Total Cost of Ownership for Enterprise Application Workloads

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1. Overview

In Fall of 2003, RFG was commissioned by IBM Corp. to perform a study of Linux application workload TCO in the enterprise. To do so, RFG examined a common task facing administrators today – upgrading an existing Java application server environment to meet growing performance requirements.

As a result of this study, RFG found that the pSeries 650 platform running Linux provided an ideal target environment for this effort as compared to Itanium, Sun Fire, and x86-based SMP and cluster systems. The p650 provided similar or greater functionality to the alternatives at up to 60% lower TCO over three years.

2. Methodology

2.1 Background

Upgrading enterprise application environments is a common challenge for IT executives. To identify suitable target environments for enterprise application workloads, RFG considered a hypothetical environment containing eight Sun Microsystems Inc. Enterprise 420R systems each configured with four UltraSPARC II 450 MHz processors and 2 GB of system RAM. These systems run Solaris 8 and Sun's Java 2 Runtime Environment. This study will evaluate several possible capacity upgrade cases to determine the most suitable upgrade path for this workload.

To provide a fair comparison between systems, RFG relied on performance characteristics published by The Standard Performance Evaluation Corp. (SPEC)[1]. SPEC publishes a test result set called SPECjbb® that focuses specifically on Java application server environments supporting business applications, and this metric provides an ideal comparison between systems for the purposes of this study.

According to SPECjbb®, the current environment provides 8,850 operations per second (ops/sec) per system, for an aggregate total of 70,800 ops/sec, and 16 GB of RAM. For this study, RFG considered an upgrade goal of increasing processing capacity to at least 110,000 ops/sec, roughly a 65% improvement, and of memory capacity to at least 20 GB, a 25% increase.

The hypothetical source environment also provides application isolation, in that LOB applications do not "fight" one another for system resources or affect the performance of other applications during peak workload periods. To incorporate isolation concepts, RFG defined four hypothetical applications for which isolation might be desirable:

- E-commerce application – 52,500 ops/sec, 10 GB of RAM (50% of total)
- Enterprise vertical - 26,500 ops/sec, 5 GB of RAM (25% of total)
- Employee portal – 13,125 ops/sec, 2.5 GB of RAM (12.5% of total)
- Business partner portal – 13,125 ops/sec, 2.5 GB of RAM (12.5% of total)

To simplify this study and level the playing field, RFG chose to compare target environments all running the same Java 2 Enterprise Edition (J2EE) application server software. RFG selected the Open Source JBoss product, which can be deployed on all of the platforms evaluated. Other application server products may also be suitable for this workload, but such an examination was beyond the scope of this study.

SUSE LINUX AG's Linux distribution was randomly chosen for the Linux environments, but Red Hat is also an option and would be equally suitable.

[1] Note: SPEC® is a registered trademark of the Standard Performance Evaluation Corporation.

2.2. Target Environments

The following systems will be used as deployment targets. Each system was chosen to meet the upgrade requirements for the hypothetical environment without significantly exceeding them, providing the most cost-effective solution for each case. Note that JBoss' performance was not tested by the vendors in each case. However, since Web application server benchmarks were beyond the scope of this study, and each system includes some margin of excess capacity, RFG believes JBoss would adequately meet the hypothetical upgrade requirement for this study.

Environment 1 – IBM pSeries 650 running Linux
This system will be configured with 6 1.45GHz POWER4 processors and 20 GB of RAM. The software stack will consist of SuSE Linux Enterprise Server 8 and JBoss. IBM's logical partitioning (LPAR) technology will be used to provide isolated application environments; LPAR capability is a standard feature on this platform.

Normalizing this system's performance characteristics when running Linux requires additional steps, since SPECjbb® benchmarks are not yet available for this particular combination. First, the pSeries 655 configured with four 1.7 GHz processors produces 96,377 ops/sec running AIX, so a six-processor system should provide approximately 144,566 ops/sec. Since the p650 evaluated was configured with 1.5 GHz processors, RFG derated this figure by 12% (1500/1700) to 127,558 ops/sec.

SPECjbb® benchmarks are also not yet available for Linux on this platform. To adjust for this change, RFG examined two other benchmarks that are available. SPECint_base2000® numbers for this platform produced a metric of 909 for AIX 5L and 886 for Linux, a derating factor of 2.5%. SPECfp_base2000® for the same configurations produced numbers of 1221 for AIX 5L and 1091 for Linux, a derating factor of 12.9%. Depending on the type of work involved, it should thus be reasonable to expect a Linux-based pSeries 650 configured as above to provide within 7% of the performance of AIX, or roughly 118,629 ops/sec. When this combination is officially tested by SPEC, the reader should adjust these figures to match the tested results. Nonetheless, there is sufficient margin in this number that RFG expects this platform to meet the requirements of the upgrade prerequisites.

Environment 2 – Hewlett-Packard Co. (HP) ProLiant DL740 running Linux
This system will be configured with eight 2.8 GHz Intel Corp. Xeon MP processors and 20 GB of RAM. The software stack will consist of SuSE Enterprise Linux 8 and JBoss. A similar system configured with four processors produces 79,572 ops/sec running BEA's JRockIt JVM on Linux, so RFG would expect a six-processor system to provide approximately 119,358 ops/sec. An eight processor system is thus over-configured to meet this workload requirement, but HP does not provide this as a customization option. This additional capacity also avoids any concerns regarding derating factors for JBoss and Linux. HP customers should contact their sales representatives for pricing if they wish to consider a six processor system.

Hardware partitioning is not available on this platform, so RFG included a software partitioning product from VMWare, Inc. VMWare's server product is available in two editions, GSX Server and ESX Server. GSX Server is the less expensive of the two, but it is a hosted environment that suffers from unacceptable levels of CPU overhead for the purposes of this study. ESX Server contains its own minimal operating system in which the virtual environments are executed, and performance degradation of 5% or lower can be expected, which is more appropriate for this type of workload. The use of this product will reduce the excess capacity of this environment, but the system is still expected to meet the requirements of this evaluation.

Environment 3 – HP ProLiant DL740 running Windows
This system will be configured identically to Environment 2 above, but Linux will be replaced with Microsoft Corp.'s Windows Server 2003 Standard Edition. VMWare ESX Server will again be used to provide application server isolation.

Windows includes application server functionality as part of the base product, but only for applications built on Microsoft's proprietary Component Object Model (COM) technology. Because it does not provide J2EE application server functionality, JBoss is still required here.

Although Windows' graphical user interface does add some CPU overhead to the environment compared to Unix systems (which can be configured to disable this feature), this system is still expected to meet the minimum performance requirements for the upgrade.

Environment 4 – Cluster of two HP rx5670 systems running Linux
Each system will be configured with two 1.5GHz Intel Itanium 2 processors and 10 GB of RAM. The software stack will consist of SuSE Enterprise Linux 8 and JBoss. This system configured with four processors provides 116,466 ops/sec running HP's Hotspot Java Virtual Machine (JVM) on HP-UX, so RFG would expect each dual-processor system to provide at least 58,000 ops/sec in the cluster.

A two-node cluster was chosen because hardware partitioning is not available on this platform. VMWare's products are also not applicable because they do not yet support Itanium systems, and VMWare has not announced a road map for supporting Itanium. This deployment thus does not fully meet the workload isolation requirement. However, RFG believes customers are more likely to deploy multi-processor Itanium systems rather than single-processor systems, and two nodes thus provides a compromise between the desire for vertical scaling and the workload isolation requirement.

Environment 5 – Cluster of two HP rx5670 systems running Windows
These systems will be configured identically to Environment 4 above, but Linux will again be replaced with Windows Server 2003 Standard Edition.

Environment 6 – Sun Fire 4800 running Solaris 9
This system will be configured with twelve Sun UltraSPARC III 1.2 GHz processors and 20 GB of RAM. The software stack will consist of Solaris 9 and JBoss.

Sun's dynamic partitioning capabilities, called Dynamic System Domains, are only available in its Sun Fire product line. Thus, Sun's more cost-effective systems, such as the V880, are unacceptable for the purposes of this study. Solaris 9 supports a concept known as "containers," which can allow administrators to restrict the amount of resources a task may consume. This can provide a form of server virtualization, but it does not provide the same level of process isolation created by true partitions. Nor can VMWare be used to provide this same capability, as it does not support the SPARC architecture.

On the other hand, the Sun Fire 6800, which does meet this study's requirements, is nearly six times as expensive as the other options considered, and it is unreasonable to assume that customers would purchase this option in lieu of other possibilities.

To provide a fair comparison, RFG configured a Sun Fire 4800 with 12 processors, which produces a SPECjbb® of 124,256 ops/sec. This configuration is priced roughly midway between the 6800 and the V880, and provides two dynamic partitions. IT executives must therefore make a sacrifice, combining application environments to create only two isolated partitions. However, RFG believes customers would generally be willing to make this case to the application owners rather than pay nearly twice the cost simply to obtain two more partitions. RFG thus feels this compromise is justified in light of the fact that this configuration is still less expensive than deploying four separate servers to handle the same workload, especially when administrative costs are factored in. According to Sun, Solaris 10 will include a concept known as “zones” that can provide this isolation requirement, but because this feature is not yet available, RFG was unable to include it in this study.

Environment 7 – Cluster of five HP ProLiant DL560 systems running Linux

Each node in the cluster will be configured with two 2.8 GHz Intel Pentium Xeon processors and 4 GB of RAM. The software stack will consist of SuSE Enterprise Linux 8 and JBoss.

In environment 2, these processors provided approximately 19,893 ops/sec each. Each dual-processor system should thus be able to provide approximately 39,786 ops/sec. Two servers will use load balancing to support the workload for the first application, and one server will support the second through fourth. VMWare is not required in this environment.

This solution could also incorporate dissimilar servers to take into account the individual processing requirements for each application. However, RFG believes customers would be more likely to choose a standard server configuration for this type of effort to reduce administration costs associated with managing dissimilar systems, and simplify the purchasing and provisioning processes.

Environment 8 – Cluster of five HP ProLiant DL560 systems running Windows
This environment will be configured identically to Environment 5 above, but Linux will be replaced with Microsoft's Windows Server 2003 Standard Edition. The same comments made in Environment 2 regarding Windows also apply here. Additionally, the reader should note that this environment includes the maximum quantity of RAM allowed by Windows Server 2003 Standard Edition; if a RAM upgrade became necessary the customer would also have to upgrade to Enterprise Edition.

2.3. Other Comments

Where possible, software and hardware elements that would be identical in all environments, such as network hubs, backup software, and storage area network (SAN) arrays, have been excluded from this study to simplify the comparison. The exception is where additional hardware would be required to access these services, such as additional network and SAN adapters for the clustered environments. The reader should factor in the appropriate support facilities for his or her own environment.

Because hardware and software purchase discounts vary widely from company to company, all prices will reflect publicly available manufacturer suggested retail price (MSRP) values in U.S. dollars. Hardware and software vendors can and do compete on the basis of price, so the reader should discuss his or her deployment plans with sales representatives from the relevant vendors to determine what, if any, discounts may apply.

While Solaris is available for the Intel architecture, RFG's experience has been that enterprise buyers are much more likely to deploy Linux on Intel-based servers in their environments. Also, while the Linux kernel can run on Sun's SPARC architecture, no major distribution vendors support this configuration, and RFG's experience is that customers are unlikely to deploy Linux on a high-end Sun server in lieu of Solaris. RFG has thus excluded these two options from this study.

Package discounts were used where retail pricing numbers were publicly available. This specifically applies to support options – if a three-year support option was available, this price was included as part of the Year 1 cost in each case. Many vendors allow customers to pay these fees on an annual basis to spread the costs out over the ownership period; the reader should contact his or her sales representatives to discuss these options.

RFG also has not yet found significant deployments of Advanced MicroDevices, Inc. Opteron-based systems, so these were excluded from this study. In the future, as vendors release systems that include these processors, these may be viable target platforms for comparison.

Finally, 3-year TCO models are the industry standard, and pricing data is the most accurate for this time scale, so RFG chose to examine this ownership period. However, business applications often live for 5 to 8 years, or longer. The reader should perform an independent calculation that includes factors such as finance charges, depreciation, charge-backs, and other elements that vary from company to company.

3. Total Cost of Ownership Breakdown

3.1. Hardware Costs

Table 1 – Hardware Cost Summary				
Environment	**Year 1**	**Year 2**	**Year 3**	**Total**
1 – p650/Linux	$102,063	$0	$0	$106,073
2 – DL740/Linux	$94,208	$0	$0	$94,208
3 – DL740/Windows	$94,208	$0	$0	$94,208
4 – rx5670/Linux	$141,394	$0	$0	$141,394
5 – rx5670/Windows	$136,722	$0	$0	$136,722
6 – Sun Fire/Solaris	$345,055	$0	$0	$345,055
7 – Cluster/Linux	$99,420	$0	$0	$99,420
8 – Cluster/Windows	$99,420	$0	$0	$99,420

Source: Robert Frances Group

Environment 1 – A standard pSeries 650 server with 6 1.45 GHz processors and 12 GB of RAM is priced at $89,695. 4 GB RAM modules are available for $7,040 each, and the SAN card costs $2,298.

$89,695 + 2 * ($7,040) + $2,298 = $106,073.

Environments 2 and 3 – A standard DL740 2.8 GHz system with four processors and 4 GB of RAM is priced at $46,498. A four processor upgrade is priced at $29,699. There are two options for upgrading to 20 GB of RAM depending on the need to keep slots free for future upgrades. RFG chose the less expensive option, priced at $13,180. HP customers should determine their future upgrade requirements, as the use of larger modules to allow for future expansion would add $15,810 to this system. A SAN adapter is not directly available for this system, but an HP D8602 SAN adapter compatible with this system was sourced through an online merchant for $1,441. Finally, a warranty upgrade that includes 3 years of 24x7 on-site support with a 4-hour response time is $3,390.

$46,498 + $29,699 + $13,180 + $1,441 + $3,390 = $94,208.

Environment 4 – A standard rx5670 1.5 GHz system with one processor and 1 GB of RAM is priced at $32,925. One additional processor is priced at $8,250. An 8 GB memory "quads" is priced at $14,000, and a 1 GB quad is priced at $1,200, giving each system 10 GB of RAM. The SAN adapter is $4,480 for a device that supports Linux. An additional power supply module is $364, and rack mount rails are $134. Finally, a warranty upgrade that includes 3 years of 24x7 on-site support with a 4-hour response time is $9,344.

2 * ($32,925 + $8,250 + $14,000 + $1,200 + $4,480 + $364 + $134 + $9,344) = $141,394.

Environment 5 – See environment 3a. This environment requires the addition of a video and USB package for Windows support for $349, and allows the replacement of the SAN adapter with a less expensive option that supports only Windows for $1,795.

2 * ($32,925 + $8,250 + $14,000 + $1,200 + $1,795 + $364 + $134 + $349 + $9,344) = $136,722.

Environment 6 – A Sun Fire 4800 with 12 1.2 GHz processors and 24 GB of RAM is priced at $299,290. This system is thus over-configured, but this combination is less expensive than adding processors and RAM to the next lower combination. A 3-year warranty upgrade to SunSpectrum Silver is $44,172. A rack-mount kit for non-Sun racks is $400, which RFG excluded as customers purchasing this server would likely have a Sun rack. Readers without this infrastructure should add $400 to this system's price. Finally, pricing for a SAN adapter was not available directly from Sun, but a JNI Corp. card compatible with this system was sourced through an online merchant for $1,593.

$299,290 + $44,172 + $1,593 = $345,055.

Environment 7 – Each DL560 server with 2 processors and 1 Gb of system RAM is priced at $14,998. A RAM upgrade to 4 GB costs $1,650. A SAN adapter is not directly available for this system, but an HP D8602 SAN adapter compatible with this system was sourced through an online merchant for $1,441. Finally, a 3-year warranty upgrade equivalent to the other environments costs $1,795.

$14,998 + $1,650 + $1,441 + $1,795 = $19,884.
Five systems = $99,420.

Environment 8 – See environment 5.

$14,998 + $1,650 + $1,441 + $1,795 = $19,884.
Five systems = $99,420.

3.2. Software Costs

Note that SuSE Premium Support and Microsoft's Software Assurance costs are included in the third section, Support Costs.

Table 2 – Software Cost Summary

Environment	Year 1	Year 2	Year 3	Total
1 – p650/Linux	$3,208	$0	$0	$3,208
2 – DL740/Linux	$20,178	$0	$0	$20,178
3 – DL740/Windows	$23,998	$0	$0	$23,998
4 – rx5670/Linux	$6,307	$0	$0	$6,307
5 – rx5670/Windows	$5,996	$0	$0	$5,996
6 – Sun Fire/Solaris	$95	$0	$0	$95
7 – Cluster/Linux	$4,704	$0	$0	$4,704
8 – Cluster/Windows	$15,990	$0	$0	$15,990

Source: Robert Frances Group

Environment 1 – An installation media kit for SuSE Linux Enterprise Server costs $109, and a three-year maintenance program costs $3,099.

$109 + $3,099 = $3,208.

Environment 2 – An installation media kit for SuSE costs $109, and a three-year maintenance program costs $2,069. Additionally, VMWare ESX Server costs $18,000 for an 8-processor license.

$109 + $2,069 + $18,000 = $20,178.

Environment 3 – Windows Server 2003 Enterprise Edition replaces SuSE at $3,999, and also requires the purchase of an external connector license for $1,999.

$3,999 + $1,999 + $18,000 = $23,998.

Environment 4 – An installation media kit for SuSE costs $109, and a three-year maintenance program costs $3,099.

$109 + 2 * ($3,099) = $6,307.

Environment 5 – Windows Server 2003 Standard Edition replaces SuSE at $999, and also requires the purchase of an external connector license for $1,999.

2 * ($999 + $1,999) = $5,996.

Environment 6 – A Solaris 9 media kit with documentation is priced at $95 for this system.

Environment 7 - SuSE is priced at $109.00 for a media kit, and $899 for a 3-year maintenance program.

$109 + 5 * ($919) = $4,704.

Environment 8 – Windows 2003 Server Standard Edition is priced at $1,199, and an external connector license is priced at $1,999.

$1,199 + $1,999 = $3,198.
5 systems = $15,990.

3.3. Support Costs

Table 3 – Support Cost Summary

Environment	Year 1	Year 2	Year 3	Total
1 – p650/Linux	$2,069	$2,069	$2,069	$6,207
2 – DL740/Linux	$1,379	$1,379	$1,379	$4,137
3 – DL740/Windows	$1,700	$1,700	$1,700	$5,100
4 – rx5670/Linux	$2,069	$2,069	$2,069	$6,207
5 – rx5670/Windows	$1,699	$1,699	$1,699	$5,097
6 – Sun Fire/Solaris	$0	$0	$0	$0
7 – Cluster/Linux	$6,549	$6,549	$6,549	$19,647
8 – Cluster/Windows	$8,500	$8,500	$8,500	$25,500

Source: Robert Frances Group

Both SuSE and Microsoft provide certain support options with their products. However, SuSE's support services are licensed only on a subscription basis while Microsoft's are typically licensed on a per-incident basis, where incidents are purchased as part of an enterprise licensing contract. SuSE's support is also available in both Maintenance (software updates and e-mail support) and Premium (adds telephone

support) options. On the other hand, Microsoft now offers some limited support options as part of Software Assurance.

This can make it difficult to determine actual support costs in a manner that allows for easy comparison. To resolve this issue, RFG selected Premium support from SuSE, and Software Assurance and a 5-incident support pack for Windows each year. Based on conversations with its customers, RFG believes these choices reflect those that would typically be made by enterprise IT executives.

Support for JBoss was excluded from this study, as a variety of support options exist and RFG has found little consistency to date in the support options adopted by enterprise customers for this product. Both free and commercial support options are available.

Environment 1 – Each year of Premium support from SuSE is priced at $2,069 for this platform.

Environment 2 – Each year of Premium support from SuSE is priced at $1,379 for this platform.

Environment 3 - Software Assurance is priced at 25% of the product purchase price, and applies both to products and to licenses. A 5-incident support pack is priced at $200.

0.25 * ($3,999 + $1,999) + $200 = $1,700.

Environment 4 – Each year of Premium support from SuSE is priced at $2,069 for this platform.

Environment 5 – Priced as in Environment 3 above, but the maintenance fees apply to two servers.

2 * (0.25 * ($999 + $1,999)) + $200 = $1,699.

Environment 6 – Support for Sun's products was included in the platform configuration and warranty upgrade in the hardware purchase section.

Environment 7 – Each year of Premium support from SuSE is priced at $6,549 for five servers.

Environment 8 – See environment 3, but for five servers.

3.4. Administration and Other Ongoing Costs

Table 4 – Administrative and Ongoing Cost Summary

Environment	Admin	Security	Utility	3-yr Total
1 – p650/Linux	$1,295	$867	$1,655	$11,451
2 – DL740/Linux	$1,295	$867	$1,605	$11,301
3 – DL740/Windows	$1,677	$2,310	$1,605	$16,776
4 – rx5670/Linux	$2,590	$1,734	$5,598	$29,766
5 – rx5670/Windows	$3,354	$4,620	$5,598	$40,716
6 – Sun Fire/Solaris	$1,292	$689	$4,033	$18,042
7 – Cluster/Linux	$6,474	$4,335	$3,783	$43,776
8 – Cluster/Windows	$8,385	$11,550	$3,783	$71,154

Source: Robert Frances Group

RFG included three key factors in this section – administrative, security management, and utility costs. Ongoing costs also include a number of soft cost factors such as platform availability, but since these are difficult to quantify, they are described in a qualitative section below.

3.4.1 Administrative Costs

To determine administrative costs, RFG relied on servers-per-administrator ratios that it had calculated based on past studies and numerous conversations with our clients. Although these numbers vary by environment type, individual skill sets, and management tools used, RFG has found the following figures to be reasonable averages for this type of environment:

Linux – 75 servers per administrator
Solaris – 80 servers per administrator
Windows – 50 servers per administrator

These figures are averages for full-time administrators. RFG then calculated an average salary for each type of administrator based on publicly available salary survey data and added 30% to the base salary to cover overhead, arriving at $103,350 for a Solaris administrator, $97,110 for a Linux administrator, and $83,850 for a Linux administrator. These figures are for urban locations, and the reader should calculate his or her own values based on average salaries within their firms.

This results in a simplistic administrative cost model, and because of the number of variables involved, these numbers are unlikely to precisely reflect each company's experiences. However, RFG believes the *ratios* between the environments do reflect a realistic expectation for most enterprise environments.

Table 5 – Administrator Cost Summary (Annual)

Environment	Admins	Cost	Total
1 – p650/Linux	1/75	$97,110	$1,295
2 – DL740/Linux	1/75	$97,110	$1,295
3 – DL740/Windows	1/50	$83,850	$1,677
4 – rx5670/Linux	2/75	$97,110	$2,590
5 – rx5670/Windows	2/50	$83,850	$3,354
6 – Sun Fire/Solaris	1/80	$103,350	$1,292
7 – Cluster/Linux	5/75	$97,110	$6,474
8 – Cluster/Windows	5/50	$83,850	$8,385

Source: Robert Frances Group

3.4.2 Security Costs

Security costs can be difficult to quantify because risk factors significantly impact security solutions and processes chosen for each application. However, RFG has developed a simplification of this model that takes into account the administrative overhead involved in patching systems. To do this, RFG counted the number of patches that were released for each platform during 2003.

Because Windows Server 2003 was not released until mid-year, RFG used Windows Server 2000 for this calculation. However, despite Microsoft's claims that this product would be more secure, the two products displayed nearly identical patch release rates in the second half of the year. This is because many of the patches apply to components such as Internet Explorer that, while less frequently used on server systems, do

represent a danger and thus should be patched when they are discovered. Since Internet Explorer cannot be removed from Windows, and since RFG's clients almost unanimously applied these patches, RFG feels that this is not an unreasonable assumption.

To obtain the Linux and Solaris counts, RFG reviewed the list of patches released by SuSE and Sun, respectively. Because these platforms make it possible to completely disable services such as the FTP server, RFG omitted patches for specific services that would not be enabled in this type of environment, including FAX services, end-user mail clients and Web browsers, and graphics manipulation libraries. The reader may wish to perform his or her own counts for the Linux, Solaris, and Windows patches that would have been installed.

For 2003, RFG identified 30 patches for Windows, and 17 patches each for Linux and Solaris. RFG then evaluated patch deployment costs based on prior conversations with its clients, and determined that on average, administrators take 1 hour to identify, test, and deploy each Linux patch, 45 minutes for each Solaris patch, and 1.75 hours per server to identify, test, and deploy each Windows patch. Extended out by the number of patches released for each platform during the year, this yields 17 administrator hours per server for Linux, 12.75 for Solaris, and 52.5 for Windows. Costs per hour were determined by dividing the administrator costs above by 48 work weeks of 40 hours each.

Table 6 – Security Cost Summary (Annual)

Environment	Patches	Hrs/Patch	Cost/Hr	Total
1 – p650/Linux	17	1	$51	$867
2 – DL740/Linux	17	1	$51	$867
3 – DL740/Windows	30	1.75	$44	$2,310
4 – rx5670/Linux	17	1 * 2 servers	$51	$1,734
5 – rx5670/Windows	30	1.75 * 2 servers	$44	$4,620
6 – Sun Fire/Solaris	17	0.75	$54	$689
7 – Cluster/Linux	17	1 * 5 servers	$51	$4,335
8 – Cluster/Windows	30	1.75 * 5servers	$44	$11,550

Source: Robert Frances Group

3.4.3 Utility Costs

Power usage levels were calculated at maximum values – actual values depend on workload, and the reader should calculate his or her own values given expected workloads and local utility costs. Power costs were calculated at $0.081/KWh, a recent national average. There are 8,766 hours in a standard (365.25) day year, and thus study assumes a 24x7 application environment. Actual power supply usage varies depending on workload and system configuration, but since this mainly represents a scaling factor, RFG compared each system at maximum load. Yearly electrical costs are thus calculated as:

Electrical cost = P.S. KW * $0.081/KWh * 8,766

Cooling costs are typically calculated in ton-hours of heat removed, and power supply wattage may be converted to this format by multiplying hourly wattage by 3,412 to obtain BTU and then dividing by 12,000 to obtain ton-hours. Finally, although air conditioner efficiency varies by device, 1.3KW/ton is not an uncommon figure for an electrical air conditioner. Thus, calculating yearly cooling costs may be performed via the following formula:

A/C Wattage = ((P.S. KW * 3,412) / 12,000) * 1,300

Cooling cost = (A/C Wattage / 1,000) * Cost/KWh * 8,766

Finally, floor space costs can vary widely from as little as $10/sq. ft. to over $100/sq. ft. even in the same city and sometimes even in the same building. Because costs per square foot represent a scaling factor that applies equally to all cases, RFG chose to use $45/sq. ft. for all cases. A standard server rack's external dimensions typically measure 23”x36”, or 5.75 sq. ft. of floor space, and provides 42U of space for servers, assuming a high-density environment in which no monitors or other devices are installed. A moderately dense data center environment must provide half of its floor space as pathways for technicians and airflow, so this number is finally multiplied by 2 to calculate effective floor space usage.

Floor space cost = (Rack Height / 42U) * 5.75 ft. * 2 * $45/sq. ft.

Table 8 – Utility Cost Summary (Annual)

Environment	Electrical	Cooling	Floor Space	Total
1 – p650/Linux	$1,136	$420	$99	$1,655
2 – DL740/Linux	$1,136	$420	$49	$1,605
3 – DL740/Windows	$1,136	$420	$49	$1,605
4 – rx5670/Linux	$3,962	$1,464	$172	$5,598
5 – rx5670/Windows	$3,962	$1,464	$172	$5,598
6 – Sun Fire/Solaris	$2,783	$1,028	$222	$4,033
7 – Cluster/Linux	$2,627	$971	$185	$3,783
8 – Cluster/Windows	$2,627	$971	$185	$3,783

Source: Robert Frances Group

Environment 1 – 8U high, 1.6 KW.
Environment 2 – 4U, two power supplies, each rated at 800W.
Environment 3 –See environment 2.
Environment 4 – Two servers, 7U high, three power supplies, each rated at 930 W.
Environment 5 – See environment 4.
Environment 6 – 18U (slightly smaller, but remaining U is unusable), 3.92 KW.
Environment 7 – 3U, two power supplies, each rated at 370 W. 5 systems.
Environment 8 – See environment 7.

4. Qualitative Statements

As part of this study, RFG encountered a number of cost factors that were difficult to quantify in such a way as to apply generally to all companies. However, these "hidden costs" can be crucial factors in enterprise environments, and RFG would be remiss if it failed to mention them, so they are summarized here.

- The pSeries and Sun Fire platforms were designed for reliability, with redundant I/O processors, hardware partitioning capabilities, and management features suited to mission-critical systems. While it is difficult to generically quantify system reliability, RFG believes it is reasonable to expect these systems to better meet the requirements of critical workloads than their lower-end counterparts.

- The utility costs calculated above did not allow for the fact that many IT executives today are challenged by data center environments with inherent maximum capacities with respect to cooling requirements, power usage, and system floor space usage and weights. As workload requirements continue to increase, clusters and even blade systems, initially attractive as they allow ever increasing deployment densities,

are often artificially limiting in that they consume more power than the data center can provide, or produce more heat than can be dealt with.

- Clustered environments require additional setup time. Even minor issues such as unboxing systems, installing them in racks, attaching and routing cabling, and provisioning the operating system and application server environment can take a significant amount of administrator time and effort, and can also increase the chances of encountering a dead-on-arrival component or requiring vendor support for similar reasons..

- Distributed environments reduce individual system costs at the expense of increasing the number of components in an end-to-end application environment. This can have a detrimental effect on mean time between failure (MTBF) calculations, leading to reduced aggregate reliability and thus higher management and support costs. This also makes it more difficult to meet availability service level agreements (SLAs).

- Although VMWare was included to provide application isolation in the vertically scaled Intel-based environments, this is a software-based option that consumes more CPU overhead than a hardware partitioning solution. Additional over-engineering may be required to meet application performance requirements where VMWare is used, especially where systems are subdivided into more than a few virtual environments.

- If Microsoft's .Net infrastructure is leveraged for enterprise applications, customers can become locked into the Windows platform, eliminating their ability to move to different hardware architectures or face a costly and time-consuming redevelopment effort.

5. Conclusions

Table 9 – Environment Totals by Year				
Environment	**Year 1**	**Year 2**	**Year 3**	**Total**
1 – p650/Linux	$115,167	$5,886	$5,886	$126,939
2 – DL740/Linux	$119,532	$5,146	$5,146	$129,824
3 – DL740/Windows	$125,498	$7,292	$7,292	$140,082
4 – rx5670/Linux	$159,692	$11,991	$11,991	$183,674
5 – rx5670/Windows	$157,989	$15,271	$15,271	$188,531
6 – Sun Fire/Solaris	$351,164	$6,014	$6,014	$363,192
7 – Cluster/Linux	$125,265	$21,141	$21,141	$167,547
8 – Cluster/Windows	$147,628	$32,218	$32,218	$212,064

Source: Robert Frances Group

As a result of this study, RFG found that the pSeries 650 server competed against Itanium systems at a similar or slightly less expensive cost. However, the p650 system is not fully equipped with processors and RAM, and thus provides additional scalability to painlessly address future workload upgrade requirements, while the Itanium option would require either another upgrade, or the deployment of an additional server. More important, the pSeries platform offers a range of management tools and redundant subsystems designed specifically for mission-critical operating environments that are not available on the Itanium system.

This system also competed against the Sun Fire system at a significantly lower cost. Additionally, the Sun Fire system did not meet all of the study's requirements by providing only two isolated system domains. As mentioned previously, Sun has announced plans to introduce a new partitioning concept known as containers in Solaris 10, but it may be some time before this facility is ready for adoption on production systems. Further, capacity demands may still call for Sun's mid-range hardware, so it may still not be possible to reduce costs by a smaller server.

Finally, cluster buyers should note the long-term ownership costs of their systems once management and administrative overhead factors are included. These systems are often attractive due to perceived low initial acquisition costs, but often exhibit much higher overall TCO. Purchasing "white box" systems to further reduce acquisition costs can extend this cost cycle another year or two, but this is rarely an appropriate choice for mission-critical environments. Ultimately, RFG believes long-term TCO is generally lower on vertically scaled systems for these types of workloads, especially when ownership periods of 5 or more years are considered.

Appendix 1 – Single Itanium Server

Although a single Itanium-based server did not meet the workload isolation requirement, some IT executives may wish to forego this option in single-application environments. The following is the cost data for this type of environment.

Environments 9 and 10 – HP rx5670 running Linux and Windows
This system will be configured with 4 1.5GHz Intel Corp. Itanium 2 processors and 20 GB of RAM. The software stack will consist of SuSE Enterprise Linux 8 or Windows 2003 Server Enterprise Edition and JBoss. This system provides 116,466 ops/sec running HP's Hotspot Java Virtual Machine (JVM) on HP-UX. VMWare is not available for this platform, so partitioning is not possible in this environment. It is thus unsuitable for mixed application workloads, but may be acceptable for a single application with vertical scaling requirements.

Table 1 – Hardware Cost Summary				
Environment	**Year 1**	**Year 2**	**Year 3**	**Total**
9 – rx5670/Linux	$104,197	$0	$0	$104,197
10 – rx5670/Windows	$101,876	$0	$0	$101,876

Environment 9 – A standard rx5670 1.5 GHz system with one processor and 1 GB of RAM is priced at $32,925. Three additional processors are priced at $8,250 each. Two 8 GB memory "quads" are priced at $14,000 each, a 2 GB quad is priced at $3,000, and a 1 GB quad is priced at $1,200. The SAN adapter is $4,480 for a device that supports Linux. An additional power supply module is $364, and rack mount rails are $134. Finally, a warranty upgrade that includes 3 years of 24x7 on-site support with a 4-hour response time is $9,344.

> $32,925 + 3 * ($8,250) + 2 * ($14,000) + $3,000 + $1,200 + $4,480 + $364 + $134 + $9,344 = $104,197.

Environment 10 – See environment 9. This environment requires the addition of a video and USB package for Windows support for $349, and the replacement of the SAN adapter with a less expensive option that supports only Windows for $1,795.

> $32,925 + 3 * ($8,250) + 2 * ($14,000) + $3,000 + $1,200 + $1,795 + $364 + $134 + $9,344 + $349 = $101,861.

Table 2 – Software Cost Summary				
Environment	**Year 1**	**Year 2**	**Year 3**	**Total**
9 – rx5670/Linux	$3,208	$0	$0	$3,208
10 – rx5670/Windows	$5,998	$0	$0	$5,998

Environment 9 – SuSE is priced at the same numbers in Environment 1 above for Itanium systems.

> $109 + $3,099 = $3,208.

Environment 10 – Windows Server 2003 Enterprise Edition replaces SuSE at $3,999, and also requires the purchase of an external connector license for $1,999.

> $3,999 + $1,999 = $5,998.

Table 3 – Support Cost Summary				
Environment	**Year 1**	**Year 2**	**Year 3**	**Total**
9 – rx5670/Linux	$2,069	$2,069	$2,069	$6,207
10 – rx5670/Windows	$1,700	$1,700	$1,700	$5,100

Environment 9 – Premium support from SuSE is priced the same as in Environment 1.

Environment 10 - Software Assurance is priced at 25% of the product purchase price, and applies both to products and to licenses. A 5-incident support pack is priced at $200.

0.25 * ($3,999 + $1,999) + $200 = $1,700.

Table 4 – Administrative and Ongoing Cost Summary				
Environment	**Admin**	**Security**	**Utility**	**3-yr Total**
9 – rx5670/Linux	$1,295	$867	$2,799	$14,883
10 – rx5670/Windows	$1,677	$2,310	$2,799	$20,358

Table 5 – Administrator Cost Summary (Annual)			
Environment	**Admins**	**Cost**	**Total**
9 – rx5670/Linux	1/75	$97,110	$1,295
10 – rx5670/Windows	1/50	$83,850	$1,677

Table 6 – Security Cost Summary (Annual)				
Environment	**Patches**	**Hrs/Patch**	**Cost/Hr**	**Total**
9 – rx5670/Linux	17	1	$51	$867
10 – rx5670/Windows	30	1.75	$44	$2,310

Table 8 – Utility Cost Summary (Annual)				
Environment	**Electrical**	**Cooling**	**Floor Space**	**Total**
9 – rx5670/Linux	$1,981	$732	$86	$2,799
10 – rx5670/Windows	$1,981	$732	$86	$2,799

Environments 9 and 10 – 7U high, three power supplies, each rated at 930 W.

Table 9 – Environment Totals by Year				
Environment	**Year 1**	**Year 2**	**Year 3**	**Total**
9 – rx5670/Linux	$114,435	$7,030	$7,030	$128,495
10 – rx5670/Windows	$116,360	$8,486	$8,486	$133,332