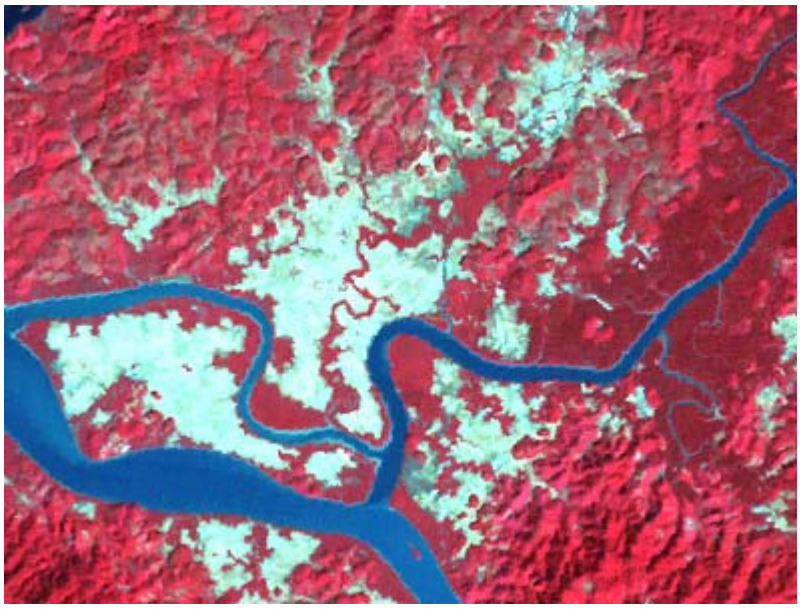

Figure 7: Original image from Landsat 5 image actual size is 400x300.

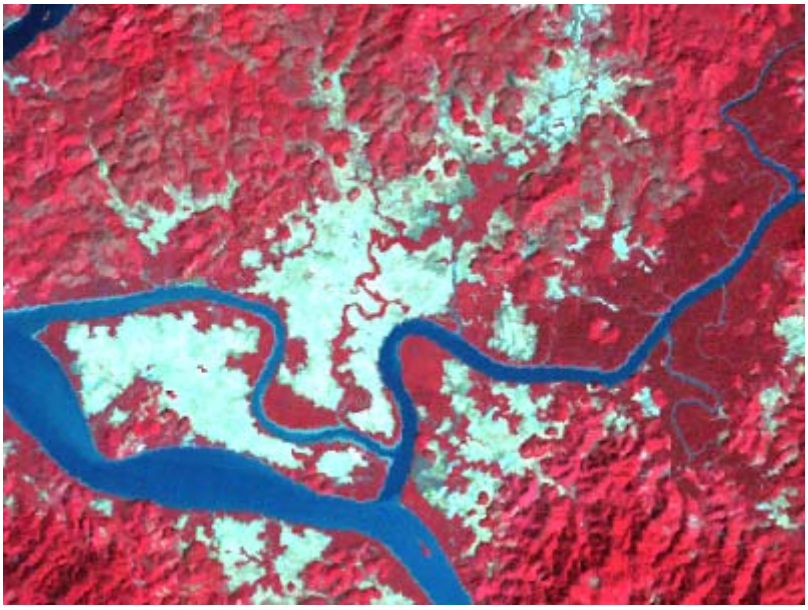

Figure 8: Png 24 bit image generated from mapserver at 400x300 size

Figures 5 and 6 are comparisons between actual image and display map image generated from mapserver. The actual image size of Figure 5 is 266x209 pixels. The display map image was generated by resampling the original image to the current display to 400x300 pixel size. As a result the quality of image reduced but not so much. The reason of this degradation may come from resampling algorithm of color allocate. Figure 7 and figure 8,

show image of same image size. The spatial resolution of display map image and color quality is also same as the original quality. As a result, the lowest resolution image (1,824 meters) for multiple resolution selection with 1,523 height pixels, was resampled to 300 height pixels to display the whole mosaic image area, while keeping the same display quality as their of the 28.5 meter resolution. Because meter per dot (MPD) value is 9,623.5 meter/dot on the ground which is still grater than meter per pixel value (MPP) 1,824 meter/pixel.

3.3 Experiment for linking multiple Web Map Servers

Linking with other WMS is one of the main objectives in this prototype to promote data sharing. The satellite image mapserver was linked with a client PC which was setup in AIT to simulate the multiserver environment. The WMS GetMap operation enables the creation of a network of distributed Map Servers from which clients can build customized map. Even if they have different map projections or if cover extents overlap or is a subset, the GetMap operation can be done easily by adding one map layer to the map file, which the server side has already prepared. Thus, the number of WMS server and client will increase easily by this approach.

GIS data in Agriculture forum client is composed of an agriculture data and some administrative data as shown in Table 4. All remote sensing data from satellite image map server is in latitude-longitude map projection but GIS data with different map projections can also be integrated together. Also different operating systems do not limit the interoperability standard. Computer specification requirement of Agriculture forum client is not a high performance specification because data handling is not a big dataset when compare with satellite image map server only RAM 512 MB is required for WMS client site. The time, which is needed for displaying an image on a client terminal, is based on processing speed of server side and also the speed of internet connection from server to client side. Normally, the speed for WMS interface is same as direct interface only internet connection from server to client is a variable for the difference.

Server Name	Computer Specification	OS	Software and components	Data to be provided
Satellite image map server	CPU Pentium IV 1.8 GHz. ,RAM 1 GB, Harddisk 360 GB (3 hard disks)	Linux Redhat 8.0	Apache(WWW server), PHP (Script language), Minnesota Mapserver 4.10 supported WMS 1.1.0	-Landsat 5 image -NOAA/AVHRR 30 day composite -NOAA/AVHARR NDVI 30 day composite
Agriculture Forum Client	CPU Pentium IV 1.8 GHz., RAM 512 MB, Hard disk 120 GB.	Windows 2000	Apache(WWW server), PHP (Script language), Minnesota Mapserver 4.10 supported WMS 1.1.0	-Agriculture GIS data such as data of Sugar Cane factory, Soil type. -Administrative data: political boundary, road

Table 4: Machine environment

4. Conclusion

By implementing two algorithms (tiling and multi-resolution), the speed of response time was drastically improved, while keeping the quality of image as same as the original image. Multi-server system was tested and has shown efficiency to serve images to users as background images. The WMS (or Web Map Server) allows use of data from several different servers, and enables the creation of a network of Map Servers from which clients can build customized maps. WMS servers interact with their client via the HTTP protocol by Standard interface of Interoperability for Spatial data. Other organizations, which have their own Mapserver with only GIS data, can make real time connection (WMS connection) with our server to get remote sensing image as a background for their GIS data without copying the data. Even with different projection, coordinate system or data format, they can put the data seamlessly.

With this prototype remote sensing image server based on WMS for GMS countries, the potential of Geoinformatics will be fully utilized and developed contributing significant benefits to the society in general. And the realization of data sharing through Open GIS and Web GIS, will showcase the potential of the technology in achieving the goals, and open the possibilities to provide valuable services information by combining data from multiple servers using web mapping technology, promoting more linkage and cooperation. Through this experiment, we are going to clear some issues on legal (e.g. ownership of data, copyright issues etc), infrastructure (hardware) technical level problems (level of know-how in implementing and using the system) and the required new GIS function, in Thailand and GMS countries. In addition, the redundancy of data was reduced; especially with remote sensing where data size is very huge and data processing need a remote sensing specialist to make an accurate data set.

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