Depiction of Experimental Findings for a Cloud Enterprise Architecture

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***Abstract*—Research and commercial efforts are currently addressing challenges and providing solutions in cloud computing. Business models are emerging to address different use scenarios of cloud computing. In this paper, we present a virtual enterprise (VE) model of cloud computing to enable Small, Medium and Micro Enterprises (SMMEs) to respond quickly to customers' demands and market opportunities, therefore Enabling Small, Medium, and Micro Enterprises through Cloud utility Infrastructure: gaining agility and flexibility needed for business success. In our virtual enterprise model, 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. 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. The pricing model obtained from our proposed business model shows the benefits that are derived from using the VE cloud model over subscription to public cloud as a single business enterprise. The pricing structure of our VE cloud model is up to 17.82 times economical compared with 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], [2], [3], [4], [5], [6], [7]. Adoption of cloud computing as a utility infrastructure lowers total cost of doing business for the Small, Micro and Medium 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 [31, 32, 50].

What appear to be the 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 the main 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 [33].

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 [34]. Our VE model of cloud utility infrastructure is attempts to enable SMMEs 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) ([8], [9]) project. 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 [8]. Cost is a key constraint for African users of technology, thus our business model of VE for cloud computing addressed pays specific attention to cost of computing utility [2], [10]. Also, because a larger percentage of users of the proposed VE model use mobile devices its design addressed challenges associated with generic cloud

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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' [11] among others [12], [13], [14]. Business service management is the main challenge addressed in this research.

II. ADVANTAGES OF CLOUD COMPUTING

The major benefits of cloud computing must be understood by architects in order to provide a future-state architecture – an architecture that considers cloud computing potential. Many major benefits emerge when cloud computing technology starts to take hold:

- Separation and decoupling of business functions from the framework required to run it.
- Adaptability to select various vendors that offer scalable and reliable business services, development environments and a framework that can be leveraged out of the box. This is charged on the basis of metering with no permanent contracts.
- Adaptable nature of the framework in order to speedily allocate and de-allocate extremely scalable assets to business services on the basis of demand.

The cloud ensures that the costs of attaining, delivering and managing computing power are cut down by allowing agencies to buy only the required computing services, rather than investing in expensive and complex IT infrastructures. The development costs can be borne by the agencies. In addition to this, agencies can cut down the costs of maintaining and testing existing and new systems. Organizations can also drive down the costs of administration and licensing of software as they can use online service with the help of the cloud.

Within a network access device, the cloud guarantees to provide users access to high-powered computing and storage resources. By providing these services, cloud computing technology helps to facilitate telework initiatives. In addition to this, it also helps to strengthen the continuity of organizational operations. The cloud is an on-going computing resource that helps users to get used to the consumption of resources to satisfy their needs. Significantly scalable, cloud computing technology facilitates its infrastructure to expand in an expedient and efficient manner, without the need for major capital investments. Since the resources are required and ended within a very short time interval, capacity should be added. Therefore enterprises can avoid the expense, latency and risk of buying software and hardware that absorbs the data space center, and cuts down the conventional time needed for scaling up the application to maintain a job.

Cloud computing facilitates enterprises to easily shift direction, remove capacity and therefore expenses as required [35]. Cloud computing can provide the advantage of resource maximization. This technology significantly eases the load on already thin IT resources which are important for an enterprise lacking IT professionals.
The advantage of collaboration is also provided by cloud computing. The cloud provides an atmosphere in which users are allowed to develop the software-based services that improve collaboration and promote greater sharing of information, not just inside the organization but also among other private and government departments [36].
Cloud computing also gives the benefit of customization. Cloud computing technology is a platform with extraordinary potential for customizing and creating applications in order to address a variety of challenges and tasks. Its agility means that particular processes can be altered easily in order to meet the varying agency needs, as the processes are mainly changeable by making an organizational change, and not by forcing redevelopment of the back-end systems.

A. Research goal and objectives

The main goal and objectives for this research are:

1) Research goal

The goal of this study is to develop a VE-enabled cloud enterprise architecture that will enable SMMEs to participate in a virtual operating environment.

2) Research objectives

In order to achieve the main goal of this research, we employ the following objectives:

- To identify issues affecting SMMEs
- To identify existing VE models, that can be adapted to meet the acute infrastructural deficiency of SMMEs.
- To model a VE-driven cloud computing architecture custom-made or custom-tested for SMMEs and deploying a cloud for evaluation purposes.

a) Research Objective 1

Existing VE technology models were reviewed, which helped us to identify useful VE models that can be adapted to meet SMMEs' needs at both business and IT levels at optimized cost.

b) Research Objective 2

This was achieved by identifying relevant literature on existing VE architectures and cloud computing enterprise architectures to enable us to design VE-driven cloud enterprise architecture. A linkage between VE and cloud computing enterprise architecture was discovered. The transformation of cloud enterprise from virtual enterprise is facilitated by means of the Internet, SOA, web services, B2B and BPMS technologies. A conceptual analysis of existing VE architectures and cloud enterprise architectures relating to our study was conducted.

c) Research Objective 3

An experimental set-up of a VE-driven cloud enterprise architecture customized for SMMEs was deployed and evaluated.

3) Resaerch Protocol

a) Objective 1

To identify issues affecting SMME productivity

- A case study conducted in KwaNongoma on issues hindering SMMEs' productivity and growth was useful in assessing the above issue. Additional related literature was reviewed.

b) Objective 2

To identify existing VE models that can be adapted to meet the infrastructural needs of SMMEs

- The literature on VE models was useful as we were able to determine how to scale down to an advantageous model that could be adopted for our proposed architecture.
- The existing literature on VE architectures was also reviewed to help us find VE architecture components that relate to cloud enterprise architecture to enable us to design and deploy our customised cloud architecture for SMMEs.
- A conceptual analysis was done of existing VE architectures and cloud enterprise architectures relating to our study.

c) Objective 3

To model a VE-driven cloud computing architecture custom made or custom tested for SMMEs and deploy a cloud for evaluation purposes

- We designed a VE-enabled cloud computing architecture for SMMEs by combining the capabilities of both existing VE architectures and cloud enterprise architecture.
- Keeping in mind the financial state and the needs of SMMEs, we evaluated the cloud computing deployment models to choose a suitable one for SMMEs.
- We performed system design to be able to define the architecture, components, modules, interfaces and data for our prototype that satisfied specified requirements.
- We implemented and evaluated an experimental set-up of a VE-driven cloud computing architecture for SMMEs.

III. RESEARCH METHODOLOGY

A. Data Collection

A background study on rural communities and e-government models was conducted. This study spoke into a questionnaire to gather the information from both the community and SMMEs on their needs. The questionnaire was administered to three communities in KwaNongoma rural. These were KwaKhangela, KwaMeme and KwaSomkhele. Respondents were asked to give their opinions on how far their needs were being met and comment on how the current situation could be improved. The survey covered several issues related to health, energy, water, education, IT usage in the running of small businesses and transport, to name but a few. The questionnaires were arranged in sections to find out:

- The government services that were available in the deep rural area of KwaNongoma.
- How the community viewed these services.
- The levels of literacy and ICT literacy in the community.

B. Conceptual analysis

1) Data Analysis

The data were analysed according to the research questions parallel with prototyping. The findings of the survey showed that a higher percentage of SMMEs do not use ICTs in running their businesses. This is due to the lack of knowledge and affordability of such resources.

The conceptual analysis was done to find existing virtual enterprise and cloud enterprise architectures that can be used to develop a prototype of VE-driven cloud computing architecture custom made or custom tested for SMMEs.

2) Primary and Secondary Methods

The main research method is conceptual design, where a VE-enabled cloud enterprise architecture custom made for SMMEs is designed to enable SMMEs to share IT resources, distribute responsibilities and capabilities hence become responsive to market changes and customer demand. The proposed architecture should provide SMMEs with the flexibility, agility and adaptability required for them to be able to cope with the rapidly changing market environment. We carried out a literature review and conceptual analysis in designing our architecture.

The secondary methods were: a literature review, and prototype. The literature review provided a theoretical background to cloud computing, virtual enterprise and other underlying technologies that make cloud computing possible.

A software prototype was used in evaluating our proposed cloud pricing model against the equivalent amazon EC2 instance type.

IV. BUSINESS MODEL OF THE PROPOSED VE MODEL

Figure 1 is the conceptual view of the business model of our proposed VE-enabled cloud. 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], [15], [7]. 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 [16], [17]. This will ensure that services are provided to consumers at the most affordable cost possible at optimum quality. We have a situation in which small 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 virtual enterprise (VE) enabled cloud business structure. The private network is made up of the virtual enterprise setting which in itself is the business aspect and the technology.

A 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. 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.

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 underutilized. Assuming that the SMMEs in the alliance understand each other better, there can be no one MSE 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.

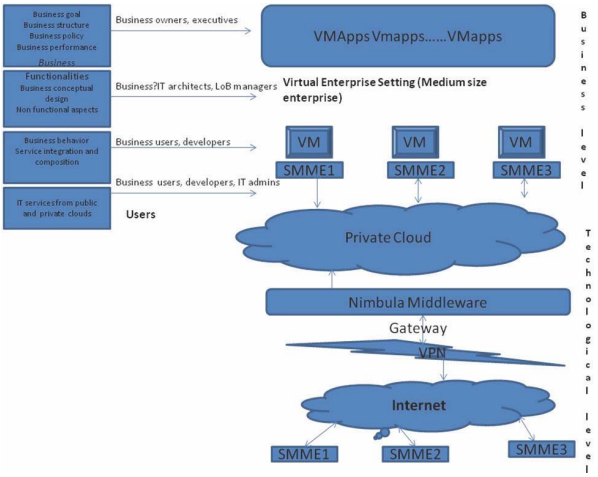

Figure 1: Business model of VE-enabled Cloud Enterprise Architecture for SMMEs

V. VE-ENABLED CLOUD ENTERPRISE PROTOTYPE DESIGN

The VE enabled cloud enterprise architecture for SMMEs prototype shown in figure 1 illustrates the basic functions of our customized architecture. We now present the prototype design of our model with the aspect of the architecture use case scenario described in this paper. The prototype design supporting the SMMEs needs is explained using UML design diagrams.

A. Use case scenario

The use case scenario is illustrated in Figure 2. The technical management team in this VE model operates as an independent business entity from the collaborating SMMEs. This independent technical operator is regarded as cloud service provider in this case. The cloud service provider customizes the images from the desktop before uploading it to the cloud. For Example, we assume that a cloud service provider would have done his task, of finding out about the users that he will be providing services to. Therefore the images are customised according to individual user groups. There can be a windows image which is loaded with HR, inventory, ERP, CRM, legal services, accounting applications. To cater for users who might not need all these services, other images may have one or two of these services. In this case we

are avoiding a situation where a user might own accessing a virtual machine with services that he does not need, which will make the bill to be unnecessarily high.

The customer requests IT services from the cloud, the system machine image provides a hard disk snapshot used to launch a virtual machine (VM) instance. The VM instance has RAM, number of CPUs and the network interface attached. Depending on individual's customers' requirements the VM instance may contain SaaS (HR system, inventory management, legal services, etc) and a specified RAM and number of CPUs. The cloud service provider creates a customer's account and instantiate a VM instance dedicated to that customer. The requester logs in to access the VM instance, as and when needed. The VM instance appears as if it runs on the user's machine when in actual sense it is seated in the cloud server because of the abstraction that the cloud provides. The customer only uses the cloud services when needed and billed according to usage (i.e Utility business model). Customers are recognised by the IP addresses assigned to their VM instances. A customer is billed when the VM instance is on the running mode. For a customer to completely end the session the VM instance must be shut down. Logging off keeps the VM instance running and the customer is billed even though it is not using the cloud services. The cloud automatically scales up and down depending to the users' needs. Now the customer can enjoy the benefits of the cloud by having access to services that he could not afford had it not been for the cloud business model. Once the session is closed by the customer, the administrator sends the bill to the customer.

1) Customer

In this case the customer is a small SMME user who cannot afford to purchase ICT infrastructure due to financial constraints. The customer utilises the services of the cloud on a pay per use basis which is cheaper than buying the ICT infrastructure. The cloud service provider does not grant the customer permission to create an instance, instances are created by the cloud SP. Utilizing the services of the cloud enables small SMME to become agile, grow in their businesses, and compete with advanced SMMEs.

2) Administrator

The administrator is an organization or department which uses the Nimbula director who will be responsible for the cost incurred from using the system. In actual sense, this is the cloud SP site. From the definition found in Nimbula director this is the customer, which has been explained above.

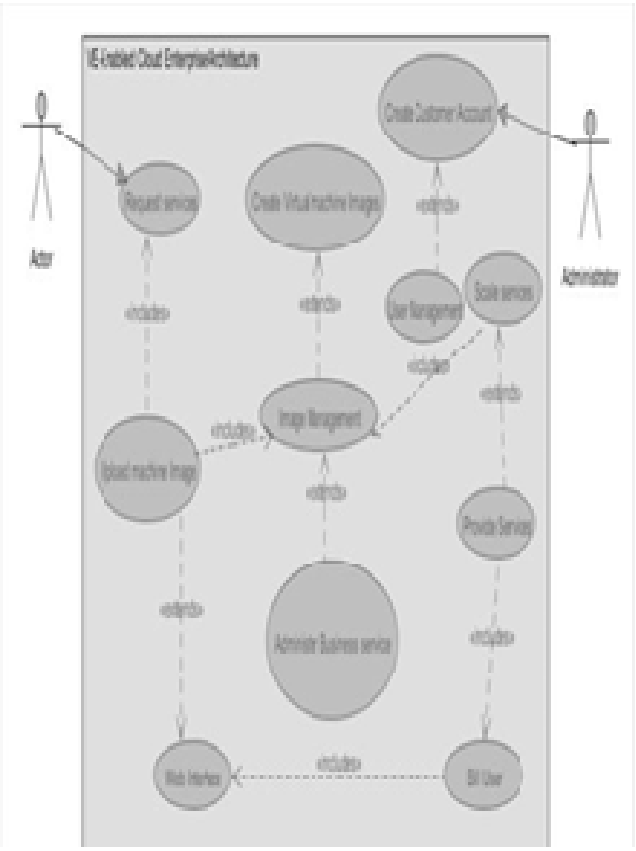

Figure 2: Use Case Scenario of VE-enabled Cloud Enterprise Architecture for SMMEs

B. Workflows of stepwise activities

Figure 3 shows the activity diagram of our VE-enabled cloud enterprise architecture. The flow of events starts by service request action initiated by the customer, where the customer logs into the system. The user management object authenticates the user; this is where a decision has to be made. If the user is a registered customer, the request is attended to. At this stage the request is fulfilled by creating the VM instance. The image management object uploads VM instance else the cloud server is scaled to cater for the request. The VM instance containing application requested by the user now can be provided to the requestor of services. It then uploads to the desktop of the requestor through a web interface. It must be noted that for services to be accessed from the cloud, the customer must have internet access, therefore any device with internet connectivity will do. When the requestor finishes utilizing the cloud services, the administrator bills the requestor per utilised services. The requester closes the session by paying for the utilised services.

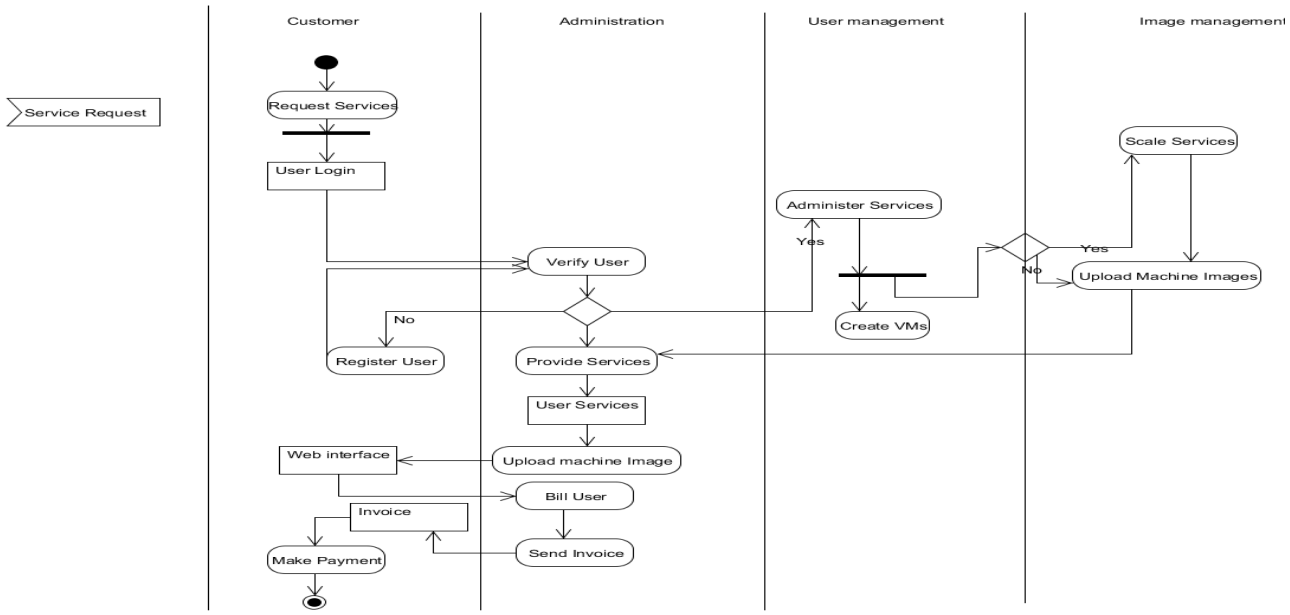

Figure 3: Activity Diagram of VE-enabled Cloud Enterprise Architecture for SMMEs

C. *Resource management in the proposed VE model*

One of the key features of resource management in GUIEST is energy-awareness [19], [20]. Power constrain is a serious concern for technology implementation and usage in Africa. Another aspect of resource management concern is flexible information processing [1], [21], [22], [23], [24], [25]. This will include dynamic service evolution to meet constantly changing service consumers' needs.

VI. 9.1 PROGRAMMING, APPLICATION AND SERVICES COMPOSITION MODEL OF THE PROPOSED VE MODEL

A simple programming for cloud computing platforms is proposed in [26]. In [27] a workflow-oriented cloud computing programming model was developed. The applications developed on GUISET-Cloud are service oriented applications [28]. As a software infrastructure, therefore a major concern in the application and services model is interoperability of 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 [29]. 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 [30].

B. *Model prototyping*

In this section we present simulated prototype of the proposed model. The cloud deployment is illustrated in terms of automation, identity, permissions and delegation, openness and choice.

1) *Basic assumption of the simulation*

In developing our simulation, the following assumptions are considered, bearing in mind the duration of the project.

- 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, infrastructure is of third party's concern
- VM are created and customized per users' request and requirements

A. *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 [12], [13], [14], [11]. 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 authorisation of infrastructure entities and agents [30].

2) *Description of the simulation*

The scenario described in chapter four is considered in simulating our model. 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.

3) Simulation environment

The simulation of our model was done by installing Nimbula Director. "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 the medium sized enterprises will be forming a cloud using their existing infrastructure to become cloud SPs for very small enterprises. To install a Nimbula director site, we needed a minimum of 3 machines setup, and a seed node machine with a DVD. The machines comprising the Nimbula Director cluster(s) need to comply with the following hardware and software requirements, therefore the machines we used meet the standard.

Nimbula director UI is divided to the top pain and the bottom pain, this allows you to create, modify and destroy objects.

The five main tasks at the top pain perform the following:

- User management create and manage groups and their permission
- Image list contains a persistence list of machine images that could be used to keep track of different versions of a machine image.
- A machine image is a VM template that you can launch into a running machine instance
- Virtual network allows you to create and manage VEthernets and VDHCP servers. VE are virtual layer 2 networks that provide isolation and in the implement of using VLANs
- VDTP servers can be created for each VEthernet to dynamically assign IP addresses to VM instances running in that Vethernet.
- Network security list let you 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 you to view and launch machine images into running machine instances.

A running VM instance created by the SMME cloud administrator was used for our demonstration. The VM instance is created using quick launch. The VM instance is created via instance management task, here an instance can be launched and viewed. Instances are customizable according to user requirements. The administrator verifies that the new VM instance has been launched and is running. The Web interface displays details like the image list, state, placement requirements, etc. for the new VM instance. An IP address to use to connect to the VM instance is also provided (i.e. VM: 172.18.1.18). Before creating a VM instance the SMME administrator creates the user SMME under the SMME customer.

VII. 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. EC2 has a number of pricing models (Amazon.com http://aws.amazon.com/ec2/pricing/). The Standard on Demand model 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. Our pricing starts at $300 per year per processor core - including support and maintenance. This is equivalent to our model. 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.

Cloud providers provide four basic cost models 1 – 4 as stated in [36]:

- Cost model for data storage (size(total)×tsub×cost(storage) where tsub is the subscription time),
- Cost model for computational machine (cost(machine)),
- Cost model for data transfer into the cloud (cost(trans f erin)), and
- Cost model for data transfer out to the cloud (cost(trans f erout))

Amazon EC2 provides the flexibility to choose from a number of different instance types to meet flexible computing needs (see TABLE I.). 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.

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

The Nimbula configuration equivalent to the highest EC2 standard instance was used in our prototype. This is shown in TABLE II

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

Instance	Virtual Cores	Memory	Instance Store Volumes	Platform	Platform	Price
Standard On-Demand Instances	4 (4x 4 virtual cores)= 16 cores	8 GB (3 x 8 RAM) & 4 GB (1 x 4 RAM)= 32GB	250 GiB (3 x 250 HD) & 500 GiB (1 x 500 GiB)= 1250 GiB	64-bit	High	$0.034 per hour

To illustrate the cost estimation, we examined the case of VE-Enabled Cloud Enterprise Architecture using the Nimbula Director Instance type in Table 3 and the amazon instance type in Table 4. TABLE III and Table 4 show the estimated costs based on instance type obtained in our private cloud and Amazon EC2 respectively. TABLE III shows a Linux-based saving for the SMMEs who are the target users of the proposed architecture. double extra-large instance in Amazon EC2. 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

TABLE III. AMAZON EC2 INSTANCE TYPE WITH HIGH-MEMORY DOUBLE EXTRA LARGE

Instance	Type	Name	EC2 Compute units (ECU)	Virtual cores	Memory	Instance store volumes	Plat-form	I/O	Price
Standard on-demand instances	High-memory double	M2.2x large	13	4 (with 3.25 ECUs each)	34.2 GiB	840 GiB (1 x 840 GiB)	64-bit	High	$0.640 per hour

VIII. 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. 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 personalisation of functionality so that consumer and provider of services can add and withdraw business resources without needing to redesign the system. In this description, we presented a high-level view of the architecture. Decomposition of the building blocks is assigned to specific research topics for implementation and prototyping as a proof of concept.

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