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Memorandum

March 15, 2011 College of Agricultural Sciences
To: VP for IT, Pat Burns
From: Ed Peyronnin, Larry Cobb, Joe Volesky, James Cizek and Stephanie Wolvington
RE: Transmittal of Analysis of Data Center Consolidation – Creating the Campus Cloud

Please find attached for your review the report, 'Analysis of Data Center Consolidation – Creating the Campus Cloud,' pursuant to your charge to the Charge to the Server and Storage Consolidation Committee on May 9, 2011. The Committee has met nearly once a week, started a pilot program and vetted the concepts, policy and business model to the campus to produce the attached report, covering an extraordinarily complex topic. The attached report, per your instructions, contains a model that can be grown into a full-fledge campus wide system and recommendations for next steps. Finally, as chair, I want to note the extraordinary effort devoted to this difficult topic from the Committee members, and wish to acknowledge their expertise, wisdom, devotion, and the overall superb effort expended to produce this report.

Analysis of Data Center Consolidation – Creating the Campus Cloud
Report to Vice President IT Pat Burns

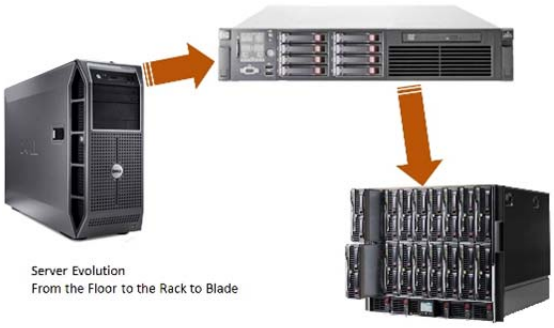
Edgar U. Peyronnin, Larry Cobb, Joe Volesky,
James Cizek, Stephanie D. Wolvington

September 26, 2011

Summary

This report proposes that the campus IT infrastructure transition to a new model in order to help the university retain its competitive advantages in Higher Education. The existing campus IT infrastructure inhibits collaboration through internal organizational barriers, limits research grant funding support (many times Facilities and Administrative budgets support research IT), promotes great inconsistency in IT support across campus (IT "haves" and "have-nots") and fails to optimize achievable hardware densities using today's technologies. The report focuses on three areas to achieve its goal: leverage the advantages of server virtualization through its inherent technology, build a comprehensive campus policy (mutually agreed upon between the units and the enterprise level IT through a healthy IT governance structure) and build a sustainable business plan that will respond to the system's maintenance, growth and evolution.

The Basic Technology


Server Evolution
From the Floor to the Rack to Blade

The campus cloud is based on virtualization of physical servers and aggregated storage solutions to optimize utilization and maximize server density. Virtualization is a means to run multiple virtual servers on individual physical servers. Two key advantages of the model are resource optimization and labor distribution. A "physical" server is typically dedicated to a single role (web server, application server, etc.) which significantly underutilizes server resources (CPU, RAM). Throughout industry, physical servers probably use only 5 – 10% of their resources. Virtualization optimizes resource utilization by increasing the number of operating systems (virtual machines) on a single CPU, and share RAM and storage. A second advantage is that the enterprise IT group can


Storage Evolution
From the Floor to the Rack to
Dedicated Rack

manage the "physical" hardware and the virtual hosting environment. In turn, unit administrators can manage servers that run within the environment. Thus enterprise administrators can manage server hardware while campus administrators can manage their servers. This layer of technology creates the separation needed to consolidate distributed environments.

Why Do It Here?

An important question is why should the campus change the way it does IT? Fundamentally, as this report will show, it will save money in each department and the university as a whole. Figure 1 at the end of this report compares buying a server or paying for the infrastructure. It estimates the hardware cost savings in the neighborhood of $3.5 to $4.5 million over ten years. Figure 2 lists one study's ROI in various industry and industry sizes. If we make the assumption that, conservatively, hardware comprises 29% of ROI, then the total ROI for the project may be in the neighborhood of $14 million over ten years. Technology leaders across campus have already adopted many of the technologies proposed to realize cost savings in their own operations. However, unit level virtualization sacrifices the economies of scale possible with the technology. In their report for IBM "Cloud Computing Payback, "An explanation of where the ROI comes from", Richard Mayo and Charles Perng identified five key areas of cloud computing payback: hardware, software, automated provisioning, productivity improvements and system administration. Hardware, software and system administration savings are achieved naturally through consolidation. Automated provisioning savings are achieved by the reduced time it takes an IT professional to build and configure a server. Productivity gains are achieved when researchers don't have to wait for IT professionals to create a new server/service. There are also tremendous cost savings for reduced power consumption, air conditioning, and facilities emergency responses to power outages across campus. Simply put, the technology offers tremendous economies of scale through consolidation. Over half of the colleges and many departments already virtualize their servers. However, the start-up costs - hardware, software and training - are distinct barriers to adoption by smaller units on campus. By virtualizing at the enterprise level, smaller units will only have to maintain their servers as they have always done and all departments will avoid start-up and data migration costs when purchasing new servers. Projects like the digital repository, creative services photographic collection will not have to piece together one-time funding to get a project started. In effect, the technology becomes a utility on campus.

Beyond cost, the model can also enhance research collaboration in a more flexible server and data storage space. Virtualized servers may be moved from one physical server to another with negligible service degradation. A virtual storage management system will allow enterprise administrators to manage multiple data storage servers from a single console and provision disk space to customers as needed. Cross-campus collaborative groups and programs such as the Geocentroid or SOGES will be able to aggregate and direct research grant funding from individual members to the cloud to receive the service without having to purchase, maintain and

house the equipment. Individual Researchers could write the cost of the service (server, storage and people to manage it) into their grant proposals to contribute to sustaining the campus IT infrastructure. Once the research is complete, the server and storage can be archived or deleted with no residual capital asset to dispose.

So why not out-source the cloud? There is still uncertainty in a commercial cloud space. Although the commercial cloud space has become more acceptable by the general public, it is vulnerable to business failure, buy-out (foreign or domestic) and exists beyond the control of the university. The risk to the university's knowledge and information is too great to place on servers that may be mirrored to sites where legal jurisdictions are fuzzy. Also, granting agencies may have rules that specifically or by implication restrict where the data may be stored. It should be emphasized that prior to strategically outsourcing its data, Colorado State University should conduct a risk assessment that addresses its archival mission, funding responsibilities and state and federal laws. Due to these inherent risks and thanks to virtualization's distinct relative advantage, higher-education institutions are seeking ways to create their own private cloud space.

The Plan

The goal of the campus cloud is to develop a policy and business driven virtualized data-center for campus use. The CSU Campus Cloud project would establish a business model for IT infrastructure as a cost recovery activity. The product would provide a virtual machine (nominally 1 CPU, 2 gigabytes RAM and 50 gigabytes of storage) in a virtualized environment for $X/ year (will be below the annualized cost of a physical server). The product would also permit customers to add resource (CPU, RAM and disk storage) at additional cost via a cafeteria plan. The cloud will be maintained by an enterprise IT group ("business owners") who would service university customers' server and storage needs. Customers will pay based on the cost of building and sustaining the infrastructure. The plan includes the technology, the governance and the business model with estimated cost projections out to ten years. The cost projections are based on the total cost of the project – equipment and software purchase, maintenance and replacement and personnel). The projected revenues generated use three adoption rates (market demand projections) for a virtual machine (VM). The rates are: Low - 25 VM's, Medium – 50 VM's and High - 83 VM's. The highest rate is based on the average aggregated response to the survey question to the campus subnet manager's list-serve "How many servers would you be willing to migrate in each of the next three years".

900	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Annual customer count	Pilot	25	50	75	100	125	150	175	200	225	250
Projected Revenue		$ 22,500	$ 45,000	$ 67,500	$ 90,000	$ 112,500	$ 135,000	$ 157,500	$ 180,000	$ 202,500	$ 225,000
Annual Expense	$182,238	$ 17,069	$ 23,800	$ 43,590	$ 119,531	$ 117,079	$ 68,852	$ 78,224	$ 87,597	$ 257,529	$ 199,077

Low Adoption Rate

Expected Cost Recovery/ Year (Breakeven analys	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
	$(176,806)	$(155,607)	$(131,696)	$(161,227)	$(165,806)	$ (99,657)	$ (20,382)	$ 72,021	$ 16,992	$ 42,914

900	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Annual customer count	Pilot	50	100	150	200	250	300	350	400	450	500
Projected Revenue		$ 45,000	$ 90,000	$ 135,000	$ 180,000	$ 225,000	$ 270,000	$ 315,000	$ 360,000	$ 405,000	$ 450,000
Annual Expense	$ 182,783	$ 47,262	$ 130,908	$ 83,429	$ 98,975	$ 278,620	$ 203,625	$ 208,421	$ 169,967	$ 295,212	$ 356,533

Medium Adoption Rate

2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
$ (185,045)	$ (225,953)	$ (174,382)	$ (93,356)	$ (146,976)	$ (80,601)	$ 25,978	$ 216,011	$ 325,799	$ 419,266

900	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Annual customer count	Pilot	83	166	249	332	415	498	581	664	747	830
Projected Revenue		$ 74,700	$ 149,400	$ 224,100	$ 298,800	$373,500	$448,200	$522,900	$597,600	$672,300	$ 747,000
Annual Expense	$182,238	$ 70,727	$ 164,701	$ 235,241	$ 226,370	$241,826	$320,991	$366,341	$437,060	$424,684	$ 427,465

High Adoption Rate

Expected Cost Recovery/ Year (Breakeven analys	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
	$(178,265)	$(193,566)	$(204,707)	$(132,277)	$ (603)	$126,605	$283,165	$443,705	$691,321	$1,010,855

Table 1Ten year breakeven analysis for three adoption rates at $900 per year per VM

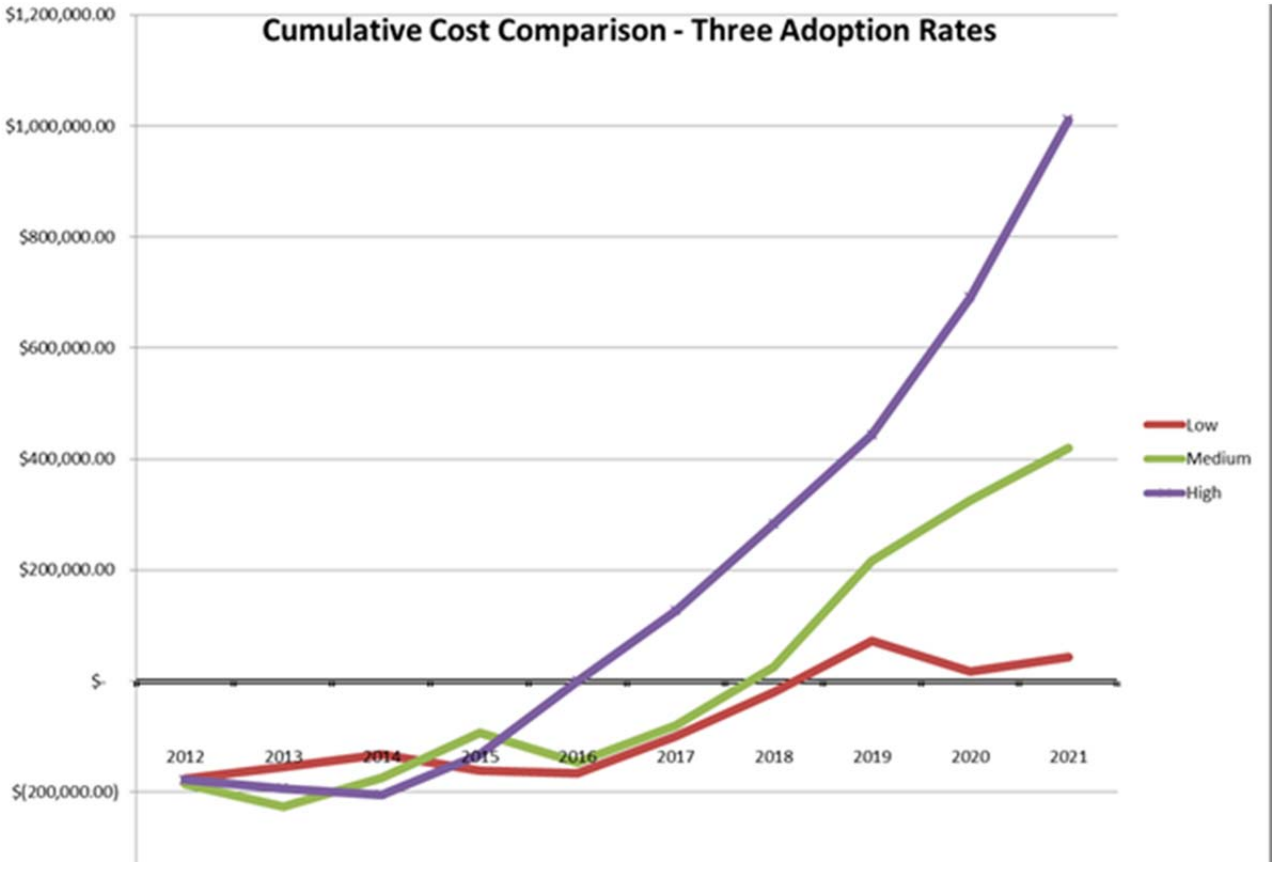


Table 2 Graph of Ten year breakeven analysis for three adoption rates at $900 per year per VM

Basis for projections

- Cost projections are based on HP virtualized, blade servers with a virtualized monolithic storage system, maintenance, licensing and support personnel
- Cost projections include growth projections commensurate with the three adoption rates
- Demand projections are based on November 2010 IT consolidation campus inventory (from the earlier campus consolidation report) and a follow-up campus survey to subnet managers in May 2011
    - Subnet managers administer about 1200 servers on campus
    - About two-thirds of those are physical servers
    - There is a willingness to participate – 72% of responding subnet managers answered yes to: "If you could manage your OS and services the same way you do now at an equivalent cost, would you be willing to run your systems as virtual machines hosted by ACNS?"

Opportunities

- The cloud can significantly reduce campus expenditures
    - hardware
    - software
    - administration
    - maintenance contracts
    - electrical and air-conditioning
- Units will pay a more predictable, normalized annual cost for IT
- Computer hardware resources are optimized
- The design inherently alleviates issues associated with the distributed research, academic and IT environment
- It provides a path to more collaboration and data sharing possibilities for staff.
- Smaller units (departments, research projects, etc.) will be able to leverage otherwise unattainable technology
- Physical and system security enhanced by bringing the system under greater control

Risks

- Lack of campus commitment to the infrastructure
- Non-acceptance/failure to meet "marketing" goals because of
    - General resistance (internal cultural challenges, NIH mentality, etc.)
    - Large scale virtualization projects on campus that bypass the business model created by the campus cloud
    - Existing free services that meet the needs of campus customers allowing them to bypass the campus cloud
    - Migration to commercially available solutions

- Physical and system security decreased by consolidating all systems into a single target
- Flexibility to account for future trends
- Failure to respond quickly to a window of opportunity

Recommendation:

The committee recommends that the campus adopt and begin to build the environment as soon as possible to meet a 1 July 2012 production rollout of the service. In order to do this, the following intermediate goals need to be accomplished:

- Immediate
    - Get approval from campus administration at the highest level to move forward
    - Obtain start-up funding
    - Hire one FTE to supplement workload (particularly in the start-up phase) – advocacy, project management and systems administration
    - Turn pilot over to a project manager
    - Purchase storage virtualization solution and storage (possible one time funding?)
    - Purchase servers
    - Finalize initial policy and cost model
    - Develop pricing model and cafeteria plan for service
- Near Term
    - If demand is low, develop incentives for participation
    - If demand is high, prioritize for participation
    - Create a re-investment fund account for training campus IT personnel from the model
- Future
    - Develop or purchase automated VM provisioning
    - Review and refine the model

Section 1
Campus Cloud Policy
&
Basic Technical Specifications

Hosted VM Service
Main Policy

Introduction

CSU's Hosted VM Service is designed to be a permanent IT service provided to the CSU community by ACNS. The Service will lease virtual machines (VMs) and file storage to any CSU entity on a cost recovery basis. The cost recovery includes amortization, replacement and possible expansion of the Service. The goal of the Service is to be self-sustaining in perpetuity.

Hosted VM Service allows the Lessee to avoid making the initial capital investment in a physical server and storage hardware. The Lessee also avoids the amortized investment in a server room, including power, air conditioning, security, fire suppression, networking hardware; and human resources to attend to all of the above and their continuing operation. Furthermore, the Lessee avoids the backup liability for that server, including the cost of consumables and the amortization of backup hardware, licenses and human resources.

Governance and Decision Making

The Service will be documented in this and related documents. IAC is responsible for approving all changes to this document and oversight of the related policy documents. ACNS is responsible for maintaining these documents. Changes to the Service will be communicated to the CSU IT community by ACNS.

Related documents:

Hosted VM Service – Service Level Agreement
Hosted VM Service – Fees & Technical Description
Hosted VM Service – Business Plan – Separate Document

In the event that a circumstance or issue arises between or among Lessee(s) and ACNS about the use or implementation of the Hosted VM Service that is not adequately addressed in these Policies, or cannot satisfactorily be settled by mutual agreement among the interested parties, then the Vice President for IT will decide the issue or circumstance.

Services Provided

1. Physical compute, storage and networking resources hosted on enterprise-class hardware, with equipment lifecycle replacement built into the lease amount.
2. Regular and timely backup of all VMs and data. Restoration from those backups is possible for explicit periods.
3. Patching and upgrades of hardware, host OS and hypervisor will typically occur without service interruption of the guest VMs. If an interruption is required, it will be coordinated and scheduled with the affected Lessee(s).
4. System administration, including:

a. Proactive review of host system parameters, logs and performance counters to identify and correct existing and potential hardware problems, and host OS and resource problems
b. Timely patches and upgrades necessary to maintain the host virtual environment
c. System performance tuning to optimize Lessee workloads
d. Assign disk space, manage permissions and security groups
e. Coordinate vendor-provided maintenance and support
f. Capacity planning
g. Prioritize capacity and resource needs among leased production, development and test systems
h. Manage and verify the integrity of backups of VMs
i. Manage and support the physical and logical network infrastructure necessary to allow the leased VMs to act as part of Lessee's departmental CSU subnet(s)
j. ACNS will maintain strict, limited access to host systems, hypervisors, etc. Only authorized personnel will have administrative access to host systems.
k. Unless requested by the Lessee, ACNS will maintain no administrative access to VM guest operating systems, and will strictly adhere to administrative boundaries set between the guest and host operating systems.

Contract Terms

Services of the Hosted VM Service are leased under the policies of this document and its related documents. Particular reference herewith is made to the Hosted VM Service – Service Level Agreement as an important document describing this contract. Services are billed monthly. Lessee may request changes in VM configuration at any time. Services used during any part of a month are billed for the entire month. Lessee may cancel a service with 30 days' notice.

Hosted VM Service is a permanent ACNS service, therefore it is not anticipated that the Service will be discontinued. But if CSU management decides to discontinue this Service, they will give the CSU community at least 1 year's notice.

Fees

Fees associated with this Service are determined and published annually, prior to each fiscal year, based on the requirements of the cost recovery model and the Business Plan mentioned above. Fees are available in Fees & Technical Description.

A ***basic*** VM configuration is available, and is specified in the Fees and Technical Description document. Custom VM configurations are also available, and the cost is based upon three variable attributes of the VM:

Number and type of configured CPUs	Fixed fee per CPU/year
Amount of configured RAM	GB/year
Disk Storage	GB/tier/year

Tiers of storage (High performance, normal performance) will be available at descending cost/GB/year.

Optional long-term storage:

Charge for storing data beyond standard retention period GB/year

Costs for the month will be based on the maximum resources allocated to the VM, regardless of the point in the month they were allocated.

For detailed descriptions of hardware, storage and VM components of the Service, see Fees & Technical Description.

Disposition of Data

After Lessee has stopped using the Hosted VM Service, ACNS and Lessee will collaborate to ensure the Lessee can retrieve all its Content and Data in a complete and secure format, including schema, definitions, documentation, and attachments in their native formats, up to the normal backup retention period. After that period, ACNS will allow all copies of this VM and its data to expire and disappear.

Backup of VMs and Data, Data Recovery

Periodic data backups will be performed for each leased VM. Two types of backup and a long-term storage mechanism are available:

- Snapshot backups of VM files (VHD/VMDK snapshots) – Snapshots will be taken on a periodic basis **<TBD in Phase II of Pilot>**. Each VM owner may request that a VM be restored to a "point in time". This scenario replaces the existing VM with a snapshot of the VM from that point in time.
- File-level backups will follow the snapshot schedule for VMs. Restoration of individual files residing inside of VM file systems may be requested <**possibly via self-service means – TBD in Phase II of Pilot** >.
- Retention for Snapshot/File-level backups is **TBD in Phase II of Pilot**, likely based on total amount of leased storage.
- Backup intervals for Snapshot/File-level backups are **TBD in Phase II of Pilot**, likely flexible on a per-VM basis.
- Optional long-term storage of data is available on an extra cost/GB/yr basis (reference: Fees & Technical Description)

Response times for VM snapshot and file restoration requests (if no lessee self-service restore capability exists) will match the response times defined in the "Severity Level Response" section of the Hosted VM Service's Service Level Agreement.

For detailed descriptions of backup operations of the Service, see Fees & Technical Description.

Security and Performance

Virtualization of information resources does not render existing security needs and policies obsolete; as such, the IT Security Policy is still in force. For example, ACNS already has the authority to scan any (virtual) system, and to take appropriate action as required "to maintain the integrity and functionality of the University's IT environment. This may include, but is not limited to, traffic analysis and disabling access to individual or multiple computers" (IT Security Policy, version 1.12, Section II.2, Network Security). Similarly, any virtual system containing sensitive information must be registered with ACNS and is subject to regular, active

vulnerability scanning. The administrator of a virtual system should continue to observe the existing requirements regarding operating system updates, application patching, service isolation, logging, backup, data protection, etc. Finally, where appropriate, software firewalls and anti-virus software should be considered in the same way they might be deployed on a physical server.

In addition, however, virtualization introduces the possibility of other avenues of intentional or inadvertent damage. The virtualization host and its switching solution represent an additional system to protect, as well as a less-visible, less-controllable network environment than the physically wired infrastructure. ACNS will keep abreast of the evolution of virtualization technologies, and will diligently administer the VM hosts, with the following limitations:

- Applications involved in credit card transactions will not be permitted, due to the difficulty of ensuring adequate segmentation according to the requirements of the Payment Card Industry Data Security Standard (PCI-DSS).
- Servers hosting significant quantities of sensitive information should not reside on the same VM host as servers offering broadly available, low-security public services (such as web servers open to content management from the internet).
- As technologies become available to gain better visibility, protection, and control of traffic flows and system activities on a VM host, these technologies will be evaluated for inclusion in this Service and the associated fee structure.

Finally, due to the multi-tenant nature of the VM Service, ACNS must also maintain the optimal performance of the Service for the tenant community as a whole. This means ACNS must retain the right to intervene in the operation of individual VMs, up to and including shutting it down, if that VM is materially affecting the ability of the Service to function.

For detailed descriptions of the security policies of the Service, see Fees & Technical Description.

Lessee Responsibilities

1. Lessee assumes all responsibilities and support for the guest OS, including but not limited to the installation, administration, patching, upgrades, configuration, programming, security, security scans, security compliance, firewalls, network addressing and management, and including any and all installations of software and related components to be used on the guest OS.
2. Lessee is responsible for the compliance of their VM with all applicable CSU security, privacy, IT and other policies and procedures, and with applicable state and federal laws and regulations.
3. Lessee is responsible for all intrusion detection, AVAS, log inspection and other forms of system integrity tracking, performance monitoring and troubleshooting for the VM.
4. Lessee assumes all responsibilities for the proper licensing of all software, including the OS installed on the VMs, except where this is expressly arranged otherwise with ACNS because of host OS licensing terms.
5. Lessee must maintain a contact list with ACNS, consisting of Technical and Fiscal personnel contact information.
6. Lessee decides which accounts have root or local admin access to the VMs.

7. LESSEE IS RESPONSIBLE FOR VERY TIMELY PATCHING OF THEIR GUEST OS WITH VENDOR-SUPPLIED FIXES OF SECURITY VULNERABILITIES.

Service Exclusions

1. Lessee will not be granted physical access to the hardware supporting their VM, or other on-site services not expressly included in these policies.
2. ACNS cannot be responsible for, but will provide best-effort advice and guidance for, the installation, configuration or management of guest OSes, and a library of pre-configured operating systems to facilitate guest OS installation. See Fees & Technical Description.
3. ACNS has no obligation to assist in the installation, configuration, or management, or the design or modification of software code or applications, or the support any of the foregoing, hosted on the VM.
4. VM guest operating systems are limited, in general, to Linux-based and Microsoft Windows –based, server-class operating systems (see Fees & Technical Description). Exceptions may be made for other types of operating systems, but ACNS has final discretion. Generally, all operating systems that have mainstream vendor support can be supported. Only in critical-need scenarios will ACNS support the installation of a guest OS that is past its vendor-published end of life. ACNS will maintain a list of operating systems that are officially supported by the vendor of the virtualization software. Although not required, ACNS recommends that the guest OS be chosen from this list when possible to maintain eligibility for vendor support.
5. ACNS will not support products that do not meet the CSU Acceptable Use Policy and other applicable University policies.

Hosted VM Service
Service Level Agreement

Part A
During the term of the Hosted VM Service – Service Level Agreement, the Virtual Machine will be operational and available to Lessee for a Monthly Uptime Percentage of at least 99.9%. If ACNS does not meet the Monthly Uptime Percentage, and if Lessee meets its obligations under this SLA, Lessee may be eligible to receive the Service Credits described below.

Part B
Hosted VM Service will be supported by ACNS personnel (on a 24 X 365 basis for "Critical" issues) using a VM Service Incident Reporting system (see Hosted VM Service – Fees & Technical Description). ACNS support will respond, based on the Severity Level mutually agreed to by ACNS and Lessee at the time of the notification, in the indicated Severity Level Response time. Only designated Lessee personnel (Technical Contact List) may contact ACNS in regard to VMs in Hosted VM Service.

Definitions:

Downtime is time where the VM cannot start, is not started, cannot be reached over the network, or does not consistently respond to normal usage requests, due to issues that are under the control of ACNS (for instance, the VM host server cluster is down, or the networking directly associated with the Hosted VM Service is down). Downtime ***specifically excludes*** unavailability of a VM's product due to problems ***inside*** the VM, such as problems specific to the applications running on the VM, or misconfigurations of the app or OS by the Lessee.

Hosted VM Service means capability of leased Virtual Machines as described in the Hosted VM Services Main Policy document and its related documents.

Lessee is the CSU unit leasing VM(s) under this service.

Monthly Uptime Percentage means (total number of minutes in a calendar month minus the number of minutes of Scheduled Downtime minus the number of minutes of Downtime) divided by (the total number of minutes in a calendar month minus the number of minutes of Scheduled Downtime).

Scheduled Downtime means those times ACNS notifies Lessee of periods of Downtime at least five days prior to the commencement of such Downtime.

Service Credit means the following:

Monthly Uptime %	Days of Service (example only)
< 99.9% to >=99.0%	3
< 99.0% to >=95.0%	7
< 95.0%	15

To be eligible for Service Credit, the value of the Days of Service accumulated across Lessee's affected VMs must be at least $25 and applicable to a single account fund. Service Credit will be applied as credit against the following month of service cost. If service is discontinued for any reason, the Service Credit will be in the form of a rebate at the end of service.

Notification of Downtime for Service Credit. ACNS will make reasonable efforts to notify Lessee of detected downtime duration. It is Lessee's responsibility to verify this, and report undetected or unreported downtime, and to make claim for Service Credit before the end of the month following the month in which downtime occurred. Failure to claim a timely Service Credit will forfeit Lessee's right to receive it.

Severity Level. The level applicable to support issues provided by ACNS to Lessees for Hosted VM Service:

- Critical – a problem causing critical impact to Lessee's business operation for which no solution is immediately available and business cannot continue.
- Serious – a problem causing significant impact to Lessee's business operation for which a workaround has been implemented, but is unacceptable on a long-term basis.
- Moderate – a problem that impairs some functionality to Lessee's business operation, but a practical workaround exists.
- Minor – a problem that does not affect any functionality of Lessee's business operation, or a request for enhancement

Severity Level Response. ACNS must acknowledge and maintain contact with Lessee with intervals not to exceed these below:

- Critical – 1 hour, 24 x 365, then as negotiated after initial response
- Serious – 4 business hours
- Moderate – 1 business day
- Minor – Acknowledge and schedule

Business Day and Hour. A work day CSU is open for regular business. An hour in one of those days.

Technical Contact List. Lessee must keep a list with ACNS of personnel Lessee currently authorizes to contact ACNS in regard to technical issues about Lessee's leased VMs. This list may have up to six personnel. Each of these listed personnel is presumed to have complete decision-making authority for technical matters concerning the Lessee's VMs. Full contact details, as requested, must be provided.

Hosted VM SLA Exclusions. The Hosted VM SLA does not apply to any service that expressly exclude this Hosted VM SLA (as stated in the documentation for such services) or any performances issues: (i) caused by factors outside of ACNS' reasonable control; or (ii) that resulted from Lessee's equipment or third party equipment, or both (not within primary control of ACNS).

Hosted VM Service
Fees & Technical Description

Prices FY12

•Standard (minimum) Virtual System 1 CPU, 2 GB memory, 50 GB disk	$X/System/yr
•Additional CPU (3 additional allowed)	$X/CPU/yr
•Additional RAM	$X/GB/yr
•Disk Storage (high performance)	$X/GB/year
•Disk Storage (normal performance)	$X/GB/year
•Data retention charge for long term off-line storage	$X/GB/year

General Description of Base Hardware Systems

Host VM Servers

Given ACNS' experience with HP blade server technology, blade chassis configurations and interconnects, VMs will be hosted on HP blades for both Hyper-V and VMWare platforms. HP technology provides a good mix of expandability and resource allocation among many blades in a single chassis.

Scalable, Shared Storage System

The requirement for clustered VM host systems and variable and expandable storage offerings require shared storage that is both highly robust and highly scalable.

From a central IT perspective, combining the Hosted VM Service storage requirements with existing central IT storage needs makes the most sense to reach economies of scale for shared storage. To that end, it is expected that central IT units and this Hosted VM Service will endeavor to purchase a "monolithic" storage infrastructure that is:

- Capable of providing multiple tiers of storage. For example, high speed SSD vs. lower speed SATA.
- Cost effective, providing economy of scale
- Highly available, providing multi-controller and multi-path connectivity. The system should have the ability to provide for high availability between different geographic sites utilizing replication technologies (possibly an ability added in the future)
- Expandable to meet the estimated current and future needs of all parties utilizing the system.
- High performing, meeting the performance needs of all parties utilizing the system.

Clustered VM Hosts

VM hosts will be clustered such that running VMs will "migrate" automatically between VM host nodes due to host failure or maintenance. Clusters will be built in "n+1" configurations such that a hot standby server can take over for any single failing VM host.

Backup Operations Technical Description

Utilizing either host-based or Storage-System-Based "snapshots", backups for Hosted VMs will be taken at regular intervals, and stored for a retention period [both **TBD in Phase II of Pilot and ongoing reevaluation**].

The backup system will provide for restoration of the VM as-is at a point-in-time determined by existing snapshot availability, and file- or "brick"-level restores depending on the VM technology in use [**TBD in Phase II of Pilot**]

In general, backup retention time will be fixed, and based upon total storage leased for a given VM (i.e., included in the amount paid for a given VM with a given amount of storage attached to that VM). Archival or long-term retention of backups will be available at additional cost [**TBD in Phase II of Pilot**]

Security Operations Technical Description

[not sure what to put here..]

Supported Guest Operating Systems

Windows Server 2003 32-bit/64-bit
Windows Server 2008 32-bit/64-bit (including R2 version)
Linux flavors (James will need to augment this part)
Link to supported OS's by VMWare and Hyper-V

Suggestions for Installation, Configuration and Management of Supported Guest Operating Systems

[this section may be better realized later when ACNS comes up with a "welcome" document/web page etc. describing things like "how to get started", "how to request your VM", "how to get your VM OS installed", "how to manage your VM once it's up" etc.]

VM Service Incident Reporting System Technical Description

[This needs to be developed after the pilot is concluded in the Spring 2012 by a sub-committee of IAC (which includes ACNS]

Section 2
Campus Cloud Business Plan

1) **Description** – In January 2011, Provost Miranda charged the IT Consolidation Committee, with developing a framework to discuss consolidation opportunities. Seven areas of consolidation were recommended, of which four were considered to have the most immediately meaningful impact on campus. In March, 2011, Provost Miranda directed that VP Pat Burns move forward with an implementation plan for each of the four areas. One of the final four recommended consolidating data centers across campus into a central location on campus using virtualization technology. The system would reduce unit purchases of expensive hardware, normalize costs for more predictable annual expenses, reduce demand on campus staff such as the Facilities department (air-conditioning and emergency response to buildings with servers in them), and reduce the necessity of maintaining otherwise underutilized physical server hardware (most servers probably use less than 10% of their processing capacity). This plan addresses the Data Center consolidation and the establishment of a "CSU Campus Cloud". The project will be established with a business model as a cost recovery activity. It will be run by ACNS personnel ("business owners") who will service the university ("customers") server and storage needs. ACNS will be responsible for building and maintaining the infrastructure for the university. Customers will pay based on the cost of building and sustaining the infrastructure. Customers will lease virtual machines and storage.

2) **Data Sources and Market Analysis**
   a) Inventory –The Consolidation Committee requested an inventory for every department to be done by the relevant IT professional as designated by that unit's IAC representative. Reported results revealed that there were about 1200 servers on campus. About 800 are physical \while 400 are virtual servers. While the initial the target "market" of the project is the physical servers, as the hosts on which these virtual servers reside age-out, these VMs also become candidates for joining the Campus Cloud.
   b) Survey – A survey conducted of the Subnet managers group confirmed approximately 1200 servers, approximately 800 physical. Of 75 respondents, 54 answered yes to the question "If you could manage your OS and services the same way you do now at an equivalent cost, would you be willing to run your systems as virtual machines hosted by ACNS?" Additionally, the respondents indicated that they would be willing to migrate an average of 83 servers per year for the next three years to the new service.
   c) We conducted a ten year projection at three adoption rates – low, medium and high. The highest adoption rate was the average of what subnet managers said they were willing to migrate in the first three years. The low and medium rates were 25 and 50 clients per year respectively. All adoption rates are linear. Each projection requires a significant up-front cost and true cost recovery doesn't occur until after the first few years. Once the project breaks even, the revenues continue to exceed expenses permitting the lowering of

prices. Higher adoptions rate will result in both earlier cost recovery and price reductions.

d) Competition includes external vendors and internal units. Several vendors offer cloud technologies at significantly higher costs. It should also be emphasized that prior to strategically outsourcing its data, Colorado State University should conduct a risk assessment that addresses its archival mission, funding responsibilities and state and federal laws.
e) Some on-campus units are large enough to fund their own data centers losing the economies of scale that the technology offers. Other units cannot afford the solution. By creating a campus-wide level datacenter, we achieve both economies of scale and break the barrier to adoption for smaller units.
f) Finally, some services are freely offered by ACNS that may directly compete with the services offered in this project.

3) **Revenue and Expense Analysis** – See Spreadsheets

4) **Additional Considerations** –

a) The complexity of the project and the number of interested parties creates a dynamic environment on all levels. There must be commitment and support from campus for success.
b) A pilot was started 1July to test concepts as we built the system. We intend to develop the campus policy and cost model in Phase I. We intend to purchase the equipment and test out Phase I concepts in Phase II. We expect a production roll-out by 1 July 2012.
c) Start-up funding will speed the project's success by allowing price drops to cost almost immediately.
d) Business records and the billing function will be retained by ACNS. The ITEC Advisory Committee will be responsible for approving the policy and any policy changes governing the activity.
e) Some of the equipment purchased for this project will be depreciable. To keep our calculations simple and to accurately project our start-up costs, depreciation expense was not included in our spreadsheet.
f) No inventory is required for this project.

Section 3
Campus Cloud Supporting Documents

1. Committee Charge
2. Ten year hardware costs savings physical/virtual
3. Data Center Consolidation ROI in Industry Statisitics
4. Survey to Subnet Managers
5. Initial cost details
6. Ten year breakeven projection – low adoption rate
7. Ten year breakeven projection – medium adoption rate
8. Ten year breakeven projection – High adoption rate
9. Ten year breakeven chart comparing three adoption rates

Charge to the Server and Storage Consolidation Committee

The ad hoc Server Consolidation Committee (the 'Committee") is hereby constituted to develop a server and storage consolidation services (the 'Services') in ACNS. Members of the Committee are: Ed Peyronnin (chair) from Agricultural Sciences, Larry Cobb from Veterinary Medicine and Biomedical Sciences, Joe Volesky and James Cizek from ACNS, and Stephanie Wolvington from CSU System Internal Auditing.

The Services shall encompass virtual instances of guest operating systems for use by CSU constituents on a cost-recovery basis, including Linux, UNIX and Windows virtualization. A business model is to be developed to specify the Services, their one-time and recurring costs for sustainability and expansion, and the policies and practices for the Services and their operation. A cafeteria-style menu of Services, each with one-time and recurring costs, shall be developed. Staffing needs for the Services shall be discussed with the Director of ACNS and addressed in the report. Other needs for ease of use of the Services, including Identity and Access Management, shall be identified and brought forth by the Committee.

As soon as practicable, a pilot project shall be conducted to determine aspects of the Services requiring definition, and to inform the development of the policies and practices for the Services.

The Committee shall represent the University and establish the Services and the associated recommended policies and practices in broad conversation with University constituents, including interaction with the IAC and others as appropriate.

The Committee shall endeavor to complete their activities by August 20, 2011, and provide to the Vice President for Information Technology: 1) a written summary of the Committee's recommendations, including definitions of the Services and operational practices, and 2) a recommended policy for the Services. The Vice President for Information Technology shall seek approval for both via the IT governance mechanisms extant at CSU.

		Costs												
Price for service	900	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021		Cost for commensurate physical servers	10 year savings
Low	Revnues-Costs	$ (176,806.42)	$ (155,606.51)	$ (131,696.18)	$ (161,226.91)	$ (165,805.55)	$ (99,657.11)	$ (20,381.59)	$ 72,021.02	$ 16,991.55	$ 42,914.16	$ 1,194,585.84		
Physical	6000	$ 150,000.00	$ 150,000.00	$ 150,000.00	$ 150,000.00	$ 150,000.00	$ 300,000.00	$ 300,000.00	$ 300,000.00	$ 300,000.00	$ 300,000.00		$ 2,271,179.20	
License	$ 132.37	$ 2,117.92	$ 2,117.92	$ 2,117.92	$ 2,117.92	$ 2,117.92	$ 2,117.92	$ 2,117.92	$ 2,117.92	$ 2,117.92	$ 2,117.92			**$ 1,076,593.36**
Medium	Revnues-Costs	$ (185,044.95)	$ (225,952.82)	$ (174,381.53)	$ (93,356.06)	$ (146,976.41)	$ (80,601.32)	$ 25,977.94	$ 216,011.37	$ 325,798.99	$ 419,265.77	$ 2,055,734.23		
Physical		$ 300,000.00	$ 300,000.00	$ 300,000.00	$ 300,000.00	$ 300,000.00	$ 600,000.00	$ 600,000.00	$ 600,000.00	$ 600,000.00	$ 600,000.00		$ 4,543,682.10	
License		$ 4,368.21	$ 4,368.21	$ 4,368.21	$ 4,368.21	$ 4,368.21	$ 4,368.21	$ 4,368.21	$ 4,368.21	$ 4,368.21	$ 4,368.21			**$ 2,487,947.87**
High	Revnues-Costs	$ (178,264.59)	$ (193,565.82)	$ (204,707.29)	$ (132,277.24)	$ (603.28)	$ 126,605.44	$ 283,164.94	$ 443,704.93	$ 691,320.70	$ 1,010,855.39	$ 3,097,644.61		
Physical		$ 498,000.00	$ 498,000.00	$ 498,000.00	$ 498,000.00	$ 498,000.00	$ 996,000.00	$ 996,000.00	$ 996,000.00	$ 996,000.00	$ 996,000.00		$ 7,542,803.50	
License		$ 7,280.35	$ 7,280.35	$ 7,280.35	$ 7,280.35	$ 7,280.35	$ 7,280.35	$ 7,280.35	$ 7,280.35	$ 7,280.35	$ 7,280.35			**$ 4,445,158.89**
High w/Price Adjustments	Revnues-Costs	$ (178,264.59)	$ (193,565.82)	$ (204,707.29)	$ (132,277.24)	$ (603.28)	$ 76,805.44	$ 88,114.94	$ 16,254.93	$ 2,420.70	$ 31,455.39	$ 4,077,044.61		
Physical		$ 498,000.00	$ 498,000.00	$ 498,000.00	$ 498,000.00	$ 498,000.00	$ 996,000.00	$ 996,000.00	$ 996,000.00	$ 996,000.00	$ 996,000.00		$ 7,542,803.50	
License		$ 7,280.35	$ 7,280.35	$ 7,280.35	$ 7,280.35	$ 7,280.35	$ 7,280.35	$ 7,280.35	$ 7,280.35	$ 7,280.35	$ 7,280.35			**$ 3,465,758.89**

Figure 1 Projected Ten Year Hardware/Virtual Cost Savings

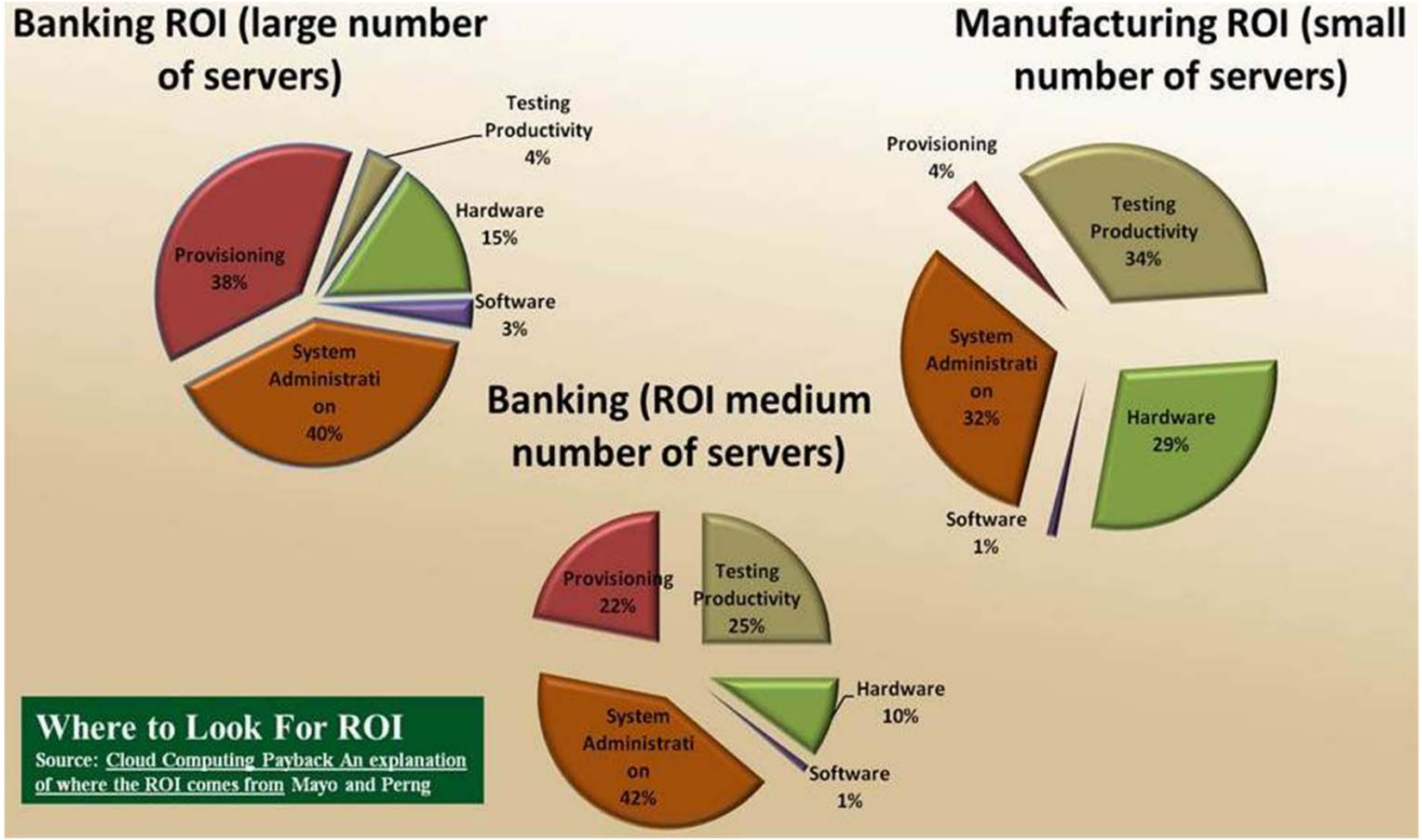


Figure 2 Data Center Consolidation ROI in Industry Statisitics

How many production servers do you run that are:

Physical - 0	Physical - 1 - 5	Physical - 6 - 10	Physical - 11 - 15	Physical - 16 - 20	Physical - 21 - 25	Physical - 26 - 30	Physical - > 30	Sum
11	**21**	**17**	**8**	**5**	**5**	**0**	**8**	
0	63	136	104	90	115	0	240	748
Virtual - 0	Virtual - 1 - 5	Virtual - 6 - 10	Virtual - 11 - 15	Virtual - 16 - 20	Virtual - 21 - 25	Virtual - 26 - 30	Virtual - > 30	
34	**11**	**11**	**5**	**3**	**3**	**2**	**6**	
0	33	88	65	54	69	56	180	545
Windows - 0	Windows - 1 - 5	Windows - 6 - 10	Windows - 11 - 15	Windows - 16 - 20	Windows - 21 - 25	Windows - 26 - 30	Windows - > 30	
18	**20**	**12**	**4**	**7**	**4**	**1**	**9**	
0	60	96	52	126	92	28	270	724
Linux - 0	Linux - 1 - 5	Linux - 6 - 10	Linux - 11 - 15	Linux - 16 - 20	Linux - 21 - 25	Linux - 26 - 30	Linux - > 30	
36	**25**	**4**	**3**	**1**	**1**	**1**	**4**	
0	75	32	39	18	23	28	120	335
Unix - 0	Unix - 1 - 5	Unix - 6 - 10	Unix - 11 - 15	Unix - 16 - 20	Unix - 21 - 25	Unix - 26 - 30	Unix - > 30	
59	**11**	**2**	**0**	**1**	**0**	**0**	**2**	
0	33	16	0	18	0	0	60	127
1 - 3 years old - 0	1 - 3 years old - 1 - 5	1 - 3 years old - 6 - 10	1 - 3 years old - 11 - 15	1 - 3 years old - 16 - 20	1 - 3 years old - 21 - 25	1 - 3 years old - 26 - 30	1 - 3 years old - > 30	
14	**32**	**9**	**7**	**4**	**2**	**2**	**5**	
0	96	72	91	72	46	56	150	583
4 - 6 years old - 0	4 - 6 years old - 1 - 5	4 - 6 years old - 6 - 10	4 - 6 years old - 11 - 15	4 - 6 years old - 16 - 20	4 - 6 years old - 21 - 25	4 - 6 years old - 26 - 30	4 - 6 years old - > 30	
16	**33**	**13**	**4**	**3**	**0**	**3**	**3**	
0	99	104	52	54	0	84	90	483
> 6 years old - 0	> 6 years old - 1 - 5	> 6 years old - 6 - 10	> 6 years old - 11 - 15	> 6 years old - 16 - 20	> 6 years old - 21 - 25	> 6 years old - 26 - 30	> 6 years old - > 30	
46	**24**	**2**	**0**	**3**	**0**	**0**	**0**	
0	72	16	0	54	0	0	0	142

Approximately what percentage of your servers are in a dedicated server room not dependent on building air- conditioning for cooling? (Respondent count)

None	less than 25%	26 - 50%	51 - 75%	greater than 75%	All
26	**2**	**6**	**3**	**8**	**30**

If you could manage your OS and services the same way you do now at an equivalent cost, would you be willing to run your systems as virtual machines hosted by ACNS?

Yes	No
54	**21**

How much would you be willing to spend per year on a server?

Whole dollars average
$ 1,222.98

How many servers would you be willing to migrate in:

FY 2012		FY 2013		After FY 2013			
Linux	Windows	Linux	Windows	Linux	Windows		
17	**61**	**14**	**80**	**13**	**64**		
Average number of servers:							
	78		**94**		**77**	**83**	

Figure 3 Results from Survey to Subnet Managers June 2011

Component		Quantity	Item Cost		Total 5 Year Cost	
HP C7000 Chassis (3 yr. up front)	D	1	$40,000.00		$ 40,000	
- Virtual Connect Flex10						
- Fans/Powersupplies Maxed						
- Includes all SFPs						
BL460c 96GB blades (3 yr. up front) * (buy 8 in bulk, seven for $8000, one free)	D	16	$ 7,000		$ 112,000	
HP Service Contract, Yr 4/5 (est.) ($200/blade/year)					$ 6,400	**$158,400**
Licensing						
Microsoft Licensing (annually on CA)		per proc				
- Windows Datacenter		22	$ 129	$2,849		
- System Center Suite Licensing (VMM/DPM/SCOM)		22	$ 75	$1,650		
Cost per processor per year			$ 204	$4,499	**$ 22,494**	
VMWare (1/2 of the MS installs)		10	$ 1,725	$2,588	$ 25,530	**$ 48,024**
Start-up Storage Costs						
Storage System License	D??		$ 100,000			
Servers to run storage	D		$ 30,000			
Storage (Terabytes raw)	D	60	$ 100,000		$ 230,000	$ 76,667
Price per GB raw	$1.67					
**'ACNS, IS, Project 3 way split					$ 76,667	
Yearly Maintenance						
Storage license			$ 15,000			
Storage			$ 8,000		$ 23,000	$ 7,667
**'ACNS, IS, Project 3 way split					$ 7,667	
Add Storage	D					
Per gigabyte cost Disk	$1.67					
Personnel		FTE/100 VMs				
Accountant	45000	0.075				
System Administrator	90000	0.25				
Unit Manager (Flat Cost)	105000	0.01				**$ 18,000**
Miscellaneous						
Cables/Racks etc					$ 10,000	
Backup startup cost					**$ 10,000**	
Backup maint		4	$ 10,000		**$ 40,000**	
					$ 60,000	**$ 60,000**
Grand Total					**$ 368,757**	
Assumptions						
VMs per blade		15				
Blades available (minus 2 for failover)		14				
Total VMs accomodated		210	420	630	840	
Raw Cost per VM / year (assuming 5 years)		**351.20**				

Figure 4 Cost Details for Equipment, Software and Personnel

900	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Annual customer count	Pilot	25	50	75	100	125	150	175	200	225	250
Projected Revenue		$ 22,500	$ 45,000	$ 67,500	$ 90,000	$ 112,500	$ 135,000	$ 157,500	$ 180,000	$ 202,500	$ 225,000
Servers											
Qty Chassis	1	1	1	1	1	1	1	1	1	2	2
HP C7000 Chassis (3 yr. up front)	$ 40,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 40,000	$ 40,000
- Virtual Connect Flex10, Fans/Powersupplies Maxed, Includes all SFPs											
Qty CPU's	16	16	16	16	32	32	32	32	32	48	48
Qty running sum, includes 2 spare/chassis	8	8	8	8	16	16	16	16	16	24	24
Qty purchased, includes 2 spare/chassis	8	0	0	0	8	0	0	0	0	8	0
BL460c 96GB blades (3 yr. up front) -											
BL460c 96GB blades (3 yr. up front) - @8000 ea.	$ 56,000	$ -	$ -	$ -	$ 56,000	$ -	$ -	$ -	$ -	$ 56,000	$ -
BL460c 96GB blades (3 yr. up front) - replacement @8000 ea.					$ -	$ 56,000	$ -	$ -	$ -	$ 56,000	$ 56,000
HP Service Contract Blades, Chassis, etc. Yr 4/5 (est.)				$ 1,600	$ 1,600			$ 1,600	$ 3,200	$ 1,600	
Licensing											
Microsoft Licensing (annually on CA)											
# licensed	8	8	8	8	19	19	19	19	19	28	28
- Windows Datacenter											
- System Center Suite Licensing (VMM/DPM/SCOM)	$ 1,636	$ 1,636	$ 1,636	$ 1,636	$ 3,885	$ 3,885	$ 3,885	$ 3,885	$ 3,885	$ 5,726	$ 5,726
VMWare purchase											
# licensed	4	4	4	4	9	9	9	9	9	14	14
VMWare purchase (1/2 of the MS installs)	$ 6,900	$ -	$ -	$ -	$ 8,625	$ -	$ -	$ -	$ -	$ 8,625	$ -
VMWare maintenance (1/2 of the MS installs)	$ 1,035	$ 1,035	$ 1,035	$ 1,035	$ 2,329	$ 2,329	$ 2,329	$ 2,329	$ 2,329	$ 3,623	$ 3,623
Storage											
Storage required (250 g/vm)	6250	12500	18750	25000	31250	37500	43750	50000	56250	62500	68750
Storage Start-up Costs (Disks, cabinets, virtualization)	$ 76,667										
Maintenance		$ 7,667	$ 7,667	$ 8,708	$ 9,750	$ 10,792	$ 11,833	$ 12,875	$ 13,917	$ 14,958	$ 16,000
Add storage				$ 10,417	$ 10,417	$ 10,417	$ 10,417	$ 10,417	$ 10,417	$ 10,417	$ 10,417
Personnel											
Accountant		$ 844	$ 1,688	$ 2,531	$ 3,375	$ 4,219	$ 5,063	$ 5,906	$ 6,750	$ 7,594	$ 8,438
System Manager		$ 5,625	$ 11,250	$ 16,875	$ 22,500	$ 28,125	$ 33,750	$ 39,375	$ 45,000	$ 50,625	$ 56,250
Unit Manager (Flat Cost)		$ 263	$ 525	$ 788	$ 1,050	$ 1,313	$ 1,575	$ 1,838	$ 2,100	$ 2,363	$ 2,625
Annual Expense	$ 182,238	$ 17,069	$ 23,800	$ 43,590	$ 119,531	$ 117,079	$ 68,852	$ 78,224	$ 87,597	$ 257,529	$ 199,077
		Expected Cost Recovery/ Year (Breakeven analysis)									
		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
		$ (176,806)	$ (155,607)	$ (131,696)	$ (161,227)	$ (165,806)	$ (99,657)	$ (20,382)	$ 72,021	$ 16,992	$ 42,914

Figure 5 Ten Year Revenues and Expenses for Low Adoption (25 VM's Per Year)

900	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Annual customer count	Pilot	50	100	150	200	250	300	350	400	450	500
Projected Revenue		$ 45,000	$ 90,000	$ 135,000	$ 180,000	$ 225,000	$ 270,000	$ 315,000	$ 360,000	$ 405,000	$ 450,000
Servers											
Qty Chassis	1	1	1	1	1	2	2	2	2	3	3
HP C7000 Chassis (3 yr. up front)	$ 40,000	$ -	$ -	$ -	$ -	$ 40,000	$ -	$ -	$ -	$ 40,000	$ 40,000
- Virtual Connect Flex10, Fans/Powersupplies Maxed, Includes all SFPs											
Qty CPU's	16	16	32	32	32	48	64	64	64	80	80
Qty running sum, includes 2 spare/chassis	8	8	16	16	16	24	32	32	32	40	40
Qty purchased, includes 2 spare/chassis	8	0	8	0	0	8	8	0	0	8	0
BL460c 96GB blades (3 yr. up front) -											
BL460c 96GB blades (3 yr. up front) - @8000 ea.	$ 56,000	$ -	$ 56,000	$ -	$ -	$ 56,000	$ 56,000	$ -	$ -	$ 56,000	$ -
BL460c 96GB blades (3 yr. up front) - replacement @8000 ea.						$ 56,000		$ 56,000	$ -	$ -	$ 112,000
HP Service Contract, Yr 4/5 (est.)				$ 1,600	$ 1,600	$ 1,600	$ 1,600	$ 1,200	$ 3,200	$ 4,800	$ 3,200
Licensing											
Microsoft Licensing (annually on CA)											
#licensed	8	8	19	19	19	28	38	38	38	47	47
- Windows Datacenter											
- System Center Suite Licensing (VMM/DPM/SCOM)	$ 2,181	$ 2,181	$ 4,362	$ 4,362	$ 4,362	$ 6,544	$ 8,725	$ 8,725	$ 8,725	$ 10,906	$ 10,906
VMWare purchase (1/2 of the MS installs)											
#licensed	4	4	9	9	9	14	20	20	20	25	25
VMWare purchase (1/2 of the MS installs)	$ 6,900	$ -	$ 8,625	$ -	$ -	$ 8,625	$ 10,350	$ -	$ -	$ 8,625	$ -
VMWare maintenance (1/2 of the MS installs)	$ 1,035	$ 1,035	$ 2,329	$ 2,329	$ 2,329	$ 3,623	$ 5,175	$ 5,175	$ 5,175	$ 6,469	$ 6,469
Storage											
Storage required (250 g/vm)	12500	25000	37500	50000	62500	75000	87500	100000	112500	125000	137500
Storage Start-up Costs (Disks, cabinets, virtualization)	$ 76,667										
Maintenance		$ 9,750	$ 11,833	$ 13,917	$ 16,000	$ 18,083	$ 20,167	$ 22,250	$ 24,333	$ 26,417	$ 28,500
Add storage/add license		$ 20,833	$ 20,833	$ 20,833	$ 20,833	$ 20,833	$ 20,833	$ 20,833	$ 20,833	$ 20,833	$ 20,833
Personnel											
Accountant		$ 1,688	$ 3,375	$ 5,063	$ 6,750	$ 8,438	$ 10,125	$ 11,813	$ 13,500	$ 15,188	$ 16,875
System Manager		$ 11,250	$ 22,500	$ 33,750	$ 45,000	$ 56,250	$ 67,500	$ 78,750	$ 90,000	$ 101,250	$ 112,500
Unit Manager (Flat Cost)		$ 525	$ 1,050	$ 1,575	$ 2,100	$ 2,625	$ 3,150	$ 3,675	$ 4,200	$ 4,725	$ 5,250
Annual Expense	$ 182,783	$ 47,262	$ 130,908	$ 83,429	$ 98,975	$ 278,620	$ 203,625	$ 208,421	$ 169,967	$ 295,212	$ 356,533
		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
		$ (185,045)	$ (225,953)	$ (174,382)	$ (93,356)	$ (146,976)	$ (80,601)	$ 25,978	$ 216,011	$ 325,799	$ 419,266

Figure 6 Ten Year Revenues and Expenses for Medium Adoption (50 VM's Per Year)

900	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Annual customer count	Pilot	83	166	249	332	415	498	581	664	747	830
Projected Revenue		$ 74,700	$ 149,400	$ 224,100	$ 298,800	$ 373,500	$ 448,200	$ 522,900	$ 597,600	$ 672,300	$ 747,000
Servers											
Qty Chassis	1	1	1	2	2	2	3	3	4	4	4
HP C7000 Chassis (3 yr. up front)	$ 40,000	$ -	$ -	$ 40,000	$ -	$ -	$ 40,000	$ -	$ 40,000	$ -	$ 40,000
- Virtual Connect Flex10, Fans/Powersupplies Maxed, Includes all SFPs											
Qty CPU's	16	16	32	48	64	64	80	96	112	128	128
Qty running sum, includes 2 spare/chassis	8	8	16	24	32	32	40	48	56	64	64
Qty purchased, includes 2 spare/chassis	8	0	8	8	8	0	8	8	8	8	0
BL460c 96GB blades (3 yr. up front) -											
BL460c 96GB blades (3 yr. up front) - @8000 ea.	$ 56,000	$ -	$ 56,000	$ 56,000	$ 56,000	$ -	$ 56,000	$ 56,000	$ 56,000	$ 56,000	$ -
BL460c 96GB blades (3 yr. up front) - replacement @8000 ea.						$ 56,000		$ 56,000	$ 56,000	$ 56,000	$ 56,000
HP Service Contract, Yr 4/5 (est.)				$ 1,600	$ 1,600	$ 1,600	$ 3,200	$ 3,200	$ 3,200	$ 3,200	$ 4,800
Licensing											
Microsoft Licensing (annually on CA)											
# licensed	8	8	19	28	38	38	47	58	66	77	77
- Windows Datacenter											
- System Center Suite Licensing (VMM/DPM/SCOM)	$ 1,636	$ 1,636	$ 3,885	$ 5,726	$ 7,771	$ 7,771	$ 9,611	$ 11,860	$ 13,496	$ 15,746	$ 15,746
VMWare purchase (1/2 of the MS installs)											
# licensed	4	4	9	14	20	20	25	30	36	41	41
VMWare purchase (1/2 of the MS installs)	$ 6,900	$ -	$ 8,625	$ 8,625	$ 10,350	$ -	$ 8,625	$ 8,625	$ 10,350	$ 8,625	$ -
VMWare maintenance (1/2 of the MS installs)	$ 1,035	$ 1,035	$ 2,329	$ 3,623	$ 5,175	$ 5,175	$ 6,469	$ 7,763	$ 9,315	$ 10,609	$ 10,609
Storage											
Storage required (250 g/vm)	20750	41500	62250	83000	103750	124500	145250	166000	186750	207500	228250
Storage Start-up Costs (Disks, cabinets, virtualization)	$ 76,667										
Maintenance		$ 11,125	$ 14,583	$ 18,042	$ 21,500	$ 24,958	$ 28,417	$ 31,875	$ 35,333	$ 38,792	$ 42,250
Add storage/add license		$ 34,583	$ 34,583	$ 34,583	$ 34,583	$ 34,583	$ 34,583	$ 34,583	$ 34,583	$ 34,583	$ 34,583
Personnel											
Accountant		$ 2,801	$ 5,603	$ 8,404	$ 11,205	$ 14,006	$ 16,808	$ 19,609	$ 22,410	$ 25,211	$ 28,013
System Manager		$ 18,675	$ 37,350	$ 56,025	$ 74,700	$ 93,375	$ 112,050	$ 130,725	$ 149,400	$ 168,075	$ 186,750
Unit Manager (Flat Cost)		$ 872	$ 1,743	$ 2,615	$ 3,486	$ 4,358	$ 5,229	$ 6,101	$ 6,972	$ 7,844	$ 8,715
Annual Expense	$ 182,238	$ 70,727	$ 164,701	$ 235,241	$ 226,370	$ 241,826	$ 320,991	$ 366,341	$ 437,060	$ 424,684	$ 427,465
		Expected Cost Recovery/ Year (Breakeven analysis)									
		2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
		$ (178,265)	$ (193,566)	$ (204,707)	$ (132,277)	$ (603)	$ 126,605	$ 283,165	$ 443,705	$ 691,321	$ 1,010,855

Figure 7 Ten Year Revenues and Expenses for High Adoption (83 VM's Per Year)

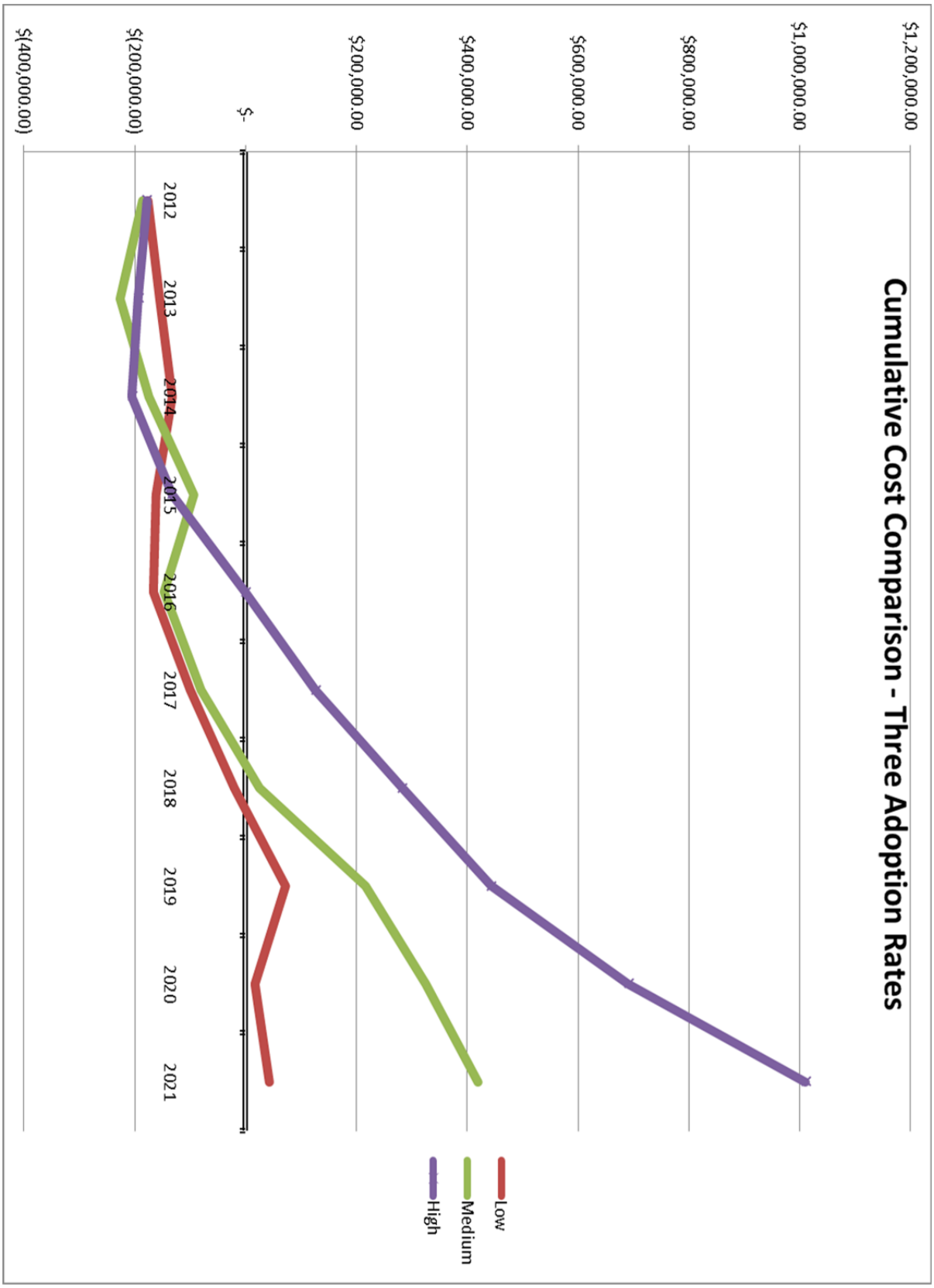


Figure 8 Breakeven chart for three adoption rates