An Architecture based on SOA and Virtual Enterprise principles: OpenNebula for Cloud Deployment

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Today enterprises have to survive in a dynamically changing business environment. Cloud computing presents a new business model where the Information Technology services supporting the business are provided by partners rather than in-house. The idea of cloud computing is on providing information technology resources over the Internet as-a-service to its consumers on demand. A research study conducted in the rural district of KwaNongoma, Zululand in South Africa proved that small, medium and micro enterprises (SMMEs) did not grow in their businesses due to limited fund and they usually could not afford to purchase information communication technology (ICT) infrastructure. For the first time, cloud computing offers SMMEs, the ability to use the most advanced business applications on an enterprise-class infrastructure without having to hire an IT team, build a computer room full of servers, and worry about patching, upgrading and maintenance. SMMEs in emerging markets are typically unburdened by established legacy infrastructures, thus reducing the complexity of deploying cloud solutions. We envision a cloud-based system built on service oriented architecture (SOA) principles and virtual enterprise (VE) principles as a solution to enhancing SMME competency. SOA is an approach to designing, implementing, and deploying information systems such that the system is created from components implementing discrete business functions. These components called "services" can be distributed across geography, across enterprise, and can be reconfigured into new business processes as needed. SOA and cloud computing enhance agility and cost effectiveness of an enterprise. The focus of this paper is on illustrating the importance of SOA and VE as an enabled framework of technology when building the cloud. The VE on the other hand is based on distributed functions and utilities' outsourced to partners that work together in a firm to deliver products to end customers. The cloud is to be deployed on an Open Nebula platform. Whilst this subscription or rent based model appeals to enterprises of all sizes; the SMMEs stand to benefit the most from this paradigm shift. With no start-up capital required, the SMMEs can quickly develop their computing capacity. However, organisations must realise that the best cloud solution is one that is customised and optimised. After all, one size does not fit all.

Keywords: Cloud computing, Virtual enterprise, Service-oriented-architecture, OpenNebula, Agility, SMMEs

1 INTRODUCTION

Cloud computing has created a big buzz today within IT circles and is being positioned as the next wave of computing. The technology behind cloud computing is anything but revolutionary; the off-site availability of hardware is not a new development. What makes cloud computing more convincing than similar previous offerings is part demand and part technology. On the demand side, more and more enterprises are considering the cloud as a deployment option because the costs of running their own data centre are escalating rapidly. But improvements in the technology, particularly in virtualization, distributed computing, and IT management, are what marry the opportunity to the demand. The decoupling of “server side” software from hardware and the flexibility, dynamics, and automation with which software is run is what led naturally to a model referred to today as cloud computing.

The term cloud computing borrows much from the utility and grid technologies that preceded it. Cloud computing describes the availability of off-premise services, traditionally pictured as a cloud in architectural diagrams, hence the name which themselves may be composed of a variety of hardware and software services. These cloud services may be subsequently re-combined as either a complementary resource, for backup or disaster recovery scenarios as an example, or used as a standalone platform. Cloud computing is characterized principally by its enablement of on demand computing. Even hardware resources such as servers or storage may be purchased in incremental fashion, and billed according to usage (Mcpherson 2009). It is a best choice when there is an IT need to increase capacity or add capabilities without investing in new infrastructure, training new personnel, or licensing new software (Ranganaathan 2011). It encompasses any subscription-based or pay-per-use service that increases the efficiency of the existing service. The three pillars of cloud computing are stated to be Software-as-a-Service (SaaS): where the application is run off the cloud; Platform-as-a-Service (PaaS): where an application is built on a cloud-based operating system; and Infrastructure-as-a-Service (IaaS): where customers can remotely use the infrastructure of the service provider, its huge data centers with hardware, software, networking, etc. to run key applications. In each of the cases, the cloud makes available services that customers pay for, based on usage.

Companies or individuals engaging in cloud computing do not own the physical infrastructure hosting the software platform in question. Instead, they avoid capital expenditure by renting usage from a third-party provider, except for the case of 'private cloud'. They consume resources as a service, paying instead for only the resources they use. Many cloud computing offerings have adopted the utility computing model, which is analogous to how traditional utilities like electricity are consumed, while others are billed on a subscription basis (Nice 2011).

Business agility is the ability to adapt rapidly and cost-efficiently in response to changes in the business environment. Cloud computing is a significant trend to increase agility and lower costs. For companies with agile IT functions, infrastructure and technology are the primary drivers of that agility. Agile companies that have already adopted enterprise-wide cloud deployments are paving the way for their IT organizations to become more responsive and flexible to the demands of the business. In contrast, in companies with non-agile IT organizations, a fundamental disconnect exists between what IT and business stakeholders see as the problem: IT mentions money and skills sets, while business mentions a lack of infrastructure and technology to meet its needs. Cloud computing plays a key role in increasing IT agility, by enabling businesses to move quickly in highly competitive business environments (VMware 2011).

This research proposes a cloud system based on SOA and VE principles to overcome the problem that is faced by KwaNongoma arts and craft SMMEs in Zululand South Africa. The SMMEs are unable to grow their business due to limited funds which hinders them from purchasing their own ICT infrastructure and employing dedicated people to look into their legal, accounting, human resource issues, etc (Mvelase 2009).

The next section describes a SOA in cloud computing while the third section is on a VE architecture. Section four is a review of cloud computing in SMMEs while the section 5 is on deploying the cloud with OpenNebula enabled SOA/VE and the last section is on the conclusion.

2 SERVICE ORIENTED ARCHITECTURE AS IT RELATES TO CLOUD COMPUTING

2.1 UNDERSTANDING SERVICES

The concept of services within an application has been around for a while. Services, much like components, are intended to be independent building blocks that collectively represent an application environment. Unlike traditional components, though services have a number of unique characteristics that allow them to participate as part of service oriented architecture.

One of these qualities is complete independence from other services. This means that each service is responsible for its own domain, which typically translates into limiting its scope to a specific business function (or a group of related functions) (Erl 2004).

This design approach results in the creation of isolated units of business functionality loosely bound together by a common compliance to a standard communications framework. Due to the independence that services enjoy within this framework, the programming logic they encapsulate does not need to comply with any one platform or technology set.

In actual sense, a service is an implementation of a well-defined business functionality that operates independent of the state of any other Service defined within the system. Services have a well- defined set of interfaces and operate through a pre-defined contract between the client of the service and the service itself.

2.2 SERVICE ORIENTATION

Service orientation is more of a business concept and service oriented architecture (SOA) is about the application of that business concept to the technology. SOA is used to enable those with needs called consumers, and those with capabilities called providers to interact through services across different domains of technology and ownership. Therefore SOA can be thought of as a way an organisation does its business i.e. the way organisation business units interact with and support each other with technology. SOA has existed for a while now, depending on individual perceptions it may mean different things to different people. Some look at SOA from a web service perspective and as a means of integration using web services. Others look at SOA as a comprehensive architectural style which is firmly grounded on principles of enterprise architecture. Another perspective of SOA is that it deals with application services which form a subset of software as a service (SaaS).

In this case SOA allows for the reuse of existing assets where new services can be created from an existing IT infrastructure of systems. In other words, it enables businesses to leverage existing investments by allowing them to reuse existing applications, and promises interoperability between heterogeneous applications and technologies. SOA provides a level of flexibility, and agility that was not possible before.

A primary aspect of a SOA is the definition of business services. Business services must perform complete units of work that are meaningful from the perspective of the business. The completeness and relevance of the business service are what make it reusable and therefore a potential component of multiple future SOA applications. As a complete entity, the business service must integrate validation logic, business transaction logic, and data access capabilities.

On the other hand cloud computing is much of a technical concept. It is about a technology that delivers services over the Internet, hence it adopts a service driven operating model. In that way cloud computing and SOA can be seen as complementary since cloud computing is developed out of a need to provide IT resources as a service. Service orientation and cloud computing combined,

enables small medium and micro enterprises (SMMEs) of all sizes to buy services from different suppliers. Those suppliers compete and are able to concentrate on the services that they are good at. In that way SMMEs do not need to waste their efforts on running an uneconomical IT department, which is not their core business. An SMME can then outsource IT department to a third party specialist who can do it much better. The combination of cloud computing with SOA brings together speed and modularity; this allows enterprises to take evolutionary technologies and approaches and revolutionise the way IT interacts with the business.

The consumption of cloud computing resources, in the context of SOA brings agility to the IT systems, also prepares the enterprise to leverage enterprise cloud computing by creating the necessary interfaces and support of standards. Extending SOA's capability to the cloud, enables the provision of resources where and when needed, to reduce costs and take advantage of Internet delivered resources that provide access to pre-built processes and services, as well as access to platforms delivered as-a-service, as well as the value of the expandability of cloud computing resources.

3 VIRTUAL ENTERPRISE ARCHITECTURE

In virtual enterprise type of collaboration, organization responds to the dynamic and globalised markets of today. Virtual enterprise priority is to realize customer needs. These needs can be wide and unique (e.g. a large project based contract) or small but with numerous variations.

Aerts, Szirbik, & Goossenaerts (2002) suggested that the strength of VEs enforce strong requirements on their ICT support. The ICT infrastructure must be highly flexible for the VE to be agile. The enterprise architecture (EA) deals with the structure of an enterprise, relationships and interactions of its elements. EA presents a holistic approach to reconcile IT and business concerns in an enterprise. The virtual enterprises architecture is built upon the principles of EA. Service-oriented architecture (SOA) to implement EA shows to be an enabler of VE at business and technology levels. The authors argue that EA alone is not sufficient to overcome the three major challenges of VE which are flexibility, adaptability, and agility. SOA provides agile, reconfigurable and loosely-coupled infrastructure for enterprise integration of diverse processes and platforms of different enterprises. At business level, SOA services composition and reuse helps VE infrastructure to quickly assemble and react to changes as they occur. SOA's service components can be reused and composed across multiple VE instances hence making it easier for business to flexibly participate in different VE at the same time (Goel, Schmidt, & Gilbert 2009).

The virtual enterprise (VE) concept is based on distributed business functions and utilities, outsourced to partners that work together with the firm to deliver the product to end customers. A VE collects data on markets and customer needs and combines it with the newest design methods and computer-integrated network that includes suppliers, distributors, retailers and consumers. Enterprise architecture layers uses virtualisation as an interface for providing business functions; this is called business layer virtualisation (Wood, Shenoy, Gerber, Ramakrishnan, & Van der Merwe 2011).

A VE "is an ad-hoc coalition of independent enterprises and organisations, collaborating to achieve an explicit and specific goal of responding to a specific situation, by leveraging resources, skills and competences of the members of the coalition". A VE has no dominant partner, legal existence or physical ownership of resource inventories. Members can join or leave the coalition at any time, but within contractual limits. A Virtual Enterprise is dissolved as soon as its explicit goal is achieved" (Amit, Heinz, & David, 2010).

One of the most striking features of the VE is its opportunistic nature. SMMEs may use the VE strategy to meet unexpected change and unforeseen events, in this way become agile. One of the beneficial results is that unused capabilities or planned overcapacity can be made productive. To cope with the temporary unavailability of a particular type of capability, a VE will include several members with similar capabilities (redundancy). This will help the VE to achieve agility. These characteristics distinguish the VE from a more long-term inter-organisational structure, such as the supply chain or the extended enterprise (Aerts, Szirbik, & Goossenaerts, 2002).

A VE aims to use Information technology such as computer networks, business process/workflow management systems and service oriented architectures, to achieve a dynamic business partnership that can easily respond to business opportunities as they occur. The establishment of cooperation agreements between enterprises is not something new, but the use of IT to support the information networking is one of the characteristics of the VE concept. The general purpose for enterprises to be involved in a VE alliance is to leverage core competencies, resources and to each provide benefits to the other for a specific set of business opportunities. Only a small headquarters staff to deal with administrative and a management detail is needed, the actual work is performed by the geographically dispersed partners joined through computer hardware and software (Barnett, Presley, Johnson, & Liles, 1994).

4 CLOUD COMPUTING TO THE RESCUE OF SMMES

SMMEs are the small, yet agile players that have an edge over larger peers due to their lively, dynamic nature and ability to quickly respond to changes in the marketplace. Most of these companies have a mindset of innovation and entrepreneurial focus, which makes them a very valuable force within the economy. At the same time, the SMME sector is also overwhelmed with challenges. SMMEs often have to look beyond their own workforces for IT expertise. By nature, they tend not to have distinct IT departments with technology professionals. SMME employees tend to be all-rounders rather than specialists in a particular field. In the main, SMMEs realize that a certain IT expertise is needed in order to maximize the value of technology, and perhaps more appropriately, to minimize risks.

But in many ways, the rise of cloud computing has provided a solution to this problem. There are many good reasons why SMMEs need to embrace cloud computing. There is a perception that cloud computing can reduce cost. In companies with limited personnel budgets, this gives cloud computing another opportunity to prove its worth. Rather than constructing and maintaining in-house data centers, SMMEs can simply delegate data storage and security to a cloud vendor. Cloud customers not only have access to advanced hardware and software tools, but also to the IT skills they need through their hosted services provider. This way, they can be sure that IT professionals rather than business generalists are keeping a close watch on their confidential data stores (Stibbe 2011).

Cloud computing services may not provide the levels of reliability, manageability, and support required by large enterprises. Today, many services are aimed primarily at SMMEs and at consumers, rather than large enterprises. Nevertheless, there are definitive interests already shown by enterprises in the SMME segment. Cloud computing, with the revolutionary promise of computing as a utility, has the potential to transform how IT services are delivered and managed. For all practical purposes, it is not a farfetched idea to claim that apart from a locally installed computer operating system and a web browser, a good deal of the today's small business technology requirements can be satisfied with the cloud-based offerings provided by the cloud computing business models.

5 DEPLOYING THE CLOUD WITH OPENNEBULA

Open Nebula is an open-source middleware. Open-source software has been on the rise in many businesses during the extended economic downturn, and one of the areas where it is starting to offer companies a lot of flexibility and cost savings is in cloud computing.

Open source technology is going to seriously impact the cloud computing world, and there are two main reasons why open source software is essentially free, and it is not generally burdened by the software license models of proprietary software. Many proprietary software vendors, such as Microsoft and Oracle, are trying to maintain old and expensive license models, even though they delay the flexibility gained by virtualization and cloud computing (Claybrook 2011).

Virtualization, a mainstream technology in most data centres and enterprises, is an important enabler of most cloud platforms. Virtualization involves the ability to abstract operating system or application

instances from the underlying platform. Coupled with live migration functionality, virtualization can and will also be an important bridge from local environments to cloud based hardware (McPherson 2009).

OpenNebula is an open source virtual infrastructure engine that enables the dynamic deployment and replacement of virtualized services i.e. group of interconnected virtual machines, within and across sites. OpenNebula extends the benefits of virtualization platforms from a single physical resource to a pool of resources, decoupling the server not only from the physical infrastructure but also from the physical location. It can be mainly used as a virtualization tool to manage your virtual infrastructure in the data-centre or cluster. This application is usually referred to as a private cloud, and with OpenNebula can be used as the engine for public clouds, providing a scalable and dynamic management of the back-end infrastructure (Open Nebula 2011).

Figure 1 illustrates the importance of virtualization in a cloud environment. It utilises Opennebula middleware for deploying a cloud. We illustrate the backend of the private cloud which shows the internal management of the infrastructure. The Internal users interact directly with the cloud; they maintain the cloud. A virtual machine manager (VMM) is responsible for the efficient management of the virtual infrastructure as a whole, by providing basic functionality for the deployment; control and monitoring of virtual machines (VMs) on a distributed pool of resources. The external users access the cloud services (PaaS, SaaS, IaaS) in a form of VMs provided on demand. The backend cloud is completely transparent to the end users.

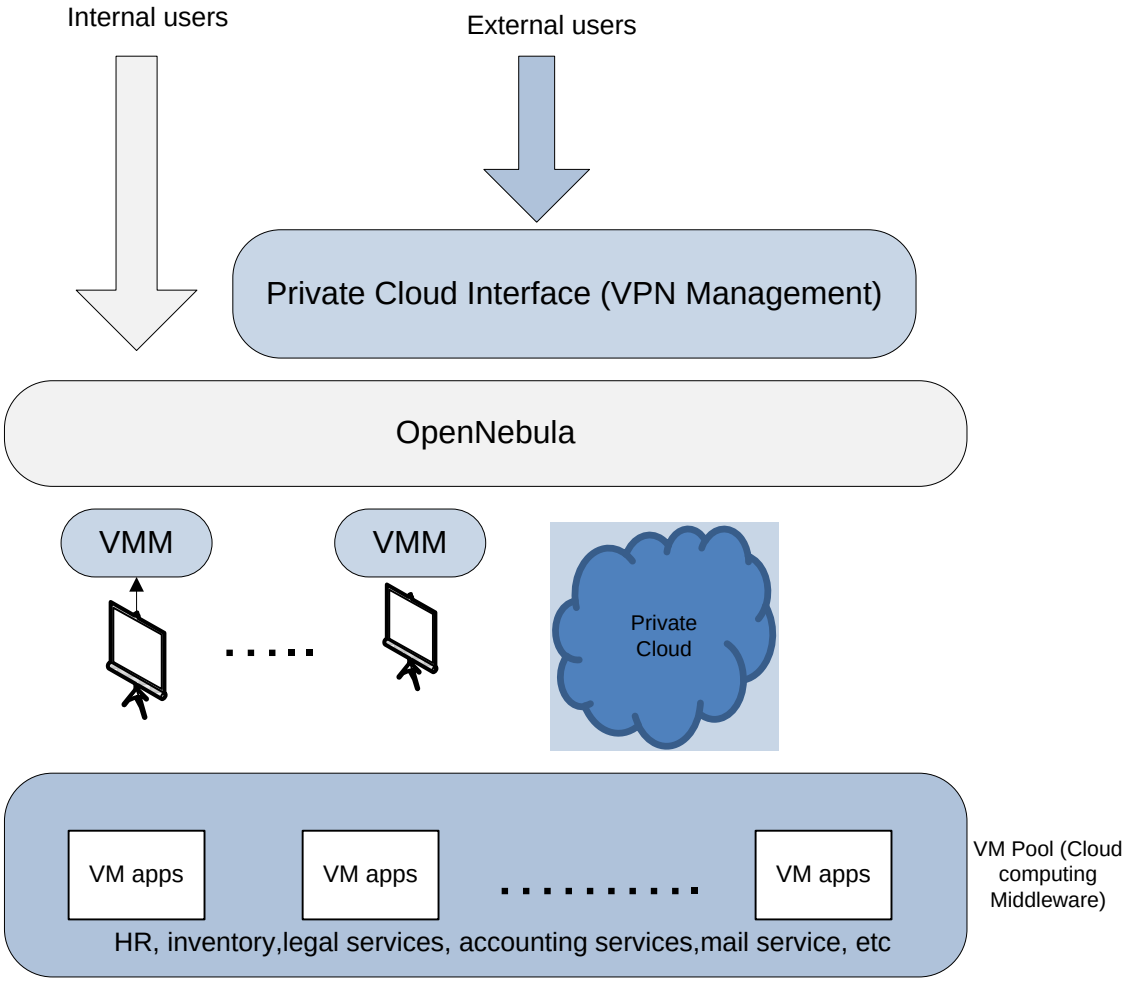

Figure 1: The virtual infrastructure engine: modified version of (Blanco 2009)

In figure 2, the open source OpenNebula virtual infrastructure engine provides the functionality needed to deploy, monitor and control VMs on a pool of distributed physical resources. The OpenNebula architecture has been designed to be flexible and modular to allow its integration with different hypervisors and infrastructure configurations. The OpenNebula Core is a centralized component that manages the life-cycle of a VM by performing basic VM operations (e.g. deployment, monitoring, migration or termination). The core also provides a basic management and monitoring interface for the physical hosts. OpenNebula is composed of three main components. The information manager is a pluggable module that governs the functionality provided by the OpenNebula core. The information manager adjusts the placement of VMs based on a set of pre-defined policies. The scheduler implements a simple match making policy and supports user-driven consolidation constraints. In order to provide an abstraction of the underlying virtualization layer, Open-Nebula uses pluggable virtualizer access drivers that expose the basic functionality of the hypervisor.

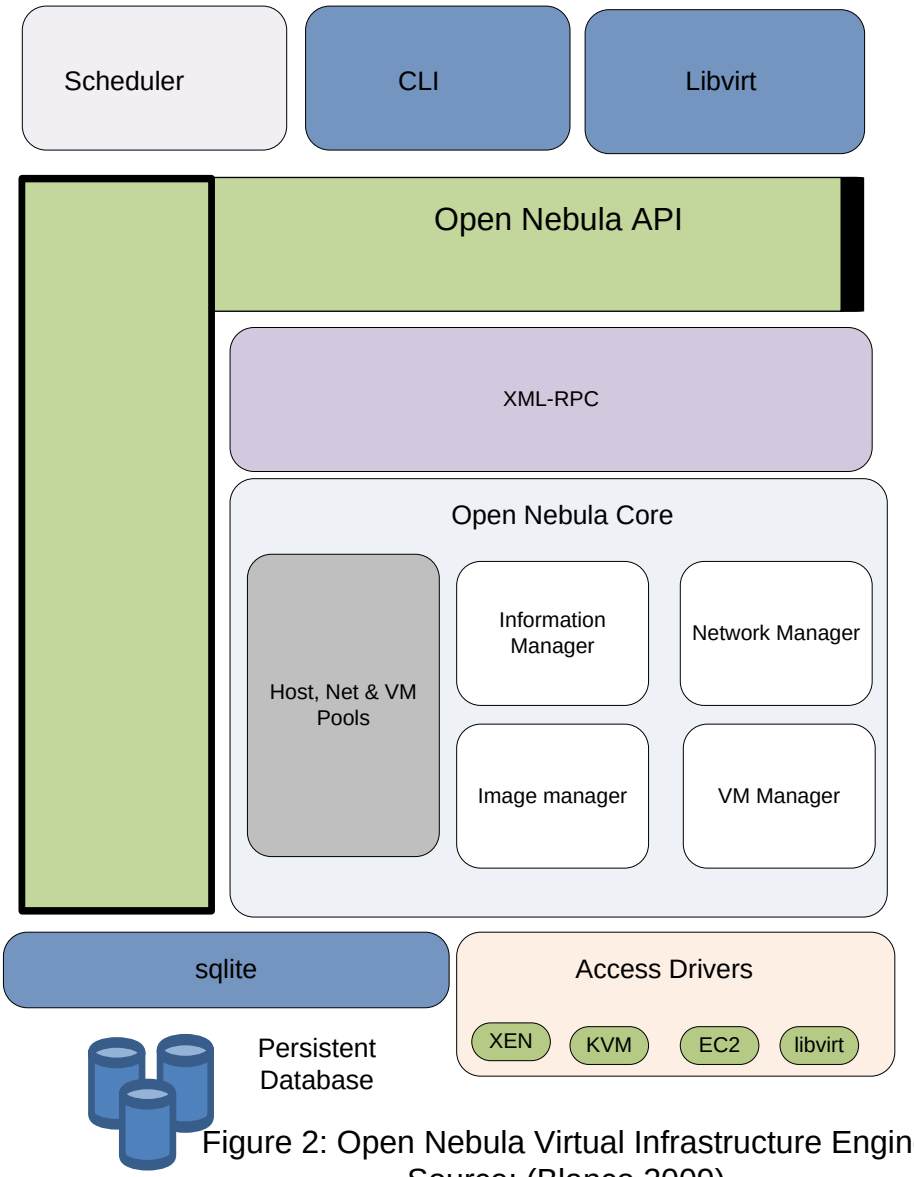

Figure 2: Open Nebula Virtual Infrastructure Engine
Source: (Blanco 2009)

Web servers can be provisioned with additional nodes to meet fluctuating or peak demands. Thus, OpenNebula is not tied to any specific environment, providing a uniform management layer regardless of the virtualization technology used. In this way, OpenNebula shapes a physical infrastructure to support the execution of a given service workload. Moreover, OpenNebula is able to dynamically scale-out this infrastructure by interfacing with an external cloud; an Amazon EC2 virtualizer driver is currently included with OpenNebula, and drivers could be developed to interface with other clouds (such as the Science Clouds, through the Globus Workspace Service interface).

This seamless integration of an external cloud with in-house resources allows for effective access of outsourced computational capacity (Sotomayor 2011).

6 OPENNEBULA-ENABLED SERVICE-ORIENTED ARCHITECTURE FOR SMMEs

We have a situation in which small SMMEs sitting in rural KwaNongoma 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 these services from a private cloud of service providers, which is a network of medium-size enterprises (MSE) participating in a virtual enterprise (VE) enabled cloud enterprise 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 consist of the medium-size enterprises in VE alliance and all its' business process utility and IT cloud 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 fulfill 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), MSEs 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 MSEs 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 MSEs in the alliance understand each other better, there can be no one MSE dominating. In case of insufficient resources the MSEs 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.

Open Nebula is middleware for the cloud. 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 physical machines. The network manager manages the communications within the cloud architecture. OpenNebula hides the complexity of the whole cloud system but giving the impression of it as one physical resource.

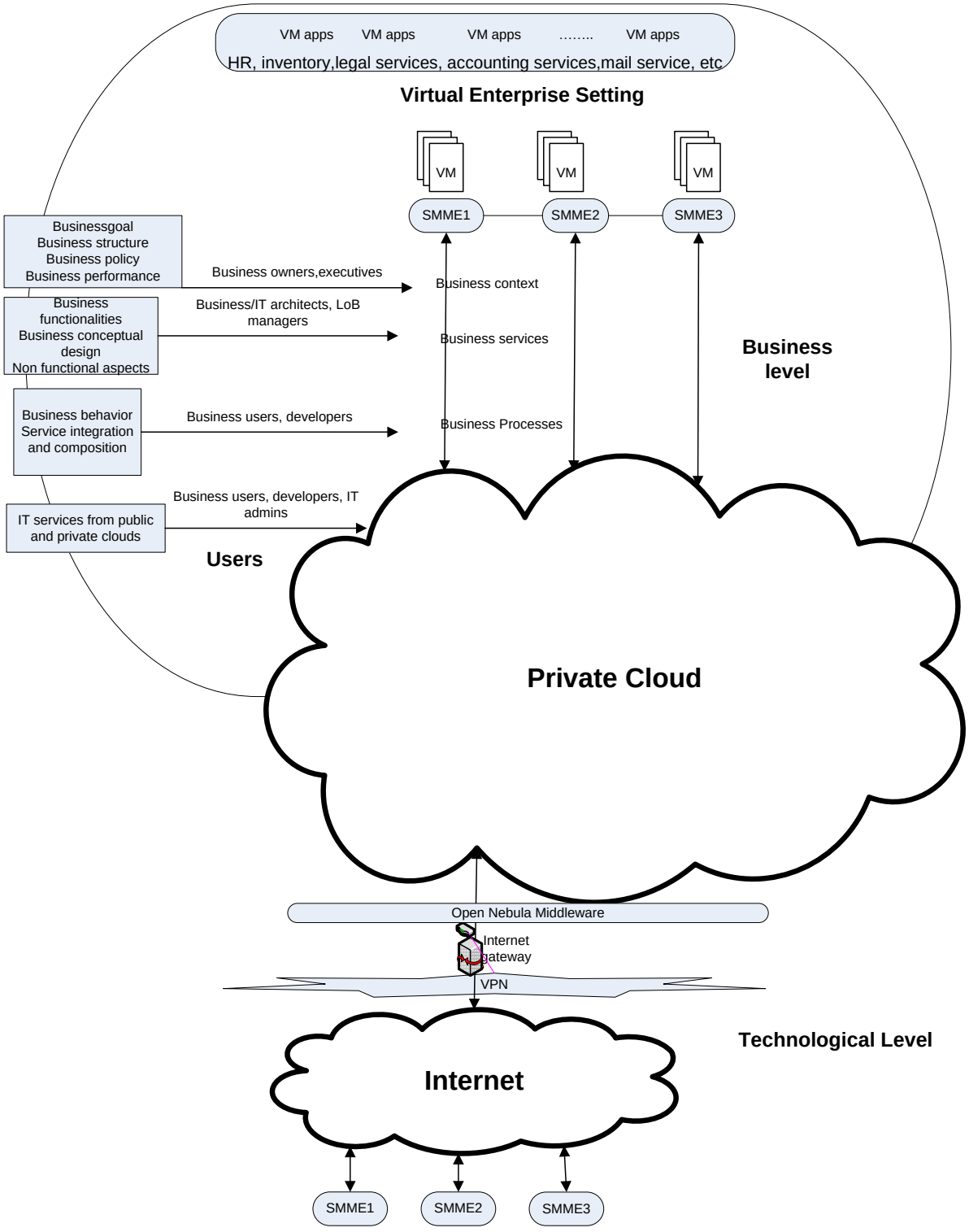

Figure 3: Cloud architecture for SMMEs

7 CONCLUSION

This research has come up with a cloud based architecture to support rural SMMEs. Virtualization has brought about a new utility computing model which is cloud computing. We have shown the importance of SOA and VE in the deployment of the cloud, the complementary aspect of the two has become obvious. Cloud computing shows potential in positioning SMMEs in the global arena. The main components of the architecture are SOA, VE and open-source. As “the latest super-hyped concept,” cloud computing is just a step in the commoditization of IT. Cloud computing allows organizations to own less and do more through virtualization and on-demand provisioning of platforms, software, applications, data and other services. Despite the increasing excitement surrounding this relatively new concept, issues such as types of cloud computing and scope of deployment still need understanding and clarification. For potential cloud users to determine whether cloud is the right solution, they must make decisions such as what type of service model would be feasible and what type of deployment model would be secure.

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