virtual infrastructure
METHODOLOGY

VIRTUALIZATION ASSESSMENT REPORT

Server Consolidation and Server Containment Through Virtualization

Prepared for:

Bakersfield College

Bakersfield College

Prepared By:

Govplace Professional Services

November 25, 2008

Contents

Executive Summary

Background

Bakersfield College is considering making an investment in virtual infrastructure. Bakersfield College engaged Govplace Professional Services to conduct a Virtualization Assessment to determine whether or not a virtual infrastructure is possible.

The assessment analyzed your server characteristics and performance utilization to determine if existing workloads could be virtualized. The assessment also gathered Bakersfield College-specific financial data to approximate the associated costs of virtualization.

We are pleased to present this report which documents the findings of our assessment. This report is intended to help you:

- Evaluate the opportunity for server virtualization at Bakersfield College
- Estimate the costs to deploy a standard virtualization solution (along with potential cost savings)
- Present a gap analysis between the standard virtualization solution and Bakersfield College's detailed requirements
- Provide a roadmap of next steps toward implementing a virtual infrastructure solution

Summary of Findings

The assessment results indicate that a virtualization strategy would be a worthwhile pursuit for the Bakersfield College. We anticipate that virtualization will help consolidate a considerable amount of existing and future server workloads. This will increase average server utilization and lower your overall hardware footprint, as well as lower associated costs.

During the assessment, we were able to successfully gather data on 18 of 19 discovered systems. The table below highlights the total number servers analyzed:

Locations	Server Count
No Connection/Incomplete Data	1
Data Center	18
Total	**19**
Total Assessed	**18**
Assessed %	**95%**

Current Server Count / Location

The following table represents the estimated number of physical host servers that could be deployed at each location and the consolidation percentage of those sites.

Locations	Est. # of Host Servers	Consolidation %
No Connection	0	0.00%
Data Center	2	1

Estimated Server Count with Virtualization

The host servers were sized to support the existing workloads and planned provisioning requests. Implementing a virtual infrastructure will dramatically improve the time and efforts required to provision new servers as well as significantly reduce the costs of deploying a new server.

The total cost of ownership (TCO) of the current server infrastructure could be reduced by nearly $218,000 over the next 3 years. This is a conservative model and does not take into account substantial savings from intangibles such as quicker time to recovery for DR, etc. This figure includes the additional hardware and software costs required to implement virtualization. The 3-Year return on investment (ROI) calculates to more than 234%. A snapshot of the TCO and ROI figures is shown below. Detailed information can be found in *Section II: Financial Analysis*.

Summary - Estimated Annual Savings			
	Year 1	Year 2	Year 3
Physical Infrastructure	$95,243	$100,950	$107,515
Virtual Infrastructure	$47,911	$20,486	$17,577
Estimated Annual Savings	$47,331	$80,465	$89,938

Year-to-Year Savings

Summary – Estimated Total 3-Year Savings			
	Year 1	Year 2	Year 3
Physical Infrastructure	$95,243	$196,193	$303,708
Virtual Infrastructure	$47,911	$68,397	$85,973
Estimated Total Savings	$47,331	$127,796	$217,734

Cumulative Savings

Return on Investment (ROI)			
Cost/Savings	Year 1	Year 2	Year 3
Virtualization Investment	$47,911	$20,486	$17,577
Savings from Virtualization	$47,331	$80,465	$89,938
Return on Investment (ROI)	-1.21%	292.79%	411.69%

Year-to-Year ROI

Virtualization Assessment Report Overview

Section I: Infrastructure Analysis

Objective: Discover, inventory, and assess the current server environment capacity and utilization; Identify virtualization candidates and estimate a virtual infrastructure solution.

A. Server Inventory Analysis
Statistics observed from the sampled set of Bakersfield College servers
B. Virtualization
Server virtualization use cases and virtualization methodology
C. Server Consolidation Assessment
Anticipated server consolidation ratios to consolidate existing workloads
D. Server Containment Assessment
Anticipated server consolidation ratios to consolidate future workloads

Section II: Financial Analysis

Objective: Present the financial justification to proceed with a virtualization strategy.

A. Total Cost of Ownership (TCO) Analysis
Direct and indirect costs of virtualization solution compared to status quo
B. Return on Investment (ROI) Analysis
Estimated return on capital investments in virtual infrastructure

Section III: Requirements Analysis

Objective: Compare and contrast a standard virtual infrastructure solution (based on assessment findings) with detailed customer requirements and limitations.

A. Assumptions
Assumptions and caveats associated with a standard virtualization solution
B. Gap Analysis
Specific requirements and limitations that should be considered in the design of a complete virtualization solution

Section IV: Next Steps

Objective: Outline a plan to move forward with a virtualization solution. Bakersfield College should engage Govplace Professional Services to discuss specific requirements, timing, and resource needs.

Virtualization Roadmap
Next steps to deploy virtual infrastructure

Section I: Infrastructure Analysis

Server Inventory Analysis

Background

Govplace Professional Services used VMware's Capacity Planner to discover, inventory, and gather performance and utilization data on 18 servers over a period of approximately 32 contiguous days from 10/13/2008 to 11/15/2008. This period spanned several weeks to obtain a representative sampling of data, including peaks and utilization trends.

Sampling Methodology

The VMware Capacity Planner identified 19 systems to be analyzed; however, valid data was collected on only 18 of these systems. We excluded 1 systems from this study because we could not obtain complete and/or valid server characteristic and utilization data. Such systems may be considered for later review only if proper and complete data can be obtained.

Our subsequent findings and analyses are based on the 18 servers and not the original 19 discovered systems.

Name	Server Population	Number	Reason for Exclusion
A	Discovered with Capacity Planner	19	
B	No data		VMware Capacity Planner unable to connect to server
C	Invalid data		VMware Capacity Planner identified questionable anomalies (e.g. CPU speed reporting as 3MHz)
D	Incomplete data	1	VMware Capacity Planner did not obtain a complete sampling of data across the entire sampling period
E	TOTAL SERVERS ANALYZED	**18**	

Servers Analyzed

Server Inventory Analysis

The workload characteristics and utilization metrics gathered from the analyzed servers suggest a good number of potential virtualization candidates for two reasons. First, we identified a group of servers that we call "obsolete" because they are running at 1.0 GHz or less, and the costs for using virtual machines as replacements is significantly lower than with like-for-like physical hardware. Second, we also found a good number of running servers with underutilized CPU and RAM resources which are ideal candidates for consolidation.

Detailed reports can be found in Appendix A: Analyzed Server Inventory Metrics.

Virtualization

Why Virtualization?

Virtualization is the act of presenting a logical grouping of physical computing resources. Each logical group, or virtual machine, is a self-contained and encapsulated unit that runs its own operating system and application workloads.

Virtualization allows multiple virtual machines to share one common underlying physical server and its resources through time and resource bandwidth sharing. Because today's hardware continues to be more powerful than the applications that run on it, virtualization allows you to run multiple application workloads on shared hardware, thereby increasing overall utilization.

VMware is the market leader and innovator in virtualization. VMware ESX Server is VMware's high-performance virtual infrastructure software that runs on top of datacenter servers to host multiple virtual machines.

Virtualization for Server Consolidation

A compelling use case for virtualization is to take the existing servers running in your data centers and migrate them to corresponding virtual machines running on fewer VMware ESX Server hosts. Such server candidates are typically underutilized servers or old, inefficient servers near the end of their expected life. By migrating these servers to virtual machines, overall server utilization can be increased while decreasing the number of physical servers and required supporting power and maintenance costs.

A challenge associated with migrating existing applications and operating systems, either off existing hardware to new hardware or off existing hardware to virtual machines, is that such applications and operating systems may need to be reinstalled and reconfigured. In the case of physical to virtual migrations, VMware solves this problem with VMware P2V Assistant. VMware P2V Assistant is an application that provides an expeditious and smooth method to virtualize physical servers to avoid having to reinstall and recreate operating system and application configurations.

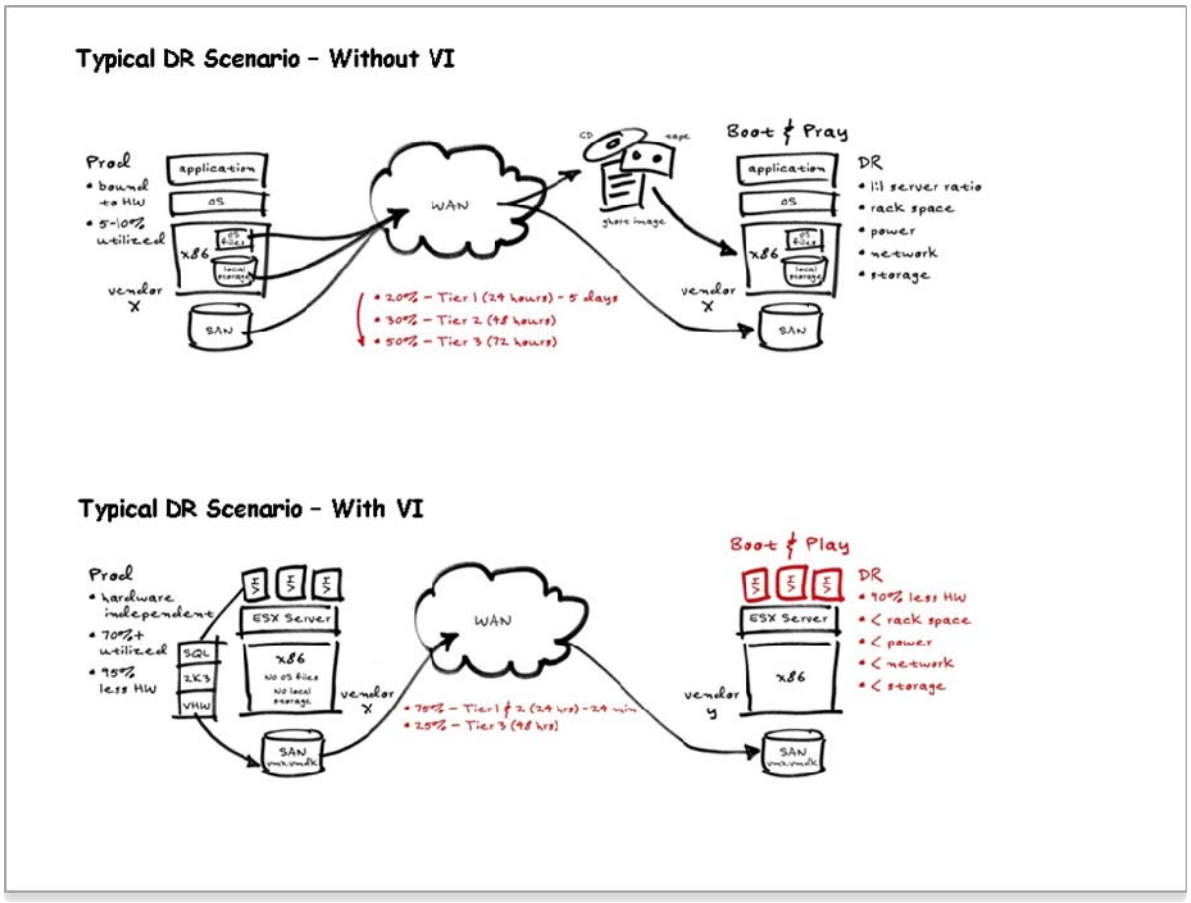
Virtualization for Server Containment

Another use case for virtualization is to proactively prepare for planned new server requests. By investing in a server coupled with VMware ESX Server, you can comfortably accommodate multiple future server provisioning requests without having to purchase additional physical servers for each request. By fulfilling future server provisioning requests as virtual machines, the need to purchase additional physical servers for the datacenter can be contained. Virtualization for server containment also provides a strategic benefit because the provisioning cycle is dramatically reduced.

Additional Benefits of Virtualization

While virtualization is immediately compelling when applied to server consolidation or server containment strategies, many customers have discovered that running virtual infrastructure can help improve services levels and availability.

For example, because virtual machines are encapsulated, their configuration and state information can easily be captured and migrated. Virtual machine virtual disks are literally files that can be backed up and restored quickly for disaster/recovery purposes. The graphic below illustrates how a Virtual Infrastructure can simplify the DR/BC process.



VMware VMotion gives customers the ability to move running workloads from one ESX Server to another without service interruption. This ability allows customers to load balance or handle maintenance on one ESX Server without the need to schedule downtime.

VMware High Availability (HA) provides easy-to-use, cost-effective high availability for virtual machines. Unplanned down time can be reduced by automatically restarting virtual machines on other ESX Server hosts in the event of hardware failure.

VMware Distributed Resource Scheduler (DRS) facilitates the use of logical pools of computing resources by scheduling virtual machine workloads across a pool of ESX Server hosts. The workloads can be dynamically shifted and rebalanced across the hosts to respond to demand and resource changes to achieve optimum efficiency.

VMware Consolidated Backup (VCB) provides an easy-to-use centralized facility for taking LAN-free backups of virtual machines, including file-level as well as disk-level snapshots.

Virtual machine provisioning enables utility on-demand computing because virtual machines are created as needed, using incremental physical resources. Test servers are particularly well-suited as virtual machines because they can be quickly provisioned, decommissioned, and even archived.

Virtual Infrastructure Methodology

To successfully implement a virtualization solution, Govplace Professional Services uses the VMware Virtual Infrastructure Methodology (VIM) that can guide you through all the necessary steps. The VIM is a four-phased methodology designed by Govplace Professional Services and based on industry best practices and experience to effectively deploy virtual infrastructure through four well-defined phases: **assess**, **plan**, **build**, and **manage**. VIM provides a proven path to aligning your business goals and strategies with your organizational, process, and technical requirements to successfully deploy virtual infrastructure.

The Virtualization Assessment we conducted contains a subset of the activities that comprise the VIM Assess phase. The Virtualization Assessment includes many standard assumptions and while an initial analysis and assessment of Bakersfield College-specific requirements or limitations has been done, the results of this assessment may not fully address all requirements. A comprehensive solution would augment the findings in this Virtualization Assessment report with additional detailed organizational, business, and operational assessments, as well as a more exhaustive infrastructure assessment, to achieve a complete VIM Assessment.

Server Consolidation and Containment Assessment

Virtualization Estimate – for Server Consolidation without Hardware Reuse

Based on the performance and utilization metrics gathered at the Bakersfield College, Govplace has chosen the HP DL360 G5 Server as the target platform for the primary Data Center. This scenario assumes all target ESX Servers are brand-new with no reuse of existing servers. In addition, this scenario was designed to accommodate future server provisioning requests. Since the utilization of planned future virtual machines is unknown, we assume that the CPU and RAM utilization will be comparable to the average utilization metrics observed from the servers we analyzed during the assessment. Govplace Professional Services estimates the following consolidation and virtualization ratios:

Range	# of Virtualization Candidates	# of ESX Server Hosts Required	Approximate Consolidation Ratios	Average CPU Utilization per ESX Server Host	Average Memory Utilization per ESX Server Host
Minimum to Possible (conservative to aggressive)	18 to 18	2	9:1 to 9:1	30 to 70	40 to 90

Consolidation Estimates

The number of virtualization candidates ranges from 18 to 18 servers, which represents 95% to 95% of the total 18 analyzed servers (this number includes an additional servers for future provisioning). The low end of the range represents our minimum expected. These figures take a conservative approach and allow for additional headroom for capacity as well as a margin of error. The minimum number of virtualization candidates was derived from a formula based on servers with CPU below 1.0 GHz and/or less than 1GB of memory.

The top end of the range represents the possible realm of virtualization candidates. Candidates identified in the upper range may not be good candidates from a utilization perspective, but nonetheless can be considered. Based on the findings, 18 of the 18 servers on average ran less than 20% of their CPU capacity. 18 of the 18 servers on average ran less than 10% of their CPU capacity.

This scenario suggest that we can increase overall CPU utilization within a virtual infrastructure from less than 10% per existing server to 30-70 on each new target host ESX Server.

Keep in mind that certain Bakersfield College-specific organizational, procedural, policy, or technical requirements or limitations may affect the actual consolidation ratios.

The respective estimates for the server consolidation component and the server containment component will be detailed in the subsequent sections.

Proposed Consolidation Target Platform

Govplace has chosen the HP DL360 G5 Server as the target platform for virtualization with the following configuration:

Hardware Component	Number	Size, Speed, Type, Make/Model
CPUs	2	2.83GHz Quad Core
RAM	---	16 GB
NIC ports	6	INTEL 1Gbps
HBAs	---	Emulex 4Gbps
Local Storage	---	72 GB SAS

Proposed Virtualization Platform (Data Center location)

Virtualization Candidates Selection Criteria

Out of the 18 servers analyzed, 0 servers were deemed non-ideal candidates for virtualization. Some of the factors that would make a server non-ideal are listed below:

- Server uses specialized peripherals not supported in VMs
- Server is using more than 4 active NIC ports
- Server requires more than 16GB RAM
- Server requires more than 4 physical CPUs
- Server is already a VMware VM
- Govplace suggests that at least one domain controller should remain on physical server

Bakersfield College did not fit this criterion on any observed server, with the exception of a domain controller.

We then analyzed performance and utilization metrics on the remaining 18 servers and identified a minimum number of 18 servers for candidates. Actual consolidation ratios and numbers will most likely lie within this possible virtualization scenario consolidation range.

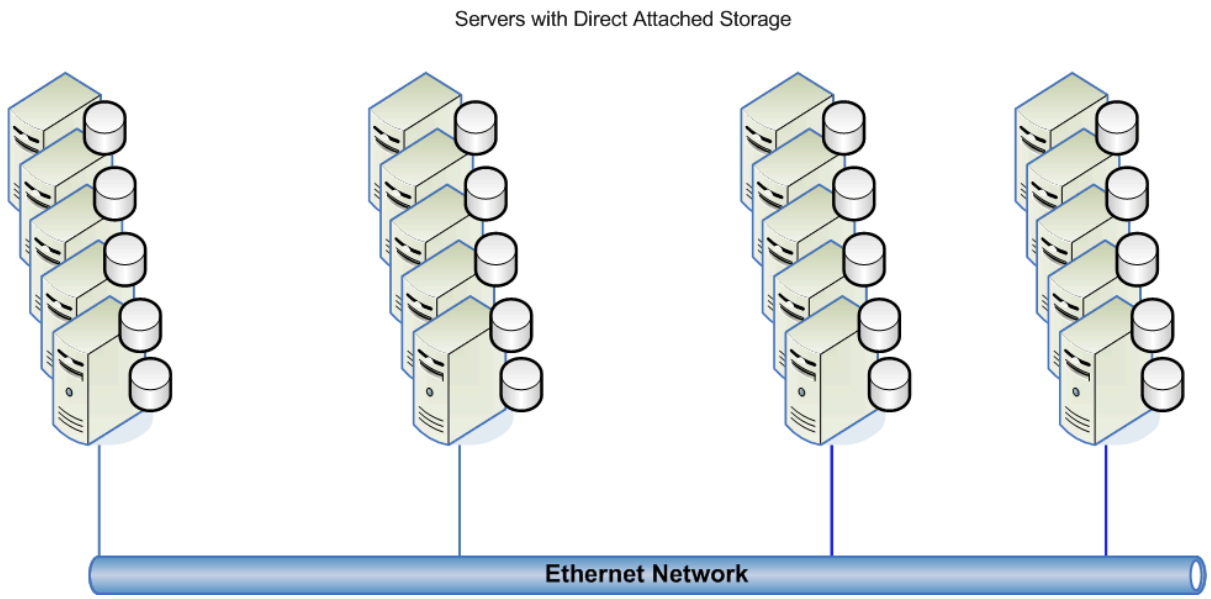
Server Population	Number	Qualification Criteria
TOTAL SERVERS ANALYZED	**18**	All servers not disqualified due to sampling errors
Do not virtualize	**0**	Not supported or potentially poor performance as VM
Viable candidates – possible	**18**	All candidates that are not obviously bad candidates
Viable candidates – minimum	**18**	Minimum/conservative number based on utilization analysis

Server Candidates for Virtualization

Server and Storage Infrastructure Diagrams

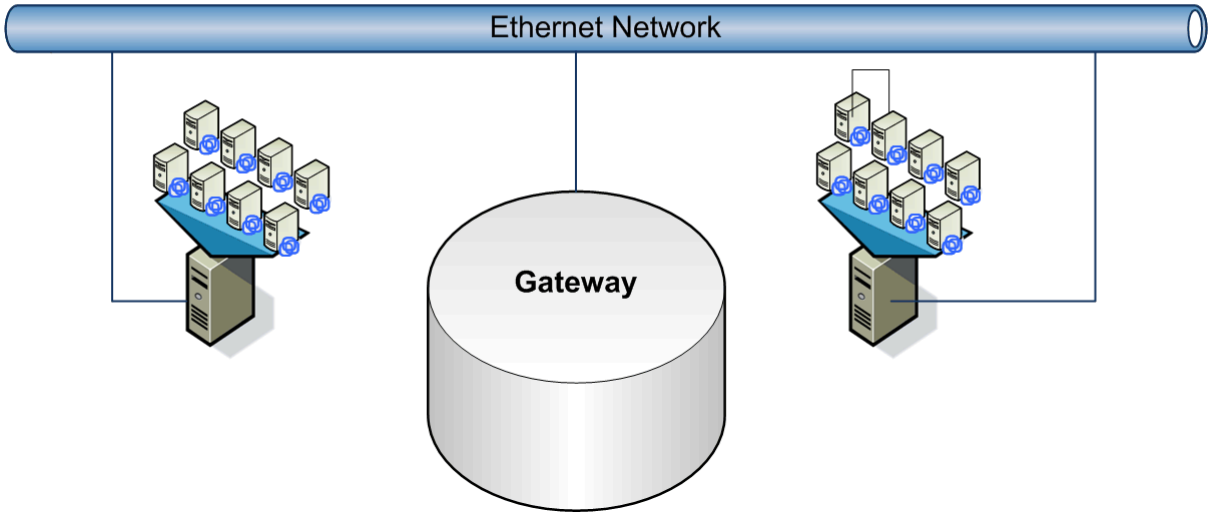
Bakersfield College has a traditional network topology consisting of an Ethernet LAN connecting all servers with none attached to the iSCSI SAN. The diagram below represents Bakersfield College's server and storage infrastructure prior to consolidation.

Bakersfield College Prior to Virtualization



The diagram below represents the Bakersfield College's server and storage infrastructure with virtualization. All servers can realize the benefits of the SAN without the additional costs of SAN connectivity.

Bakersfield College after Virtualization



Section II: Financial Analysis

Total Cost of Ownership (TCO) Analysis

Summary of Estimated Costs/Savings for Virtualization

Summary - Estimated Annual Savings			
	Year 1	**Year 2**	**Year 3**
Physical Infrastructure	$95,243	$100,950	$107,515
Virtual Infrastructure	$47,911	$20,486	$17,577
Estimated Annual Savings	$47,331	$80,465	$89,938

Year-to-Year Savings

Summary - Estimated Total 3-Year Savings			
	Year 1	**Year 2**	**Year 3**
Physical Infrastructure	$95,243	$196,193	$303,708
Virtual Infrastructure	$47,911	$68,397	$85,973
Estimated Total Savings	$47,331	$127,796	$217,734

Cumulative Savings

TCO calculations cover a 3-year period. Costs are derived from running a combined total of 18 virtual servers on 2 ESX Server hosts:

- **Server Consolidation**. 18 total virtualization candidates will be consolidated onto 2 ESX Server hosts, with no hardware reuse. We assume all virtualization candidates can be migrated in the first year. This is a conservative savings estimate, and assumes that no servers are refreshed or replaced.

- **Server Containment**. The servers configured for this project have room for growth. This would allow for the quick and efficient provisioning of additional servers without the purchase of additional hardware or virtualization software.

Only tangible costs are considered in this estimate. You may expect sizeable savings in the form of intangible cost savings resulting from higher availability and less downtime. Virtual machines offer the possibility for higher availability through services such as VMotion or faster backup and recovery, due to the encapsulation properties of virtual machines and virtual disks and the ability to capture virtual machine states.

The detailed costs are broken down in the following table. Refer to Appendix D: TCO Model for a detailed model and calculator, as well as a detailed list of assumptions used in this model.

Option 1 -New Physical Servers					
Number of servers	19		19	22	25
Estimated Annual Server Refresh	20%				
Estimated Annual Server Growth (%)	15%		**Year**		
	Server Count	**Cost Per**	**1**	**2**	**3**
New Physical Servers/Year (Refresh + Annual Growth)	7	$7,000	$46,550	$46,550	$46,550
3 Yr Maintenance (33% of servers / year)		$500	$3,167	$3,642	$4,188
Server Migration/Setup (new servers)	7	$1,600	$10,640	$10,640	$10,640
Management Costs		$325	$6,175	$7,101	$8,166
Power and Cooling Costs		$1,511	$28,711	$33,018	$37,970
SAN Connectivity/Server Dual Path	0	$1,800	$0	$0	$0
Total Yearly Costs			**$95,243**	**$100,950**	**$107,515**
Total Cumulative Costs			**$95,243**	**$196,193**	**$303,708**

Estimated Annual Cost for Current "Traditional" Server Infrastructure

Option 2 -Virtual Infrastructure (Primary Site only)					
Physical Servers (non-virtual)	2		2	2	2
Physical Servers w/ virtualization	2		2	3	3
Estimated Annual Physical Server Growth (DC Only)	1				
			Year		
	Server Count	**Cost Per**	**1**	**2**	**3**
VMWare Hosts (Rack-Mount servers):					
Virtual Center Management Server	1	$3,529	$3,529	$0	$0
VMware Host Servers	2	$4,990	$9,980	$4,990	$4,990
3 Yr Maintenance (33% of servers / year)	2	$510	$340	$340	$340
Server Migration/Setup (new servers)		$1,600	$0	$1,600	$1,600
Management Costs		$325	$1,300	$1,625	$1,625
Power and Cooling Costs		$1,511	$6,044	$7,556	$7,556
SAN		$0	$0		$0
SAN Connectivity/Server Dual Path		$1,800	$0	$0	$0
VMWare Software Licenses		$2,909	$5,818	$2,909	$0
VMware Platinum S&S (3 Year)		$1,466	$2,932	$1,466	$1,466
Virtual Center plus support		$3,968	$3,968		$0
Consulting Services and Implementation		$14,000	$14,000	$0	$0
Total Yearly Costs			**$47,911**	**$20,486**	**$17,577**
Total Cumulative Costs			**$47,911**	**$68,397**	**$85,973**

Estimated Annual Cost Virtual Server Infrastructure

Return on Investment (ROI) Analysis

Estimated ROI for Virtualization

Return on Investment (ROI)			
Cost/Savings	Year 1	Year 2	Year 3
Virtualization Investment	$47,911	$20,486	$17,577
Savings from Virtualization	$47,331	$80,465	$89,938
Return on Investment (ROI)	-1.21%	292.79%	411.69%

Year-to-Year ROI

Our ROI calculation uses the previous corresponding TCO Analysis calculation for the savings amounts. For purposes of clarification, ROI is calculated as:

ROI = (Benefit of Virtualization – Cost of Virtualization) / Cost of Virtualization

Based on these calculations, the estimated **3 Year ROI is 234%**. Taking into account the total capital and operational outlay for maintaining a traditional physical environment, the payback (break-even) period is estimated to be 15 - 17 months if all candidate servers are virtualized.

Section III: Requirements Analysis

Assumptions

The virtualization scenarios presented in this report must be qualified with assumptions and caveats. It is important to note that changes to these assumptions and caveats could impact the calculations previously made and invalidate the estimates.

A standard virtualization solution includes the following assumptions. These assumptions qualify the solution to handle most situations optimally. A detailed assessment of your situation is needed to ensure that your business and technical needs will be met. Without this knowledge, we assume optimum conditions. Any specific requirements in terms of business, technical, organizational, or procedural policies, requirements, and limitations will require further analysis to determine the need for additional resources to build a suitable virtual infrastructure solution.

Target Platform

- All target VMware ESX Server host servers at the Data Center will be identical in configuration. Differences in configurations could impact sizing and may require modeling additional scenarios.

- All planned hosts planning will be located in one single physical location.
- All NIC ports in the target ESX Server hosts will be active. If not all ports will be active, more ESX Server hosts may be required to distribute the potential network load to avoid network-based performance bottlenecks.
- The use of Gigabit NICs assumes a network using Gigabit speeds.
- Shared storage using a SAN will be available to all ESX hosts planning to utilize the VMotion and other capabilities of VMWare. Third party solutions will be incorporated for redundancy to augment the replication capabilities of those hosts located at offsite facilities.
- All target ESX Server hosts will have access to required storage, and storage limitations are not considered a gating factor.
- An additional server and database will be required for the VirtualCenter management server and system.
- All workloads will utilize VMware virtual disks residing on a VMFS file system, and no virtual disks will map directly to SAN LUNs.

Hardware Reuse

- Servers considered for reuse will have CPU specifications to support VMotion compatibility. Non-identical hardware will limit the ability to use VMotion and restrict the ability to shift loads across multiple ESX Server hosts.
- Server reuse will likely incur additional costs to upgrade and prolong the expected life of the server to be reclaimed.

Current Utilization

- The sampled servers are representative, and any extrapolations to be made of their utilization metrics to a larger server universe must assume no dramatic differences in utilization.
- The current utilization rates observed will not increase significantly in the future.

Future Utilization

- The target ESX Server hosts are reserved exclusively for server consolidation of the existing servers and server containment to support future provisioning requests, respectively. These hosts do not account for unplanned additional workloads, other than for contingency or workload balancing.
- All target ESX Server hosts will be utilized to their maximum potential and workloads can be freely balanced across the target hosts with no network limitations. Customer-specific requirements could limit this assumption and require additional target hosts due to lower anticipated realized throughput.

Gap Analysis

Our initial assessment of the requirements specific to Bakersfield College relative to our standard set of assumptions is that Bakersfield College may need additional ESX Servers (or at least be on the lower end of the estimated virtualization consolidation ratio) to handle the anticipated number of virtual machines. The additional ESX Servers are needed to work around limitations imposed by these special requirements. Additionally, we recommend further analysis to confirm that such requirements are not the result of misunderstandings of virtual infrastructure capabilities. We also recommend detailed design sessions to accurately architect virtual infrastructure configuration to ensure that the organizational, operational, infrastructure and business requirements at Bakersfield College will be met.

Section IV: Next Steps

Virtualization Roadmap

Should you decide to undertake a virtualization effort, we have outlined the next steps needed to deploy your solution.

Plan and Build Virtual Infrastructure

- Assemble an architecture team with key subject matter experts and stakeholders
- Conduct a gap analysis to review specific requirements relative to the assumptions made in this report to develop detailed specifications
    - VIM Assessment (augment the findings in this Virtualization Assessment report)
- Plan and design virtual infrastructure
    - VIM Plan Project
        - Develop a project plan for deployment – VIM Project Plan
        - Develop detailed design and assembly procedures – VIM Blueprints
        - Develop an implementation test plan – VIM Test Plan
        - Develop a plan for managing virtual infrastructure – VIM Management Plan
- Arrange knowledge enablement VI Jumpstart workshops to involve your team in the design process
    - VMware Infrastructure with P2V Jumpstart workshop
        - Develop a prototype
        - Conduct a proof of concept server migration
- Develop and document procedures for migrating servers and provisioning new servers
- Train owners
    - VMware Infrastructure classes
- Implement virtual infrastructure and migrate servers
    - VIM Build Project
- Manage Virtual Infrastructure
    - Virtual Infrastructure Health Check

VIM Phases

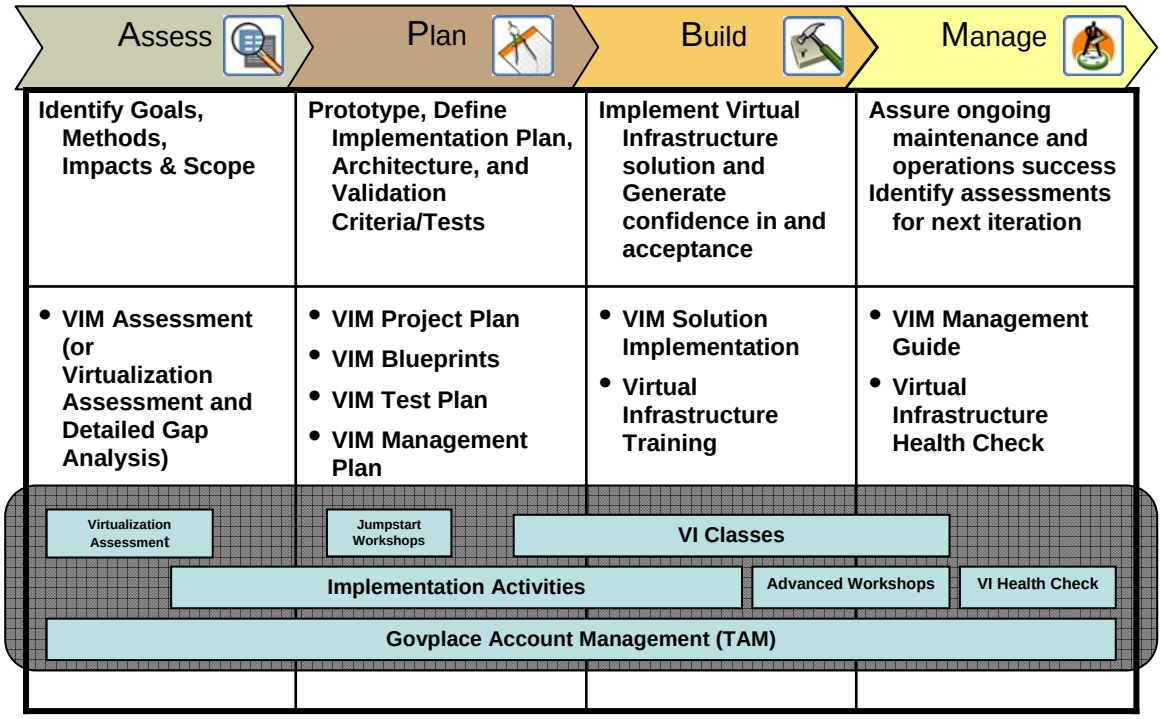


Figure 2

Appendix A: Analyzed Server Inventory Metrics

Inventory Breakdown by Model

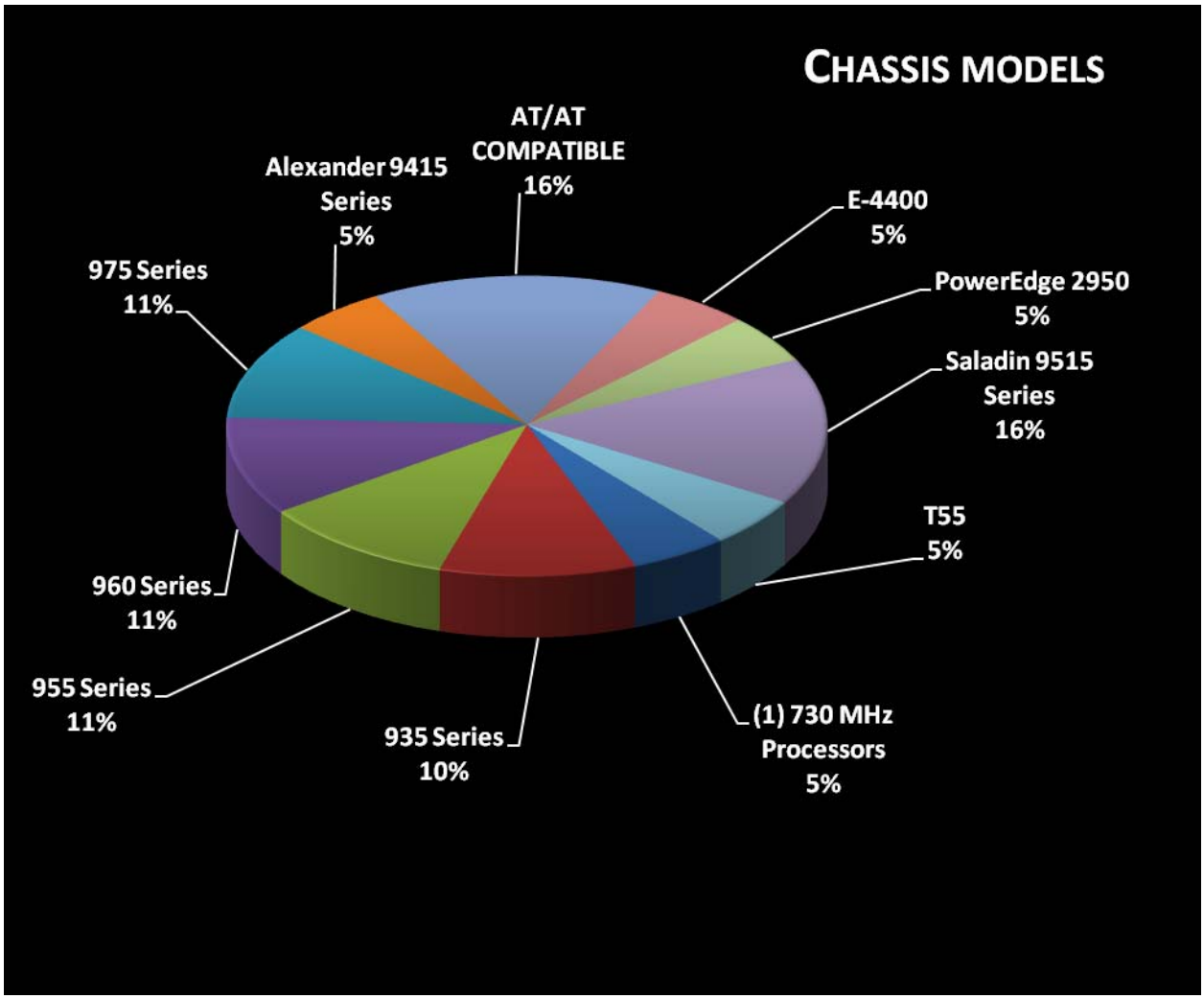


Chart A-1

Inventory Breakdown by CPU Count

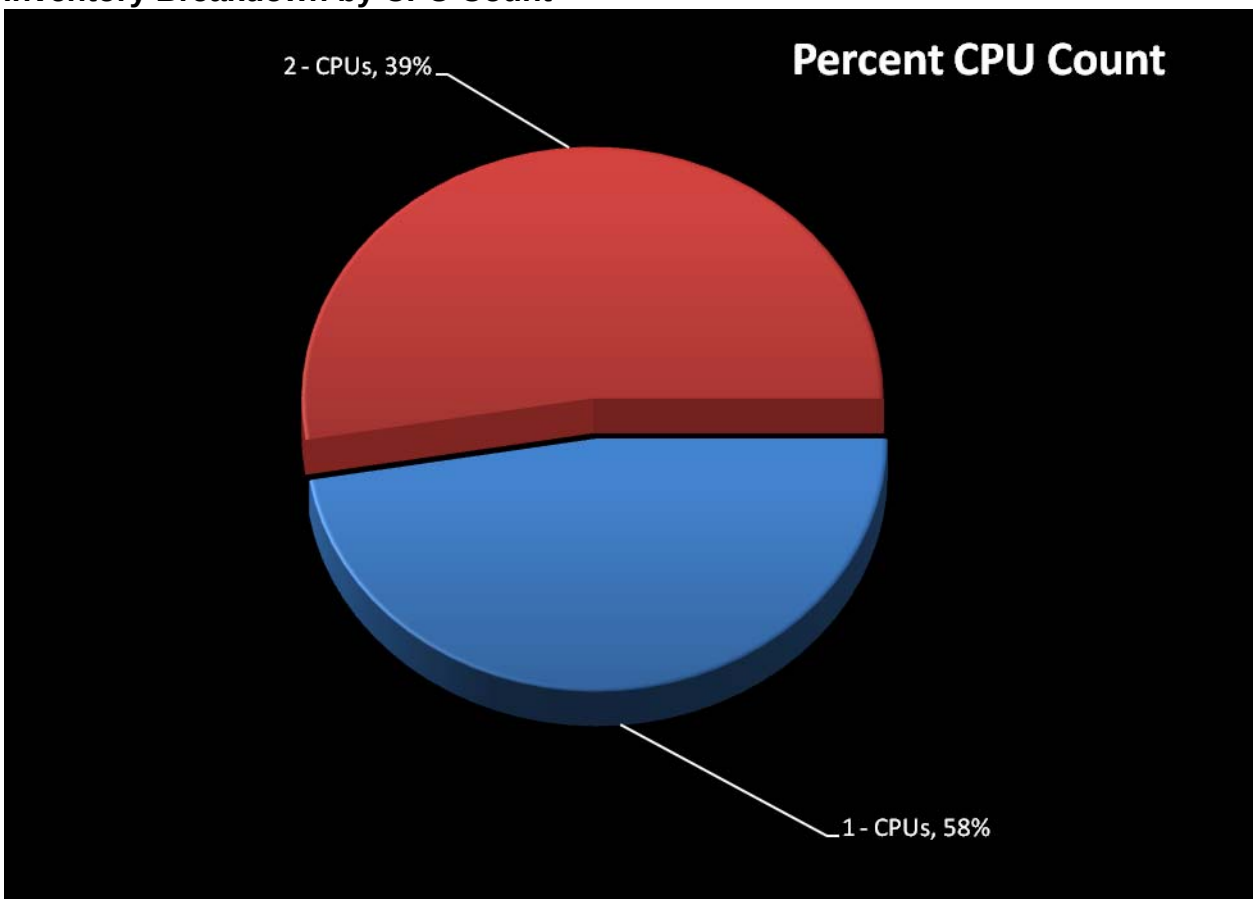


Chart A-2

Inventory Breakdown by CPU Speed (MHz)

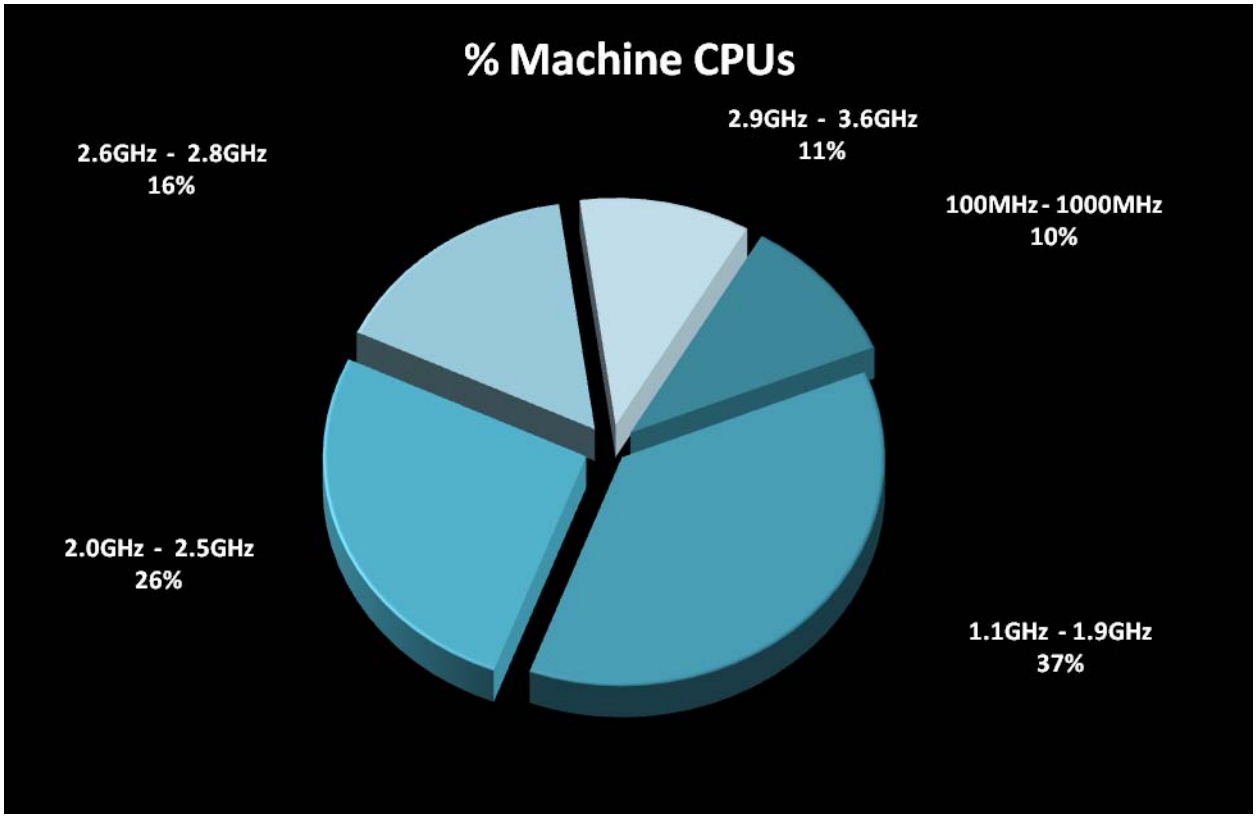


Chart A-3

Average CPU Utilization

We observed that the average CPU utilization for the analyzed servers was less than 10% over the period of data collection.

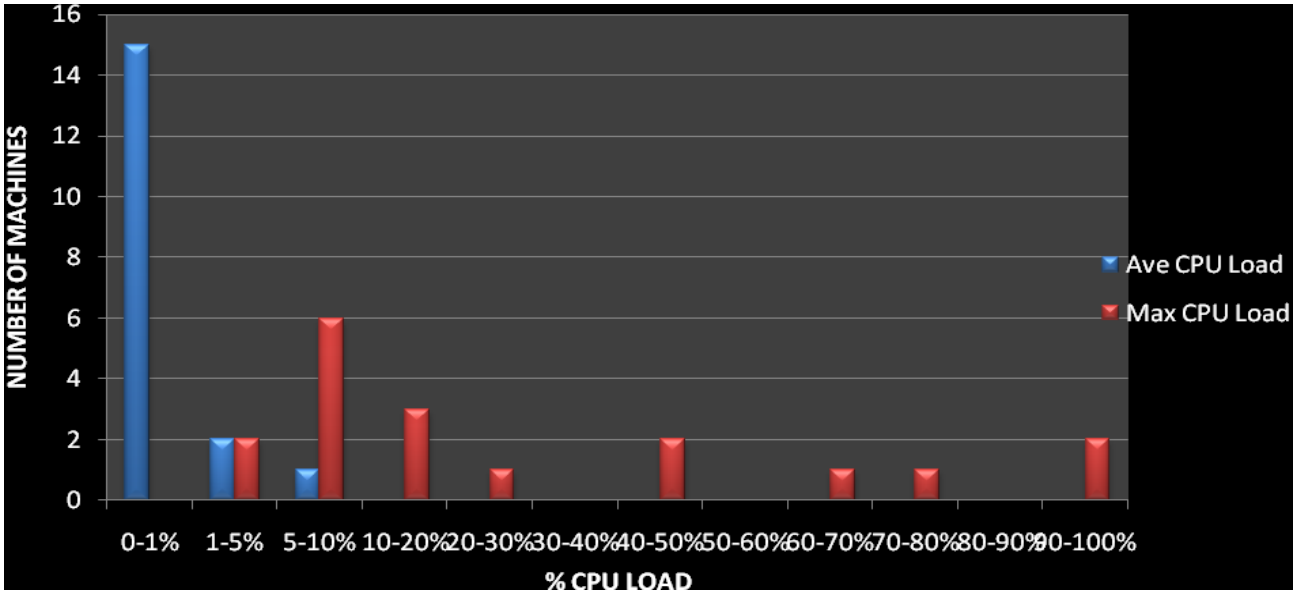


Chart A-4

Relative CPU Consumption

Relative CPU Consumption, or RCC, is intended to display the aggregate CPU computing power that is going underutilized in your environment.

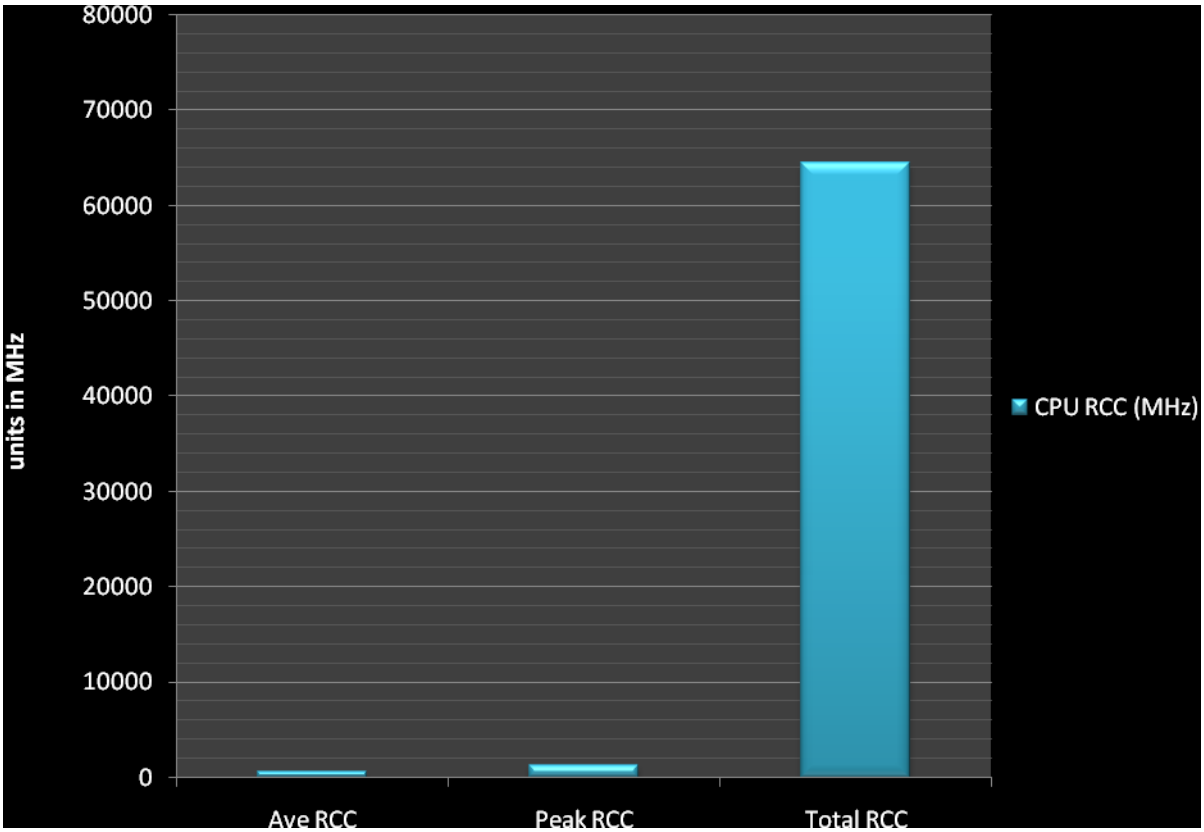
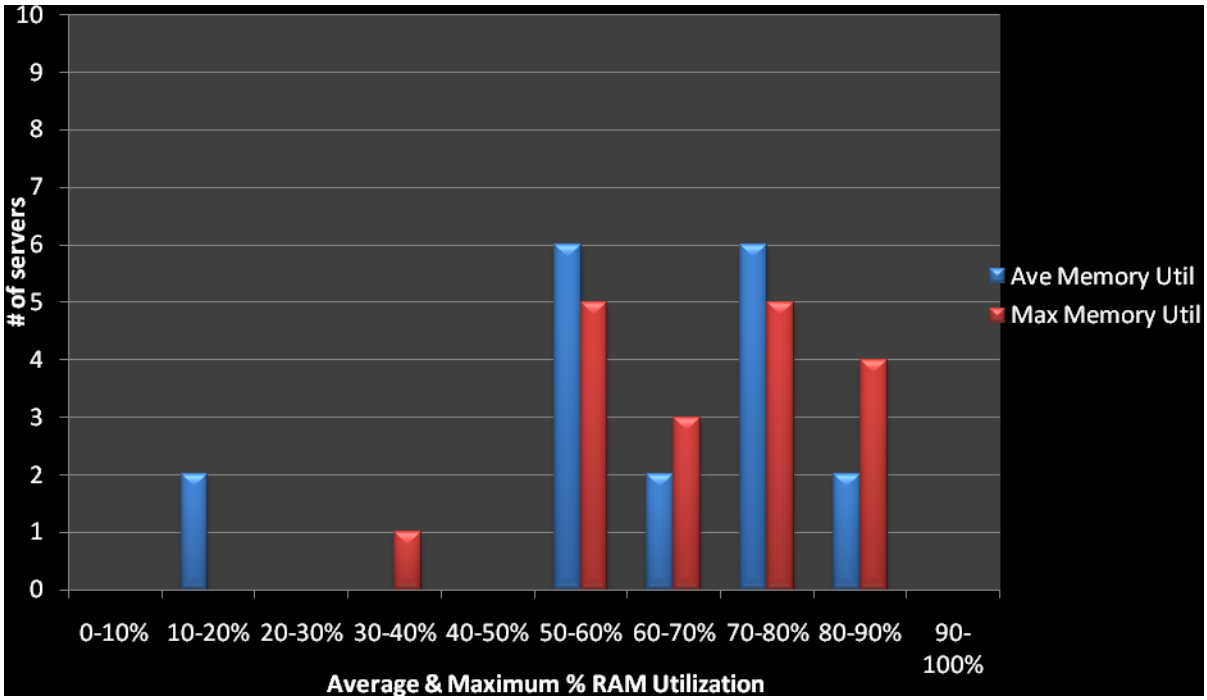


Chart A-5

Inventory Breakdown by RAM Utilization



Graph A-6

Inventory Breakdown by RAM (MB)

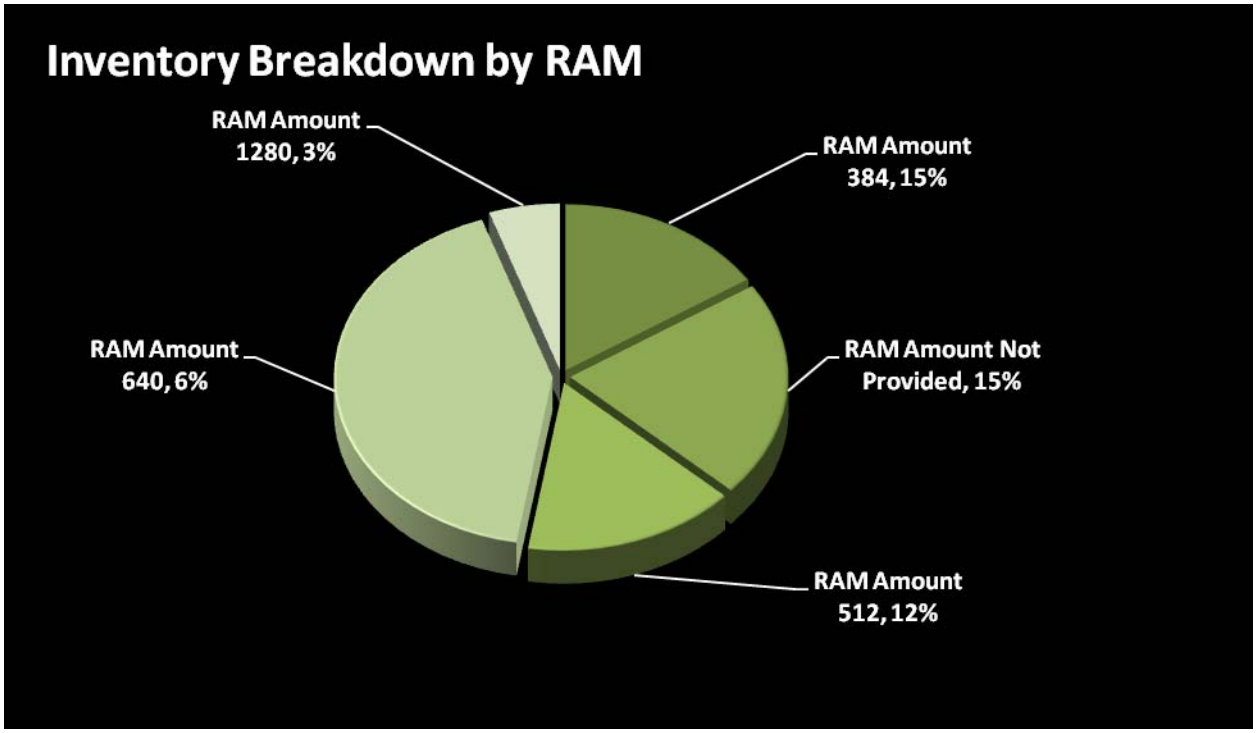


Chart A-7

Inventory Breakdown by Operating System

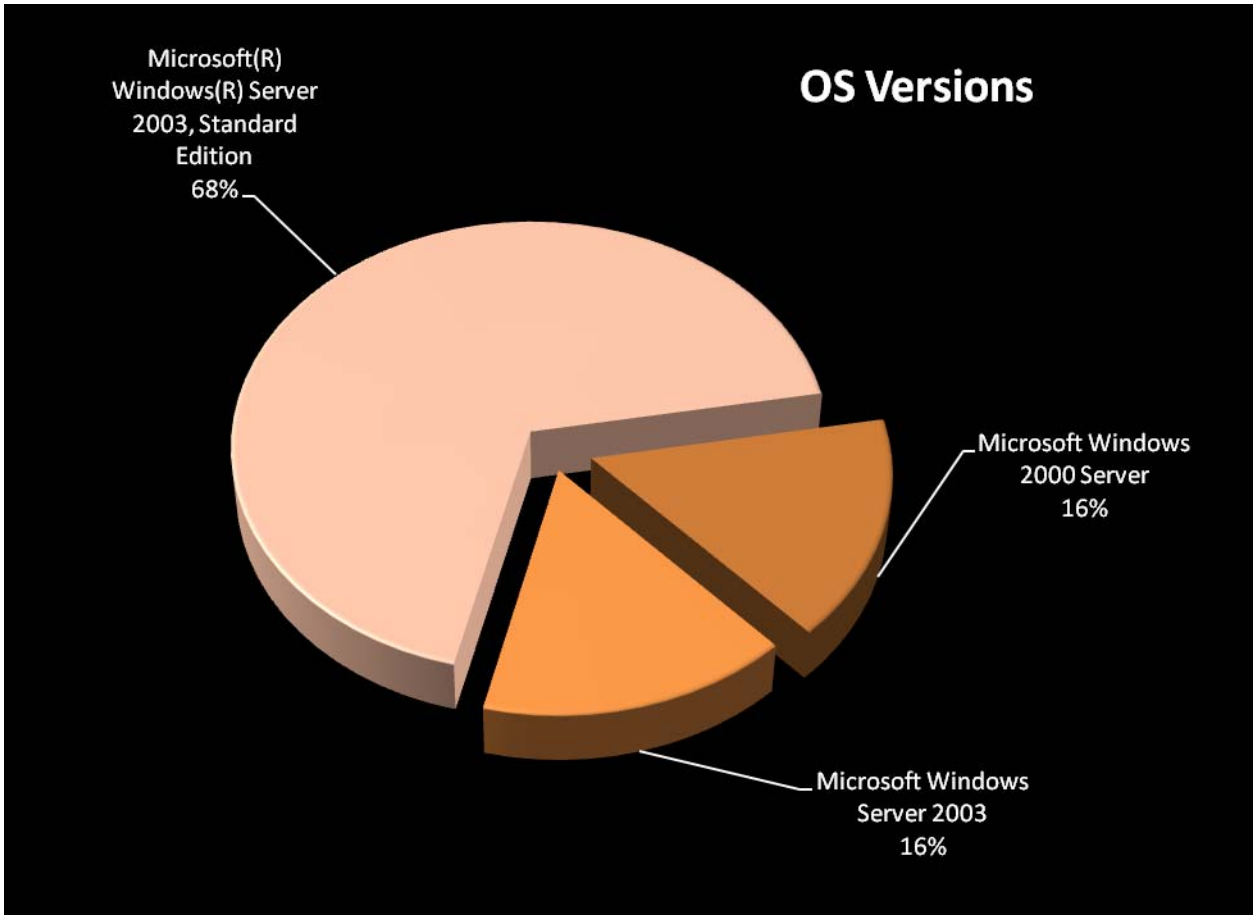


Chart A-8

Possibly Obsolete Servers

System Name	# of CPU	Description	Model	Speed
BCIS-IMAGE	1	Gateway	E-4400	930
BC-LICSERV	1	Not Provided	(1) 730 MHz Processors	796
DST-WSUS	1	AT/AT COMPATIBLE	AT/AT COMPATIBLE	1594

Table A-9

Appendix B: VMware Capacity Planner Analysis Output

The following table includes the inventory of servers discovered at the Bakersfield College during the assessment.

Hostname	OS	Chassis Model	# of CPU	CPU Speed MHz	RAM Size MB
BCADMIN	Microsoft(R) Windows(R) Server 2003, Standard Edition	Saladin 9515 Series	2	2793	2048
BC-BKUPEXEC	Microsoft(R) Windows(R) Server 2003, Standard Edition	975 Series	1	2392	1536
BCCADLAB	Microsoft Windows 2000 Server	960 Series	2	1993	1024
BCDELANO	Microsoft Windows Server 2003	AT/AT COMPATIBLE	2	1866	2048
BCDELANO-COLAB	Microsoft(R) Windows(R) Server 2003, Standard Edition	960 Series	1	2392	1024
BC-DHCP	Microsoft Windows 2000 Server	935 Series	1	1262	1024
BCIMAGE-DATA	Microsoft(R) Windows(R) Server 2003, Standard Edition	Saladin 9515 Series	2	3192	2048
BCINSTRUCT	Microsoft(R) Windows(R) Server 2003, Standard Edition	Saladin 9515 Series	2	2793	2048
BCIS-IMAGE	Microsoft Windows 2000 Server	E-4400	1	930	512
BC-LICSERV	Microsoft(R) Windows(R) Server 2003, Standard Edition	(1) 730 MHz Processors	1	796	512
BCPLATO	Microsoft Windows Server 2003	AT/AT COMPATIBLE	2	3192	2048
BC-PSERVER	Microsoft(R) Windows(R) Server 2003, Standard Edition	Alexander 9415 Series	2	2793	2048
BC-TREND-OSCE	Microsoft(R) Windows(R) Server 2003, Standard Edition	PowerEdge 2950	2	1995	4096
BC-TSERV	Microsoft(R) Windows(R) Server 2003, Standard Edition	935 Series	1	1129	2048
BCWEILL	Microsoft(R) Windows(R) Server 2003, Standard Edition	T55	2	1993	1024
BC-WININST8	Microsoft(R) Windows(R) Server 2003, Standard Edition	975 Series	2	2392	2048
BC-WSUS-II	Microsoft(R) Windows(R) Server 2003, Standard Edition	955 Series	1	2392	1536
DST-WSUS	Microsoft Windows Server 2003	AT/AT COMPATIBLE	1	1594	512
EXTREMEONEX	Microsoft(R) Windows(R) Server 2003, Standard Edition	955 Series	1	2392	1536

Table B-1

Appendix C: Total Cost of Ownership (TCO) Model

TCO Model

The TCO model we employed illustrates potential cost savings, over 3 years, due to reduction in total cost of ownership (TCO) over the depreciation period of existing hardware. It also calculates return on investment (ROI) based on additional hardware and software expenses.

The TCO calculator used and included with this assessment is based on the Gartner model and focuses on major expense areas split between tangible vs. intangible costs, and direct vs. indirect costs of servers. Direct costs are financial outlays specific to acquiring and implementing server hardware, whereas indirect costs are "hidden" charges accounted for at an aggregate data center level for costs associated with administering and running servers and not directly billed per server. Tangible costs track expenditures, while intangible costs measure productivity losses (or gains).

Tangible Costs:

- Direct Costs
    - Hardware and Software
- Indirect Costs
    - Operations
    - Administration

Intangible Costs:

- Downtime

The TCO calculator also uses default maintenance costs and durations from 3 primary sources in lieu of actual amounts being available and provided by Bakersfield College:

- IT Industry Analyst reports on TCO – including Gartner, IDC and Meta Group
- VMware customer data – surveys of more than 40 server customers over 2 years
- Vendor data from OEMs, including IBM, HP, Dell, Citrix, etc.

For simplicity, our TCO model does not specifically address intangible costs. We also assume constant server administration costs between physical versus virtual servers. Many customers do realize a reduction in server administration costs after implementing virtual infrastructure because the number of physical servers goes down; however, the number of logical servers does not go down after server consolidation.