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CLOUD COMPUTING: SMES TECH-DRIVER FOR GLOBALIZATION

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Abstract

The economic growth and development of any nation depends on the success of its Small and Medium Scale Enterprises (SMEs). Despite its characteristics, Information and Communication Technology (ICT) have not been utilized fairly by the SMEs most especially in developing economies. This is due to lack of requisite ICT skills, knowledge, physical infrastructure and cost of adoption. Therefore, there is an impending need to investigate and understand the current challenges faced by SMEs as well as proffer a unique solution to make ICT readily available ubiquitously. This paper presents a trace of the historical linkage from distributed computing to cloud computing as well as discusses various technologies and architecture underlining cloud computing, presents the current ICT adoption challenges faced by SMEs and finally presents a working cloud computing framework to help overcome these challenges in this globalization age.

Keywords: Cloud computing, ICT, Globalization, SMEs, Framework.

1.0 Introduction

The architecture and design of computing in recent times consist of services that are delivered in a manner similar to basic services such as water, electricity and gas. In such situations, users access services based on their requirements without regard to where the services are hosted or how they are delivered. This advance in technology can also be called utility computing. Presently, contents can be accessed over a network such as the Internet without reference to the infrastructure hosting such contents, an act also referred to as Distributed Computing. There is a noticeable increase in the adoption of distributed computing and systems by organizations and enterprises in recent years. This adoption has been enabled by factors such as accessibility to the Internet and improvement in secure communications technology (Srinivasan and Treadwell, 2005).

The style of content distribution ranges from clusters of homogenous systems to wide and global-scale homogenous or heterogeneous systems. These distributed contents are managed by content providers. They reside in well managed, monitored and maintained data centers across the globe. Several Distributed computing standards have been developed over time with each recording varying degrees of success. In recent times, the technologies or paradigms evolving are designed to ease the cost of deployment and maintenance of distributed systems. Such technologies include Service-Oriented Architecture (SOA), Web services, Cluster computing, Grid computing, and more recently, Cloud computing (Srinivasan and Treadwell, 2005; Buyya et al., 2009).

1.1 Distributed Computing Technologies

Several Distributed computing standards have been developed over time with each recording varying degrees of success. In recent times, the technologies or paradigms evolving are designed to ease the cost of deployment and maintenance of distributed systems. Such technologies include service-oriented architecture (SOA), Web services, Cluster computing, Utility computing, Virtualization, Grid computing, and more recently, Cloud computing (Srinivasan and Treadwell, 2005; Buyya et al., 2009).

i. *Service-Oriented Architecture (SOA)*

Architecture, as defined by The Open Group Architecture Forum (TOGAF) by Portier (2007) is "A formal description of a system or a detailed plan of the system at component level to guide its implementation". It also defines it as "the structure of components, their interrelationships, and the principles and guidelines governing their design and evolution over time".

SOA generally refers to design and not implementation. SOA is an architectural style of designing and building reliable distributed systems that deliver functionality as services, with the additional emphasis on loose coupling between interacting services (Srinivasan and Treadwell, 2005). A service is a discoverable resource that executes a repeatable task, and is described by an externalized service specification (Portier, 2007). Features of services include (Srinivasan and Treadwell, 2005; Singh and Huhns, 2006;Portier, 2007):

- Services communicate with their clients by exchanging messages
- Service Choreography: they participate in a workflow, and the outcomes of their operations are determined by the order in which the messages are received.

- Services are encapsulated (self-containing), and described in terms of interfaces, operations, semantics, dynamic behaviors, policies, and qualities of service.
- Services reusability is supported by services granularity design decisions.
- Services agreements are between entities, namely services providers and consumers. These agreements are based on services specification and not implementation.
- As they go through their life cycle, services are hosted and discoverable, as supported by services metadata, registries and repositories.
- Loosely-coupled services are aggregated into intra- or inter-enterprise business processes or composite applications.
- Services advertise their details such as their capabilities, interfaces, policies and supported communication protocols.

ii. Web services

Web services are distributed software components that provide information to applications rather than to humans, through an application-oriented interface (Srinivasan and Treadwell, 2005). Web services are an implementation technology; they publish details of their functions and interfaces, but keep implementation details private, a feature that makes them applicable to a distributed heterogeneous environment. Web services address discovery and invocation of persistent services; these are services that outlive their clients(http://www.cnaf.infn.it). They are available until the server is shut down. Web services use the following key specifications (Srinivasan and Treadwell, 2005; Singh and Huhns, 2006):

- XML (eXtensible Markup Language), for formatting and exchanging structured data;
- SOAP (Simple Object Access Protocol), for specifying envelope information, contents and processing information for a message;
- WSDL (Web Services Description Language), an XML-based language used to describe the attributes, interfaces and other properties of a Web service.

iii. Utility Computing

It is a model of providing resources on-demand and charging customers (clients) based on usage rather than a flat rate (Zhang, Cheng &Boutaba, 2010). Service providers maximize resource utilization while minimizing operating cost with on-demand provisioning and utility-based pricing.

iv. Virtualization

Virtualization is a technology that abstracts away the details of the physical hardware and provides virtualized resources for high-level applications (Zhang, Cheng &Boutaba, 2010). It is a technique for hiding the physical characteristics of computing resources to simplify the way in which other systems, applications, or end users interact with those resources.

v. Cluster Computing

This consists of a collection of locally inter-connected stand-alone computers working together as a single integrated computing resource (Pfister, 1998). Clusters have tightly-coupled and homogenous nodes. Computing in clusters did not provide efficient use of idle resources, and highly susceptible to failure as a result of homogenous nodes (single point of failure). An improvement on Computer Clusters brought about the Grid.

vi. Grid Computing

Grid computing is a concept (Foster, Kesselman&Tuecke, 2001); it is a kind of distributed computing over a network (public or private). It is based on the principle of virtualization of computing and data resources. These resources include processing, network bandwidth, and storage capacity. They are used to provide seamless access to vast IT capabilities (Joseph and Fellenstein, 2004). It's set of standards and protocols are open and as such enable communication across heterogeneous and geographically dispersed environments. Grid computing provides a platform for enterprise high-performance computing (HPC) and large scale data sharing, utility computing. They are characterized by decentralized management, which gives room for heterogeneous resources; they operate on a large and global scale and are widely distributed. Grids in recent times have adopted the SOA style using Web services as the implementation tool. The rapid advances in Web services technology and standards have paved way for grids to be standardized, service-oriented and enterprise adaptive; hence, the development of the Open Grid Service Architecture (OGSA). Grids can either be compute grids, or data grids (Srinivasan and Treadwell, 2005). Compute grids lay emphasis on the shared use of computational resources while Data grids provide a platform for federation, integration and mining of data resources. This classification dictates the type of grid infrastructure needed. However, grids are not efficient when running applications that cannot take advantage of Message Passing Interfaces (MPIs).Grids are not also efficient when large computing speed is required and when applications require licenses to run across servers. Cloud computing is an extension of Grid computing that encompasses the features of the Grid, builds on its limitations with its own special attributes (Liu et al., 2012).

1.2 Cloud computing

A definition of Cloud computing as proposed by Buyya et al., (2009) denotes a Cloud as a type of parallel and distributed system. It consists of a collection of inter-connected and virtualized computers. These computers are dynamically provisioned and presented as one or more unified computing resource(s) based on service-level agreements. These service level agreements are established through negotiation between the service provider and consumers. The National Institute of Standards and Technology (NIST) in 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." The super-computing power of a cloud is made available by a network of data centers in which several servers are installed. Cloud computing represents the infrastructure as a "Cloud". Users (tenants and clients) are able to access cloud applications from anywhere in the world on demand (On- demand computing). This is gradually and rapidly transforming the computing world towards developing software to be consumed as a service (Software-as-a Service: SaaS), rather than to run on their individual computers. There are sets of parameters and features that clearly distinguish Cloud computing (Buyya et al., 2009). They include:

- Single ownership,
- It is populated by commodity computers and high-end severs whose network speed is high-end with low latency and high bandwidth.
- The resources in a Cloud are either centralized or distributed with their capacities provisioned on demand.
- Clouds have strong support for virtualization with high potential for dynamically creating value-added services with web-service interface and for fail over and content replication.
- Clouds guarantee high-level security and privacy as each application has its own virtual machine and support access control list.

Some emerging cloud platforms and technologies include: Amazon Elastic Compute Cloud EC2, Google App Engine, Microsoft Azure, Sun Grid, Aneka, Virtual Workspaces, OpenNebula, CloudSim and Reservoir. Cloud computing application areas include social networking, web hosting, gaming portals, business applications, scientific workflows, healthcare, content delivery and data processing and storage.

1.3 Cloud Computing Architecture

Cloud computing architecture is generally made up of three layers. Each layer is loosely coupled with the layers above and below. This makes the architecture more modular, and allows each layer to operate separately. The architecture can be compared with the OSI model for network protocols. The layers are discussed as follows and depicted in Figure 1.

- Application layer: this represents the customer's actual interface. It delivers applications via the virtualized platform and infrastructure layers. The services in this layer are of two types; software-as-a service and on-demand web services.
- Platform layer: it resides on top of the Infrastructure layer and provides value-added services from both technical and business perspective. It consists of operating systems and application frameworks. This layer minimizes the burden of deploying applications directly into VM containers. Platform services are of two types: Development platforms and Business platforms.
- Infrastructure layer: this is an important layer of the architecture. Virtualization takes place at this layer. It provides the enabling technologies for the cloud. It provisions a pool of storage and computing resources through virtualization technology. In this layer also reside the physical resources (hardware) of the cloud. These include the physical servers, routers, switches, power and cooling systems.

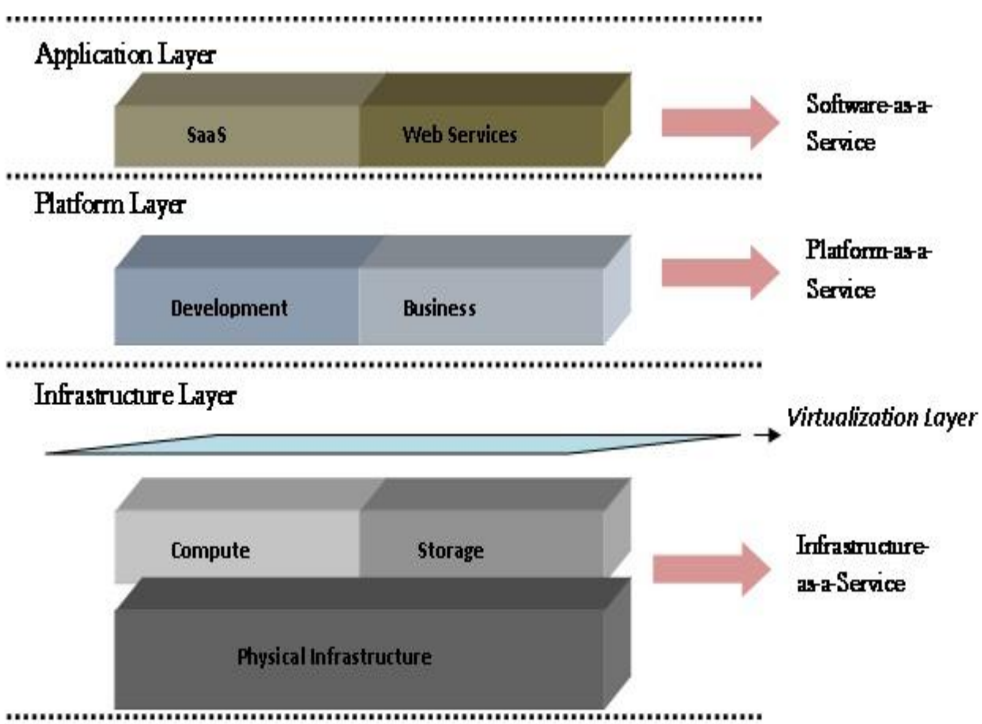

Figure 1: Cloud Computing Architecture (Source: Rita & Nicholas, 2011).

1.4 Cloud Business Models

Cloud computing employs a service-driven business model. Organizations are coming up with different models on various aspects of cloud computing daily. A Cloud Business Model Ontology was proposed by Youseff et al., (2008) based on the layered cloud architecture; to help attain a better understanding and a conceptualization of Cloud computing. The ontology attempts to provide taxonomy of different business models. It consists of three layers which groups the services offered by the cloud:

- Infrastructure as a Service (IaaS): Also called "Infrastructures in the cloud", the IaaS layer offers storage and compute resources that developers and IT organizations can use to deliver business solutions. These cloud computing infrastructures are organised in a cluster-like structure to facilitate virtualization technologies.
- Platform as a Service (PaaS):Also called "Platforms in the cloud",The PaaS layer offers black-box services with which developers can build applications on top of the compute infrastructure. This might include developer tools that are offered as a service to build services, or data access and database services, or billing services.
- Software as a Service (SaaS): In the SaaS layer, the service provider hosts the software so you don't need to install it, manage it, or buy hardware for it. All you have to do is connect and use it. SaaS Examples include customer relationship management as a service.

2.0 Small and Medium Scale Enterprises (SMEs)

The accelerated development and economic stability of a country especially the developing countries lies on active, participating and sustained small scale businesses (Duan et al., 2002). The socio-economic difference created by recession has its negative impact on less developed countries like Nigeria and such adverse impact include stagflation, increased rate of unemployment among graduates and falling foreign exchange earning among others (Abdullahi et al., 2-15) . Hence the economic foundation of and growth of a nation mostly depends on its ability to run and efficiently maintain small scale business. Small scale businesses are as well important entrepreneurial wise, because it is ground for training, and preparing entrepreneur as it provides the logical starting point for big businesses, important also it is, in carrying the entrepreneurial thrust as spring board of the latter. Numerous reports have indicated that micro and small enterprises constitute 95 per cent of enterprises within the developed world, and directly serve as both backbone and driver of national economies (Kotelnikov, 2007).

In this modern economic environment being dominated by globalization, hyper-competition, knowledge and revolution in information, has changed the way businesses and their environments are conducted, hence information technology adoption is inevitable. This is evident in the intensified investment in computer processing and data preparation appliances, in the manufacturing and service industries, education organization, even in the house hold and also readily available for small scale business too. Thus, the implementation, application and utilization of information technology is gaining more ground globally, the adoption of this technology can generate business opportunities and other benefits. There have been a number of studies that was conducted to study and discuss adoption of information technology in small and medium enterprises (SMEs) both in the developed and developing countries (Lucchetti&Sterlacchini, 2004; Love &Irani, 2004; Clarke et al., 2006). Ritchie and Brindley (2005) studied the significance of information and communication technology (ICT) in the growth of SMEs, and concluded that adoption of information communication technology increases the efficiency of the organization. Beheshti (2004) also, in his study of the impact of ICT on SMEs in United States of America, discovered information technology can be used to create competitive opportunities for the organization. Chen et al., (2006) identified that the lack of ICT skills and knowledge in SMEs as one of the major challenges faced by all European countries, particularly in the United Kingdom, Portugal and Poland in their study. Lal (2007) investigated the adoption of ICT in SMEs in Nigeria and found that one of the major factors inhibiting ICT diffusion and intensive utilization is poor physical infrastructure. Figure 2 shows a recent survey carried out in Malaysia, the survey depicts that infrastructure and cost are the two major drawbacks of ICT adoption by SMEs (Shah Alim,Ali&Mohd. Jani, 2011). Kapurubandaraet al., (2006) have categorized internal and external barriers that impede adoption of ICT by SMEs in a developing country. The internal barriers include owner/manager characteristics, cost and return on investment, and external barriers include, infrastructure, social, cultural, political legal regulatory.

Small scale businesses cannot depend fully on the unprofessional book keeping records to draw information that allow them to grow into big businesses as expected. Without full adoption of information technology, in this time of hyper-competition, growth is not feasible and many will not last long. The adoption of information technology can help maintain good customer service and relationship, create more opportunities for going international, enhance fast and low cost communication within and without, while they also enjoy faster inventory replenishment, enhanced data processing, storage and retrieval.

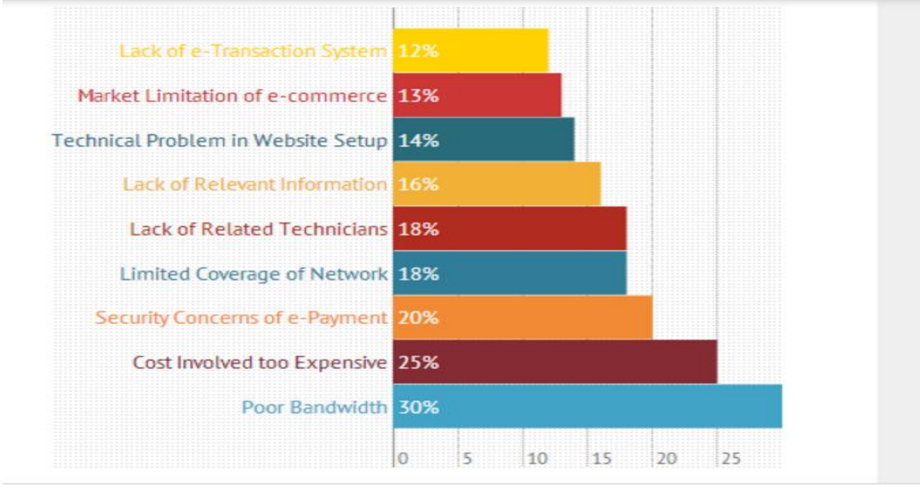

Figure 2: Malaysian SME Survey on Adoption of ICT (Source: Shah Alim,Ali&Mohd. Jani, 2011).

A major determining factor in SMEs' adoption of IT is resources. SMEs are have restricted access to particular resources compared with large organizations(Nieto& Fernandez, 2005).The literature on IT adoption suggest that, due to the SMEs' unique characteristics, their financial resources, technical and managerial resources, information resources accessibility, market accessibility, internal and external expertise, and in-house IT knowledge and experience can hinder or simplify the adoption of IT in SMEs, and negatively or positively affect this processes as well (Nguyen, 2009) . Financial resources are critical success factor of any small business and are one of the most crucial resources which are known as key SMEs performance requirement.

Hence, limited financial resources compel SMEs to be cautious about their investment and capital spending (Ghobakhloo et al., 2011; Ghobakhloo et al., 2011). An imprecise decision on IT investment can cause drastic financial consequences for small business and in extreme circumstances, may lead to insolvency and economical failure (Sarosa & Zowghi, 2003).

As implementation of a new IT system and its components requires long term investment as well as high cost of IT infrastructure, only SMEs that have adequate financial resources would consider adoption of IT as a feasible project to undertake. SMEs also lack in-house IT expertise which affects process of IT adoption negatively, resulting in SMEs facing significant risks and problems with their computerization regarding their inadequate knowledge of IT implementation.

Caldeira and Ward (2003) revealed that internal expertise consisting of employees, supervisors, or those from top management teams are powerful determinants of IT adoption and success. In addition, development of internal knowledge of IT and skills is one of the most important bases required for providing superior levels of IT adoption and satisfaction to solve the issue of CEOs being bewildered by swift development of IT tools. Organizational characteristics such as culture, business size, type of industry, technological maturity; and external and competitive pressure are other factors affecting technology adoption.

4.0 Cloud Computing Approachto Resource Provisioning

The methodology adopted in this design is Software-as-Service (SaaS). This delivers a single application through the browser to thousands of customers (users) using a multitenant architecture. SaaS architectures are generally classified to one of four "maturity levels", where each level differs from the previous by unique attributes as represented by Figure 2.

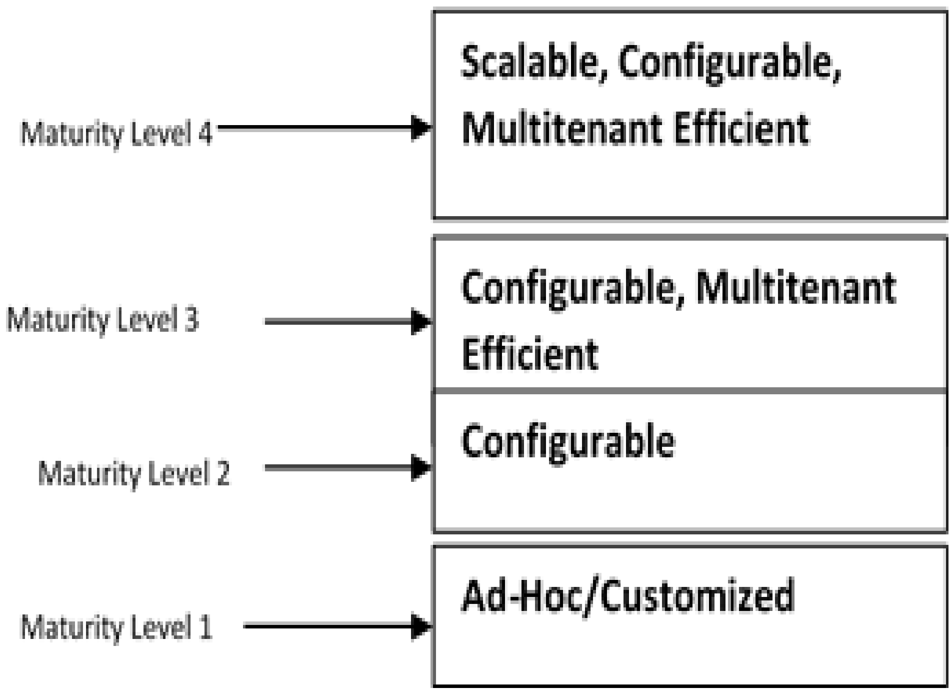

Figure 3: SaaS Architecture (Buyya et al., 2009).

Multitenancy allows several customers to share resources, without the customers being aware of it. This can be done without compromising the privacy and security of each customer's data. SaaS is a higher level abstraction of the cloud, where there are now services in the place of data pipes, routers and servers.

The underlying hardware and software of networking is still available but there are now higher level service capabilities available to build applications. Cloud Service users are only particular about its accessibility with a high level of reliability. They are not concerned about the service implementation, the technologies adapted and the service management.

This methodology ensures no upfront investment in servers or software licensing for clients or users; while with just one application to maintain, providers enjoy minimum costs compared to conventional hosting.

4.1 Cloud Architecture Model for Voice Service Delivery

The proposed Business Cloud runs on a multitenant architecture. Multitenancy refers to a principle in software architecture where a single instance of the software runs on a SaaS vendor's server, serving multiple SMEs (tenants) (Liu et al., 2012).

The multitenant data will be managed using a single database server. The database server will be virtualized, thereby provisioning virtual servers for each tenant, these resources will be provided as services.

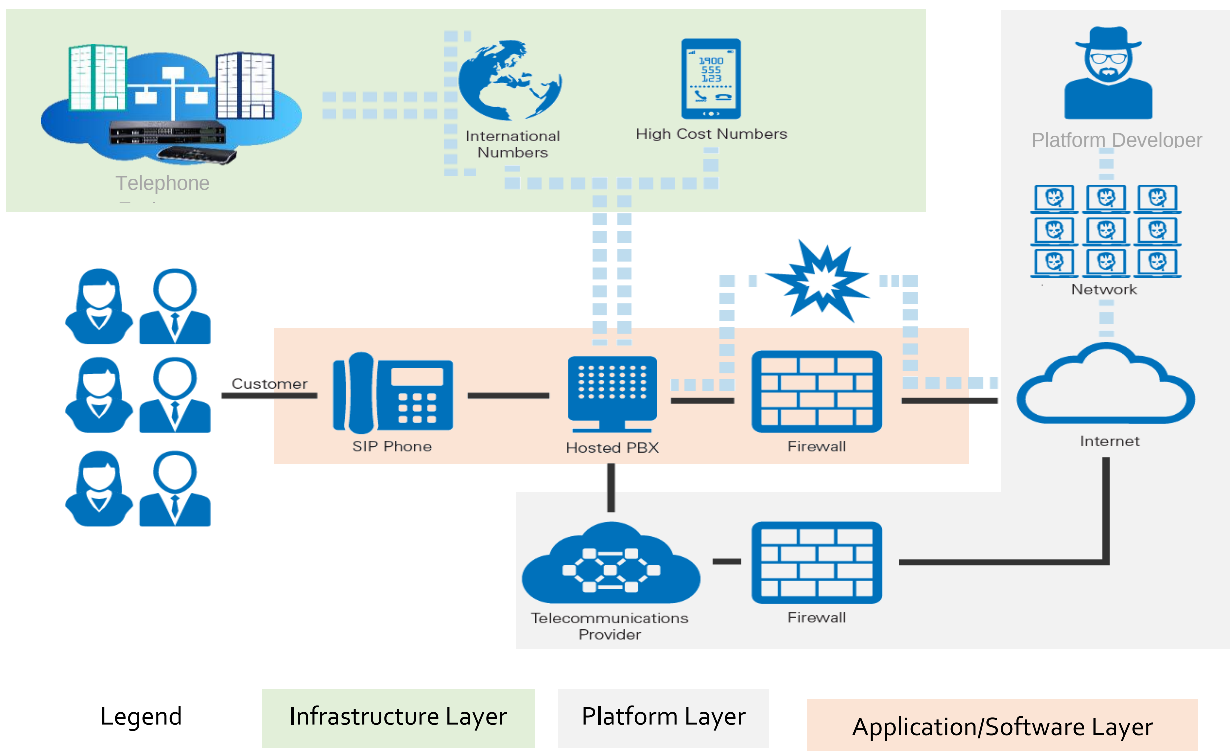

Figure 4: Software as a Service (SaaS) Cloud Architecture for Voice Service Delivery.

In the above architecture, voice and telephony services are being delivered as a service following the Software as a Service (SaaS) Cloud Business Model. This final layer of service delivery has undergone Infrastructure- and Platform as a Service models by various infrastructure and platform owners to eliminate the need for the small business and her end users having to invest in any of the infrastructure, platform or software that is required to operate a robust, scalable and mission critical business telephony service. The breakdown of the entire architecture consists of

- **The Infrastructure Layer**: Here, the core telephony infrastructure is provided by a telephone exchange operator, usually an arm of government or licensed corporations with extensive investment in telephony infrastructure popularly known as a public switched telephone networks (PSTN). The PSTN serves as the physical backbone or exchange infrastructure that connects various geographic regions within which the operator is licensed to operate. With this infrastructure, the owner or operator is able to provide local and international telephone service and numbers as well as high cost specialized numbers such as the toll free 0800 and 0700 numbers to resellers who operate smaller platforms.

- **The Platform Layer**: With an infrastructure of this magnitude, several opportunities abound to extend, develop, integrate, evolve and improve upon or around the infrastructure through smaller development platforms. This gives credence to the development of various platforms by programmers, developers and engineers. Platform developments are made possible through APIs, Web Services and other integration protocols which provide both code segregation as well as containment for the various platform developers. In the architecture, example of platforms that the infrastructure layer is able to support and that platform developers can take advantage of include voice, telegraph, telex, facsimile, etc. Possible integrations also include IP-PSTN integration for data-audio transcription using compression and decompressions (CODEC) technologies and Gateways, which have led to the development of Voice over IP (VoIP) protocols.
- **The Application Layer**: This is the consumer's layer where the small and medium enterprise utilize one or all of the applications that have been developed over the protocols or technologies that the platform engineers have put in place. VoIP applications at this layer can be IP telephony, audio or video conferencing, instant messaging, file sharing, fax services, international calling, roaming as well as toll-free numbers – all of which were at one time exclusively reserved to large corporations and government agencies. Despite the importance of wide-reaching modern communication to the small and medium enterprise, owning and operating a telephone exchange infrastructure is usually beyond their budget and capacity, so also are the skills, manpower and cost of developing or integrating platforms or applications. However, with cloud services made available by the cloud architecture, developers, freelancers and contributors can provide the SMEs with usable applications that require no coding or technical expertise to use. The applications are fully developed and managed by the application developer in one of many ways – as a single code or multiple similar codes – usually the former – in such a way that a single instance of the application can be utilized by multiple users or enterprises *referred to as tenants* in seemingly

isolated containers. The cost of infrastructure, platform and application development are then shared in a service-utility type arrangement between all tenants based on usage, consumption or fixed monthly rental cost. This also makes it possible for the application developer to maintain the application's code much easily and immediately roll out updates to all customers at once.

5.0 Conclusion

This study provides an understanding about the adoption of ICT by SMEs in developing countries, especially in Nigeria. Compared to SMEs in developed countries, the level of ICT adoption by the SMEs in developing countries lags far behind. This condition certainly has implications for SME proprietors to further increase their efforts through promoting effective programs and initiatives to encourage the level of ICT adoption by Nigerian SMEs.This study also provided acloud computing approach to resource provisioning as well as a cloud architecture model to benefit SMEs. Implementation of this model would definitely enrich the understanding of SME owners about the potential benefits of cloud computing as an ICT resource. A greater understanding about this will increase their probability to allocate some resources towards adopting cloud computing.Finally, this study also showed that the return on investment benefits realized by SMEs tend to be increased by the increase in the level of cloud computing adoption.

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