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A Conceptual Framework of Deploying Cloud IaaS in Higher Educational Institutions

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***Abstract*—All cloud services require the fundamental layer known as Infrastructure as a service (IaaS). Clouds have the benefit of being cost effective, while improving productivity. This paper is focused on a proposed conceptual model for deploying Cloud IaaS in Higher Educational Institutions in Africa with Nigeria as a Case Study.**

As an IT professional working in the educational sector in this region the investigator has experience the gains of ICT in both learning and dissemination of information

Though the focus of this research is on Nigeria, the resulting structure can be implemented across the African continent and other developing countries.

Keywords-Data Centres, Power, Cost, Services, scalable.

I. INTRODUCTION

Data Centres and ICT Infrastructure in developing countries have suffered a lot of set back due to a number of factors which include but not limited to lack of proper planning, power, manpower and cost.

The cost of having a standard traditional data center is expensive any where in the world but it's more expensive in the developing countries. It involves various kind of infrastructure like the IT systems, air conditioners, alternative power supplies and even the structures cost money because you have to build it to some specifications with raised floors, fire suppression among others [1].

Also while planning for data centres usually the individual power consumption of the infrastructure, is not taken into consideration. As a result the infrastructure don't usually perform optimally and they usually don't last as long as they should.

The epileptic power supplies in these countries have made centres to run alternative power supplies like solar and generators and because the power consumption of the infrastructure has not been properly calculated they sometimes end up being inadequate too for these centres to run effectively and efficiently.

The centres usually need experienced staff to man and monitor it effectively. In developing countries there is still a dire need of IT skilled staff because it is still a growing technology. These data centres usually have different applications with different hardware and it would require experienced in-house IT staff to deliver 24x7x365 response to the site.

The Centres and the Data also need to be secured and protected physically and monitored against environmental threats such as fire, overheating and theft.

Cloud Computing would affect how data centres are built, it would address the present inefficiencies of traditional data centres and its inflexible, un-scalable infrastructure demands where you have to purchase an entire system even if you don't need that much. It is unlikely that one cloud provider can provide everything you want in a data centre, so the answer is be your cloud provider and customise your needs, this can be deployed through community cloud.

With Cloud comes availability, elasticity, resource pooling and sharing. These are very important for educational institutions in developing countries. With a conceptual model, these resources would make the institutions more efficient and effective.

There are different types of cloud computing models through which services are delivered but the four common ones are: Infrastructure as a Service (IaaS) Platform as a Service (PaaS), Software/Application as a Service (SaaS/AaaS) and Business Process as a Service (BpaaS). These models can then be deployed in a number of ways depending on the need of the client namely - Private, Public, Community or Hybrid cloud deployments [2,3]. These delivery models are laid in layers and each layer requires the structure and standards of the one below with the exception of IaaS since it's the core. Though IaaS is at the lowest level and the foundation of all cloud computing, many tend to overlook this delivery model. All cloud services require the fundamental layer known as Infrastructure as a service (IaaS). It is also important to note that there are stakeholders in cloud-computing that take on different roles and they include the end-users, cloud service providers, cloud tool providers and cloud application vendors [4].

This paper is investigating a proposed conceptual framework of deploying IaaS, deployed as a research community cloud for Higher Educational Institutions particularly in developing countries (with Nigeria as a

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Case Study) to provide readily available and effective IT infrastructure to these HEIs, where majority of them do not have standardised scalable data centres. Since the HEIs have the same needs and mission, It is important that it is deployed as a community cloud [2]. This is because it would help in building alliances among the institutions, saving costs and protection of data according the locality's legislation on data and its Data Acts.The paper has therefore been divided into the following sections: section 2 investigates the existing system, its needs, requirement gathered and an analysis of existing cloud providers. Section 3 presents a case scenario and proposes a framework based on the requirement gathered in section 2. Section 4 presents the conclusion and further work.

II. Existing System

The investigation of the existing system, its needs and requirement gathered are presented.

Most HEIs in developing countries do not have scalable standard data centres. Very few have standard data centres, some have a skeletal data centre running basically one or two services and outsource some of the services if they have anymore, while most don't even have one, the services available if any are outsourced.

All the institutions with a standard data centre have problem of insufficient power supply to the data centre as the supply from the national grid isn't constant and the power back-ups are not sufficient enough to power these equipment for a long time and provide availability of services uninterrupted. The power consumption of the equipment is not usually considered when providing the power back-ups so making it to be in sufficient even when they have been provided.

Some institutions do not have the required skilled manpower to manage the centres and as such only get equipment that have minimal management which means they can only run limited services and if there is the need to have more services it out-sourced to other companies at some cost.

Some of the institutions cannot afford the cost of the infrastructure and maintaining a standard data centre, so they end up not having one at all.

A. Need of HEIs

As explained in section II, there is a dire problem in developing countries as regards provision and availability of scalable IT infrastructure and therefore necessary software/ applications development is hindered due to lack of standard data centres and availability of infrastructure, which also affects the essence of research, which is teaching, learning and collaboration. The HEIs need test platforms, high availability and dynamic scalability of infrastructure to function effectively as researchers and students.

The need to collaborate and share resources with other institutions would also improve development and reduce cost.

B. Requirement of HEIs

To propose a framework, it is important to gather requirement about the existing system and its needs.
Questionnaire and Unstructured Interview were the research instruments used. These have been found to be successful, efficient ways of collecting honest facts for quantitative and qualitative research [5].
The following are requirements produced from the analysis of the results and comments from the questionnaire and interview:

1. **Need to share ICT infrastructure resources:** At present most Institutions don't share ICT resources, **t**he need to share ICT resources was very important to respondents.
2. **Need for standard scalable data centres:** HEIs in developing countries have the desire to deploy educational activities over the Internet / network but this cannot be done without the existence of a standard data centre which is absent in some of these institutions. Where it is present the data centres do not scale to meet increased or decreased demands. How sophisticated your data centre is would determine the type of ICT services that can therefore be deployed.
3. **Need to collaborate with other institutions:** An important aspect expressed by these responders was the need for collaboration among institutions, which would help in teaching and learning. It would provide the institutions with needed resources.
4. **Need to reduce cost** Cost of infrastructure for a data centre is high. The need to reduce this cost is very important to HEIs and it would have hindered the provision of more robust data centres even in institutions where there is a desire to own one.
5. **Need for power back up:** Without proper power back up, the systems cannot function optimally and efficiently. The need for sufficient power back up even for HEIs with standard data centres was expressed. With a standardised data centre it has been noted based on interview results that performance is still affected due to the fact that the total power consumption wasn't considered and hardware choice i.e. low energy hardware wasn't also considered.
6. **Need for Policies and Standard:** Specific policies and standards that would accommodate the needs of the institutions and improve sustainability.
7. **Need for Manpower:** Based on the interview conducted, HEIs exist that have the money for a data

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centre yet lack of manpower hinders the setup of a data centre.

C. Analysis of Existing Cloud Providers

A number of industry based commercial cloud providers exist that provide cloud services for example GoGrid, Amazon EC2, Windows Azure and Rackspace among others. Though these providers provide services that are needed by the HEIs in developing countries, the following have to considered:

- Providers can terminate their services to the users when they are pressured like in the case of Amazon EC2 and Wiki Leaks in 2010. This is even backed in their terms of service where providers decide who to service [6].
- The Providers all have different pricing modes, some are flexible others are not. For example Amazon EC2 is based on tier pricing while GOGrid is based on main memory allocation. There isn't a unified pricing mode [7].
- The providers don't have a unified interface so users would have to learn how to use the different interfaces[7]
- The terms and conditions of these providers are some times not clear, say like in the case of the data centres located in certain regions, it is still not clear which location in that region the data is stored [8]
- Providers provide to a variety of users so users with some particular interest area can't ensure that issues important to them is addressed.
- Most of the providers don't have data centres in the African region located in an African country and this would increase latency and cost of bandwidth and should there be an institution with low bandwidth, then connection would never be steady, it would keep losing resources and no provider would take liability. Basically all of them are services across the Internet, which would increase cost for African HEIs.
- In the case of an outage, if you have no failsafe plan then you have no access to resources.

III. Proposed Framework

The need to develop a framework for deploying CIaaS in HEIs in Nigeria is to accommodate the peculiar needs as discussed in section II.

HEIs require high performance, which needs high bandwidth and low latency. The framework would be built on the requirements gather.

This framework is different from the rest of the commercial IaaS providers because it would be deployed as a community cloud for the Institutions and within the Research Education Network (REN). Since its deploy within the REN traffic is local, it is traffic between the intranet and not across the internet which would not affect the cost and size of bandwidth and its services would be tailored across the requirement of the educational and research institutions.

The framework consists of the following components: the first important foundation component for the framework is the formation of a Research and Educational Network. The formation of the REN is important since the REN would be the provider of the cloud infrastructure service and only that way can it be deployed as a community cloud. The formation of the REN would make it possible to keep traffic local within the intranet and not across the Internet; this would reduce cost and size of bandwidth for HEIs. With the formation of the REN and the service deployment, only then would the services provided meet the requirement of educational and research institutions. With the formation of the REN, cost of ICT infrastructure can also be bargained with commercial vendors. When the REN is functional, the network connections among the institutions (intranet and internet) and bandwidth availability would be administered and maintained by the REN. The REN provides internal network services between HEIs and external network service between the HEIs and the world.

The network administration is done first by the HEIs connecting across regions then the regions connect to one another and then to the backbone, this makes the network fail-safe. When forming the REN some peculiar factors relating to the community and environment would have to be considered like the circumstances of the individual member institutions, political situation in the country particularly with the Telco regulators and availability of fibre among other things. Based on these consideration, steps to forming a REN should be done in groups / phases because that way there would be minimal failure / challenges and the system would be better administered: - first smaller research groups come together and form a smaller network, then the HEIs with minimal network connections can then be connected to the initial network and the system be studied further and improvements be made, then lastly HEIs without network connection, this is the last stage because consideration have to be made on how they would access the facility and how their internal network can also be set up. The process of the formation of the REN is implemented this way because it would allow the REN build up with minimal challenges.

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The formation of the REN is important because it would be flexible and responsive and therefore becomes a vital resource for HEIs because it meets their needs effectively and efficiently. The REN would depend on members' dues and external funding to run the Network. Since the REN provides the services mentioned above, in-evidently it becomes the cloud provider. The cloud provider is another component of the framework. The provider would administer the users and the services. The provider approves or rejects the request of the user based on membership, members' dues / payment and approved use policies using the user's filled SLA form. When a user logs into the system the administrator gets an sms alert informing him of the user's activity and from which IP address the connection was initiated, this is for accountability, monitoring and security purposes.

Building on this foundation, the next important component is the SLA. This is important because it provides an agreement to provide sustainable cloud services accordingly, based on users' requirement. The resources would be grouped based on critical and non-critical requirement. The resources would then be powered based on their requirement; the non-critical resources would be powered using locally generated power sourced through the wind and sun and the critical resources would be powered using the national grid and power back-up. The users download, read, scan and email or post back the completed SLA to the provider. The SLA contains the integration of resource demand and supply between member institutions and the REN. The SLA commits also to jurisdiction as regards where data would be kept and the data policies that would be binding the data services, financial obligation of the members; it provides what access a user has and also the long term viability of the Provider and the sustainability of the REN and its activities.

The final component is the user who must hold some form of membership with the REN. The user must be an HEI and also pays some form of membership fee to have access to required resources. User accounts are created based on the information entered in the filled SLA. Immediately a user account is accessed an sms and email is sent to the user with the details of the current login and from which IP address the connection was initiated, once a user logs out, an sms is again sent to the user. An instant sms and an electronic mail alert is sent to the user if the user exceed its limits and the process running is requiring more resources that can or cannot be accommodated by the provider.

A. Prerequisite

- Since CIaaS model would be deployed as a research community cloud, the entities in the research community cloud would be known as the stakeholders and the stakeholders must be HEIs in Nigeria. This would allow HEIs share resources and management tasks because they have common interest.
- he stakeholders would include the user – who wants access to services and pays for, the Vendor who could be the REN / consortium would sell the services / resources to the users, the provider who would provide the services to user, checks whether the user is allowed to obtain the requested service and authorises the service based on the SLA

Six data centres would be deployed in the six geo-political regions of Nigeria and one in the Federal capital as the main data centre. These six data centres would be the edge providers to the users (institutions) around them. This would provide low latency and maximise availability. Figure 5 shows how the data centres interact where they all communicate and share information and should any one fail, load balancing is implemented and the affected institutions automatically interact with another data centre seamlessly.

These geo-political zones would all have separate power connections and a back up network connection. This would enhance the fail-over solution.

- The services that would be provided and shared among these institutions are compute services like CPU, memory, storage, servers and network among others.
- It would be deployed over the Research Network (REN) so traffic between these institutions would be over the intranet not the Internet. This would also encourage sharing and collaboration.

B. Operation

It would be an automated self-service deployment. This would make it convenient for HEIs to get only the require infrastructure as at when needed.

An institution must be authenticated first before it can be authorised to access the resources.

To be authenticated each Institution would belong to the REN and agree to the service level agreement. The SLA will address issues like availability, outages, service credits the different roles, acceptable use and termination process. Once this is done an instance is created for the institution.

The SLA would be free of the use of computer-"jagoons" to allow all stakeholders communicate effectively and it would also state the mode of payment.

When a request is made to the provider, the provider checks if its an authenticated user, that is if its an HEI in the REN, if it is, the provider checks what resources / services it is entitled to. An institution can be provided

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with what it is entitled to or can use below or above its entitlement depending on the request and availability

The resources are then deployed to the institution. Which means authorisation has then been granted.

The resources are monitored and should there be an instance where some of the resources are not been used the un-used resources would be decommissioned.

The decommissioned resources can be deployed to another instance where and when needed.

The model would be deployed across the 6 geo-political regions and load balancing implemented to prevent unavailability due to power or infrastructure failure and to reduce latency.

Users can further be placed into the different geo political regions to suit their locality.

IV. Conclusions and Further Work

This framework deployed as a community cloud would provide HEIs the opportunity to share resources and collaborate together.
Though this paper seeks to provide a proposed CIaaS framework for HEIs further work in detailed security issues, laws / standards and interoperability among HEIs in different continents still needs to be done.

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