Using the cloud as a replacement for traditional GIS

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Abstract— Geographical information systems (sometimes called "geospatial information systems") are used to collect, organize, analyze, and present data that is spatially referenced. The usefulness of GIS in many disciplines has led to its widespread adoption in recent years. Maps, statistical analyses, computer systems, and information are all examples of the several kinds of data that may be integrated into a GIS. GIS is often used as a decision-making tool due to its capacity to display and analyze both spatial and non-spatial data. The most efficient use of time and resources is achieved by making GIS available to as many people as feasible. Researchers and developers have spent the better part of the past several decades honing conventional GIS applications so that they can cater to a larger range of users in more locations. As the notion of "cloud computing" has gained popularity in recent years, it has been described as "the next natural step in the evolution of on-demand information technology services and products." Cloud computing has the potential to solve the problems that emerge while utilizing GIS applications. In this work, we present a brief evaluation of several Cloud Computing implementations of GIS and propose a tiered architecture for a GIS Cloud System.

Keywords- Cloud Computing, High Performance Computing, Microsoft's Windows Azure, Elastic Computing Platform, Geographical Information Systems.

I. INTRODUCTION

Businesses, governments, educators and scientists, environmental and conservation organizations, natural resource groups, researchers, and many more all utilize Geographical Information Systems [1] regularly. Data that is tied to specific places may be captured, stored, analyzed, managed, and displayed with the help of Geographical Information Systems (GIS) or Geospatial Information Systems (GIS).

Increasingly, organizations are turning to cloud computing as a central computing platform for pooling resources like servers, programs, and even whole business procedures. In order to facilitate the sharing of cloud resources, virtualization is essential [5].

Industry giants like Google, IBM, Microsoft, and Amazon are adopting cloud computing as a new method of software deployment and maintenance [7], [14]. Multiple early versions of software and web services, including

Elastic Computing Platform [13], Amazon Cloud [16], Google App Engine [17], and IBM's "Blue Cloud" architecture [18]. Information support systems may one day adopt the cloud computing model [8].

This article provides a quick overview of how the Cloud Computing paradigm might be used to GIS. In Section 2, we gave a brief overview of Cloud Computing, in Sections 3 and 4, we defined the GIS Cloud System, and in Section 5, we proposed a multi-tiered architecture for the GIS Cloud System, which is a centralized, elastic pool of compute and storage system to collect, manipulate, analyze, and display spatial data.

Part II: EXPLAINING "THE CLOUD"

Cloud computing, as defined by the National Institute of Standards and Technology (NIST), entails the following.

As defined by the Cloud Computing Definition, "Cloud Computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (such as networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."

An enterprise may "plug-in" to this virtual computing environment and make use of the available computing resources on an as-needed basis, making Cloud Computing similar to the notion of a utility [6]. A web client may access the platform's applications and their data from anywhere in the world thanks to the platform's centralization on a (virtual) server. Application components may be chosen at runtime from a catalog of available services, with coordination and processing taking place locally, on the cloud, or across both. The "distributed" program executions, which may be deeply buried all over the cloud, must be consistent with the use of multiple IP rights, private data, ownerships of data of different customers and components [12].

Cloud computing can be conceptualized as having three delivery models (SaaS - software as a service, PaaS - platform as a service, IaaS - infrastructure as a service), and four deployment models (private, community, public, hybrid) [4]. These five characteristics define the essence of Cloud computing.

Researchers and IT organizations alike have gained access to hitherto unexplored territory because to the advent of cloud computing's use in enabling auxiliary information systems like GIS.

III. Geographic Information System (GIS) on the Cloud GIS is an Integrated System of Computer Hardware, Software, and Spatial Data (topographic, demographic, tabular, graphic image, digitally summarized), which performs manipulative and analytical operations on this data to generate reports, graphics, and statistics and manages geographic data processing workflows.

Cloud computing is defined as "a type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements" [9] by Buyya et al. This description reflects the reality that applications that are both computationally and informationally intensive, such as GIS applications, may be gracefully migrated to the Cloud.

The GIS cloud is a promising method for modernizing traditional GIS programs and expanding the range of services available to users anywhere. The subject of whether or not to switch from GIS's broad usage throughout the decades to the better alternative of the Cloud Computing Paradigm has been raised. There has been a significant push to move Geographic Information System (GIS) applications into the cloud, with some of the largest GIS providers in the world, including ESRI and GIS Cloud Ltd, already having made the transition. These companies are dedicated to meeting the needs of their diverse user base by making their services available whenever they are needed. Amazon (Amazon EC2 & S3), Microsoft (Microsoft Windows Azure, Windows Server Hyper-V), and IBM (IBM Cloud) are the three major GIS Cloud infrastructure suppliers in the world, providing dependable and secure cloud IT infrastructure on-demand.

The GIS Cloud, Part IV: Why Use It?

When optimization and cost reduction are top priorities, GIS Cloud's reliable solutions may be invaluable. To be taken seriously as the next generation GIS computing paradigm, GIS Cloud must adhere to a few defining characteristics.

A. Supplying the Backbone for Applications

The GIS Cloud is a specialized infrastructure for geo-enabling enterprise information and tools. With the right use of GIS Cloud resources, businesses that have already invested in GIS may get even more help in analyzing, authoring, and managing their business and geographic data. Organizational geographic data may be made more accessible, publishable, and consumable with the use of GIS Cloud's web-services and application hosting.

Using a GIS cloud allows users to take use of virtualized, high-powered hardware and software resources for creating, analyzing, modifying, and visualizing data, making it a viable computing paradigm for geographical data. Easy-to-use shared tools boost GIS's adoption in the workplace and beyond.

C. Declining Investment in Upkeep and Support

People with specific expertise and advanced technical abilities are needed for in-house GIS implementation inside a business. When you utilize GIS Cloud, you won't require a local GIS server to access standard geo-data. In businesses that already have access to GIS technology, this will free up highly trained employees to focus on strategic initiatives rather than administrative tasks like updating databases. Customers should expect to spend no more money up front on deployment, and they will have far less work to do internally to support and maintain their IT systems over time.

D. Lessening the Price of Implementation

With its cutting-edge geo-technology infrastructure, services, and geo-spatial data, GIS Cloud is uniquely positioned to meet the needs of its clientele. Initial effort and money spent are minimal, and there is no need for periodic upkeep. This is crucial since the investment in a corporate GIS might be substantial. Many businesses don't provide their consumers GIS solutions because of the high price tag associated with doing so. That barrier to access is reduced considerably using GIS Cloud.

E. Taking Command With Data

Imagery and topographical mapping are fundamental to a GIS and serve as a backdrop against which to layer more spatial information. The acquisition and processing of geographical data from a vendor is quite expensive for GIS application providers. The GIS Cloud is equipped to provide this foundational data as an integral part of the main services accessible from any device with an Internet connection. GIS Cloud's quick elasticity guarantees that its customers may add or remove resources as needed. User input, analysis, and manipulation of Spatial Information are all made possible by GIS Cloud. Users may benefit from the powerful GIS Cloud services available for storing and managing spatial data.

Resource sharing that doesn't rely on geography
With GIS Cloud's powerful capabilities, users may share resources regardless of their physical location, with processing and storage needs being distributed evenly over a shared infrastructure. GIS cloud's pay-as-you-go model ensures that users only pay for the resources they really use, whether it's in the form of storage, bandwidth, or processing power.

G. Transforming and Displaying Information
When you use a data conversion service, your information is converted and imported into a different database. It is crucial for a GIS to have its own in-house technical resources, such as hardware, software, and trained personnel. With GIS Cloud, customers may convert geographical data whenever they need to, without having to invest in expensive infrastructure. Using GIS Cloud's cutting-edge features, such as the 3D display of geographical information, you may forget about the boring "pancake perspective" that flattens everything into a forcibly-fitted planar geometry.

GISCLOUD ARCHITECTURE
Cloud computing is seen by some service providers as a means to provide computing and storage resources on demand through a scalable, parallel infrastructure. Some people may confuse Cloud Computing with software as a service, another method for providing access to software through the web. Analysts in the field of information technology often see Cloud Computing through the lenses of its elastic scalability and flexible price model. Cloud computing is being considered by CIOs as a low-cost alternative to traditional data center design. Consumers, the press, and stock experts all see things differently.

what it means to use Cloud Computing [3]. If you have a number of customers or organizations that need access to GIS application services, the GIS Cloud may be a viable option for providing compute or storage capacity as a service. This capacity is made available from a parallel, on-demand processing platform that takes advantage of economies of scale. Having discussed the features of the GIS Cloud at length, it is now time to delve into the system's design. The proposed GIS Cloud architecture is shown in Figure 1; it may be used to create a unified, elastic pool of computing and storage system for collecting, manipulating, analyzing, and displaying geographical data. To get the most out of the many features offered by the GIS Cloud system's various parts, we've used a multi-tiered architectural strategy. GIS users will benefit from the supplied system's adaptability, heterogeneous platform, scalability (horizontally and vertically), security, personalization, comprehensive business intelligence system, and elastic platform.

The proposed GIS Cloud architecture can be broadly divided into two major components which are:

- **GIS Cloud Web-Interface.**
- **GIS Server.**

A. GIS Cloud Web-Interface
Using Web 2.0 and related technologies, the goal of the GIS Cloud Web-Interface is to provide users a web-based interface that is both powerful and inexpensive. One of the most important parts of GIS Cloud, which is designed to be always-available and constantly updated with new features, is the GIS Cloud Web-Interface. The primary goal is to improve the user experience by making the download time shorter than 10 seconds. Totally interactive and adaptable to each individual user. Create a content management system (CMS) that can execute the workflow (from accessing raw content to delivering the processed copy) for publishing content in 3-5 minutes in routine situations and have exceptions to the process to take care of Emergency scenarios; this will make content available using a variety of technologies (broadband, mobile, RSS, etc.) and increase employee productivity.

To better plan for the system's future expansion, users should be able to see, update, and merge maps, and the GIS team should be able to evaluate user activity and all online properties, such as online map generation.

The combination of all components that enables cross-disciplinary connection of geographic data in the form of text, audio, video, maps, etc.

Type B GIS Server
The goal of the GIS Server is to provide a highly-scalable computing infrastructure for the GIS Cloud, which handles things like the administration of databases, configuration, server logic, server-side utilities, communication interfaces, and powerful processing architecture. The planned GIS Cloud Server will have five levels or tiers, and they are as

follows:

Layers of communication, storage, utilities, logic, and configuration for a cloud-based geographic information system.

1) Layer for Cloud-Based GIS Communication
The GIS Cloud Communication Layer will serve as the interface for communication between the GIS Server's logical modules and services.This layer will be in charge of coordinating and regulating all GIS Cloud System-related communications (both internal (Inter- Layer Communication) and external (to and from the GIS Cloud System). As shown in Figure 1, the GIS Cloud Communication Layer will allow the on-premises computer systems of GIS-Service provider companies to exchange data with the GIS Cloud. To accommodate the needs of GIS Service provider businesses, especially as they relate to the Paradigm Shift (Adoption of Cloud Technology), there will be a series of specialized logical modules numbered from Module1 to Module(n). Enhancements to spatial, non-spatial, and temporal (the development of spatial and non-spatial data through time) data creation and import into the GIS cloud system will be the responsibility of the specialized logical modules. For the same reasons, we'll be dealing with authentication and authorisation procedures on the same plane.

In addition, a standardized XML Service Oriented Messaging System [11] will be available at the GIS Cloud Communication Layer to provide a tractable method of remote computing, widespread interoperability, and direct support for service orientation in the form of Web-Services (Sevice1 - Service (n)). To allow businesses to combine geographical, non-spatial, and temporal data and business processes with the GIS Cloud system, the GIS Cloud Web-Interface will consume these services depending on user needs.

GIS Cloud-Based Logic Layer
This layer will function as the 'Heart' of the GIS Cloud System and hold all the logic that underpins the whole thing. Layered here will be the GIS Cloud System's display logic, business logic, and data access logic, along with logic for handling more sophisticated processing tasks.

Layer 3 of the GIS Cloud Repository
This layer will be an API-based data repository that standardizes the exchange of information between a GIS Cloud System and a spatial database management system (DBMS) like Oracle Spatial, SQL Server 2008, or PostGIS. All geographical and nonspatial data stored and accessed via the GIS Cloud System will be governed by this. To further benefit data consumers, this layer will also include geographic information that may be found in spatial databases.

4) A Layer of Cloud-Based GIS Services
The tools in this layer will help the GIS Cloud System as a whole run more smoothly and efficiently. Address search, mapping, routing, reverse geocoding, and navigation are just some of the uses for the specialized GIS utilities that will be included in the package.

Layer for Configuring Cloud-Based GIS
This will be part of the GIS Cloud System and will be used to store and manage system configurations. The GIS Cloud Configuration Layer is responsible for keeping the system consistent and optimized regardless of what changes are made to the underlying GIS Cloud System. System performance, consistency, and state changes will be tracked through thread-based logical modules.

The aforementioned GIS Cloud System may be hosted on any safe and dependable cloud platform. This includes Amazon EC2 and S3, Microsoft Windows Azure, Windows Server Hyper-V, IBM Cloud, and many more.

The elimination of information access bottlenecks is a major feature of Cloud Computing, as is the ability to access cloud services from any internet-enabled device. The GIS Cloud System may be accessible via the GIS Cloud Web Interface or through the GIS-Service provider's internal computer networks.

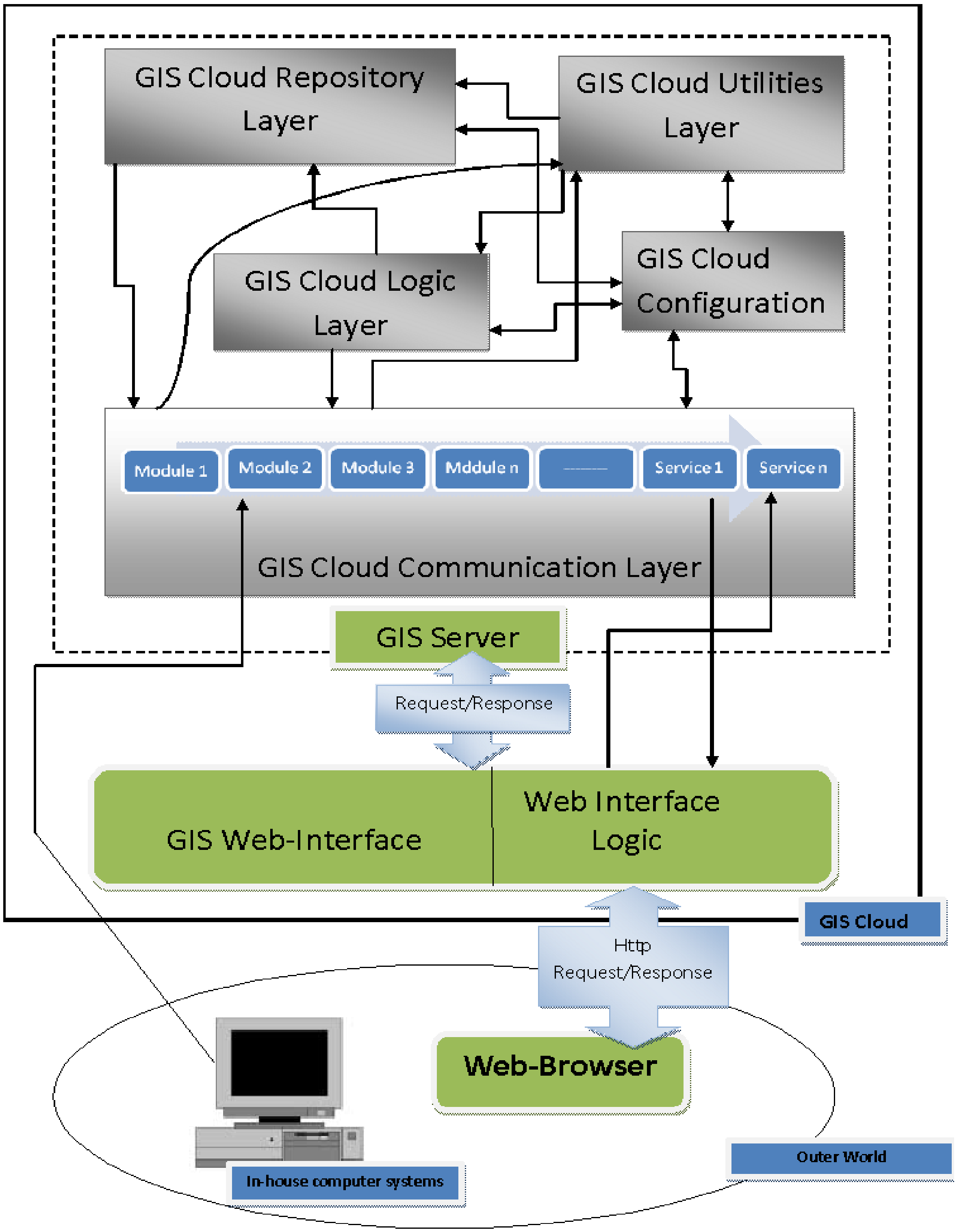

Figure 1: Proposed GIS Cloud Architecture

II. Conclusion

In this study, we examine the advantages of adopting a Cloud Computing strategy for GIS applications. To further facilitate the collection, manipulation, analysis, and presentation of geographical data, we also attempted to design a multi-tiered architecture for a GIS Cloud System, which is a centralized, elastic pool of computing and storage system. A well-designed Cloud Architecture for GIS applications has the potential to enhance scalability, accessibility, and usage of GIS data, however this framework is yet conceptual in nature.

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