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A Review on Geospatial Information Systems in Cloud Computing

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Abstract— Cloud computing technology is one of the most important technology in information systems (IS) today. It is an important alternative that ensures powerful data processing, storage and exchange. And as a result of the emergence of multiple sources of spatial data and their tremendous growth and the expansion of areas of use of Geospatial Information Systems (GIS), it became necessary to integrate these tow technologies to achieve the optimum benefit of these technologies to make Geospatial Information Systems capable of accommodating the large, rapid, and diverse amounts of spatial data available nowadays. Cloud computing is a new paradigm in Geographic Information Systems. Although there are many publications related to cloud computing in Geographic Information System, there is no systematic review of current research taxonomies .The purpose of this paper is to conduct a survey on GIS Cloud Computing. It addresses the different GIS Cloud frameworks or architectures. The search for articles carried out in general academic databases including the Scopus database, Web of Science Core Collection, and Google Scholar Citations. Retried articles are analysed according to inclusion and exclusion criteria, finally articles selected for review.

Keywords— Spatial Data, Cloud Computing, GIS, GIS Cloud Computing, GIS Cloud frameworks.

I. INTRODUCTION

Recently, Cloud Computing (CC) was raised to help in solving a lot of problems in a wide range of different sectors. By using (CC)it became much easier to handle a large amount of data and services with a less cost using the utility of pay-as-you-go (PAYG) which is a computing billing method implemented in cloud computing. It allows the user to scale, customize and provision computing resources, including software, storage and development platforms where the resource charges are based on the used services. Cloud computing also gives access to these data and services without time or location dependency. While (GIS) is playing an important role in a lot of sectors, its value would be much bigger by getting the access to its services 24/7 regardless the location and the time where an internet connection is all you need[1]. According to IBM estimates, 90% of the world's data has been created in the last two years. Other forecasts say that in 2025 there will be 175 ZB of data in the world, which means an increase from 33 ZB in 2018. This data is big data. This increase also applies to spatial data, which have particularly gained importance due to mobile devices equipped with geolocations [2, 3, 4, 5] constellations of various geostationary and non-geostationary satellites [6, 7, 8, 9] Volunteer Geographic Information [10], or finally Global Positioning System [11]. It should also be added that spatial data have a decidedly different character than alphanumeric information, hence the increasing amount of this type of data forces the use of a dedicated approach to handle it [12, 13, and 14].To respond to these new requirements GIS Cloud is now being adopted.

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II. METHODOLOGY

Our methodology in this survey is to conduct an overall review for all articles related to GIS Cloud Computing. Following keywords and terms Cloud Computing, Framework in GIS CLOUD, Geographic Information Systems and Cloud GIS) and spatial data used to search for articles in general academic databases including the Scopus database, Web of Science Core Collection, and Google Scholar Citations. We reached our final set of articles after eliminating some duplicates and irrelevant articles. Also we exclude articles that did not present Architectures or frameworks for GIS cloud.

III.FRAMEWORKS OF GEOSPATIAL INFORMATION SYSTEMS CLOUD

In [16] the research discussed the Cloud Computing approach to GIS applications and the benefits of implementing former for later applications. Also the authors have proposed GIS Cloud architecture be broadly divided into two major components which are GIS Cloud Web-Interface and GIS Server. The proposed GIS Cloud Server composed of five tiers or layers which are GIS Cloud Communication Layer, GIS Cloud Repository Layer, GIS Cloud Utilities Layer, GIS Cloud Logic Layer, and GIS Cloud Configuration Layer.

In[17] authors have proposed GIS Cloud architecture and the study depends on the integration between GIS and cloud computing, and the research discusses as well as to the cloud computing service models – Software-as-a-Service (SaaS); Platform-as-a-Service (PaaS); and Infrastructure-as-a Service(IaaS), there are some extension services for the GIS cloud, and that is just to deal with geospatial data, as follows: GIS-as-a-Service (GaaS): This is an extension of the Software-as-a-Service model for providing GIS solutions as a service, usually offering specializations in areas like incidence reporting, disaster and transport management. Imagery-as-a-Service (IaaS): Where ready-to-use GIS datasets are available as Data-as-a-Service(DaaS) , the on demand solution, customers are now able to find, acquire and subscribe to available data sets digitally rather than relying on data delivery on external storage. Applications-as-a-Service (AaaS).In [18] the research discussed about the currents existing GIS solutions for emergency system focusing the earthquake, and discusses the current challenges of those systems, specifically managing spatial data. A detailed architecture is presented in the study, consisting of several layers as GIS cloud layer, GIS cloud application layer, GIS cloud management layer, cloud storage layer, GIS platform layer, and infrastructure layer. Microsoft windows azure platform is selected for the realization of the proposed architecture, a detailed workflow diagram is also presented to understand the flow process of the architecture.

In [19], authors have presented a framework that couples cloud and high-performance computing for the parallel map projection of vector-based big spatial data The parallel map projection framework is based on the integration of capabilities of three layers: GPU-enabled high-performance computing, cloud computing and Web GIS .The research discusses about GPUs, with a foundation on the many-core computing paradigm provide unprecedented massively parallel computing capabilities that are shifting mainstream computing paradigm. Benefiting from numerous cores that are tightly coupled, GPUs are allowed to reap computing performance that is often several orders of magnitude of CPUs Therefore, commodity programmable GPUs have been extensively used as co-processors to accelerate general-purpose. The use of multiple GPUs that are interconnected (i.e., GPU clusters that couple both CPU processors and GPU co-processors) is urgently needed to handle efficiently big data using GPUs.

In [20], authors had presented a design and architectural framework for geoprocessing over Cloud platform, based on OGC standards. The architecture includes developing geoprocessing service, and data management services as an essential part while storing/processing the geospatial data from heterogeneous sources. The architecture model including data management and geoprocessing can be bind together in a cloud platform to have an on demand service as per the requirement of end user.

In (21) the study proposed An Agent-as-a-Service (AaaS)-based geospatial service aggregation to build a more efficient, robust and intelligent geospatial service system in the Cloud for flood emergency response It involves an AaaS infrastructure, encompassing the mechanisms and algorithms for geospatial Web Processing Service (WPS) generation, geoprocessing and aggregation. The method has the following advantages:

1) It allows separately hosted services and data to work together, avoiding transfers of large volumes of spatial data over the network;

2) it enriches geospatial service resources in the distributed environment by utilizing the agent cloning, migration and service regeneration capabilities of the AaaS, solving issues associated with lack of geospatial services to a certain extent;

3) It enables the migration of services to target nodes to finish a task, strengthening decentralization and enhancing the robustness of geospatial service aggregation;

4) It helps domain experts and authorities solve interdisciplinary emergency issues using various Agent-generated geospatial services.

In [22], authors combined Docker and OpenStack to build a containerized based cloud power grid GIS platform management framework. To take advantage of Docker container's characteristics such as lightweight, low system overhead, high system resource utilization, easy deployment with multiple running instances and

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great extensibility, they combine OpenStack to manage the resource in a uniform supervisor which simplify development, testing and maintenance and enhance the system efficiency. They Compared classic cloud based deployment method in a simulated system, with their framework they claimed that their framework can reduce GIS based application deploy time greatly and poses better extensibility as cloud node numbers increase.

In [23], authors have presented the Cloud WPS framework to support implementing Earth science model as WPS. Specifically, to make the Community Multiscale Air Quality (CMAQ) model easier to use for scientists through the latest standard-based Web service technology, CMAQ-WS, a prototype of CMAQ as a Service, is developed and tested. Authors claimed that their result of the experiment shows the framework significantly improves not only the performance of but also ease of use of the CMAQ model thus providing great benefits to the environmental modeling community. Meanwhile, the proposed framework provides a general solution to integrate Earth science model, WPS, and cloud infrastructure, which can greatly reduce the workload of Earth scientists.

In [1] the study proposed a framework that integrates the Geospatial Information Systems with the Hybrid Cloud Computing to let them work together and get greater powerful benefits via applying the concept of cloud computing to overcome the flaws related to the desktop GIS including the huge startup cost and the storage capacity and to provide the feature of location independence accessibility where the GIS can be accessed from anywhere and anytime. The hybrid cloud computing was picked to be integrated with the GIS to gain the elasticity and security of dealing with different types of data; private and public data. This integration is presented in three dimensions. The first one is architecture with seven segments that illustrate the main structure for the Hybrid Cloud GIS within a mix of private environment and public environment. The second one is the types of the participants and their workflow within the two environments.

IV. CONCLUSIONS

Technological developments on many fronts, such as the rapid growth of cloud computing and the emergence of multiple sources of spatial data and its tremendous growth, need for integrate these technologies to enable geospatial information systems to handle the large, rapid, and varied amounts of geospatial data available today .The purpose of this paper is to conduct a survey of previous research on geospatial information systems in cloud computing.

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