

University of Pardubice

Faculty of Economics and Administration

**Comparison of Private Cloud Management Tools for
Organization**

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**Bachelor Thesis
2018**

DISSERTATION ASSIGNMENT
(PROJECT, ART WORK, ART PERFORMANCE)

First name and surname: **Shadrack Tieku**
Study program: **B6209 System Engineering and Informatics**
Identification number: **E14004**
Specialization: **Regional and Information Management**
Topic name: **Comparison of Private Cloud Management Tools for Organization**
Assigning department: **Institute of System Engineering and Informatics**

Rules for elaboration :

Description: This project should help to select a private cloud management tool for an organization using multicriteria decision.

Outline:

- Preselection of tools for comparison.
- Definition of criteria.
- Evaluation and recommendation for given organization.

Scope of graphic works:

Scope of work report

(scope of dissertation): **30 - 40 stran**

Form of dissertation elaboration: **printed/electronical**

Language of dissertation elaboration: **English**

List of specialized literature:

RATH, Sangram. Hybrid Cloud Management with Red Hat Cloud Forms. Packt Publishing Ltd, UK, 2015. ISBN 9781-1-78528-357-4.

COLLIER, Michael, SHAHAN, Robin. Microsoft Azure Essentials-Fundamentals of Azure. Microsoft Press, USA, 2015. ISBN: 978-0-7356-9722-5. KÖKSALAN, M. Murat, WALLENIOUS, Jyrki, and ZIONTS,

Stanley. Multiple Criteria Decision Making: From Early History to the 21st Century. World Scientific publishing co., Singapore, 2011. ISBN-13 978-981-4335-58-4. POSEY, Brien. Hyper-V for VMware Administrators:

Migration, Coexistence, and Management. VMware Press, USA, 2015. ISBN 978-1-4842-0380-4.

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Date of dissertation assignment:

1 September 2017

Date of dissertation submission:

30 April 2018

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DECLARATION

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Shadrack Tieku Boadu

Acknowledgment

I am grateful to the God for the good health and well-being that were necessary to complete this thesis.

I wish to express my sincere thanks to Ing. Jana Pekařová (Mrs), Coordinator for Bachelor and Master Studies of the faculty, for providing me with all the necessary facilities for the research. I place on record, my sincere thank you to the doc. Ing. Romana Provazníková, Ph.D. Dean of the Faculty, for the continuous encouragement.

I am also grateful to Mgr. Ing. Oldřich Horák, Ph.D., my supervisor, and a lecturer, in the Department of System Engineering and Informatics. I am extremely thankful and indebted to him for sharing expertise, and sincere and valuable guidance and encouragement extended to me.

I take this opportunity to express gratitude to all of the Department faculty members for their help and support. I also thank my parents for the unceasing encouragement, support, and attention. I am also grateful to my partner who supported me through this venture.

I also place on record, my sense of gratitude to one and all, who directly or indirectly, have lent their hand in this venture.

TITLE

Comparison of Private Cloud Management Tools for Organization

ABSTRACT

As more organizations adopt private clouds, the need for management software is becoming clear. But not all private cloud management tools are created equally. IT pros must ensure the tool they choose will best meet their organization's requirements.

This study seeks to collect or preselect the private cloud management tools organization in Ghana are already using and compare the management tools of private cloud and suggest or recommend the tools for organizations in Ghana who are now going for a private cloud management tool from third party vendors. Also, some areas such as cloud computing services, types of cloud computing deployment model, cloud structure or layers (infrastructure component), multiple criteria decision making and private cloud management tools are being talked about.

Keywords: Cloud Computing, Private cloud, Public Cloud, Hybrid Cloud, Private Cloud Management, IaaS (Infrastructure as a service), Platform as a service (PaaS), Software as a service (SaaS), Multiple Criteria Decision Making.

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LIST OF ABBREVIATIONS AND ACRONYM

NIST	National Institute of Standards and Technology
WAN	Wide Area Networking
VMM	Virtual Machine Manager
IAAS	Infrastructure as a Service
PAAS	Platform as a Service
SAAS	Software as a Service
HPC	High-performance computing
BI	Business Intelligence
QoS	Quality of Service
TCP/IP	Transmission Control Protocol/Internet Protocol
SMEs	Small and Medium enterprises
AWS	Amazon Web Services
GB	Gigabyte
IPSec	Internet Protocol Security
IPS	In-plane Switching
SSO	Single Sign-On
ICT4D	Information Communication and Technology for Development
USBs	Universal Serial Bus
SPSS	Statistical Package for Social Science
MCDM	Multi Criteria Decision Making
MCDA	Multi criteria Decision Analysis

INTRODUCTION

While there is no contend about the adopting power of the cloud model and the benefits it can bring to any organization or government, mainstream adaptation depends on several key variables falling into alignment that will prove users the reliability, desired outcomes, and levels of trust necessary to truly usher in a cloud revolution. Until not long ago, early adopters of cloud computing in the public and private sector were the catalyst for helping drive technological innovation and increased adoption of cloud-base strategies, moving us closer to this inevitable reality.

Today, more organizations are moving towards the cloud computing as a low cost means of delivering quick time to time solution for mission-critical operation and service. The word cloud has been used historically as a metaphor for the internet. The usage was originally derived from its common depiction in network diagram as a contour of a cloud, used to consitute the transport of data across carrier backbone to an endpoint destination on the other part of the cloud environment. This concept dates back as early as 1961, when professor John McCarthy suggested that computer time sharing technology might lead to a future where computing power and even specific application may be sold through a utility-type business model. This idea became very common in the late 1960s, but by the mid-1970s the idea disappear away when it became obvious that the IT-related technologies of the day were unable to sustain such as a futuristic computing model. However, since the revolve of the millennium, the notion has been brace. It was during this time of reviving that the term cloud computing began to emerge in the technology circles

Because more organization are now moving into the private cloud, it has induced the author to research into private cloud management tools which existing organizations are using in Ghana to manage their private cloud environment. In recent years the population of organizations in Ghana who has adopt to the private cloud has increased due to the fact that their organizations are benefiting when it comes to the cloud so therefore they will need their own private cloud which will save cost but also improve the day to day work of their organization. These organizations are mostly using their private to store data, host their websites and a whole other service which are been delivered by the private cloud environment. These organizations are from the finance sector, the local government institutions, privately own institutions and many more.

Chapter one and two will be the theoretical foundation of the entire work, studying and explain how cloud computing came about in the first place. Furthermore, it will then focus on the area of private cloud since it is the main agenda of the project. We will get to know how organizations are using private cloud and how it is also being managed. We will also highlight on some challenges the organization are facing on using private cloud.

Chapter three and four is the methodology and techniques for selecting and evaluating private cloud management tools and the analysis of the most relevant outcome of the research. The project closes with the authors recommendations and conclusion which is a short summary of the entire project work.

The aim of this thesis is to preselect the private cloud management tools which are been used by organizations and compare the given management tools. The end goal is to compare and evaluate the private cloud management tools the organizations are using now in Ghana and suggest or recommend them to organization who are yet to adopt the private cloud and go for a private cloud management tool. These organizations who are yet to adopt will have knowledge in what other organization are already using and the capabilities or what they are gaining from their private cloud management tools.

The output of the thesis will be the suggestion or proposal for organizations who have recently adopt or moving into the private cloud environment and are now going for management tools to consider what other organizations are using.

1 BACKGROUND TO STUDY

Scientifically, the term cloud refers to accessing computer, information technology, software application through a network connection, often by connecting data centers using wide area networking (WAN) or Internet connectivity. Almost all IT resources can depend on the cloud, a software program, or application, a service, or an entire infrastructure. For example, if an organization want to build an IT infrastructure, typically they would install the servers, software and networking resources which are needed, but almost all those services and resources are now accessible by going to third parties that offered them in the cloud market. The cloud sign or ideogram is typically used to serve the internet. Cloud computing is now usually used to describe the delivery of software, infrastructure and storage services over the internet.

Cloud computing is generically a term which anything that involves delivering hosted service and computing resources over the internet. It is a way of computing where hugely scalable IT-enabled capabilities are delivered as services to external(multiple) customers using Internet technologies [1]. On the authority of NIST (National Institute of Standards and Technology, US), it provides a suitable or appropriate, on-demand network access to a shared pool of computing resources [2,3].

Forester [4] explains that cloud computing refers to a pool of pensive, highly scalable and contrlled infrastructure capable of hosting end-customer requests and billed by utilization. This is the latest paradigm in distributed computing that encourages to revolutionize IT and business by making computing accessible as a utility over the world wide web.

The general public has been using Cloud Computing in the form of Internet services like Hotmail (since about 1996), YouTube (since about 2005), Facebook (since about 2006) and Gmail (since about 2007). Hotmail is the first cloud computing application that allowed the general public to keep their data in the form of text and files at the vendor's servers. Since then, a lot of other services have emerged that allow users to store information (such as text files, photographs, video clips and music) and perform processing without paying any upfront fees. Cloud computing is now making life easier and entertaining for the general public. For example, some well know platforms are Twitter, Myspace, Wikipedia and Google Docs. These are probably consumer-oriented services that are to provide the storage space and processing capability.

As discuss previously, the term cloud is often used as a metaphor for the internet and has become a familiar cliché. However, when the cloud is combine with computing, it causes a

lot of confusion. Market research analysts and technology vendors alike tend to define cloud computing very narrow, as a new type of utility computing that basically uses virtual servers that have been available to third parties via the internet. Others lean to define the term using a very broad all-encompassing application of the virtual computing platform. They assert that anything beyond the firewall perimeter is in the cloud. A more tempered perspective of cloud computing considers it the carriage of computational resources from a position other than the one from which you are computing. [18].

1.1 Significant to Study

The private cloud model is what is referred to as "PaaS" or Platform as a Service, where a specific client has access to a physical pool of computing resources via a virtualized environment. In other words, the client is storing data, running programs or backing up information in a virtual environment that is provided by servers that are in a different physical location from their own. While organizations can set up their own private cloud networks, many opt to use a secure network provided by a third party as it takes the hassle and responsibility of management and maintenance off their shoulders. Private cloud services are best ideal for a variety of organizations, from the enterprise level organization in need of vast amounts of data storage to government organizations that require a secure environment in which to carry out sensitive tasks. In fact, many kinds of organizations such as financial organizations, schools, corporations, government agencies, healthcare providers and more use private cloud networks either by requirement of law or because of the security it allows them to offer their customers. The benefits of private cloud networks are clear: enhanced the security, increased the control, improved the reliability and have greater efficiency, all at a reduced cost. Moving to the cloud isn't as great a leap as many organizations might think so. As technology carries on to improve, so will the cloud networks be. In fact, for many organizations, the private cloud is fast becoming a natural and even expected first step away from traditional solutions and into the future. There are numerous considerations that should be considered when choosing a private cloud management tool (product). At first, it might appear as though the most important considerations are directly related to the private cloud's core functionality, such as the virtual network configuration or the self-service provisioning. Private cloud management software is better suited regarding providing awareness into your virtualization infrastructure and the workloads that are running on it.

1.2 Uses of Cloud computing

We all may be using cloud computing right now, even we may not know it. If you use an online service to send email, edit documents, watch movies, listen to the radio, play games or store your files or documents, it's most likely that cloud computing is driving and making it all possible which we may not even know. The first cloud computing services are mostly a decade old, but already a variety of organizations from tiny startups to global corporations, government agencies to non-profits are enhancing the technology for all sorts of reasons. Listed below are some uses of the cloud.

1.2.1 Test and development

In the best way for the use of a cloud is a test and development environment. This helps to secure a budget, setting up your environment through physical assets, significant manpower and time. Here come the installation and configuration of your platform. All this are most often extending the time it takes for a project to be completed and stretch your milestones.

1.2.2 Big data analysis

This is one of aspect offered by elevating cloud computing is the ability to tap into large quantities of both framed and unframed data to harness the benefit of extracting business values. Retailers and suppliers are now extracting information derived from consumers' buying patterns to target their advertising and marketing campaigns to a segment of the population. Social networking platforms are now providing the basis for analytics on behavioral patterns that organizations are using to derive meaningful information.

1.2.3 File Storage

Organizations and business are now storing their valuable files and documents in the cloud. This is very safe and secure since it has the best maximum protection of your stored file. Furthermore, the cloud can offer you the prospect of storing your files and accessing and retrieving them from any web-enabled interface. The web services interfaces are mostly simple. At any time and location, you have high availability, speed, scalability and security for your environment.

1.3 Layered Architecture of Cloud Computing

Cloud computing services are mainly categorized based on the abstraction level of ability and service provided by the cloud computing service provider. These abstraction levels may also stand as layered architecture in the cloud environment. The layered architecture [5] of cloud computing can be categorized into four layers which are data center layer, platform layer, infrastructure layer, and application layer. The image below is the rare overview of cloud computing architecture.

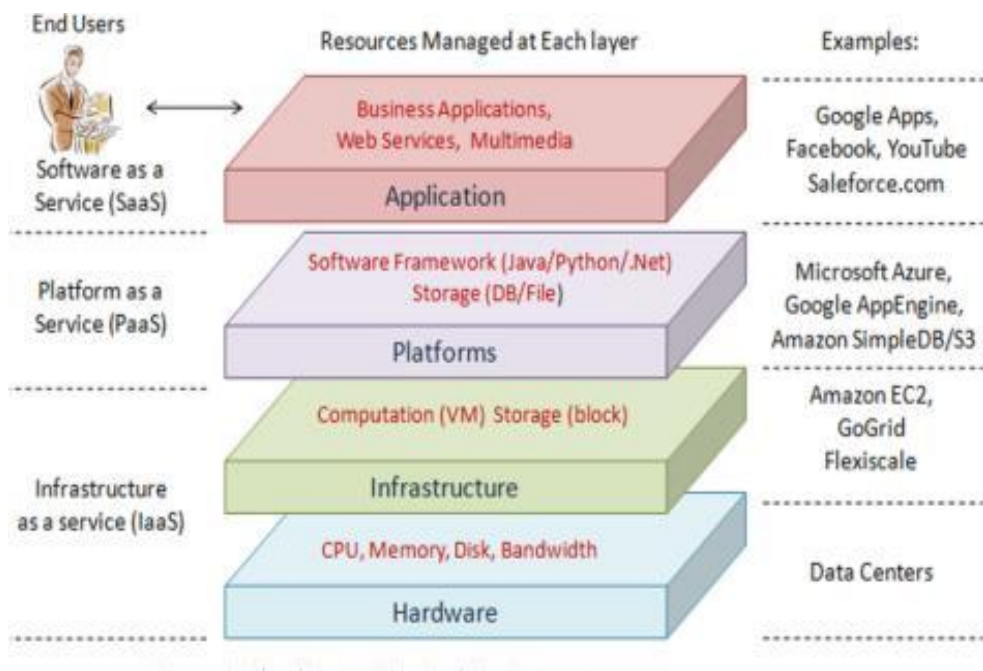


Figure 1: Cloud Computing Architecture

Source: [6]

1.3.1 Data Center Layer

The data center layer is responsible for managing physical resources like servers, routers, switches, power supply, cooling system etc. in the various data center of the cloud computing environment. The resources are managed in data centers in very large numbers to provide services to end users. The data centers are made up of a large number of physical servers which are connected to high-speed devices like routers and switches.

1.3.2 *Infrastructure Layer*

The infrastructure layer helps or allows a software system to interact with external systems by receiving, storing and providing data when they are requested. Moreover, the infrastructure layer is not the sole layer that allows the system to interact with other systems. There are also other constituents involved in the connectivity process. Infrastructure layer is a very essential layer, in spite of the fact that it is an optional layer in a software system, especially for systems that need to regularly interact with external systems in the cloud computing environment. Nevertheless, this layer is the core of the cloud computing environment where cloud resources are dynamically provisioned using virtualization technology.

1.3.3 *Platform Layer*

A Platform Layer comprises the platform software and settings required for layers and layered images to run flawlessly in your environment. This layer consists of application software and operating system. The purpose of the layer is to deploy applications directly on the virtual machine.

1.3.4 *Application Layer*

The application layer delivers services for an application program to ensure that effective communication with another application program on a network is possible. This layer consists of different cloud services that are used by cloud users. The services of this layer are applicable to end users as per their requirements.

1.4 Benefits of cloud computing

1.4.1 *Cost*

Cloud computing reduces the capital expense of buying hardware and software and setting up and running on-site datacenters, the racks of servers, the round-the-clock electricity for power and cooling, the IT experts for managing the infrastructure [7]. This helps organizations to save more when it comes to cloud computing.

1.4.2 *Speed*

Expanding in the cloud enables users to get their application to the market very quickly and save more time. This helps organizations or end users to be more efficient and deliver the best.

1.4.3 *Data security*

Hardware breakdown does not result in loss of data because of networked backups in cloud computing, we have network backups which retrieves and store all data in the cloud so, therefore, once there is a hardware breakdown, you can easily get all your stored data back from the cloud.

1.4.4 *Performance*

The huge cloud computing services run on a worldwide network of secure data centers which are mostly updated to the latest generation of the fast computing hardware. This brings many benefits to a single organization data center, including reduced network which is not yet being developed.

1.4.5 *Accessibility*

With the huge task carried by cloud computing, employees of an organization or a company can easily access the application they need remotely from wherever they are. Whereas in the pre-cloud age they will have to travel across town to access an organization or company machine before they can log into their network to access their files or applications [8].

1.5 Types of Cloud Computing Services.

Cloud service models explain how cloud services are made available to clients. The basic service model consists of the combinations of IaaS (infrastructure as a service), PaaS (platform as a service), and SaaS (software as a service) [15]. These service models might have combined effort between each other and be dependent on each other. For example, PaaS is dependent on IaaS because application platforms require physical infrastructure.

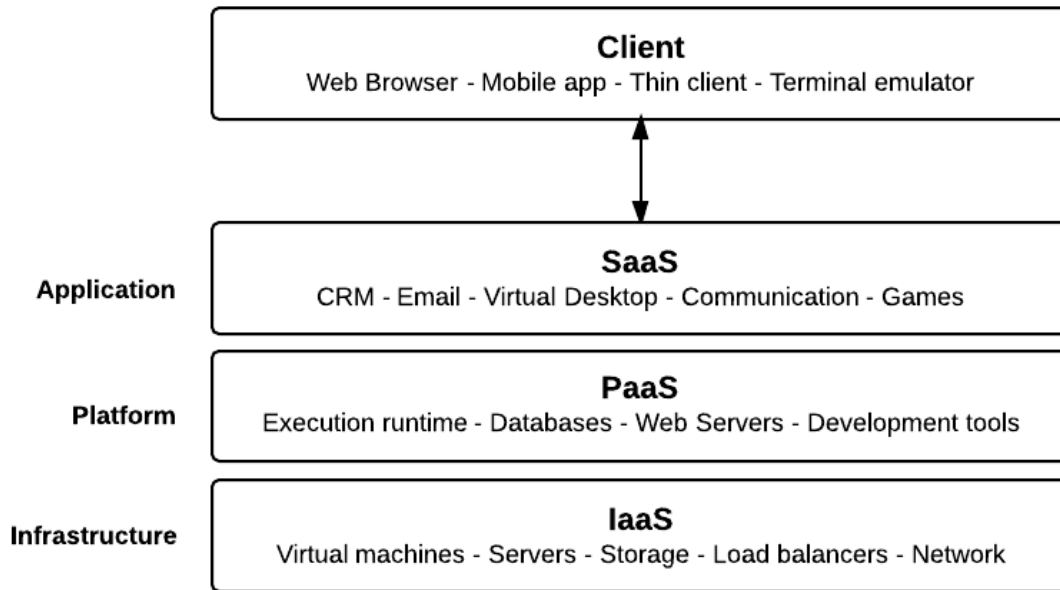


Figure 2: Cloud computing service models

Source [9]

1.5.1 IaaS (Infrastructure as a service)

Infrastructure as a service (IaaS) is an immediate computing infrastructure, provisioned and managed over the Internet. Fast scale up and down with demand, and pay only for what you use. IaaS enables you to avoid the expense and complexity of buying and managing your own physical servers and other data center infrastructure. Each resource is propounded as a separate service component, and you only need to rent a specific one for as long as you need it. The cloud computing service provider manages the infrastructure, while you purchase, install, configure, and manage your own software, operating systems, middleware, and applications [11].

IaaS business synopsis

- ✓ Test and development: Groups can quickly and easily set up and dismantle test and development environments, bringing new applications to market faster.
- ✓ Website hosting: Running websites using IaaS can be less expensive than traditional web hosting.
- ✓ Storage, backup, and recovery: Organizations avoid the capital outlay for storage and complexity of storage management, which typically requires a skilled staff to manage data and meet legal and compliance requirements.

- ✓ **High-performance computing:** High-performance computing (HPC) on supercomputers, computer grids, or computer clusters helps solve complex problems involving millions of variables or calculations.

1.5.2 Platform as a service (PaaS)

Platform as a service (PaaS) is a outright development and deployment environment in the cloud, with resources that warrant you to convey everything from easy cloud-based apps to experienced cloud-enabled enterprise applications. You obtain the resources you need from a cloud service provider on a pay-as-you-go basis and access them over a secure Internet connection.

Like IaaS, PaaS includes infrastructure, servers, storage, and networking, but also middleware, development tools, business intelligence (BI) services, database management systems, and more. PaaS is designed to help the complete web application lifecycle: building, testing, deploying, managing, and updating. PaaS allows you to prevent the expense and complexity of buying and managing software licenses, the underlying application infrastructure, and middleware or the development tools and other resources. You manage the applications and services you expand, and the cloud service provider typically manages everything else [12].

IaaS business synopsis

- ✓ **Business intelligence:** Tools given as a service with PaaS grant organizations to examine and mine their data, finding insights and patterns and predicting outcomes to boost forecasting, product design decisions, investment returns, and other business decisions.
- ✓ **Development framework:** PaaS provides a framework that developers can build upon to develop or customize cloud-based applications. Like the way you create an Excel macro, PaaS lets developers create applications using built-in software components.
- ✓ **Additional services:** PaaS providers may bring other services that enhance applications, such as workflow, directory, security, and scheduling.

1.5.3 Software as a service (SaaS)

Software as a service (SaaS) grant users to connect to and use cloud-based apps over the Internet. Common examples are email, calendaring, and office tools (such as Microsoft Office

365). SaaS brings a complete software solution that you purchase on a pay-as-you-go basis from a cloud service provider [15]. When you rent the use of an app for your organization or team, your users connect to it through the Internet, generally with a web browser. All the underlying infrastructure, middleware, app software, and app data are in the service provider's data center. The service provider administer the hardware and software, and with the correct service agreement, will make sure the availability and the security of the app and your data as well. SaaS allows your organization to get quickly up and running with an app at a minimal upfront cost [13]

SaaS business synopsis

- ✓ **Use free client software:** Users can run their SaaS apps straight from their web browser without requiring downloading and installing any software, although some apps require plugins. This means that you don't need to purchase and install special software for your users.
- ✓ **Access app data from anywhere:** With data stored in the cloud, users can access their information from any Internet-connected computer or mobile device. And when app data is cache in the cloud, no data is lost if a user's computer or device damage.

1.6 Cloud Computing Features

Cloud computing brings several new features compared to other computing paradigms (Wang et al., 2008; Grossman, 2009). [22] [23] There are briefly described in this section.

- ✓ **Scalability and on-demand services.** Cloud computing gives resources and services for users on demand. The resources are scalable over several data centers.
- ✓ **User-centric interface Cloud interfaces.** Cloud computing are location independent and can be accesses by well-established interfaces such as Web services and Internet browsers.
- ✓ **Guaranteed Quality of Service (QoS).** Cloud computed can guarantee QoS for users in terms of hardware/CPU performance, bandwidth, and memory capacity.
- ✓ **Autonomous system.** The cloud computing systems are autonomous systems controlled and directed transparently to users. However, software and data inside clouds can be automatically recon- figured and consolidated to a simple platform depending on user's needs.

- ✓ **Pricing.** Cloud computing does not require up-front investment. No capital expenditure is required. Users pay for services and capacity as they need them.

1.7 Difference between Cloud Computing and VMware

Most people contradict themselves on cloud computing and VMware. As discussed earlier on cloud computing, cloud computing is based on Transmission Control Protocol/Internet Protocol (TCP/IP) model. Cloud computing takes place over the internet. It consists of a collection of integrated and networked hardware, software and internet infrastructures. These infrastructures are used to provide various services to the users.

VMware is a virtualization and cloud computing software provider based in Palo Alto, California. Founded in 1998, VMware is a subsidiary of Dell Technologies. VMware offers a range of products and services from the organization named VMware, Inc. It is a main provider in the industry of virtual server products. VMware mainly works in the field of desktop software, server software, cloud management software, virtual desktop infrastructure, application platform, backup software. The VMware Cloud Platform uses a new and updated class of technology to bring a manageable cloud infrastructure. The cloud services are known as vCloud Hybrid services. [14].

2 CLOUD DEPLOYMENT MODELS

The IT industry is attracted by the simplicity and cost effectiveness represented by cloud computing concept that IT capabilities are delivered as services in a scalable manner over the internet to a massive number of remote users. Because of the different characteristics and trade-off of the various cloud computing deployment models, it is important the organizations IT professionals have a clear understanding of their organization specific needs as well as how the various systems can help them meet these needs. There are three Cloud models which companies can choose from, which are public Cloud computing, private Cloud computing and hybrid Cloud computing.

2.1 Public Cloud

Public cloud is a model where the service providers make the resources accessible to the public users over the internet. It is possessed by an organization selling cloud services. It may be free or executed as pay-per-usage policy. Anybody can access the resources according to their requests and scale up/down on its basis. The immense lead of public cloud is the cost interest it offers. There is no requirement for the SMEs (Small and Medium enterprises), organizations and individual users to set up any resources in advance; they can use them as and when need through the public cloud service providers by the means of a network connection. For example, Google, Amazon, Microsoft (Windows Azure), Apple (iCloud) etc. provide cloud services to the public users over the Internet. Typical business example of a public cloud deployment model based solution is the Treasury Department, which has moved its website Treasury.gov to a public cloud using Amazon's EC2 cloud service to host the site and its applications. The site includes social media attributes, including Facebook, YouTube and Twitter which allows for rapid and effective communication with constituents.

2.2 Private Cloud

Private cloud is a model which provides cloud services to a private organization. It may be managed by the organization itself or a third-party organization either on its premises or some other place away from it. Private clouds give the advantage of security to its organization, as all the data is stored on its own private servers, though the organization has to bear the initial set-up expenditure but it's worth the security benefit it provides [19]. The scalability rely on the available resources and is limited unlike the public cloud, where unlimited resources can be utilized and high level of scalability can be achieved. Furthermore, private cloud in contrast

represent a deployment model where enterprise offer cloud services over the corporate network (can be virtual private network) to its own internal users behind a firewall-protect environment. Recent advance in virtualization and data centres consolidation have allowed cooperate network and data centre administrators to effectively become service providers to meet the needs of their customers within these corporation. Private cloud allows large corporations to benefit from the “resource pooling” concept associated with cloud computing and their very own size, yet in the meantime addressing the concern on data security, corporate governance, government regulation, performances, and reliability issues associated with public clouds today [20]. The difference that sets a private cloud apart from a commercially-used public cloud is where the hardware is kept and how it’s conserve or maintained. A private cloud is usually hosted on the company’s own servers, within their own network infrastructure.

2.3 Hybrid Cloud

The hybrid cloud is a model which is a formation of two or more clouds (private, public, community). These clouds are separate bodies which are bound by some standards or technology and enables data and application portability (e.g. load balancing during cloud bursting) [21]. Hybrid clouds offer the combine advantages of the public and private clouds. The scalability no longer rely on the private resources but can be extended into the public cloud resources if the need be. Similarly, the data security concern can be handled easily in hybrid cloud by keeping the sensitive and confidential data on the private servers.

2.4 Differences between private cloud, public cloud and hybrid cloud

By comparison of these three types, a private cloud is created and maintained by an individual enterprise. The private cloud might be build on resources and infrastructure already present in an organization's on-premises data center or on new, separate infrastructure. In both cases, the enterprise itself owns and operates the private cloud.

A public cloud is where an independent, third-party provider, such as Amazon Web Services (AWS) or Microsoft Azure, owns and maintains compute resources that customers can access over the internet. Public cloud users share these resources, a model known as a multi-tenant environment.

A hybrid cloud is a model in where a private cloud connects with public cloud infrastructure, granting an organization to orchestrate workloads across the two environments. In this model, the public cloud effectively becomes an addendum of the private cloud to form a single,

uniform cloud. A hybrid cloud deployment need a high level of compatibility between the repressing software and services used by the public and private clouds.

2.4.1 Use cases for Private clouds

Now we turn to use cases for each type of Cloud. First, we consider Use cases for Private clouds. Private clouds will be chosen if there is a requirement for High data I/O and low network latency: disk intensive processes, wide sensor network, or process control. There are Legacy applications and in some cases special equipment requirements. There are Specialty hardware or configuration requirements, e.g. VM with 32+GB for in-memory data processing and governance or regulatory requirements.

2.4.2 Use cases for Public and Hybrid Clouds

Use cases for Public and Hybrid Clouds include, situations where there are Unpredictable growth: game or social websites, marketing campaigns. Where Cyclical: applications with regular daily or seasonal traffic fluctuation such as financial markets or eCommerce. Or for easily parallelized: applications using batch processing, data analytics, media encoding Example use cases Web/social web and mobile applications Development and test, proof of concept Big Data analytics, business reporting.

2.4.3 Use cases for Hybrid clouds

Use cases for Hybrid clouds covers where an organization merge both private and public clouds. For example, the Private cloud hosts efficient workload and master processes, also security and compliance critical applications/tasks. The Public cloud hosts non-critical and not regular but computing intensive workload. This scenario need compatibility between private and public cloud platforms. Hybrid cloud supports the notion of Cloud bursting – term widely used by businesses to describe a situation when workload is temporarily migrated to cloud, extending and replicating the private cloud resources and VMs (using formula “buy the base, rent a spike”)

2.5 Advantages and disadvantages of private cloud

When an organization correctly architects and implements a private cloud, it can deliver most of the similar advantages found in public clouds, such as user self-service and scalability, and also the ability to provision and configure virtual machines (VMs) and change or optimize

computing resources on demand. An organization can also implement chargeback tools to track computing usage and ensure business units pay only for the services they use.

Private clouds are mostly adopted when public clouds are considered unsuitable or insufficient for the business need. For example, a public cloud might not deliver the level of service availability or uptime that an organization needs. In other scenarios, the danger of hosting a mission-critical workload in the public cloud might surpass an organization's danger tolerance, or there might be security or regulatory disquiet associate to the use of a multi-tenant environment. In these scenarios, an enterprise might choose to invest in a private cloud to discern the advantages of cloud computing, while sustaining total control and ownership of its cloud environment.

Nevertheless, private clouds also have some drawbacks. First, private cloud technologies, of a kind like increased automation and user self-service, can convey some complexity into an enterprise. These technologies usually require an IT team to rearchitect some of its data center infrastructure, as well as acquire extra or more management tools. As an outcome, an organization might have to regulate or even increase its IT staff to implement a private cloud successfully. This is different than public cloud, where most of the underlying complexity is handled by the cloud provider.

Another potential drawback of private clouds is cost. An advantage of the public cloud is cost mitigation along the use of computing as a "utility" customers are only billed with the resources they use. When an organization possesses its private cloud, nonetheless, it bears all of the acquisition, deployment, support and maintenance costs involved.

2.5.1 Private Cloud Security Issues

Private Clouds have the same security concerns as public Clouds also have, but mostly on a smaller scale since private Clouds are operated solely for an organization. However, there are some specific concerns towards this Cloud model:

Security Architecture

Perimeter Security and insider attacks: very often, traditional perimeter security is not configured to protect resources from strikes that come from within the organization [28].

Hypervisor vulnerabilities and network level authentication (IPSec, IPS/IDS): virtual machines are solely used in Private Clouds. It is granted that those virtual machines will be able to have virtual communication with other virtual machines. Virtual machines should only be interfacing

or communicating with the ones they need to. Encryption and authentication mechanisms should be execute using IPSec and/or IPS/IDS [28].

Security Zones

Resources of different types and sensitivity levels should be located in separate security zones [29]. Based on previous studies and the definition of a private Cloud, private Clouds will immediately seem to be more secure than public Clouds because of how the infrastructure is designed. It gives the organization more control over their policies and security. According to NIST, the internal private Cloud is more suitable deployment models that offer an organization greater oversight and authority over security and privacy, and better limit the types of tenants that share platform resources, reducing exposure in the event of a failure or configuration error in a control. Private Clouds typically would suffer from perimeter complacency; thinking that because it is on the internal network, it must be secure; the Internet and viruses are still present. So, caution and security standards should not be lowered just because it is private [30]. Moreover, the private Cloud requires that to own total control over all layers of the stack, which includes any traditional network perimeter security you might want to have in location. In the private Cloud model, the Cloud services are not usually exposed to the general Internet users and remote access to private Cloud hosted resources is enabled through mechanisms used in traditional data centers. Private Cloud computing typically uses virtualization technologies to increase hardware utilization and to abstract compute, memory, network, and storage component from Private Cloud consumers [31].

2.6 Cloud Management

Cloud management refers to the management of cloud computing products and services. Public clouds are govern by public cloud service providers, which comprises the public cloud environment's servers, storage, networking, and data center operations.

Users of public cloud services can usually select from three basic categories: User self-provisioning: Customers purchase cloud services straight from the provider, typically through a web form or console interface. The customer pays on a per-transaction basis. Advance provisioning: Customers contract in advance a predetermined amount of resources, which are prepared in advance of service. The customer pays a flat fee or monthly fee. Dynamic provisioning: The provider designates resources when the customer requires them, then decommissions them when they are no more needed. The customer is billed on a pay-per-use principle. Managing a private cloud needs software tools to help create a virtualized pool of

computing resources, brings a self-service portal for end users and handle security, resource allocation, tracking, and billing. Management tools for private clouds tend to be service driven, as opposed to resource-driven because cloud environments are typically highly virtualized and organized concerning portable workloads. In hybrid cloud environments, compute, network and storage resources must be contrived across multiple domains, so a good management strategy should begin by defining what needs to be executed, and where and how to do it. [24] Policies to help administer these domains should consist of configuration and installation of images, access control, and budgeting and be reporting. Access control often comprises the utilize of Single sign-on (SSO), in which a user logs in once and are granted access to all systems without being triggered to log in again at each of them. [26]

2.7 Managed Private Cloud

Managed private cloud as highlighted previously is the principle in software architecture where a single instance of the software runs on a server, helping a single client organization (tenant), and managed by a third-party. This contrasts with multitenancy where multiple client organizations are on a single server, or an on-premises deployment where the client organization hosts their own instance. Managed Private Clouds also fall under the larger umbrella of cloud computing. Customers who choose a managed private cloud deployment usually choose them because of their desire for an efficient cloud deployment, but the need for customization or integration only available in a single-tenant environment. [25]

2.7.1 Uses of Private Cloud Services

Private cloud services are mostly ideal for a variety of organizations, from the enterprise level organization in need of vast amounts of data storage to government organizations that require a secure environment in which to carry out sensitive tasks. In fact, many kinds of organizations such as financial organizations, schools, corporations, government agencies, healthcare providers and more use private cloud networks either by requirement of law or because of the security it allows them to offer their customers [27].

Control and flexibility: Private clouds can be establish to meet an organization's requirements. Steadfast has been building bespoke infrastructure platforms for over a decade, and we onboard that expertise and experience to our private cloud platform. Private clouds can be developed to conform to the performance, scaling, and architecture requirements of each customer.

Performance and scalability: Resources of a private cloud are mostly at the disposal of the cloud's owner, removing any risk of resource or capacity contention. At the virtual layer, scaling is as simple as deploying and configuring new cloud servers. At the physical layer, new bare metal servers can be quickly added to increase the overall capacity of the cloud platform.

Example of an organization private cloud.

The public cloud offering although very attractive in price can lack personalization, flexibility and customization. With a public cloud, clients may feel the impact of other client loads, traffic, scheduled and unscheduled maintenance and physical maintenance such as changes or upgrades to the solutions architecture. In addition, your business may not always be able to gain access to an easy feature of a solution since the public cloud offers less flexibility. This is where the strength of the private cloud can really benefit your business. Some common real-time examples and benefits of a private cloud include:

- ✓ The ability to offer full flexibility of Microsoft Exchange along with the benefits of the always on/redundant data center.
- ✓ Transferring email to a private cloud solution can also be as simple as moving it into another environment.
- ✓ Moving an on-premise telephony infrastructure (i.e. Avaya Private Cloud) to a private cloud solution to get best of both worlds. [17].

2.8 How Organizations in Ghana are benefiting from Private Cloud.

The benefits of Cloud computing are of immense importance to the developmental needs of sub-Saharan African countries especially under the Information Communication and Technology for Development (ICT4D) program. In Ghana, with the relatively high mobile phone and mobile internet penetration rate of 139.09% and 69.83% respectively, Ghana stands to benefit enormously from an effective implementation of Cloud Computing infrastructure. Since the declaration of the government of Ghana Information Communication Technology for Development (ICT4D) program in 2012 and subsequently the launch of the Accra Smart city project, there has been an upsurge in interest in Cloud Computing by both public and private establishments, industry and academia [33].

Over the past few years, the number of infrastructure hosting options available to organizations has multiplied. Sometime ago, the only real option was to develop an onsite server room or data

center. Currently, companies can choose from bare metal servers, cloud servers, platform-as-a-service products, and private clouds, among others. Today, most organization in Ghana are considering using a private cloud. Here are some benefit organizations are gaining for using private cloud services are:

Availability

An advantage of cloud computing to organizations is that you can scale resources as you need them. Even if a single server goes down, your data is automatically replicated to other backup locations, making it available to you anytime. Also, during peak periods, bandwidth and network resources can be scaled up to support your needs.

Stability

Organizations in Ghana are now satisfying on how cloud computing largely replaced hard drives, computers, flash drives, and USBs. While it still uses many different types of drives to build its storage platforms, it also provides a greater degree of data security by distributing data to secure hosting sites and ensuring everything stays online. However, for the best protection, you need sound protocols in place and comprehensive disaster recovery and backup solutions. Private clouds are particularly convenient for storing sensitive files, as your in-house teams are responsible for ensuring that your platform keeps running.

Customization

The organization can configure their platform in the way that best suits you and your business's needs. Private cloud can adapt to companies of different sizes, industries, overhead, objectives, and other factors. More organizations are now looking into their company's requirements and decide what works best for you based on your availability, security, and scalability needs.

Cloud Compliance

With the ability to fully control cloud storage and bandwidth, customize environments, or adjust security settings, organizations have greater control over their infrastructure.

These are helping the organization to build a platform that is compliant with relevant laws and industry regulations base on their business objectives. As opposed to the public cloud, private cloud data can harder become a subject of external inspection or malevolent interception.

2.9 Challenges for the organizations in Ghana using Private cloud.

Because more organizations are adopting to private clouds, the wants for management software is becoming very important. But not all private cloud management tools are created the same. IT pros must make sure the tool they select will best meet their organization's needs.

All major private cloud vendors offer their own products for building managing private clouds but not all are same. Although these management tools provide basic capabilities for managing the virtualization infrastructure that makes up a private cloud environment, there are numerous third-party products that deliver management capabilities beyond what the platform.

3 METHODOLOGY

3.1 Objectives of the survey

Here is the most vital and core chapter of the whole project. The following will describe the methods and approach used selecting and gathering the experience encountered by heads of IT professional in their organizations when it comes to using or management of their organizations private cloud environment in Ghana. When most heads of IT professional in Ghana meet or gather during functions like seminars and others, they express their views on how their organizations private cloud which is been managed by a third party is making their day to day business well successful when it comes to private cloud management.

The objective of this project is to analyses the view and opinions of the heads of IT professionals from their organization in Ghana on their private cloud management tools they are using to manage their private cloud environment and how well their organization is benefiting from since they started using those private cloud management tools. This means we are going to have idea on what management tools they are using now and how satisfied are they on the tools they are using. We will also have the knowledge of what private cloud management tool is been use in organization in Ghana and what they are gaining from those tools. The final result should evaluate the management tools the various organizations are using in Ghana to manage their private cloud environment. This result will be suggestion or recommendation to upcoming organizations in Ghana who are about to adopt private cloud in their organization and go for a management tool for their cloud. At lease it will help this upcoming organization to know what the existing organizations are using to manage their private cloud and what there are gaining from those tools. In order to get such information, a quantitative statistical research has been conducted that should answer questions that heads of IT professionals from their organization would need answers from.

3.2 Approach for evaluating the private cloud management tools.

The approach for evaluating the private cloud management tools in were the simple random sampling of organizations IT professionals through the questionnaire and remote interview which elicit information about the IT professionals experience and preferences.

In a distant interview the interviewer is geographically set apart from the interviewee. Transmission equipment helps the interview to carry on in real time, either for live broadcast or recording. Distant interviews can happen between two places, between a site location and

temporary field location. The signature of the distant interview is the divided screen. This establishes both locations and provides comfortable transitions between them. The remote interview was used to explore concrete user preferences, opinions and subjective reactions.

Questionnaire is referred to as a research instrument consisting of a multiples of questions for the purpose of gathering information from respondents. The questionnaire was originated by the Statistical Society of London in 1838. In spite of the fact that questionnaires are often designed for statistical analysis of the responses, this is not always the case. Questionnaires have odds over some other types of surveys in that they are cheap and they do not need as much effort from the questioner as verbal communication surveys, and usually have standardized answers that make it easy to compile data. Nevertheless, such standardized answers may frustrate users. Questionnaires are also sharply finite by the fact that respondents must be able to read the questions and respond to them. Thus, for some demographic groups conducting a survey by questionnaire may not be concrete. The model of questionnaire used here was computerized questionnaire administration, where the items are presented on the computer. The questionnaire was sent to the organization in Ghana remotely for the heads of IT professionals to fill out and send it back. We send out 60 questionnaires. The questionnaire had 50 complete responses. Opportunity was given to the heads IT professionals where they can accept to have a skype interview. From 50 IT professionals who answered the questionnaires, I was fortunate to have 10 of them were ready to have the skype interview with me. The structure of the questionnaire how the organizations started using the private cloud management tools and how satisfied are they with the management tools.

3.3 Methodology of the research

The selected research method was the statistical random sampling survey of heads of IT professionals in their organizations through questionnaire which is a quantitative research which will gather the data about management of private cloud environment or the private cloud management tools for organizations in Ghana.

In the random sampling survey, gathering of the data was structured as questionnaires and it answers provided quantify the incidence of preferences and experiences of the population under consideration. The research was conducted as an online survey and was launched between the 14th of May and the 18th of May 2018 in the English language.

Two types of platform were used for building and gathering the survey. Since our target of audience was randomly on organizations in Ghana, the first platform used was remote interview with skype with the heads of IT professional from their organization. The second platform was SurveyMonkey which is also a web software that delivers the student or researchers to develop their research the availability to gather survey data. The platform enables the possibility of basic analysis of the data and more importantly it gives the possibility of exporting the data in the form of computer software like Microsoft Word, Excel and SPSS.

The Method for processing the final analysis of the data from the survey was from decision making which is Multi Criteria Decision Making (MCDM) or Multi criteria Decision Analysis (MCDA). The agenda will be on the preselection of the management tool been used by the organizations in Ghana which was evaluated by using Multi Criteria Decision Making (MCDM) or Multi criteria Decision Analysis (MCDA). Multiple criteria decision making (MCDM) or multiple criteria decision analysis (MCDA) is a sub-discipline of operations research that clearly evaluates multiple conflicting criteria in decision making. Conflicting criteria are typical in evaluating options: cost or price is usually one of the main criteria, and other measure of quality is usually another criterion, easily in conflict with the cost [32]. The benefits of this method are the chances and capabilities to handle both qualitative as well as the quantitative object. The output of this method is a mathematically correct quantitative judgement of the alternatives.

3.3.1 *Data Analysis*

The data collected were edited, coded and analyzed. The statistical tool adopted in analyzing the data was a descriptive statistic. The data were entered using the Statistical Package for Social Science (S.P.S.S.) In order to get the direction of the responses from the respondents, percentages and frequencies were used. A higher percentage of responses showed a favorable response from the respondents. However, a lower percentage showed an unfavorable response to a particular item in the questionnaire.

3.3.2 *Structure of the Survey*

The structure of the survey contains seven main point which was our focus. These main focus point are, number of years their organization started using private cloud management tools, how satisfied are they with your private cloud management tool, is their Organization investing more

in private cloud management tools, how often does their organization train the IT team on private cloud management tools, how satisfied are they with the training on the private cloud management tool, do they wish to have more training on private cloud management tools, and how useful has the adaptation of the private cloud management tools benefit or improve your organization?

3.3.3 *Sampling*

The first step of the sampling process was to define the population of interest. The chosen population of interest was population heads of IT professional from various organizations. Although the questionnaire does not have the sole purpose of identifying all the problems encountered by heads of IT professionals experience with the private cloud management tool their organization is using. The initial target number of respondent was 60. However, at the end of the collecting the data stage, 50 respondents were registered (40 completed responses and 10 response plus skype interview).

The chosen sampling method was simple random sampling and the link of the survey was distributed on the social media like Skype, LinkedIn and Email for the organization in Ghana. Additionally, in sending of the questionnaires, options were given for the IT professional who will be available for a skype interview as well. This option enabled anyone with access to the Internet to have a chance to complete the survey.

The link: (<https://www.surveymonkey.com/r/B3YSNDN>)

3.3.4 *Limitations of the survey*

It is essential to recognize the limitation of the survey in order to provide clear understanding and view of the reality of the project. The lack of time needed for the research on such a medium. A number of difficulties were encountered while undertaking the research. Few of the IT professionals were willing to accept the skype interview. The researcher wanted to have more respondent for the skype interview since it gives the best interaction and have more knowledge about their experience. Also, as a result of limited time inadequate funding, the researchers could not administer the questionnaires to the entire heads of IT professionals in their organizations.

Despite the challenges, the researcher was able to do this by explaining to the various heads of IT professionals in their organizations. Also, I had to explain to IT professional that the information they were providing would be kept highly confidential.

4 RESULTS AND DISCUSSION

This chapter discusses the presentation and analysis of the data that was collected from the respondents in order to find answers to research questions.

Table 1: Number of years of using private cloud management tools

Number of Years	Frequency	Percentage
1 to 3	10	20
4 to 6	20	40
6 to 10	15	30
10 and above	5	10
Total	50	100

Source: (Authors own)

The study sought to know the number of years the companies involved in the study have been using private cloud management tools. From table 1, we could deduce that, twenty (20) out of the 50 representing 40% of the total companies interviewed had 4 to 6 years of experience in the use of private cloud management tools. This was followed by fifteen (15) companies having used private cloud management tools. This implies that, most of the companies involved in our research have experience in using private cloud management tools and therefore are equipped with a better understanding on the use of private cloud management tools.

Table 2 shows response on how satisfied respondents in the survey are on the use of private cloud management tools. Fifty-seven Percent (57%) out of 50 employees invited indicated they are satisfied with the use of private cloud management tools. This was followed by 34% who indicated very satisfied for the use of private cloud management tools. This indicates that, the use of private management tools by the various companies involved in our study has had a positive impact on the growth and effectiveness of the companies.

Table 2: How satisfied are you with your private cloud management tool?

Response	Frequency	Percent
Very Satisfied	17	34
Satisfied	27	54
Neither	6	12
Total	50	100

Source: (Authors own).

Private cloud management tools have been attributed as an integral part of any growing company in terms of data storage and security of data stored. It is therefore important for any company which sort to keep confidentiality of data processed and use in the company to invest adequately in the maintenance of private cloud management tools. The study therefore investigated if the companies employed in the study invest more into the use of private cloud management tools. From table 3, 80% of the total respondent answered yes when the question of investment was asked. However, 10 of the respondents representing 20% answered no. This shows that, most of the companies involved in the study invest more into the use of private cloud management tools.

Table 3: Is your Organization investing more in private cloud management tools?

Response	Frequency	Percent
Yes	40	80
No	10	20
Total	50	100

Source: Authors own.

Another most important aspect of the private cloud management tools is training. There are always new technologies and updates being pushed and therefore constant trainings are needed to keep employees up to date concerning the latest and newly developed private cloud management tools.

Table 4: How often does your organization train your IT team on private cloud management tools?

Response	Frequency	Percentage
Always	15	30
Usually	20	40
Sometimes	9	18
Rarely	6	12
Total	50	100

Source: Authors own.

Deducing from table 4, response showed that, 40% representing 20 respondents confirmed that, trainings on private cloud management tools are done usually given. 15 respondents answered trainings are done always. 9 (18%) and 6 (12%) of the total respondents answered sometimes and rarely respectively when asked IT training on private cloud management tools. This implies that, most of the companies used in the study organize training which keeps the respondents up-to date with new software updates and changes in policy in terms of the use of private cloud management tools.

Tables: 5 and 6 indicates response on how satisfied respondents are the respondent in terms of training on private cloud management. Most respondents from the analysis answered satisfied (48%) which was followed by 20% of the total respondents answering very satisfied with the training.

Table 5: How satisfied are you with the training on the private cloud management tool?

Response	Frequency	Percent
Very Satisfied	20	40
Satisfied	24	48
Neither	6	12
Total	50	100

Source: Authors own.

Though most of the respondent is answered very satisfied and satisfied with the trainings received on private cloud management, most respondents as shown in table 6 require more training. As already established, investing in private cloud management tools is very important when dealing with storage. One area of investing is the organisation of trainings on

development and as such, 96% of the total respondents requested for more training on private cloud management tools as established in table 5.

Table 6: Do you wish to have more training on private cloud management tools?

Response	Frequency	Percent
Yes	48	96
No	2	4
Total	50	100

Source: Authors own.

As deduced from tables 4, 5 and 6, private cloud management tools form an integral part in the use private cloud. Table 7 below depicts how beneficial the adaptation and use of private cloud tools has helped in improving the efficiency and growth of the company.

Table 7: How useful has the adaptation of the private cloud management tools benefit or improve your organization?

Response	Frequency	Percent
Extremely useful	13	26
Very Useful	37	74
Total	50	100

Source : Authors Own.

Table 8: What type of private cloud management tool does your organization use?

Private cloud mgt. tool	Frequency	Percent
Embotics vCommander Enterprise Cloud Management Software	17	34
VMTurbo Operations Manager Cloud Edition	14	28
Solarwinds Virtualization Manager	12	24
WhatsUp Gold WhatsVirtual	7	14
Total	50	100

Source: Authors own.

Table 8 shows response on the private cloud management tools the organizations are using in Ghana. From the table, 34% representing 17 of the total respondents made mention that their using Embotics vCommander Enterprise Cloud Management Software as their private cloud management tool. This was followed by VMTurbo Operations Manager Cloud Edition and then Solarwinds Virtualization Manager representing 28% and 24% respectively. The least respondent of the private cloud management tool as per the study result is the WhatsUp Gold WhatsVirtual management tool with 14%. The study further analysed on why the organisation considered the management tool their using now. The last question from the questionnaire was very important to us because these tools were rank base on the services or features the tools are providing them. We can call these considerations as the features of the tool. From table 9, the management tools have been value base on the respondent answer on what services or features there are receiving from those tools. As vindicated in table 9, the (17) seventeen respondent from different organization with a percentage of 34% gave more features or services under their tool (Embotics vCommander Enterprise Cloud Management Software) they are using which valued their tool to be excellent. Followed by the (14) fourteen respondent features or services from their tool (VMTurbo Operations Manager Cloud Edition) made the value of the tool to be very good. Solarwinds Virtualization Manager and WhatsUp Gold WhatsVirtual continue with the value of good and satisfied.

Table 9: What services or features are you getting from the private cloud management tool you are using?

Criteria	Value	Frequency	Percentage
Embotics vCommander Enterprise Cloud Management Software	Excellent	17	34
VMTurbo Operations Manager Cloud Edition	Very good	14	28
Solarwinds Virtualization Manager	Good	12	24
WhatsUp Gold WhatsVirtual	Satisfied	7	14
Total		50	100

Source: Authors own.

Following up, we will now describe what our respondent said about the features or services they are gaining from their private cloud management tool. Obviously, we are going to have the description under the four tool we came up from the respondent. On our first tool which is Embotics vCommander Enterprise Cloud Management Software was mention buy seventeen (17) different organization with a percentage of 34% out of the 50 correspondents. These organization who are using this tool to manage their private cloud environment came up with the following features which will be described. These features or capability of their tool is, diagnostic capabilities, multi-platform support, resource monitoring and performance tracking.

Secondly, 14 different organization also came up with VMTurbo Operations Manager Cloud Edition. The features or capabilities of this tool is multi-platform support, resource monitoring and performance tracking. Followed by 12 different organization who made mention of using Solarwinds Virtualization Manager. Its features mentioned by the respondent were, resource monitoring, diagnostic capabilities and basic performance tracking. The seven (7) correspondent who came up with WhatsUp Gold WhatsVirtual as their management tool also highlight these features from their tool. The features are, basis resource monitoring, basic performance tracking and diagnostic capabilities. The features or capabilities mentioned by the respondent on their management tool will be explain.

Diagnostic capabilities

Organizations server virtualization infrastructures are compounded or composited because they involve a lot of different components working together to provide reliable workload hosting. This complexity increases exponentially when the infrastructure is configured to act as a private or hybrid cloud because of the additional layers of abstraction. This complex and widely distributed infrastructure can make it difficult to detect and remediate potential issues before they lead to real problems. As such, any good management product should be able to detect conditions that could lead to serious concerns. A poor management tool who provide basic diagnostic capability might not be detect all problem and this can ruin your organization. An example of work done of a management tool on diagnostic capabilities is providing diagnostic alerts that make use of the management tool alert center. The alert center is a single pane of glass interface that gives organization-wide alerts and notifications of events happening across the whole organization, so alerts concerning to the server virtualization infrastructure are shown or expose to view within the same interface as more generalized alerts. It this case any problem

which will occur will be detected since the diagnostic run all over the organization server virtualization infrastructures.

Multi-platform support

Here is where the management tool can support more platforms in your private cloud environment. More environments are using multiple hypervisors to match economics and workloads. The more platforms a management tool supports, the more flexibility you have. Example when the tool is able to supports more platforms like, VMware and Microsoft environments, Citrix support, Amazon EC2, etc.

Resource monitoring

This is where the tool has the ability to reclaim wasted storage and ensure your physical resources are being utilized most efficiently. A management tool with a basic monitoring might not be able to reclaim wasted storage and ensure your physical resources are being utilized most efficiently but may only reclaim wasted storage. For example, a full management tool provides "rightsizing" reports that detail which virtual machines are consuming the most memory and storage resources. The tool will also offer reports detailing resource consumption, which show how resources are being consumed over time, and by whom. The tool's resource monitoring features are its intelligent workload placement capabilities. The management tool can either recommend workload placement or automatically move workloads based on business requirements and available hardware capacity.

Performance tracking

This is also an important feature of a management tool for private cloud environment. Performance tracking is the keeping virtual infrastructure balanced and running at peak efficiency which is the key to maximizing your private cloud deployment. This capability of a management tool is important because, a tool with full performance tracking also can track your physical hardware and virtual machine performance. This is the only way to ensure mission-critical workloads are running efficiently. A management tool with basic performance tracking will not be able to have full tracking on organizations infrastructure on their private cloud.

4.1 MULTI-CRITERIA DECISION

The Multi Criteria Decision Making (MCDM) delivers strong decision making in areas where selection of the best alternative is highly complex. In our daily life, so many decisions are being made by considering several other criteria, so decisions can be made by providing weights to different criteria and all the weights are obtained from expert groups or decision makers. It is essential to determine the structure of the problem and explicitly evaluate multi criteria.

4.1.1 *Define the problem*

This process must bring out root causes, limiting assumptions, system and organizational boundaries and interfaces, and any stakeholder issues. The target is to express the issue in a clear, one-sentence problem statement that describes both the initial conditions and the desired conditions. The problem statement must however be a concise and unambiguous written material agreed by all decision makers and stakeholders.

4.1.2 *Determine requirements*

Requirements are conditions that any admissible solution to the problem must meet. Requirements brings out what the solution to the problem must do or action. In mathematical form, these requirements are the limitation or restriction describing the set of the feasible (admissible) solutions of the decision problem. It is very essential that even if subjective or judgmental evaluations may happen in the following steps, the requirements must be declared in exact quantitative form, i.e. for any possible solution it has to be decided in a manner that is not open to more than one interpretation whether it meets the requirements or not.

4.1.3 *Establish goals and objectives*

Goals are general guidelines that explain what you want to achieve. Goals are broad statements of purpose and desirable programmatic values. Goals go beyond the minimum essential must have (i.e. requirements) to wants and desires. In mathematical form, the goals are objectives direction to the requirements that are limitation or restriction. The goals can be conflicting but this is a natural associate of practical decision situations.

4.1.4 *Identify alternatives*

Alternatives are objects or options to be evaluate or estimate and they bring or deliver different approaches for changing the commence condition into the desired condition. If the possible numbers of alternatives is finite, we can investigate each other if it run into the conditions. The impossible ones must be deleted from the further deliberation, and we obtain the direct or plain list of the alternatives. If the possible number of the alternatives is infinite, the set of alternatives is considered as the set of the solutions fulfilling the restriction or limitation in the mathematical form of the requirements.

4.1.5 *Define criteria*

Decision criteria, which will differentiate among alternatives, must be based on the goals we are aiming towards. It is important to explain differentiating criteria as objective measures of the goals to measure how well each alternative achieves the goals. It will be useful to group together criteria into a series of sets that relate to separate and identifiable elements of the overall objective for the decision. This is particularly useful if the emerging decision structure contains a relatively large number of criteria. Grouping criteria can help the way of checking whether the set of criteria selected is right or preferable to the problem, can ease the process of calculating criteria weights in some methods, and can facilitate the emergence of higher level views of the issues.

4.1.6 *Select a decision-making tool*

There are many tools for solving a decision problem. Some types of decision making are pairwise comparison, saaty method and others. Some of the decision-making types will be briefly described or explain here, and references of further readings will also be suggested. The selection of an correct tool is not a straight foward task and rely on the concrete decision problem concerning the objectives of the decision makers. For example, regarding our situation in this project, you cannot use pairwise comparison to evaluate the response from the correspondent. This is because the pairwise methods will not give you the opportunity to compare multiple criteria against their alternatives. Sometimes the simpler the method, the better but complex decision problems may require complex methods, as well.

4.1.7 Evaluate alternatives against criteria

Every correct method for decision making needs, as input data, the evaluation of the alternatives against the criteria. Depending on the criterion, the assessment may be objective, with respect to some commonly shared and understood scale of measurement reflecting the subjective assessment of the evaluator. After the evaluations the selected decision-making tool can be applied to rank the alternatives or to select a subset of the most promising alternatives.

4.1.8 Validate solutions against problem statement

The alternatives selected by the applied decision-making tools have always to be endorsed against the requirements and goals of the decision problem. It can sometimes happen that the decision-making tool was pervert or abused. In complex problems the selected alternatives may also call the attention of the decision makers and stakeholders that further goals or requirements should be added to the decision model. Multi-Criteria Decision Analysis is important and valuable tool that we can apply to many complex decisions. It is most relevant to solving problems that are characterized as a choice among alternatives. It also brings out a unique way for people to consider and talk about complicated or complex trade-offs among alternatives. In effect it aids people think, re-think, query, adjust, decide, test, adjust, and finally decide. MCDA problems are comprised of five components and they are:

1. Goal
2. Decision maker or group of decision makers with opinions (preferences)
3. Decision alternatives
4. Evaluation criteria (interests)
5. Outcomes or consequences associated with alternative/interest combination.

4.1.9 Multi Criteria Decision Analysis

Multiple-criteria decision-making or multiple-criteria decision analysis (MCDA) is a subdiscipline of performance research that forthrightly considers multiple criteria in decision-making environments, either in our daily lives or professional settings, there are typically numerous conflicting criteria that need to be evaluated in making decisions. The steps in multi criteria decision making are:

- 1, defining the problem
- 2, determine requirements
- 3, establish goals
- 4, identifying the alternatives
- 5, define criteria
- 6, evaluate alternatives against the criteria

Regarding our study, criteria of the private cloud management tools are:

CRITERIA

C1 - Embotics vCommander Enterprise Cloud Management Software

C2 - VMTurbo Operations Manager Cloud Edition

C3 - Solarwinds Virtualization Manager

C4 - WhatsUp Gold WhatsVirtual

ALTERNATIVES

Excellent

Very good

Good

Satisfied

Where: W_i is weights of criteria

C_i is criteria and $C_i / \sum w_i$ is average.

Geomean: This is nth root of the product of numbers for the weights of criteria.

Table 10: The evaluation of criteria against alternative

W1	C1	C2	C3	C4	GEOMEAN	Ci/SUM
C1	1	6	7	8	4.28	0.66
C2	1/6	1	5	4	1.35	0.21
C3	1/7	1/5	1	3	0.54	0.08
C4	1/8	1/4	1/3	1	0.32	0.05

Source: Authors own.

4.2 Recommendations

As also ready discussed, it is very important for organization in Ghana who have or now adopting the private cloud take into consideration of purchasing private cloud management tool that will manage their private cloud environment. Therefore, it is also important for these organization to have a consider what other organization who have already adopt the private cloud and what management tools there are using. Also, to get to know why those organizations selected those tools or what they are gaining from the management tools. Not all private cloud management tool is created the same so the organizations who are going to purchase the private cloud management tool should really have a critical look on what the management to can provide or the capabilities of the tool. Organization will also have to set their goals first, thus their requirement need for choosing the tool for their business need. From our result and discussion, we had a clear description on the features or capabilities of the private cloud management tools. The management tool may provide four features or capabilities but you must ask yourself are those capabilities in full services? For example, we can have two different private cloud management tools with the same four capabilities, that is diagnostic capability, multiple platform support, resource monitoring and performance tracking. Since they all have four capabilities that not means that they will be providing the same services. Private cloud management tool one (1) may provide full services on the capabilities but private cloud management tool two (2) may provide two full services and two basic services on their capabilities. So, let's say when it comes to resources monitoring, where the tool has the ability to reclaim wasted storage and ensure your physical resources are being utilized most efficiently. A management tool with a basis monitoring might not be able to reclaim wasted storage and ensure your physical resources are being utilized most efficiently but may only reclaim wasted storage. A full management tool provides "rightsizing" reports that detail which virtual machines are consuming the most memory and storage resources. The tool will also offer reports detailing resource consumption, which show how resources are being consumed over time, and by whom. Now we can see that a tool with basis capability might not deliver full service and this might affect the organizations infrastructure when it comes to private cloud environment. In conclusion, it is very important for organization not only to consider the management tools other organizations are using but should give a critical look to the capabilities of the management tool as well.

CONCLUSION

The goal of the researcher on this project was to help organizations select private cloud management tool for their private cloud environment. These organization are mostly those who are now or about to purchase the private cloud management tool. The main aim was to preselet the management tool by know what the existing organization are already using. The general idea behind this work is the expressed or enlighten the new adopt organization to know what other private cloud management tool organizations in Ghana are using and the capabilities of the tools their are gaining. In this case it will give them a fair knowledge as well as to their business requirement before purchasing a private cloud management tool to manage their private cloud environment.

The beginning of the chapter brought about a short theoretical background of cloud computing in general and then to the types and deployment of cloud computing. It also enlighten us on uses, features or benefit of the cloud computing in general. Not mentioning how organization are also using and benefiting from private cloud. We also know how nesscesary it has become for organization to have management tools to manage their cloud environment.

As Ghana is under developing country when it comes to technology, It will be good for newly adopting organization to know what other or previous organizations are into when it comes to technology in general so that they may not end up in making poor choices.

In order to provide the information needed to compare the private cloud management tools for organizations, a quantitative research was organized in the form of an online survey. The survey was designed not just to obtain the general information about the what other private cloud management tools other organizations are using but also to know the capabilities of the tools they are using to be able to meet business requirement. The survey which included the participation of 50 respondent retrieved interesting and diversified results.

After processing the results from the survey with the word, excel and Multi Criteria Decision Making (MCDM) the weights of criteria indicated that most organization in Ghana to be precise in the eastern region are using Embotics vCommander Enterprise Cloud Management Software as their management tool for their private cloud environment and base on our evaluation it was rate as excellent. The next management tool which was rank very good which means second most use tool by the organizations is VMTurbo Operations Manager Cloud Edition. Followed by Solarwinds Virtualization Manager and WhatsUp Gold WhatsVirtual which was rank third (3rd) and forth (4th) tools used by organizations as good and satisfied.

These management tools were rank base on the capabilities of the tools. At the end of the day using Embotics vCommander Enterprise Cloud Management Software was the best tool with best capabilities comparing to the other three tools been used by other organizations. It must be clear to the organization that it is not only using Embotics vCommander Enterprise Cloud Management Software which is the best tool out there but the most important thing the organization should look for is the capability of the tool or what services the tool is providing to supports your private cloud environment.

In conclusion if the proposed recommendations are followed by the organization who are about to purchase a tool to manage their private cloud, it will improve and make their decision easy on when going to purchase the tool since they now have a clear knowledge on what other organizations are using and what they are gaining from the tool.

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