

The Pivotal Role of Geospatial Information Systems based on Hybrid Cloud Computing for the Health Sector in Egypt

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Abstract

Mapping is always a tedious task which has been improved rapidly with the use of high performance computers and digital data processing techniques. As a result for the technology revolution, Geospatial Information Systems (GIS) play a pivotal role in wide range of sectors. Using such a tool for the Health sector is very useful as a supporting system for making best possible decisions through spatial and non-spatial data relations, visualization and processing. GIS is more beneficial when it's available to many people as possible everywhere and anytime. So Cloud Computing could be applied to offer the location independence accessibility. But which cloud deployment model would be the best to apply for the health sector? This paper answers the question by defining the different cloud deployment models and declaring the benefits of the proposed framework that merge the GIS with the concept of Cloud Computing depending on the Hybrid deployment model to solve the problem of bad distribution of health services and to cover the shortage areas by making Data analysis and classification using different approaches in order to present this data on useful maps that will help the decision makers in making more accurate and right decisions in order to illustrate the benefits of using the Cloud GIS.

Keywords: Geospatial Information Systems, Cloud Computing, Deployment Models, Hybrid Cloud.

1. INTRODUCTION

Nowadays, Geospatial Information Systems (GIS) is playing an important role in the public health care around the world. The ability to spatially link health, population and environmental data on a common platform by using location as a logical nexus which creates a powerful tool that gives the public health specialists the ability to analyze the health data in a clear form in order to use this valuable information in identifying health care shortage areas, mapping populations at risk, and monitoring diseases over time. This paper aims to define a suitable solution using the Geospatial Information System (GIS) based on Hybrid Cloud Computing to help in improving the health services in Egypt.

The Paper is organized in six sections. Section one gives the introduction. Section two demonstrates the main concepts related to the GIS and the Cloud Computing while section three presents the related work. Section four describes and compares the different deployment models

of the Cloud Computing and section five explains the role of the GIS in the health sector. The last section is a conclusion which summarizes the key outcomes.

2. GEOSPATIAL INFORMATION SYSTEMS AND CLOUD COMPUTING OVERVIEW

This section demonstrates the main definitions and concepts related to the GIS and the Cloud Computing where the GIS is a computer based tool for collecting, storing, transforming, retrieving and displaying spatial data from the real GIS world. GIS provides facilities for data capture, data management, data manipulation, analysis, and presentation [2]. GIS is the merging of cartography, statistical analysis, hardware, software, and data. GIS is commonly used as a supporting system for making best possible decisions through spatial and non-spatial data relations, visualization, and processing [1].

By using GIS, drawing maps and visualizing spatial distributions can be easier. Also measuring distances and areas is an important feature that can be applied while using GIS. This feature would play an important role in the health sector by making the disease's maps for diseases tracking and control that will help in mapping populations at risk and identifying health care shortage areas.

Nowadays Cloud Computing (CC) is considered one of the most important technologies where Cloud describes the use of a collection of services, applications, information, and infrastructure comprised of pools of computers, network, and information and storage resources. Cloud computing refers to the use of networked infrastructure software and capacity to provide resources to users on demand environment. With cloud computing, information is stored in centralized servers and cached temporarily on clients that can include PCs, notebooks and other devices [4]. According to NIST, National Institute of Standards and Technology, Cloud Computing is: "A model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" [1].

The Cloud Computing Characteristics include [3]:

- On-demand Service: Get computing capabilities as needed automatically
- Broad Network Access: Services available over the net using PCs, Laptop...etc
- Resource Pooling: Provider resources pooled to server multiple clients
- Rapid Elasticity: Ability to quickly scale in/out service
- Measured Service: control and optimize services based on metering

Cloud Computing technology would be deployed through different Models [5]:

- Public Cloud: Owned and operated by one organization; services offered to the general public
- Private Cloud: Owned and operated by one organization; services offered to their internal users
- Community Cloud: Owned and operated by organizations of a specific community
- Hybrid Cloud: Composition of two or more clouds (Public, Private, Community)

The services of the Cloud Computing are offered in different shapes including [6]:

- Software as a Service (SaaS):
Applications that are enabled for the cloud support an architecture that can run multiple instances of itself regardless of location.
- Platform as a Service (PaaS):
A platform that enables developers to write applications that runs on the cloud. It would usually have several application services available for quick deployment.
- Infrastructure as a Service (IaaS):
A highly scaled redundant and shared computing infrastructure accessed by Internet technologies. It consists of servers, storage, security, databases, and other peripherals.

As a result for merging the concept of Cloud Computing with the Geospatial Information systems; Cloud GIS has been a suggestive approach to upgrade the conventional GIS applications in order to provide broad spectrum services to the users across the globe [3]. The extensive use of GIS over the decades has been put to a question mark whether to shift it to more superior alternative i.e. Cloud Computing paradigm [5]. Geospatial Information System (GIS) applications have been moving into the cloud with increased drive, Global organizations like ESRI, GIS Cloud Ltd etc. have already taken the quantum leap and taken a technological shift to Cloud Computing Paradigm and are committed to provide on-demand services to their extensive shade of users. World's largest Cloud GIS infrastructure providers are Amazon (Amazon EC2 & S3), Microsoft (Microsoft Windows Azure, Windows Server Hyper-V), and IBM (IBM Cloud) which

provide reliable and secure cloud IT infrastructure to the customers on-demand [6].

3. RELATED WORK

The Cloud Computing was presented as a solution for the traditional desktop GIS to overcome most of the local desktop GIS defects including the weak computing power when dealing with a large scale of spatial data and the resources limitation including the computing and storing resources that are limited to be accessed only by the local users. The waste of money and time when it comes to software upgrading and maintenance was considered also as a defect that would be more cost effective when it comes to the cloud computing technology.

Cloud GIS provides authoritative tools which can help many sectors, especially, when optimization and cost reduction are critical. Some basic principles which characterize Cloud GIS to be accepted as the serious contender for next generation GIS computing paradigm are providing the application infrastructure, supporting the technology infrastructure, reducing the implementation cost, the location independent resource pooling and the data conversion and presentation [1].

Some providers look at Cloud Computing as a way to provide compute or storage capacity as a service, provisioned from a parallel, on-demand processing platform that leverages economies of scale. Others may equate Cloud Computing with software as a service, a delivery model for making applications available over the Internet. IT analysts view Cloud Computing from the perspective of variable pricing without long-term commitments and massive elastic scaling of services. IT leaders look at cloud as an infrastructure architecture alternative that can reduce costs. End users, the media and financial analysts have still other perspectives on what Cloud Computing represents [22].

For GIS applications the Cloud GIS can prove to be an approach to provide compute or storage capacity as a service, provisioned from a parallel, on-demand processing platform that leverages economies of scale to varied shade of users and organizations requiring GIS application services [1]. Therefore, Cloud GIS is considered as a suitable tool to improve and upgrade traditional GIS applications and provide a broad spectrum to users across the globe.

Recently, GIS based on cloud computing started to be proposed as a solution for different fields. It was proposed in Egypt in 2013 for earthquakes prediction and earthquakes emergency management based on Cloud computing platform (Microsoft Windows Azure). The benefits of this Cloud GIS model are reduction in development cost, easy use and management of data and application and high security. This model was a public deployment one where Microsoft Windows Azure platform was selected as the public cloud computing environment. It's a six layers model including client, application, data management, storage, and platform and infrastructure layers. This model used to apply

earthquakes prediction application to give warning of potentially damaging earthquakes early enough to allow appropriate response to the disaster, enabling people to minimize loss of life and property [23].

Based on public deployment model, the enforcement of that merge between the GIS and the cloud computing was proposed as a solution for the emergency management but it can be applied to be a solution for various problems in different fields based on different deployment models not only the public one. The aim of this paper is to propose the Cloud GIS as a solution for a lot of problems related to the health sector based on the hybrid deployment model to get the benefits of the combination between the public cloud and the private cloud and that what will be explained in details in section five.

4. CLOUD COMPUTING DEPLOYMENT MODELS REVIEW

Cloud computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the datacenters that provide those services. The services themselves have long been referred to as Software as a Service. The datacenter hardware and software is what we will call a cloud. When a cloud is made available in a pay-as-you-go manner to the general public, we call it a public cloud; the service being sold is utility computing. We use the term private cloud to refer to internal datacenters of a business or other organization, not made available to the general public [8]. Community cloud shares infrastructure between several organizations [9]. Hybrid cloud provides the flexibility of in-house applications with the fault tolerance and scalability of cloud based services [10].

The first model is the Public Cloud that provides services in a virtualized environment and is constructed in a shared pool of computing resources in a shared environment such as Internet. Anyone can access the resources of public cloud and can scale their use on demand and do not need to purchase hardware to use the services [15]. The cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services [9]. In public clouds, resources are offered as a service, usually over an internet connection, for a pay-per-usage fee. Users can scale their use on demand and do not need to purchase hardware to use the service. Public cloud providers manage the infrastructure and pool resources into the capacity required by its users [11]. Public clouds are available to the general public or large organizations, and are owned by a third party organization that offers the cloud service [12]. A public cloud is hosted on the internet and designed to be used by any user with an internet connection to provide a similar range of capabilities and services [13]. Public cloud users are typically residential users and connect to the public internet through an internet service provider's network [14]. There are many advantages for the Public Cloud including the data availability, on demand scalability, cheap startup and

setup and preventing wastage of resources. On the other hand, it had some weakness points concerning the privacy and data security where anyone can access the resources available on a public platform.

The second one is the Private Cloud. It is a distinct and secure environment where only specified client can operate. It is accessed by only a single organization or third party and may exist on premise or off premise with greater control and privacy. It is hosted in the data center of a company and provides services only to users inside that company or its partners [16]. The purpose is not to offer cloud services to the general public, but to use it within the organization. For example an enterprise that wants to make consumer data available to their different stores [17]. A private cloud is hosted in the data centre of a company and provides its services only to users inside that company or its partners. The high data security and privacy would be the most important advantage for the private cloud where only authorized users can access the data but in comparing with the public cloud it needs much more startup cost to be applied.

The third model is the Hybrid Cloud that is a composition of at least one private cloud and at least one public cloud. A hybrid cloud is typically offered in one of two ways: a vendor has a private cloud and forms a partnership with a public cloud provider, or a public cloud provider forms a partnership with a vendor that provides private cloud platforms [18]. Hybrid cloud infrastructure is a composition of two or more clouds that are unique entities, but at the same time are bound together by standardized or proprietary technology that enables data and application portability [9]. In hybrid cloud, an organization provides and manages some resources in-house and some out-house. For example, the data related to the health sector is divided into general data (can be accessed by anyone) that would be accessed and saved by the public cloud and on the other hand there is a private data (patients and diseases data) that must be saved and accessed by the private cloud. Hybrid clouds [19] offer the cost and scale benefits of public clouds, while also offering the security and control of private clouds.

The hybrid cloud has a less startup cost than the private cloud and has a more data security and privacy than the public cloud where the data is distributed between the public and the private zones. According to this distribution, important and critical data would be saved in the private zone to be only accessed by the authorized people while other data would be saved in the public zone to be accessed by anyone.

The fourth model is the Community Cloud which is similar to the private cloud. Private cloud provides resources to only one particular organization, but it provides resources, privacy and security of two or more organizations [20]. It falls between public and private clouds with respect to the target set of consumers. It is somehow similar to the private cloud, but the infrastructure and computational resources are exclusive to two or more organizations that have common privacy, security, and regulatory considerations, rather than a

single organization [21]. The Community Cloud is less in startup cost than the private cloud due to the cost division on the organizations but higher than the public cloud. Also it offers sharing Information between the organizations and allows management outsourcing by a third party. The disadvantage of this model is the amount of the bandwidth and data storage that is fixed and shared between the community members.

The Following table shows the differences between the main three deployment models:

Table 1: CC Deployment Models Comparison

	Public cloud	Private cloud	Hybrid cloud
Data availability	High	Low	High
Data Security	Low	High	High
Cost	Low	High	Medium

This quick review has highlighted all the cloud computing deployment models in order to know the main differences between them and to make it easier to choose the suitable model.

5. THE ROLE OF GIS BASED ON HYBRID CLOUD COMPUTING FOR THE HEALTH SECTOR

The role is considered as a solution built on a proposed framework that will be developed to help in solving the problem of the difficulty of the distribution of the health services in Egypt and the current bad distribution. Cause of this problem is the late, inaccurate and unclear information used by the decision makers. Also the dimensions related to the shortage of health services in the areas with population density and the poor areas that are hard to be solved based on numeric data but it may be much easier to be solved using the graphical presentation. On the other side, health providers and stakeholders in Egypt could not access the information needed for making right decisions. In addition, no published standards for health sector in Egypt, all partners are working individually so each provider plays a different role cause no unique health platform found to gather all health and spatial information in one pool based on cloud computing techniques to support all decision makers in Egypt to enhance health services.

The proposed framework should merge the GIS with the concept of Cloud Computing based on the Hybrid deployment model and make them work together in the health sector in Egypt to solve the current problems that will be mentioned below and to help in improving the sector services by sharing the data on maps that will help the decision makers in making more accurate and right decisions.

The current situation for the health sector in Egypt now is well described in two words "Separate Islands" where all the partners play individual roles due to the lack of the

common indicators and the benchmarking for any process. Also the bad distribution for the resources is the most common flaw where no fixed numbers for the hospitals, patients and diseases so as a result the resources are distributed without the accurate analysis needed for the process success.

Here comes the role of the GIS to help in solving a lot of the common flaws by drawing maps and visualizing spatial distributions to accurately measure distances and areas in order to track and control diseases and identify health care shortage areas to map populations at risk to start the process of redistributing the resources according to accurate indicators. The role of the GIS would be more effective by applying the concept of cloud computing that will provide the feature of the location independence access where the GIS can be accessed from anywhere and anytime. Also it provides the application infrastructure and the feature of the resource pooling to all the related partners. But which deployment model would be the suitable one for the health sector in Egypt? The answer depends on the types of data privacy related to the health sector which is:

- Public data: the data related to the general information about the hospitals that can be accessed by anyone.
- Private data: the critical data related to the patients and the diseases that must be accessed only by the authorized ones.

Due to these two types of data, the proposed framework should depend on the Hybrid Cloud deployment model to get the benefits of the combination between the public cloud and the private cloud where some resources are managed and provisioned by the authorized partners and hosted in private cloud environments while others are delivered by public cloud services. Hybrid cloud model provides security to user data and also used for storing large amounts of data.

Applying such a solution on the health sector in Egypt will return a lot of benefits including the redistribution for the resources according to an accurate analysis and decisions. Also it will help in making a full integration for all the related partners to let them all work on a common platform using common data resources that will help in making full strategic future plan for the whole sector. In addition, it will help in categorizing hospitals, making networked street path, mapping medical drugs and making regions with full health services.

6. CONCLUSION AND FUTURE WORK

After reviewing the importance of the GIS and the different deployment models of Cloud Computing we've concluded that merging the Geospatial Information Systems with the Cloud Computing based on the Hybrid deployment model could provide us with the best solution for the health sector in Egypt in order to help in solving

the problems related to the bad distribution of the resources and the data location dependence that affect on the taken decisions. In future work, the proposed framework would be built using the Hybrid cloud computing and applied on the Health sector in Egypt in order to start in solving the current problems related to the health sector and to accomplish the mentioned target.

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