Extended Essay

Virtualization and the effects of implementing it in Schools and Industries

Subject: Information Technology in a Global Society

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Abstract:

"Can the use of virtualization in Industries and Schools increase efficiency and productivity: are the benefits greater than the side-effects?"

This essay analyses the impact that the recent rise of virtualization has had on the information technology sector. Many companies have migrated to virtual systems, to make work easier, but this also comes with several risks which can affect both industries and schools.

The first section, explores the rise of the virtualization, and how every minor decision made by the industry affects the industries and the stakeholder, seeing the multi-nodal values of each. Next, the social, economic, and ethical sections explore the implications of such a technology and the impact it has on the stakeholders on the way they operate on a day-to-day basis. One of the biggest problems everyone faces is that of the privacy and security of the data of the individual. This is sacrosanct.

I conducted both primary and secondary research, and used the former to validate the latter. I took a survey of the students from Grade 9 to Grade 12 in my school, as well as members from the administrative team and industries. I also took interviews of Peter Zeglis, Vice President (Asia-Pacific-Japan) at VMware and Kapil Patil, IT Head at Aditya Birla World Academy (ABWA).

The results showed that most people expect virtualization to be the next step for industries as well as schools. Analysis showed the main problem to be the same mentioned above, which can be tackled through various solutions.

Savings, cost-effectiveness, smartness and ease of access has ensured the virtualization is important and here to stay to help improve schools, industries and create new job opportunities.

Word Count: 275

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Introduction

The rise of the innocent beast, Information Technology, has led to upgrades in living standards across the planet. Who would have thought few decades ago that we could connect up with data from servers several miles away? However, despite the paradigm shift it has made in the way we communicate today, several social and ethical issues circumnavigate it and burning questions appear: is it safe? Is it more productive? Is it cost-effective?

I have written my essay in Information Technology in a Global Society. Though I am not currently doing a course in this, I have an interest in the subject; especially the manner in which the virtual revolution is affecting society. My initial interest was in Facebook, but after an internship at VMware, Singapore, I learnt that several companies use virtualization and as an active user of the cloud, this topic caught my interest and I switched researching to this.

Virtualization (a.k.a V12N) is a relatively new industry, yet from its very genesis in the late twentieth century it has had immense potential. Whilst we learn more about this recent technology we will discover new uses and threats.

Thus I came to the research question:

"Can the use of virtualization in Industries and Schools increase efficiency and productivity: are the benefits greater than the side-effects?"

This essay covers the social and ethical implications of this technology and the economic impacts of its implementation in schools and industries, measuring the benefits against risks.

Section 1: Virtualization, IT and its History

Virtualization allows a physical server or device to simulate several virtual servers or devices, of the same type. They have the same functions and external interfaces[1], but differ in attributes, such as size, performance and cost. Recent 32-bit processors (x86 processors) are only built to run a single Operating System (OS)[2] and application software, leaving the machines underutilized.

Virtualization helps run several virtual machines on one physical machine while making the system believes it is running only one i.e. the **Virtualization System Software**. The traditional architecture of a server (see picture) is a single OS and an application.
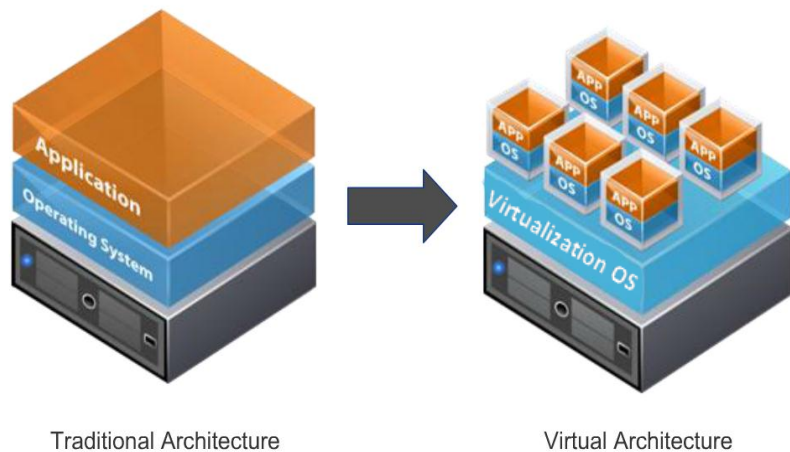

Figure 1: The Different Computer Architechures

With virtualization, the architecture shifts, where the Virtualization OS is the base, on which several traditional machines run; i.e., it is running several virtual machines (VMs). VMs are combinations of applications and OS that share the resources from the data pool of the physical server.

Virtual systems function through three properties[3]. The first, **Partitioning**, is the division of resources among the VMs. Since VMs share resources from the physical server, there is a limitation to how many machines can be run on the system depending on the CPU, memory, network, etc.; however this is the only hardware limitation. Next, **Isolation** helps isolate and find

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[1]VMware. (n.d.). What is Virtualization? Retrieved June 1, 2012, from VMware:
http://www.vmware.com/virtualization/what-is-virtualization.html

[2]VMware. (n.d.). *History of Virtualization, VM, Server Consolidation*. Retrieved July 5, 2012, from VMware:
http://www.vmware.com/mx/virtualization/virtualization-basics/history.html

[3] VMware. (2012, April 7). *VMware Events*. Retrieved July 2, 2012, from VMware Webcast Series:
http://event.on24.com/r.htm?e=440466&s=1&k=33C623CF41DA05004B97B6D946F3CBCE

any bug in the system. Lastly, **Encapsulation**; all VMs are condensed into normal files and can undergo Virtual to Virtual (V2V) or Physical to Virtual (P2V) transfer.

Each VM appears to be real – to clients that connect to them they are traditional machines with dedicated hardware. The VM is also allowed to run all the input-output devices connected to the server, consolidating "real" machines on a physical server.

Virtualization was first initialized in 1964 by IBM on the project CP–40, now the parent of IBM virtual systems. By 1970 they built a newer model with virtual memory. 1985 onwards Intel started on the same lines, building VMs for customers and a decade later VMware started. We are rolling into the third era of virtualization deployment (3.0), which is taking on cloudlike attributes for highly virtualized and automatically managed organizations[4].

There are six main kinds of virtualization[5]: Hardware, Storage, Desktop, Software, Memory and Network. In industries and schools four kinds of virtualization that are currently most commonly used and are of benefit are: hardware, software, storage and desktop virtualization. Therefore we will only be analyzing these four methods of virtualization to increase efficiency and productivity and understand if their benefits are greater than their side effects.

Hardware virtualization is the virtualization of a machine e.g. servers, and is the most commonly used virtualization service. **Storage** virtualization is the abstraction of logical storage, i.e., the removal of usable partitions and space from the physical storage to make more partitions and/or virtual disks. **Desktop** virtualization separates the PC-desktop environment from the physical desktop, allowing users to access the same desktop environment from different locations. It shares the PC over the IP of the internet connection being established, i.e., PCoIP. **Software** virtualization runs multiple environments or operating systems on a single instance of the main OS.

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[4] Milberg, K. (2009, September 29). *IBM and HP Virtualization*. Retrieved July 2, 2012, from developerWorks: http://www.ibm.com/developerworks/aix/library/au-aixhpvirtualization/index.html

[5] decipherinfosys. (2009, February 12). *Virtualization Basics and the different types of Virtualization « Systems Engineering and RDBMS*. Retrieved July 2, 2012, from Wordpress: http://decipherinfosys.wordpress.com/2009/02/12/virtualization-basics-and-the-different-types-of-virtualization/

Section 2: Social Implications of Virtualization

The development of IT systems has an impact on society, specifically the consumer. Social issues enlist as follows: reliability, stability, integrity and cultural ramifications.

In a virtualized company, the reliability of the hardware, software and state of their co-existence is examined. Unlike other servers where the OS can only be installed on a particular configuration of hardware, virtualization OS can be installed on almost any server. The speed depends on the server configuration: CPU speed, the access speed of the hard-drive and amount of RAM.

A virtual system gives stability to the physical system. It enables the user to have a united, simple view of the resources on the network and easy access to them irrespective of the location. This system helps users reduce the overall management of the environment, and provides interoperability, leading to increased reliability of the system.

[6]During the course of my research I did an internship at **VMware**. One of the main aspects of their system is the dynamic sharing of the resources through a program called '**HYPERVISOR'**. It ensures that every machine under every data centre under every server
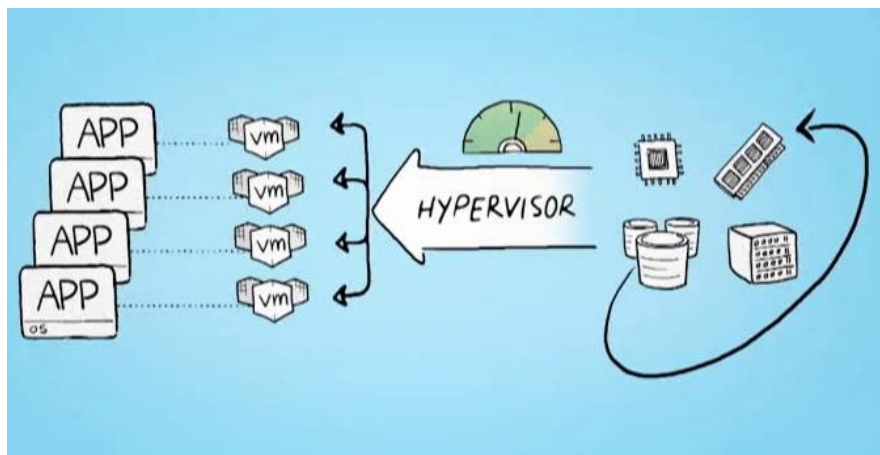
Figure 2: Process of the Hypervisor

has access to all resources to ensure peak performance. In case another client-side computer needs more resources than what has been assigned, these are automatically re-routed, ensuring

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[6]Figure 2: VMware. (n.d.). *Video*. Retrieved July 2012, from Video:
http://admin.brightcove.com/viewer/us20120705.1016/BrightcoveBootloader.swf?playerID=167300424
0001&playerKey=AQ~~%2CAAAABZT3vhQE~%2CBjUqi80WkWbbGR_I0RDyGtmSiFoAXSRo&%40videoPlay
er=1708110718001&autoStart=&bgcolor=%23FFFFFF&debuggerID=&dynamicStreaming=true

no loss in work as well as a quicker and simpler job for the IT Department as compared to installing new resources all together.

Developments like Morse code, the ARPAnet (for the US Army) and more recently, the Internet, have led to the increase in connectivity over borders. Extending this notion, virtualization diminishes geographic, political and economic boundaries, helping in globalization and making everyone a "Digital Citizen". Having this citizenship however doesn't isolate the client from his/her own cultural background, but simultaneously broadens perceptions.

Virtualization aids human faculties by easing and smoothening work. This technological development does not cause job loss as it has been made with the key purpose of increasing efficiencies of machines.

Section 3: Benefits of Virtualization

For academia and industries that have budget constraints, virtualization provides a "more with less" deal. After 2010, a virtual system is able to provide task such as VM configuration, lifecycle management of the entire system and policy based management. These systems also provide disaster recovery.

On a national level, the government takes interest in the country's progress. With a decreased carbon footprint, virtualization makes the country greener, reducing the load of thousands of servers to only a handful. I used a case study on Amway for my research.

Section 3.1 Benefit to Industries

The graph on the below shows the different industries who preferred installing virtualization rather than the hard drive itself:
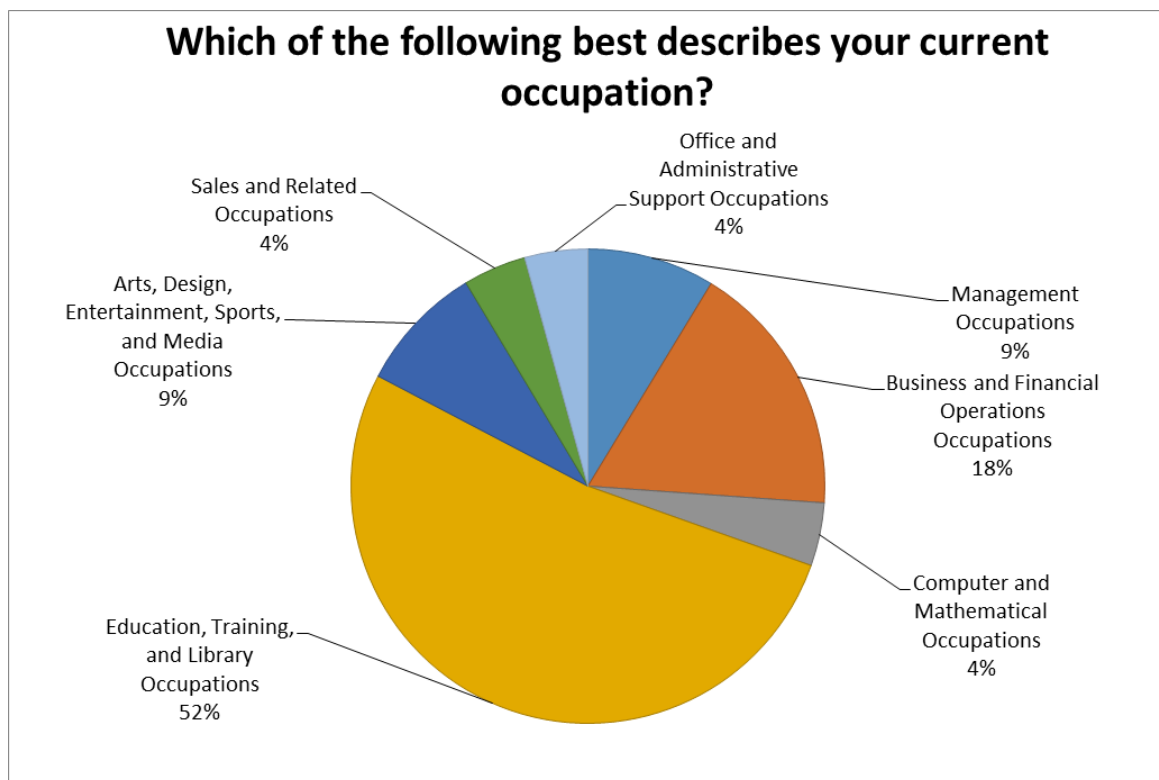
Graph 1: Occupations of the Industries surveyed[7]

To ensure a fast and smooth business, the IT system needs to be able and agile. Amway uses VMs to consolidate hosts while improving the reliability and manageability of its technology

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[7] Appendix B: Survey of 23 Industries

infrastructure increasing the company's efficiency and taking advantage of the 'economies of scale'. The company has over 13,000 employees and 3 million partners. They maintain records for each partner and give each partner dedicated server space. They are **60%** virtualized and certain smaller sites in Europe are a **100%** virtualized[8]. They have not implemented any kind of software virtualization as their main deployment is the creation of virtual servers and as of 2009 also includes virtual desktop solutions. To virtualize hardware they have a Server Consolidation Ratio (SCR: number of virtual servers in one physical server) of 25:1. Desktop virtualization, which has been implemented in *PILOT* mode, i.e., under test in a particular department or section of the company to assess the system, involves as of now 2,500 desktops. Implementing them at such a fast rate mainly revolves around their aim of reducing the service costs to the company. It allows Amway to store all their desktop data in one centralized datacentre under a virtual infrastructure, providing an uncompromised user experience and virtual desktop interface (VDI). A VDI makes desktop provisioning simpler – rather than buying an entirely new infrastructure, a new virtual desktop can be created for clients. This partition will also reduce the labour as well as the cost to deploy new applications in the entire organization. The partner can access this desktop from any part of the world as long as the credentials are right, making meetings easier and more interactive.

The entire VDI environment depends on one simple feature which makes and breaks it, that is, the requirement to connect to a virtual private network (VPN).

After a TCO (Total Cost of Ownership) analysis, Amway said that after three years they will see a $4million savings especially in areas like power and desktop deployment costs. The diagram to the right shows the reduction in server rooms and general costing before and after virtualization. The costs
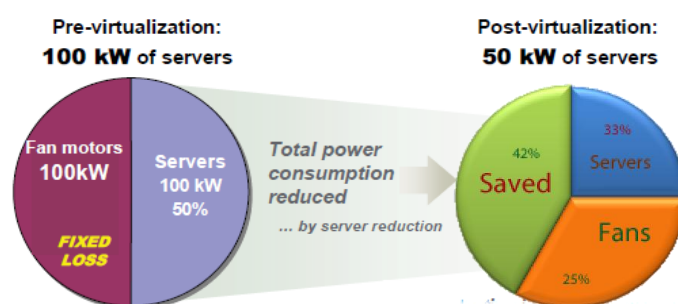

Figure 3: Savings through virtualization

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[8] VMware. (2010). *AMWAY Case Study.* Palo Alto: VMware.

of fans and servers are reduced and the savings are increased helping the company generate an increase in profits.

In the survey conducted, 60.9% per cent said that they would prefer using Virtual Servers over using Hard Drives[9] primarily because the data is secure on a server, time is saved in accessing the data from anywhere and centralized data is more uniform and easily available. Hence they will use less energy and will gain carbon credits for the same, helping to increase sales.

Section 3.2 Benefit to Schools

"I'm in the line of business where you only hear from your customer when something goes wrong – so if you don't hear from them, it's a good thing." said the Chief Information Officer of the National Institute of Education (NIE)[10]

NIE (Singapore) is an institution that migrated to virtualization for their main I.T infrastructure. Along with a 99.5% uptime, an improvement from the previous average 60-70% of multiple physical servers, they achieved a recovery time down from three days to thirty minutes, 0.69% of the time taken. In a physical system, if the server breaks down, the hardware would first need to be configured, after which the OS will be installed, reconfigured according to the manufacturers settings and finally recovery will start. In a virtual system, only the VM in which the problem has occurred needs to be restored and then restarted which takes between thirty minutes to around three hours.

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[9] Appendix B: Survey of 23 Industries
[10] VMware. (2011). *NIE Case Study.* Palo Alto: VMware.

Do you use any cloud service (Dropbox, Skydrive, iCloud or Google Docs) to store or access any of your data?

Graph 2: Users of Cloud Services
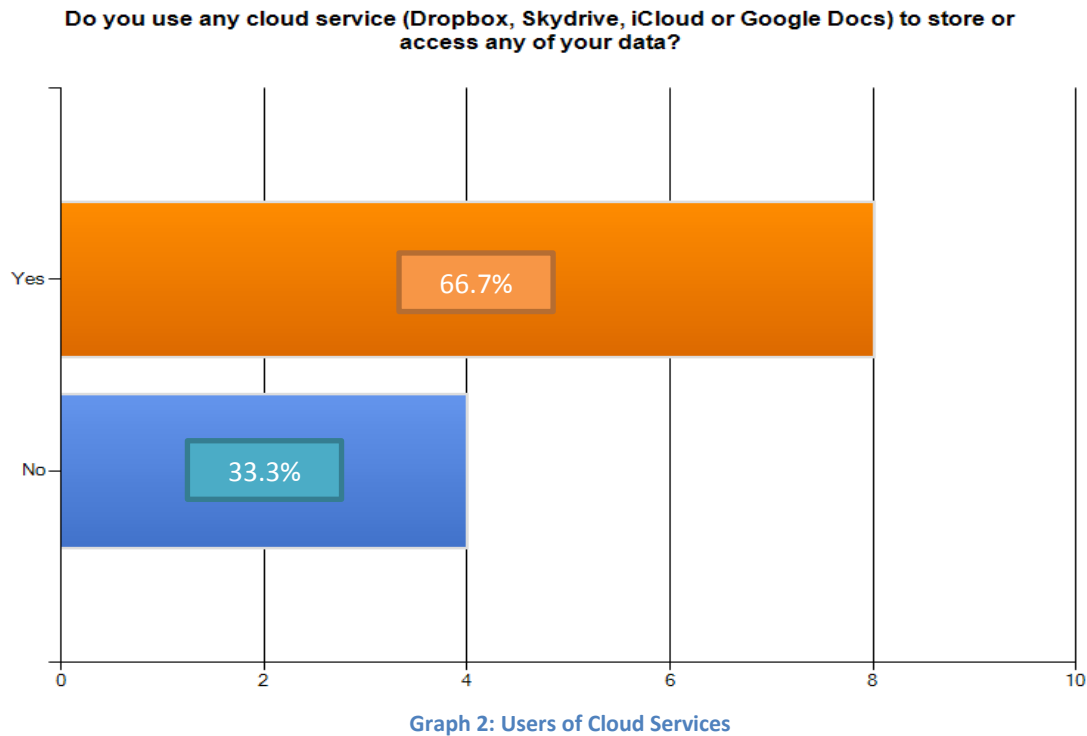
In the survey for firms around 52.5% were from the education sector. 40% of the total knew what the concept of virtualization revolved around.[11] A majority of them (see graph) used services like Dropbox, SkyDrive and Google Drive which are types of virtualization as they are cloud services. At ABWA, for the IBDP Physics Program, the students have implemented a Dropbox system to make file transfer easier. Every student has a 2GB folder, while the teacher as an administrator, can view all the folders and share class notes. It helps students and teachers share the other's resources. This makes the virtual service inherently more secure since all of the data resides on a secure virtualized centre rather than all over the school.

In an interview with Peter Zeglis[12], I learnt schools can also implement software virtualization.

This environment allows applications to run multi-platform, for example, "Winebottler" or "Wine" allows Linux and Macintosh users to run Windows applications. It protects the main OS from bugged code. Unfortunately, not all applications can be fully virtualized; however, "Wine" enables these software packages to run on different operating systems by providing their ideal environment.

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[11] Appendix B: Survey of 23 Industries
[12] Appendix A: Interview

Data and OS migrations become very simple and efficient over the virtual layer without needing to make any registry changes. This allows the school to run software from the virtual servers on every computer connected to that server, removing the complications of compatibility between different OS. This makes learning more efficient and gives a unity to the school teaching services.

Schools can also implement desktop virtualization; this allows them to use the old computers rather than purchasing new ones. Each user will be able to customize his/her environment (as permitted). Unlike on a single assigned PC, the student's entire workspace travels with them as long as they sign-in to the virtualized server. Laptop crashing and failure is a common problem in schools; a VDI will ensure that their workspace is saved even if any workstation should fail. As the workspaces are virtualized, the school will only need to buy software licenses depending on the peak usage of software, saving money.

Would it be easier if all the data in your school could be accessed from a centralized virtual server or would you rather have a harddrive?

Hard Drive, 17.5%
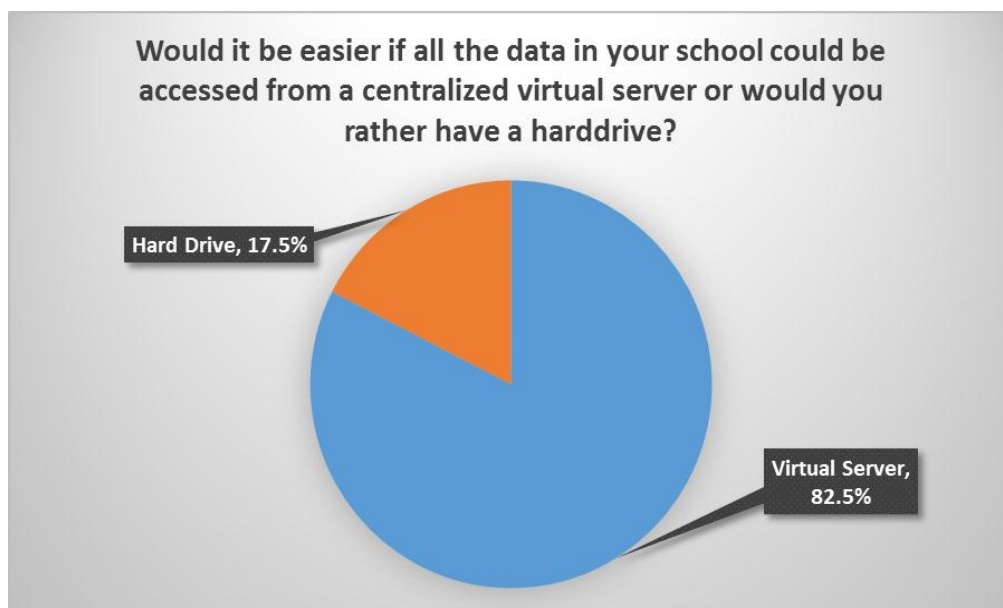
Virtual Server, 82.5%

Graph 3: Ease of Access of data

In the survey conducted for students 82.5% of the students said that a virtual server is more beneficial than[13] a physical hard drive. Their main motive behind this decision was that they have experienced how the loss of a data due to a virus becomes very time consuming. Data from laptops, pen drives and external hard drives can easily be attacked by viruses when inserted in infected computers or in contact with malware.

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[13] Appendix C: Survey of 57 Students

Section 4: Economic Implication

Industries and Schools need to pay attention to capital investment for the initial setup along with the operating costs. The longer the time for installation and training, the longer the downtime, hence, they will need to be 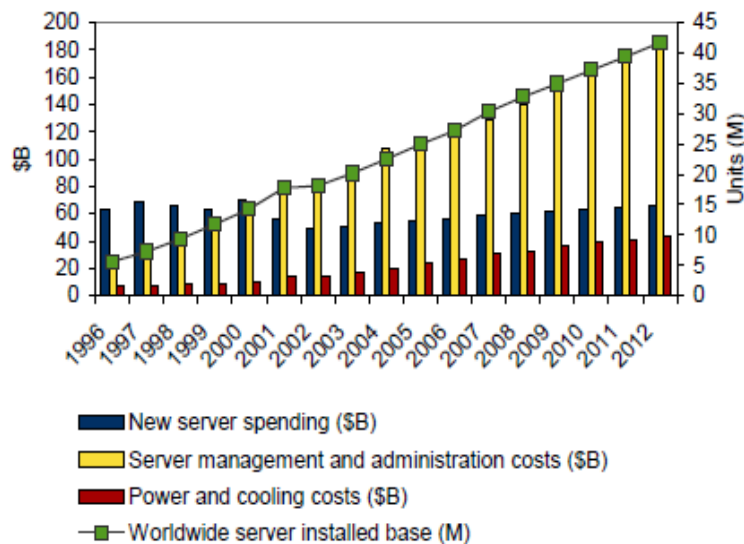aware of installation methods they choose. Schools should do a phased implementation to check data at every step and Industries, a pilot implementation, to test the system before removing the old. The cost for systems maintenance has risen 600% to over $160 billion annually, while, cost to power installed servers has inflated from $2 billion to $10 billion per year during that same period.

Figure 4: Spending on IT maintenance

The accounts published in IDC's[14] cost model shows Landmark© to have 96 physical servers, each one costing $610 giving a total of $58,500. With additional costs of $360/server for cooling and back up, the TCO was $145,336. Thus, every VM costs $1,514. The following year, 2009, they had a SCR of 35:1 across three physical servers. The total cost of virtualization came to $4,572 and the TCO came to $67,480. Hence the cost per VM was $643, a reduction of over 50%! In 2011 they upgraded to better servers, advanced systems and a 32 TB Storage space and their costs despite the inflation was $106,012 with a per VM cost of $815.

An organization's move through the stages of its journey sees accelerating returns on their investments. As per reports by VMware and Citrix[15], organizations using virtualization for IT products reported a Return on Investment (ROI) of 214%, and organizations using virtualization for IT services saw a ROI of 249%. The main cause of this is that a substantial number of working

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[14]IDC. (2009). *The Economics o f Virtuaization: White Paper.* Framingham: IDC.

[15] CiTrix. (n.d.). *Security_Index_Whitepaper.* CiTrix.

efficiencies are gained by adopting virtualization, due to its 'multiplatform abilities', 'consolidation' and 'green saves', as well as greater efficiency of IT staff (significantly less rework, testing, and maintenance). [16]

The graph shows how over the years of being a customer of virtualization, an average company's ROI, increased.
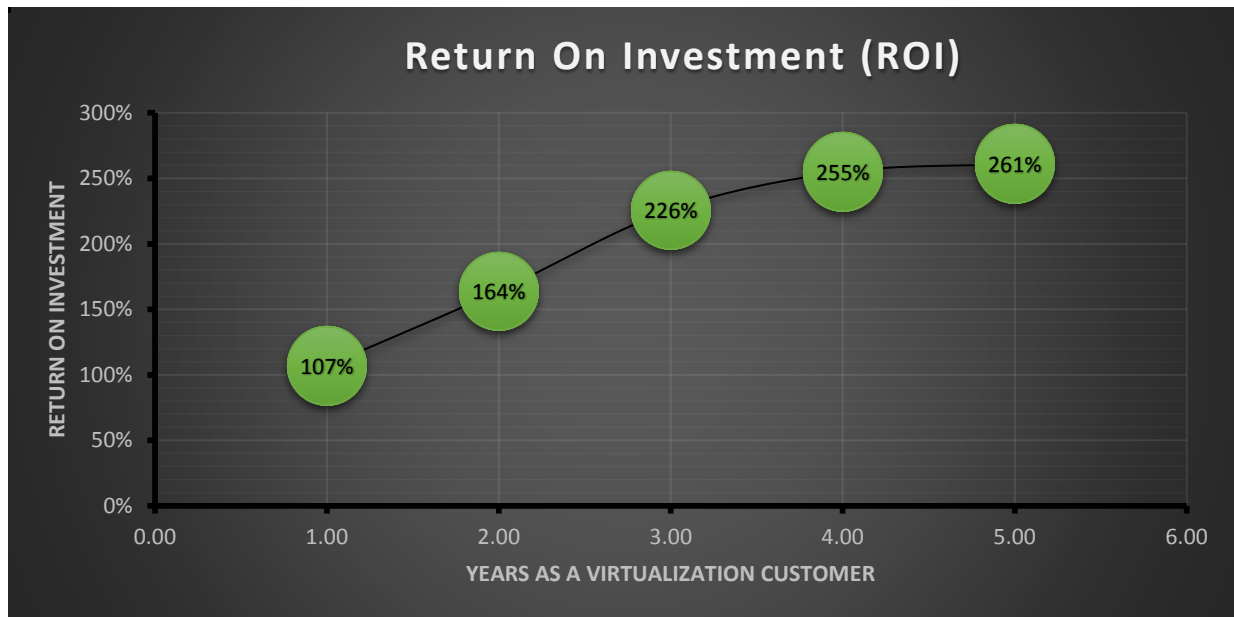
Graph 4: Return on Investment[17]

The pie-chart shows the results of a survey on consolidation ratios companies might prefer[18]
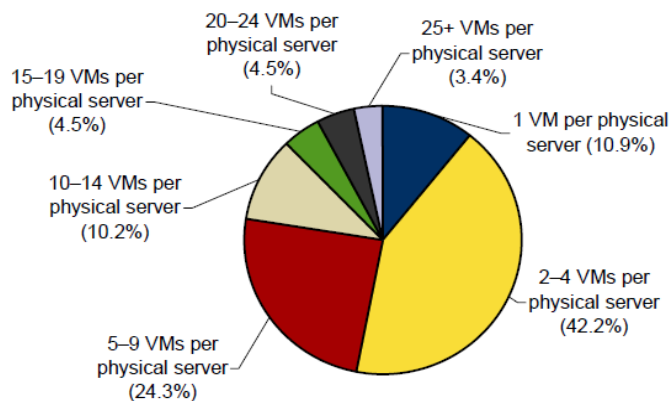
Graph 5: Consolidation Ratio's

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[16] VMware. (2011). *VMware Business Financial Benefits Virtualization.* Palo Alto: VMware.

[17] VMware. (n.d.). *VMware_Business_Agility_and_the_True_Economics_of_Cloud_Computing_White_Paper.* Palo Alto: VMware.

[18] IDC. (2009). *The Economics o f Virtuaization: White Paper.* Framingham: IDC.

ABWA currently has 4 servers in the school to share data between the different sections over the network.

Their total cost in year four, their current year, is $Rs.\,12,00,000$ which amounts to $\$\,24,000$[19]. The approximate cost per year per server (including power costs) is $\$\,6000$[20]. When I asked the IT Administrator he mentioned he would go for a consolidation ratio of 4:1.

Keeping those values into account, using the VMware ROI-TCO analysis, [21]for each server of $\$2000$, a virtual server will cost $\$2517 + \$5619$ to install a completely virtual based system with four VMs. Therefore, for a cost $\$6000$ per server, the cost would be $\$7551 + \$5619$ for the software, a cost of $\$13,170$. A total decrease of $\$10,830$ which means the school cuts costs by 45% in the IT sector. With virtualization, some IT staff can be redeployed for other system functions, as teachers will have easy access to the VMs.

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[19] Exchange rate $1 = Rs. 50
[20] Appendix A: Questionnaire with Kapil Patil
[21] Appendix D: ROI TCO Analysis

Section 5: Ethical Implications of Virtualization

The implementation of virtualization gives rise, as does any I.T development, to a few ethical issues.

5.1 Data Security and Privacy in Industries/Offices

An IT department has to ensure data security, privacy and anonymity. **Security** is the protection of hardware, software and networks from unauthorized access; **privacy** is the ability of the users to determine when and to what extent data is shared with others.

Since data is available on a cloud, hackers can gain access to the network. The company providing the service and the employees of the company where the service is provided remain responsible. Similarly in a VDI, Single Sign-On also increases the threat of security. All VMs run on the same host, via the same network making it easy to alter the Media Access Control address of the system to access the VM. By impersonating a registered address, the hacker exists within the same 'sphere of trust'[22]. The hacker can isolate any VM that is available and get the data without affecting the other or raising security issues.

Integrity of the data is also important for the IT departments. Short circuits due to bad wiring or damage of the server due to ill-handling causes data loss. In a virtualized server, all VMs will die out, which means that, in a server concolidation ratio of 25:1, if one physical server fails then 25 VMs will fail.

When the firms were asked whether the risk of data security is worth the drop in costs, from the survey, majority said it was worth the cost especially since, as Kapil Patil stated that, "it is worth the cost from an enterprise, institution perspective, as (though) it reduces privacy for the user, the security gives more stability to the organizations on the data and intellectual property as they have everything virtualized and backed up in their datacenters."[23]

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[22] Information Security Short Takes:. (n.d.). *Hacking Virtual Machines Part 4 - Knowing That the Target is a Virtual Machine*. Retrieved December 1, 2012, from Information Security Short Takes:: http://www.shortinfosec.net/2010/11/hacking-virtual-machines-part-4-knowing.html

[23] Appendix A: Questionnaire with Kapil Patil

5.2 Data Security and Privacy in Schools

The security and anonymity discussion in schools is less portent. Yet, the system can be attacked by hackers in school who attempt to gain classified files, via the process of impersonation.

Teachers at ABWA expressed their opinion by saying, "The data will be vulnerable on the server. Though security steps can be taken, it seems to be a big shift." Staff of the school object to it, they ask the question "What's the use of paying when you don't know whether your information is going to be private or not?"

Desktop virtualization would ensure that everyone would have their own ID to connect to the system, however, the user may not be the registered user, he/she may merely be someone who has the credentials for the ID. This would lead to issues of plagiarism in projects.

When asked, students said virtualization was worth the expense despite the different views across the student body. This was mainly because of the low probablity of data centers crashing and losing the data, which they said was "relief from the everyday mayhem caused when data was lost, especially in IBDP." The graph shows the survey results.[24]
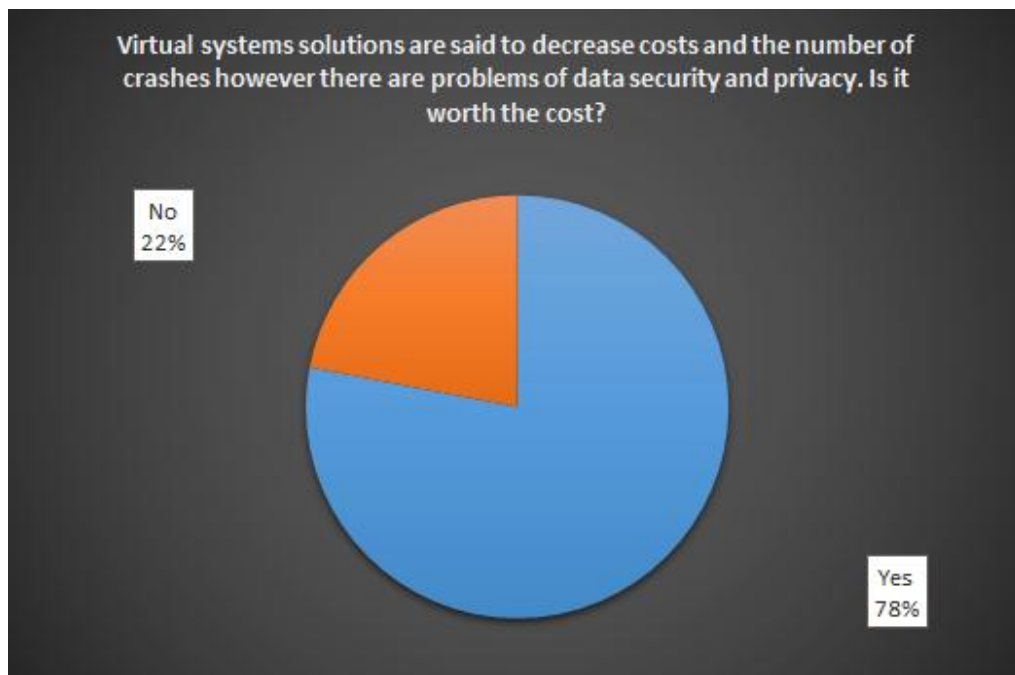
Graph 6: Are virtual systems worth the cost?

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[24] Appendix C: Survey of 57 Students

Section 6: Solutions to the problem of data integrity, security and privacy

Security and privacy can be tackled by the Independent Software Vendors (ISVs) and the virtualization vendor. Two key features which currently help address most issues are Encapsulation and Isolation. **Encapsulation** allows the systems data to be saved as a file. The V2V and V2P (Virtual to Physical) transportation of data creates an automatic backup without affecting the systems performance. Section 4.2 mentioned the installation of virtualization at ABWA. Here, the virtualized server will transfer files to a new partition, in the same server, as a VM file. The V2P converts VMs into a physical format to a spare server. This migration and backing up of files happens live with a zero down time.
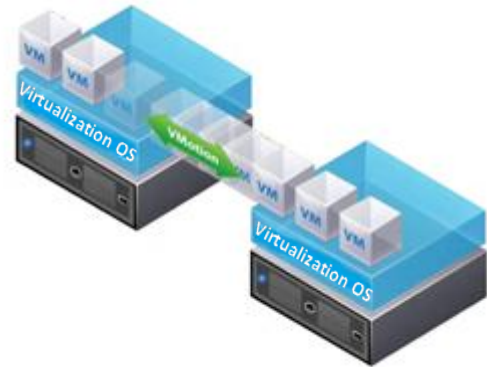
Figure 5: VM Motion

Isolation, involves the blocking out of a particular instance to get rid of a security breach. The 'Virtualization OS' detects the VM where the security breach, bug or fault has occurred and transfers its user to the backed up file and blocks the bugged VM out. Hence, at schools/companies, a failure in one system will not affect others. Various software manufacturers write plug-ins for VMs; these range from Anti-Virus to security/alarm software. Using the Isolation capability of the systems and related Application Program Interface, the manufacturers can activate security measures when a VM is infected.

Large industries have racks of virtualized servers. Data loss here can affect an entire department. Through migrations and encapsulation, **High Availability** (HA)[25] ensures the data remains intact by restarting the VMs on a different server in event of a failure, in real time. Compared to traditional data clustering, there is minimum downtime and service disruption. The department whose server crashed can continue functioning. This is an essential for companies who deal in the stock market. The picture below is a schematic diagram of how HA works.

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[25] VMware. (2011). *VMware vSphere High Availability (HA)*. Retrieved November 2, 2012, from VMware:
   http://www.vmware.com/products/datacenter-virtualization/vsphere/high-availability.html
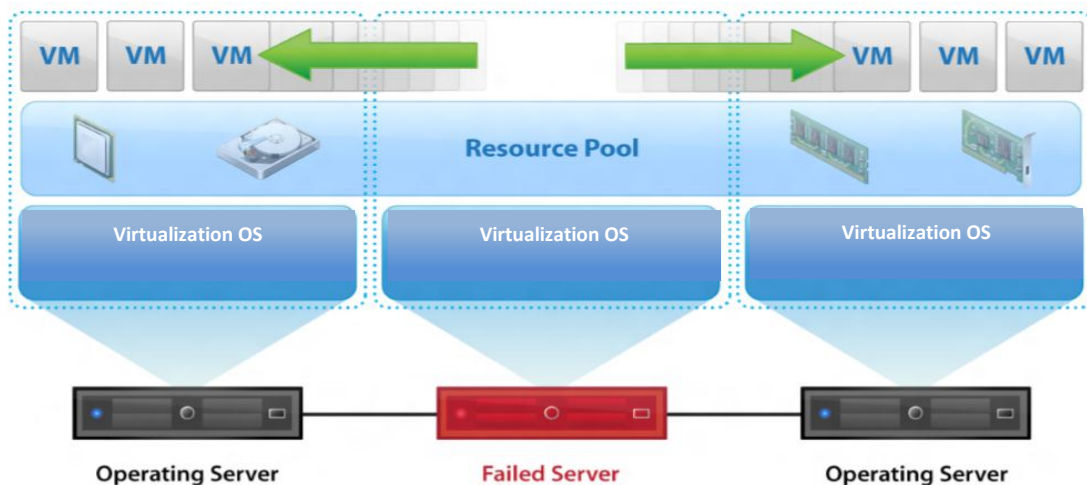
Figure 6: Real Time motion and HA[26]

Lastly Lockstep technology[27], a concept that was used only for redundant computer systems, has been reengineered by Intel. This technology provides continuous protection for a VM in case of a failure. It is based on the 'Record and Replay' technology which records all the previous VM activity and in case of failure will replay it on another system. It is commonly called **Fault Tolerance** (FT)[28] and is embedded into several processors. FT allows immediate failover between two instances in the event of hardware failure, eliminating even the smallest chance of data loss. It controls existing HA data clusters, hence, any number of VMs within the cluster can be protected with FT. Applications that require continuous protection during certain critical periods of time, such as financial processing, can utilize FT for higher assurance of availability during those time periods.[29]

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[26] Figure 6: VMware. (2012, April 7). *VMware Events*. Retrieved July 2, 2012, from VMware Webcast Series: http://event.on24.com/r.htm?e=440466&s=1&k=33C623CF41DA05004B97B6D946F3CBCE

[27] Wikipedia. (n.d.). *Lockstep (computing)*. Retrieved October 1, 2012, from Wikipedia - The Free Encyclopedia: http://en.wikipedia.org/wiki/Lockstep_(computing)

[28] Siebert, E. (2009, May 20). *VMware Fault Tolerance: What it is and how it works - Virtualization Pro*. Retrieved October 2, 2012, from IT Knowledge Exchange: http://itknowledgeexchange.techtarget.com/virtualization-pro/vmware-fault-tolerance-what-it-is-and-how-it-works/

[29] VMware. (n.d.). *VMware vSphere Fault Tolerance (FT) for Zero Downtime*. Retrieved October 2, 2012, from VMware: https://www.vmware.com/products/datacenter-virtualization/vsphere/fault-tolerance.html

For anonymity and data integrity, transferring data between the VMs through P2V, V2V and V2C, as said by Peter Zeglis, [30]"…is a direct copy-paste migration of the data from one VM to the other; so far we have conducted this for over a hundred industries and a handful of government systems and there have been no issues … government and federal bodies such as treasuries are using it and that suggests it is pretty secure." Anonymity can be protected by ensuring, that when on the network, a phishing filter and a firewall are activated. A VDI may have an increased risk of hacking but in this virtualized environment the data will only be available when the VM or the computer is switched on, under the firewall, reducing the risk.

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[30] Appendix A: Interview

Conclusion

Virtualization is technology of the future. By increasing computing throughput, freeing up floor space, disaster recovery and facilitating load migration it saves money. The savings can be increased if power and cooling is modified to suit virtualization infrastructure.

To manage the extra heat, the load should be spread with supplemental cooling, and dedicated areas of high and low server density should be present in the data center. The approaches and solutions in this essay should be examined to maximize the overall efficiency of the virtualized clusters.

ISV support in virtualization is becoming more omnipresent, rendering addressability across an ever-growing number of applications. With more datacenters migrating to private clouds with the advent of virtualization, two outcomes are emerging in regards to the new infrastructure: there is more availability and there are more pronounced, and truly adaptive, service levels. Virtualization's definitive mission is to transform IT into a vigorously flexible service that culminates in higher

Graph 7: Is virtualization the next step?

efficiencies. As seen from Graph 7, 82.1%[31] said that they think virtualization is the next step in education. The clear verdict seems to be that virtualization's enhanced service-based management, scalability and availability, along with FT technology, tip the balances more to 'reward' than 'risk' in both industry and academic environments.

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[31] Appendix C: Survey of 57 Students

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Appendix A

Interview

Interviewer: Mahir Kothary

Interviewee: Peter Zeglis, Vice-President at VMware (Asia Pacific Japan)

Interview Date: 21st July 2012

Mahir Kothary: How long have you been working specifically in the field of Virtualization?

Peter Zeglis: I have been working in the industry for 30 years and specifically in Virtualization for around 8 years….

Mahir Kothary: I conducted a survey which students, teachers, industrialists, management, etc., and about 60% to 70% of the students said they know about Virtualization because of the cloud, 30% to 40% of the industry said that they know what it is, and 82% yet said that Virtualization is their next step, so what you would like to say about that?

Peter Zeglis: What do you mean by next step…

Mahir Kothary: The next step for industry…

Peter Zeglis: Let me give you a simple analogy - if you go back to the industrial revolution… it is actually game changing and it is a major step, and a major disruption in technology… and going back to the industrial revolution, where in those days no electricity was around and manufacturing companies used to have behind their manufacturing facilities and have a huge room a steam generation plant to drive the production line and conveyor belt. With the advent of the electricity it basically enabled those manufacturing plants to do away with the huge engines and huge plants. It's the same thing with IT, you go into a company, you have a data centre with servers, equipment, boxes, etc., and now that is going out of the door and hence what's we are providing is an IT communication service. IT is coming in like a telephone service, which you pay for, its pay-to-use, without keeping big infrastructure in the backend. So it's major, it's disruptive, its game changing.

Mahir Kothary: I think NIE in Singapore has introduced virtualization specifically for the computer science course, PCoIP mainly, so do you think for schools all over and large universities, virtualization is what they should be looking at.

Peter Zeglis: This is no different from what Windows is in the Universities courses. They have their basic curriculum around Windows software applications and this is exactly the same thing. It is just that with the advent of those technologies in the late 80s Window-base software which took off, this is no different now, and as we go forward you will see this more and more.

Mahir Kothary: How will implementing Virtualization benefit the universities – both the faculty and the students?

Peter Zeglis: The main thing is that the school does not need to have the equipment or the infrastructure on the ground. Perhaps there will be classes where you have a tutorial with back to back and you can scale up or scale down 40 work stations, now you can bring that down to may be 10 or 20 and add as you go forward so this would bring down the cost.

Mahir Kothary: What are the different rules and policies when you implement your system at the client's site?

Peter Zeglis: We have a number of different methodologies and tools. This is the intellectual property that we have developed within VMWARE and this includes Best Practices, Standards, Guidelines and really a very very clean top methodology in terms of implementation, storage, installations, configuration, planning, and designing, building, managing and operating. So we have a full life cycle of methodologies, processes that is well documented and we have consultants to go in and implement the process and who will hand over the deliverables.

Mahir Kothary: Let's say someone is starting a website, say Facebook, and have various users all over the world. So there is a possibility of virtualization in that kind of a scenario?

Peter Zeglis: Actually it is very much of use in that kind of environment and in the right virtualization world, will actually take clusters of hard disk, clusters of CPU, clusters of memory and depending on demand it will absorb and utilize more hardware as it is needed and to fulfill this huge demand what a company like Facebook does is spawn more, more and more virtual machines on the fly. In a physical environment you cannot just walk in there and add the more and more boxes on the fly. It doesn't work. In a virtualization environment you can spawn this machines on an as need basis and be very elastic.

Mahir Kothary: You do V2V, V2 C and C2C transfers. How reliable are they not only from your stand point but also from the industry standards.

Peter Zeglis: So this is a migration activity. So in terms of the services provide to migrate they are very reliable. It is a direct copy-paste migration of the data from one VM to the other, so far we have conducted this for over a hundred industries and a handful of government systems and there have been no issues. We have migrated thousands of servers for banks, telcos, government agencies and companies and it's a happening thing and there's no turning back. Very reliable, yes!

Mahir Kothary: What are the ethical issues surrounding virtualization?

Peter Zeglis: Good question… historically in a physical environment you would walk in to a data centre and you would see racks and racks of physical machines, and typically each of those different machines has the different security policy. Now, through a virtualization standpoint, you pick up racks of these machines and substitute them with a single machine. So instead of

going through 5 or 6 machines you have to go to only one machine, so there are security issues but we addressed them with much tight security policy and some of the software we are bringing up. We believe that we have world's Best Standards and Best Practices around security. We don't seem to have any issues with any of the banks. As an example, financial and banking institution, government and federal bodies such as treasuries are using it and that suggests it is pretty secure.

Mahir Kothary: You must have heard about CERN it's a large scale institution in Geneva… they are coming up with new technology called 'the GRID'. It is great computing which is really the new internet. What they have an entire room full of server and they are not willing to touch it at all. So how would you actually try and convince about changing? What would be the benefit list would you give them?

Peter Zeglis: In terms of computer power we could virtualize the entire environment. It would give them the same amount of capacity, same compute power and do the same job, the difference being that it would occupy far less physical space, and you would consolidate the physical boxes to several hosts running machines within machines. So you would have saving cost in real estate as well as in maintenance of those boxes. Purely from an ongoing maintenance standpoint are you going to manage 1000 servers in a physical environment or support and maintain 500 servers? So it is really from a cost point of view – is it going to be virtual or real.

Mahir Kothary: Thank You for your time!

Peter Zeglis: Any time.

Questionnaire

Questioner: Mahir Kothary

Questioned: Kapil Patil, Head of Information Technology at Aditya Birla World Academy

Date: 25st October 2012

Q1.   What kind of server facilities are you currently using in school?

Active directories windows 2008 server antivirus server (Symantec) library automation server and a financial accounting server. DELL and IBM Servers.

Q2.   How many servers are active in the school?

There are four servers currently running through school for the individual sections.

Q3.   What is the total cost for the IT Department for current year 2012-2013?

The total cost in year four, is Rs.12, 00,000 which amounts to $ 24,000. The approximate cost per year per server (including power costs) is $ 6000.

Q4.   What server consolidation ratio would you prefer if the school were to introduce virtualization?

Since we have four servers, it would make sense to go for a ratio of 4:1.

Q5.   Virtual systems solutions are said to decrease costs and the number of crashes however there are problems of data security and privacy. Is it worth the cost? Please Comment.

It is worth the cost from an enterprise, institution perspective, as (though) it reduces privacy for the user, the security gives more stability to the organizations on the data and intellectual property as they have everything virtualized and backed up in their datacentres.

Q6. Do you agree with the VMware ROI TCO analysis that was carried out on 24th October 2012?

Yes.

Q7. What kinds of virtualization are important and beneficial to school?

Hardware and Desktop virtualization go without a say, along with that Software virtualization can be useful for those who want to use IB and other software not compatible on Macs.

Q8. Cloud or virtualization?

I would go for virtualization because it is in its third stage now and will soon enable even Virtual to Cloud transfer which will make accessing data easier in the future. Virtualization leaves you with more options than being stuck only to the cloud.

Appendix B

Survey of 23 Industries [https://www.surveymonkey.com/s/eefirmssurvey]

Q1. Which of the following best describes your current occupation?		
Answer Options	**Response Percent**	**Response Count**
Management Occupations	8.7%	2
Business and Financial Operations Occupations	17.4%	4
Computer and Mathematical Occupations	4.3%	1
Education, Training, and Library Occupations	52.2%	12
Arts, Design, Entertainment, Sports, and Media Occupations	8.7%	2
Sales and Related Occupations	4.3%	1
Office and Administrative Support Occupations	4.3%	1

Q2. Are you aware of a concept called virtualization? (a.k.a. virtual systems)		
Answer Options	**Response Percent**	**Response Count**
Yes	73.9%	17
No	26.1%	6

Q3. Have you implemented any form of virtualization in your company? If yes, please specify.			
Answer Options	**Yes**	**No**	**Response Count**
1.1 Hardware	4	15	19
1.2 Desktop	5	12	17
1.3 Software	8	11	19
1.4 Memory	6	13	19
1.5 Storage	11	10	21
1.6 Data	9	11	20
1.7 Network	8	11	19

Q4. Do you use any cloud service (Dropbox, Skydrive or Google Docs) to store or access any of your data?		
Answer Options	**Response Percent**	**Response Count**
Yes	56.5%	13
No	43.5%	10

Q5. Would it be easier if all the data in your office could be accessed from a centralized virtual server or would you rather have a harddrive?		
Answer Options	**Response Percent**	**Response Count**
Virtual Server	60.9%	14
Hard Drive	39.1%	9

Q6. Why? (Follow up to the previous question)	
Number	**Response Text**
1	It makes work easier to work.
2	I find hard drives to be a safer form of preserving my privacy & data.
3	easier to manage, accessed from anywhere and failure proof with proper backups etc.
4	There is pros n cons of both, but HDD is better as access is faster and no dependency on network.
5	In today's day and age lot of people I know do not sit in a cubical and are traveling, working from home, etc. In such a case having a base server would bring the infrastructure cost much lower.
6	Yes, Would it be easier if all the data in your office could be accessed from a centralized virtual server.
7	As I have not used virtual server and am familiar with Hard Drive.
8	For uniformity and easy availability of resources in teaching.
9	Whenever I need access to data in school it is readily available on the server.
10	It can be accessed from any part of the world. Also available 24 x 7.
11	Can be accessed from anywhere including cell phone.
12	I would rather trust a hard drive physically with me, rather than a virtual server.
13	Easier access for all of the employees in the office
14	The virtual serve may get clogged as all of them would retrieve their data from it.
15	Because the data is centralized and more secured compared to
16	Because then everybody can access it
17	I would like to have a demo as to how a Virtual server works
18	Quick access from anywhere.
19	Easier accessibility around all areas of the office.
20	to save time
21	Because there are no chances of data loss.
22	just so used to it
23	Easy to access. Safe. No crashes

Q7.Virtual systems solutions are said to decrease costs and the number of crashes however there are problems of data security and privacy. Is it worth the cost? Please Comment.	
Number	**Response Text**
1	No
2	Privacy & Security are two most important aspects that need to be preserved... i would rather take the necessary measures to safeguard it at home than to have it being misuse over the internet.
3	Reduces privacy for the user however gives more security for the organizations on the data and intellectual property as they have everything saved and backed up in their datacenters.
4	Yes if the system architecture demands it.
5	Yes.
6	Yes, it is worth as it gives "High Availability"
7	Not aware of the system. Hence cannot comment.
8	Yes, data that i wish to share with my students that is above and beyond that is available to me can be, on specific occasions, carried on a hard drive.
9	There is nothing to hide in a teaching profession. We always believe in Sharing our resources with one another.
10	Depends upon the policy you sign up with cloud service providers. If you pay minimal amount then there are no security and privacy problems.
11	Choose proper vendors and hardware/software.
12	Definitely not worth the decrease in costs, at the cost of data security and privacy.
13	Yes
14	Don't know much abt the creation of this facility. So unable to comment.
15	Yes it is worth the cost because of the ease of access

16	It will depend on the kind of security and privacy that is provided. If the cost benefit analysis is in favor, then one should go for virtualization.
17	Security and privacy are one of the important aspects.
18	Yes
19	Don't know.
20	provided the data is harmless
21	I am not aware of the cost, but I am sure it would be worth as there would be less crashes and the efforts put into creating that work would be worth it.
22	privacy over rides cost so i would think twice
23	Yes

Cross Tab Responses

Appendix C

Survey of 57 Students [https://www.surveymonkey.com/s/eestudentssurvey]

Q1. Which grade are you in currently?		
Answer Options		**Response Count**
I am in grade:	9	14
	10	14
	11	11
	12	14
	University	4
	Total	**57**

Q2. Are you aware of a concept called virtualization? (a.k.a. virtual systems)		
Answer Options	**Response Percent**	**Response Count**
Yes	75.4%	43
No	24.6%	14

Q3. Do you use any cloud service (Dropbox, Skydrive, iCloud or Google Docs) to store or access any of your data?		
Answer Options	**Response Percent**	**Response Count**
Yes	75.4%	43
No	24.6%	14

Q4. Would it be easier if all the data in your school could be accessed from a centralized virtual server or would you rather have a harddrive?		
Answer Options	**Response Percent**	**Response Count**
Virtual Server	82.5%	47
Hard Drive	17.5%	10

Q5. Why? (Follow up to the previous question)	
Number	**Response Text**
1	It isn't practical to give files to everyone on a hard drive, while on a virtual sever you can access the files whenever you want.
2	Because if one computer stops working then you can always transfer data onto the other working computer without using any flash drives or other such devices.
3	I believe it would be easier for both sides, they simply attach the document and then send it to us and then we complete it and send it back but it might slow down our writing speed in the exam.
4	Everything would be easily accessible and readily available. You could get the document needed, faster than a hard drive and it would be efficient.
5	so that i can access the information from anywhere even if i don't have that particular hard drive
6	Virtual Servers can be extremely helpful, because you don't always need a pen drive or anything, to transfer information.
7	Because is saves a lot of space, and consumes less energy. It also gives out a lot less heat.

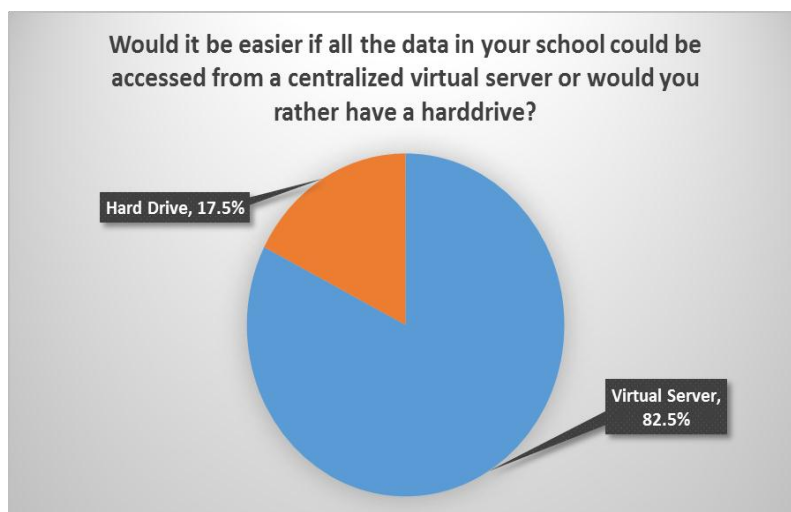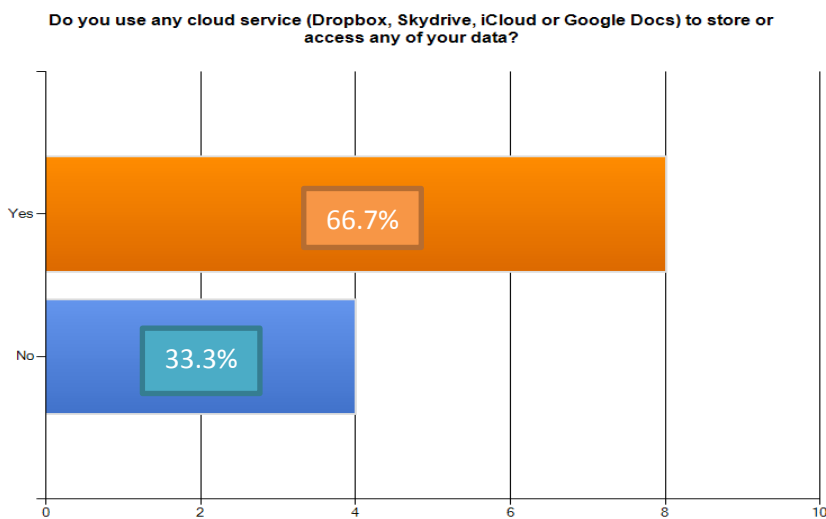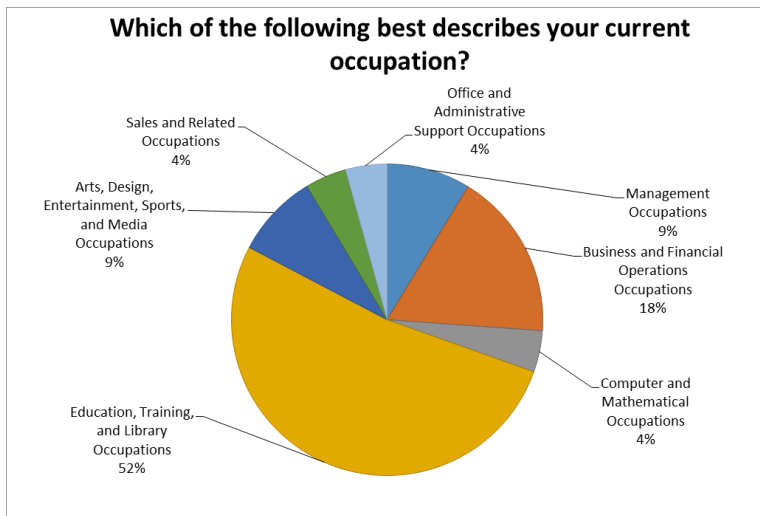| 8	So the sharing of data doesn't have to be done physically. It can be shared on the spot.
9	It will be really good and will be really fast and easier to work.
10	Because it would be really convenient and easy to access
11	This is because it can be accessed from anywhere by any student that has the login and therefore consumes less time and effort.
12	you are sure everyone has it and you can always refer and all the questions that everyone puts up
13	Everything you do on one device is there on any device and can easily be accessed.
14	Can access it from any place with an internet connection. Decreased costs. Could lose an external hard drive.
15	Easier.
16	Much easier to access the data.
17	It decreases costs and is more convenient.
18	It is easier to use and does not have a limit to how much you can store.
19	As they make work easier, costs less.
20	It would be easier and more cost efficient.
21	because you don't need to have a separate physical server for different application server
22	LESS HARDWARE REQUIRED
23	Because hard drive can also get lost or get a virus and use a lot of space.
24	If there is a problem with the central server then data cannot be accessed. Also since hard drive is portable the data can be accessed anywhere and anytime
25	it will be cheap
26	It is more convenient. In dropbox, info can be shared between several people by just emailing the link to the person so it is a very fast process.
27	The risk of losing data/the hard drive is not there.
28	easier access
29	Safe keeping
30	Cause it's convenient and easy to use.
31	easy to use and data accessing becomes easy
32	Easier than having to access a hard drive again and again
33	More convenient
34	Easier
35	It can be accessed from any computer in school, which becomes easier to retrieve data
36	It would become like a centralized data bank where everyone could access everything and nothing would have to be restricted.
37	learn a new thing and all
38	It's better, as we don't have to carry anything extra
39	Faster and easier
40	More convenient as no need to carry a hard drive
41	It would be simpler to share files with classmates and it would become simpler for the school if they wanted students to have certain files. Its more convenient than passing around a hard drive to every student in the school.
42	portable your own, more convenient to me
43	A centralized server is easily accessible, can have a vast amount of data and is always safe. In case of doubts, one can always use back-up storage. However, hard drives are physical devices one can control limiting access, unlike virtual servers which can be hacked easily.
44	The hard drive will remain with us.
45	Avoids mobility and usage of hard drives. Allows everyone to stay connected through one centralised body
46	It take up less space in your computer ensuring things are more smooth flowing. Secondly i could be more reliable.
47	Access for everyone, central access.
48	All data would be available at all times..

49	The data is easier to access and it is all kept on one single server rather than on several physical system or server, while also giving a better security to this isolated system
50	It's much simpler to do so because everything is available on one specific location
51	Eliminates syncing, no hassle of carrying drive all over. Creates common platform for teachers and students.
52	It's cheaper
53	Easier access
54	Because anyone may have access to the virtual server. Some virtual servers are location specific (if I am not mistaken) and a hard drive is just more convenient. If I were to share files, I can share it with whoever I want, through the hard drive, airdrop or whatever. However, a virtual server like Google docs I would use only when I need to share data, not to store data. I do not feel it is safe to store important data on an internet server.
55	Easier accessibility all-round the school.
56	Network reliability! There may not be internet everywhere. Also, I have to pay for the data download/upload A hard drive is always with me and I get faster transfer speeds
57	my layout and my config

Q6. Virtual systems solutions are said to decrease costs and the number of crashes however there are problems of data security and privacy. Is it worth the cost? Please Comment.

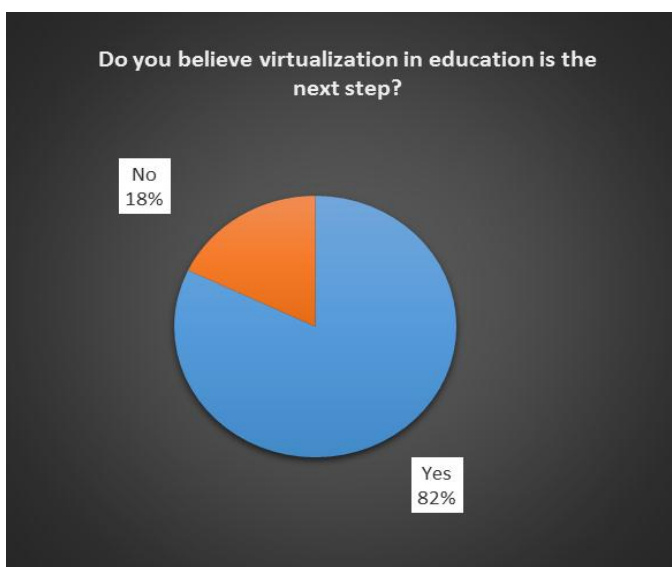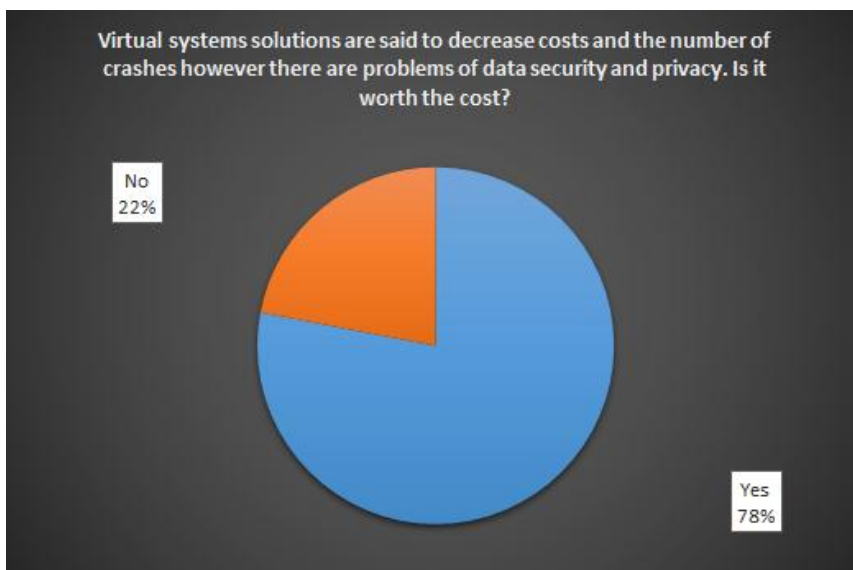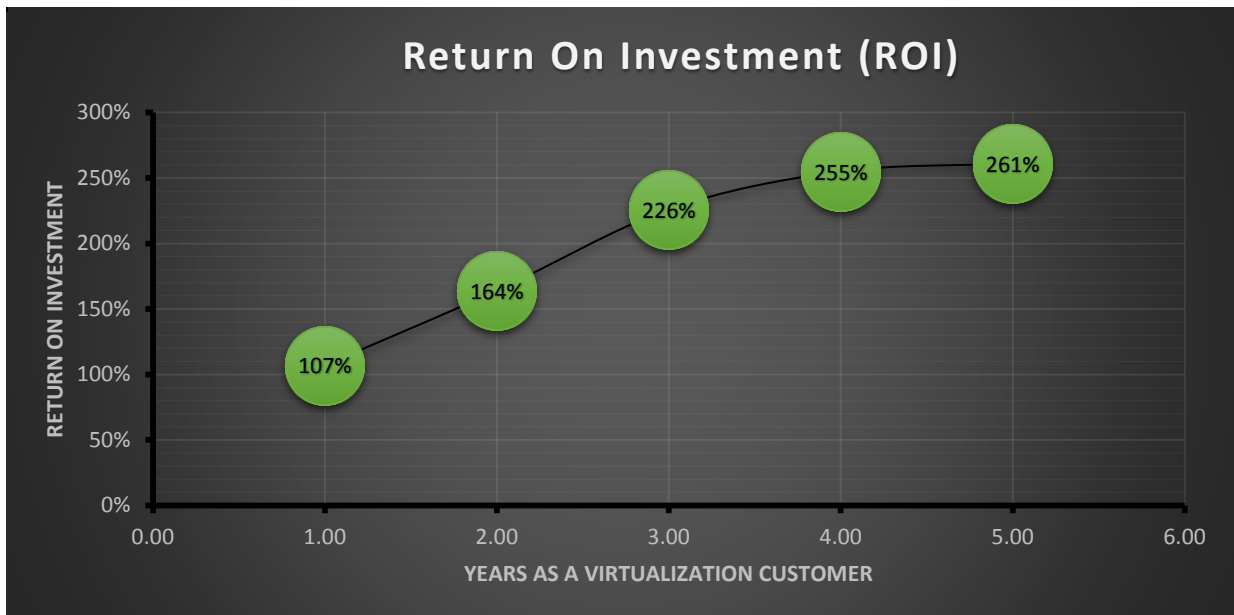| Number	Response Text
1	Yes it is because it is much more practical
2	They can make it better but more expensive.
3	Yes it is worth the cost because I don't really see the point in people being able to check your homework, they won't really be able to benefit from it, and actually maybe they might just learn something.
4	No. It isn't worth it. Privacy and security are two important things especially if it's extremely personal. If others can view your work then might as well not have it
5	Yes, because in anything we do we're taking a risk. Even just posting a status on Facebook is a potential threat to your privacy; i believe that this is a risk worth taking...
6	No, it's not. What's the use of paying when you don't know whether your information is going to be private or not?
7	Well...it depends on the content in the servers. If it is really confidential information, then it is worth the costs. But, if it is no so serious information that would do no harm if it got into the wrong hands, then the costs are NOT worth it
8	Yes, since other measures can be taken for data security
9	yes it is worth the cost because you rather use virtual system rather than hard drives
10	It is worth the cost as it is really helpful to companies and people who have a lot of stuff stored on their hard drives or whatever.
11	Yes, I believe it is worth the cost as it saves a lot of time and in the end privacy is not as important if you have to send something to many students.
12	Yeah
13	Yes, because crashes and privacy problems occur even with hard-drives.
14	Although the cost is decreased tremendously hacking would be a major problem, so it shouldn't be made live unless a strong firewall and encrypt the data.
15	It would definitely be worth the cost as it is said that from around 800 servers- now reduced to 60. Therefore, it may be expensive but it is an easier and more efficient method
16	Yes
17	Hard Drives themself have security issues but do not decrease the number of crashes thus using a virtual system makes more sense.
18	yes it is worth using virtual system as many people can access it and you do not need to send it to

	everyone
19	No
20	Yes
21	Yes
22	YES
23	Yes
24	I dont think it is worth the cost because there are several issues already related to misuse of personal information so virtual systems will make it even easier for hackers to access someone else's data
25	yes, it is
26	yes it is worth it...the students should have a backup somewhere incase their data gets erased or altered.
27	yes.
28	NO.
29	Security is primary, so i would stick with Hard disks.
30	So long as it isn't used for highly important documents and files, it is worth the cost.
31	Yes
32	Yes it is
33	Yes
34	Yes
35	Security comes first, especially for confidential and personal information. Thus instead of cost reduction, efforts should be made for ensuring safety of data
36	It is worth the cost as the data is more secure due to lesser crashes.
37	No
38	Yes, if there is nothing that is very private or confidential, as it is stated that security and privacy are problems, then it is pretty much worth the cost.
39	No there can be data loss security is a major issue these days
40	Our data has to be safe and where safety comes into play there can be no compromise. I'd say it's the worth the price as in the long term these servers will be comparably cheaper.
41	Some data is highly confidential and one would not want to to put up on the internet because the risks are quite high. It depends on what this system is going to be used for. It's not worth uploading private and official documents on such systems.
42	yes it is, but most people won't know how to use it
43	This would be the only drawback of virtual systems. It wouldn't be worth the cost as data, sometimes confidential should not be entrusted to a virtual server that can be hacked easily. A hard drive does not need to be online to be accessed, unlike virtual systems, hence proving to be reliable AND safe.
44	No
45	Depends on the purpose intended. . If very private information is supposed to be stored and transferred, it is b better to find an alternative
46	Depending on the level of confidentiality of the files one should decide if its worth the cost installing such a system in a specific environment, e.g. school or military headquarters.
47	Yes. More cost efficient as it reduces cost of hardware.
48	Yes it is worth the cost. It would completely revolutionize the way people learn.. Make people more technologically independent and make a lot of work a lot easier
49	Yes, because the security being one of the main problems of today will lead to better measures in the present as well as the future making all the data more secure
50	It is not worth the cost but its much more convenient but on the hand a little risky
51	Costs will rise as you increase security. Depending on how much you want to spend/how much security you want, your decision will be influenced. But overall, yes, it eliminates alot of hassle and helps create more seamless communication
52	Yes it is especially when the data is not worth much
53	in some cases yes it is worth the cost, however in industries where privacy is the top most concern virtual systems are not worth it.

54	As mentioned in above I do not feel it is safe to store important data on a internet server. When it comes to things like this, its better to be safe than sorry.
55	might be worth
56	Maybe for big organizations but not for individuals.At least not as of now. Once we get 4g in India and data rates drop down, it maybe worth it.
57	not in a system where people are not familiar with computers and virtual systems.

Yes or No Count	Response Percent	Response Count
Yes	78%	43
No	22%	13

Q7. Do you believe virtualization in education is the next step?		
Answer Options	Response Percent	Response Count
Yes	82.1%	46
No	17.9%	10

Q8. Virtual systems solutions are said to decrease costs and the number of crashes however there are problems of data security and privacy. Is it worth the cost? Please Answer		
Answer Options	Response Percent	Response Count
Yes	78.0%	44
No	22.0%	12

Appendix D

Graphs

Which of the following best describes your current occupation?

- Office and Administrative Support Occupations 4%
- Sales and Related Occupations 4%
- Arts, Design, Entertainment, Sports, and Media Occupations 9%
- Management Occupations 9%
- Business and Financial Operations Occupations 18%
- Computer and Mathematical Occupations 4%
- Education, Training, and Library Occupations 52%

Do you use any cloud service (Dropbox, Skydrive, iCloud or Google Docs) to store or access any of your data?

- Yes 66.7%
- No 33.3%

Would it be easier if all the data in your school could be accessed from a centralized virtual server or would you rather have a harddrive?

- Hard Drive, 17.5%
- Virtual Server, 82.5%

Appendix E

VMware ROI TCO Analysis

Analysis Time Period					
Number of Years (max 10 years)	1				
Start Year	2012				
End Year	2012				

Start of 2012: Physical Servers (before virtualization)	CPU's / Server	Cores / CPU	Number of Workloads	Number of Servers	Avg Price / Server
Define Configuration of Physical Servers	1	4	4	4	$ 2,014
(server costs excluding HBA's and TOE cards)	2	2			$
					$
					$
					$
Number of Unvirtualized Workloads & Servers			4	4	

If 100% virtualized, what kinds of servers would host VM's?	CPU's / Server	Cores / CPU	Number of Workloads	Number of Servers	Avg Price / Server
Define Configuration of Host Servers	1	4	4	1	$ 2,517
(server costs excluding HBA's and TOE cards)					$
					$
					$
					$
Number of Virtual Machines & Host Servers			4	1	
Current Consolidation Ratio (Workloads / Server)				4:1	
Maximum Consolidation Ratio (Workloads / Server)				6:1	

VMware ROI TCO Calculator

Analysis Name: ABWA

October 24, 2012

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Server Opening Questions

Analysis Time Period					
Number of Years (max 10 years)	1				
Start Year	2012				
End Year	2012				
Start of 2012: Physical Servers (before virtualization)	CPU's / Server	Cores / CPU	Number of Workloads	Number of Servers	Avg Price / Server
Define Configuration of Physical Servers	1	4	4	4	$ 2,014
(server costs excluding HBA's and TOE cards)	2	2			$
					$
					$
					$
Number of Unvirtualized Workloads & Servers			4	4	
If 100% virtualized, what kinds of servers would host VM's?	CPU's / Server	Cores / CPU	Number of Workloads	Number of Servers	Avg Price / Server
Define Configuration of Host Servers	1	4	4	1	$ 2,517
(server costs excluding HBA's and TOE cards)					$
					$
					$
					$
Number of Virtual Machines & Host Servers			4	1	
Current Consolidation Ratio (Workloads / Server)				4 : 1	
Maximum Consolidation Ratio (Workloads / Server)				6 : 1	

Server Opening Questions: Key Assumptions

Assumes all host servers are new purchases, and existing servers are fully depreciated and retired as infrastructure transitions	
Based on Average Number of Virtual Machines (VM's) per physical Core of:	1.50
Are servers leased?	No
(if yes, average price per server represents annual leasing cost)	

Server Virtualization Savings On Server Hardware

Savings on Server Hardware	Start	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
A) Extension of Unvirtualized Environment												
Number of Workloads	4	5	0	0	0	0	0	0	0	0	0	5
Number of Servers	4	5	0	0	0	0	0	0	0	0	0	5
Servers retired		0	0	0	0	0	0	0	0	0	0	0
Servers purchased for workload growth & refresh		1	0	0	0	0	0	0	0	0	0	1
Cash Expenditure (avg $ 2.0K per server)		$ 2,014	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 2,014
B) Transition to Virtualized Environment												
Virtualization Schedule (% workloads virtualized)		50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
Number of VM's												
Virtualized Workloads		3	0	0	0	0	0	0	0	0	0	3
vCenter Server		1	0	0	0	0	0	0	0	0	0	1
vCenter Server Database		1	0	0	0	0	0	0	0	0	0	1
Total		5	0	0	0	0	0	0	0	0	0	5
Number of Host Servers (06:1)		1	0	0	0	0	0	0	0	0	0	1
Servers retired		0	0	0	0	0	0	0	0	0	0	0
Servers purchased for workload growth & refresh		1	0	0	0	0	0	0	0	0	0	1
Cash Expenditure (avg $ 2.5K per server)		$ 2,517	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 2,517

Savings on Server Power & Cooling

Savings on Server Power & Cooling	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
A) Extension of Unvirtualized Environment											
Number of Servers	5	0	0	0	0	0	0	0	0	0	5
Power: Operating (kWatt hours)	16,380	0	0	0	0	0	0	0	0	0	16,380
Power: Cooling (kWatt hours)	21,294	0	0	0	0	0	0	0	0	0	21,294
Power: Rate (per kWatt hour)	$ 0.100	$ 0.103	$ 0.105	$ 0.108	$ 0.110	$ 0.113	$ 0.116	$ 0.119	$ 0.122	$ 0.125	$ 0.100
Power & Cooling Expense	$ 3,767	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 3,767
B) Transition to Virtualized Environment											
Number of Servers	3	0	0	0	0	0	0	0	0	0	3
Power: Operating (kWatt hours)	9,828	0	0	0	0	0	0	0	0	0	9,828
Power: Cooling (kWatt hours)	12,776	0	0	0	0	0	0	0	0	0	12,776
Power: Rate (per kWatt hour)	$ 0.100	$ 0.103	$ 0.105	$ 0.108	$ 0.110	$ 0.113	$ 0.116	$ 0.119	$ 0.122	$ 0.125	$ 0.100
Power & Cooling Expense	$ 2,260	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 2,260
Server Power & Cooling Savings (A-B)	$ 1,507	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 1,507

Savings on Server Power & Cooling: Key Assumptions

Servers		Weeks		Days/Week		Hours/Day	Avg operating power (kW) per server:	
Hours of Operation	=	52	x	7	x	24	Existing - unvirtualized	0.375
							New - virtualized (75% of nameplate rating)	0.375
Hours of Operation per Year				8,736				
Multiple of Operating Power required for Cooling				1.3 x				
Annual growth rate of electricity rate				2.5 %				
Manually adjust cost per kWatt hour each year?				No				

Server Impact On Server Storage

Impact on Server Storage	Start	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
A) Extension of Unvirtualized Environment (25% of servers attached to shared storage)												
Number of FC SAN HBA's	1	2	0	0	0	0	0	0	0	0	0	2
HBA's retired		0	0	0	0	0	0	0	0	0	0	0
HBA's purchased		1	0	0	0	0	0	0	0	0	0	1
Cash Expenditure		$ 1,200	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 1,200
Number of FC SAN Switches	2	2	0	0	0	0	0	0	0	0	0	2
FC SAN Switches retired		0	0	0	0	0	0	0	0	0	0	0
FC SAN Switches purchased		0	0	0	0	0	0	0	0	0	0	0
Cash Expenditure		$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Number of iSCSI SAN TOE Cards	0	0	0	0	0	0	0	0	0	0	0	0
iSCSI SAN TOE Cards retired		0	0	0	0	0	0	0	0	0	0	0
iSCSI SAN TOE Cards purchased		0	0	0	0	0	0	0	0	0	0	0
Cash Expenditure		$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Amount of Storage (GB)												
Direct Attached Storage (DAS)	300	375	0	0	0	0	0	0	0	0	0	375
SAN / NAS shared storage	100	125	0	0	0	0	0	0	0	0	0	125

Server Product Selection Editions: Key Assumptions

Investment in VMware Software & Support (Over 1 Years: 5 Workloads on 1 Host Servers)

vSphere Edition:	Essentials+			
Price per Unit (License + Subscription & Support):	$ 5,619	Support & Subscription:	Production	Discounts?	No
x Req'd Number of Units:	1	Years of SnS:	1		
Total vSphere License + Subscription & Support [1 yr(s)]:	$ 5,619	SnS Cost per Year	$ 2,623		
vCenter Server Edition:	NA			
Price per Unit (License + Subscription & Support):	$ NA	Support & Subscription:	Production	Discounts?	No
x Req'd Number of Units:	1	Years of SnS:	1		
Total vCenter License + Subscription & Support [1 yr(s)]:	$ 0	SnS Cost per Year	$ 0		
Total License & Support:	$ 5,619			
OR				
Select to enter known costs	e			
Enter Historical or ELA Cost	2012			
VMware SW: Server Virtualization	$			

Data Summary

Summary of Virtualized Infrastructure Environment									
Server Infrastructure									
WORKLOADS									
Server Infrastructure	2012								
Unvirtualized Workloads									
Extension of Existing	5								
% Virtualized	50%								
VM's: Dev & Test + Production									
Total[1]	**5**								
VM's: Business Continuity + Disaster Recovery									
Total	**0**								
VM's: Network Security									
Total	**0**								
[1] Includes vCenter Server instances									
SERVERS									
Server Infrastructure	2012								
Dev & Test + Production									
Total	**1**								
Consolidation									
(VM's to Servers)	5:1								
Business Continuity + Disaster Recovery									
Total	**0**								
Network Security									
Total	**0**								
STORAGE (GB's)									
Server Infrastructure	2012								
Total	**763**								
Infrastructure Administration (Hours)									
Server Infrastructure	2012								
Unvirtualized									
Workloads[1]	5								
Administrators (FTE)	0								
Hours	**228**								
Virtualization Savings									
+vSphere	71								
+AppSpeed	0								
+vCloud Director	0								
+SRM	0								
+vShield Edge & App	0								
Savings	**71**								
Total	**299**								
Reduction	(31)%								
[1] Including count of specialized Network Security hardware (Firewalls & Load Balancers) if applicable									

SCOM Server license with SQL	$ 1,321	$ 330	0		
Essentials 2010 with SQL Server 2008	$ 870	$ 218	0		
Essentials 2010	$ 103	$ 26	1		
Essentials Server ML (1 MLP)	$ 103	$ 26	1		

Red Hat

	Note: Non-USD prices here translated from USD price points			
Server OS				
Red Hat Enterprise Linux				
Edition	Advanced Platform			
Premium Support	$ 2,499			
Virtualization				
Red Hat Enterprise Virtualization for Servers	Support	Units		
Premium	$ 749	2		

Citrix

	Note: Non-USD prices here translated from USD price points			
Virtualization				
Citrix XenServer	Support	Units		
Preferred Extend (5 incidents pack)	$ 3,000	1		
(unit count assumes one 5 incidents pack for every 3 servers)				
Citrix Management and Automation				
Edition	Advanced			
	License	Units		
License cost, per Server	$ 1,000	2		

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