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Cloud Computing: The Next Generation Computing Model to Accelerate Innovation in Kenya

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Abstract

The need for innovation is becoming more imperative today for Africa and Kenya as a nation. Countries in Africa have been unable to compete in the global market due to lack of innovation in various industry sectors. A major area of Innovation is in information technology, engineering and technology. The business world globally is witnessing rapid developments in information technology that is significantly changing the way business is being done. One such technology is Cloud Computing. This paper focuses on the Cloud Computing technology and seeks to enunciate it as a potential and significant platform that can drive and accelerate innovation in Kenya within various industry sectors. The paper reviews the Cloud computing technology and current impact on global innovation, discusses the need for innovation in Kenya and readiness for the adoption of the technology. The paper concludes with Cloud Computing utilization strategies as well as innovation opportunities within Kenya.
Relevance to innovation. This paper addresses the innovative computing technology of Cloud Computing. As a pervasive technology that is presently changing business processes and businesses, Cloud computing is described in general and posited as an innovative technology necessary for adoption in Kenya and the African continent as a whole. The paper shows Cloud computing as a world class technology with the potential to change the whole discipline of computing and software engineering as we know it. Adopting Cloud computing in Kenya across various industry sectors is considered a major innovative strategy for educating a new workforce, creating economic growth and rapid product and service development.

Keyword. Business, Cloud, Computing, Innovation, Software

Introduction

There is need for innovation across various sectors of industry especially in product development and manufacturing. Kenya as a country needs to continue to encourage and

make a paradigm shift to a truly production economy. This would require significant development and progress in the design and manufacturing industry. In improving innovation across industries, there is urgent need to leap frog ahead to at least start to compete in a global economy that is increasingly becoming ubiquitous. The last two to three decades has witnessed significant advancement in computing technologies and information technology. These advancements have literarily changed the business world to the extent that IT has clearly in the last couple of years become a significant factor of business competitiveness. In the recent past, a major technology that is gradually changing the business world and would certainly change the business paradigm for the 21st century is Cloud Computing.

The adoption of Cloud Computing technology in the global economy has been increasing steadily within the last 10 years, but much more rapidly within the last 3 years. Evidence is abounding that it is a technology that would not only be beneficial to global economy, but will likely radically change the way business processes will be performed in the future across all industry sectors and markets. Just like the adoption of Cloud computing is rapidly growing, the amount of and body of research is also expanding globally with various sectors such as manufacturing and construction, beginning to explore how Cloud computing can enable and improve business processes.

Cloud Computing Fundamentals

What is Cloud Computing

The evolution of Cloud computing has drawn significantly from other prior technologies such as Service Oriented Architecture (SOA), Web Services, web 3.0, grid computing and virtualization. The increasing development and adoption of Cloud computing has caused significant shift in the computing paradigm making utility computing a more realizable goal as the management of services over the internet have become more pervasive and easily achievable.

Cloud computing has been described and defined in several ways. Some of the key and more common definitions are as follows: Cloud computing enables rapid delivery and consumption of IT on-demand services in concert with constantly changing business drivers. The Cloud is a model that encompasses business requirements, technology, organization, automated process and a real, IT-as-a Service lifecycle management framework. The Cloud computing framework whilst supporting IT applications synchronizes with new innovation of the future (Gamull, 2013).

Cloud Computing has been proposed as follows: A computing Cloud is a set of network enabled services, providing scalable, Quality of Service (QoS) guaranteed, normally personalized, inexpensive computing platforms on demand, which could be accessed in a simple and pervasive way (Wang and Laszewski, 2008).

From an economic perspective, Cloud Computing is defined as follows: Building on compute and storage virtualization technologies, and leveraging the modern Web, Cloud Computing provides scalable and affordable compute utilities as on-demand services with variable pricing schemes, enabling a new consumer mass market (Klems et al, 2009).

Cloud computing refers to both the applications delivered as services over the internet and the hardware and systems software in the datacenters that provide those services. The services themselves have long been referred to as software as a service (SaaS). The datacenter hardware and software is what we will call a Cloud (Armbrust et al, 2010).

Cloud computing is both a UX and a business model. It is an emerging style of computing in which applications, data, and IT resources are provided to users as services delivered over the network. It enables self-service, economies of scale, and flexible sourcing options an infrastructure management methodology a way of managing large numbers of highly virtualized resources, which can reside in multiple locations (IBM, 2010).

Clouds are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms, and/or services). These resources can be dynamically reconfigured to adjust to a variable load (scale), allowing also for an optimum resource utilization. This pool of resources is typically exploited by a pay-per-use model in which guarantees are offered by the infrastructure provider by means of customized SLAs (Vaquero et al, 2009).

A cloud is a type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service level agreements established through negotiation between the service provider and consumers (Buyya et al, 2008). Frost & Sullivan (2013) define cloud computing as a flexible and scalable IT environment in which service providers leverage virtualization technologies to create and distribute computing resources to customers on an as-needed basis, through a private or public network and where the service is priced according to a per-use basis.

The U.S. Department of Commerce National Institute of Standards and Technology (NIST) defines Cloud Computing as" a model for enabling ubiquitous, 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. This cloud model is composed of five essential characteristics, three service models, and four deployment models.

The above NIST definition developed over a period of years by many researchers working together is perhaps the most popular and widely used. This definition summarizes the key contents and activities of the representative standard Cloud Computing Architecture by NIST. This overarching architecture shows Cloud Computing as robustly consisting of five major actors, namely: Cloud consumer, Cloud provider, Cloud broker, Cloud auditor and Cloud carrier (NIST, 2013), as shown in Figure 1.

The Cloud consumer is a person, or organization that maintains a business relationship with, and uses service from Cloud Providers. The Cloud provider is a person, organization or entity responsible for making a service available to Cloud Consumers. The Cloud broker is an entity that manages the use, performance and delivery of cloud services, and negotiates relationships between Cloud Providers and Cloud Consumers. The Cloud auditor is a party that can conduct independent assessment of cloud services, information system operations, performance and security of the cloud implementation. The Cloud carrier is the intermediary that provides connectivity and transport of cloud services from Cloud Providers to Cloud Consumers.

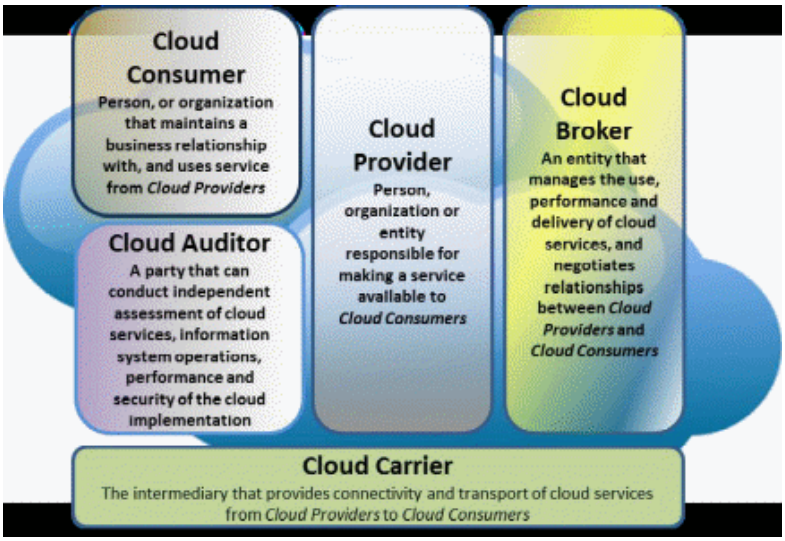

Figure 1- Cloud Actors (NIST, 2013)

Main Characteristics/Attributes of Cloud Computing

The NIST definition identifies five key and essential characteristics that define what has come to be known as Cloud Computing. They are:

- On-demand self-service
- Broad (Ubiquitous) network access
- Resource (location independent) pooling
- Rapid (Scalable) elasticity
- Measured service

Other characteristics include the following (Mayfield , 2011):

- Disperse geographical distribution
- Homogeneity
- Service orientation
- Advanced security
- Massive scale
- Virtualization
- Relatively low cost software
- Multi-tenant
- Reliability
- Utility based subscription
- Resilient computing

Cloud Computing Deployment/Delivery Models

In the implementation of Cloud computing, depending on the requirements and desired use and application, four main deployment/delivery models are generally adopted. These

models can be deployed individually or in combination with one another to achieve the desired result for users. These models also comprehensively defined by (NIST, 2013) are: Private Cloud, Public Cloud, Community Cloud and Hybrid Cloud as described below.
Private cloud. This deployment model is developed exclusively for use by a single organization, with multiple users/consumers and business units/divisions. It is akin to company intranets where only those within the individual organization have access to it. Private clouds can be owned, managed/maintained, and operated by the organization, a third party, and in some cases by both.
Public cloud. This model/infrastructure is provisioned for open use by the general public. It can be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It is usually accommodated on the premises of the cloud provider.
Community cloud. This model/infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises.
Hybrid cloud. The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds).

Cloud Computing Service Models

The generally known service models are Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). More recently and especially for applications within major business enterprises, the emerging Business process as a Service (BaaS) is being developed. These service models operate within the Cloud computing infrastructure.

A cloud infrastructure is generally considered to be the collection of hardware and software that enables the five essential characteristics of cloud computing. The cloud infrastructure contains both a physical layer (hardware resources that are necessary to support the cloud services being provided, and typically includes server, storage and network components) and an abstraction layer (the software deployed across the physical layer, which manifests the essential cloud characteristics).
Software as a Service (SaaS). The capability provided to the consumer is to use the providers applications running on a cloud infrastructure. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based email) or a program interface. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings. Applications used by businesses are provided on a subscription basis
Platform as a Service (PaaS). The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using

programming languages, libraries, services, and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment. PaaS involves virtualized development and runtime platforms.

Infrastructure as a Service (IaaS). The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications, and possibly limited control of select networking components (e.g., host firewalls). IaaS consists of both shared virtualized, dynamic provisioning and raw infrastructure available on an as need basis for private or public clouds.

Business process as a Service (BaaS). Involves capability provided for the user and a new and an emerging concept within cloud computing. It comprises of standardized and best of breed industry specific processes as well as standardized horizontal and vertical business processes provided on a subscription basis to individual clients or industries.

Need for Innovation in Kenya and Africa

Kenya as a developing economy in the 21^{st} century like most of the countries in Africa is in great need of accelerated growth and development to at least start to close the gap with the rest of the world. There is need for inward investment as well as from the international community to energize and cause rapid development in the various sectors of the economy. There cannot be development and growth in an economy void of innovation. Innovation is needed in every facet of the economy from government, manufacturing, finance, infrastructure to commerce, logistics, telecommunications, healthcare and agriculture to name a few. This innovation week organized in Nairobi is a significant and positive move to encourage and push forward the agenda of economic development, job creation and growth in the Kenyan economy. With increasing population of young people less than 30 years old, Kenya certainly needs a more concerted effort towards encouraging innovation in various sectors of the economy. A key enabling sector for all of these other sectors is information and communication technology or more generally information technology. Innovation in the ICT sector appears to have witnessed the greatest proportion of innovation by leaps and bounds world wide. The emergence of various computing technologies including the internet, mobile and network technologies, big data, the internet of things and cloud computing inter-alia has resulted in significant advancement and development in design, manufacturing and business process innovation on a global scale that has hitherto not been witnessed even in advanced and developed economies.

The Kenyan government has taken a significant lead in Africa towards encouraging innovation in ICT (2014). This document covers a strategic plan to be implemented over the period of 2013/2014 to 2017/2018. The report enunciates that, although Kenya has a low innovation index, the country however has a great potential for developing innovations in the ICT sector. It believes that ICT is a critical tool in Kenyas vision of a knowledge based economy, and should focus on innovation where creation, adoption,

adaptation and use of knowledge as the key source of economic growth are main drivers. The government is encouraged to create appropriate policies and infrastructure necessary to foster creativity and innovation in the ICT sector. In this regard, efforts are being made to establish innovation centers of excellence (CoEs) and Science and Technology (S&T) parks to carry our research in the ICT sector for application and services, that can readily be translated into entrepreneurial ventures and economic growth in the country.

The report by the Kenyan Ministry of Planning and National Development, courtesy of UNDP (2005), argued that science, technology and innovation play a significant role in achieving all the eight Millenium Development Goals discussed in the report.

In the specific area of Mobile technologies, the Digital Entrepreneurship in Kenya 2014 report (Drouillard, 2014) addresses current trends in Kenyas digital innovation and entrepreneurship ecosystem. Whilst making some key and important recommendations to government, research agencies, innovation hubs, investors and financial institutions, the report highlights that the potential for Kenya (and especially Nairobi) to become a leading hub for digital entrepreneurship in Africa is extraordinary.

The Impact of Cloud Computing on Current Global Business Innovation

The global cloud computing market is expected to reach approximately US$86 billion in 2016 from an estimated US$36 billion in 2013, growing at a compound annual growth rate of 33.4%. While SaaS continues to be the most popular cloud service offerings with users, IaaS is witnessing growing adoption and is expected to grow at 40% per annum for the 2013-2016 period (Frost & Sullivan, 2013).

There is no doubt that the uptake of Cloud Computing in various sectors of industry is rapidly increasing and its impact on business is evidently being discussed, explored and realized. In some sectors, Cloud Computing is now being seen as an integral part of the wider evolution of application development [Compuware]. Cloud computing is no longer just about new ways of delivering software, but now a valuable model for software development and testing as well as offering a new business model for managing development tools employed for application development.

Koeppel (2014) in his article says that Cloud computing is ideally positioned to become a significant catalyst of business model innovation, and CIOs and their IT staff need to be thinking about how to leverage cloud computing to increase the value of their IT investments and evolve their roles as value-added enablers of business outcomes. (LeBlanc, 2014) of IBM in his paper, discusses three trends that can speed up the adoption of Cloud computing. These are: (i) Linking systems of records with next-generation systems of engagement, (ii) Using clouds to speed innovation and (iii) Using clouds to speed innovation

From his interview with Adam Davidi of the Guardian Media Network, (Midgley, 2013) stressed that"Cloud computing has levelled the playing field as smaller companies gain the resources to compete in ways that were very expensive and often cost prohibitive in the past. The industry is moving towards a cloud enabled enterprise, especially by becoming more agile.

Berman et al. (2012) in their paper comment that:"To take advantage of clouds potential to transform a companys internal operations, customer relationships and industry value chains, organizations need to determine the best way to utilize cloud enabled business models that promote sustainable competitive advantage. They also highlight that cloud computing business innovation enablers do so by helping to spur innovation across customer value propositions (Enhance, Extend, Invent) and across company and industry value chains (Improve, transform, create.

In a recent report by the intelligence unit of the Economist, (Ridley, 2014) posits that cloud adopting by companies is rendering the division between IT and business obsolete and the associated organization chart. Expert and user roles are merging, blurring the lines between business and technology functions. (Huomo, 2014) highlighted that for ICT providers, moving to the cloud is beyond the adoption of a new technology platform but also about transforming the way they deliver value to their customers. She enunciates the idea of Future Cloud highlighting the fact that switching to the cloud is not just about the technology its about seeing the bigger picture: new products and services, new processes, new business models and new potential. This is not about business growth, but business transformation. With respect to impact on jobs, (Liebenau, 2014) indicates that cloud computing will create jobs and new business opportunities, but which countries and sectors see the most benefits, will partly depend on policy.

(RightScale, 2015) surveyed 930 technical professionals across a broad cross-section of organizations about their adoption of cloud computing. Key findings include:

- Cloud is a given and hybrid cloud is the preferred strategy.
- Public cloud leads in breadth of enterprise adoption, while private cloud leads in workloads.
- Significant headroom for more enterprise workloads to move to the cloud.
- Enterprise central IT teams take the reins to broker cloud services.
- DevOps (Development and Operations) rises and Docker soars.
  - Dockeris an open platform for developers and system admins to build, ship, and run distributed applications, whether on laptops, data center VMs, or the cloud.
- Amazon Web Services (AWS) continues to dominate in public cloud, but Azure makes inroads among enterprises.
- Private cloud stalls in 2015 with only small changes in adoption.

Benefits of Cloud Computing

In the report by (Compuware, 2011), it was highlighted that a significant benefit of Cloud Computing is the move from a world dominated by Capex (Capital Expenditure) with its associated write-downs and depreciations, to a world of Opex (Operational Expenditure), or to put it very simply a pay-as-you-go model. Money is thus directed towards solving the business needs rather than increasing the business asset pool. Benefits have been shown to grow with increasing cloud usage and adoption maturity (Mayfield, 2011, RightScale, 2015, Compuware, 2011, Frank, 2008, The Institution of Engineering and Technology, 2012).

- Cost Savings
- Business Agility and more flexibility
- Business Innovation at low risks
- Focus on Core competency
- Enables mobility, Big data and Social trends
- Enhanced efficiency and scalability
- Automation, standardization and Control
- Greater scalability, faster access to infrastructure, higher availability, faster time to market, efficiency of IT staff, Geographic reach, Business continuity, Higher performance, Move CapEx to OpEx
- Managed operations, Utility pricing/monthly payments, virtualized resources, elastic resource capacity, standards based systems, delivered over the internet, self service provisioning, third party ownership, management automation
- Pay only for what you use
- East/fast deployment to end users
- Low monthly payments
- Requires less in-house IT staff and costs
- Simpler systems/information sharing
- Easier group collaboration
- Device independence
- Lower capital costs
- Lower management and operation costs
- Reduced CO2 emissions
- Speed of deployment

In the Enterprise Resource Planning (ERP) arena, (Mattison & Saideep, 2012) argue that the migration of ERP systems to the Cloud environment is no longer a matter of"if, but"when. They believe that the capabilities and potential savings offered by moving to Cloud based ERP are too great to ignore. Such benefits include inter-alia:

- Faster implementation: easier to use and deploy
- Greater flexibility: system configuration, pricing is more flexible
- Lower total cost of ownership (especially start-up cost): savings can be 30% to 50% of TCO compared to on-premise ERP
- Less dependency on IT staff and/or on-premise hardware

In our view, the critical question isnt whether cloud computing will become a fundamental deployment model for ERP systems in the next decade; but how successfully companies will profit from the capabilities it offers.

In emerging economies of Africa, Asia and South America, cloud computing is also fast gaining ground. (Finger, 2009) highlights the following key observations:

- Cloud Computing has the potential of leveling the playing field between large and smaller companies. Thus opening a new world to developing and emerging economies along with the industrialized world
- Cloud computing will enable the creation and deployment of new and innovative business processes and operations that would allow more collaboration across the enterprise

- Cloud computing will enable businesses to be more adaptable and interconnected
- Cloud computing would be an enabler of new business models

Cowhey and Kleeman (2012), in their paper also argued the following

- The Cloud is central to global competitiveness because goods and services are becoming more ICT intensive
- The Cloud is vital to being competitive in South-South commerce the fastest growing share of trade and investment and the future home to most of the worlds middle class
- Cloud Computing strengthens SMEs, stimulating job creation and it levels the field for technology suppliers in the Global South, allowing near parity in content and services economics with traditional suppliers
- The Cloud has the potential to lower the barriers to access to ICT capabilities for businesses and citizens around the world and fundamentally improve the integrity, quality and speed of the delivery of government services.
- It gives SMEs in the Global South functionally the same ICT capabilities as many Fortune 50 firms, and doing it at similar unit and transaction costs. In South Africa small firms with under 100 employees have full CRM functionality via Cloud delivered Salesforce.Com
- Global in scope and massive in scale, the Cloud is permanently altering the economics and delivery of IT enabled capabilities. In India a study showed that move to Cloud based systems would reduce a typical firms IT costs by 1/3rd. A direct marketing firm increased transactions by 100 times in 3 years, moving to the Cloud to help them scale and respond to peak demand without making costly capital investments.

Current Readiness Assessment of Cloud Computing Uptake in Kenya

Previous work done by Omwansa and Waema (2013) has comprehensively addressed the current situation on Kenya with regards the uptake of Cloud computing in Kenya. They key points of that research are summarized as follows:

- Cloud computing is a few years old in Kenya. Private Cloud is more popular. 57% of the respondents indicated they adopted cloud technology in either 2010 or 2011. More organizations utilized pure private cloud (39%) compared to utilizing a public cloud (22%).
- Majority are not aware of cloud computing standards, policy or legal frameworks 75% are not aware of any standards. 80% are not aware of policy or legal frameworks. Those aware feel the frameworks are not as comprehensive, flexible and effective as they ideally should be.
- Market is ready for cloud technology but awareness and skills are low 90% of the respondents thought the cloud services market was ready but there are a lot of misunderstandings about the technology. Some technical skills are seriously lacking.

- Government to be the champion by promoting and adopting cloud By adopting the cloud, the government would set pace for better uptake by the private sector. By providing services through the cloud, the government is likely to improve overall quality of delivery.

Proposed Strategy for Cloud Computing Utilization in Kenya

There is now sufficient evidence in literature and from the experience of businesses in many sectors that the adoption of Cloud Computing results in significant benefits. As part of the ideas being enunciated in this Innovation week, the authors believe that Kenya is well positioned to start exploring ways to adopt cloud computing for the benefit of the country. The proposed strategy would be to adopt an incremental approach for the uptake of the new technology. This will consider the current status and maturity of cloud computing uptake in Kenya.

Rightscale (2015) enunciates the idea of Cloud uptake by organizations based on a Cloud Maturity Model. The model segments organizations based on their levels of cloud adoption, and identifies four distinct stages of cloud maturity based on least to greatest experience as shown below.

- Cloud Watchers –organizations that are developing cloud strategies and plans but have not yet deployed applications into the cloud. Cloud watchers want to evaluate available cloud options and determine which applications to implement in the cloud.
- Cloud Beginners– are new to cloud computing and are working on proof-of-concepts or initial cloud projects. Cloud beginners want to gain experience with cloud in order to determine future projects.
- Cloud Explorers – these have multiple projects or applications already deployed in the cloud. Cloud Explorers are focused on improving and expanding their use of cloud resources.
- Cloud Focused – businesses that are heavily using cloud infrastructure and are looking to optimize cloud operations as well as cloud costs.

From the prior research work by Omwansa and Waema (2013), the strategy enunciated towards the adoption of Cloud Computing in Kenya includes inter-alia:

- Assessment of the cloud readiness of the country: to clearly understand the current situation at national level through an elaborate national study.
- Developing a national cloud strategy: focusing on issues like capacity building, architectures and implementation.
- Government as a champion of cloud services: by adopting use of the cloud to provide services, government would set pace for better uptake by the private sector.
- Enhance the relevant legal and regulatory frameworks: protection of cloud service users, addressing cyber security challenges, guaranteeing secure online payments, privacy and data security need to be clearly articulated.
- Develop the human resource capacity: technical skills, legal skills and management skills to ensure contracts are well formulated and managed need to be developed.

- Enhance the awareness of cloud technologies: through a multi-stakeholder approach, the technology needs to be demystified and accurate information sent to potential consumers.

Innovation Opportunities of Cloud Computing in Kenya

Making the case for the adoption of Cloud computing as an innovative technology for the Kenyan industry is clearly justifiable. There is evidence of recent developments within the industrial sector, educational institutions and the government engagement. Within the current trend and climate, anticipated sectors that would immediately benefit and provide the opportunity platform for Kenya include the following:

- Government institutions both at national and local levels
- Manufacturing industries particularly small to medium enterprises
- Construction companies
- Mobile Applications
- Education & Training
- Banking
- Healthcare
- Customer Relationship Management (CRM) applications
- Enterprise Resource Planning (ERP) applications

Cloud computing models for these sectors can include one or a combination of public, private, Hybrid and multi cloud models and frameworks.

Conclusion

Cloud computing as a rapidly emerging digital technology has been briefly reviewed in this paper along with discussions on how it is impacting the global business climate. This paper clearly argues that this emerging technology is needed in Kenya today for the desired innovation and economic development of the country. Prior work gives an indication of how cloud computing can be implemented and taken advantage of in the country in the various industrial, educational and governmental sectors in the country. Cloud computing as a next generation computing model is expected to undoubtedly change and impact software development for the future in the global economy. Kenya as well as other African nations keen to not remain observers, but engaging and possibly leap frogging in technological advancement at least in the ICT sector, would do well to get involved now with Cloud computing.

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