International Symposium on Applied Geoinformatics (ISAG-2019)

OPEN SOURCE CLOUD GIS FRAMEWORK FOR REAL ESTATE VALUATION

Muhammed Oguzhan Mete [1]*, Tahsin Yomralioglu [1]

[1] Istanbul Technical University, Faculty of Civil Engineering, Department of Geomatics, Istanbul, Turkey
(metemu/tahsin@itu.edu.tr); **ORCID 0000-0002-9312-1965**, **ORCID 0000-0002-8532-747X**

*Corresponding Author

ABSTRACT: Geospatial technologies have become more prominent over the last decades with the emergence of improvements in this field. Widespread usage of internet and requirements in dynamic systems in Geographic Information Systems (GIS) have revealed Web GIS and cloud GIS solutions. Desktop GIS products are still used in the community frequently, however Web GIS and cloud GIS applications have drawn attention and have become more efficient for users. Cloud computing is the system where many computations and analysis tasks are performed and shared services in web-based computer centers instead of local desktop systems. Cloud computing models offer scalable, secure and robust systems with less people, money and hardware needs. Cloud GIS applications provide real time data visualization, enable multi-users access, deliver significant cost savings. Using open source geospatial tools integrated with cloud computing technology, complete GIS systems can be created with limited budget or free of charge. In this study, Amazon Web Services (AWS) cloud computing infrastructure, PostgreSQL, GeoServer, and Leaflet are used to create cloud GIS solution for real estate valuation. AWS Elastic Compute Cloud instance is created for storing and serving spatial data on cloud. Open source server application GeoServer which can be regarded as Platform as a Service model is installed on virtual cloud server in order to share real estate valuation data and maps as a web service in Open Geospatial Consortium standards such as Web Feature Service, Web Map Service, and Web Coverage Service. PostGIS, spatial database extender of PostgreSQL Relational Database Management System, is used on AWS so as to store and deploy spatial data. On the other hand, Leaflet JavaScript web mapping library is used for visualizing and publishing shared data and maps on the web. In the paper, it is aimed to build cloud-based GIS environment to store, analyze, visualize, and share real estate values and maps by using open source geospatial tools. Using open source GIS applications for real estate valuation on the cloud environment resulted in enhanced performance and efficiency, while reduced implementation costs in comparison with the local GIS infrastructures.

Keywords: *Cloud Computing, Cloud GIS, Open Source GIS, Real Estate Valuation*

1. INTRODUCTION

Rapidly growing existence of geospatial data requires different approaches for storing and sharing big data bulks. With the development of cloud computing systems, it is possible to store, process, and share large data volumes on virtual machines through the web. Cloud computing has changed the way people look into the Information Technologies (IT) infrastructure since it has many advantages in comparison with conventional system architecture. There are various cloud computing providers with different leading features in the market. In this paper, Amazon Web Services (AWS) is adopted as cloud computing service provider to build open source geospatial stack on the cloud environment.

Real estate valuation is an estimation of property values with technical knowledge and it depend on many internal and external factors (Yomralioglu, 1993). Evaluating lots of real estates in large areas like city or district scale requires numerous analysis, data process, and long time. In order to carry out this procedure with scientific methods objectively, Geographic Information Systems (GIS) can facilitate to store, view, analyze and share real estate data and maps (Mete, 2019).

GIS cloud framework provides high performance of data storage and computing capabilities, in addition, it decreases requirements of hardware and IT staff. Furthermore, platform and service deployment models on the cloud systems eliminates installment and maintenance steps on the user side. In this view, open source server software, GeoServer is installed for sharing real estate data and maps on AWS Elastic Compute Cloud (EC2). Besides, PostgreSQL open source database system is installed on Amazon Relational Database Service (RDS) for dynamically storing geospatial data on the cloud environment. Using Leaflet open source JavaScript web mapping library, raster and vector data is presented on the web browser so as to share up-to-date real estate values with users.

2. CLOUD COMPUTING

Cloud computing is a model that provides omnipresent, proper, on-demand network access to a shared bank of adjustable computing supplies like networks, servers, storage, applications, and services. It does not require much exertion or involvement on client's side when configuration and deployment of the system (Mell & Grace, 2011).

Cloud computing technology comprises five major features: *i) On-demand service configuration, ii) wide network access, iii) resource pooling, iv) rapid elasticity, and v) pay as you go characteristics.* Among leading technology companies, there are prominent cloud computing service providers like Amazon Web Services, Google Cloud Platform, Microsoft Azure, IBM Cloud, Oracle Cloud etc. In this paper AWS is adopted as cloud computing platform, since it has many service alternatives, reasonable service costs, datacenters in many locations, and highly available services.

2.1 Amazon Web Services

AWS is one of the major public cloud service providers in terms of functionality, availability, service variety, sizing, and cost (Dillman, 2016). As a third-party cloud provider, AWS has computing, storage, networking, database, analytics, application services, deployment, and management solutions. In this paper, the most known and used AWS services, EC2 and RDS will be explained.

2.1.1 Elastic compute cloud

EC2 is a web service that offers secure, resizable compute capacity and scalable deployment of applications in the cloud. EC2 service can be regarded as IaaS since AWS takes the responsibility of server, storage, networking, and virtualization itself; on the other hand, users are responsible for handling operating system, data applications, middleware and runtime. Users can launch an Amazon Machine Image (AMI) to create a ready-to-use virtual machine, which is called "instance". AMI consist of Windows or Linux operating system, software and applications. Management and configuration of the instances can be controlled over management panel called "console" (Shao, Di, Guo, & Gong, 2012).

2.1.2 Relational database service

Amazon RDS provides relational databases in the cloud via web service. It is designed to ease the setup, control, and scaling processes of the database. RDS also makes enable automatically patching, back up and incremental recovery (Hubbard, 2019). According to the users' needs, it supplies scalable, resizable database with memory, Input/Output bottleneck, or performance optimization. RDS, which is a Software as a Service (SaaS) offers well-known database systems like Amazon Aurora, MariaDB, MySQL, Oracle Database, PostgreSQL, and SQL Server. Moreover, users can migrate their existing databases to RDS with AWS Database Migration Service quickly and securely.

3. CLOUD GIS

Cloud GIS notion has arisen as the compound of GIS and cloud computing. Beyond GIS capabilities, it enables highly available, scalable, secure, and cost-friendly data storage, software, and contents. Using GIS on the cloud environment, users can reach data, maps, and geoprocessing services easily (Peng & Wang, 2014).

Cloud GIS has many benefits like supplying implementation environment, providing hardware and software resources, minimizing IT professionals and support needs, decreasing costs, enabling advanced data management, and offering location-free resource pooling. With the help of IaaS service model, it is provisioned to create GIS infrastructure on the cloud systems. Implementation of Cloud GIS provides users to facilitate geo-data management, analysis, and storage. It also enables web services and application hosting to access, publish, and consume the data easily (Bhat et al., 2011).

Cloud computing systems provides hardware and software for enabling computing resources, software, and applications to build a whole geospatial environment on the cloud. Users can create instances with intended specifications according to the needs of computing power, performance and budget. Furthermore, operating system, GIS software, applications and tools can be installed using cloud machine images simply.

4. USE CASE FOR REAL ESTATE VALUATION

Real estate valuation is a complex procedure since there are numerous factors that affect the value. To assess real estate values objectively and analyzing the effects of internal and external factors is possible thanks to the GIS. It is also possible to share those real estate data and maps with the users through Web GIS and Cloud GIS technologies. In this study, land values of Istanbul city produced by GIS based nominal valuation method were stored and published using AWS cloud infrastructure and open source geospatial tools.

4.1 Building Open Source Geospatial Stack on Cloud

In this study, open source geospatial tools are adopted on the cloud in order to share real estate valuation data and maps with the users dynamically. Foremost, EC2 instance is created on AWS for creating GIS infrastructure on the cloud. The process steps are respectively: Choosing an AMI to assign operating system, choosing instance type, configuring instance, adding storage, adding tags, and configuring security group. After completing required configurations, "t2.micro" instance with Windows Server 2019 is created. It is possible to access to the instance via command line interface using Secure Shell (SSH) connection or remote desktop protocol.

In order to store the data on the cloud environment, PostgreSQL object-relational open source database management system is preferred. Therefore, Amazon RDS database instance is created on AWS and PostgreSQL is installed with PostGIS extension to enable spatial data storage. All required vector and raster datasets like district and neighborhood boundaries, parcel boundaries, real estate valuation data loaded into the database. It is possible to manage Amazon RDS PostgreSQL database using both pgAdmin and interactive terminal psql shell.

After creating EC2 and RDS instances, GeoServer, Java-based free and open source software server, is installed on EC2 instance for enabling geospatial data sharing. GeoServer implemented Open Geospatial Consortium (OGC) standards like Web Feature Service (WFS), Web Map Service (WMS), Web Map Tile Service (WMTS), Web Coverage Service (WCS), and Web Processing Service (WPS) for data sharing and processing on the web. In order to share real estate data which stored in the PostgreSQL/PostGIS database, PostGIS data source created on GeoServer to connect to the Amazon RDS instance. All the published cloud-based geospatial data can be accessed by web services using desktop GIS software (QGIS, ArcGIS etc.), or web browsers with the help of web mapping libraries.

Web mapping libraries are using Application Programming Interface (API) to present and work with the geospatial data. There are many JavaScript web mapping libraries like ArcGIS API for JavaScript, Leaflet, OpenLayers, Mapbox GL JS for displaying maps on the web browsers. In this paper, Leaflet JavaScript open source web mapping library is used, since it has simple, lightweight, usable design, readable source code, and well documentation. Figure 1 illustrates open source geospatial framework on the cloud environment.

Figure.1 Open source geospatial stack on the cloud

Using Leaflet library, real estate valuation data which published from cloud GIS environment is presented on the web (Figure 2). Users can display nominal valuation map and find the current value of any parcel in the Istanbul city. On the other hand, satellite images, topographic maps, and vector maps can be displayed as a basemap by using REST API and OGC web services.

5. CONCLUSION

With the continuously developing computer technologies, enterprises or individual users can find improved solutions to the growing needs and problems. Cloud computing systems offer significant opportunities by removing borders in storage, computing, and networking fields. Cloud GIS infrastructure has changed the approach towards geospatial systems in terms of data storage, data visualization, geoprocessing, and data sharing. Using those improvements in GIS-based decision support systems can facilitate to build automated, dynamic geospatial framework on the web.

Real estate valuation applications are carried out in many fields such as purchase and sale, capital market activities, taxation, zoning applications, and urban renewal. Objective valuation of real estate and sharing up-to-date market values with the relevant public is a crucial matter in which it helps regularization of the market by preventing speculations. In this study, cloud based open source geospatial software stack was created to store, view, analyze and share real estate data and maps on the web environment.

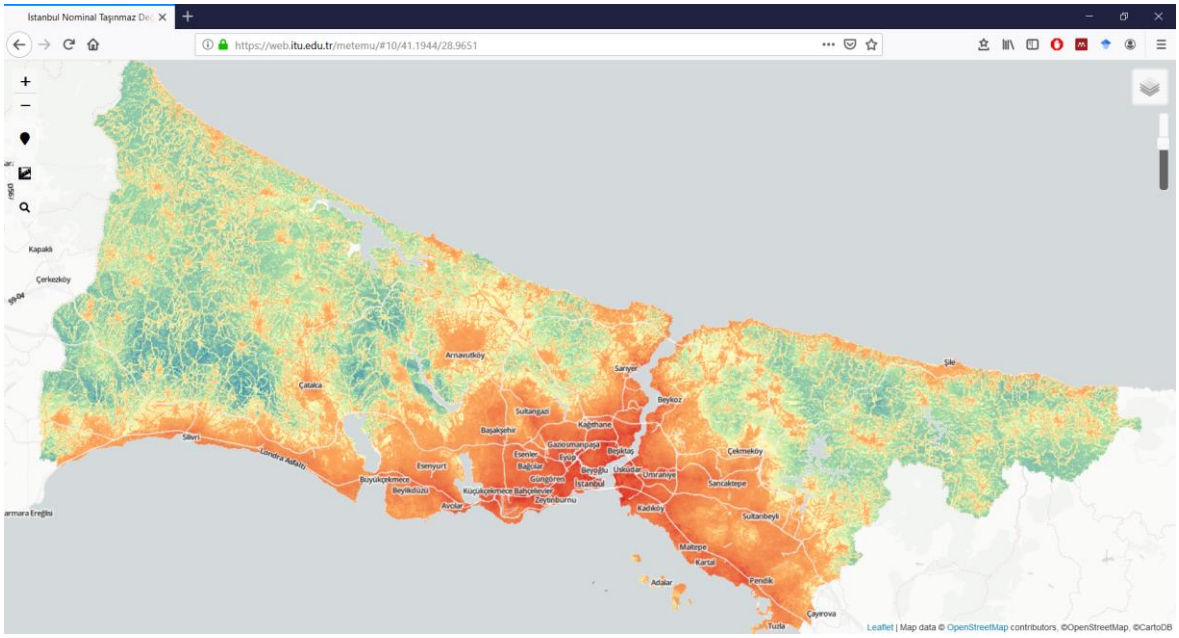

Figure.2 Presenting nominal land valuation map of Istanbul city on the web browser

ACKNOWLEDGEMENTS

This work was supported by Scientific Research Projects Coordination Unit of İstanbul Technical University. Project Number: MYL-2018-41706.

REFERENCES

Bhat, M. A., Shah, R. M., & Ahmad, B. (2011). Cloud Computing: A solution to Geographical Information Systems (GIS). *International Journal on Computer Science and Engineering, 3*(2), pp. 594-600.

Dillman, J. (2016, May 25). Comparing Cloud Providers: Amazon vs. Google vs. Microsoft [Web log post]. Retrieved September 29, 2019, from https://www.inovex.de/blog/comparing-cloud-providers.

Hubbard, A. (2019). Amazon EC2 to S3: A guide to AWS products. Retrieved from https://searchaws.techtarget.com/feature/Amazon-Web-Services-product-directory.

Mell, P., & Grance, T. (2011). The NIST definition of cloud computing, *National Institute of Standards and Technology Special Publication* (800-145).

Mete, M. O. (2019). *Creation of nominal asset value-based map using Geographic Information Systems in Istanbul city* (Master's thesis, Istanbul Technical University Institute of Science and Technology). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/TezGoster?key=Mir2lXQK1dkmQ9Ige3PZbu1Yx9CcVR0iMMy8sXZw9pkxXd-x3C3BRPToxuQ54z52.

Peng Y., Wang Y. (2014). Geographic Information System in the Cloud Computing Environment. In: Wong W.E., Zhu T. (eds) *Computer Engineering and Networking*. Lecture Notes in Electrical Engineering, vol 277. Springer, Cham.

Shao, Y., Di, L., Bai, Y., Guo, B., & Gong, J. (2012, August). Geoprocessing on the Amazon cloud computing platform - AWS. In *2012 first international conference on agro-geoinformatics (agro-geoinformatics)*, pp. 1-6. IEEE.

Yomralioglu, T. (1993). *A Nominal Asset Value-Based Approach for Land Readjustment and Its Implementation Using Geographical Information System*, PhD Thesis, Department of Surveying, University of Newcastle upon Tyne, pp.1-327, England.