

# Exploring the Potential of Cloud Computing Infrastructure in Third World Context

Lulseged Ayele

Postgraduate Degree Student of Computing Science

University of South Africa,

Cell phone 251-911-137123; [Email: 45377707@mylife.unisa.ac.za](mailto:45377707@mylife.unisa.ac.za)

## Abstract

*The technology landscape is rapidly evolving in cloud computing, its accessibility, scalability and effectiveness can embark socio-economic development. The paper aims at providing an analysis of cloud computing in by exploring the ICT infrastructure and the patterns of cloud system for socio-economy development in the regions. Cloud computing is very new and embryo stage in Africa, and the difusion of computing in the region is promising due to the improvement of cloud carriers and consumers participation. The challenges are fragmented cloud computing practices in the continent. The cloud computing conceptual reference model are not widely used for electronic socio-economic development activities. Therefore, the fastest economy growth countries in the region will be vibrating by the import ICT goods (import inflation) cost and market competitiveness in the global market share. This paper provides insight threats and opportunities when adopting a cloud computing for electronic socio-economic development. Systematic literature review and data analysis from international databases like World Bank and International Telecommunication Union (ITU) are a key data source.*

**Keywords:** Cloud computing, Cloud infrastructure, Service model

## **I. Introduction**

After the financial crises, people make predication of the world with their toughest of problems in accelerating globalization, environment warming, growing threats to social stability and order, and the impact of new technology. The significances of the challenge are more serious for third world countries.

Not today, and not quite tomorrow, Africa will be haphazard by traditional ICT infrastructure investments, with large capital and operational spending on fragmented data centers and heavily customized suites of application software, with legacies that do not easily link. While there is good news for the fastest economic growth countries to mitigate those problems by adopting a cloud computing, it is as the major enablers for socio-economic transformation. Adopt cloud computing initiatives that intend to cut costs on infrastructure and reduce the environmental impact of government computing system [5].

According to National Institute of Standards and Technology, Information Technology Laboratory, cloud computing is defined as 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 [15]. The beginner and the leading of cloud computing is U.S, and it is very new in Africa. The U.S government estimates its IT spending on migration to cloud computing solution for 2010 at \$ 20 billion. EU and Kasumigseki cloud at Japan's [13,14] are also under going project in cloud industry. This tendency is motivated with widely acclaimed cloud scenarios that focus on cost reduction, elasticity, reliability and energy-saving aspects of cloud.

In the paper, the reflection of cloud computing actors' opportunities and challenges were identified for researcher, policy maker and investor. Its purpose is promoting the diffusion of cloud computing initiatives in Africa by exploring the infrastructure and the

regional patterns of cloud system. The paper is used for an input for the new comer researchers.

Cloud computing is not yet matured, time to time, there are various research and developed products are released. In order to describe, synthesize, evaluate and integrate the results of existing scientific work in comparison of cloud actors and distinguishing of cloud infrastructures offering, this paper adopted a systematic literature review and data collection approach. This research method ensures that an extensive number of relevant papers and raw data are considered.

The first step in the literature and database selection process was conducted to identify a comprehensive list of literature sources and available database. The source of Journals, books, conference papers and database were identified by Google scholar search engine.

In a subsequent step, the researcher of this paper chose topic related papers and database from the selected literature and raw data providers. An initial list of papers and database were generated by using key words such as “cloud computing infrastructure, cloud provider, key ICT indicators, imported ICT goods, fastest economy growth in Africa, cloud computing model + requirements + education +Health + e-government + e - commerce + ,actors of cloud computing, cloud computing Vs Africa ” to search for titles, abstracts and key words. The author of this paper only scanned the directories of the journals and conference proceedings manually if no electronic search was possible. Furthermore, this study paper expanded its scientific foundation by reviewing the citations in the papers identified in the first cycle of literature exploration to determine previous papers that should be considered for an analysis in a subsequent cycle of literature exploration. The author of this paper identified 48 papers and website that are dealing with Cloud Computing infrastructure or at least containing related keywords, and then manual reviewed which have high tied content related with the article title. It is surprising that almost the entire set of finally selected papers consists of few points regarding to Africa cloud computing environments. This probably shows that there is a

lack of research regarding to Cloud services and distinguishing opportunities and challenges in Africa context.

In addition to literature review, the study paper were identified the fastest economy growth in the region (Ethiopia, Mozambique, Tanzania, Congo, Ghana, Zambia and Nigeria) since 201 1-2015[8]. The ICT penetration test data that found the World Bank and International Telecommunication Union (ITU) database indicator of cloud readiness in developing countries.

Complementary to the literature and database review the provider market of cloud computing infrastructure and hosting countries were investigated. This analysis was base on extensive internet research where the websites of relevant companies were examined regarding their success story.

Finally, based on this analysis the research paper compiled the potential of cloud computing infrastructure in socio-economic development and the challenges that will be persist in Africa.

## **II. Related Works**

### **2.1 The Welfare of Cloud Computing**

Muhamad Yunus in his book “Creating a world without poverty” laid out a framework of three basic interventions to bring people out of poverty. Firstly, it is about establishing marketplaces of social business; secondly, about extending the reach of social services, and thirdly establishing advanced information and communication technology (ICT). The literature review is focus on the benefits of adopting cloud computing for the improvement of a target-socio-economic statistics-like education, health, e-government and e-commerce.

### **2.1.1 Education**

For the last decades, Africa economy is depending on agriculture, the consequence of this, our continent economy become weak. Those Africa countries are not well addressing the basic needs of their citizen like education and health. The distribution of education among urban and rural is not equitable due to lack of professional teacher and teaching aid materials. Student versus book and teacher ratio are not matching with the standard of quality education due to budget and lack of infrastructure. Cloud computing provides an innovative alternative to bricks-and-mortar schooling, and enabling personal and interactive learning.

The cloud would allow students to interact and collaborate with an ever-expanding circle of peers, regardless of geographical location. It changes the way people study by means of interactive learning in the primary, secondary and higher education spheres. It also gives greater longevity to information by storing it in the cloud. There are good success story in various Africa countries, for instance, Ethiopia school Net and Tanzania e - education portal projects. When FullArmor proposed the cloud based nationwide school information systems in Ethiopia, it was possible to re-imagine on a clean slate how content could be delivered to schools nationwide by fully exploiting the unique advantages of the cloud [16]. The initiative projects allowed the students to access a central curriculum and knowledge repositories base in the cloud, the story show us, developing country's citizens could prove to be an equalizer to the gap that stands between rich and poor countries through cloud. In addition, advanced skills and quality education can be widespread in short period.

### **2.1.2 Health**

The cloud computing can improve the access, efficiency, effectiveness, and quality of clinical and business processes utilized by healthcare organizations, practitioners, patients, and consumers to improve the health status of patients. A good benchmark project is Uganda Health Information Network (UHIN), since 2003, 175 remote health

facilities serving more than 1.5 million people are able to send and receive data and medical updates using personal digital assistants (PDAs). The system is used to transmit disease surveillance data, reports related to HIV/AIDS, tuberculosis, malaria, and data for monitoring drug usage and stocks [11]. Integrated health Management Information Systems (HMIS) and eHealth education can improve the chronic death rate. Adopting cloud computing is cost-effect delivering approach for health sector in Africa.

### **2.1.3 E-governance**

E-governance is no longer luxuries but it is key service delivery channel to empower citizens in economic and social opportunities. To know the benefits of e-governance, no required special laboratory test, it make more efficient government management like less corruption, increase transparency, greater convenience, revenue growth, and or cost reduction. Those Africa governments are proactive in the benefits of interactive service to citizens and businesses through E-governance. The domain and the planning of new way of interacting are not well diffuse in Africa region. However there are good success stories in few Africa countries. According to the Waseda University Institute of e - Government has released the 2011 World e-Government Ranking report. Tunisia (62.10) , South Africa (59.71) and Egypt (56.13) are good exampliers for other Africa countries. Those countries are fulfilling the seven main indicators- like network preparedness, required interface-functioning applications, management optimization, National portal, Chief Information Officer (CIO) in government, e-Government promotion and e - participation [12]. Cloud computing based e-governance implementation can make integrated management with automated problem resolution, manages security end to end, and helps budget based on actual usage of data. In other words, reliability, cost effectiveness, ease to maintenance, and other nonfunctional issues addressed through cloud.

#### **2.1.4 E-commerce**

All the large IT manufacturing companies are adding cloud computing to their business due to inspired the enterprise to reduce their capital and operational expenditure, thus offering an affordable way to access services, technical and cost effective manner that is relevant to Africa.

In tradition IT management, companies paid for space and resources to handle their IT functions, whether needed or not. This means buying more desktop computers and accessories, licensed business application, and adding more machines to their internal server rooms. However, cloud computing provide an environment in which virtual assets are made to be flexible and dynamic and can be offered on a subscription or on-demand basis. This means that business is only using and paying for actual assets used. Cloud computing approach is one of market penetration strategy for Africa manufacturing industries, they can reduce operational and market transaction cost by pay-on-demand base, the cost and reliability of Customer Relation Management (CRM) and Supply Chain Management (SCM) services are cheap in the cloud.

### **2.2 Essential Elements of Cloud Computing**

In any cloud environment, service model, deployment model and major actors (conceptual reference model) are the basic organs that have to address in cloud computing environments.

#### **2.2.1 Cloud Service Model**

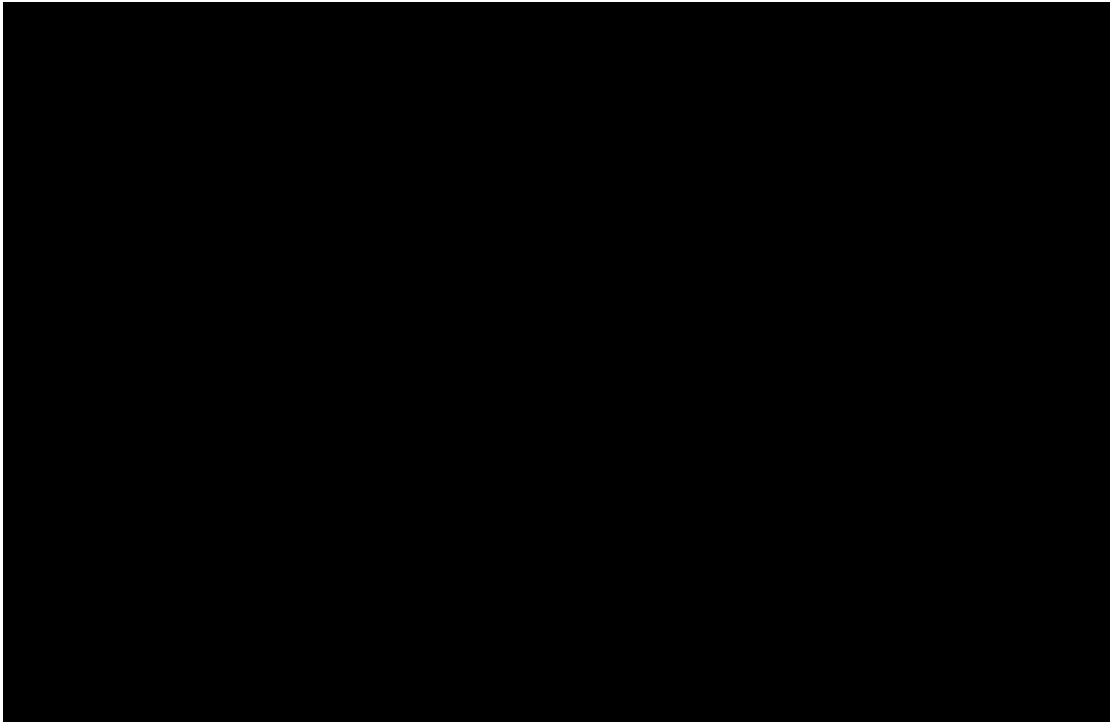
According to the National Institute of Standards and Technology U.S department of commerce [15], there are three types of cloud service and four deployment models; Cloud Infrastructure as a Service (IaaS), Cloud Platform as a Service (PaaS) and Cloud Software as a Service (SaaS).

Cloud Infrastructure as a Service (IaaS) covers the provision processing, storage, networks, and other fundamental computing resources. The supplier maintains and upgrades these resources and the user pays for the service depending on the amount of usage. The major advantage is that users only pay for the exact amount of resources used, and resources available can be easily scaled to accommodate rapidly changing needs. Architecture scalability is achieved through Full- or Para-virtualization, such that multiple systems or operating systems can be run at the same time on a virtual machine or across multiple machines; Amazon, IBM, Microsoft's Azure are examples for IaaS

Cloud Platform as a Service (PaaS) provides computational resources via a platform enabling the user to deploy onto the cloud infrastructure consumer-created software or service development without downloading tools and software to client machines. In the cloud, there are not standards for interoperability or data portability issues. Google App Engine, Windows Azure, [Force.com](http://Force.com) can be the examples for PaaS [4].

Cloud Software as a Service (SaaS) enables the use of the provider's applications running on a cloud infrastructure. Good example is Google's Gmail. Clients access software services such as email, word processing, spreadsheets, etc. from the Cloud instead of running these applications directly on their client computers.





**Figure 1: Resource Based Cloud Service Model**

### **2.2.2 Deployment Model**

Cloud computing offers four deployment models; private, community, public and hybrid[6]. Private cloud infrastructure is operated solely for an organization whereas community cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns. The members of the community share access to the data and applications in the cloud. Public Cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services. The term “Public” doesn’t always mean free and data is publicly visible. The difference between a private cloud and a public cloud is that in a private cloud-based service, data and processes are managed within the organization without the restrictions of network bandwidth, security exposures and legal requirements that using public cloud services might entail [9]. Lastly, hybrid cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound

together by standardized or proprietary technology that enables data and application portability.

### 2.2.3 Major Actors of Cloud System

The five major participating actors are the cloud consumer, provider, Auditor, broker and carrier. Each actor is an entity (a person or an organization) that participates in a transaction or process and or performs task in cloud computing [6]. Cloud consumer is an actor that maintains a business relationship with, and uses services from cloud providers where as the provider are responsible for making a service available to interested parties. Good examples for this [Amazon.com](http://Amazon.com), it is a cloud provider, and you and me are cloud consumers. Cloud Auditor is one of the actors that can conduct independent assessment of tangible and intangible resources. Cloud broker is the responsible party that can manage the pro and cons dispute negotiation between consumer and providers regarding to performance and delivery of cloud services. The last major actor is cloud carrier, it is served as intermediary actor that provides connectivity service from cloud providers to cloud consumer. The major roll and responsibilities of the actors are described in the following figure.

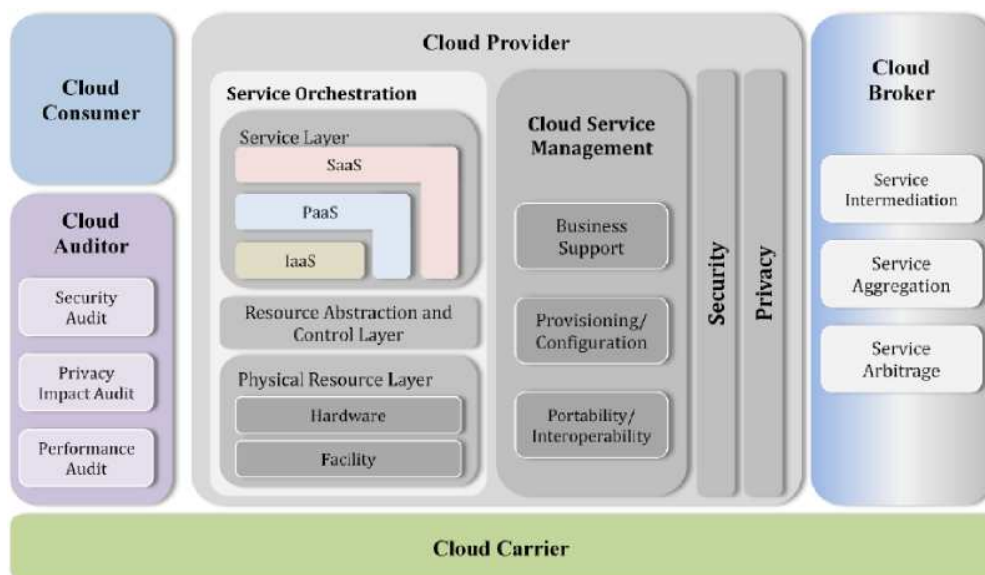


Figure 2: The Conceptual Reference Model [6]

### **III. Cloud Computing in Africa**

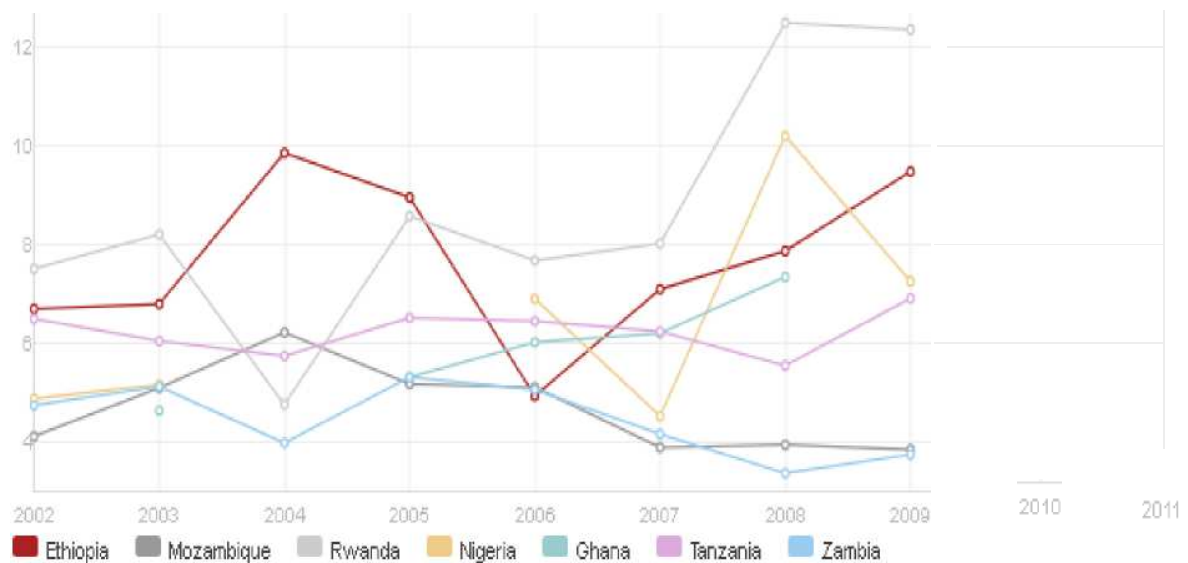
Recently Africa Economic is growing in fastest track, and has an inspiration for the new market entrance investors in the cloud environment due to the expansion of mobile, wireless and broadband infrastructure. The majority of the population will be “consumers” of information rather than “producers” and scattered over a large geographical landscape. A Cloud Computing approach makes most sense since these population centers cannot really afford to maintain their own data centers from a financial, logistical, and knowledge perspective. By implementing the cost effective cloud environment, our continent will improve service deliver on education, health, e - government, e- commerce and creating green IT environment. However, the cloud computing diffusion in Africa are not performed an integrated passion, the good example for this, electronic socio-economic development project in Africa are not sustainable due to missing the basic organs of cloud computing during the project design. Projects are usually donor-driven and funded hence their short-term rather than strategic or long-term commitment led them to struggle after withdraw. Best example for this, Uganda Health Information Network project, due to fund withdrawal the project was challenged transferred technologies and technical experts [1]. Therefore, adopting integrated cloud computing for the region is not optional. The state-of-the-art Cloud technologies have limited support and cost-effective management.

One of the determinate factors that a cloud will be exists in one country, the availability of advanced ICT infrastructure. The cloud consumers can obtain cloud service through network access devices such as computer, laptops, mobile phone, and mobile Internet device (MID). The growth trend of ICT infrastructure is at various stages according to their economic development. However, Countries at large, the development of ICT infrastructure is increase dramatically. The International Telecommunication Union (ITU) report show that ICT penetration rate is increasing years to years, for example, the fastest economic growth countries in Africa region is extremely booming specially mobile and Internet users.



**Figure 3: Key ICT Indicator at Developing Countries (Totals and Penetration Rates) [10]**

The above ICT penetration test show that a good news for cloud computing actors. While, the bad new is a negative effect on import inflation for those fastest economic developing countries, For example, Ethiopia and Mozambique are the highest scored since 2007 (figure 4). The percentage of import ICT goods figure is increasing rapidly due to traditional IT management, its consequent has be reflected on import inflation, therefore the emerging economy countries in the region have to adopt cloud computing approach to down size the cost of the import items.



**Figure 4: ICT Goods Imports (% Total Goods Imports)[7]**

(Source: Information and communication technology goods imports include telecommunications, audio and video, computer and related equipment; electronic components; and other information and communication technology goods. Software is excluded.)

The Internet users are increase time to time but Internet infrastructure in the Africa is still vulnerable, as a great deal of international traffic in the region is carried by a small number of undersea cables, therefore, more innovations are required for cloud computing environment in Africa context.

The second key area that cloud computing need to be considered is cloud Computing Reference Architecture framework. Different Africa countries have been taking cloud computing projects, for example, Ethiopia and Tanzania have good success story in e - education. Tunisia, South Africa and Egypt have outstanding performance in e - government, and Ugandan is best mHealth. All those initiative are good starting point for those countries. But when comparing the cloud computing theories (Service and Deployment model) and the conceptual Reference Model [6], they are at infant stage and performed fragmented way. Adopting cloud computing framework at national and economic region in Africa is not tomorrow job, because our scare resources will be

passing over to non-transparent market with many small and large providers. Moreover, our export oriented industries will be less competitive at international market due to lack of horizontal and vertical market integration through cloud computing. Those Africa countries and Africa Union, which are regional economy integration member countries, will be work together based on their road map. The donors and participants of cloud have to give more attention for long-term socio-economic improvement strategy.

#### **IV. Conclusion**

After the world economy crisis, Africa is the best destination for foreign investors due to potential resource and the fastest economic growth in the region. The cloud carriers are growing years to years due to the rapid growth of ICT infrastructure and the purchasing power of information consumers. However, the cloud computing diffusion is not moving well structure passions. Therefore the governments, donors and investors have to work hand in hand and maximized the economical benefits of Cloud computing.

The trend of Application and software are a pay-for-use licensing model, and it is no longer running on bare metal but on virtual machines (VMs). Hardware systems should be designed at the scale of a container Infrastructure. The traditional IT infrastructure management approach is no more appreciate due to technical challenges like data scaling, auditing and logging, rolling out new instances, replication and migration, disaster recovery, policy management system, integration and legacy software, obsolete technologies and migration to new technologies. Top of these, budget limitation and high power consumption requirements are another headache for those who are not adopting cloud computing framework. Therefore, All Africa countries have to promote cloud computing approach on their ICT strategy, give incentive for local and International cloud providers.

One of the tools that narrow digital divide among citizen, countries and continents are cloud computing. Cloud computing is the cheapest system for information service

provider and receivers. Therefore, to bring drastic change of e-health, e-education, e - governance, e-commerce and other societal issues, cloud computing is not an optional. So every country has their own road map for cloud computing.

This paper does not discover the benefit of cloud computing in ICT equipment power consumption and creating green IT environment, In principle, cloud computing can be an inherently energy-efficient technology [9]. Therefore, it is open for the next researcher.

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