

Utilizing web based GIS services for retrieving and disseminating geographic information for disaster management

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Abstract. The development of Information and Communication Technology (ICT) related to web-based services such as portals, web services and databases (DB) services for searching, retrieving, disseminating and sharing information has also happened in the field of Geographic Information Systems (GIS) through web-based GIS Services. In GIS, the portal is replaced by Geoportal, Web Service by Web Mapping Service (WMS) and Web Feature Service (WFS) while DB Services is replaced by Geographic Database (GeoDB) services. Web based GIS services can be classified as Geoportal, WMS, WFS and GeoDB Services. This research developed a prototype of web-based GIS services for the management of Geographic Information related to disaster management. There are several techniques for developing GIS based web services such as using Content Management Systems for GIS, namely OpenGeo Suite, GeoNode, and ArcGIS based GIS Services. This research focuses on Web-based GIS Services with the ArcGIS platform. The prototype of Web-based GIS Services was built focusing on Geographic information in disaster management cycles such as recovery (rehabilitation and reconstruction), prevention (mitigation), preparedness and emergency response periods.

1. Introduction

Geographic Information System (GIS) has taken part in the development of Information Technology and Communication (ICT) related to web-based services such as portals, web services and databases (DB) services for searching, retrieving, disseminating and sharing information through web-based GIS Services. In GIS, the portal is similar to Geoportal, Web Service to Web Mapping Service (WMS) and Web Feature Service (WFS) while DB Services is replaced by Geographic Database (GeoDB) services [1]. Web based GIS services can be classified as Geoportal, WMF, WFS and GeoDB Services [2]. Geoportal is a web application that gateway for discovering geographic content [3].

Disaster management cycle includes emergency response, recovery (rehabilitation and reconstruction), prevention (mitigation), and preparedness period [4]. When Sumatera Earthquake and

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Tsunami 2004 occurred, huge geographic information (GI) has been acquired and produced. For instant during the emergency response GI has been produced for rapid assessment and damage lost assessment, and during recovery process GI has been produced for rehabilitation and reconstruction process [5]. These GI were not only used during emergency response but also were used for disaster prevention or mitigation. New geographic information was also produced during emergency response and preparedness for instances, a lot of geographic information has been produced during Pidie Jaya Earthquake 2016.

There are several techniques for developing GIS based web services such as using Content Management Systems for GIS, namely OpenGeo Suite⁵, GeoNode⁶, and ESRI ArcGIS⁷ based GIS Services. Spatial Data Infrastructure supported by integrated framework can be implemented to support utilization of geospatial data for disaster management [4]. This research focuses on Web-based GIS Services using the ArcGIS platform. This research developed a prototype of web-based GIS services for the management of Geographic Information related to disaster management. The prototype of Web-based GIS Services was built focusing on Geographic information in disaster management cycles such as recovery (rehabilitation and reconstruction), prevention (mitigation), preparedness and emergency response periods.

2. Methods

2.1. Data

The data used in developing the Web-based GIS Service were collected during Aceh Nias recovery process for Sumatera Earthquake and tsunami 2004. The data include barrack locations during emergency process, damage assessment by Aceh Rehabilitation Reconstruction Information System (ARRIS) during early recovery, and other data collected in housing and asset project. In this research for testing and evaluating the system, geospatial data were collected from several sources. This data has been produced during emergency response, recovery and prevention and preparedness period when Sumatera Earthquake and Tsunami 2004 and Pidie Jaya earthquake 2016. Data was also collected during previous study and survey including ICAIOS's Aftermath of Aid project and Nusantara Secom Indonesia (NSI)'s hazard map in Banda Aceh city and Aceh Besar district. Some of data were reproduced from ESRI personal geodatabase (mxd), ESRI File geodatabase (gdb), shapefile (shp), Global Positioning System (GPS) Survey data, and Unmanned Aerial Vehicle (UAV) or Drone for some tsunami affected area.

2.2. System architecture

The Web based GIS Services architecture was developed using ESRI platform as shown in Figure 1. The GIS Services architecture was adopted from common Web based GIS Services architecture [5]. As an integrated GIS System, a Web based GIS service commonly consists of a Web Server (Apache Tomcat or Internet Information Services), GIS Server (ArcGIS Server), Geoportal (ESRI Geoportal), and Geographic Database (PostgreSQL 9.6/PostGIS 2.4). ArcGIS Server reads geographic data stored in the Geographic Database via SDE connection and publishes them as Map Server Service, Feature Access, WMS, and WFS. ESRI Geoportal lists the GIS services in an online catalogue which is stored in a DBMS. Users can find the GIS services they need by searching the catalogue in the Geoportal by using Web Client and Smartphone [1][2][3]. Web client can also browse the published service directly from the ArcGIS Server because the server exposes the GIS services via HTTP through port 6080 and HTTPS through port 6443. Based on the information provided by the geoportal, users can use ArcGIS Desktop, Web GIS, and mobile GIS to consume the GIS Services. Direct access of the geographic data to the geographic database is allowed only for authorized users by using ArcGIS Desktop.

⁵ <http://93.187.166.52:8081/opengeo-docs/>

⁶ <http://geonode.org>

⁷ <https://www.esri.com/en-us/arcgis/products/geoportal-server/overview>

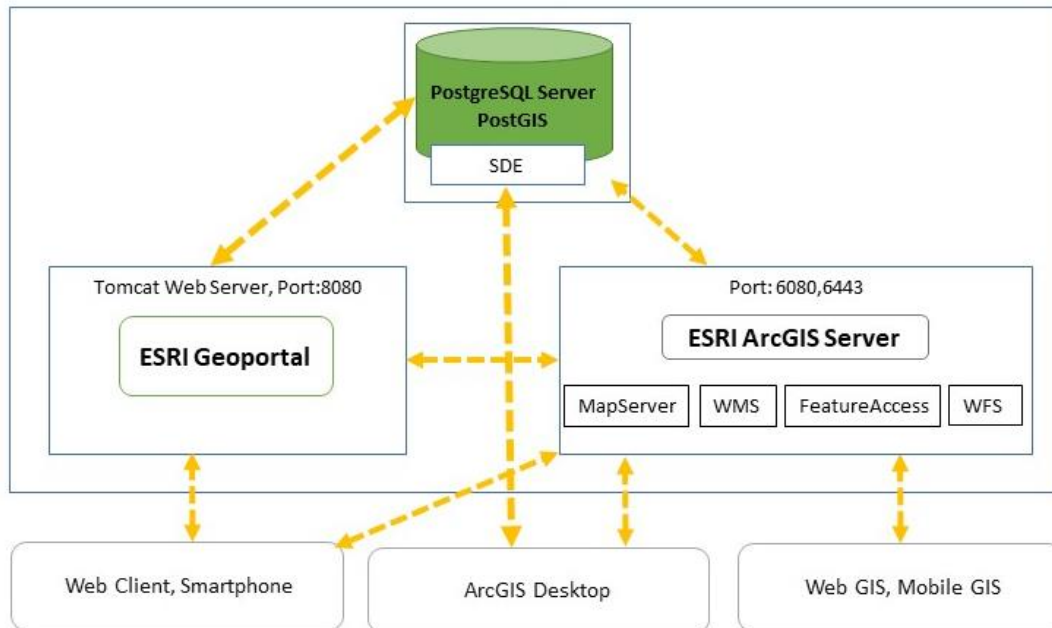


Figure 1. System Architecture.

2.2.1. PostgreSQL/PostGIS

PostgreSQL is the most developed object-relational database management system, while PostGIS is an extension to PostgreSQL for managing spatial database [6]. In the system architecture shown in Figure 1, PostgreSQL/PostGIS functions as a Geodatabase Management System (GDBMS) which stores and manages geographic data published as GIS services by the ArcGIS Server. When the GDBMS is used as the geographic data storage, the ArcGIS Server will not need to copy the data to the server computer. However, the GDBMS should be registered to the ArcGIS Server. The registration process is carried out by first creating a database connection using an ArcGIS Desktop application and then importing the connection file (.sde) created to the ArcGIS server. Connecting and Registering the GDBMS are also a requirement for publishing a Feature Access or WFS services which allow authorized user to edit the geographic data stored in the GDBMS.

Connecting a GIS application to a GDBMS allows it to access data in the geodatabase. The geographic dataset related to disaster in a geodatabase which have been connected to an ArcGIS Desktop application will be shown in tree view. The geographic data in the connected geodatabase can be used for doing analysis and making maps. A user can even add, modify or delete a geographic feature in the data if he or she has the permission.

2.2.2. ArcGIS server

ArcGIS Server is software that manages GIS services [7], which are web services created from geographic data. ArcGIS Server is accessed via ArcGIS Desktop to publish a service from one or more geographic data. Alternatively, ArcGIS server can also publish a service directly from service definition file created by using ArcGIS Desktop [1][2]. ArcGIS server does not require a GDBMS to publish a service, but the use of GDBMS makes the publishing a service more efficient because the data do not need to be copied into the server machine especially for WFS. Furthermore, services that allow data editing, such as Feature Access and WFS, can only be created if the geographic data is stored in a geographic database. ArcGIS server does not need a web server, but it handles request for GIS services via web protocol HTTP/HTTPS at port 6080/6443. Therefore, it is possible to access the services using a web browser.

2.2.3. MapServer, WMS, FeatureAccess and WFS

In this research, ArcGIS Server was used for publishing data in the format of MapServer [8], FeatureAccess [8], WMS and WFS [9]. MapServer and FeatureAccess Services can only be consumed by ESRI product, such as ArcGIS Desktop [10][1][2][5]. MapServer service provides geographic information in JPEG or PNG format, so users can display the information but cannot edit the data. A MapServer service can be used as a map layer as it is. The symbolization of a layer from a map service cannot be changed. A FeatureAccess service provides a capability for authorized users to add or edit the data using ESRI software product. WMS is the opensource equivalent to MapServer, while WFS is equivalent to FeatureAccess.

2.2.4. Geoportal

The ESRI Geoportal Server runs on the Apache Tomcat Web Server at port 8080 and was connected to the PostgreSQL DBMS. This combination was simpler than the geoportal set up by Mabeya and Waithaka [11]. The geoportal was used to register services from WMS Services as show in Figure 2.



Figure 2. List of registered Geographic Information Services.

3. Result and discussion

The web-based GIS service that utilized ArcGIS based GIS Service was compared to the GIS Service that implemented by using GeoNode platform. There were two major components in each method, namely Geoportal and GIS Server. ArcGIS based GIS Service uses ESRI Geoportal as the geoportal application and ArcGIS Server as the GIS Server, while GeoNode platform uses GeoNode and Geoserver. The comparison results are shown in Table 1.

The geospatial data was stored in PostgreSQL/PostGIS geodatabase via Database Connection in ArcMap Catalog. The feature classes in the geodatabase were grouped into several Feature Datasets according the provider of the data and their spatial reference. There are three spatial references that are commonly used in Aceh Province, namely Geographic Coordinate System (WGS84) as well as Universal Transverse Mercator (UTM) zone 46N and 47N. Those grouping were to make it easier for users to find the data that fit their purpose. When the data were published as GIS Services, the name of data provider and spatial reference code were suffixed into the name of the GIS Services as shown in Table 2. User can easily choose and directly use these services in GIS Desktop, Web Mapping Application, or ArcGIS Online.

Table 1. Comparison of two major components of GeoNode platform and ArcGIS based GIS Services.

No	Functionality	GeoNode CMS	ESRI based GIS Services
1	Geoportal	GeoNode <ul style="list-style-type: none"> • Open Source • For spatial data Catalog • Can publish GI Services • Geoserver as the default GIS Server 	ESRI Geoportal <ul style="list-style-type: none"> • Open Source • For spatial data Catalog • Cannot publish GI Services • No default GIS Server
2	GIS Server	Geoserver <ul style="list-style-type: none"> • Opensource • Services: WFS, WMS, WCS, WMTS, WPS • Geographic Database: PostgreSQL, Oracle, SQL Server (For WFS Services) 	ArcGIS Server <ul style="list-style-type: none"> • Commercial • Services: WMS, WCS, WFS, Schematic, Network Analysis, Mapping, Feature Access • Geographic Database: PostgreSQL, SAP HANA, SQL Server, dan Oracle (for WFS services)

Table 2. List of registered Geographic Information Services.

No	Service Name	Disaster Management Cycle
1	AlueDeahTeungoh UAV (Drone Data)	Mitigation preparedness
2	Buliding_Vulnerability_Grid500_NSI_20161116_WGS84	Mitigation
3	EarthquakeHazardLevel_20130818_TDMRC	Mitigation
4	EarthQuakeVillage_Pidie_Jaya_EQ_MIK_20161212	Mitigation
5	GeoHazard_46N_SLGSR_Bappedalda_TDMRC_20170727	Mitigation and preparedness
6	IDP_Camp_MIK_20161112	Emergency response
7	Landslide_Vulnerability_46N	Mitigation
8	Village_Boundary_Pidie_Jaya_EQ_MIK_20161212_WGS84	Mitigation
9	Relocation_House_Final_2016248_AOA_46N	Rehabilitation
10	Desa_BNA_Tsunami_20140821_AOA_47N	Mitigation and preparedness
11	Escape_building_20052704_AOA_46N	Mitigation and preparedness
12	Innundation_Area_PLY_JICA_ARRIS_46N_20150723	Mitigation and preparedness
13	Houses_Main_Survey_Banda_Aceh_20140904_AOA_46N	Recovery
14	Tsunami_20131205_AOA_47N	Mitigation and preparedness
15	Polygon_tsunami_area_A_Barat_20131211_AOA_47N	Mitigation and preparedness
16	Polygon_tsunami_area_A_Jaya_20131211_AOA_47N	Mitigation and preparedness
17	Polygon_tsunami_area_A_Jaya_full_20131212_AOA_47N	Mitigation and preparedness
18	Polygon_tsunami_area_A_Barat_edit_20131213_AOA_47N	Mitigation and preparedness
19	Polygon_tsunami_area_ABA_BAC_20131219_AOA_WGS84	Mitigation and preparedness
20	Batas_Kec_BNA_20150904_AOA_WGS84	Recovery
21	Education_Banda_Aceh_20152104_JICA_ARRIS_46N	Recovery
22	Spot_Damage_Assessment_20152104_JICA_ARRIS_46N_	Emergency Response
23	Tsunami_Affected_Line_20161804_JICA_NSI_47N	Preparedness
24	AffectedVillageVictim_IOM_20050711_WGS84	Emergency Response

4. Conclusion

This research focused on Web-based GIS Services with the ArcGIS platform. The prototype of Web-based GIS Services was built focusing on geographic information in disaster management cycles such as recovery (rehabilitation and reconstruction), prevention (mitigation), preparedness and emergency response periods. The geographic data were classified into the Feature Datasets based on geospatial data provider. GIS Services can be accessed using any GIS Desktop and web application including mobile application that will be used for mitigation, preparedness and future emergency response. This

research will continue with the completion of geodatabase and GIS services that can be used by any users as base map or data for analysis.

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