Overview of Using Private Cloud Model with GIS

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Abstract

Cloud computing is an emerging computing technology that enter many fields due to its benefits; which are the high speed in processing as it depends on parallel computing, high storage capacity, and high speed of data transfer. In GIS, when dealing with raster data, the main obstacles are the data size- a characteristic of raster data- and the need for long processing time. By benefiting of Cloud computing, GIS raster data model used easily without worrying about its obstacles. This paper highlights the recent researches that relates the integration of GIS and private Cloud computing model through studying the published papers related to this area. Our review effort led to that the cloud computing service model in all studies was Platform as a Service (PaaS), studies conducted are in its preliminary stages, and these studies had different point of interest; storage - processing - an attempt to develop a Software as a Service (SaaS) for civil engineering sector.

Keywords: Cloud Computing; GIS; Private Cloud Computing

1 Introduction

One of the rising computing technology nowadays is Cloud computing. Cloud computing, according to National Institute of Standards and Technology NIST, "is a model for enabling ubiquitous, 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" [3].

A Geographic Information System (GIS) enable us to visualize, question, analyze, and interpret data to understand relationships, patterns, and trends. GIS benefits organizations of all sizes and in almost every industry. The interest and the awareness in the value of GIS is growing [8]. Data is considered the backbone of any information system. In GIS, data are represented in two models, vector and raster data models. Vector model represents the world as a collection of coordinates connected with line or arcs, while raster model represents the world as a grid of pixels. The main issues when dealing with the raster model is the data size and the time needed for processing its data. By benefitting from Cloud computing, we can use easily the raster data model. In this paper, we try to identify the recent findings in the area of integrating GIS with private Cloud computing model. A systematic literature reviews were conducted based on a structure search process. The keywords "GIS" and "private cloud" were used and the search was limited to ABI/INFORM database Computer Science Index - ProQuest computing, Applied Science & Technology Source - EBSCO, and Google scholar.

This paper is organized as follows. Section 2 presents an overview of Cloud computing and GIS. The details of the review process is presented in Section 3. In Section 4 the results of the review is presented and discussed. Section 5 presents the conclusion of this study.

2 Cloud Computing and GIS

This section is divided into two subsections. The first is for an overview of Cloud computing technology and the second is about GIS.

2.1 Overview of Cloud Computing

One of the recent rising computing technology is Cloud computing. Cloud computing, according to National Institute of Standards and Technology NIST, "is a model for enabling ubiquitous, 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" [3, 14] (See Figure 1).

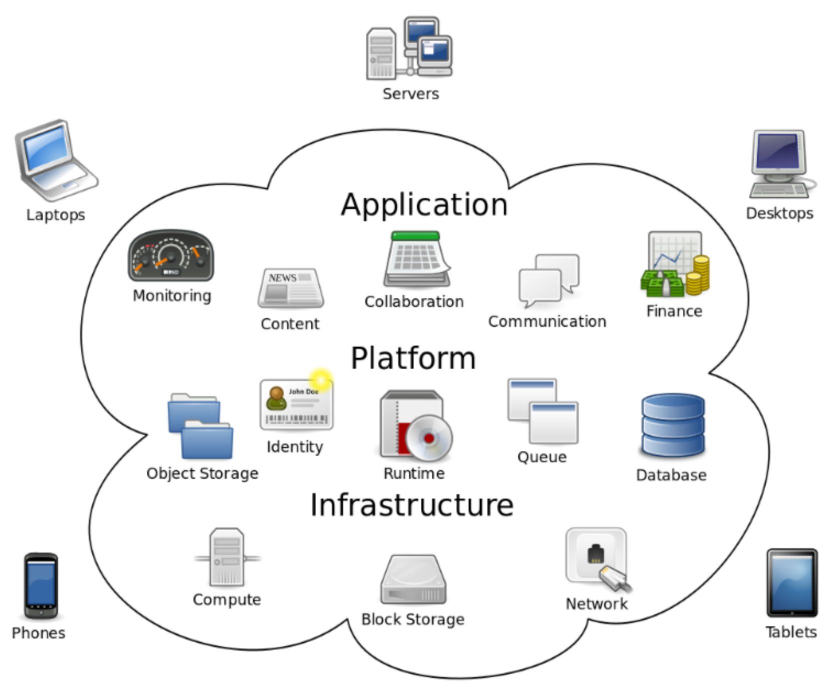

Figure 1: Cloud computing

The cloud model is composed of five essential characteristics, three service models, and four deployment models [14].

2.1.1 Essential Characteristics

1) On-demand self-service. A consumer/tenant can alter his computing capabilities (e.g., server time and network storage) from the service provider as needed automatically without the need of any support.

2) Broad network access. Cloud resource can be accessed through different device types (e.g., mobile phones, tablets, laptops, and workstations) and from various locations.

3) Resource pooling. The Cloud computing resources (e.g., storage, processing, memory, and network bandwidth) are pooled to serve multiple consumers/tenants either physical or virtual. These resources can be adjusted to suit the needs of every consumer, and the consumer does not need to know the exact location of resources provided.

4) Rapid elasticity. (scalable services). For the consumer/tenant, the resources available for provisioning often seems unlimited and can be obtained in any quantity at any time.

5) Measured service. Cloud provider automatically measure, monitor, and control the use of cloud resource (e.g., storage used, processing used, bandwidth consumed, and active user accounts) for different reasons (e.g. billing, effective use of resources, and overall predictive planning).

2.1.2 Service Models

Cloud computing services are divided into three service models, namely: Infrastructure as a Service, Platform as a Service, and Software as a Service, these three models conform the Cloud computing stack (See Figure 2):

1) Infrastructure as a Service (IaaS): In this service model, the consumer/tenant is capable to provision different cloud resources (e.g. processing, storage, networks, and other fundamental computing resources) and the consumer/tenant is able to deploy and run software system, which can include operating systems and applications. The consumer/tenant only control the software system not the cloud infrastructure; and he possibly has a limited control some networking components (e.g., host firewalls). Infrastructure services are the base layer of cloud computing systems [3, 17].

2) Platform as a Service (PaaS): In this service model, the consumer/tenant is capable to deploy onto the cloud infrastructure his applications that are supported by the provider technology. The consumer/tenant only has control over his staff (the deployed applications, its settings) and does not have control of the underlying cloud infrastructure [3].

3) Software as a Service (SaaS): In this service model, the consumer/tenant is to use the applications offered by the cloud provider. The consumer/tenant only manages the setting of the applications he uses [3].

2.1.3 Deployment Models

Cloud computing can be presented/deployed using four different models. Regardless of the service model adopted in the cloud, the cloud can classified as Public, Private, Community, and Hybrid cloud depending on the adopted deployment model (See Figure 3).

1) Public cloud: The cloud is hosted by a third party organization, and located off premise at multiple locations outside the consumer organization. This cloud is "made available in a pay-as-you-go manner to the general public" [2]. Also, public cloud may be free.

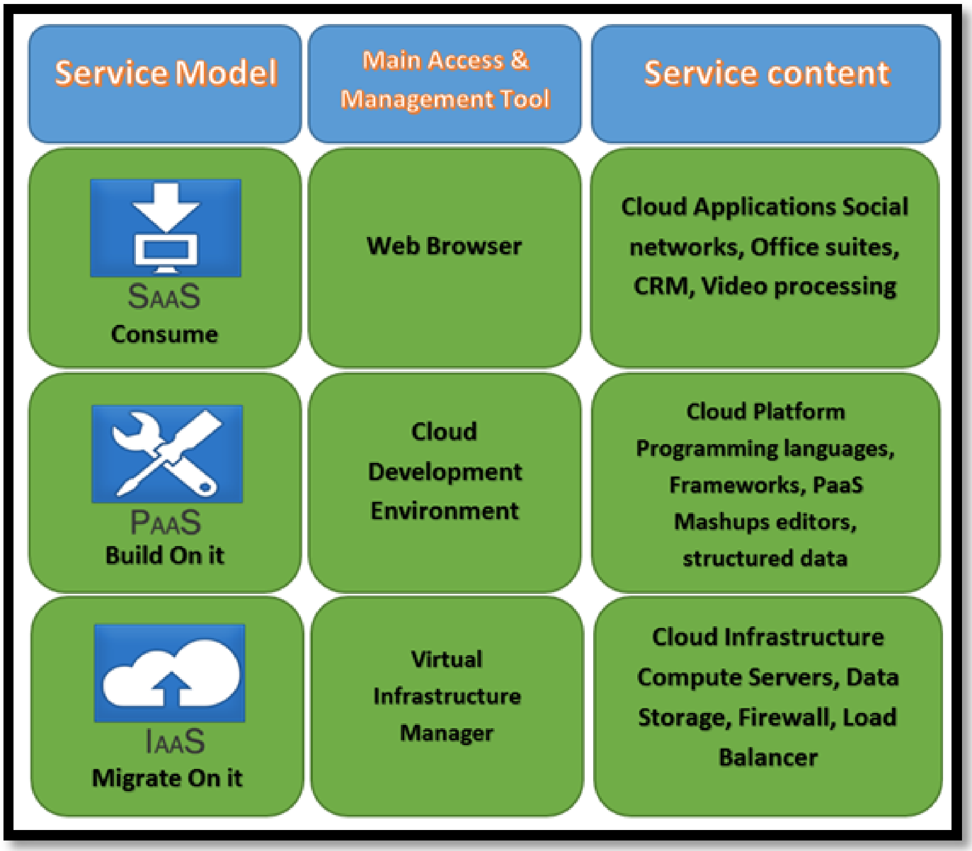

Figure 2: Cloud-computing stack [17]

2) Private cloud: The cloud infrastructure is provisioned for exclusive use by a single organization serving multiple consumers (e.g., business units). The organization itself or a third party, or some combination of them may manage the Private cloud, and it may be hosted on or off premises [3].

3) Community cloud: A specific community of organizations that have common concerns (e.g., mission, security requirements, policy, jurisdiction, and compliance considerations) provisions the cloud infrastructure for exclusive use. One or more of the organizations in the community may own, manage, and operate this model, or get a third party to perform these tasks, or some combination of both, and it may exist on or off premises [3].

4) Hybrid cloud: The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that keep unique entities, though the clouds are bounded together offering the benefits of multiple deployment models (e.g., cloud bursting for load balancing between clouds) [3, 4].

5) To sum up, Cloud Computing has five key characteristics (on-demand self-service; broad network access; resource pooling; rapid elasticity; and measured service), three delivery models (SaaS -

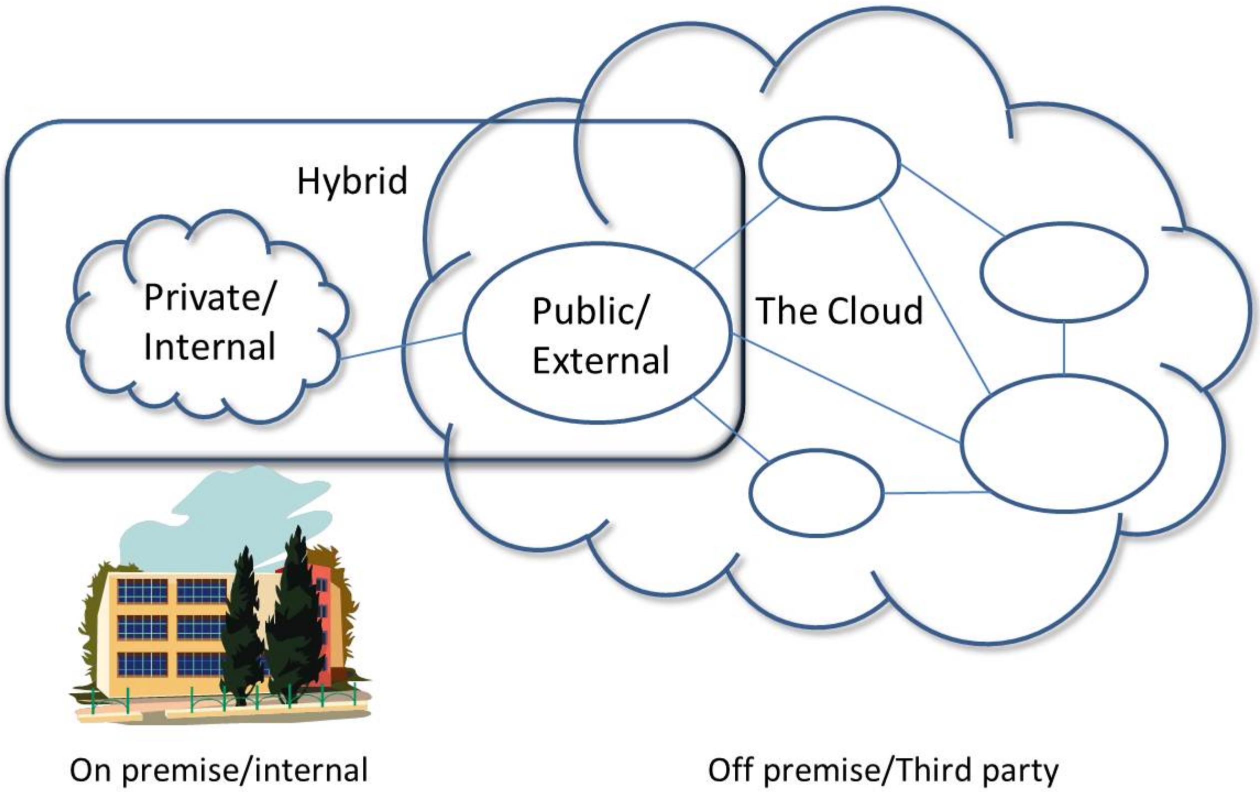

Figure 3: Cloud computing deployment types [16]

software as a service, PaaS - platform as a service, IaaS - infrastructure as a service), and four deployment models (private, community, public, hybrid) [9] (See Figure 4).

2.2 GIS in Business

GIS is an integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes. A GIS provides a framework for gathering and organizing spatial data and related information so that it can be displayed and analyzed [8]. Furthermore, GIS enables the geographic mapping of information such as the locations of customers, competitors, suppliers, sales prospects, suppliers, and partners. GIS can be used for site selection, trade area analysis, environmental analysis, sales territory design, and the targeting of marketing [11].

The current market has huge amount of data. This data could be sales, inventory, retail, real estate, insurance, or any other kind of information. Most of this business data is spatial data-that identifies the geographic location of features and boundaries on Earth -. Therefore, business today depends on GIS to analyze this data spatially. Business GIS and mapping have evolved into a formidable tool by which corporate world can use spatial information to manage their business [6]. GIS is customized to the business requirements, can improve the productivity of the business. Especially for companies trying

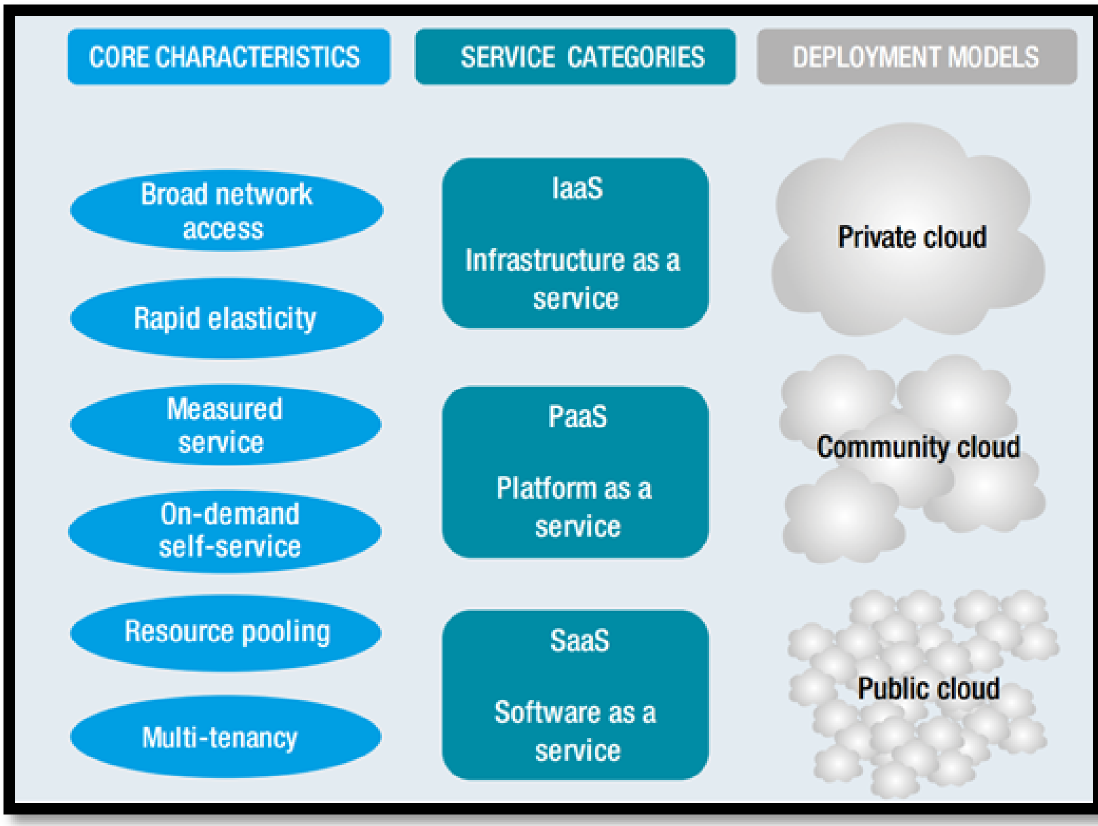

Figure 4: Characteristics and types of cloud computing

to identify uncovered markets, GIS would efficiently assist in identification of new customers, optimize media campaigns, cutting costs, finding new retail distribution centers, aligning sales territories to utilize the sales force efficiently and monitoring business trends and performance spatially [10].

GIS includes a variety of advanced features in information processing, and its basic functionality is data collection, management, processing, analysis and output. Relying on these basic functions, GIS implements a variety of applications using spatial analysis, modeling, network technology, database and data integration technology, and further development environment to meet the broad needs of users.

The emergence of cloud computing brings a new solution to massive data storage, data processing, spatial analysis. Thanks to cloud computing, the needed massive data can be scheduled and processed in parallel entirely within the cloud instead of being transferred on the network.

3 Methodology

In order to perform our overview of GIS and private cloud, a descriptive study was adopted by performing a systematic literature reviews that based on a structured search process. The key words "GIS" and "private cloud" were used and the search was limited to ABI/INFORM database Computer Science Index - ProQuest computing, Applied Science & Technology Source - EBSCO, and Google scholar.

Papers resulting from this search were investigated carefully to understand the current research areas between GIS and private cloud. Next, the results, derived from our understanding, were discussed leading to number of research questions.

Just four papers that form our search results that focus on both GIS and "Private Cloud". These papers were published as follow: one paper in 2012, two papers in 2014, and one paper in 2015.

4 Results

Jun Chen et al. [7], discussed the internal private cloud framework and the design of distributed file system under the LAN environment. Then they analyzed how to store image pyramids for raster data in the distributed file system, and then proposed the Map/Reduce technology based on G/S mode (G: geological data browser or grid browser, S: spatial information server), to achieve load-balancing strategy for data download. This paper concentrated on the storage and the display of GIS raster data in the framework of the private cloud. At the end of this study, they concluded that when data nodes -in the private cloud- increase, the raster data download speeds continue to increase, until the flow limit of the client network card. With this, they have proved the significance of private cloud store and display raster data [7].

Ekkarat Boonchieng et al. [5] used GIS and Private Cloud to develop a smart phones software named "SaraphiHealth" to collect medical data about the residents of a certain district in Thailand. They used the PaaS service model of cloud computing by using the open source software "OpenNode" to build their private cloud. Then they developed their own software to collect the medical data. The focus in this search was to collect medical data of residents from a developed software for both Android and iOS platforms or from a web-based application, then generate different types of reports (tables, figures and maps). Their work emphasized on the ability to benefit from integrating GIS with "Private Cloud" to add value to the business. That benefit was proven through the report generated from the system that had a major benefit directly to the Saraphi District Hospital. Healthcare providers were able to use the basic health data to provide a specific home healthcare service and to create health promotion activities according to medical needs of the people in community [5].

In 2014, Fifth International Conference on Computing for Geospatial Research and Application, Sang-Yong Kang and Young-Hoon Lee used GIS and "private Cloud" with expert system software, and Open Geospatial Consortium (OGC) [13] software technology to support Civil Engineering design process. They used the SaaS cloud service model to develop their system by uploading the software using to a private cloud. They claimed that they developed the first harmonized application service platform in mixing civil engineering and cloud computing area. Their system was called CEDP (Civil Engineering Design support SaaS cloud Platform). The developed system collected a real-time field survey data then sent it to the remote Geo-cloud platform. The Expert software analyzed the collected data to draw the Civil Engineering survey line automatically in the CEDP platform. After that the basic design drawings were drawn. The GIS map receives the result immediately. Therefore, the future view of the civil construction product can be viewed within a day [12].

Dejian Zhang et al. developed a prototype web-based decision support for watershed management (DSS-WMRJ) [18] (See Figure 5).

DSS-WMRJ was based integration between Geoserver as a web-GIS tool, SWAT- Soil and Water Assessment Tool- as a modelling component, and a private cloud adopting Hadoop [1]. The system was organized in four tiers: the presentation tier, the proxy tier, the application tier, and the database and model tier as in Figure 6.

Then, they generated a scenario that took about 111 minutes to finish in the series processing and tested the developed system with that scenario. The developed system performed that scenario in about 5 minutes. Considering that, their private cloud consists of eight TaskTracker and each TaskTracker

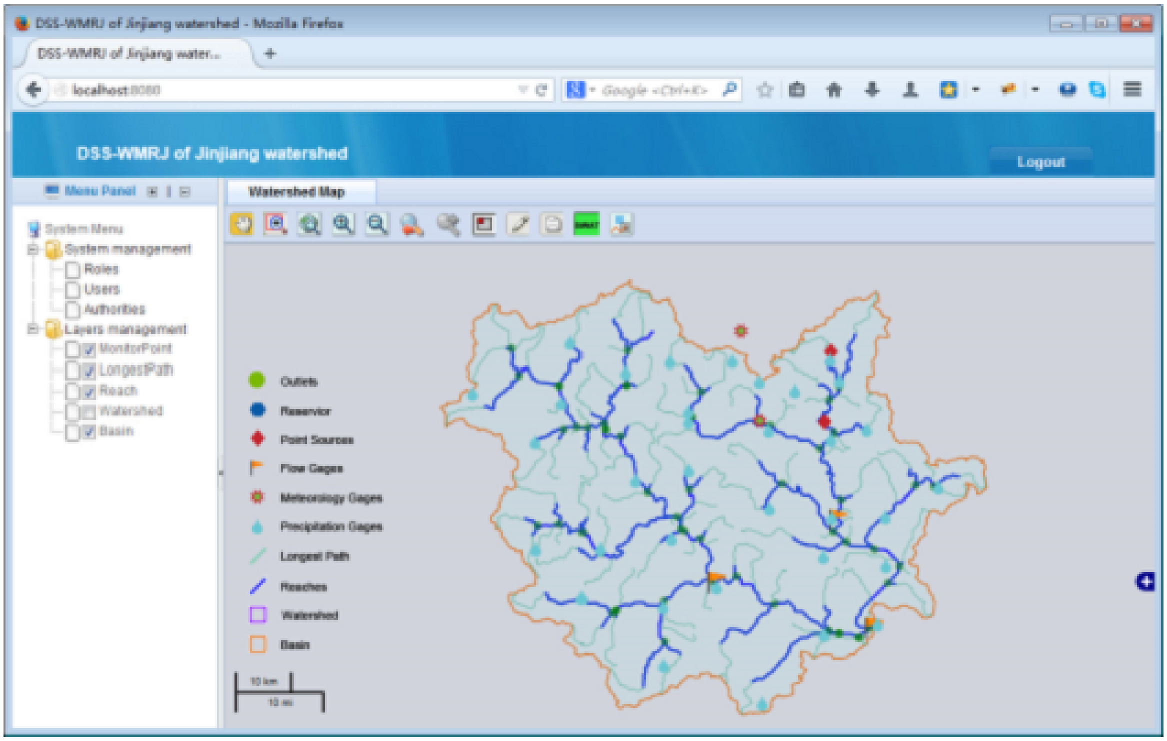

Figure 5: Main interface of DSS-WMRJ

was allowed to perform four tasks simultaneously. From these results, they concluded that the lowest simulation time that could be achieved is about 2.14 minutes by using 23 TaskTrackers (See Figure 7).

They performed another test on their system by comparing it with a widely used SWAT (Soil Water Assessment Tool) auto-calibration tool (SWAT-CUP) [15], which operates on a PC. SWAT-CUP took 97.9 min to finish 92 simulations, while their system only took 4.4 min when running on eight TaskTrackers.

Therefore, they proved the significant of integrating private cloud capabilities to GIS software as their proposed model simulation service substantially reduced the execution time by parallelizing the model simulations.

5 Conclusion

Due to the importance and spread of GIS systems and the new emerging of cloud computing, this research investigated the studies that had been performed in benefitting from cloud computing (private cloud) capabilities to leverage the performance of GIS systems especially the systems that manipulate raster data. A descriptive study was conducted to review the literature in GIS and private cloud. Using ABI/INFORM database Computer Science Index -ProQuest computing, Applied Science & Technology Source -EBSCO, and Google scholar search engine a search was conducted, and there were only four studies found. A main discover from this study is that the integration between GIS and raster models of GIS is in its earlier stage. All studies performed used the PaaS service model of the cloud computing

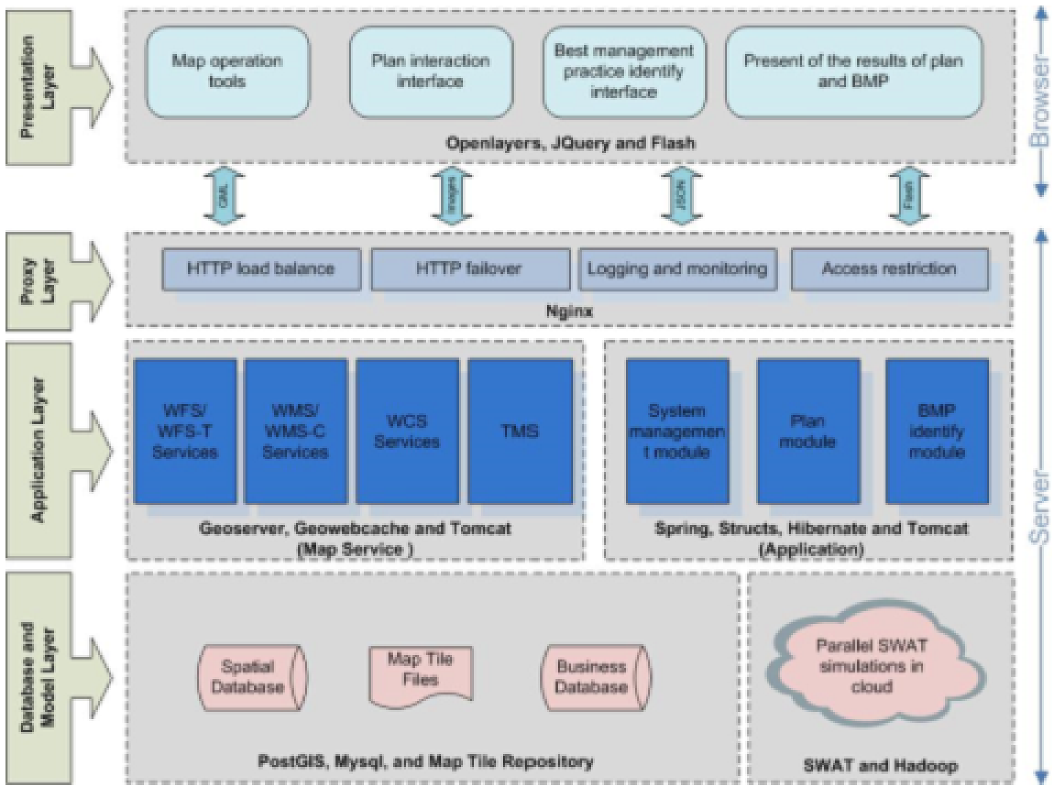

Figure 6: The system architecture of decision support system for watershed management (DSS-WMRJ)

service models and offered their software to their customers. Only one study claimed to develop the first CEDP SaaS service model of the cloud computing that relates to the use of GIS in the area of Civil Engineering.

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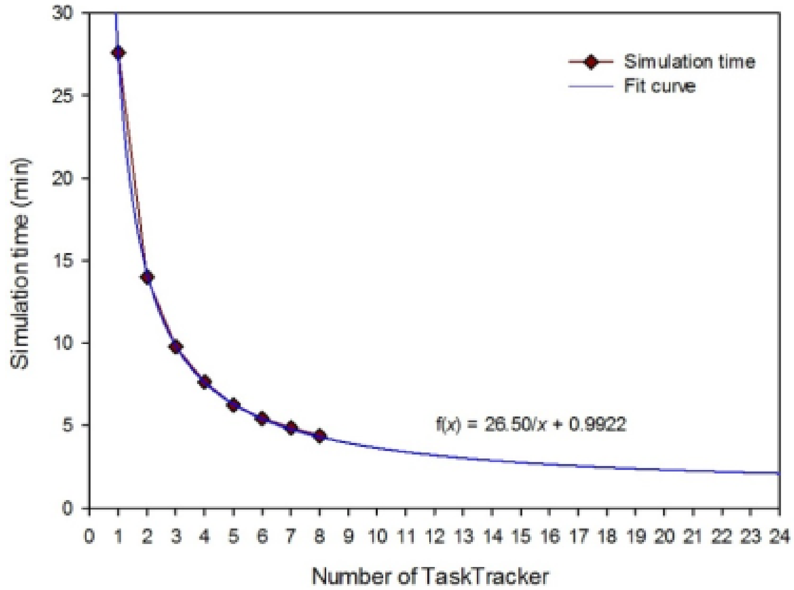

Figure 7: The performance of the model simulation service

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Biography

Salah E. Elgazzar graduated from Faculty of Computer and Information Sciences, Mansoura University, Mansoura, Egypt in 2001. Salah received his master degree in 2012 in Information Systems from the same. His main research interests are in the areas of GIS, Cloud Computing, Databases, and Information Systems.

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