# GOING VIRTUAL
## *Popular Trend or Real Prospect for Enterprise Information Systems*

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Abstract: Organisations are faced with a number of challenges and issues in decentralised, multiple-server, physical, non-virtualized IT environments. Virtualization in recent years has had a significant impact on computing environments and has introduced benefits, including server consolidation, server and hardware utilization and reduced costs. Virtualization's popularity has led to its growth in many IT environments. This paper provides an overview of the IT challenges in non-virtualized environments and addresses the question of whether virtualization provides the solution to these IT challenges.

## 1 INTRODUCTION

Virtualization technology is not entirely new. The concept of virtualization dates back to the early 1950s when the first prototype of virtual memory was introduced. However, with the introduction of low-cost minicomputers and personal computers in the 1980s and 1990s, the use of virtualization declined. These low-cost minicomputers and personal computers led to an explosion in the number of physical servers. Due to security concerns and resource limitations, organisations relied on low-cost distributed systems. Some of the problems experienced in distributed, multi-server computing environments include underutilized servers; deployment, update and support challenges; security issues; increased physical infrastructure; human resource costs; and challenges around disaster recovery. These problems led to questions being asked about the viability of servers being consolidated and to the revival and growth of the concept of virtualization in many IT environments across all organisations.

In order for organisations to decide on virtualization as a strategy, it is important that the organisation understands the IT challenges within a non-virtualized environment and the potential benefits of virtualization as solution to these challenges. The focus of this paper is to provide an overview of the challenges in non-virtualized IT environments and the potential of virtualization addressing these challenges.

Section 2 of the paper provides some background to the concept of non-virtualized environments and virtualization. Section 3 describes the research process followed. The IT challenges in non-virtualized environments are discussed in section 4, while the potential of virtualization to solve these IT challenges is detailed in section 5. Section 6 concludes the paper.

## 2 BACKGROUND

Virtualization enables multiple operating systems and applications to run concurrently and in isolation on a single physical host machine. It furthermore enables multiple virtual machines to share in the resources of the physical host machine, which in turn ensures better utilization, optimization and resource efficiency (Microsoft Corporation, 2009, VMware Inc., 2009, Perri, 2008, Killalea, 2008, Campbell and Jeronimo, 2006, Singh, 2004).

A typical virtual environment is depicted in Figure 1 illustrating the concepts of multiple virtual machines running on and utilizing a single host operating system and the physical computer hardware. The virtualization layer- / hypervisor runs on the physical hardware and is responsible for the hosting and managing of the virtual machines.


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Different applications and operating system versions can therefore run simultaneously on the one physical host machine.

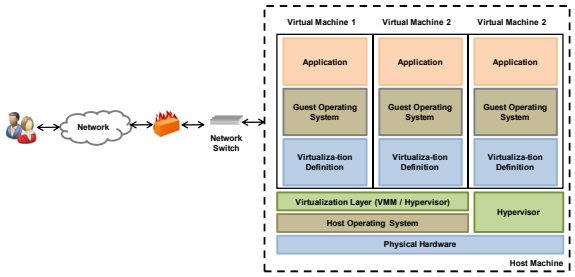


Figure 1: Virtual environment.

Virtualization was introduced as early as the 1950s through initiation of automatic page replacement and was the first working prototype of virtual memory (Campbell and Jeronimo, 2006, Singh, 2004). The first virtual machines (VMs) introduced in the early 1960s were based on the concept of self-virtualizing processor instructions. The virtual machine allowed users to run multiple operating systems on a single processor machine. This concept was enhanced during the mid-1960s with the emergence of time sharing. Hardware virtualization was introduced next.

By the mid-1970s virtualization was well established and organisations enjoyed benefits such as increased storage (memory) capability, expanded system capacity, less complex programming, increased production and cost effectiveness.

Virtualization usage declined with the introduction of low-cost minicomputers and personal computers in the 1980s and 1990s. Placing more than one application on a server was not a viable option, and rather than sharing resources centrally, organisations relied on low-cost distributed systems. This resulted in underutilized servers, change management challenges, security issues, increased costs, and disaster recovery challenges (Campbell and Jeronimo, 2006, Singh, 2004, Killalea, 2008).

Options such as consolidation, better resource utilization and security controls were investigated and virtualization was reintroduced during 1997 when Mendel Rosenblum (Stanford University) used virtual machines to run multiple commodity operating systems on a single scalable commodity PC (Killalea, 2008). Through utilization of VMware during 1998, they further enhanced virtual machine capability by running multiple instances of x86-compatible operating systems on a single commodity PC. Xen, an open source VMM (virtual machine monitor), was released during 2003, allowing multiple commodity operating systems to share conventional hardware effectively. During 2007 the major operating system vendors (Microsoft, Oracle, Red Hat and Sun) announced significant virtualization capabilities (Campbell and Jeronimo, 2006, Singh, 2004, Killalea, 2008).

EMA (2008) estimates in their research report that the virtualization market will grow by 20 percent on average for all virtualization technologies during 2009 and 2010. In a report published by Catbird Networks (2008) it is stated that virtualization is expanding into mission critical and core processing functions. Currently there are claims that virtualization is being widely adopted (NetIQ Corporation, 2009), is becoming the standard infrastructure for data centres (Killalea, 2008) and that its popularity is due to the promise of quick deployment and cost savings (Perri, 2008, Singh, 2004).

The history and development of virtualization is graphically depicted in Figure 2, from the IBM Virtual Machine in the 1960s, up until recently in 2007 and beyond.

# 3 RESEARCH FOCUS AND METHOD

With the emergence of low-cost minicomputers and personal computers, management no longer needed to incur the cost of expensive mainframe systems. This led to an explosion in server numbers, as placing more than one application on a server creates security, management and compliance concerns. Non-virtualized environments are therefore characterized by multiple servers (i.e. a server for each application, different servers for different operating systems, web-, database-, development-, testing- and back-up or replication-servers) as shown in Figure 3. As a result IT resources, server, maintenance, physical environmental and management costs are becoming a predicament in these non-virtualized IT environments.

In order to appreciate the host of benefits introduced through virtualization, it is imperative to understand the challenges experienced in non-virtualized environments. The benefits derived from virtualization are a direct result of these IT challenges, as described in the latter part of this paper.

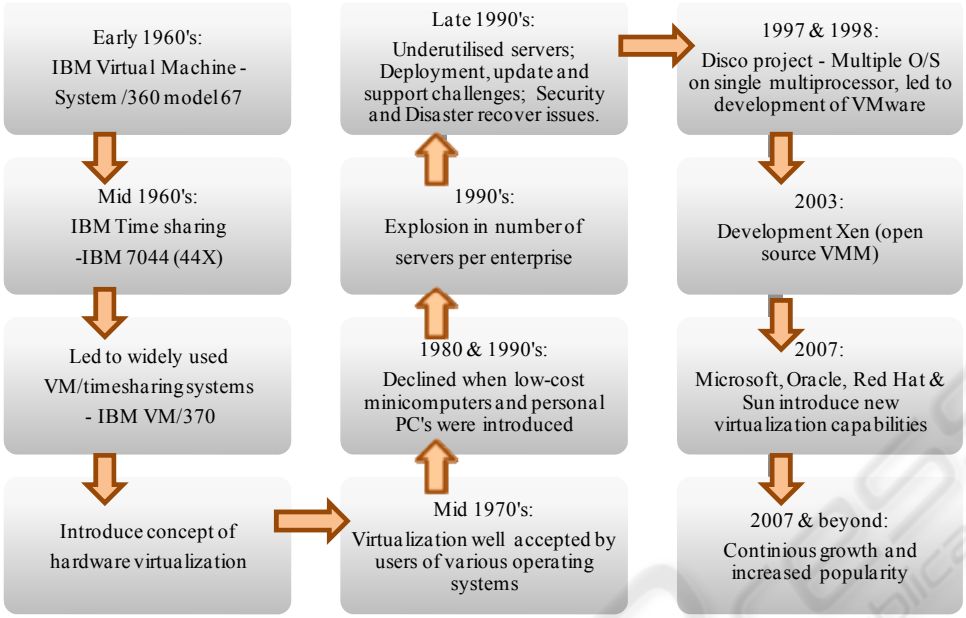


Figure 2: History and development of virtualization (Campbell and Jeronimo, 2006, Singh, 2004, Killalea, 2008).

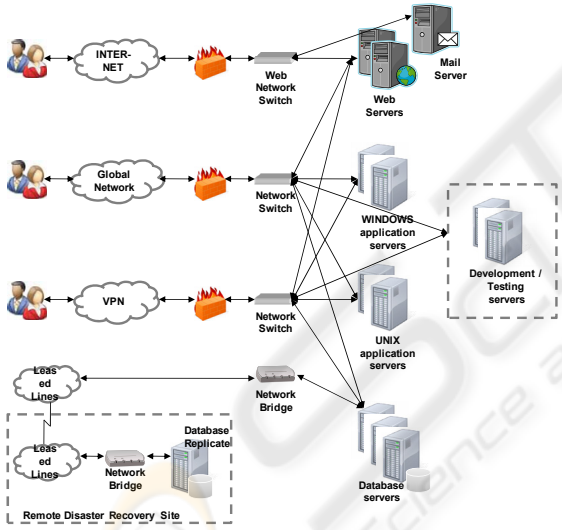


Figure 3: Non-virtualized environment.

This article reviews the challenges in non-virtualized IT environments and discusses the prospect of virtualization as a solution to these challenges within the context of enterprise-wide information systems.

The review was mainly based on a literature study, conducting a contextual analysis to identify the challenges and the proposed solutions provided through virtualization. The literature study followed an inductive reasoning approach, using representative secondary resources (selecting a sample of work or texts in order to understand and conceptualise the necessary information). These resources included available databases online library catalogues, published articles, relevant textbooks, industry specific information and trusted resources from the internet. The construction research method was followed to derive, analyse and present a summary from the literature survey through interpretive research.

Section 4 presents the challenges identified, whilst section 5 discusses how virtualization may provide a solution to these challenges.

## 4 IT CHALLENGES IN NON-VIRTUALIZED ENVIRONMENTS

During the review and analysis of the literature, server proliferation was found to be the most common challenge in non-virtualized environments (Figure 4). Other concerns include high costs, being unable to run more than one operating system on a machine, and change management. Centralization was the concern mentioned the least in the literature. Each of these challenges is briefly discussed below.

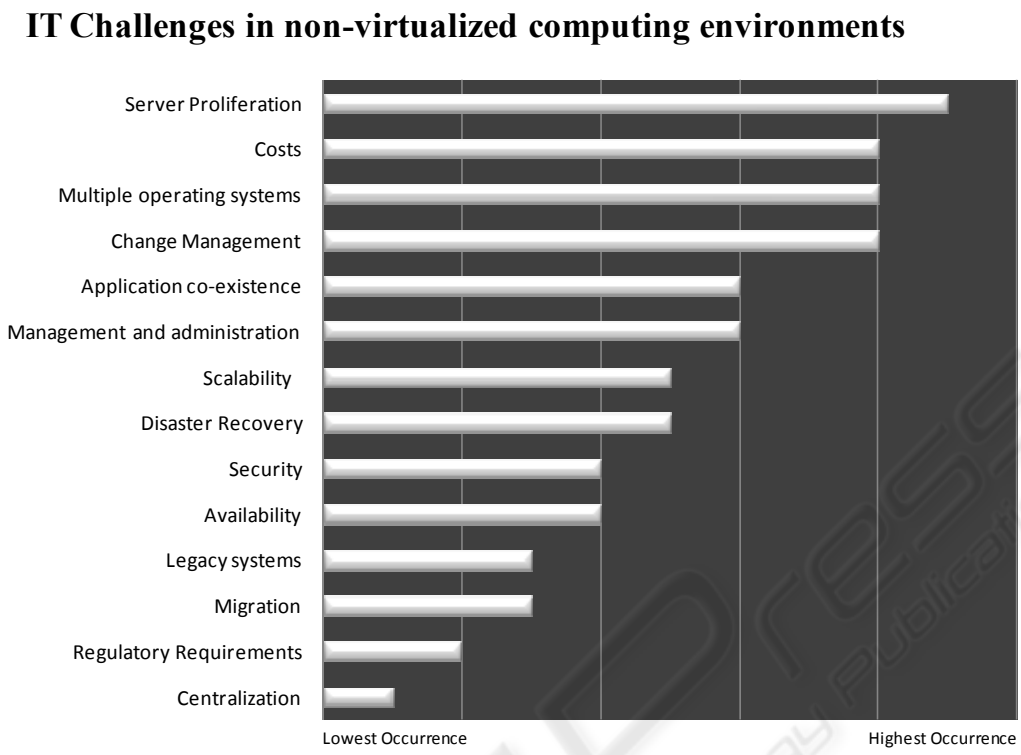


Figure 4: IT challenges in non-virtualized environments.

- *Server proliferation:* Vulnerability to software faults, security threats, the inability of applications to co-exist on a single server, scalability considerations and avoiding a single point of failure have led to the implementation of multiple servers or server silos. This, in turn, introduced a host of problems such as: underutilization of resources; deployment, update and support challenges; management and administration issues and costs; additional data centre costs; and operational complexities (Sgallari, 2009, Hewlett Packard Development Company, 2009, Qureshi, 2007, VMware Inc., 2006, Nellitheertha, 2006, Humphreys and Grieser, 2006, Campbell and Jeronimo, 2006, Singh, 2004).
- *Costs:* The proliferation of servers and decentralised nature of non-virtualized IT environments led to increased environmental, management and administration costs. These costs include: power and cooling; floor space; physical hardware; software licences; application support; deployments and updates; labour; resource requirements; and redundancy. Such costs are leading to increased total cost of ownership (TCO) and a reduced return on investment (ROI) (Sgallari, 2009, Hewlett Packard Development Company, 2009, Qureshi, 2007, VMware Inc., 2006, Nellitheertha, 2006, Campbell and Jeronimo, 2006, Singh, 2004).
- *Multiple operating systems:* Non-virtualized environments are characterised by the inability to run multiple operating systems, different versions or even entirely different systems simultaneously, because the operating systems are bound to the underlying physical hardware. Some of these systems may also be difficult or impossible to run on newer hardware. This impedes the ability to freely load-balance resources and to ensure resource utilization (Sgallari, 2009, Hewlett Packard Development Company, 2009, Qureshi, 2007, VMware Inc., 2006, Nellitheertha, 2006, Campbell and Jeronimo, 2006, Singh, 2004).
- *Change management:* Server proliferation further complicates the ability to adapt smoothly to changes in demand for services and it also complicates the process of patching, upgrading, troubleshooting and maintaining operating system and application software. Another challenge is machine unavailability while performing maintenance. Furthermore, debugging and performance monitoring lead to loss in productivity. High costs are also associated with the setup of separate test and development environments to ensure that changes are subjected to proper change

and test management (Sgallari, 2009, Hewlett Packard Development Company, 2009, Qureshi, 2007, VMware Inc., 2006, Nellitheertha, 2006, Campbell and Jeronimo, 2006, Singh, 2004).

- *Application co-existence*: Many applications are not written to co-exist within a single execution environment and often create conflict. Single application workloads also do not scale well as demand increases. The cost due to underutilization and management complexity increases (Singh, 2004, Campbell and Jeronimo, 2006, Humphreys and Grieser, 2006, Nellitheertha, 2006, VMware Inc., 2006, Qureshi, 2007).
- *Management and administration:* Multi-server, decentralised environments lead to complex and difficult management and administration of the server, data centre and desktop infrastructures. More servers require more administration. Complexities in infrastructure management further lead to a decrease in productivity and efficiency (Singh, 2004, Campbell and Jeronimo, 2006, Nellitheertha, 2006, Qureshi, 2007, Hewlett Packard Development Company, 2009).
- *Scalability*: The ability to deploy new services and responsiveness in supporting new business initiatives or organisational changes is critical to remain competitive. As the organisation grows – and the number of users who could encounter installation and upgrade problems increases –the support burden for the roll-out of IT-approved and tested systems and application software increases. As the number of machines increases, manual patching, upgrading and maintaining operating system and application software simply does not scale well. In data centres scalability is often achieved by deploying more physical hardware to meet demand. This entails acquiring new machines or additional resources, which can be expensive to maintain (Campbell and Jeronimo, 2006, VMware Inc., 2006, Qureshi, 2007, Sgallari, 2009).
- *Disaster recovery*: With disaster recovery in non-virtualized environments, users typically experience a delay as administrators prepare a new server and recover the data if a failure occurs. Back-up and restores also impact availability of systems. Maintaining mirrored or replicated servers for back-up and recovery purposes is expensive (Singh, 2004, Campbell and Jeronimo, 2006, Hewlett Packard Development Company, 2009, Sgallari, 2009).
- *Security*: Security threats include system breaches and data theft. Having to patch or upgrade a critical server can also result in unacceptable system downtime. As a result, it is not unusual for servers to continue to run unpatched software long after a security exploit has been discovered and a software vendor has released a patch for it, which also means non-compliance with change management policies (Singh, 2004, Campbell and Jeronimo, 2006, Nellitheertha, 2006, Qureshi, 2007).
- *Availability*: Enterprises provide for excess capacity in terms of resources, computing power, storage and bandwidth to ensure availability. Preparing separate machines for software updates for back-up and restore purposes of prior versions, requires additional hardware, or taking down the currently running servers to update them, which impacts availability. Physical hardware failures further augment unavailability of systems. To prevent this, redundancy is built into the IT infrastructure, but at an exponential cost (Campbell and Jeronimo, 2006, Nellitheertha, 2006, Hewlett Packard Development Company, 2009, Sgallari, 2009).
- *Legacy systems*: To maintain the continuity of the business, the IT department must keep potentially unsupported and obsolete operating systems and applications for legacy or in-house developed systems up and running. Porting the older programs to the new operating systems is a potential solution, but is usually not an option because of the costs associated with software development. Co-existence with other applications on the same server is not a viable option because of security, compatibility, or data integrity issues (Singh, 2004, Campbell and Jeronimo, 2006, Nellitheertha, 2006).
- *Migration:* Application migration provides difficulties such as 1) balancing downtime; 2) optimal total migration time; 3) dependence on operating system resources such as file descriptors, network connections and shared memory segments; and 4) the requirement that the original machine remain available in some instances, thereby preventing administrators from taking down the original machine for servicing. Difficulty is also experienced in terms of the complexity of hardware upgrade cycles for notebook computers, requiring the users to migrate their customized environments and data to the new machines (Singh, 2004, Campbell and Jeronimo, 2006, Nellitheertha, 2006, Qureshi, 2007).
- *Regulatory requirements*: There is a climate of increasingly stringent regulatory requirements that IT management and teams must adhere to (VMware Inc., 2006, Qureshi, 2007).
- *Centralization:* Server proliferation and the management of cost versus security threats have led to the decentralization of data centres and servers, communication and desktops. Decentralized

environments require specialists in different platforms on each site, as well as a database administrator and infrastructure administrator (Sgallari, 2009).

# 5 VIRTUALIZATION AS SOLUTION TO CHALLENGES IDENTIFIED

Virtualization introduces many benefits, hence the rapid growth of the technology and adaption of virtualization by the majority of organisations. The actuality of virtualization providing a solution to IT challenges in non-virtualized environments is widely acknowledged. For example, Qureshi (2007:1) states that " ... there are bright spots on the horizon – technological innovations that promise to help IT departments cope with these challenges. Among these, virtualization technology is a top contender for providing relief". Nellitheertha (2006:2) also indicates that "virtualization is an efficient means of addressing these problems". EMA (2008:11) states that "there is little doubt that virtualization is delivering significant value – both measurable and intangible – to the majority of enterprises that are deploying it". Humphreys and Grieser (2006:1) concur with these statements when indicating that over the past years virtualization was made an important solution for scaled-out hardware resource sharing. Hewlett Packard Development Company (2009) states that "...the technology is established as a proven solution for increasing server hardware utilizations, consolidating existing servers, controlling physical server sprawl while making it faster and easier to deploy new servers all while reducing costs".

Virtualization's potential to solve the IT challenges, identified in section 4 are as follows:

- *Server proliferation*: A widely acknowledged primary benefit of virtualization is the ability of this technology to consolidate servers, thereby increasing utilization and reducing costs (Bass, 2009, Berman, 2009, Campbell and Jeronimo, 2006, Check Point Software Technologies Ltd., 2009, Enterprise Management Associates, 2008, Gardner, 2009, Hewlett Packard Development Company, 2009, Hoesing, 2006, Humphreys and Grieser, 2006, Killalea, 2008, Nellitheertha, 2006, Qureshi, 2007, Robb, 2008, Sgallari, 2009, Singh, 2004, Sun Microsystems Inc., 2009, VMware Inc., 2006).
- *Costs*: Mentioned by more than half of the sources considered and widely regarded as one of the main advantages of virtualization is the reduction in costs. These include hardware, administration and management, energy efficiency (i.e. power and cooling), and software costs (Berman, 2009, Campbell and Jeronimo, 2006, Enterprise Management Associates, 2008, Gardner, 2009, Hewlett Packard Development Company, 2009, Hoesing, 2006, Nellitheertha, 2006, Newman, 2009, Novell Inc., 2008, Perri, 2008, Qureshi, 2007, Robb, 2008, Senft and Gallegos, 2009, Sgallari, 2009, Singh, 2004, Strom, 2008, Sun Microsystems Inc., 2009, VMware Inc., 2006).
- *Multiple operating systems:* Virtualization technology has the ability to host multiple operating systems of different platforms (i.e. Windows and UNIX) on a single server. This consolidation of servers also increases resource sharing and therefore leads to better utilization of hardware and servers (Campbell and Jeronimo, 2006, Hewlett Packard Development Company, 2009, Humphreys and Grieser, 2006, Killalea, 2008, Nellitheertha, 2006, Singh, 2004, VMware Inc., 2006).
- *Change management*: IT's ability to deploy changes quickly and efficiently is greatly enhanced, given the ability of VMs to be suspended, resumed and migrated across physical platforms without interrupting service availability. Other advantages include 1) enforcement of company policy through pre-configured VM images and 2) easy distribution of changes (Bass, 2009, Campbell and Jeronimo, 2006, Enterprise Management Associates, 2008, Gardner, 2009, Haber, 2009, Hewlett Packard Development Company, 2009, Hoesing, 2006, Humphreys and Grieser, 2006, Killalea, 2008, Nellitheertha, 2006, Newman, 2009, Novell Inc., 2008, Perri, 2008, Qureshi, 2007, Robb, 2008, Senft and Gallegos, 2009, Sgallari, 2009, Singh, 2004, Strom, 2008, VMware Inc., 2006).
- *Application co-existence*: "Virtualization lets you run multiple virtual machines on a single physical machine, sharing the resources of that single computer across multiple environments. Different virtual machines can run different operating systems and multiple applications on the same physical computer" (VMware Inc., 2009).
- *Management and administration*: Ease of administration and management include 1) simplifying server management and maintenance by reducing the number of servers (consolidation); 2) higher availability due to easy deployment of VM images, making backup and recovery easier and more manageable; 3) easier and quicker deployment options; 4) flexibility to be responsive and adaptable to changing needs with speed and agility; 5) quick

live migrations; 6) reduced downtime; 7) adequate, effective and feasible development and testing environments; and 8) powerful debugging and performance monitoring capabilities (Campbell and Jeronimo, 2006, Gardner, 2009, Hiner, 2009, Humphreys and Grieser, 2006, Nellitheertha, 2006, Novell Inc., 2008, Strom, 2008, VMware Inc., 2006).

- *Scalability*: The following contribute to the ability of an IT department to respond quickly to organisational changes: 1) running different operating systems simultaneously on a single platform; 2) duplicating and moving VMs seamlessly between different hosts; and 3) the ease and efficiency of deploying changes (Berman, 2009, Campbell and Jeronimo, 2006, Hernandez, 2009, Humphreys and Grieser, 2006, Killalea, 2008, Nellitheertha, 2006).
- *Disaster recovery*: Virtualization provides a more cost-effective and less complex solution to replication and redundancy strategies. Data backup capabilities are enhanced through virtualization's snapshot (portable file) feature. Other benefits include: 1) saving on hardware costs for disaster recovery; 2) reducing time to restore services; and 3) cost savings by migrating VMs between sites (Bass, 2009, Campbell and Jeronimo, 2006, Enterprise Management Associates, 2008, Gardner, 2009, Hewlett Packard Development Company, 2009, Hoesing, 2006, Humphreys and Grieser, 2006, Killalea, 2008, Nellitheertha, 2006, Newman, 2009, Perri, 2008, Robb, 2008, Sgallari, 2009, Singh, 2004, Sun Microsystems Inc., 2009).
- *Security*: It is possible to create separate isolated VMs and thereby reduce potential security risks. IT security policy enforcement is less complex when applied per VM and it also enhances administrative control of resources (Campbell and Jeronimo, 2006, Check Point Software Technologies Ltd., 2009, Enterprise Management Associates, 2008, Killalea, 2008, Nellitheertha, 2006, Novell Inc., 2008, Qureshi, 2007, Senft and Gallegos, 2009).
- *Availability*: Virtualization technology enables a VM to be moved dynamically, "on the fly", to other hardware platforms with little or no effect on the user. This means that VMs can be migrated while the applications continue to run. System downtime is therefore eliminated or reduced (Bass, 2009, Campbell and Jeronimo, 2006, Enterprise Management Associates, 2008, Gardner, 2009, Hewlett Packard Development Company, 2009, Hoesing, 2006, Humphreys and Grieser, 2006, Killalea, 2008, Nellitheertha, 2006, Newman, 2009, Perri, 2008, Robb, 2008, Sgallari, 2009, Singh, 2004, Sun Microsystems Inc., 2009).
- *Legacy systems*: Virtualization's ability to run multiple operating systems within one physical environment enables IT scenarios where legacy operating systems need to run side by side with modern systems (Campbell and Jeronimo, 2006, Humphreys and Grieser, 2006, Killalea, 2008, Nellitheertha, 2006, Newman, 2009, Singh, 2004, VMware Inc., 2006).
- *Migration*: VMs (operating systems or applications) can be moved automatically or manually between platforms with little effort. The migration is validated in virtual partitions and therefore lessens the possibilities of service disruptions (Campbell and Jeronimo, 2006, Humphreys and Grieser, 2006, Killalea, 2008, Nellitheertha, 2006, Novell Inc., 2008, Perri, 2008, Qureshi, 2007, Singh, 2004, VMware Inc., 2006).
- *Regulatory requirement s*: There is no reason why a virtualized environment should not conform to regulatory requirements. Virtualization however lessens the management and administration burden and therefore makes the implementation and management of regulatory requirements easier.
- *Centralization*: Consolidation and better utilization of resources have led to the reduction in system administration cost, responsibility and increased productivity, as well as to the centralization of systems (Bass, 2009, Berman, 2009, Campbell and Jeronimo, 2006, Check Point Software Technologies Ltd., 2009, Enterprise Management Associates, 2008, Gardner, 2009, Hewlett Packard Development Company, 2009, Hoesing, 2006, Humphreys and Grieser, 2006, Killalea, 2008, Nellitheertha, 2006, Qureshi, 2007, Robb, 2008, Sgallari, 2009, Singh, 2004, Sun Microsystems Inc., 2009, VMware Inc., 2006).

It can therefore be concluded that the benefits of virtualization are a direct result of having to deal with the IT challenges in non-virtualized environments. Virtualization has been presented as the solution to these challenges, hence the popularity of this technology.

# 6 CONCLUSIONS

In this paper the focus was on providing an overview of the challenges experienced in non-virtualized IT environments and to discuss virtualization as a solution to these challenges. The main challenge in non-virtualized environments was identified to be

server proliferation, which led to underutilization of resources, change management challenges, management and administration issues and costs, additional data centre and other hardware and software costs, and operational complexities. A number of these challenges in the non-virtualized environment have the potential to be addressed through virtualization. In this paper an overview were given of the different solutions suggested in literature, including the consolidation of multiple operating systems and applications to co-exist on a single platform, reduction in costs, better resource utilization, quick and efficient change management, ease of administration and management, scalability, cost-effective and less complex disaster recovery solutions, increased security and reduced system downtime.

Virtualization has shown tremendous growth and increasing popularity in recent years. The major benefits of implementing virtualization are based on IT challenges experienced in non-virtualized environments. It is also highlighted in the literature that virtualization will continue to grow in the years to come - especially given that cloud computing uses virtualization as a technology for enablement. In future research it is necessary to address the importance of virtualization in a cloud environment and also to investigate the benefits and risks introduced by virtualization. Virtualization is therefore not just another popular trend: it is providing a solution to IT challenges experienced in non-virtualized environments.

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