A Comparative Analysis of Pricing Models for Enterprise Cloud Platforms

Promise Mvelase, George Sibiya, Nomusa Dlodlo
Centre for High Perfomance Computing
CSIR Meraka Institute
Pretoria, South Africa
{pmvelase, gsibiya, ndlodlo}@csir.co.za

John Oladosu, Matthew Adigun
Centre of Excellence for Mobile e-Services,
Department of Computer Science,
University of Zululand
KwaDlangezwa 3886, South Africa
{johnoladosu, profmatthew} @gmail.com

***Abstract*— Research and commercial efforts are currently addressing challenges and providing solutions in cloud computing. Business models are emerging to address different use case scenarios of cloud computing. In this paper, we present the evaluation of a virtual enterprise (VE)-enabled cloud enterprise architecture for small medium and micro enterprises (SMMEs) against EC2 pricing model to prove that our pricing model is more suitable for small medium and micro enterprises (SMMEs). This model is based on the realization that it is not economically viable for SMMEs to acquire their own private cloud infrastructure or even subscribe to public cloud services as a single entity. In our VE-enabled cloud enterprise architecture for SMMEs, temporary co-operations are created to realize the value of a short term business opportunity that the partner SMMEs cannot (or can, but only to a lesser extent) capture on their own. The pricing model obtained from our proposed business model shows the benefits that are derived from using the VE cloud model over subscription to a public cloud as a single business enterprise. The pricing structure of our VE cloud model is up to 17.82 times economical compared to the equivalent Amazon EC2 instance type pricing model.**

Keywords*— *Cloud Computing, Service Computing, SMMEs, Virtual Enterprise

I. Introduction

Cloud computing is a computing paradigm in which every layer of computing from infrastructure to application is a service. It enables usage of computing hardware and hardware belonging to a 'third-party' thus lowering cost of ownership of computing and enabling mobile computing [1 – 7]. Adoption of cloud computing as a utility infrastructure lowers total cost of doing business for the Small Micro and Macro Enterprises (SMMEs). The SMMEs contribute to economic growth and promotion of equitable development. The employment potential of SMMEs at low capital cost has been the major advantage of the sector. Employment intensity of the SMMEs sector is much higher than that of the large enterprises. The SMMEs constitute over 90% of total enterprises in most of the economies and are credited with generating the highest rates of employment growth and account for a major share of industrial production and exports [8, 9].

Major constraints to the development of SMMEs in many developing countries are limited access to finance, technology, markets and management skills. Access to and awareness of business information is also a serious constraint to the development and growth of SMMEs in developing economies. Limited access to information resources to start, survive and grow is one of the challenges faced by SMMEs in enterprise development [10].

In the current e-business environment, individual enterprises, including SMMEs cannot survive on their own. It is crucial that SMMEs engage effectively with their partners and customers. These enterprises require a certain way of e-business interaction with their partners. The virtual enterprise (VE) business concept, also known as the networked enterprise, consists of distributed business functions and utilities, outsourced to partners that work with the firm to deliver the product to end customers. The VE model is one such business environment that can facilitate cloud computing for SMMEs. Emerging technologies, including cloud computing, have the potential to transform and automate the business processes of SMMEs and enable them to engage with trading partners and customers in global networks [11]. Our VE model of cloud utility infrastructure is an attempt to enable SMMEs to take advantage of cloud computing in a VE business model.

The network enterprise model is identical to the Grid-based Utility Infrastructure for SMMEs-enabled Technology (GUISET) project [12, 13]. GUISET is modelled to provide computing utility infrastructure for small and medium enterprises as well as the average rural dweller of African communities from a cooperative/networked enterprise viewpoint [12]. Cost is a key constraint for African users of technology, thus our business model of VE for cloud computing pays specific attention to cost of computing utility [2], [14]. Also, because a larger percentage of users of the proposed VE model use mobile devices, its design addressed challenges associated with generic cloud and mobile cloud [3], [4]. These are some of the ways in which the design of the proposed VE model is peculiar.

A good number of cloud computing solutions exist in commercial and research efforts, however, many issues are largely open to research. They include 'security, availability, scalability, interoperability, service level agreement, data integration, data governance, trust pyramid, user-centric privacy, transparency, political and legal issues, business service management' [15] among other issues [16 – 18].

Business service management is the main challenge addressed in this research.

This paper introduces the VE business model in Section 2. In section 3 it looks at the architecture of the VE model. Section 4 is the cost evaluation of VE pricing model and EC2 pricing model.

II. Business model of the proposed VE model

Fig. 1 is the conceptual view of the business model of our proposed VE-enabled cloud enterprise architecture for SMMEs. The business model is pay-as-you-use just like any other cloud infrastructure [1]. The goals of cloud computing, among others, are to lower total cost of ownership (TCO) and provide "business flexibility" for acquisition and use of computing resources either for business, governance, research, personal or any other use [1], [2], [7], [19]. This goal is more critical for the proposed VE model, because the target users are the small and medium enterprises in Africa. It is also intended for personal computing needs of the common African citizens in E-Health, Emergency response, E-learning, M-Commerce etc. Obviously, cost is a critical factor for these set of target users.

In achieving this goal, the proposed VE model is designed to use licensed open source infrastructures wherever possible without compromising the high agility, resilience, availability, reliability and scalability that a high performing computing infrastructure like cloud requires [20, 21]. This will ensure that services are provided to consumers at the most affordable cost possible at optimum quality. For instance given a situation in which SMMEs in rural settings cannot afford the services of a dedicated lawyer, human resource practitioner, accountant, etc. Since these are services that are required once-off as and when necessary the architecture proposes that these SMMEs get those services from a private cloud of service providers, which is a network of medium-size enterprises (SMMEs) participating in a VE-enabled cloud business structure. The private network is made up of the virtual enterprise setting (the business aspect) and the technology.

In order to explain the design criteria for this work, we considered the following scenario of the cloud enterprise architecture for SMMEs.

The KwaNongoma arts and crafts are set up of dissimilar groups of SMMEs. These SMMEs want to purchase services from the cloud service provider since it is a cheaper business model for enterprises who cannot afford purchasing ICT infrastructure necessary for the running of the business. SMMEs select services they need from the cloud service catalogue. After selecting services, the user places an order of the selected cloud services and sends the request to the cloud service provider. The request for is the cloud service order fulfilled by creating a virtual machine with the requested service applications. The user can now enjoy the benefits of applications sitting on the cloud without purchasing huge servers on a pay per use basis. On completion of the session, the SMME signs out, this means that the virtual machine provided to the SMME is destroyed immediately. The virtual machines run task as long as required and then shut down when the task is complete. The implementation details, such as whether a virtual machine is actually shut down or allocated to another job, is cloud specific. Logically, it appears to the cloud users that virtual machines are no longer allocated to them. In the cloud, physical servers become shared resources without the drawbacks such as:

- Incompatibility with the operating system or applications on the server
- Conflicts in the scheduling of workloads
- Difficulties allocating costs to owners of the jobs running on the server
- Irresolvable violations of security policies regarding access controls and data protection policies

These problems can occur when trying to share a single server across application or organizational boundaries let alone hundreds or thousands of servers that may be required for a compute-intensive job. The problems are avoided with cloud computing because of three characteristics of the technology, which include: rapid allocation of servers, standardized hardware and persistent clod storage, among others.

Together, these characteristics provide the benefits of sole use servers with the efficiencies of shared resources. The VE-enabled cloud enterprise structure and operation consists of the medium-size enterprises in VE alliance and all its business process utility and IT clouds computing services and their providers. The cloud enterprise architecture for medium-size enterprises participating in a VE setting is made up of the business context, business services, business processes and IT services (Fig. 1). The business context layer is responsible for the definition of business goals, strategies, structure, policies and performance metrics and indicators. The main users of services at this level are business owners and executives who are hardly ever IT experts. The main functions of a business such as human resources, payroll, accounting, etc. are defined as coarse-grained services, called "business services" in the business services layers. Users such as business or IT architects may define or select the required business services from out-of-box business services blueprints. The IT services layer represents the services that are obtainable in the cloud. Finally, the business processes layer is the illustration of selection, design, integration and composition of IT services in the form of workflows that fulfil the needs of outlined business services. In this architecture, the medium-size enterprises in the virtual setting share business context, business services, and business processes to improve competitive advantage, and quickly respond to market opportunities. Hence the VE enabled cloud enterprise architecture comes down to a value system, which involves a number of companies' value chain that is collaborating to deliver the end product to the customer. The aspect of value chain is not covered in this paper.

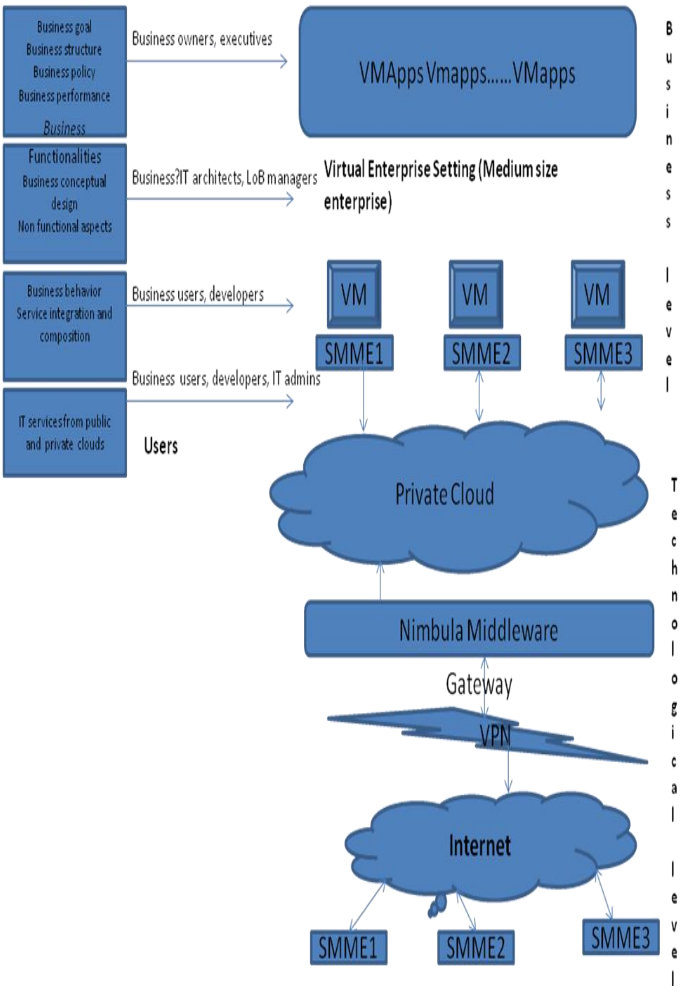

Fig. 1. Business model of VE-enabled Cloud Enterprise Architecture for SMMEs

Rather than relying on established organizations (e.g., Google cloud, Amazon EC), SMMEs in the VE setting form their own private cloud, where they collaborate their existing IT infrastructure, skills, processes, organizational models and core-competencies. There should be in place, strategies on sharing competencies. We should remember that the SMMEs also compete with one another; hence they cannot expose all their competencies. The reason that they do not host their IT services on a third party cloud service provider is because of the advantages that come from the collaboration of resources within the VE. Hosting their entire IT infrastructure to the cloud service provider could cost them even more, and the resources can be underutilized. Assuming that the SMMEs in the alliance understand each other better, there can be no one organisation dominating. In case of insufficient resources, the SMMEs can then tap into external public cloud. This comes down to a hybrid deployment model. Therefore, cloud computing capabilities provide the VE alliance with agility, flexibility, and adaptability required due to its' highly flexible ICT infrastructure.

III. Architecture of The proposed VE model

A. *Modifications to Generic Cloud Architecture*

Modifications of the generic cloud computing architecture to reflect the specific application of the cloud infrastructure exist in literature. An example is the work of Alvaro and Barros in [22] where they proposed a cloud computing architecture for music composition. The proposed VE model in this work is design for SMMEs and personal computing needs in M-Commerce, E-Health, Emergency response and E-learning in Africa. The high level architecture of its technological level as shown in fig. 2 is thus design around these specific needs. The technological level specially focuses on the Software as a Service (SaaS) layer of the cloud architecture. Participation in the collaborative e-infrastructure is open to any interested organization or individual. The software platform in the proposed VE model is composed of middleware and applications services developed according to GUISET project ([12, 13]) to meet the needs of target users.

Nimbula Software for building private and public clouds is one of the middleware for this proposed cloud architecture. Nimbula was used in prototyping the model. The middleware has SQLite for database management, the information manager for resource planning, the virtual machine manager to provide the cloud owners with the virtual machine power (PaaS, IaaS). The virtual manager manages one or more virtual machines. Each virtual machine runs particular software. The SaaS subscribers use these applications. In this case the subscribers are SMMEs from KwaNongoma. These virtual machines run off the cloud infrastructure. The network manager manages the communications within the cloud architecture. Nimbula hides the complexity of the whole cloud system but giving the impression of it as one physical resource.

As shown in fig. 2, users and third-party developers can interact with the proposed VE-enabled cloud model software layer. End-users can utilize the proposed VE model application services and applets on generic internet or mobile internet. Third-party may use the proposed VE model applets and middleware infrastructure to develop applications. All The proposed VE model applications, services applets and third-party applications interact with the proposed VE model middleware infrastructure that is embedded the SaaS layer. The proposed VE model middleware will provides a secure identity management, selective authentication and authorization. It is also being designed with robust end-user perspective and agile, scalable and interoperable architecture

B. *Resource management in the proposed VE model*

One of the key features of resource management in GUIEST is energy-awareness [23, 24]. Power constrain is a serious concern for technology implementation and usage in Africa. Another aspect of resource management concern is flexible information processing [1], [25 – 29]. This will include dynamic service evolution to meet constantly changing service consumers' needs.

C. *Programming, application and services composition model of the proposed VE model*

A simple programming for cloud computing platforms is proposed in [30]. In [31] a workflow-oriented cloud computing programming model was developed. The applications developed on GUISE-Cloud are service oriented applications [32]. As a software infrastructure, therefore a major concern in the application and services model is interoperability of

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application services among heterogeneous platforms. Quality of services (QoS) is also a prime concern as the services are user-centric. Applications are developed as web services that are dynamically re-versioned to meet constant changes in users demand. Applications services are also multi-tier [33]. The application and services composition model of the proposed VE model must therefore, address challenges associated with these features as well as related challenges. This is done by addressing the end-user perspective with the goal of providing simplicity of access to and use of services. The architectural perspective of the proposed VE model is a large evolutionary system dealing with ontologies and metadata; adaptation models and context-awareness and reasoning under uncertainty and increasing complexity. The infrastructure is made up of interconnected nodes of any type providing resources ranging from computational to knowledge resources [34].

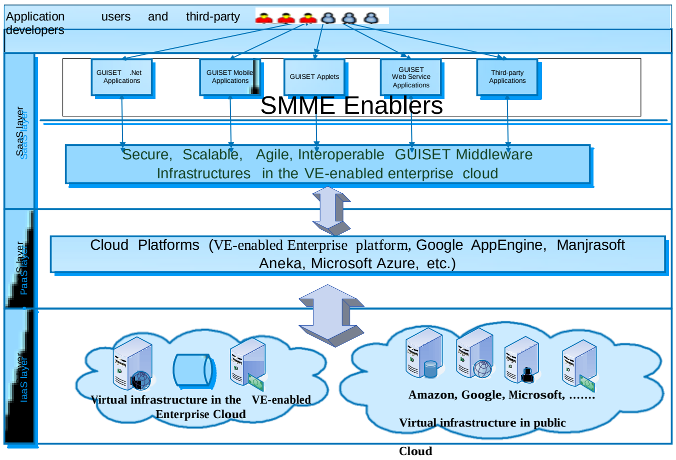

Fig. 2. High level architecture of the proposed VE model

D. *Innovative security in the proposed VE model*

Security issues in cloud computing is still an open research topic just as many other cloud related issues [15 – 18]. The proposed VE model addressed security challenge in cloud computing by finding the appropriate identity management model that supports single-sign on, selective authentication and authorization of infrastructure entities and agents [34].

IV. DISCUSSION OF EXPERIMENT

A. *Basic assumptions of the experimental set-up*

For our experimental set-up, the following assumptions were made:

- The cloud infrastructure is running; services are deployed and service consumers request services.
- Services are consumed by users on a pay-per-use basis, hence maintenance, scalability and infrastructure is third party's concern.
- VMs are created and customised as per users' request and requirements.

B. *Description of the experimental set-up*

The scenario described in Section II is considered in the experimental set-up of our model. The end-consumer requirements, infrastructure capabilities and cloud service catalogue that operate in fulfilling a particular request were considered. In order to fulfil a request, end-user requirements are the deciding factor. The cloud is scaled according to the number of users [35].

C. *Experimental setup environment*

For simulation and evaluation of our model/concept we used Nimbula Director (Nimbula.com). "Nimbula Director is an automated cloud management system which allows customers to easily repurpose their existing infrastructure and build a private computing cloud in the safety of their own data centre." This cloud deployment model is appropriate for our architecture since medium-sized enterprises will form a cloud using their existing infrastructure to become cloud SPs for very small enterprises. To install a Nimbula Director site, we needed to set up a minimum of three machines and a seed node machine with a DVD drive.

Nimbula Director User interface is divided into a top pane and a bottom pane, which allows one to create, modify and destroy objects. The top pane is where main tasks are performed. There are five main functions:

- User management creates and manages groups and their permissions.
- Image list contains a persistence list of machine images that can be used to keep track of different versions of a machine image. A machine image is a VM template that can be launched into a running machine instance.
- Virtual network allows one to create and manage VEthernets and VDHCP servers. VEs are virtual layer 2 networks that provide isolation and the implementation of VLANs. VDTP servers can be created for each VEthernet to dynamically assign IP addresses to VM instances running in that VEthernet.
- Network security list lets one configure a built-in distributed firewall for isolating instances and regulating traffic in and out of the cloud that is dynamically configured and independent of the underlying network.
- Instance management allow one to view and launch machine images into running machine instances.

V. COST SAVING EVALUATION

In evaluating the performance of our model, we have evaluated our model according to utility evaluation of an SMME to see if the utility requirements are fulfilled. Cost saving is the basic requirement of our VE-enabled cloud model. We compared our model with the Amazon Elastic Compute Cloud (EC2) pricing. We used Standard on Demand EC2 cost model in evaluating our model. Cloud providers provide four basic cost models 1 – 4 as stated in [36]:

- Cost model for data storage (*size(total)*$\times t_{sub}\times$*cost(storage) where* t_{sub} *is the subscription time*),
- Cost model for computational machine (cost(machine)),
- Cost model for data transfer into the cloud (*cost(trans f* er_{in})), and
- Cost model for data transfer out to the cloud (*cost(trans f* er_{out}))

Amazon EC2 has a number of estimated pricing models available on their website [37]. The Standard on Demand model of EC2 (Table 1) is the pricing model equivalent to the cloud infrastructure in this work. In the Standard on Demand model, the user pays for compute capacity by the hour with no long-term commitments or upfront payments. This is equivalent to our model. Our pricing starts at $300 per year per processor core - including support and maintenance. Our model is based on Nimbula Director, where software price is only based on number of physical processor cores on which it runs (i.e. the bigger the physical infrastructure, the more you pay because you have more cores). This is the same criteria for similar EC2 pricing models. However, for the configuration and proposed model in this research, the Standard on Demand pricing model is the ideal comparable model. The comparison of pricing model of the proposed VE-enabled Cloud Enterprise Architecture for SMMEs is therefore based on the EC2 Standard on Demand pricing model. This does not suggest rigidity in the pricing model of the proposed architecture, but the analysis is done to show the cost saving capability of the model.

Amazon EC2 provides the flexibility to choose from a number of different instance types to meet flexible computing needs (see Table 1). Each instance provides a predictable amount of dedicated compute capacity and is charged per instance-hour consumed. The standard instance type has memory-to-CPU ratios suitable for most general-purpose applications.

To illustrate the cost estimation, we examined the case of VE-Enabled Cloud Enterprise Architecture using the Nimbula Director Instance type in Table 2 and the amazon instance type in Table 3. Table 2 and Table 3 show the estimated costs based on instance type obtained in our private cloud and Amazon EC2 respectively. Table 3 shows a Linux-based double extra-large instance in Amazon EC2.

The Nimbula configuration equivalent to the highest EC2 standard instance was used in our prototype. This is shown in Table 2. The configuration we used is equivalent to a double extra-large EC2 machine instance-type. The price of the EC2 instant type configuration is 17.82 times more expensive than the equivalent VE-cloud configuration in the proposed architecture. This is a huge saving for the SMMEs who are the target users of the proposed architecture.

TABLE I. THE EC2 STANDARD INSTANCE TYPES

Standard On-Demand Instances	**Linux/Unix Usage**	**Windows Usage**
Small (Default)	$0.080 per Hour	$0.115 per hour
Medium	$0.160 per Hour	$0.230 per Hour
Large	$0.320 per Hour	$0.460 per Hour
Extra Large	$0.640 per Hour	$0.920 per Hour

TABLE II. NIMBULA DIRECTOR INSTANCE TYPE USED FOR OUR VE-ENABLED CLOUD

Instance	Virtual Cores (VC)	Memory	Instance Store Volumes	Platform	Platform	Price
Standard On-Demand instances	4(4*4 VC)=16 cores	8GB (3*8RAM) & 4GB (1*4RAM) = 32GB	250GB (3*250HD) & 500GB (1*500GB) = 1250GB	64 bit	High	$0.034 per Hour

TABLE III.

Instance	**Type**	**Name**	**EC2 Compute Units**	**Virtual Cores**	**Memory**	**Instance store Volumes**	**Platform**	**I/O**	**Price**
Standard On-Demand Instances	High-Memory Double	M2.2* large	13	64 bit	64- bit	High	64 bit	High	$0.60 per hour

VI. CONCLUSION AND FUTURE RESEARCH

In this paper, we presented the architectural design of a cloud infrastructure targeted at providing service computing to SMMEs in economically disadvantaged business context. Results from this work show that our proposed VE-enable cloud business model resulted into a tremendous cost saving for SMMEs compared with utilizing public cloud infrastructure. The various perspectives presented are specific in focus but global in applicability. For instance the business model presented can be applied to developing economy in any part of the world. The research issues highlighted such as security model, software and application model and resource management is informative for researchers, designers and managers of cloud and service computing.

Our on-going research is intended to build an evolutionary system that demonstrates dynamic adaptation and personalization of functionality so that consumers and providers of services can add and withdraw business resources without needing to redesign the system. Deploying the cloud confirmed the suitability of the proposed architecture for SMMEs. However, the simulation is only an approximation of reality; therefore another primary goal of future work is to observe the behaviour of the proposed approach in a real-life environment. We would add an element of mobile cloud to allow disadvantaged SMMEs the opportunity to access cloud services since, for the most part disadvantaged SMMEs do not possess computers but use mobile devices.

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