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The Virtual Machine: A Tool for Business Continuity Planning

Disaster recovery, or business continuity planning, is an ever-increasing issue for IT personnel. Why? Well, try to name a company that is beyond dependence on computer and internet technology to maintain a viable business. O.K., besides the Benedictine monks who make that great liqueur or Amish farmers. The fact is, most companies today quickly come to a standstill without email, data servers or workstations. And the reason business continuity planning is increasingly on the radar of IT personnel is that computer syst...

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GSEC Practical Assignment V.1.4b (option 1)
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Introduction

Disaster recovery, or business continuity planning, is an ever-increasing issue for IT personnel. Why? Well, try to name a company that is beyond dependence on computer and internet technology to maintain a viable business. O.K., besides the Benedictine monks who make that great liqueur or Amish farmers. The fact is, most companies today quickly come to a standstill without email, data servers or workstations. And the reason business continuity planning is increasingly on the radar of IT personnel is that computer systems can be interrupted in so many ways. First of all, there are interruptions caused by human error, massive power failures or natural disasters. Secondly, the nefarious, irresponsible individuals and groups who create viruses, trojans, and various kinds of other attacks are relentless in their attempts to create havoc in business systems and on the internet. Third, thanks to 9/11, our world (the western world) has come to the somber realization that terrorism can happen anywhere. Is any western country or city confident that it couldn't happen to them? Yet even in light of these things business continuity planning is not a reality in most small to mid-sized companies. Even with all their resources large enterprises struggle to implement and maintain business continuity plans (BCPs).

All that goes into preparing and implementing a BCP from start to finish is beyond the scope of this paper. Instead, I will focus on the use of the virtual machine as a tool for business continuity for the small to mid-sized business. The virtual machine could make it conceivable to implement a reliable and fast means of getting back up and running in the event of an interruption. First, I will examine the use (or lack) of business continuity planning in small to mid-sized companies, answering the question: If companies have not adopted a plan, why?

Business Continuity/Disaster Recovery Defined

If something goes wrong—anything from a critical server going down due to a malicious cyber attack to the local office where all the servers reside being in some way incapacitated—you want to be able to get up and running again as soon as possible. One definition for business continuity is "the development of strategies, plans, and actions which provide protection or alternative modes of operation for those activities or business processes which, if they were to be interrupted, might otherwise bring about a seriously damaging or potentially fatal loss to the enterprise."[1] *Business continuity* and *disaster recovery* are terms

[1] Benvenuto, Nicholas and Zawada, Brian. "The Relationship Between Business Continuity and Sarbanes-Oxley". Protiviti.
URL: http://www.protiviti.com/knowledge/current_feature/031204.html

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generally used interchangeably or at least in the same breath, and as Jon Toigo writes in his article "Disaster Recovery Planning: Data at Risk":

> At the end of the day, we don't care a whit what you call it—DRP, BCP or EIEIO. It all means the same thing: Avoid preventable interruptions and develop strategies to cope with interruptions you can't prevent.[2]

Business continuity will be the term that will be used in this paper.

The Lack of Business Continuity Planning

If one were to ask any IT manager or even a company executive whether being able to survive a minor or major interruption in their company's business life is important, it is certain they would respond affirmatively. Statistics show, however, that a majority of businesses have not implemented a BCP or have given little time, effort or finances to the BCP that they do have. For example, Vandana Mangal in her article entitled "Business Continuity Planning is a Challenge for CIOs" notes that Gartner analyst Roberta Witty "estimated last July (2003) that even after the terrorist attacks on the U.S., less than 25% of large enterprises have comprehensive business continuity plans."[3] The London Chamber of Commerce and Industry found that in 2003, "83% of London SMEs (small to medium enterprises) have neither a written security policy nor a written contingency plan."[4] These are just two of many examples of what one finds in the literature and sites related to business continuity.

So why are companies, especially the smaller to mid-sized ones, not doing all they can to assure their continued existence in the face of some unforeseen disaster? Here are some answers to that question. First, there is the seemingly formidable cost to having a viable BCP. Second, the IT manager and business executive alike, while having good intentions, never get around to giving serious time and effort to it. Third, there is the temptation to think that disaster could never come our way. Nothing has ever happened to us to warrant taking such precautions. This latter excuse falls under the "famous last words" category.

The High Cost of Business Continuity

Having access to the information you need, and knowing that your critical servers, file, data and email are always available, means having redundancy for

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[2] Toigo, Jon William. "Disaster Recovery Planning: Data at Risk". Network Computing. 22 January 2004.
URL: http://www.nwc.com/shared/article/printFullArticle.jhtml?articleID=17301515
[3] Mangal, Vandana. "Business Continuity Planning is a Challenge for CIOs." Computerworld. 7 April 2004.
URL: http://www.computerworld.com/printthis/2004/0,4814,91998,00.html
[4] London Chamber of Commerce and Industry "Information Center Guide". May 2003
URL: http://www.londonprepared.gov.uk/business/lcc_disaster_recovery.pdf

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all these things. Large enterprises have the means and manpower to implement complete replication of their business environment. The small to mid-sized business may have a backup plan that entails offsite storage of the company's critical information, but beyond that not much else. Who can justify the cost of replicating the file, data, and mail servers, not to mention the firewall, authentication server, the ftp server, and so on, when no threat is on the horizon? Having all that hardware on standby and assuring that this standby hardware keeps up to pace with the upgrades on production machines may be hard to justify in a small or mid-sized business's budget.

The Road Paved with Good Intentions

The IT staff of a small to mid-sized business may be two or three over-worked individuals who probably understand that having a BCP is important. Yes, someday they'd like to sit down and work through what they could do to see that the company could recover from a disaster. But the urgent always overtakes them: the need to replace some workstations, the introduction of a new payroll system, the upgrade of the mail server, etc. The IT staff's watchword could very well be "The urgent tramples on the important." Moreover, the company executive may be satisfied with offsite backup tapes, knowing that critical data is available if the system fails. The budget may not allow for much more.

Famous Last Words

Imagine a small company that has been in operation for over 20 years. Except for the odd power outage, not much has occurred to interfere with its business operation. One looks at the cost of keeping a redundant environment versus the size of the risk and it's easy to say, "How can we justify the cost? We should be o.k. as we are." But the threat of fire, flood, earthquake, or a terrorist attack on the city in which the company is located could terminate the company and one's livelihood. After 9/11 nothing seems outlandish anymore. It would be unfortunate if "we've been o.k. so far" were your company's "famous last words" before encountering an unforeseen disaster. Or, there's the more likely scenario of one of the company's critical servers being brought down by some form of cyber attack. How long could the company be without that server before its productivity would be affected?

The Virtual Machine in Business Continuity Planning

What can be done to increase the implementation of business continuity planning among smaller companies? One solution is the use of virtual machines, which can offer server redundancy while keeping costs down. Virtualization technology

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has been around for decades, mostly in mainframe machines.[5] But because of more powerful computers being used generally, virtualization is now being seen as a viable tool by a wider audience. Its appeal is in its cost savings and its flexibility in terms of hardware use and replacement. Most of the interest lies in how virtualization can help in data storage and server consolidation. For example, a Gartner article written by Thomas Bittman even recommends that enterprises should "pursue a server virtualization strategy" as a means of consolidating their existing hardware.[6] Products such as VMware and Virtual PC are becoming quite popular for their versions of the virtual machine.

The Virtual Machine Defined (VMware GSX 3)

The virtual machine has also been called "a computer in a computer." Essentially, you are drawing from the physical computer to enable a virtual computer within it. Diane Greene, CEO of VMware, describes it this way: "Virtual machine technology is a layer of abstraction that sits between the physical hardware and the software (operating system and applications)."[7]

An example of virtual machine technology is VMware's GSX Server 3. VMware documentation describes it as an "enterprise-class virtual infrastructure for departmental server consolidation and streamlining development and testing operations."[8] GSX provides the user with a management console in which one can access all the virtual servers built on that particular physical machine. It offers the user the possibility of building servers with a variety of operating systems such as Windows, Linux and Netware. With one installation of GSX Server 3 it is possible to run up to 64 virtual machines on one piece of hardware.[9] The GSX virtual machine has the capacity of running just like a physical computer. For example, floppy and cd-rom drives, serial, parallel and usb ports, ethernet cards, ide and scsi controllers, memory, hard drives, bios, and processors are all virtualized.

All that makes up the virtual machine is found in a folder on the physical machine thus making it easy to copy and move to another server, or to back up. Below are the files typically found in a virtual machine folder:

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[5] Scheier, Robert. "Storage Virtualization Gets Down to Business". Computerworld. 19 January 2004.
URL: http://www.computerworld.com/hardwaretopics/storage/story/0,10801,89118,00.html
[6] Bittman, Thomas. "Predicts 2004: Server Virtualization Evolves Rapidly." 14 November 2003
URL: http://www.vmware.com/vinfrastructure/gartner.html
[7] Lock, Tony. "Interview with Diane Greene, CEO VMware". IT-Director.com. 13 November 2003.
URL: http://cuu.it-director.com/article_f.php?articleid=11427
[8] Products VMware GSX Server 3.
URL: http:// /www.vmware.com/products/server/gsx_features.html
[9] Products VMware GSX Server 3
URL: http://www.vmware.com/products/server/gsx_faqs.html

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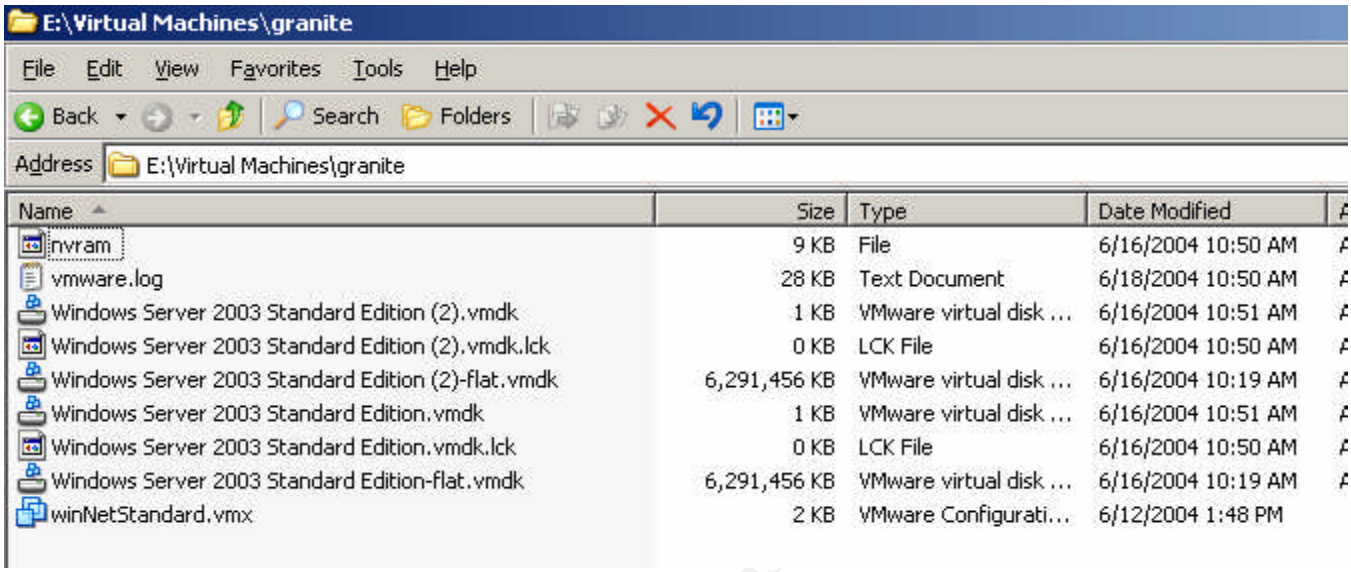

Name	Size	Type	Date Modified
nvram	9 KB	File	6/16/2004 10:50 AM
vmware.log	28 KB	Text Document	6/18/2004 10:50 AM
Windows Server 2003 Standard Edition (2).vmdk	1 KB	VMware virtual disk ...	6/16/2004 10:51 AM
Windows Server 2003 Standard Edition (2).vmdk.lck	0 KB	LCK File	6/16/2004 10:50 AM
Windows Server 2003 Standard Edition (2)-flat.vmdk	6,291,456 KB	VMware virtual disk ...	6/16/2004 10:19 AM
Windows Server 2003 Standard Edition.vmdk	1 KB	VMware virtual disk ...	6/16/2004 10:51 AM
Windows Server 2003 Standard Edition.vmdk.lck	0 KB	LCK File	6/16/2004 10:50 AM
Windows Server 2003 Standard Edition-flat.vmdk	6,291,456 KB	VMware virtual disk ...	6/16/2004 10:19 AM
winNetStandard.vmx	2 KB	VMware Configurati...	6/12/2004 1:48 PM

The .vmdk files are the virtual disks that were created, in this case two virtual disks of six gigabytes. There are two choices in how to build the virtual machine: with virtual disks (allocated or non-allocated), or with physical disks. In the above example, allocated virtual disks were chosen. Six gigabytes was the size chosen for the system partition of the virtual machine (vm). After the vm was created another six-gigabyte partition was added by using the virtual machine's editor which is found on GSX's management console. Another option when building the vm is to designate a "non-allocated" virtual disk which allows the virtual disk to grow vis-à-vis the data being added. The problem in choosing to use a non-allocated virtual disk is that the system performance is significantly slower. When choosing the physical disk option, the vm draws directly from the host machine.

The nvram file contains the state of the virtual machine's bios. The .vmx file is the virtual machine configuration file which contains the settings chosen for that particular vm.[10]

The virtual machine can be configured to start up automatically in the event of the physical machine having to be re-booted, ensuring that the virtual server will not be inadvertently overlooked. Even when logging off the physical server the virtual machines will continue to run without interruption.

The Virtual Machine Reduces Costs and Increases Server Utilization

In Thomas Bittman's Gartner article we are told that significant savings can occur in the area of hardware upgrades with the use of the virtual machine. He predicts that "by 2008, enterprises that do not leverage virtualization technologies

[10] Products VMware GSX Server 3
URL:http://www.vmware.com/support/gsx3/doc/index.html

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will spend 25 percent more annually for hardware, software, labor and space for Intel servers."[11] VMware claims that using its virtual technology could save a company anywhere from 29 to 64 percent in its total cost of ownership (TCO).[12] TCO entails administration, hardware and software, operations, and downtime. It is not hard to see how a company that has virtualized most of its servers can save in hardware costs and maintenance. Compare having a separate file server, mail server and domain controller to having one server that houses a virtual file server, mail server and domain controller.

Not only is there less hardware to purchase, there is less concern that the server in use is going to be under-utilized. Doug Allen in his article "From the Data Center to the Network" states that IT staff commonly struggle to "wrest more performance out of its servers, which are typically serial underachievers…These usually utilize a third or less of their total CPU or I/O, while others max out on occasion."[13] Referring to Thomas Bittman's Gartner article again, we see that virtualization offers a solution to the problem of server under-utilization.

> Whereas mainframes are commonly utilized above the 80 percent range, RISC server utilization usually averages half of that, and Intel servers running at 10 percent to 15 percent utilization are common…The growth of virtualization technology deployment will create a significant discontinuity in the RISC and Intel server market. Utilization of RISC server capability should increase by 30 percent or more. Intel server utilization should double.[14]

The Virtual Machine Decreases Downtime

As was mentioned before, when creating a virtual machine a directory of files containing all that makes up that virtual machine is created on the physical machine. These files are easily backed up and can be moved to another server expeditiously. This makes server recovery time a matter of how long it takes to copy those files to another server. There is no need to reload the operating system and restore data. It has all been backed up within the virtual machine's folder directory.

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[11] Bittman, Thomas. "Predicts 2004: Server Virtualization Evolves Rapidly." 14 November 2003
URL: http://www.vmware.com/vinfrastructure/gartner.html
[12] Products VMware GSX Server 3. "Reducing Total Cost of Ownership with VMware Server Software" Vmware.
URL: http://www.vmware.com/pdf/TCO.pdf
[13] Allen, Doug. "From the Data Center to the Network: Virtualization Bids to Remap the LAN" Network Magazine. 5 February 2004
URL: http://www.networkmagazine.com/shared/printableArticle.jhtml?articleID=17602026
[14] Bittman, Thomas. "Predicts 2004: Server Virtualization Evolves Rapidly." 14 November 2003
URL: http://www.vmware.com/vinfrastructure/gartner.html

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A Small Business Scenario with Virtual Machines

In order to demonstrate how the virtual machine can be used to contribute to business continuity planning we will examine a fictitious company (loosely based on a real company with which the author of this paper is affiliated) which shall be called Marketdirect that is in the process of virtualizing its servers.

The company in question is a successful direct marketing business having approximately 50 employees. A significant part of its business involves handling its clients' customer databases. Windows is mainly used for its servers and workstations. The main servers are the file server, mail server, and client database server. There is also the ftp server, firewall server, web server and authentication server. Other servers are used for printers, finance applications, backup, domain controllers and fax. In all, there are approximately 13 servers. A daily backup of the files, databases and the exchange information store is kept offsite. Other than this backup, nothing else is being done to assure continuity in the event of some kind of interruption.

Marketdirect has for several years contracted out its IT services to ITWeBe. A plan was devised at the initiative of ITWeBe to use the virtual machine to consolidate its servers on less hardware. The agreement would have ItWeBe use a co-location site (called BigHouse) as a contingency site for Marketdirect's critical services. The physical servers that would not be used at Marketdirect would be brought to BigHouse to be used for the company's BCP.

Presently Marketdirect has two domains, one for its accounts and one for the client databases. The breakdown of what the servers do is listed below:

Domain 1 (Accounts)

1. file server, domain controller (dns, dhcp, wins) and exchange mail server
2. mac file server, domain controller (dns, wins), printer server
3. ftp server
4. backup server, Security Updates Service (SUS), enterprise anti-virus
5. firewall server (Check Point)
6. Authentication server (RSA Security ACE/Server)
7. Replica Authentication server
8. Accounting and finances applications, printer server
9. Fax server
10. Web server

Domain 2 (Databases)

1. File server, domain controller (dns, wins)
2. Backup server, domain controller (dns,wins)
3. Database server

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Marketdirect wants to use its existing hardware to transition its servers to virtual machines. By using GSX Server 3 virtual machines, physical servers would be pared from 13 down to six. (The remaining servers would be sent to the co-location site to be used in the event of an emergency. The need for backup power supplies (UPS) would be lessened as well.) The firewall server would be set up on a Check Point Edge appliance. The company also owns two ultrium backup drives, one for up to 200 gb tapes and the second for up to 400 gb tapes. The new breakdown of server with virtual machines would be:

On Domain 1

Server 1:	file server vm
	Corporate anti-virus vm
	Domain Controller (dns, dhcp, wins) vm
Server 2:	Mac files (files used by Macintosh users who work mainly with graphics) vm
	FTP server vm
	Web server vm
Server 3:	Exchange1 mail server vm
	RSA Security Authentication server vm
	Accounting applications and printers server vm
	Backup, SUS (on the host server)
Server 4	Domain Controller (dns, wins) vm
	Fax server vm
	Exchange2 mail server vm
	RSA Security Authentication replica server vm

On Domain 2

Server 5	file server vm
	2 Domain controller vm's (dns, wins)
Server 6	Database server vm

Each of these vm's has its own directory which can be backed up and stored offsite on a regular basis. Vmware warns the user that the virtual machine needs to be shut down or placed in a suspended state when doing a backup otherwise the vm could hang. Vmware has a command utility that is included with GSX Server 3 called vmware-cmd utility. This utility allows you to suspend, stop or start the virtual machine. Therefore a scheduled batch file in which the vm's are stopped, backed up and then started again would be required. In order to have quick access to a saved vm a 200 gb external hard drive was connected to Server 1 and a 500 gb external drive on Server 6 where the vm's would be backed up weekly. The vm's would be backed up overnight over a period of 3 nights, Friday, Saturday and Sunday. The backup schedule would be:

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Friday night (early Saturday): On Domain 1, Server 1 vm's backed up to 200 gb external drive at 3:00 AM
On Domain 2, Server 5 vm's backed up to 500 gb external drive at 3:00 AM

Saturday night (early Sunday): On Domain 1, Server 2 and 4 vm's backed up to 200 gb external drive at midnight
On Domain 2, Server 6 vm's backed up to 500 gb external drive at 3:00 AM

Sunday night (early Monday): On Domain1, Server 3 backed up to 200 gb external drive at 1:00 AM

If the host server were ever incapacitated one could easily connect the external hard drive to another server and resume operations in a matter of minutes. Then on a bi-weekly basis the saved vm's on the external hard drives would be backed to tape for offsite storage. This backup could occur during office hours since it would not interfere with any server's operations.

Server 1 (host machine) has 3 vm's (guest machines). A batch file was created to shut down, backup (using ntbackup) to the external drive and start up the vm's.

Server1vmbckp.bat:

```
c:
cd  "program files\vmware\vmware vmperl scripting api"
call vmware-cmd "e:\virtual machines\iron\winnetstandard.vmx" stop
call vmware-cmd "e:\virtual machines\granite\winnetstandard vmx" stop
call vmware-cmd "e:\virtual machines\slate\winnetstandard vmx" stop
call  C:\WINDOWS\system32\ntbackup.exe backup "@C:\Documents and
Settings\Administrator\Local Settings\Application Data\Microsoft\Windows
NT\NTBackup\data\backup1.bks" /n "Backup.bkf created 6/16/2004 at 1:19 PM"
/d "Set created 6/16/2004 at 1:19 PM" /n "Backup.bkf created 6/16/2004 at 1:19
PM" /v:no /r:no /rs:no /hc:off /m normal /j "backup2" /l:s /f "E:\backup\Backup.bkf"
cd  "program files\vmware\vmware vmperl scripting api"
call vmware-cmd "e:\virtual machines\iron\winnetstandard.vmx" start
call vmware-cmd "e:\virtual machines\granite\winnetstandard vmx" start
call vmware-cmd "e:\virtual machines\slate\winnetstandard vmx" start
```

There continues to be a daily backup of files and data as well to ensure the restoration of specific files or folders. A copy of all the vm's is also stored at the co-location site in the event of Marketdirect's office being incapacitated.

Having vm's backed up to tape is helpful when you have a tape drive to use when a restoration is needed. But what if the tape drives are no longer available? How could the vm's be restored? As an added precaution two more external hard drives are utilized in the vm backup procedure. After the vm's have been backed to the external drives these would be kept offsite. The new external drives would

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be put into place for the next backup. There would have to be a copy of the vm's on both sets of external hard drives thus ensuring shorter downtime. On a weekly basis after backups are completed the external hard drives would be switched.

To reiterate,

1. Daily backups of files and data for offsite storage.
2. Weekly backups of all virtual machines to external hard drives
3. External hard drives with vm's taken offsite and replaced
4. Bi-weekly backup of virtual machines on external hard drives to tape for offsite storage.

IT would want to think about how often information changes on any given server. For example, the file and database servers would need to be backed up regularly. But an authentication server may be backed up with less regularity based on the infrequency of change in its database.

Conclusion

Business continuity planning for companies is an issue which must not be neglected and yet remains an elusive reality for many enterprises. The virtual machine can be utilized to offer affordable redundancy for small to mid-sized companies who have to deal with limited budgets. Not only are there fewer physical servers to maintain and replace, but the use of other pieces of hardware such as back-up power supplies (UPS) is lessened. Back-up routines are almost as straightforward as with non-virtualized machines, and the ease and speed of getting the a system back up and running after even a minor interruption is a cost-saver in terms of IT staff time as well as business productivity. Given its cost effectiveness and flexibility, the virtual machine can serve as a vital component of a full-fledged business continuity plan.

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Reference List

1. Allen, Doug. "From the Data Center to the Network: Virtualization Bids to Remap the LAN." Network Magazine. 5 February 2004 http://www.networkmagazine.com/shared/printableArticle.jhtml?articleID=17602026
2. Benvenuto, Nicholas, and Brian Zawada. "The Relationship Between Business Continuity and Sarbanes-Oxley." Protiviti. http://www.protiviti.com/knowledge/current_feature/031204.html
3. Bittman, Thomas. "Predicts 2004: Server Virtualization Evolves Rapidly." 14 November 2003 http://www.vmware.com/vinfrastructure/gartner.html
4. Lock, Tony. "Interview with Diane Greene, CEO VMware." IT-Director.com. 13 November 2003. http://cuu.it-director.com/article_f.php?articleid=11427
5. London Chamber of Commerce and Industry "Information Center Guide." May 2003 http://www.londonprepared.gov.uk/business/lcc_disaster_recovery.pdf
6. Mangal, Vandana. "Business Continuity Planning is a Challenge for CIOs." Computerworld. 7 April 2004. http://www.computerworld.com/printthis/2004/0,4814,91998,00.html
7. Products VMware GSX Server 3. "Reducing Total Cost of Ownership with VMware Server Software" Vmware. http://www.vmware.com/pdf/TCO.pdf
8. Products VMware GSX Server 3. http:// /www.vmware.com/products/server/gsx_features.html
9. Products VMware GSX Server 3 http://www.vmware.com/products/server/gsx_faqs.html
10. Products VMware GSX Server 3 http://www.vmware.com/support/gsx3/doc/index.html
11. Scheier, Robert. "Storage Virtualization Gets Down to Business." Computerworld. 19 January 2004. http://www.computerworld.com/hardwaretopics/storage/story/0,10801,89118,00.html
12. Toigo, Jon William. "Disaster Recovery Planning: Data at Risk." Network Computing. 22 January 2004. http://www.nwc.com/shared/article/printFullArticle.jhtml?articleID=17301515

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