

The Challenges of Cloud Computing Adoption in Nigeria

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Abstract—Cloud computing, a technology that is made possible through virtualization within networks represents a shift from the traditional ownership of infrastructure and other resources by distinct organization to a more scalable pattern in which computer resources are rented online to organizations on either as a pay-as-you-use basis or by subscription. In other words, cloud computing entails the renting of computing resources (such as storage space, memory, servers, applications, networks, etc.) by a third party to its clients on a pay-as-go basis. It is a new innovative technology that is globally embraced because of its renowned benefits, profound of which is its cost effectiveness on the part of organizations engaged with its services. In Nigeria, the services are provided either directly to companies mostly by the key IT players such as Microsoft, IBM, and Google; or in partnership with some other players such as Infoware, Descasio, and Sunnet. This action enables organizations to rent IT resources on a pay-as-you-go basis thereby salvaging them from wastages accruable on acquisition and maintenance of IT resources such as ownership of a separate data centre. This paper intends to appraise the challenges of cloud computing adoption in Nigeria, bearing in mind the country's peculiarities' in terms of infrastructural development. The methodologies used in this paper include the use of research questionnaires, formulated hypothesis, and the testing of the formulated hypothesis. The major findings of this paper include the fact that there are some addressable challenges to the adoption of cloud computing in Nigeria. Furthermore, the country will gain significantly if the challenges especially in the area of infrastructural development are well addressed. This is because the research established the fact that there are significant gains derivable by the adoption of cloud computing by organizations in Nigeria. However, these challenges can be overturned by concerted efforts in the part of government and other stakeholders.

Keywords—Cloud computing, data centre, infrastructure, IT resources, network, servers, virtualization.

I. INTRODUCTION

CLOUD computing sets the pace for a new era of computing globally. This is because it changes the way applications are developed, deployed, scaled, updated, maintained, and paid for, and the infrastructure on which they run. On the other hand, it is nothing new because it uses already established practices and concepts.

Historically, computing has passed through evolutions over the decades starting with mainframe data centre computing in the 1960s. This was closely followed by personal/mini-computer computing. At a later stage, we entered into an era of distributed model known as Client-Server computing which finally led to the materialization of the Internet and the Web.

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Today, virtualization within networks has given rise to the evolution of cloud computing as it enables a dynamic data center (comprising of several servers) to provide a pool of resources that can be exploited as needed by clients to meet their workloads and business demands [1].

The intent and extent of cloud computing has grown beyond bounds as there exists increasing investments in it from all frontiers. The distinctiveness of cloud computing architecture is that it saves cost as its applications are run by a third party whose infrastructure can be deployed by a customer/client on a pay-as-you-go basis. This is unlike a desktop or client server application which can only run on the customer's own infrastructure that has been installed with lots of capital and operational costs attached to it [2].

The service could be provided using an enterprise's data centre, or that of a cloud provider. Major Cloud providers in Nigeria are Microsoft, Google and International Business Machines (IBM). These companies render cloud computing services either directly to customers/organizations or in partnership with other IT major players like Cisco, NetApp, Accenture, Sunnet, Descasio, Wyse technology, etc. This paper discusses the broad challenges that organizations face in the effective adoption of cloud computing in Nigeria.

II. RESEARCH HYPOTHESIS

For the purpose of this study, the following null hypotheses were formulated to be later subjected to a scientific test to verify its validity or otherwise.

- H_0 : There is no enormous challenge to the feasibility of cloud computing adoption by organizations in Nigeria.
- H_0 : There is no enormous gain/benefit derivable by the adoption of cloud computing by organizations in Nigeria.

III. QUESTIONNAIRE

The following two sets of questionnaires were used to get information that would aid the researcher in the testing of the hypotheses stated above.

- 1.) Kindly identify with a tick (✓) the impediments/challenges you envisage that face the adoption of cloud computing by organizations in Nigeria by choosing one of the three (3) options in response to each of the identifiable challenge as stated in the table below.
- 2.) Kindly identify with a tick (✓) the perceived gains, in your view, that organizations stand to benefit by their adoption of cloud computing technology.

TABLE I
 CHALLENGES OF CLOUD COMPUTING ADOPTION IN NIGERIA

No.	Identifiable Challenge	Options		
		Strongly Agree	Partially Agree	Disagree
1.	Unstable Electricity			
2.	Poor Internet Connectivity			
3.	Lack of Adequate Infrastructure			
4.	Corruption			
5.	Security Issues			
6.	Lack of Awareness			
7.	Lack of Strong Legal Framework			
8.	Infrastructure Sharing Lack (Community Cloud)			
9.	Lack of Effective Network Coverage Nationally			

TABLE II
 BENEFITS OF CLOUD COMPUTING ADOPTION IN NIGERIA

No.	Identifiable Benefits	Options		
		Strongly Agree	Partially Agree	Disagree
1.	Effective Cost Management			
2.	Resource Sharing			
3.	Focus on Core Business			
4.	Enhanced Business Profitability			
5.	Zero/Minimal Capital Expenditure			
6.	Reduction in IT Staff			

IV. DEFINITION AND CHARACTERISTICS OF CLOUD COMPUTING

Several definitions have been given on cloud computing by different authors. However, the most generally accepted definition comes from United States National Institute for Standard and Technology (NIST) which defines cloud computing 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” [3]. The diagram below depicts a general view of a cloud environment which illustrates provider’s response to clients’ fluctuating changes in demand.

Fig. 1 simply illustrates what happens in the cloud. At every time span, some clients initiate access requiring the cloud provider’s service while some others terminate access releasing the resources that they once held. At the same time, some other clients may still be well engaged with the services they require from the service provider. The service provider has several hardware to enable it effectively manage peak service requirement by clients. The hardware not in use is turned off to save energy and cost thereby boosting resource efficiency. Moreover, in case of hardware failure, the cloud is able to relinquish the use of failed hardware and utilize working ones while the provider replaces the old failing hardware with new ones in due course in order to maintain steady service delivery in spite of service failures and service life expirations [4].

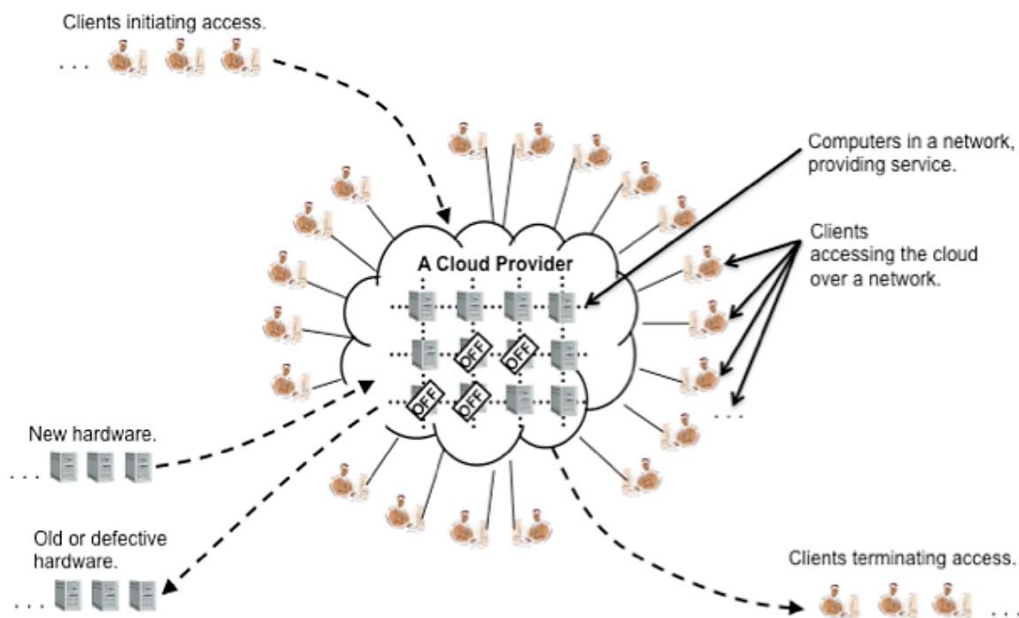


Fig. 1 General cloud and subscriber view

Reference [3] states five essential characteristics of cloud computing as:

- On-demand self service. That is the ability of a client to sign up and receive services at will from any cloud provider.
- Broad network access. This refers to the ability of a client to access the cloud provider’s services using any standard computing device with internet connectivity like desktop, laptop, mobile phone, etc. Fig. 2 shows cloud computing

capability of being accessed across several classes of users.

- Resource pooling. Regardless of the client's location, the cloud provider's computing resources are readily available and can be accessed as desired by each client to meet up its needs.
- Rapid elasticity. Due to varying demands in workloads by different clients, cloud computing has the ability to scale up and down to meet up each client's demand.
- Measured service. Computing resource usages by clients are transparently recorded to reflect the actual rate of usage by each client.



Fig. 2 Service users using diverse computing tools [5]

V. FEASIBILITY OF CLOUD COMPUTING ADOPTION IN NIGERIA

Cloud computing offerings globally are taking centre stage in strategizing businesses for more profitability and cost management. Nigeria is not an exception as major players in the service provision sector are making some giant strides and intensifying their efforts to create more awareness and contribute substantially in helping companies migrant to the cloud. Reference [6] opined that cloud computing saves costs for servers and storage, offers speed and streamlines application deployment without upfront capital. He stressed that for this reason alone many organizations are now considering adoption of cloud computing to provide more efficient and cost effective network services. Similarly, the Chief executive of Sunnet Systems says that Nigerians should take advantage of the cloud computing technology to improve and drive their businesses to greater heights. The companies - Sunnet and IBM collaborate to provide dynamic infrastructure technology that would ensure that ISPs and businesses remain on track maximizing their profits and reducing infrastructural risks. IBM is currently managing the data centre of Airtel (Nigeria) as the later had outsourced its infrastructure in Lagos to IBM. This in turn has driven down the cost of using the services of Airtel, and would really lead to the company's sustainability. This implies that if the telecommunication industries outsource their infrastructure to a major cloud solution provider as Airtel had done, cost of rendering services would be drawn down drastically which invariably would lead to less pay in making use of their services. To further enhance Nigerian businesses, IBM is partnering with Sunnet technology solution provider to offer organizations a dynamic

infrastructure and cloud computing solution that would enable organizations ensure that their infrastructural risks are well managed to promote their efficiency and reduce cost of running their businesses thereby making them more profitable than ever [7].

Today, NetApp technology is being used by the Central Bank of Nigeria (C.B.N.) as well as the top eight (8) banks in Nigeria. Moreover, the CBN is championing the course of creating a common Software-as-a-service (SaaS) as well as Infrastructure-as-a-service (IaaS) for all banks in Nigeria. The development of having a common banking application and infrastructure provided and run by a third party (NetApp technology) gave rise to the recent change of bank account numbers to a uniform 10-digit number, popularly referred to as Nigerian Uniform Bank Account Number (NUBAN) [8]. It is a laudable project as cost of infrastructure and software provisions are no longer going to be borne by the individual banks alone, but are shared among banks to reduce the cost of doing business and boost the profitability of these banks.

Google (Nigeria) offers lots of cloud computing services rendering enormous support to its clients and partners. Google Apps messaging tools which include email, calendar, and instant messaging solutions helps people to communicate and stay connected anytime anywhere as they wish. One of its key partners in Nigeria is Descasio Ltd which has numerous clients like Coscharis Group, Transcorp, etc. With Google Apps Engine cloud platform, data is never lost and searches can easily be performed with much data storage space available to each user anywhere anytime for hosting documents of different formats, and for easy downloads, enabling secure real-time collaboration among workgroups, etc. For example, Gmail provides each user with up to 10GB inbox storage space in the cloud, which is quite enormous.

Wyse technology, a cloud provider, offers its services to Electronic Test Company (eTC) in the conduct of examinations in Nigeria. The services of eTC are transforming the way examinations are conducted in Nigeria. eTC has built several centres across the nation's universities with plans to extend it to other examinations like WEAC, etc. With this development, testing will be fast and reliable devoid of inherent fraud that characterized the traditional paper-based examinations which is time consuming when it comes to marking, scoring and computation of the results [9].

Business Connexion offerings in Nigeria include IaaS, Messaging as a service, Sharepoint-as-a-service, and also builds private clouds for clients – government and private establishments [10].

Main One, a leading provider of internet connectivity in West Africa, is really widening its scope geared towards providing reliable and affordable broadband internet services across the nation. Phase 3 Telecom is partnering with Main One towards the realization of this ambition of extending Main One's services from Lagos to various parts of the country [11].

Industry analysts opined that Nigeria has a cloud computing market potential of over \$1 billion if broadband infrastructure

bottlenecks are quickly addressed to deepen internet penetration [12].

VI. IMPEDIMENTS TO CLOUD COMPUTING ADOPTION IN NIGERIA

For cloud computing to be sustainably adopted in Nigeria, the following addressable impediments to its feasibility needs to be addressed.

1. Inadequate power supply: Inadequate power supply in this country had been a major setback to the introduction of cloud computing in Nigeria. The current status of electricity generated in Nigeria with regard to its populations is grossly inadequate. This is because Nigeria with a population of over 140,000 persons generates electricity that is slightly above 5,000 mega watts [13].
2. Corruption: Corruption is one of the biggest problems that are challenging Nigeria as a nation today. In 2014, Transparency International ranked Nigeria 136th out of 174 surveyed countries which mathematically translates that Nigeria is the 38th most corrupt country out of the 174 surveyed countries. This is really appalling because these monies would have been wisely invested in the economy and encourages growth in infrastructure [14].
3. Persistency of poor internet services: Reference [11] opined that the absence of robust national backbone has led to increased cost of moving capacity around the country. Investigation reveals that to get connected from Lagos to London costs \$600 per megabyte as against \$1,100 between Lagos and Abuja. Main One has invested over \$250 million in building the underwater cables and constructing distribution networks. The federal government needs to conduct a review of the national backbone infrastructure, manage the country's national frequency spectrum resource as well as encourage infrastructure sharing amongst telecoms operators in order to improve internet penetration in the country.

According to Nigeria Communications Commission (NCC), as at December 2014 the telecom operating companies had deployed a combined total of 80,938 km of fibre optics. This result indicates that the internet penetration across the country is yet to be adequate. Also, some of these providers offer skeletal services to the populace. This must change to enable cloud computing to work viably in Nigeria [15].

4. Need for backbone infrastructure sharing/general communication problems: Infrastructure sharing by mobile operators in Nigeria will no doubt reduce both capital expenditure (CAPEX) and operating expenditure. Reference [16] identified several communication problems which could hamper the smooth take off of cloud computing in Nigeria. Some of these problems range from broadband to backbone infrastructure. He pointed out the lack of focus on the part of ISPs as all the ISPs (MTN, Globacom, Airtel, etc) target national coverage with none thinking of being a regional operator or provider. For instance, Visafone concentrating on eastern region, and making sure that coverage is highly optimized, steady and efficient. Being a regional operator

would result to cost effectiveness and improved delivery since the cost would be less. As a result of these developments, the broadband offerings of all the service providers in Nigeria are very frustrating/unreliable due to inadequacy of infrastructure and funding. The next section discusses the feasibility of cloud computing in Nigeria.

VII. HYPOTHESIS TESTING AND EVALUATION

The researcher wishes to establish the validity or otherwise of the above postulated null hypothesis using the t-distribution test technique. The t-test is worked out using:

$$t = \bar{X} - \mu_x / \sigma_x = (24.65 - 20) / (7.02 / (\sqrt{16})) = 2.65$$

$$d.f. = n - 1$$

$$\sigma_x = S / \sqrt{n}$$

$$S = \sqrt{\sum_{i=1}^n (X_i - \bar{X})^2 / n - 1}$$

where, \bar{X} = Sample mean, μ_x = Population mean, S = Standard deviation, n = Number of samples, X_i = Sample, d. f. = Degree of freedom, The two null hypotheses for testing are re-stated as:

- H_0 : There is no enormous challenge to the feasibility of cloud computing adoption by organizations in Nigeria.
- H_0 : There is no enormous gain/benefit derivable by the adoption of cloud computing by organizations in Nigeria.

In order to test the two (2) null hypotheses, the researcher designed two (2) broad research questions (see appendix 'a') which were distributed electronically to a sample of sixteen (16) IT staffs of some of the organizations covered. They were successfully retrieved for computation and analysis. The average percentages of each sampled member was computed and applied appropriately in order to test each of the null hypotheses.

We can prove its validity or otherwise by stating thus:

$$H_0: \mu < \mu_x$$

$$H_a: \mu > \mu_x$$

where, μ = the sample mean = \bar{X} , μ_x = the postulated mean = 20.

The t-distribution test is used in this testing using the above stated formula.

VIII. TEST AND EVALUATION OF NULL HYPOTHESIS 1

To find \bar{x} and S , the following computations are made as shown in Table III.

$$Mean = \sum X / n = 394.44 / 16 = 24.6525 = 24.65$$

$$S = \sqrt{\sum_{i=1}^n (X_i - \bar{X})^2 / n - 1} = \sqrt{738.55 / 15} = 7.02$$

TABLE III
 COMPUTATION FOR TESTING H₀ 1

Sample (n)	Average Rating (X)	X _i - \bar{X}	(X _i - \bar{X}) ²
1	22.22	-2.4325	5.92
2	16.67	-7.9825	63.72
3	27.78	3.1275	9.78
4	33.33	8.6775	75.30
5	22.22	-2.4325	5.92
6	16.67	-7.9825	63.72
7	11.11	-13.5425	183.40
8	27.78	3.1275	9.78
9	33.33	8.6775	75.30
10	27.78	3.1275	9.78
11	33.33	8.6775	75.30
12	16.67	-7.9825	63.72
13	22.22	-2.4325	5.92
14	27.78	3.1275	9.78
15	33.33	8.6775	75.30
16	22.22	-2.4325	5.92
	394.44		738.55

Calculating t at 95% confidence interval, which is a one-tailed test;

$$t = \bar{X} - \mu_x / \sigma_x = (24.65 - 20) / (7.02 / (\sqrt{16})) = 2.65$$

Using the t-table for 15 degree of freedom, we reject the null hypothesis if the calculated t is greater than the critical t, then R: t > 1.75.

Since t calculated is greater than the critical t, we reject the null hypothesis which states that there is no enormous challenge to the feasibility of cloud computing adoption by organizations in Nigeria.

IX. TEST AND EVALUATION OF THE NULL HYPOTHESIS 2

To verify the validity or otherwise of the second null hypothesis which states that there is no enormous gain/benefit derivable by the adoption of cloud computing by organizations in Nigeria, the following computations were made using Table IV.

$$Mean = \sum X / n = 383.33 / 16 = 23.958125 = 23.96$$

$$S = \sqrt{\sum_{i=1}^n (X_i - \bar{X})^2 / n - 1} = \sqrt{954.41 / 15} = 7.98$$

Calculating t at 95% confidence interval, which is a one-tailed test;

$$t = \bar{X} - \mu_x / \sigma_x = (23.96 - 20) / (7.98 / (\sqrt{16})) = 1.98$$

Using the t-table for 15 degree of freedom, we reject the null hypothesis if the calculated t is greater than the critical t, R: t > 1.75.

Since t calculated (1.98) is greater than the critical t (1.75), we reject the null hypothesis which states that there is no

enormous gain/benefit derivable by the adoption of cloud computing by organizations in Nigeria.

TABLE IV
 COMPUTATION FOR TESTING H₀ 2

Sample (n)	Average Rating (X)	X _i - \bar{X}	(X _i - \bar{X}) ²
1	33.33	9.371875	87.83
2	16.67	-7.288125	53.12
3	25.00	1.041875	1.09
4	25.00	1.041875	1.09
5	16.67	-7.288125	53.12
6	8.33	-15.628125	244.24
7	25.00	1.041875	1.09
8	16.67	-7.288125	53.12
9	33.33	9.371875	87.83
10	33.33	9.371875	87.83
11	16.67	-7.288125	53.12
12	25.00	1.041875	1.09
13	33.33	9.371875	87.83
14	33.33	9.371875	87.83
15	25.00	1.041875	1.09
16	16.67	-7.288125	53.12
	383.33		954.41

X. CONCLUSION

In Nigeria, several cloud computing projects are either under study or already in place. Foremost of these projects is the result of partnerships between international players and African/Nigerian IT firms. Examples of such partnership include Google and Descasio companies, Sunnet and IBM companies, etc.

Based on the research questionnaire (see appendix 'A'), the hypothesis and the scientific testing of the hypothesis using t-distribution test, the researcher hereby concludes that:-

There are enormous challenges to the adoption of cloud computing by organizations in Nigeria.

There are significant gains/benefits derivable by the adoption of cloud computing by organizations in Nigeria.

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