Implementation of Tile Based Geographic Information System in Indonesia E-Government

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Abstract
Indonesia is the largest archipelago country in the world with complex topological conditions and has great potential of natural resources, but on the other hand susceptible to natural disasters, requiring a comprehensive spatial management. This led to the role of Geographic Information Systems/GIS becoming very crucial in the governance of Indonesia. However, implementation of GIS in Indonesia is not yet widespread. The study by Ramadhan et al (2011), from 91 E-Government systems that were examined, only 19% are implementing GIS. One of the possible constraints might be infrastructure problems, which is narrow bandwidth hence resulting in high response time. This issue is potentially reducing the efficiency of GIS functionality and user interest for the use of GIS. This paper proposes Tile based GIS technique that increases the speed of mapping application by displaying only the relevant layers. The system construction process applies Rapid Prototyping method. The next step is testing the system by real users of E-Government, which are citizens from various regions in Indonesia. The results of the test analysis showed statistically significant difference between static and tile based mapping system.

Keywords: *Tile based GIS, SIG, E-Government.*

1. Introduction

Nowadays, government agencies and related organizations are often required to be able to respond quickly and appropriately on the occurrence of natural disasters (tsunamis, floods, etc.), industrial accidents (mud, etc.), the environmental crisis (Buyat Bay, etc.), and also various forms of threats to national security (terrorism). Complex problems on the one hand, and the limited resources on the other hand, cost-effective and efficient policies are more and more needed. So the government has to act wisely in any policy formulation. For this purpose, spatial-based information is an urgent need. Therefore, the availability of accurate and up to date even up to second geospatial data is very important.

Geospatial data is processed into geospatial information through a system called a Geographic Information System. By definition, a Geographic Information System (GIS) are systems that capture, store, analyze, organize, and display data related to location [1]. Generically, Geographic Information Systems can be defined as the ability to manipulate the computer-based geographic data [2].

At this time, GIS has shown tremendous benefit in various fields, such as: reading trends, disaster mitigation, maintaining the country integrity, precise farming, change management, public facilities planning, tourism management, etc [3]. However, implementation of GIS in Indonesia has not been quite widespread, marked by only 19% of the E-Government of Indonesia has applied GIS [2]. This is mainly due to inadequate and unevenly spread infrastructure.

The purpose of this study is to design tile-based geographic information system that is suitable for E-Government of Indonesia. The objective is to reduce the response time and to adjust the conditions of the autonomous regional government. To validate this design, tile-based dynamic mapping and static mapping (as a representation of GIS used in E-Government of Indonesia) prototype is built. The response time of both prototypes will be compared in various scenarios. Testing will be conducted by testers from 12 provinces in Indonesia, so testers of these systems represent the real user of E-Government.

2. Review of State of the Art

Geographic information systems play an important role in the management and dissemination of spatial information, data management, statistical analysis, and decision support on E-Government systems. Therefore, a study evaluating the integration of Geographic Information Systems with E-Government is necessary. Xiaolin Lu [4] discusses the basic needs and essential technology for information management and offers integrated E-Government information management framework based on Web GIS technology, J2EE, and EJB.

Other technique for implementing web GIS is ActiveX. This is done by Hai Bo Liu et al which utilize ActiveX components and XML technology to produce smaller and simpler components of Web-GIS in lower level. The benefits of this research include the adoption of XML files to store information, making GIS information to be more suitable for network transmission and develop web GIS system that integrates with e-Government [5].

Another approach made by Lian Wang et al that integrate Geographical Information Systems with Decision Support System that is applied to the E-Government. Wang et al design a software platform based on Geographic Information System and Integrated Decision Support System to be implemented in the construction of E-Government in China. This system has been implemented on various government projects [6].

3. Tile Based Mapping System

Tile based GIS uses logical tile scheme that maps the position of the earth's surface in the form of two-dimensional map and divide it into smaller parts. This can be seen in figure 1 [7].

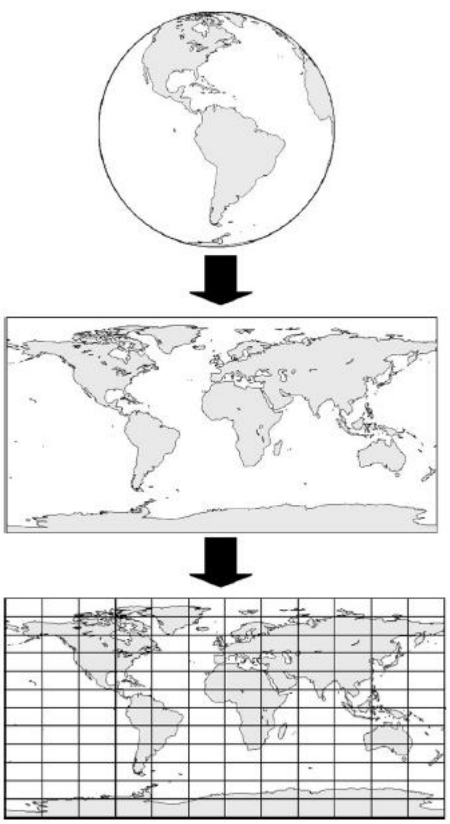


Fig. 1. Tile Based Mapping System

Tile based GIS technique aims to overcome the latency problem on a static map. On conventional maps, each time panning and zooming is done, the whole map is returned for each query, even though only a fraction of the map that is new. Meanwhile, with tile-based GIS techniques, only the relevant parts are returned. This gives significant effect on reducing response time.

4. Methodology

Overall, the methodology of this study follows these steps:

• Problem identification
• Goal Determination
• Literature Study
• Data and information collection
• System analysis
• System design and implementation
• Application testing
• Results analysis
• Conclusions and suggestions

5. Construction of Tile Based GIS

Data used in this study are data of 33 provinces in Indonesia which are divided into 31 shapefiles. The system is developed using the principle of Rapid Prototyping. Prototype or working model can be constructed quickly and tested for functionality, performance, and output. Features and new ideas can be illustrated by prototype and feedback from users can be obtained earlier.

Tile-based mapping system architecture consists of data storage that stores the vector data and tile web service. Both parts are exported to the mapfile. Mapfile can be run or viewed through browser in two ways:

- Mapserver CGI application, by running the mapserv.exe program equipped with parameters about the mapfile path, mode, and layer.
- MapScript application. This study utilizes PHP MapScript to display mapfile in browser. PHP MapScript references mapfile and provide the necessary functions such as panning, zoom in, zoom out, selecting layer and others.

This research uses Apache as web server. Other alternative is IIS web server. The output of this mapping system is image, as can be seen in Figure 2.

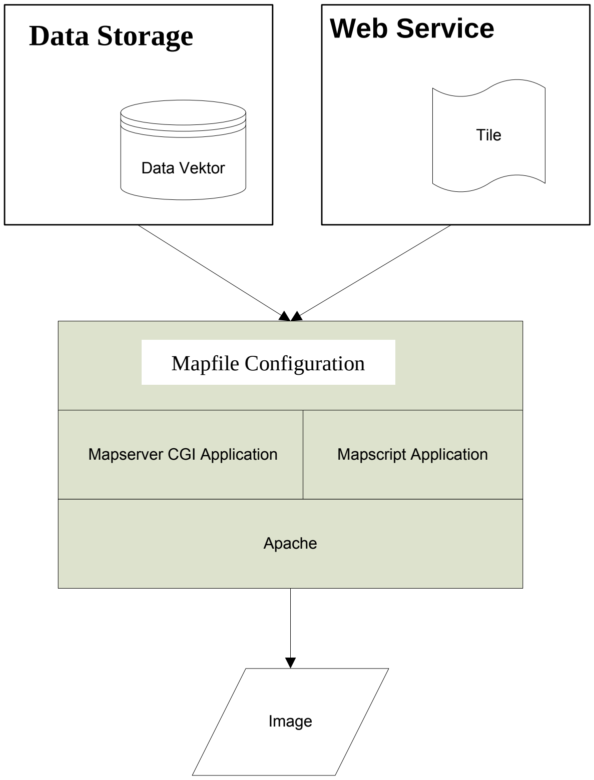


Fig. 2 Tile Based Mapping System Architecture

Static mapping system as well as tile based system on this study using 3-tier system specification for deployment. The system is built with the following distribution:

A. Client Layer

This tier is an application residing on the client side. Clients use web browser to open the web either using Internet Explorer, Modzilla Firefox, Opera or the others. However, for testing purpose, we use Mozilla Firefox because it has add on that can record the response time, namely Firebug and YSlow.

2. Application Layer

This tier is a web application server. On this web server, Apache is implemented with PHP MapScript as dynamic language. Server used run on Linux operating system, so it does not require mapserver emulator, as well as MS4W is required as mapserver emulator on Windows.

3. Data Layer

This tier is the source of all data. The data used is the data on the server that cover all 33 provinces and the distribution of 24 types of minerals shapefiles. Deployment diagrams can be seen in Figure 3.

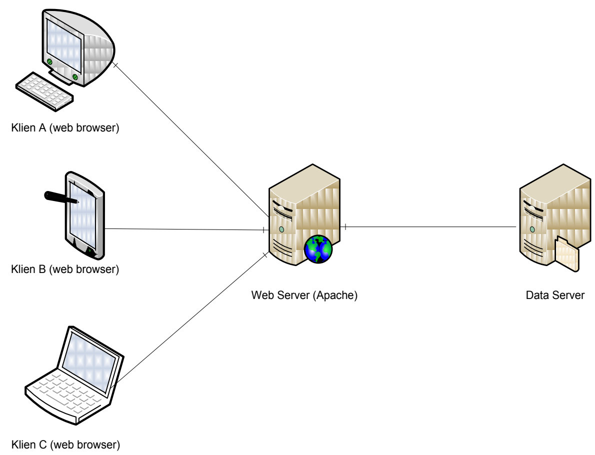


Fig. 3 Deployment Diagram

The mapping system is constructed through the following stages:

1. Data Collection.

   The data collected is shapefile of 33 provinces. The data obtained from [3]. Figure 4 depicted 33 provinces shapefiles displayed using desktop GIS software, Quantum GIS.

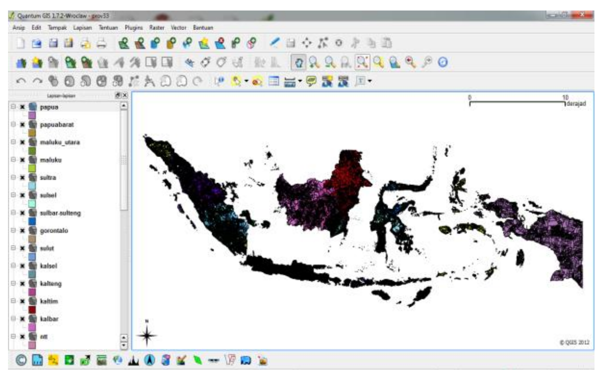


Fig. 4 Shapefiles of 33 Provinces

2. Data digitization of mineral distribution into data vector. Digitization performed using Quantum GIS.

3. Creating and editing mapfile.
   Creating mapfile is conducted through Quantum GIS by using Mapserver Export Plug In.

4. Creating tile index.

Tileindex is an index of all shapefile that is necessary to construct a map. Tile index allows only required shapefile to be loaded, which could be only a fraction of the data. Tile index showed by figure 5.

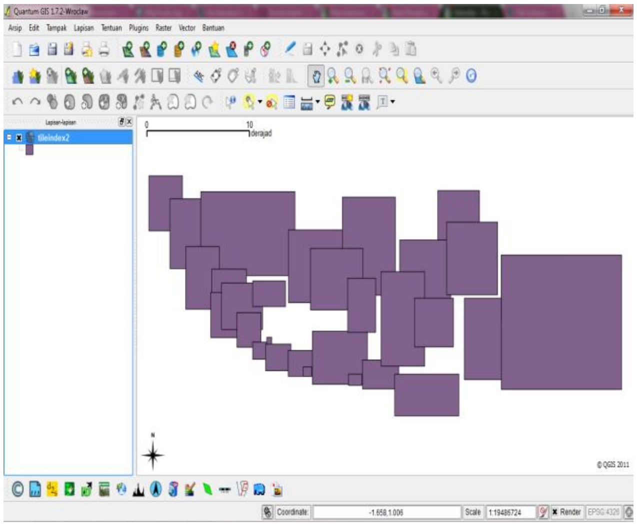


Fig. 5 Tile Index

5. Programming in PHP MapScript.

Mapfiles are displayed in the browser using command `cgi-bin/mapserv.exe` but must provide parameter that include name of mapfile, layer, and mode. To give a better view, mapfile file referenced via PHP MapScript. In this file, several features are created, such as panning, zooming in, zooming out, full extents, and selecting layer of 24 types minerals distribution.

6. Viewing in browser

PHP MapScript can be displayed in browser by entering the server name and file name in address bar. Figure 6 display the constructed mapping.

Fig. 6 Display of Constructed Mapping

6. Testing and Analysis

Testing is conducted through several steps:

1. Record IP, upload speed, and download speed, by accessing speedtest.net and select "Begin Test".
2. Download and install Mozilla Firefox add on: Firebug and YSlow to measure response time.
3. Open static mapping site and measure features such as: refresh, panning, zooming in, zooming out, and selecting mineral distribution.
4. Open tile based mapping site and measure same features as in static mapping site.
5. Record response time of both sites.

The test results are recorded by testers located in several provinces. On each test case, the response time is noted in second unit. The test cases are full extent, zoom in and zoom out for several points, refresh, and view distribution of minerals.

5.1. Test Results and Analysis of Refresh Features

Refresh feature are tested several times and the average is calculated for each technique. Calculation result can be seen in table 1 and figure 7 depicts relations between the two techniques.

Table 1 Average Response Time of Refresh Feature

Province	**Static**	**Tile**
Riau	26,782	20,411
East Kalimantan/Kaltim	4,127	3,448
Papua	22,047	8,493
Jakarta	6,894	4,285
Riau Islands/Kepri	22,960	21,028
East Java/Jatim	5,714	3,721
South Sulawesi/Sulsel	8,175	3,811
West Nusa Tenggara/NTB	46,521	5,401
West Papua	35,270	18,177
West Java/Jabar	3,897	3,170
Banten	5,070	4,960
Jogjakarta	10,689	9,270

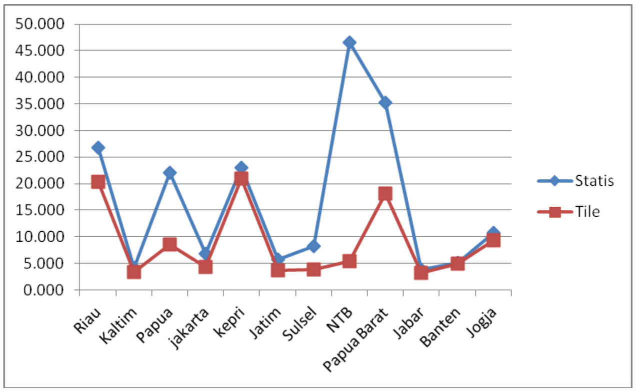


Fig. 7 Comparison of for Static and Tile based Techniques on Refresh Feature

Figure 7 depicted that response time for tile technique is always under the response time of static techniques. This is also evidenced by the T-Test that returns a value of 0.0463 with a degree of freedom 11. That scores fall below the value of α 0.05, so by convention, the value of this difference is statistically significant.

5.2. Test Results and Analysis of Panning Features

Panning feature is tested several times and the average is calculated for each technique. Calculation result can be seen in table 2 and figure 8.

Table 2 Average Response Time of Refresh Feature

Province	**Static**	**Tile**
Riau	22,958	12,872
East Kalimantan/Kaltim	4,119	2,392
Papua	13,931	8,749
Jakarta	4,555	2,351
Riau Islands/Kepri	25,738	12,961
East Java/Jatim	4,883	4,231
South Sulawesi/Sulsel	3,731	2,688
West Nusa Tenggara/NTB	29,622	12,252
West Papua	39,948	12,186
West Java/Jabar	4,422	2,356
Banten	5,742	2,520
Jogja	20,678	16,144

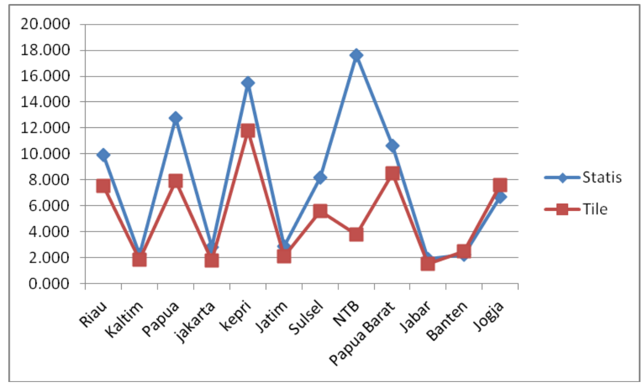


Fig. 8 Comparison of for Static and Tile based Techniques on Panning Feature

It can be seen from the graph that response time for tile technique is always under the response time of static techniques. This is also evidenced by the T-Test that returns a value of 0.0436 with a degree of freedom 11. This scores fall below the value of α is 0.05, so by convention, the value of this difference is statistically significant.

5.3. Test Results and Analysis of Zoom In Features

Zoom feature was tested in three sizes, namely 2,3,4 zooming point. Point 2 was tested by zooming in 7 times in a row. Point 3 was tested by zooming in 5 times in a row. Point 4 was tested by zooming in four times in a row. The averages of these processes are calculated and the results obtained as shown in table 3 and graph 9.

Table 3Average Response Time of Zooming In Feature

Province	**Static**	**Tile**
Riau	9,909	7,515
East Kalimantan/Kaltim	2,240	1,875
Papua	12,777	7,890
Jakarta	2,841	1,801
Riau Islands/Kepri	15,488	11,793
East Java/Jatim	2,887	2,133
South Sulawesi/Sulsel	8,201	5,599
West Nusa Tenggara/NTB	17,643	3,784
West Papua	10,633	8,498
West Java/Jabar	1,932	1,524
Banten	2,250	2,476
Jogja	6,674	7,594

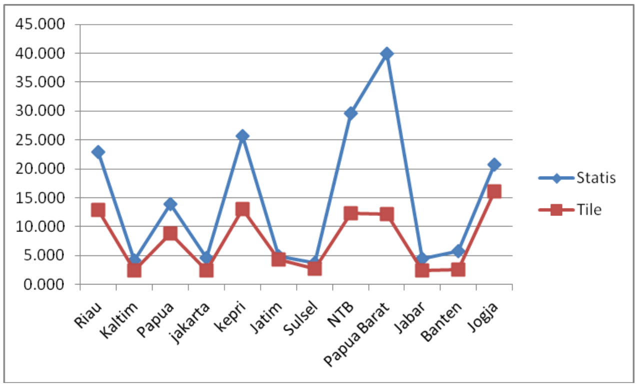


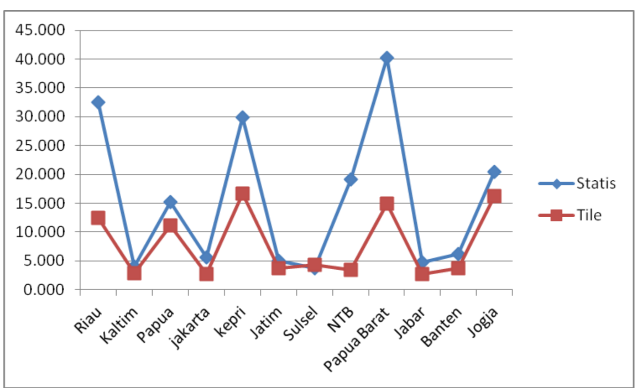
Fig. 9 Comparison of for Static and Tile based Techniques on Zooming In Feature

As shown in above graph, response time for tile technique is always lower than response time of static techniques. This is also evidenced by the T-Test that returns a value of 0.0102 with a degree of freedom 11. This scores fall far below the value of α is 0.05, so by convention, the value of this difference is statistically significant.

5.4. Test Results and Analysis of Zoom Out Features

As well as the zoom in feature, zoom out was also tested in three sizes, namely 2, 3, 4 zoom point. Point 2 was tested 7 times in a row. Point 3 was tested 5 times in a row. Point 4 was tested 4 times in a row. Then, the average of each point is calculated and the result is shown in table 4 and graph 10.

Table 4 Average Response Time of Zooming Out Feature



Province	**Static**	**Tile**
Riau	32,547	12,380
East Kalimantan/Kaltim	4,025	2,789
Papua	15,177	11,116
Jakarta	5,551	2,724
Riau Islands/Kepri	29,865	16,682
East Java/Jatim	5,066	3,764
South Sulawesi/Sulsel	3,719	4,297
West Nusa Tenggara/NTB	19,181	3,477
West Papua	40,228	14,891
West Java/Jabar	4,694	2,655
Banten	6,169	3,755
Jogja	20,468	16,262

Fig. 10 Comparison of for Static and Tile based Techniques on Zooming Out Feature

Figure 10 depicts fact that response time of static techniques is always higher than response time for tile technique. This is also evidenced by the T-Test that returns a value of 0.0106 with a degree of freedom 11. The Score fall below the value of α is 0.05, so by convention, the value of this difference is statistically significant.

5.5. Test Results and Analysis of Full Extent Features

Full Extent feature serves to restore the full map, which had been moved, enlarged or reduced. Testing result of this feature can be seen in table 5 and figure 11.

Table 5 Average Response Time of Full Extent Feature

Province	**Static**	**Tile**
Riau	12,127	13,253
East Kalimantan/Kaltim	4,219	3,514
Papua	4,817	5,713
Jakarta	3,805	2,898
Riau Islands/Kepri	22,217	23,883
East Java/Jatim	4,516	3,945
South Sulawesi/Sulsel	7,333	3,754
West Nusa Tenggara/NTB	4,917	15,99
West Papua	23,130	16,57
West Java/Jabar	4,160	3,27
Banten	4,815	6,259
Jogja	9,895	13,493

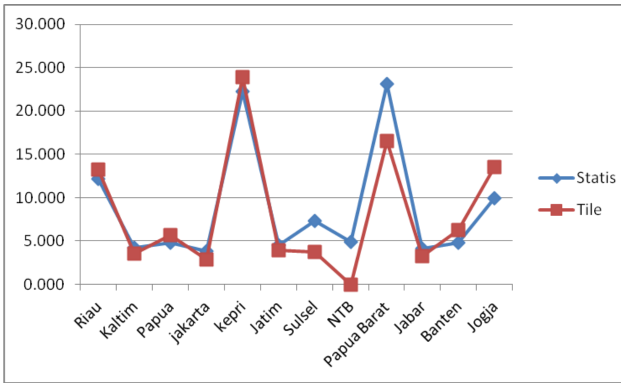


Fig. 11 Comparison of for Static and Tile based Techniques on Full Extent Feature

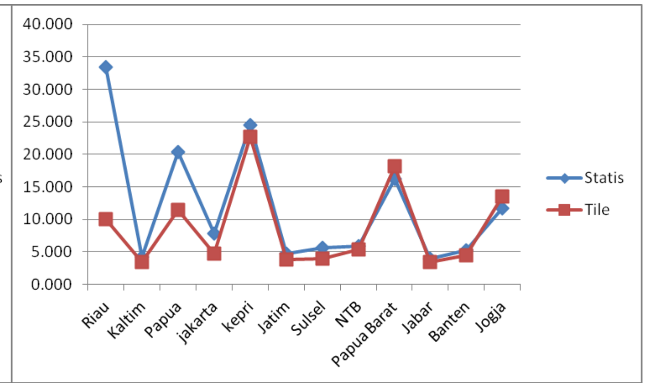


Fig. 12 Comparison of Static and Tile based Techniques on Selecting Mineral Distribution Feature

As can be seen from the graph, response time for the tile based technique sometime approach time response of a static technique. In addition, T-Test returns a value of 0.6353 with a degree of freedom 11. This value is above the value of α 0.05, so by convention, the value of this difference was not statistically significant.

5.6. Test Results and Analysis of Selecting Layer of Mineral Distribution Features

The response time is recorded whenever this feature is executed. The mean value are then calculated and shown in table 6 and chart 12.

Province	**Static**	**Tile**
Riau	33,360	10,023
East Kalimantan/Kaltim	4,159	3,481
Papua	20,330	11,409
Jakarta	7,779	4,713
Riau Islands/Kepri	24,525	22,716
East Java/Jatim	4,740	3,869
South Sulawesi/Sulsel	5,612	3,935
West Nusa Tenggara/NTB	5,869	5,388
West Papua	16,217	18,123
West Java/Jabar	3,883	3,470
Banten	5,263	4,403
Jogja	11,707	13,525

As shown in figure 12, response time for tile technique approaches the response time of static techniques. T-Test returns a value 0.1374 with degree of freedom 11. This value is above value of α 0.05, so by convention, the value of this difference was not statistically significant.

In general, it can be concluded that tile techniques yield a lower response time than static techniques that proved statistically significant difference for refresh, panning, zoom in, and zoom out features. This is due to panning and zooming, tile-based mapping system does not return the entire map, but only return the relevant parts only. As for the static technique, each time testing is done, the entire map image will be returned even if only a few new parts.

Vice versa, tile technique does not contribute significant reduction response time in full extent and selecting mineral distribution feature. Even few times, the static technique gives a lower response time. One possible cause of this event is easier to restore a large map rather than accessing the index and create a mosaic of shapefile, if at the end, the overall map will be returned.

7. Conclusions

Indonesia's geographical condition that consists of islands, disaster-prone, but has abundant resources, have made geographic information systems become a strategic role in supporting development and solve various problems in Indonesia. However, the use of GIS in Indonesia has not been so widespread. One massive obstacle of GIS implementation in Indonesia is a matter of infrastructure, particularly Internet infrastructure. This paper offers a different approach in applying GIS by using tile-based GIS.

After testing carried by the real user of E-Government, which is citizen of 12 provinces in Indonesia, tile-based GIS proved lower response time than static mapping techniques. The results were tested using statistical techniques T-Test. On the test with T-Test, two features, full extent and selecting mineral distribution layer, do not showed significant difference between static technique and tile based techniques. This is due to this feature displays the map as a whole, so the superiority of tile technique that is to reduce the response time when only a few new areas shown, could not be applied. While other features such as panning, refresh, zoom in and zoom out give statistically significant difference between tile techniques and static techniques. This means that different treatments can provide results that are expected to make sufficient difference, not just a coincidence.

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