Implementing Cloud Computing Storage In Nigerian Tertiary Institutions

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ABSTRACT

Digital infrastructures are innovative systems that help researchers to find opportunities to face the challenge of increasing economic growth and improve the quality of life for their communities. These digital infrastructures have produced a new scientific paradigm known as e-science. e-Science is a pioneering method that uses integrated collections of Information and Communication Technologies (ICTs), or e-Infrastructures, to enable scientists across the world to collaboratively work on more and more ambitious projects. One of such digital infrastructures that has become pervasive even in education and research is cloud computing. Cloud computing is a model for enabling network users' on-demand access to a shared pool of configurable computing resources that can be rapidly provisioned and released to the client without direct service provider interaction. In this research work we developed a model of a stable cloud infrastructure that enables researchers to collaborate and share data among the academia. The design and implementation is based on the Synnefo cloud.

Keywords: - Cloud, Computing, Storage, Nigeria, Tertiary Institutions

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1. BACKGROUND TO THE STUDY

Technology development and progressions have always had important impacts on education. The pressure to deliver good services from very minimal resources has overwhelmed learning institutions all over the world. But if resources are shared among learning institutions, then there is a better chance that such institutions will concentrate more on research work and core academic activities. Cloud computing plays a major role in improving the quality of education to attain high performance by offering many benefits for education such as flexibility, scalability, providing infrastructure with low cost, collaboration, flexibility and ease-of-use. Furthermore, it allows users to store and access data on-demand from anywhere via the internet (Al-Shqeerat, Hammoudeh, & Abbasm, 2016). The cloud services and applications enable users to store and access their local data in the remote data centre by using their personal computers, or mobile devices (Raoa and Selvamanib, 2015).

The use of cloud computing in higher educational institutions has provided them with lots of benefits. Firstly, cloud computing is cost effective therefore it is efficient where the resources are minimal. Secondly, the academicians derive a positive experience from its use. Moreover, cloud computing helps in increasing the productivity of IT staff in universities. In today's world, various applications are provided on cloud platforms by various companies especially Google and Microsoft that are providing various applications and services free of charge for use by staff and students in different learning institutions. Cloud Computing offers On-demand network access to a shared pool of configurable computing resources like networks, servers, storage, applications, and services, rapidly provisioned with minimal management effort and provider interaction (Cachin, 2011) and delivers infrastructure as a service (IaaS), Software as a service (SaaS), Platform as a Service (PaaS), Storage as a Service, and recently, Security as a Service (SECaaS), etc in a multi-tenant

model at relatively low cost, and high resource availability over fast Internet connectivity. Fig 1 shows how these services are layered.

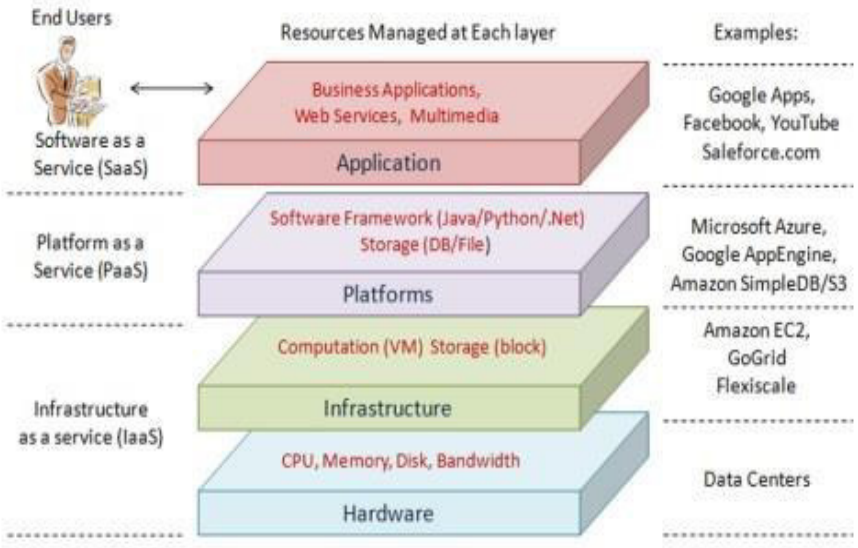


Fig. 1: Cloud computing service layers

1.1 Description of the main cloud computing services

Cloud computing comprises five types of service:

- Infrastructure as a Service (IaaS): virtualized on-demand server, virtualized data centre, flexible on-demand storage space, flexible local networks (LANs), firewalls, security services, etc.
- Platform as a Service (PaaS): platform for cloud computing service provision (customer service management, billing, etc.)
- Software as a Service (SaaS): business applications, customer relations and support (CRM), HR, finance (ERP), online payments, electronic marketplace (for very small and small and medium sized enterprises), etc.
- Communication as a Service (CaaS): audio/video communication services, collaborative services, unified communications, e-mail, instant messaging, data sharing (web conference).
- Network as a Service (NaaS): managed Internet (guaranteed speed, availability, etc.), virtualized networks (VPNs) coupled with cloud computing services, flexible and on-demand bandwidth.

1.2 Characteristics of cloud computing

Cloud computing services have characteristics which distinguish them from other technologies:

- As a rule, cloud computing users do not own the IT resources they use, the servers they exploit are being hosted in external data centres.
- Services are provided via the pay-per-use model or subscription model.
- The resources and services provided to the client are often virtual and shared among several users.
- The services are provided via the Internet.

With these characteristics, cloud computing technology is a new solution that provides users the option to access software and IT resources with the desired flexibility and modularity and at very affordable prices.

Key prerequisites for cloud computing were identified as:

a) Good Internet connectivity.
b) A sound software and hardware market.
c) Applications need to be virtualized.
d) Trust in the security of the systems used.
e) Access, privacy, reliability and compliance in cloud computing.
f) Liability and regulation in regard to cloud computing.
g) Data location.

1.3 Gains of Cloud Computing

Cloud computing can actually help institutions reduce high expenditures on hardware, software and IT maintenance. It can also offer enhanced availability, low environmental impact, reduced IT complexities, mobility, scalability, increased operability and reduced investment in physical asset. The other gains include:

i) Data security.
ii) Cost effectiveness for the following reasons:

– No need for an expensive computer or protected storage system.
– No IT maintenance costs.
– No expensive software.
– Cloud computing works via the Web, with access to services by means of a simple browser and, increasingly, with free operating systems.

1.4 Cloud Computing in Nigeria: Situation and Prospects

With the current 6.8 to 10 percent broadband penetration in Nigeria, the economy still remains a huge market for cloud computing (Opeke, 2017),. Unfortunately Nigeria is not among the top 24 countries listed in 2016 BSA Global Cloud Computing Score Card (Opeke, 2017). The cloud services adopted in Nigeria include: e-mail, storage, ISP hosting, SaaS

1.5 Tertiary Institution Clouds in Nigeria

Instances of cloud deployment in Nigeria is not known apart from the University of Nigeria Cloud Computing infrastructure, which this paper sets out to describe.

2. STATEMENT OF PROBLEM

Because of the demands of increasingly complex problems over the recent decades, developments in science and engineering have been stepped up to meet with these challenges. Scientific research today is so much based on large amount of numerical simulation, data analysis/analytics, as well as on collaborative research. Research in the 21st century is data-intensive, simulation-based, distributed across virtual communities, and collaborative. In recent years data-intensive science has been conducted on a scale that was unimaginable a few years ago. Sensors, storage systems, computers and networks have greatly improved in capability and integration to create huge data archives that has changed the way research was conducted in the fields of medicine, physics, astronomy, biology etc.

The big question is where is Africa in the scheme of things with respect to e-science deployment and usage? These are the questions this study attempts to answer by looking at e-infrastructure projects and initiatives in Africa, success stories, challenges, how e-science has improved Africa's scientific endeavours and the way forward.

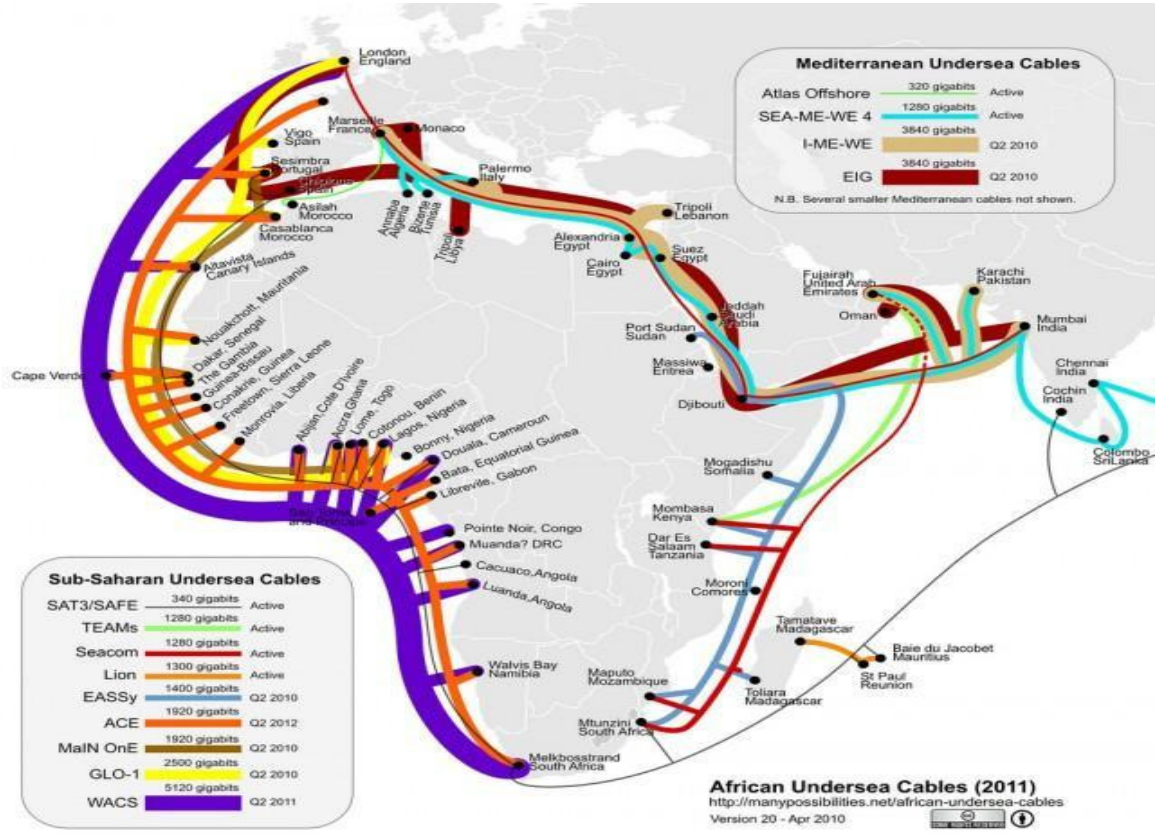
2.1 Challenges to Cloud Computing in Nigeria

To achieve global competitiveness, governments in developing countries are evolving and implementing information technology policies, to enable their countries participate in the current ICT revolution. One barrier to attaining the education objectives of the policies is inadequate national ICT infrastructure and services. The absence of ICT infrastructures leads to brain drain and outsourcing. Researchers with projects that need high processing power will need to have access through the IaaS provider (Yadav, 2014). The inadequacy of ICT infrastructure and services is attributed to inadequate government funding, which in turn becomes difficult for education institutions to own and use sophisticated ICT facilities. Broadband availability in Africa has been a major issue for both business and personal access to the cloud. Fortunately, African bandwidth has improved dramatically over the past few years—especially for businesses looking to connect to cloud resources elsewhere in the world.

2.2 Challenges of Cloud Computing in Nigeria

Bandwidth challenges are being solved by the efforts of commercial cable companies like Main One, Glo One and a number of EU projects like TANDEM, AfricaConnect2, Ubuntu Net Alliance, etc. Would-be cloud service providers in Africa face another serious problem: the power grid. Fig 2 shows

the map of Africa with Internet connectivity network projects aimed at alleviating Africa's connectivity challenges. Along with the unreliability, there is lack of electric power capacity. "If one is in a power-hungry environment, there is usually not enough power being generated to keep one going,"



However, in other developed countries the use of cloud computing technology in higher institutions of learning is expanding quickly and this expansion comes with adoption and learning challenges to the

users. The influence of users' perceptions toward the cloud computing technologies was investigated by (Ashtari and Eydgahi, 2017). The researchers focused on the associations between variables identified in the literature that where considered to be influencing the perception of students in university in Southeast Michigan. These variables include users' perceptions of the usefulness and effectiveness of cloud computing applications, perceived ease of use, Internet self-efficacy, computer anxiety, computer self-efficacy. They carried out an online survey among 40 undergraduate students in Michigan University and used the Technology Acceptance Model (TAM) to analyse the adoption of cloud computing by students (Ashtari and Eydgahi, 2017)..

The adoption of cloud computing in education institutions can enhance knowledge management. In 2017 (Arpaci, 2017) investigated the antecedents and consequences of adopting cloud computing education to achieve knowledge management using TAM. He carried out a survey using questionnaire among 221 undergraduate students in Turkish university and analysed his survey data using structural equation modelling. The result of the survey suggested that educational institution may promote the adoption of cloud computing by increasing the awareness of knowledge management (Arpaci, 2017).

(Oyeleye , Fagbola and , Daramola, 2014) investigated the impact and challenges of the adoption of cloud computing in public universities in the Southwestern part of Nigeria in 2014. They selected a sample size of 100 IT staff, 50 students and 50 para-IT staff from 10 public universities in the southwestern part of Nigeria. They used stratified sampling techniques to select their same and administered 2000 questionnaires and 1724 were returned. The findings obtained from the research showed that adoption of cloud computing has major impact on cost effectiveness, enhanced availability, reduced investment in physical assets, reduced IT complexities and increased operability. But, the major challenges affecting the adoption of cloud in theses universities are, regulatory compliance concerns, data insecurity, lock-in and privacy concerns (Raed , Fash and Chang, 2015).

(Abdulsalam and Fatima, 2011) explored the applications of cloud computing in higher education in Nigeria, they identified the factors limiting the implementation of cloud computing in Nigeria's higher institutions as high cost of ownership, lack of access, unsteady and inadequate electric power supply, high cost to the consumer. They also discussed the benefits of transition to cloud computing in higher institutions. They concluded this research by stating that cloud computing has great potentials in improving the ICT applications and infrastructure at higher levels of education in Nigeria and advised that every university that wishes to adopt this must plan the transition carefully and keep close contact with well-established organisations like NIST (National Institute of Standards and Technology) in order to ensure smooth transition (Abdulsalam and Fatima, 2011).

3. OBJECTIVE

The objective of this research was to design and develop a cloud computing infrastructure for e-science made available to universities in Nigeria. This infrastructure known as the Lion Cloud is domiciled locally in the University of Nigeria's Data Centre. The infrastructure gives a researcher access to use it for data storage (IaaS), create virtual machines (VMs), (PaaS) and access to authentication services (SaaS). In this report, however, our focus is on the storage services of this project.

Advantages of a university-owned cloud include:

i. Complete ownership and management
ii. Security of data
iii. Quick response time because of nearness of the cloud servers to local users
iv. Unlimited storage space
v. No external bodies regulating or eavesdropping
vi. Availability of free data backup facility for the academia
vii. Provision of large data repository for experimental results and datasets

4. METHODOLOGY

During this work we deployed two numbers of HP PROLIANT GL360, G5 servers, each with 2.4GHZ XEON CPUs, 4GB RAM, 1TB HDD, with Debian Linux 8 (Debian Jessie) installations. Each machine has a public IP address. On these machines we deployed and configured the Synnefo cloud stack version 0.19. Synnefo was developed by the Greek Research and Education Network (GRNET) ("Open Source Cloud Software Free, Scalable, Production Ready").

4.1 The Research Design

Synnefo is a complete open source IaaS cloud stack written in Python that provides Compute, Network, Image, Volume and Object Storage services, similar to the ones offered by AWS. Synnefo manages multiple Ganeti clusters at the backend for handling of low-level (VM) operations and uses Archipelago to unify cloud storage. To boost 3rd-party compatibility, Synnefo exposes the OpenStack APIs to users ("Welcome to the Synnefo documentation"). Synnefo has three main components which provide the corresponding services: Astakos which provides Identity/Account/Quota services. Pithos is responsible for Object Storage Services and Cyclades in charge of Compute/Network/Image/Volume services. It equally unifies storage resources (Objects/Volumes/Images/Snapshots) using Archipelago as the common storage substrate for all services. An overview of the Synnefo services is shown in fig. 3 below

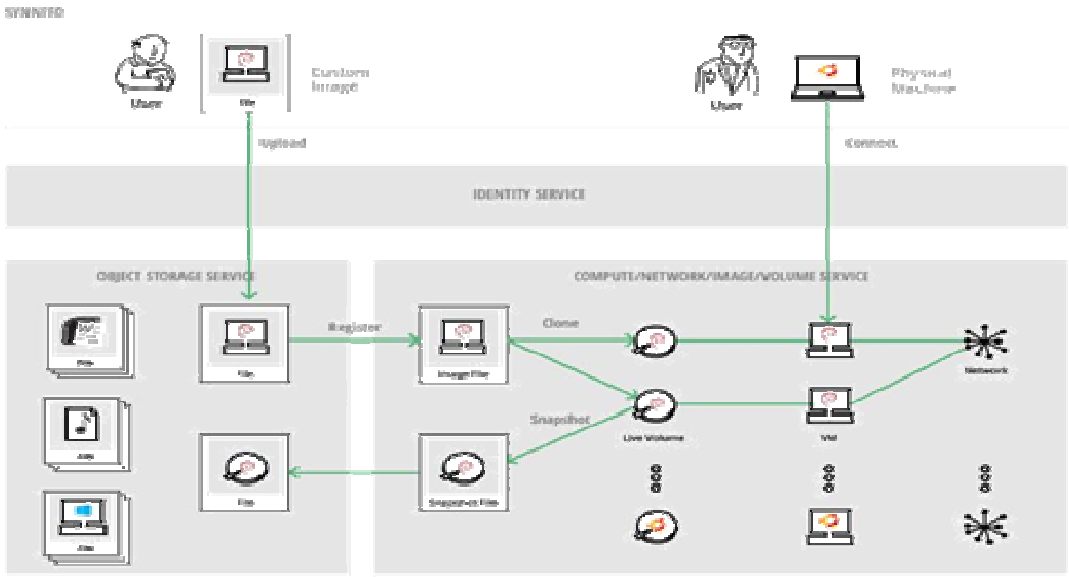


Fig 3: An Overview of the Synnefo Services

Synnefo is designed with simplicity, scalability and stability in mind. Although it can be deployed in small configurations, it was initially designed to address large-scale installation problems. All Synnefo components use an intuitive setting mechanism that adds and removes settings dynamically as components are getting added or removed from a physical node. All settings are stored in a single location.

There are three major attractions to us for using Synnefo;

i. It is open-source and encourages full user reconfiguration
ii. It requires minimal number of servers, 2 servers, unlike Open Stack that needs a minimum of five. This makes implementation quick, cheap and less troublesome
iii. It is completely free of charge and has some level of support.

5. DISCUSSION OF FINDINGS

Configuring the infrastructure was a rigorous process that involved the availability of good Internet connectivity which the University provided. It involved the installation of so many libraries and their configurations. After a period of about two months of hard work we were able to build a cloud storage service which allows a user to register, be authenticated and authorized by the Astakos authentic service, as well as created personal folders, upload and share data with users within and outside the Lion Cloud through Pithos, the storage service. Fig 4 shows the screenshot of the Lion Cloud storage service.

User experiences show that the infrastructure was easy to use and interactive. It is also observed that response time was very fast because of local usage, this is one advantage over Google cloud and AWS, etc. Total cost of ownership (TCO) was also minimal. It also provided high level of user data security since it used secured (https) protocols.

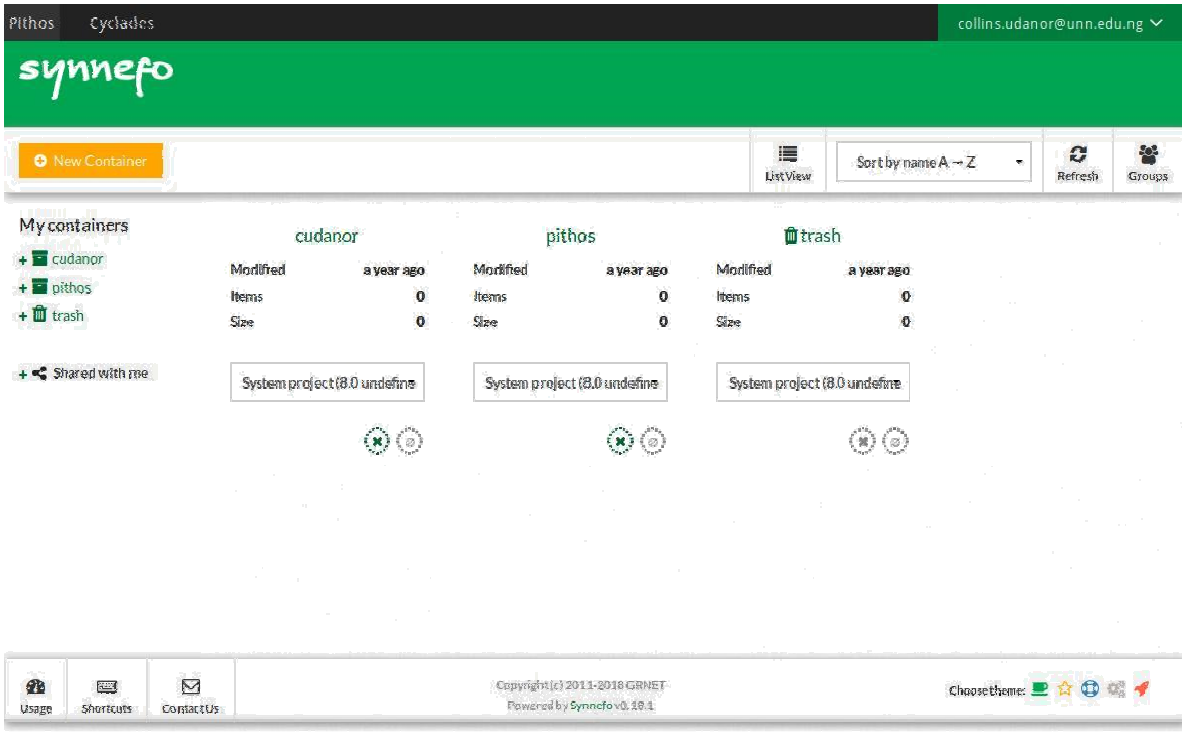


Fig 4: A screenshot of the cloud storage for the Lion Cloud UNN

6. CONCLUDING REMARKS

Through this work we have been able to show that Nigerian Tertiary institutions can build and own their cloud facilities tailored to their specific needs at a minimal cost. With an infrastructure such as this, the universities do not need to outsource commercial clouds where they store university data, some which are not meant for the public domain such as students' results, transcripts, research and field work data, administrative records, etc. The common experience in many universities is that they host these sensitive data with commercial vendors, and after sometime lose the data, either as a result of not being able to renew the hosting contract or aggrieved contractors may delete the data because their contracts were not renewed. With this infrastructure these problems are brought to an end. Universities can also host their websites locally on this platform. Individual users can buy storage spaces for their personal data if the university wants to make money through this infrastructure for its future sustenance.

Finally, the investigation revealed that it could be necessary to legislate against excessive importation of unwholesome media contents where when it is possible to do so. The government needs to monitor and legislate against websites known for Internet fraud and pornography. In conclusion, it is very possible to exhibit and transmit our cultural values using ICTs (the Internet/cable channels). Thus, productions on African values which are programmed for cable transmissions and on-line communication is a viable way to popularize the indigenous culture The focus of this study is not purely quantitative: measuring numbers and proportion but in the qualitative or descriptive part of the research.

7. CONTRIBUTIONS TO KNOWLEDGE

Nigeria as one of the countries that are undeveloped suffers so much setbacks in terms of access to funds for Research and Development. As a result of this, researchers in Nigeria lack adequate resources that are necessary for credible research works that are globally competitive and relevant to the locals. In view of this, this research work provides an enabling environment for state of the art for research and development in Nigeria and access to costly resources at affordable prizes. This will invariably contribute positively towards the advancement of education and the industries in Nigeria.

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