Server Consolidation and Virtualization at Cinergy

By

Mike C. Whitener

Submitted to
the Faculty of the Information Engineering Technology Program
in Partial Fulfillment of the Requirements for
the Degree of Bachelor of Science
in Information Engineering Technology

University of Cincinnati
College of Applied Science

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Mike C. Whitener	Date
John F. Nyland, Faculty Advisor	Date
Patrick C. Kumpf, Ed.D. Interim Department Head	Date

Acknowledgements

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Abstract

Cinergy, provides gas and electric services to Ohio, Kentucky and Indiana and maintains over a thousand servers in three data centers. Cinergy experienced rapid server growth over the past five years due to emerging technologies that enable it to better serve its customers. This growth dramatically increased the total cost of ownership of its data centers. Cinergy needed a server consolidation project that would enable it to consolidate existing servers, lowering its total cost of ownership while providing for availability, resiliency and growth. This server consolidation project consists of a multi-pronged plan that includes the consolidation of existing servers into three highly utilized server platforms and the implementation of a new server provisioning model. The server platforms are comprised of consolidated SQL servers, HP blade servers and VMware ESX virtual servers. The new provisioning model regulates data center growth by channeling server requests to one of the consolidated server platforms. The new server platforms and provisioning model ensure the maximum utilization of data center resources, lowering Cinergy's total cost of ownership, while providing robust and scalable server resources to the enterprise.

Server Consolidation and Virtualization at Cinergy

1. Statement of the Problem

Cinergy maintains more than one thousand servers in three data centers located in Ohio, Indiana and Texas. The company has experienced rapid server growth over the past five years due to emerging technologies that enable it to better serve its customers. This growth has dramatically increased Cinergy's total cost of ownership of these resources.

Cinergy's historical approach to server provisioning allowed for a single server to be allocated for each component of a project or application. This non-shared architecture, coupled with departmental and political divisions, has created a heterogeneous infrastructure with multiple servers performing the same function.

A simple overview of Cinergy's server portfolio shows many underutilized SQL, web, file and application servers, as well as a tremendous amount of underutilized storage. This underutilization results in an overpopulation of servers which puts a strain on infrastructure resources such as power, cooling, network and KVM, and it also drives up the cost of licensing for antivirus, monitoring and patch management software.

Cinergy needs a server consolidation plan that will enable it to consolidate existing servers, thus lowering its total cost of ownership while providing for availability, resiliency and growth.

2. Description of the Solution

The solution consists of a multi-pronged plan that consolidates existing servers into highly utilized sub-infrastructures which will lower the total cost of ownership, while providing for availability, resiliency and growth. Upon completion of the project, this plan will transform into a strategy and guideline for future server provisioning. This

multi-pronged plan includes the consolidation of SQL servers, the physical virtualization of Cinergy's servers through the implementation of HP blade servers, and the logical virtualization of servers through the implementation of VMware ESX servers.

2.1 User Profile

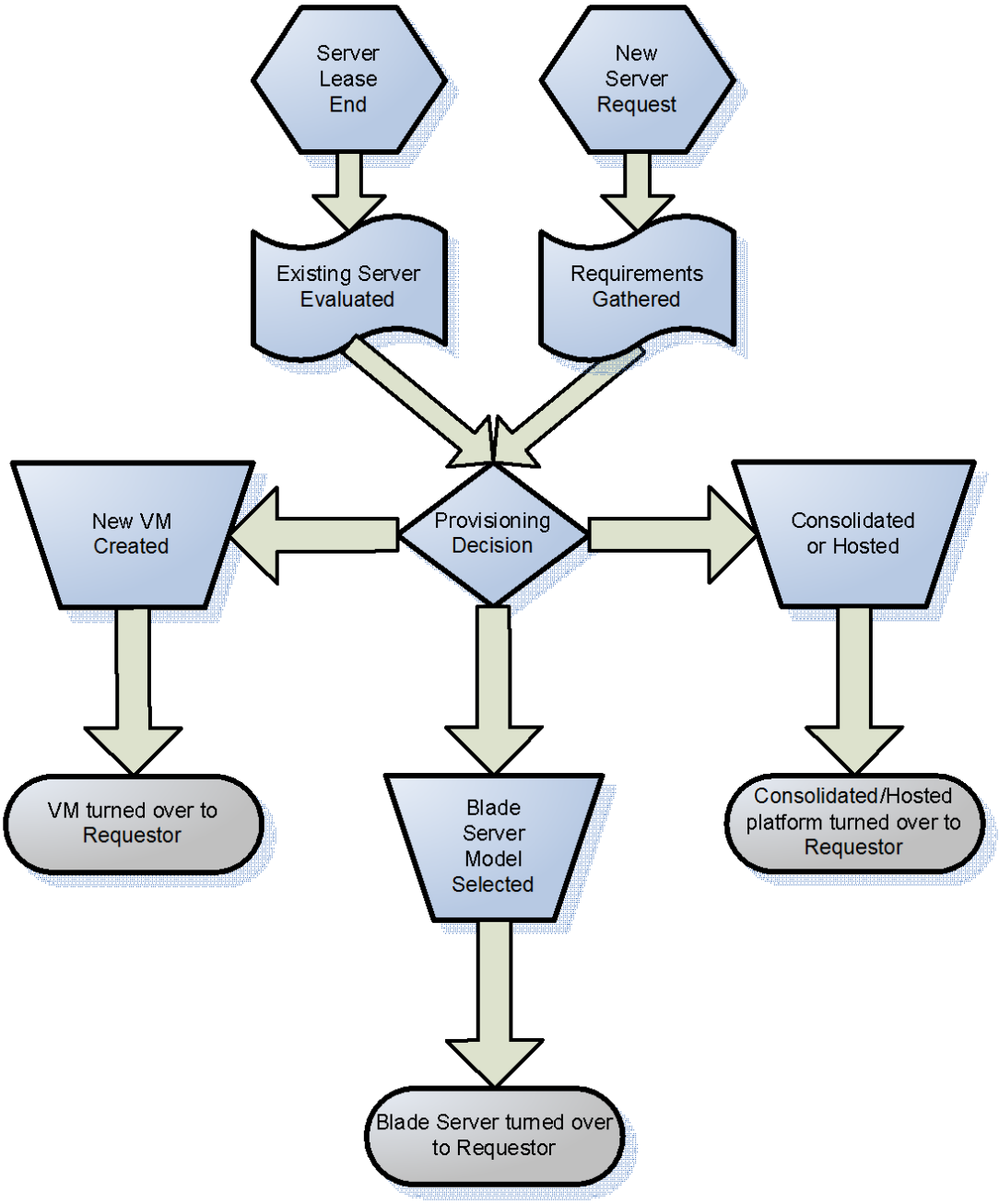
The intended users of this consolidation plan are Cinergy's Server Operations staff. and the various IT support staff that utilize servers at Cinergy. These users are expected to be familiar with HP blade server technology, virtualization concepts and Windows and Linux operating systems.

2.2 Design Protocols

2.2.1 Server Provisioning Model

The provisioning of server lease replacement and new server requests will be the primary driver for this consolidation project. Cinergy's leasing strategy provides an opportunity for each server to be reevaluated upon the termination of its lease. Requests for new servers will utilize the same provisioning mechanism with the ultimate goal of eliminating one for one provisioning. The server provisioning diagram on the following page illustrates the new provisioning model and how it is the primary driver for this project.

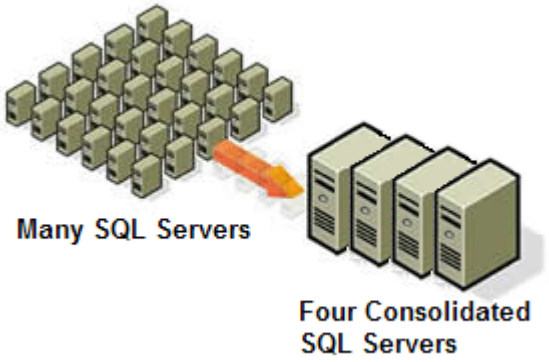
Figure 1. Server Provisioning Diagram



2.2.2 Consolidation of SQL Servers

Cinergy's abundant SQL servers will be consolidated into four consolidated SQL servers running Microsoft SQL Server 2000. Two servers will house production databases and the other two servers will house test and development databases. These servers will be HP ProLiant DL580 G3 servers with quad 3.33GHz Xeon processors, eight Gb of memory and will have SAN attached storage. Figure 2 depicts the consolidation of many small-to-mid SQL servers into four large SQL servers.

Figure 2. SQL Consolidation



2.2.2.1 Rationale

Three areas of consolidation were considered: file servers, SQL servers and web servers. SQL server consolidation appeared to be the most efficient option offering the earliest return on investment. A project already existed to consolidate file servers into a network attached storage (NAS) environment and web consolidation appeared to be tedious and did not offer the type of return that SQL consolidation offers. SQL consolidation also provides an immediate option for future database server requests thus allowing Cinergy to transition more quickly to a new shared resource provisioning model. For these reasons, SQL consolidation was chosen as the consolidation focus area among server groups.

2.2.3 Physical Virtualization of Servers with HP Blade Servers

Cinergy will deploy a rack of HP ProLiant BL20p blade servers. This new platform will reduce the data center footprint of existing servers while physically virtualizing infrastructure components such as power, network, KVM and SAN fibre. A single rack can support 48 BL20p blade servers (4). The new platform will utilize HP System's Insight Manager to manage the blade environment. Figures 3 and 4 depict current and future state platforms and illustrate the virtualized hardware environment within the blade server platform.

Figure 3. Current State Stand-Alone Server Platform

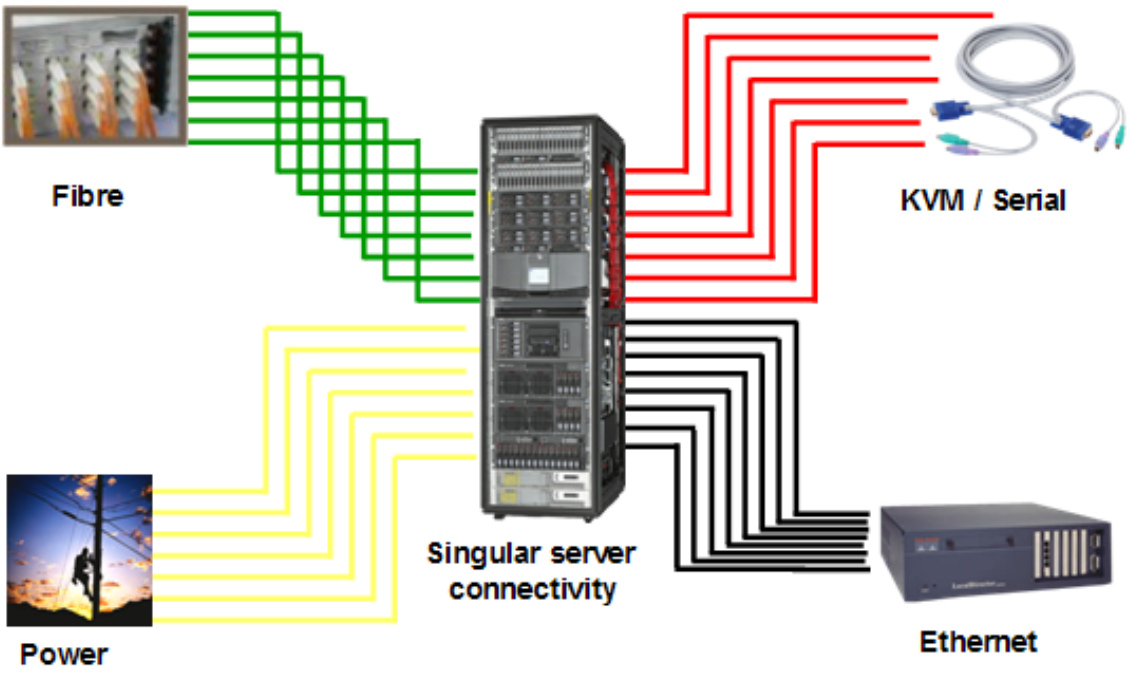
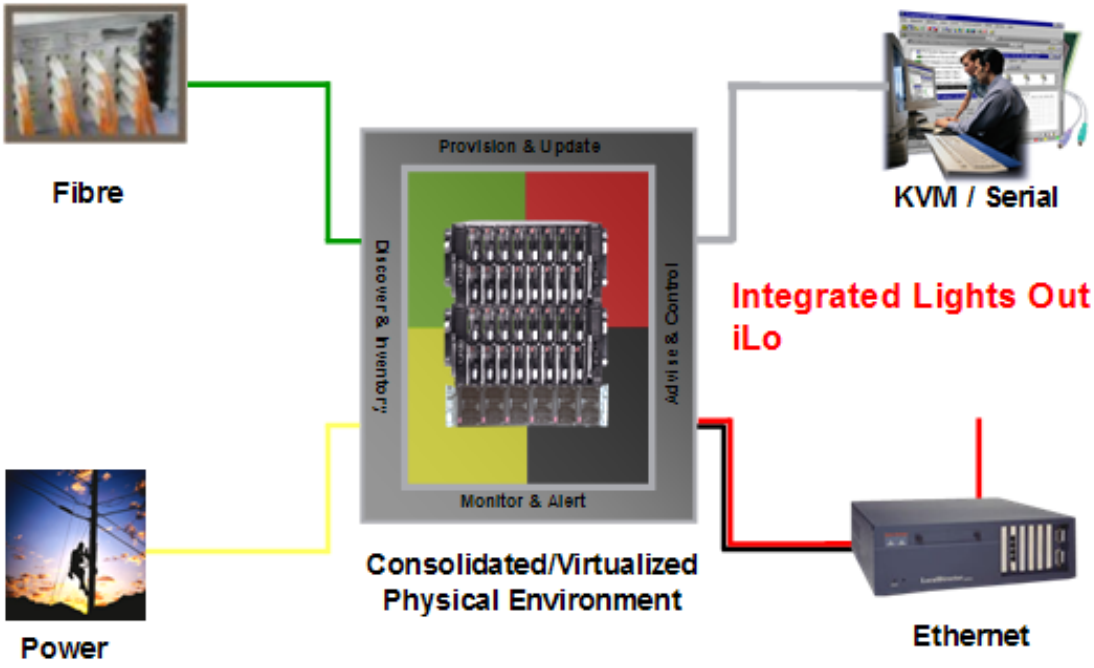


Figure 4. Future State HP Blade Server Platform



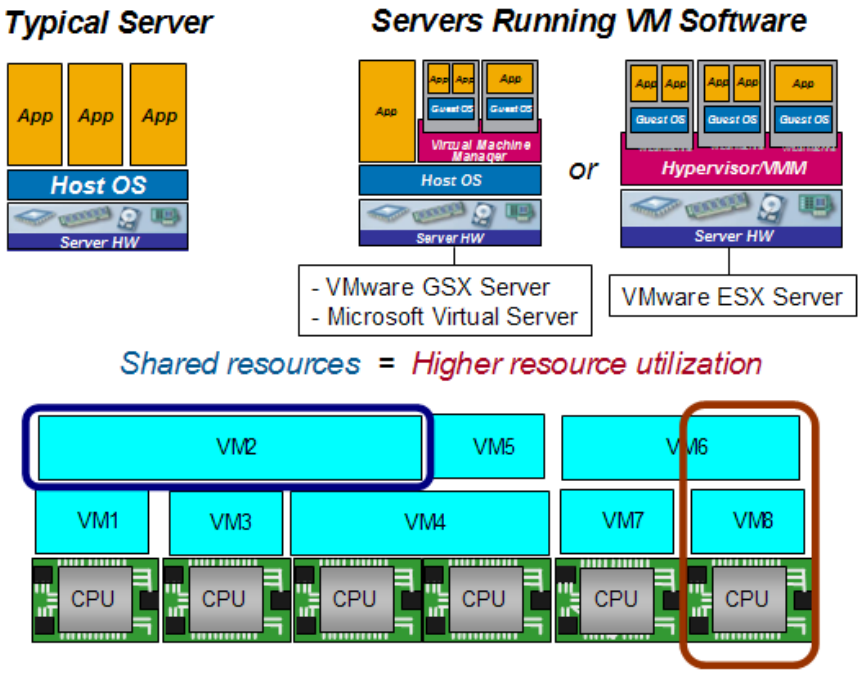
2.2.3.1 Rationale

HP is currently one of Cinergy's strategic technology partners and its blade servers are second to none. HP's blade servers have consistently won industry awards and HP continues to drive this technology by partnering with manufacturers of network and storage devices allowing them to offer a wide array of blade solutions. For example, many organizations do not wish to mix and match network or SAN devices. HP's modular interconnectivity approach offers options from CISCO, McData, Brocade, Emulex and QLogic as well as HP components (4). This allows for the complete physical virtualization of network and SAN devices within the blade infrastructure without compromising interconnectivity and supportability. In other words, a CISCO shop can remain a CISCO shop without having to support other manufacturer's hardware (5). For these reasons, HP blade servers were chosen as the blade solution for this project.

2.2.4 Virtualization with VMware ESX Server

Cinergy will deploy six VMware ESX Servers. Two servers will be for testing, two for development and two for production. This new environment will allow for rapid server provisioning and will also permit the housing of small applications that are not resource intensive. VMware's ESX Server allows for multiple operating system instances to run on a single server by means of an underlying hardware manager known as a hypervisor. The hypervisor manages the hardware abstraction between ESX Server and guest operating systems and allows for shared access to resources while maintaining a stable operating environment. The VMware host operating system is managed via a web console or telnet console (12). Figure 5 illustrates how virtualization technology permits multiple guest operating systems to run on a single server and how the hypervisor manages access to the server's shared resources.

Figure 5. Virtualization



2.2.4.1 Rationale

VMware offers two types of virtualization software, ESX and GSX Server. ESX Server has a Linux operating system while GSX is installed on top of Windows Server (12). ESX server naturally has less overhead due to its Linux core and a smaller footprint than GSX. It also has the ability to dynamically reallocate memory and processing resources. GSX is similar to running Windows on top of Windows which causes it to have more overhead but offers a more familiar environment for administrators. ESX is superior to GSX when it comes to performance which is why it was chosen as the virtualization solution for this project.

3. Deliverables

The following deliverables have been identified as critical to the project's success:

- Establish a paradigm shift with regard to server provisioning.
- Successful procurement and deployment of SQL servers, HP blade servers and VMware servers as prescribed in the Design Protocols.
- Consolidation of 15 or more SQL servers
- Consolidation of 55 or more physical servers into HP blade servers.
- Virtualization of 40 or more physical servers.
- Successful handoff of the new server platforms to Server Operations.
- Establish instant capacity on demand (ICOD) practices and procedures.
- Ensure the resiliency of the new server platforms.

4. Design and Development

4.1 Budget and Estimated Savings

The project budget was estimated to be almost $800,000 with a combined estimated savings of nearly one million dollars. The cost of this project is less than the forecasted savings due to the number of servers that could be eliminated. (See Figure 6.).

Figure 6. Project Budget and Estimated Savings

Server Consolidation and Virtualization Project Budget and Savings

Item	Cost	Physical Servers	Logical Servers	Consolidated Cost	Standard Server Cost	Per Server Savings	Extended Savings
SQL Consolidation Hardware and Software	**$229,979.00**	**4**	**40**	**$5,749.48**	**$19,033.52**	**$13,284.05**	**$531,361.80**
Blade Server Hardware and Software	**$308,442.70**	**40**	**N/A**	**$7,711.07**	**$13,296.52**	**$5,585.45**	**$223,418.10**
VMware Hardware and Software	**$143,541.12**	**6**	**60**	**$9,569.41**	**$13,296.52**	**$3,727.11**	**$223,626.72**
Infrastructure Total	**$681,962.82**						
Estimated Labor (*Per HP contract*)	**$100,000.00**						
Project Total	**$781,962.82**						**$978,406.62**

See Appendices B through D for a detailed cost breakdown and Appendices E through G for cost comparisons.

4.2 Timeline

The project schedule depended heavily on the availability of the new server platforms. Procurement and installation of the new shared resource environments was a key milestone. Following procurement was the actual consolidation effort which spanned the rest of the project timeline. The detailed timeline can be found in Appendix A., Timeline.

5. Proof of Design

The next section details how the deliverables of the project were fulfilled.

5.1 Consolidation of SQL servers

Cinergy procured and put into service four HP ProLiant DL580 G3 servers. These servers are named SQLPROD01 and SQLPROD02, SQLTD01 and SQLTD02 and are for production and testing databases, respectively. The servers are SAN attached and are running Microsoft Windows 2003 Server and Microsoft SQL Server 2000 Enterprise Edition. Various databases on stand alone SQL servers were moved to these servers and requests for new database servers were deferred to these existing hosts. More than 190 databases were consolidated onto these four servers.

5.2 Physical Virtualization of Servers with HP Blade Servers Proof of Concept

Cinergy procured and put into service two complete racks of HP blade servers. The original specification was for one rack but the high demand of this new server platform quickly utilized the first rack and a second rack was ordered and put into service. Cinergy has more than 70 blade servers in service to date and is expected to more than double that number this year due to server lease expirations and demand for new servers. This new platform has been extremely successful and is more robust than

previously anticipated. The BL20p servers have saved Cinergy on average over $5000.00 per each server.

5.3 Virtualization with VMware ESX Server Proof of Concept

Cinergy procured and put into service more than 20 VMware ESX host servers which far exceed the original specification of 6 host servers. This increase was due to the high demand of this platform for testing and development virtual servers and the need to balance higher workloads across multiple virtual hosts. Cinergy has more than 100 virtual servers deployed to date resulting in an approximate 5 to 1 virtual to host ratio. These virtual servers replaced many physical servers and have also provided a method of cost avoidance for requests of new physical servers.

6. Testing

6.1 Consolidation of SQL servers Testing

Testing for the consolidation of SQL servers was simple since it involved one key question: Could the four new consolidated SQL servers support the loads of multiple SQL servers? Testing proved the answer to this question to be a resounding yes. Candidates for SQL consolidation were easily identified by their small databases and lack of processor and memory utilization. The four new consolidated SQL servers were far more powerful than the servers they were eliminating and the databases were easily moved to the new consolidated server platforms.

6.1.1 Application Awareness

Testing proved that the real challenge to this effort was ensuring that the database's host application was able to find and communicate with the database that had been moved. For example, the production application X on XAPP server that pointed to

the XSQL server needed to be changed so that it could find the database that had been moved from XSQL server to the SQLPROD01 consolidated server. This successful transition involved updating DNS records, ODBC connections and sometimes reconfiguring the application.

6.1.2 Overall Test Results

Overall test results proved that the four consolidated SQL servers were a viable option for hosting multiple databases and that this platform was highly scaleable. Testing showed that resource contention was not an issue and that care would have to be taken to ensure that the moving of databases did not disrupt the applications that were using them.

6.2 Physical Virtualization of Servers with HP Blade Servers Testing

This new server platform was similar to the existing rack mounted HP ProLiant servers that Cinergy used with the exception that many of the blade server's interfaces were virtualized. Because of this, testing centered on the ability of this new platform to interface with existing data center infrastructure and ability to be configured, maintained and supported as easily as existing rack mounted servers. HP field engineers assisted with the configuration and implementation of the blade servers which permitted the acceleration of testing.

6.2.1 Network Interconnect Testing and Port Congestion

Cinergy originally chose to utilize the RJ-45 interconnect panel for network connectivity which in testing proved to be cumbersome due to the number of cables protruding from the back of the blade enclosures. Cinergy later adopted the CISCO switch interconnect that permitted fewer cables and increased bandwidth to the enclosures.

6.2.2 ILO Testing

HP blade servers do not have the traditional keyboard, mouse and video connections like rack mount servers. A blade server's console is accessed by way of its Integrated Lights Out port or ILO. ILO is a KVM over IP technology that provides a java based web console via the network to an authenticated user. This eliminates the need for keyboard, mouse and video cables to be connected to the blade server (4). A dongle that has keyboard, mouse and video connections can be plugged into the front of the blade server in the event of an emergency or failure. The ILO performed well in testing but the dongle permitted faster configuration and loading of the blade servers

6.2.3 Overall Test Results

Overall test results proved that the HP blade servers functioned just as well as their rack mounted counterparts and that the virtualized interfaces did not inhibit the ability to configure, maintain and support them. In fact, testing showed that the new platform increased the efficiency and speed of server deployment. Supporting infrastructure components such as power, network and SAN connectivity can be preconfigured on empty enclosures. This allows for blade servers to be brought online in the time it takes to slide them into the waiting enclosure.

6.3 Virtualization with VMware ESX Server Testing

The addition and integration of the VMware ESX server platform was the most foreign of the three new server platforms but was still able to be accomplished with only the slightest of learning curves. Testing for this platform obviously focused on performance due to the multiples of logical servers that were being hosted on a single

physical server. Testing also focused on the ability to deploy virtual servers on this new platform.

6.3.1 Performance

VMware ESX server utilizes a Linux based operating system. Linux has a thin, non-resource intensive kernel which allows for a larger number of virtual servers than its Windows based cousin GSX server. Testing showed that an ESX host server could easily support multiple virtual servers providing virtual servers with higher workloads were properly distributed among multiple ESX hosts. Two or more resource intensive virtual servers could quickly overwhelm an ESX host causing performance issues. VMware's Virtual Center console provides a holistic view of hosts, virtual servers and their utilization and allows virtual servers to be moved from one ESX host to another ESX host in real time, without taking the server offline.

6.3.2 Deployment

Deploying servers with VMware ESX server was easier than expected since ESX virtual servers support PXE booting from a Windows remote installation server (RIS) (12). Cinergy currently uses a Windows RIS server to deploy operating systems to servers which made the integration of this new server environment seamless. Testing a new image was simple since the virtual server did not require any special drivers.

6.3.3 Overall Test Results

Overall test results were very positive and proved that virtualization technology has matured enough to be a viable server platform. Testing showed that performance concerns can be alleviated if resource intensive virtual servers are properly allocated

among the host servers. Concerns about the deployment of virtual servers were quickly eliminated when RIS testing proved successful.

7. Conclusions and Recommendations

7.1 Conclusions

This project was created in response to Cinergy's rapid server growth. Three new server platforms, consolidated SQL servers, HP blade servers and VMware ESX virtual servers were implemented. These new platforms are driven by a new server provisioning model that eliminates one for one server provisioning. Testing proved that the new platforms would be as easily deployable and supportable as legacy rack mounted servers and that the new platforms could interface with existing data center infrastructure. The project was completed over the Senior Design Sequence. The timeline, budget and cost savings were all on target and all Design Freeze deliverables were met or exceeded.

7.2 Recommendations

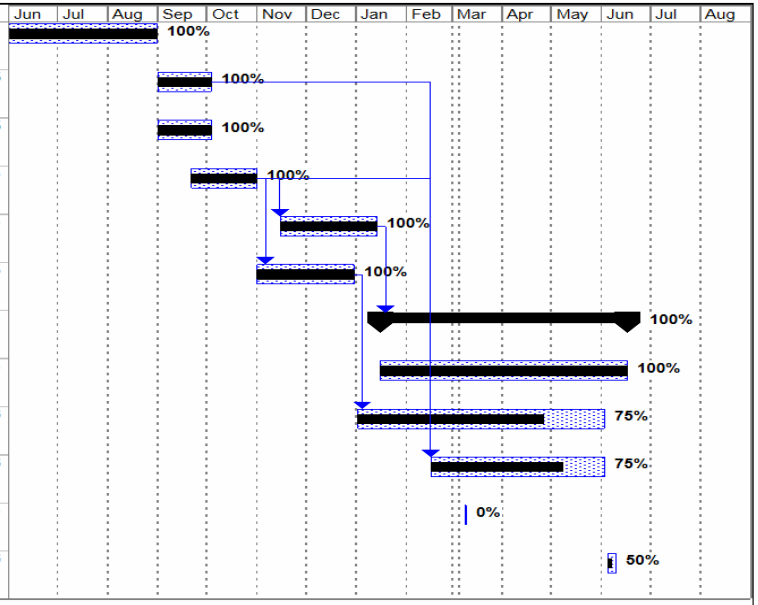
It is recommended that Cinergy continue to use the new server provisioning model to prevent a regression back to one for one server provisioning. One for one provisioning was a root cause of rapid server growth and should be avoided.

It is further recommended that Cinergy employ the HP blade server platform as the primary server platform and expand this platform to include quad-processor blade servers and VMware ESX server on blades. Traditional rack mount and tower servers should be used only when absolutely necessary to allow a complete data center conversion to blade servers. Blade server benefits such as built in KVM and network switches should be exploited to drive down the costs associated with supporting infrastructure.

Finally, it is recommended that Cinergy develop and adopt a disaster recovery strategy based on virtualization and storage replication. Such a strategy could provide Cinergy with a near real-time recovery of critical systems in the event of a disaster and lessen Cinergy's dependence on sourced recovery vendors such as SunGard.

Appendix A. Timeline

ID	Task Name	Start	Finish
1	Consolidation Project Research and Design	Wed 6/1/05	Wed 8/31/05
3	SQL Server Consolidation Candidates Identified	Thu 9/1/05	Mon 10/3/05
4	Virtualization Candidates Identified	Thu 9/1/05	Mon 10/3/05
2	Equipment Procurement and Installation	Wed 9/21/05	Mon 10/31/05
6	Blade Server Familiarization and Deployment Testing	Tue 11/15/05	Fri 1/13/06
7	VMware Familiarization and Deployment Testing	Tue 11/1/05	Fri 12/30/05
8	**Blade Server Rollout and Provisioning**	**Mon 1/16/06**	**Fri 6/16/06**
9	Establish Instant Capactiy on demand with HP (ICOD)	Mon 1/16/06	Fri 6/16/06
10	Virtualization of Physical Servers and VM Provisioning	Mon 1/2/06	Fri 6/2/06
5	Consolidation of SQL Servers	Thu 2/16/06	Fri 6/2/06
11	Senior Design Project Management I Presentation	Thu 3/9/06	Thu 3/9/06
12	Turnover New Infrastructure to Server Operations	Mon 6/5/06	Fri 6/9/06



Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

Appendix B. SQL Server Cost Breakdown

4 Consolidated SQL Servers

Quantity	Part Number	Description	Discounted Price	Total
4	364636-405	HP ProLiant DL580 G3 Chassis - Rack Model	$4,345.20	$17,380.80
	"	Embedded NC7782 Dual Port PCI-X 10/100/1000T Gigabit network adapter		$0.00
	"	Ultra320 Smart Array 6i Controller (integrated on system board)		$0.00
	"	Five Standard 64-bit non-hot plug PCI-X slots (3 x 133MHz, 2 x 100Mhz)		$0.00
	"	One (1) Hot Plug Power Supply with one (1) low line NEMA power cord and One high-line IEC power cord		$0.00
	"	Six (1) Redundant Hot Plug Fans		$0.00
	"	Wide Ultra3/U320 Duplex Drive Cage (can be Simplex configured)		$0.00
	"	Integrated Lights-Out (iLO) Standard Management		$0.00
	"	Rack (4U), 7-inch		$0.00
	"	Protected by HP Services, including a three-year, Next Business Day, on-site limited Global warranty and extended Pre-Failure Warranty, which covers processors, memory, and hard drives - Certain restrictions and exclusions apply.		$0.00
4	348111-L22	X3.33-8M 580 G3 FIO	$4,312.80	$17,251.20
4	391717-001	HP DL580G3 3.33GHz/8MB US Perf Pack 2nd Intel Xeon Processor MP and Processor Power Module, 2nd Rear Accessible Hot Plug Redundant Power Supplies, 128MB Battery Backed Write Cache for the embedded Smart Array 6i	$5,185.01	$20,740.04

		controller		
	348111-B21	Intel X3.33GHz/667-8MB 570/580 G3		
8		Processor Option Kit	$4,844.15	$38,753.20
	375004-B21	HP - Memory - 4 GB (2 x 2 GB) - DIMM 240-pin - DDR II - 400 MHz /		
8		PC2-3200	$1,999.20	$15,993.60
	264007-B21	Slimline DVD-ROM Drive (8X/24X)		
4		Option Kit (Servers)	$103.20	$412.80
	286778-B22	HP 72GB 15K U320 Pluggable Hard	$440.04	
8		Drive		$3,520.32
		HP 300GB 10k Ultra320 UNI Hard	$911.24	
8	350964-B22	Drive		$7,289.92
8	LP9002L-F2	Emulex 2GB/sec HBA PCI Adapter	$1,214.00	$9,712.00
	263825-B21	HP Integrated Lights-Out Advanced		
4		Pack	$251.28	$1,005.12
4	P73-00178-BV	MS WIN SVR STD 2003 ENG MVL B	$569.00	$2,276.00
		MS SQL Server 2000 Enterprise		
4		Edition 4P	$23,911.00	$95,644.00
			Total	**$229,979.00**

Appendix C. HP Blade Server Cost Breakdown

40 BL20p Blade Servers

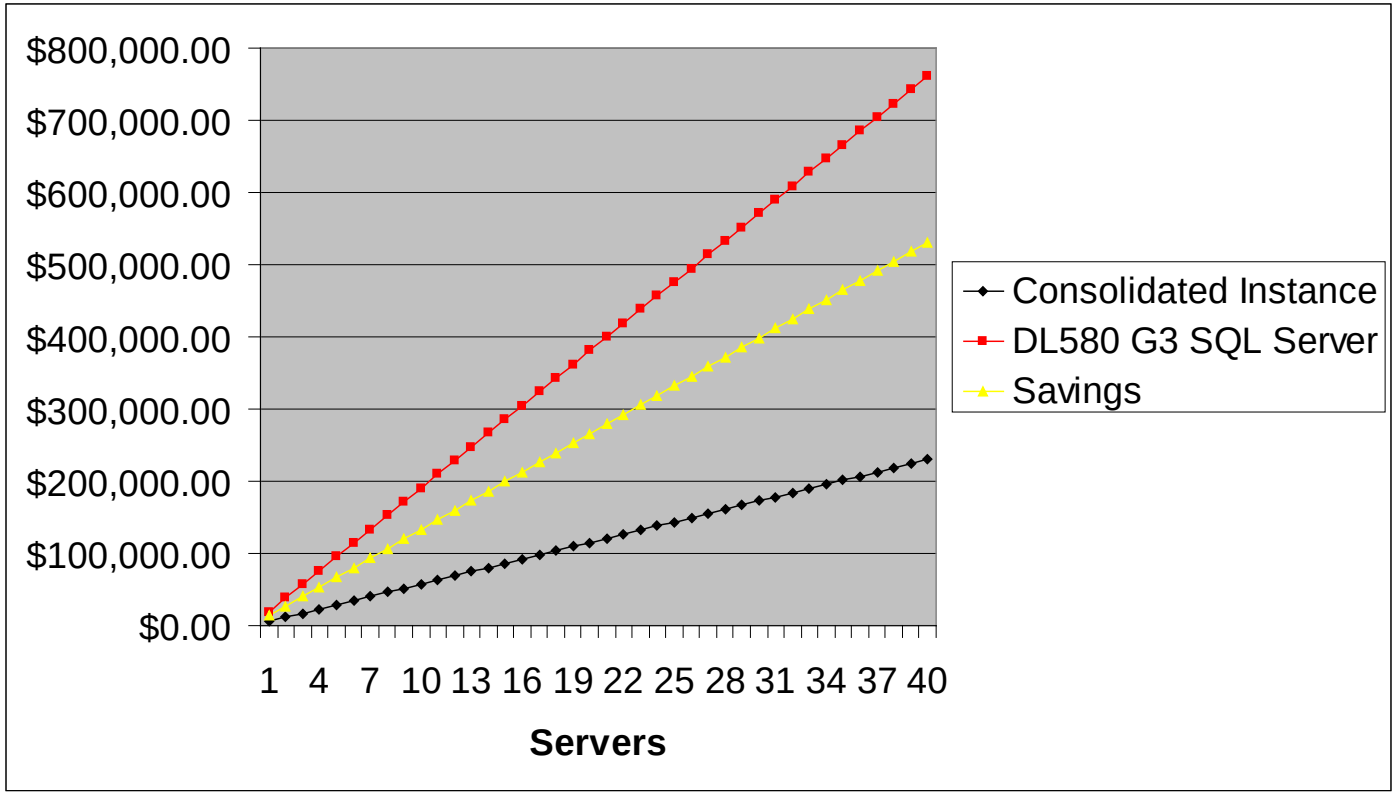
Quantity	Part Number	Description	List Price	Total
40	396226-405	HP BL20pG3 CTO US Blade Svr	$2,063.00	$82,520.00
40	381019-L21	Intel X3.2GHz/800 2MB BL20p G3 FIO Base	$150.00	$6,000.00
40	375004-B21	HP 4GB PC2-3200 2 Rank DDR SDRAM Memory	$2,049.00	$81,960.00
40	394757-B21	Emulex Based BL20pG3 FC Mezz HBA	$899.00	$35,960.00
40	381019-B21	Intel X3.2GHz/800 2MB BL20p G3 Processor	$699.00	$27,960.00
80	286778-B22	HP 72GB 15K U320 Pluggable Hard Drive	$479.00	$38,320.00
40	346914-B21	HP SA6i Battery Backed Cache Enabler	$199.00	$7,960.00
1	245161-B22	HP 10642 42U Shock Rack Pallet	$1,603.00	$1,603.00
1	246099-B21	HP 10K Graphite Metallic 42U Side Panel	$312.00	$312.00
5	378926-B21	Cisco BLp Ethernet Switch	$4,799.00	$23,995.00
5	243564-B22	HP BLp Enhanced Enclosure	$1,499.00	$7,495.00
1	230769-001	HP BLp 3Phase Redundant US Pwr Enclosure	$2,619.00	$2,619.00
1	240560-B21	HP BLp-Class Scalable Bus Bar	$699.00	$699.00
40	P73-00178-BV	MS WIN SVR STD 2003 ENG MVL B	$569.00	$22,760.00
			Total	**$340,163.00**
			Discounted Total	**$308,442.70**

Appendix D. VMware Servers Cost Breakdown

6 VMware Servers

Quantity	Part Number	Description	Discounted Price	Total
6	371293-405	HP ProLiant DL380G4 Rack Chassis	$1,369.28	$8,215.68
	"	NC7782 Dual Port PCI-X Gigabit Server Adapter (embedded)		$0.00
	"	Ultra320 Smart Array 6i Controller (integrated on system board)		$0.00
	"	Three available 64-bit PCI-X slots, including two non-hot plug 100MHz slots and one non-hot-plug 133MHz slot		$0.00
	"	575 Watt hot plug power supply, CE Mark Compliant.		$0.00
	"	One Lowline NEMA power cord and One Highline IEC Power cord		$0.00
	"	5 hot plug fans		$0.00
	"	Rack (2U), (3.5-inch)		$0.00
6	311583-L22	Intel X3.4GHz/800-1MB 380G4 FIO BASE	$1,079.10	$6,474.60
6	311583-B21	Intel Xeon X3.4-1MB/800MHz Processor Option Kit	$1,079.10	$6,474.60
6	343057-B21	4GB of Single-Ranked PC2 PC3200 DDR2 SDRAM DIMM Memory Kit (2x2048 MB)	$4,871.16	$29,226.96
6	338732-B21	HP ProLiant Slim CD-ROM	$41.80	$250.80
6	346914-B21	Smart Array 6i 128MB Battery Backed Write Cache Enabler Option Kit	$151.24	$907.44
6	364507-B21	Floppy Drive Option Kit	$37.24	$223.44
6	355892-001	Hot Plug AC Redundant Power Supply Module (NEMA and IEC cords)	$189.24	$1,135.44
6	263825-B21	HP Integrated Lights-Out Advanced Pack	$251.28	$1,507.68
60	P73-00178-BV	MS WIN SVR STD 2003 ENG MVL B	$569.00	$34,140.00
12	LP9002L-F2	Emulex 2GB/sec HBA PCI Adapter	$1,214.00	$14,568.00
12	286778-B22	HP 72GB 15K U320 Pluggable Hard Drive	$440.04	$5,280.48
6		VMWARE ESX Server	$5,856.00	$35,136.00
			Total	**$143,541.12**

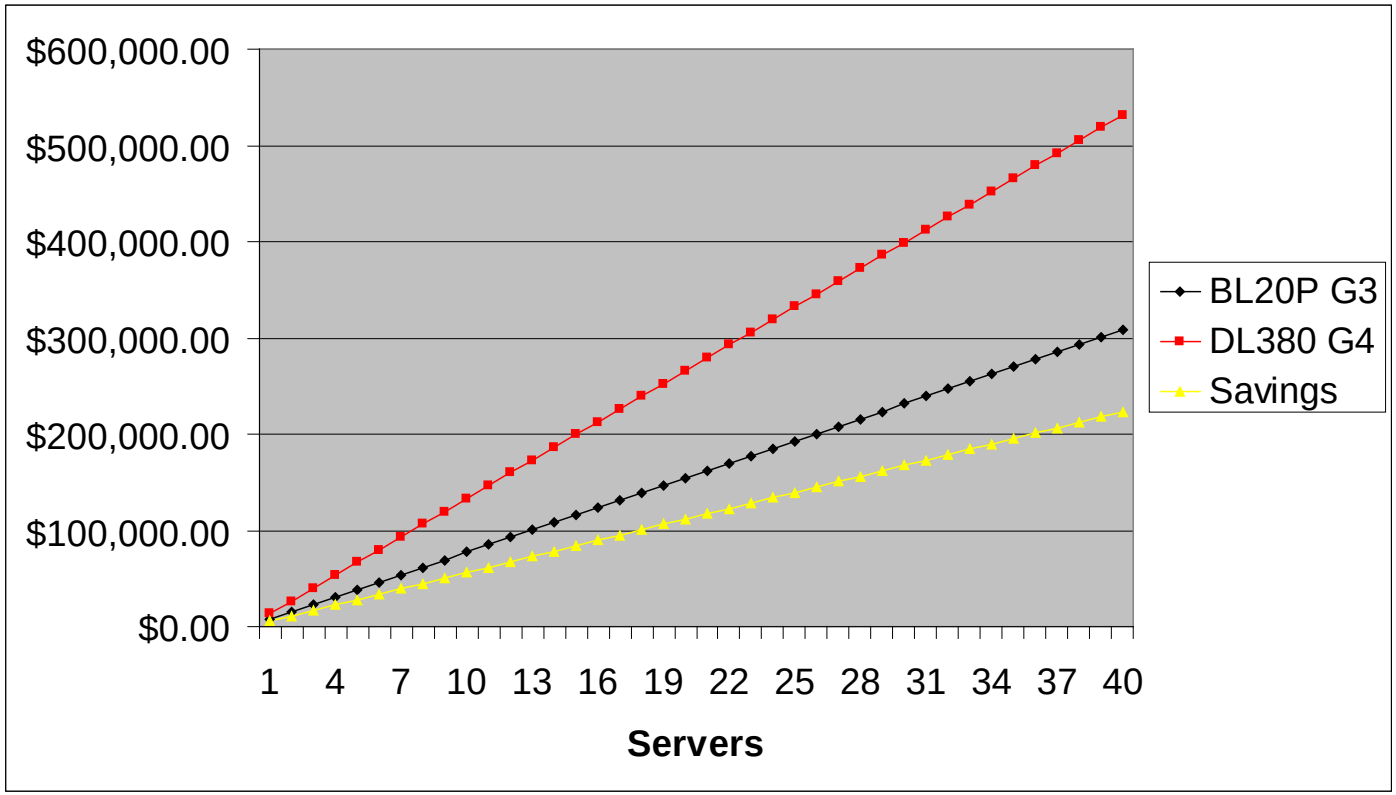
Appendix E. Cost Comparison Between Consolidated DL580 G3 SQL Database Servers and Stand Alone DL580 G3 SQL Servers*



*Includes Microsoft Windows 2003 Server and Microsoft SQL 2000 licensing. Assumes 10 or more SQL Databases per consolidated SQL server.

Consolidated Cost per Database - $5,749.48
DL580 G3 SQL Server Cost - $19,033.52

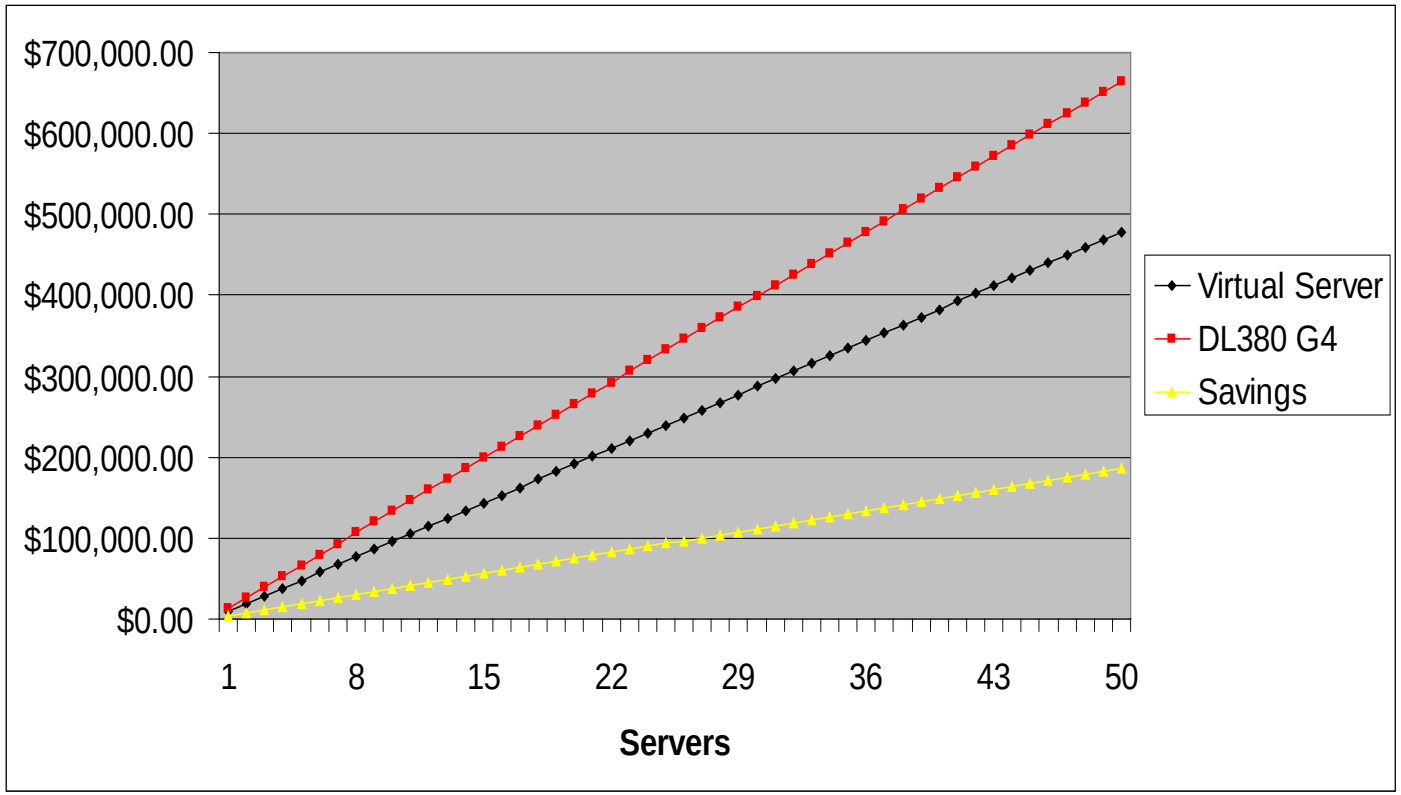
Appendix F. Cost Comparison Between HP BL20p G3 Blade Servers and HP DL380 G4 Rack Servers*



*Servers configured comparably.

BL20p G3 – 2 Intel Xeon 3.2 GHz Proc, 4GB Mem, 2 72GB 15K U320 Drives, ILO, Dual PS, 2 HBAs $7710.57
DL380 G4 – 2 Intel Xeon 3.4 GHz Proc, 4GB Mem, 2 72GB 15K U320 Drives, ILO, Dual PS, 2 HBAs $13.296.52

Appendix G. Cost Comparison Between VMware Virtual Servers and HP DL380 G4 Servers.*



*Performance is not guaranteed in a shared server environment. Includes VMware ESX and Microsoft Windows 2003 licensing. Assumes 10 or more Virtual servers per VMware host.

Virtual Server Instance Cost - $9569.41
DL380 G4 Cost - $13.296.52

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