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MANAGEMENT BRIEF

BUSINESS CASE FOR IBM SYSTEM X, BLADECENTER, AND SYSTEM STORAGE

Comparative Economics for Business Unit Deployments in Large Organizations

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EXECUTIVE SUMMARY

The View from the Middle

At the end of 2002, the typical U.S. Fortune 1000 corporation contained approximately 2,600 x86 servers. By the end of 2007, the number had increased to more than 7,000. Although virtualization tools such as VMware and Xen have begun to slow the rate of growth in numbers of physical servers, use of these is still at an early stage in most organizations.

The challenges created by this situation have become all too familiar. Fragmented server bases expand management overhead, increase pressures on system administration and technical support staff, magnify network complexities, and make it more difficult to maintain availability and security. Power costs as well as demands on data center space and cooling infrastructures continue to escalate.

Large-scale server virtualization may mitigate some of these effects. But users are discovering that reductions in numbers of physical servers are accompanied by new challenges in managing and securing more complex, multi-layer software environments.

Many large organizations are moving aggressively to deal with these issues. New strategies are being adopted, new tools are being deployed, and new skill sets and operating practices are being developed.

But what does the picture look like for organizational units that operate smaller server bases – dozens of platforms, or at most a few hundred? The IT groups of business units, divisions, and equivalents face the same challenges as their corporate-level counterparts – but fewer resources are available to them.

Business unit and equivalent IT staffs are smaller, and skill sets are typically more limited than in corporate-level IT groups. One implication is that the benefits of simplified server administration are greater than in installations with larger, more diverse skill bases.

Another is that business unit and equivalent IT functions are less likely to have high-level storage system and network management capabilities. The challenges – and costs – of managing server and storage resources are more closely interdependent than in large installations with thousands of servers, hundreds of terabytes (TB) of storage, and sophisticated network infrastructures linking these.

This report deals with these issues. Specifically, it examines the economics of employing x86 servers, and low-end and midrange disk system supporting these, from four vendors – Dell, Hewlett-Packard (HP), IBM, and Sun Microsystems. It is based on data supplied by 34 business unit and equivalent users in large companies and government organizations in North America, Europe, and the Asia/Pacific region.

Using this data, nine composite profiles of business unit and equivalent installations with from 8 to 58 physical x86 servers, and 7 TB to 86 TB of disk system capacity supporting these, were constructed. Three-year costs for hardware, software, maintenance, server and storage administration personnel, and facilities (primarily power and cooling) were then calculated for each profile and vendors' systems.

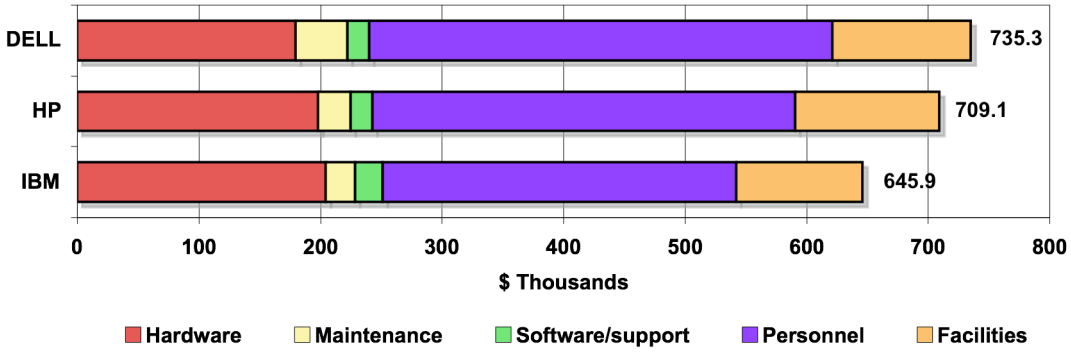
Cost Comparisons

Costs were first compared for six installations employing Dell, HP, and IBM x86 servers and disk systems. Installations included Intel- and Advanced Micro Devices (AMD) Opteron-based blade as well as rack servers running Windows and Linux directly or as VMware guests.

Results for these comparisons may be summarized as follows:

- ***Server costs***. Overall three-year costs, including hardware, maintenance, software, personnel and facilities for use of IBM System x and BladeCenter platforms averaged 12.2 and 8.9 percent less than for use of Dell PowerEdge and HP ProLiant and BladeSystem equivalents respectively. Figure 1 illustrates these results.

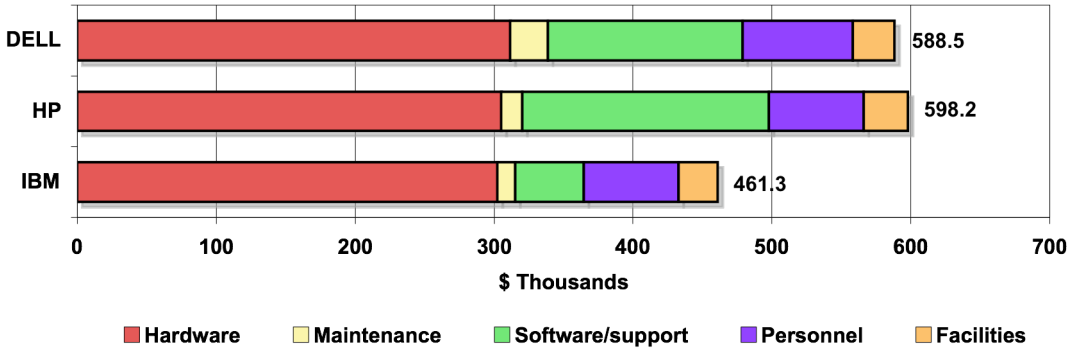
Figure 1
Three-year Costs for Dell, HP, and IBM x86 Servers: Averages for All Installations



Although there were some differences in pricing practices, hardware, maintenance, and software costs for all three vendors' platforms were generally similar. Lower IBM server costs were due primarily to lower system administration personnel and energy costs enabled by distinctive System x BladeCenter hardware and software features.

- ***Disk system costs***. Overall three-year costs, including the same components as for servers, averaged 21.6 percent less for IBM DS3000 and DS4000 systems than for Dell/EMC AX4 and CX3 systems, and 22.9 percent less than for HP Modular Storage Array (MSA) and Enterprise Virtual Array (EVA) systems. Figure 2 illustrates these results.

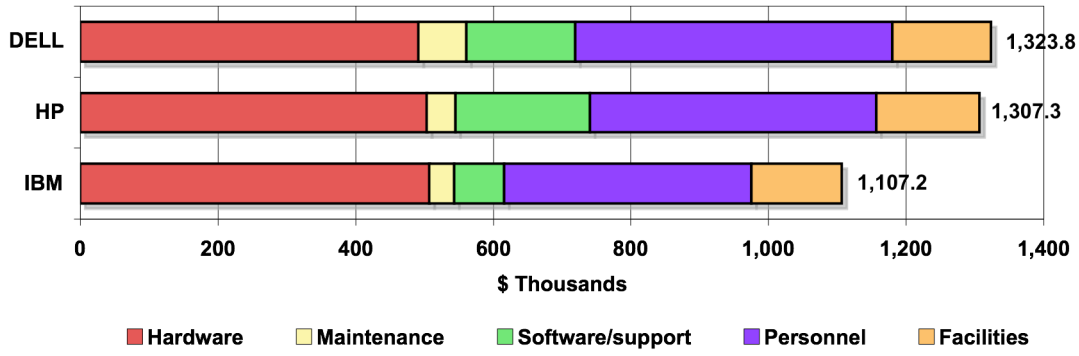
Figure 2
Three-year Costs for Dell, HP, and IBM Disk Systems: Averages for All Installations



Hardware costs for all three vendors' platforms were generally similar. License and support costs for IBM disk systems software, however, were significantly lower than for Dell/EMC and HP equivalents. Average maintenance, personnel and facilities costs for use of IBM disk systems are also lower than for Dell and HP equivalents, although differences were more incremental.

- ***Combined server and disk system costs***. Reflecting the differences described above, combined three-year costs for IBM server and disk system platforms averaged 16.4 and 15.3 percent less than for Dell and HP equivalents respectively. Figure 3 illustrates these results.

Figure 3
Combined Three-year Costs for Dell, HP, and IBM x86 Servers and Disk Systems: Averages for All Installations



A second set of comparisons involves three Linux installations for which the same cost components were calculated for use of IBM System x, BladeCenter, and DS3000 and DS4000 disk systems; and Sun Fire Opteron-based x86 servers and Sun StorageTek 2500 and 6000 disk arrays.

For these comparisons, overall three-year costs for use of IBM servers averaged 17.3 percent less than for Sun equivalents, while disk system costs averaged 18.6 percent less, and combined server and disk system costs averaged 17.9 percent less than for Sun equivalents.

Comparative server costs showed more variation than for the first set of comparisons, with lower hardware, personnel, and facilities costs for IBM platforms, and lower maintenance and software costs for those of Sun. For disk systems, however, IBM costs were lower in all areas. Disparities in disk system software costs were, again, particularly significant.

Conclusions

Certain conclusions may be drawn from these results. One is that business unit and equivalent IT organizations need to pay closer attention to overall cost structures for x86 server installations.

Hardware, maintenance, and software costs for different vendors' servers may be similar, but platform choices also affect personnel and facilities costs. Over-focus on platform choices may cause organizations to neglect larger savings opportunities. As the results presented here indicate, small differences in the capabilities of individual servers may have a major impact on the economics of the installation as whole.

Storage costs in general, and disk system costs in particular, should also receive scrutiny. A low-end storage unit may be inexpensive. But this is not the case for a networked disk system equipped to manage, protect, and ensure availability of business-critical data. Functional requirements and cost structures for such systems are entirely different.

A broader conclusion also emerges. In many organizations, x86 servers and the storage resources that support them are regarded as "commodities." This may have been a reasonable assumption in the past, but it is clearly no longer correct. The technical sophistication of x86 environments, and the value of applications deployed on Intel- and Opteron-based servers have both increased. Expectations for the capabilities of platforms and for the vendors that supply them must also change.

SUMMARY OF RESULTS

Dell, HP, and IBM Comparisons

Server Costs

Comparisons of Dell, HP, and IBM server costs are based on scenarios developed for use of each vendor's platforms in six composite profile installations.

These may be summarized as follows:

- ***Financial services company*** profile is for the regional operations of a major global bank. The organization uses 20 blade servers in two frames for capital markets, trading, and other specialized functions, along with 38 rack servers, including 8-way (for HP and IBM scenarios) models hosting a wide range of business and infrastructure applications. Windows and Linux are employed. There are more than 200 VMware virtual machines.
- ***Manufacturing company*** profile is a local subsidiary of a multinational manufacturing firm. Enterprise resource planning (ERP) and other major business systems run on large rack servers, including 8-way (for HP and IBM scenarios) and 16-way (for IBM scenarios) models. Overall, the organization has 19 rack servers and 23 blade servers. Most applications are Windows server-based. There are more than 100 VMware virtual machines.
- ***Insurance company*** profile is for the server infrastructure supporting a large Microsoft Exchange e-mail network in a major insurance company. The Windows server-based network runs on 14 blade servers configured in a single frame. VMware is not used.
- ***Telecommunications company*** profile is for servers supporting Windows- and Linux-based business and infrastructure applications in a business unit of a major telecommunications company. There are 17 rack servers, including (for HP and IBM scenarios) 8-way models, and more than 100 VMware and Xen virtual machines.
- ***Transportation company*** profile is a regional hub operated by a multinational logistics company. Windows server-based warehousing, shipping, and administrative applications are supported by 10 rack servers. There are more than 50 VMware virtual machines.
- ***Government agency*** profile is for servers supporting Linux-based infrastructure, development, and test applications in a state government agency with approximately 2,000 employees. There are 24 rack servers and more than 60 VMware virtual machines.

Numbers of servers vary slightly between scenarios, as there are differences in the scalability between high-end vendor platforms. Dell does not offer larger than 4-way Intel- or Opteron-based models, while HP offers up to 4-way Intel-based and 8-way Opteron-based, and IBM offers up to 4-way Opteron-based and up to 16-way Intel-based models.

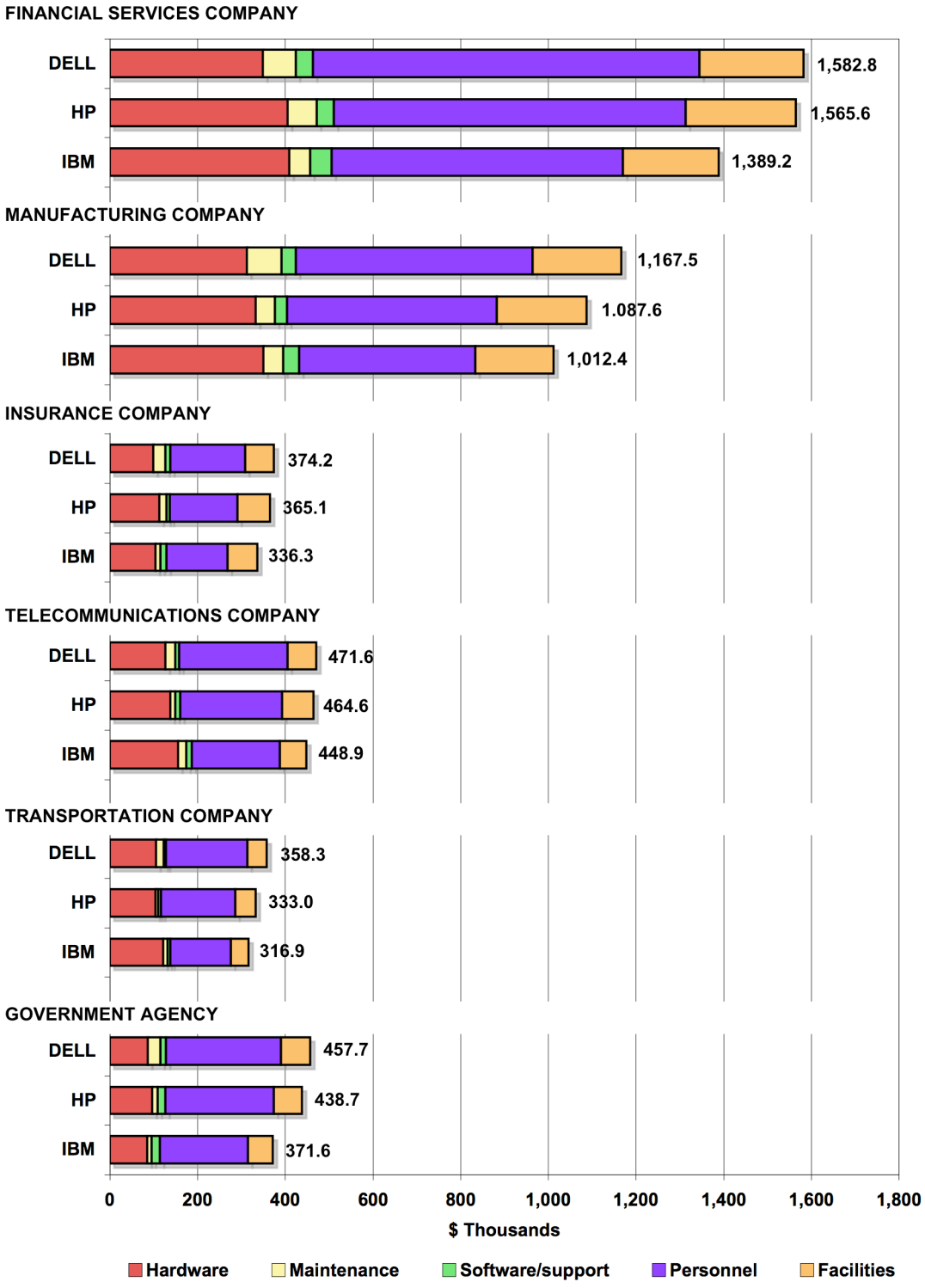
In some cases, it was necessary to configure, for example, two 4-way Dell servers to provide capability equivalent to one 8-way HP or IBM model, or four 4-way Dell and two 8-way HP servers to provide capability equivalent to a single IBM 16-way model. In the descriptions above, numbers of servers given are for Dell scenarios. They are slightly lower for HP and IBM scenarios.

Software costs are license and support fees for Dell OpenManage, Hewlett-Packard Integrated Control Environment (ICE), and IBM Systems Director management toolsets. Costs of operating systems and other software, which would be the same or similar across platforms, are not included.

For these installations, three-year server costs for IBM scenarios averaged 12.2 and 8.9 percent less than for Dell and HP equivalents respectively.

Figure 4 illustrates these results.

Figure 4
Three-year Costs for Dell, HP, and IBM x86 Servers by Installation



Lower overall IBM costs were due to two main factors:

1. ***Personnel costs***. Costs for server administration personnel for IBM scenarios averaged 23.6 percent less than for Dell PowerEdge and 16.3 percent less than for HP equivalents.

   Lower costs for use of IBM platforms were due to lower full time equivalent (FTE) system administrator staffing enabled by IBM Systems Director and embedded management functions; by distinctive reliability, availability, and serviceability (RAS) features in IBM platforms; and by economies resulting from the use of high-end 8- and 16-way IBM System x3950 models.

2. ***Facilities costs***. For IBM scenarios, facilities costs averaged 9.0 and 12.6 percent less than for Dell and HP equivalents respectively. Lower costs for IBM platforms were due to design features resulting in lower power consumption by individual servers and to incremental improvements in utilization enabled by the Active Energy Manager component of IBM Systems Director.

In terms of hardware, maintenance, and software costs, Dell scenarios demonstrated a slight lead. Combined three-year costs for these averaged 1.1 and 4.4 percent less than for use of HP and IBM platforms respectively.

Overall three-year costs for use of HP platforms averaged 3.6 percent less than for Dell, largely because of lower FTE system administrator staffing for servers equipped with ICE compared to Dell OpenManage. Dell facilities costs, however, were marginally lower than for HP. This was primarily due to lower electricity consumption by Dell blade systems.

Although not addressed in this report, another cost differentiator may be significant for many users. IBM x3850 and x3950 servers, which are equipped with the company's X Architecture technology, benefit from embedded features that, for certain applications, enable them to achieve higher levels of performance than comparably-sized Dell and HP platforms.

As a result, fewer processors may be required to handle workloads than would be the case for Dell or HP equivalents. This may translate into savings in databases, middleware, and other software priced on a per processor basis.

Among user organizations that contributed to the composite profiles, large System x n-way models were also seen as enabling higher levels of VMware server consolidation than could be realized with smaller machines. One organization had deployed more than 50 VMware virtual machines on a single 8-way x3950 server, and another had deployed more than 60 on a comparable platform.

Disk System Costs

The disk system components of the same profile installations may be summarized as follows:

- ***Financial services company*** employs 68.4 TB of Fibre Channel (FC) and 18 TB of higher-capacity, lower-performance Serial ATA (SATA) disk capacity on four disk systems. Business-critical data is mirrored to a second site for disaster recovery purposes.

  Vendor scenarios are built around Dell/EMC CX3-40 and CX3-20; HP EVA8100, 6100, and 4400; and IBM DS4800, DS4700, and DS4200 systems.

- ***Manufacturing company*** employs dual systems with a combined FC disk capacity of 50.4 TB. Critical data is again mirrored for disaster recovery. Vendor scenarios are built around Dell/EMC CX3-40 and CX3-20; HP EVA8100 and 4400; and IBM DS4800 and DS4700 systems.

- ***Insurance company*** employs a single mirrored Dell/EMC CX3-20, HP EVA6100, or IBM DS4700 disk system with 26.4 TB of FC capacity.

- ***Telecommunications company*** employs dual mirrored disk systems with a combined FC disk capacity of 31.2 TB. Vendor scenarios are built around Dell/EMC CX3-20, HP EVA4400, and IBM DS4700 systems.

- ***Transportation company*** employs two low-end systems with 9.6 TB of Serial Attached SCSI (SAS) and 9 TB of SATA disk capacity. Vendor scenarios are built around Dell/EMC CX3-10 and AX4, HP MSA2212, and IBM DS3400 systems.

- ***Government agency*** employs a single low-end Dell/EMC AX4, HP MSA2212, or IBM DS3400 with 7 TB of SAS disk capacity.

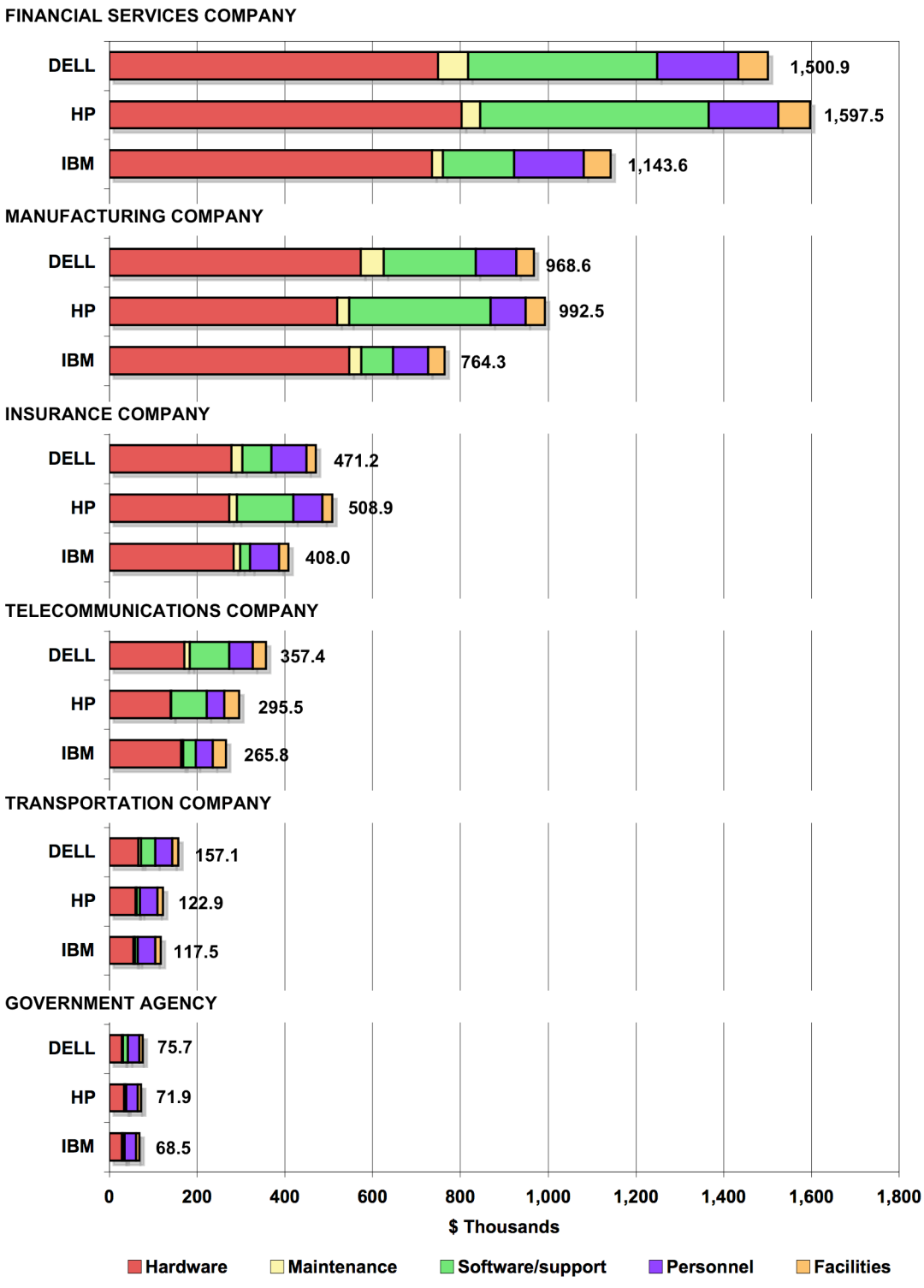
For these installations, three-year costs for IBM scenarios averaged 21.6 and 22.9 percent less than for Dell and HP equivalents respectively. Figure 5 illustrates these results.

Disk systems software included functionally equivalent Dell/EMC, HP, and IBM tools for management, internal and/or remote copying, and host access. Software configurations varied between profiles.

Lower IBM software costs were due to a multiple factors: IBM bundles key management functions into its operating systems, while Dell and HP charge separately for these; IBM pricing is more aggressive; and the company offers a three-year warranty for its offerings. In comparison, Dell and HP offer 90-day software warranties, and costs of support subscriptions over a three-year period are substantial.

Figure 5

Three-year Costs for Dell, HP, and IBM Disk Systems by Installation



Hardware costs for Dell, HP, and IBM platforms were generally similar, but disparities in software costs were significantly larger. Three-year license and support costs for IBM disk systems software averaged 64.8 and 72.1 percent less than for Dell and HP scenarios respectively.

Relative Costs

The significance of disk system relative to server costs in the installation profiles was striking. As figure 6 illustrates, in most installations disk system costs represented 35 to 60 percent of combined totals, and overall averages were in the 40 to 50 percent range.

Figure 6

Dell, HP, and IBM Comparisons: Disk Systems as Percentage of Combined Costs

	DELL	HP	IBM
Financial Services Company	48.7%	50.5%	45.2%
Manufacturing Company	45.3%	47.7%	43.0%
Insurance Company	55.7%	58.2%	54.8%
Telecommunications Company	43.1%	38.9%	37.2%
Transportation Company	30.5%	27.0%	27.0%
Government Agency	14.2%	14.1%	15.6%
OVERALL AVERAGE	**44.5%**	**45.8%**	**41.7%**

Disk system costs were particularly elevated in larger installations with duplexed midrange platforms equipped with real-time replication software for disaster recovery purposes. The comparatively low percentages for the government agency reflect the fact that this organization employed a single low-end platform with no provision for failover – it would have been necessary to recover data from tape in the event the system was disabled.

IBM and Sun Comparisons

These comparisons involve three installations for which scenarios were developed for the same IBM platforms – IBM System x, BladeCenter, and DS3000 and DS4000 disk systems; and for Sun Fire x86 servers and Sun StorageTek 2500 and 6000 disk arrays. All servers run Linux operating systems.

Profile installations may be summarized as follows:

- ***Technology company*** profile is a regional manufacturing and logistics complex operated by a global electronics company. ERP, customer relationship management (CRM), and other business systems, along with office and infrastructure applications, are deployed on 16 one- to four-way rack servers. There are more than 40 VMware virtual machines.

  The organization employs dual IBM DS4800 or Sun 6540 midrange systems with a combined FC disk capacity of 52.8 TB. Systems are mirrored for disaster recovery purposes.

- ***Financial services company*** profile is for the local operations of a multinational investment bank. The organization uses 20 blade servers in two frames for securities trading and other functions, including VMware instances. In addition, 15 rack servers support other business and infrastructure applications. There are more than 60 VMware virtual machines.

  The organization employs dual IBM DS4700 or Sun 6140 midrange systems with a combined FC disk capacity of 33.6 TB. Systems are again mirrored for disaster recovery purposes.

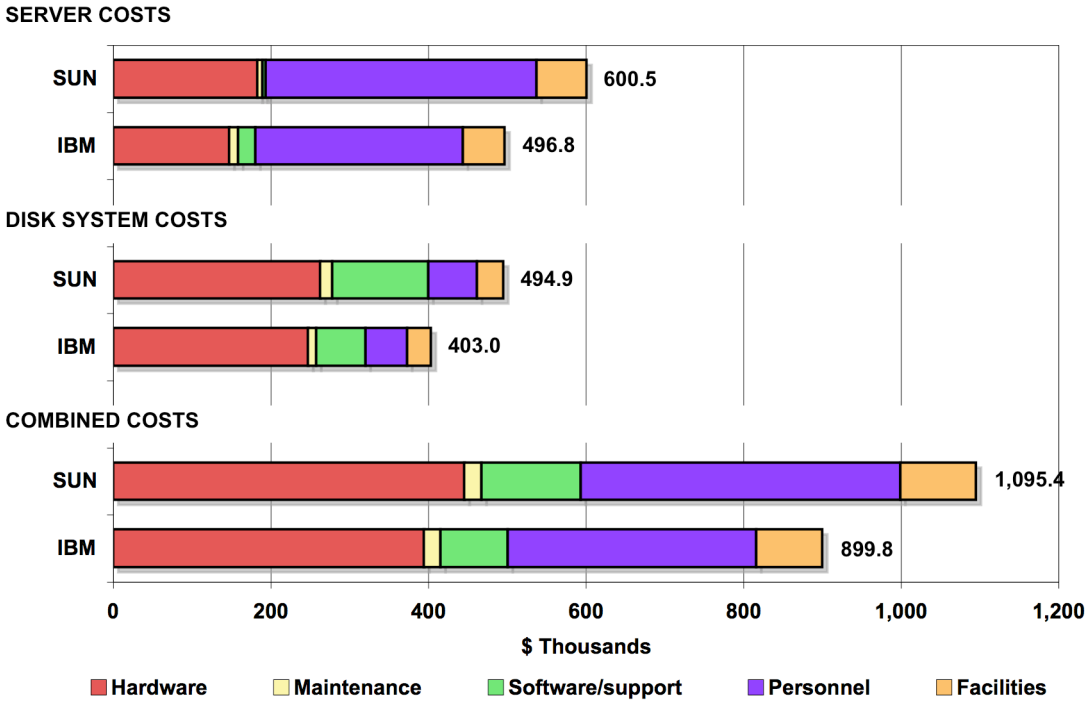
- ***Energy company*** profile is of servers supporting marketing, sales, and customer service functions within a major independent oil and gas company. There are 21 rack servers and more than 20 VMware virtual machines supporting a mix of business and infrastructure applications. A low-end IBM DS3400 or Sun 2540 system with 10.8 TB of SAS disk capacity is also installed.

For these comparisons, overall three-year costs for IBM servers averaged 17.3 percent less than for Sun equivalents. Three-year disk system costs averaged 18.6 percent less, and combined server and disk system costs averaged 17.9 percent less than for Sun equivalents. Figure 7 illustrates these results.

Comparative server costs showed more variation than for the first set of comparisons, with lower hardware, personnel, and facilities costs for IBM platforms, and lower maintenance and software costs for those of Sun. For disk systems, however, IBM costs were lower in all areas. As for Dell, HP, and IBM comparisons, disparities in disk system software costs were particularly significant.

Profile installations were constructed based on input from organizations that had migrated some or all of their applications from Solaris to Linux, and results reflect cost structures that might be experienced after such migrations. The x86 version of Solaris, however, is equally supported on IBM System x and BladeCenter platforms.

Figure 7
Three-year Costs for IBM and Sun x86 Server and Disk Systems: Averages for All Installations



Disk system relative to server costs followed the same general pattern as for Dell, HP, and IBM comparisons. For the technology company profile, disk systems costs represented 64.0 and 64.8 percent of combined totals for IBM and Sun scenarios respectively, and the comparable ratios for the financial services and energy companies were 33.4 and 33.1 percent, and 22.6 and 24.4 percent. Overall averages were 44.8 and 45.2 percent for IBM and Sun scenarios respectively.

Disk system costs were particularly elevated for the technology company profile, where comparatively large duplexed systems were equipped for real-time replication and failover. As for Dell, HP, and IBM comparisons, the lowest percentages – in this case, for the energy company profile – were where a single low-end system was employed.

DETAILED DATA

Dell, HP, and IBM Comparisons

Profile Installations

Profile installations for Dell, HP, and IBM cost comparisons are summarized in figure 8.

In this presentation, numbers of processors and cores are shown for each server or group of servers – e.g., "4/16 x Xeon 2.4 GHz" refers to a configuration with four quad-core Xeon 2.4 GHz processors for a total of 16 cores, while 2/4 x AMD 2.6 GHz refers to a configuration with two AMD Opteron 2.6 GHz dual-core processors for a total of 4 cores. All servers are rack-mounted or blade models.

Profiles were constructed using data on applications, x86 server and disk system bases, use of server virtualization tools, system administration staffing, and other variables supplied by 23 units in large organizations in the same industries and approximate size ranges.

Units that contributed data primarily employed Dell PowerEdge, HP and/or Compaq ProLiant, and IBM System x and xSeries servers, or combinations of these running Windows and/or Linux operating systems, along with entry-level or midrange disk arrays from these vendors.

In constructing profiles, a "best practices" approach was adopted; e.g., the experiences of one commercial bank unit with blade-based trading systems were combined with those of another with VMware server consolidation, and a third with remote replication of disk systems for failover purposes. Other profiles were constructed in a similar manner.

In most cases, units employed a mix of servers and disk systems of varying ages, including older technology hardware and software.

Where this was the case, server bases were translated to current technology models based on functional descriptions (e.g., 1U dual-processor Xeon servers, dual-processor Opteron blades), standard configuration assumptions (e.g., 1 GB, 2 GB or 4 GB per processor core, depending on processor types and applications), relative processing power (e.g., a 4-way server equipped with old technology processors might be translated into a 2-way model with current technology quad-core processors), application and workload requirements, and other variables.

Disk systems were translated into functionally equivalent current technology models of Dell AX4 and CX3, HP MSA and EVA, and IBM DS3000 and DS4000 systems based on installed capacity in gigabytes or terabytes, and application and workload requirements.

For servers and disk systems, industry configuration norms were also used to size configurations for major applications such as Microsoft Exchange and Lotus Domino, ERP and CRM systems, and (for the financial services profile), trading and market data tools.

Servers and disk capacity supporting VMware and (in the case of the financial services and telecommunications company profiles) Xen VMs were sized based on user-supplied data. Organizations often did not supply detailed configuration data – one reported, for example, that it had deployed more than 50 VMs on a single 8-way server, another cited around 40 VMs on three 2-way servers, and others supplied similar input. Numbers of virtual machines indicated in profiles are thus approximate.

In some cases, server configurations were updated to allow for the use of current-technology hardware; e.g., a unit which had deployed 25 VMs on two early Xeon-based 4-way servers was assumed to have consolidated these onto a single Xeon quad core-based 4-way server.

Figure 8

Profile Installations for Dell, HP, and IBM Cost Comparisons

FINANCIAL SERVICES COMPANY		
BUSINESS PROFILE		
Regional operations of major global bank	5,000+ employees	Headquarters + 12 offices
APPLICATIONS & PLATFORMS		
Blade servers Capital markets, currency trading & payments applications **Business applications** Financial reporting, SQL Server Oracle databases, data warehouses & data marts, EPM. Microsoft Exchange, project management, customer service/contact center, sales automation, forms & workflow, document management & digitization	**Infrastructure** Access control, antivirus, Blackberry, Citrix, directory services, domain controllers, file & print servers, firewalls, FTP servers, gateways, IIS, intrusion prevention, service management, gateways, system management, VirtualCenter, Web caching **Development, test & staging, sandboxes, user acceptance & training instances**	**Windows Server 2003 & Linux operating systems** **200+ VMware & Xen virtual machines**
SERVERS		
Dell	**Hewlett-Packard**	**IBM**
PowerEdge M1000e 12 x M605 2/4 x AMD 2.6 GHz/16 GB	BladeSystem c3000 12 x BL465c 2/4 x AMD 2.6 GHz/16 GB	BladeCenter H 12 x LS21 2/4 x AMD 2.6 GHz/16 GB
PowerEdge M1000e (failover) 8 x M605 2/4 x AMD 2.6 GHz/16 GB	BladeSystem c3000 (failover) 8 x BL465c 2/4 x AMD 2.6 GHz/16 GB	BladeCenter H (failover) 8 x LS21 2/4 x AMD 2.6 GHz/16 GB
4 x R900 4/16 x Xeon 2.4 GHz/32 GB 2 x R900 4/16 x Xeon 2.93 GHz/64 GB 2 x R900 4/16 x Xeon 2.4 GHz/64 GB 3 x R900 4/16 x Xeon 2.13 GHz/64 GB	2 x DL785 8/32 x AMD 2.3 GHz/64 GB 1 x DL785 8/32 x AMD 2.3 GHz/128 GB 2 x DL580 4/16 x Xeon 2.4 GHz/64 GB 3 x DL580 4/16 x Xeon 2.13 GHz/64 GB	2 x x3950 8/32 x Xeon 2.4 GHz/64 GB 1 x x3950 8/32 x Xeon 2.4 GHz/128 GB 2 x x3850 4/16 x Xeon 2.4 GHz/64 GB 3 x x3850 4/16 x Xeon 2.13 GHz/64 GB
3 x 2950 III 2/8 x Xeon 3.16 GHz/32 GB 1 x 2950 III 2/8 x Xeon 2.83 GHz/32 GB 8 x 1950 III 2/8 x Xeon 2.5 GHz/16 GB 2 x 1950 III 2/8 x Xeon 2.0 GHz/24 GB 2 x 1950 III 2/8 x Xeon 2.0 GHz/16 GB	3 x DL380 2/8 x Xeon 3.16 GHz/32 GB 1 x DL380 2/8 x Xeon 2.83 GHz/32 GB 8 x DL360 2/8 x Xeon 2.5 GHz/16 GB 2 x DL360 2/8 x Xeon 1.6 GHz/24 GB 2 x DL360 2/8 x Xeon 1.6 GHz/16 GB	3 x x3650 2/8 x Xeon 3.16 GHz/32 GB 1 x x3650 2/8 x Xeon 2.83 GHz/32 GB 8 x x3550 2/8 x Xeon 2.5 GHz/16 GB 2 x x3550 2/8 x Xeon 1.6 GHz/24 GB 2 x x3550 2/8 x Xeon 1.6 GHz/16 GB
3 x R200 1/4 x Xeon 2.4 GHz/4 GB 1 x R200 1/4 x Xeon 2.13 GHz/8 GB 2 x R200 1/4 x Xeon 2.13 GHz/4 GB	3 x DL320 1/4 x Xeon 2.4 GHz/4 GB 1 x DL320 1/4 x Xeon 2.13 GHz/8 GB 2 x DL320 1/4 x Xeon 2.13 GHz/4 GB	3 x x3250 1/4 x Xeon 2.4 GHz/4 GB 1 x x3250 1/4 x Xeon 2.13 GHz/8 GB 2 x x3250 1/4 x Xeon 2.13 GHz/4 GB
5 x R200 1/1 x Celeron 1.8 GHz/1 GB	5 x DL320 1/1 x Celeron 2.0 GHz/1 GB	5 x x3250 M2 1/1 x Celeron 2.0 GHz/1 GB
Total: 58 servers	Total: 55 servers	Total: 55 servers
OpenManage	Insight Control Environment	IBM Systems Director
DISK SYSTEMS		
CX3-40 (mirrored) 28.8 TB FC	EVA8100 (mirrored) 28.8 TB FC	DS4800 (mirrored) 28.8 TB FC
CX3-20 (mirrored) 15.6 TB FC	EVA4400 (mirrored) 15.6 TB FC	DS4700 (mirrored) 15.6 TB
CX3-20 (failover) 24.0 TB FC	EVA6100 (failover) 24.0 TB FC	DS4700 (failover) 24.0 TB FC
CX3 - 20 18 TB SATA	EVA4400 18 TB SATA	DS4200 18 TB SATA
Total: 86.4 TB	Total: 86.4 TB	Total: 86.4 TB
NaviSphere Manager, PowerPath, SnapView, SAN Copy, MirrorView	CommandView, SecurePath, Business Copy, Continuous Access	DS4000 Storage Manager, Host Kits, FlashCopy, VolumeCopy, Enhanced Remote Mirroring

MANUFACTURING COMPANY		
BUSINESS PROFILE		
Packaging subsidiary of multinational manufacturing company	$600 million sales 3,000+ employees	Three local manufacturing plants + distribution center
APPLICATIONS & PLATFORMS		
Business applications ERP, CRM, supply chain planning, transportation management, data warehouse, enterprise reporting, Lotus Domino, EDI, e-procurement, handheld computer applications, SQL Server & MySQL databases	**Infrastructure** Antivirus, Apache, domain controllers, file & print servers, fax servers, firewalls, Microsoft Terminal Server, software updates, system management, VirtualCenter, WebSphere, various **Development, test & training instances**	**Windows Server 2003 & Linux operating systems** **100+ VMware virtual machines**
SERVERS		
Dell	**Hewlett-Packard**	**IBM**
PowerEdge M1000e 2 x M600 2/8 x Xeon 3.0 GHz/32 GB 3 x M600 2/8 x Xeon 2.5 GHz/32 GB 8 x M600 2/8 x Xeon 1.6 GHz/16 GB	BladeSystem c7000 2 x BL460c 2/8 x Xeon 3.0 GHz/32 GB 3 x BL460c 2/8 x Xeon 2.5 GHz/32 GB 8 x BL460c 2/8 x Xeon 1.6 GHz/16 GB	BladeCenter H 2 x HS21 2/8 x Xeon 3.0 GHz/32 GB 3 x HS21 2/8 x Xeon 2.5 GHz/32 GB 8 x HS21 2/8 x Xeon 1.6 GHz/16 GB
PowerEdge M1000e (second site) 3 x M600 2/8 x Xeon 2.66 GHz/32 GB 3 x M600 2/8 x Xeon 2.0 GHz/16 GB	BladeSystem c3000 (second site) 3 x BL460c 2/8 x Xeon 2.66 GHz/32 GB 3 x BL460c 2/8 x Xeon 2.0 GHz/16 GB	BladeCenter S (second site) 3 x HS21 2/8 x Xeon 2.66 GHz/32 GB 3 x HS21 2/8 x Xeon 2.0 GHz/16 GB
4 x R900 4/16 x Xeon 2.4 GHz/32 GB 2 x R900 4/16 x Xeon 2.13 GHz/64 GB 2 x R900 4/16 x Xeon 1.6 GHz/32 GB 2 x R905 4/16 x AMD 2.2 GHz/64 GB	2 x DL745 8/32 x AMD 2.3 GHz/64 GB 1 x DL745 8/32 x AMD 2.2 GHz/128 GB 2 x DL580 4/16 x Xeon 1.6 GHz/32 GB 2 x DL585 4/16 x AMD 2.2 GHz/64 GB	1 x x3950 16/64 x Xeon 2.4 GHz/128 GB 1 x x3950 8/32 x 1.6 GHz/128 GB 2 x x3850 4/16 x 2.13 GHz/64 GB 2 x x3755 4/16 x AMD 2.2 Ghz/64 GB
2 x 2950 III 2/8 x Xeon 3.0 GHz/32 GB 1 x 2950 III 2/8 x Xeon 2.0 GHz/24 GB 2 x 2950 III 2/8 x Xeon 2.83 GHz/32 GB 4 x 1950 III 2/8 x Xeon 1.86 GHz/16 GB 3 x 1950 III 2/4 x Xeon 2.33 GHz/8 GB 1 x R300 1/4 x Xeon 2.33 GHz/4 GB Total: 42 servers OpenManage	2 x DL380 2/8 x Xeon 3.0 GHz/32 GB 1 x DL380 2/8 x Xeon 2.0 GHz/24 GB 2 x DL380 2/8 x Xeon 3.0 GHz/32 GB 4 x DL360 2/8 x Xeon 1.6 GHz/16 GB 3 x DL360 2/4 x Xeon 2.33 GHz/8 GB 1 x DL320 1/4 x Xeon 2.33 GHz/4 GB Total: 39 servers Insight Control Environment	2 x x3650 2/8 x Xeon 3.0 GHz/32 GB 1 x x3650 2/8 x Xeon 2.0 GHz/24 GB 2 x x3650 2/8 x Xeon 2.83 GHz/32 GB 4 x x3550 2/8 x Xeon 1.6 GHz/16 GB 3 x x3550 2/4 x Xeon 2.33 GHz/8 GB 1 x x3350 1/4 x Xeon 2.33 GHz/4 GB Total: 38 servers IBM Systems Director
DISK SYSTEMS		
CX3-40 36.0 TB FC CX3-20 (failover) 14.4 TB FC Total: 50.4 TB NaviSphere Manager, PowerPath, SnapView, SAN Copy, MirrorView	EVA8100 36.0 TB FC EVA4400 (failover) 14.4 TB FC Total: 50.4 TB CommandView, SecurePath, Business Copy, Continuous Access	DS4800 36.0 TB FC DS4700 (failover) 14.4 TB FC Total: 50.4 TB DS4000 Storage Manager, Host Kits, FlashCopy, VolumeCopy, Enhanced Remote Mirroring

INSURANCE COMPANY (EXCHANGE INFRASTRUCTURE)		
BUSINESS PROFILE		
Diversified insurance company	c. 25,000 employees $100+ billion assets	Property & casualty, life insurance, & wealth management services
APPLICATIONS & PLATFORMS		
Microsoft Exchange infrastructure for 20,000+ users	Production systems	**Windows Server 2003**
SERVERS		
Dell	**Hewlett-Packard**	**IBM**
PowerEdge M1000e 6 x M600 2/8 x Xeon 2.83 GHz/32 GB 4 x M600 1/4 x Xeon 2.66 GHz/16 GB 4 x M600 1/4 x Xeon 2.0 GHz/16 GB Total: 14 servers OpenManage	BladeSystem c7000 6 x BL460c 2/8 x Xeon 2.83 GHz/32 GB 4 x BL460c 1/4 x Xeon 2.66 GHz/16 GB 4 x BL460c 1/4 x Xeon 2.0 GHz/16 GB Total: 14 servers Insight Control Environment	BladeCenter H 6 x HS21 2/8 x Xeon 2.83 GHz/32 GB 4 x HS21 1/4 x Xeon 2.66 GHz/16 GB 4 x HS21 1/4 x Xeon 2.0 GHz/16 GB Total: 14 servers IBM Systems Director
DISK SYSTEMS		
CX3-20 26.4 TB FC Total: 26.4 TB NaviSphere Manager, PowerPath, SnapView, SAN Copy, MirrorView	EVA6100 26.4 TB FC Total: 26.4 TB CommandView, SecurePath, Business Copy, Continuous Access	DS4700 26.4 TB FC Total: 26.4 TB DS4000 Storage Manager, Host Kits, FlashCopy, VolumeCopy, Enhanced Remote Mirroring

TELECOMMUNICATIONS COMPANY		
BUSINESS PROFILE		
Business unit of major telecommunications company	1,000+ employees Three principal facilities	Business communications services
APPLICATIONS & PLATFORMS		
Business applications Customer service/contact center, sales automation, business intelligence, customer e-mail, facilities management, professional engineering applications, Oracle & SQL Server databases	**Infrastructure** Citrix, file & print serving, IIS, internal e-mail, domain controllers, firewalls, intranet servers, security applications, system & network management, VirtualCenter, wireless infrastructure **Development, test & training instances**	**Windows Server 2003 & Linux operating systems** **100+ VMware & Xen virtual machines**
SERVERS		
Dell	**Hewlett-Packard**	**IBM**
3 x R900 4/16 x Xeon 2.93 GHz/64 GB 2 x R900 4/16 x Xeon 2.4 GHz/64 GB 4 x 2950 III 2/8 x Xeon 2.5 GHz/32 GB 3 x 1950 III 2/8 x Xeon 2.0 GHz/16 GB 5 x R200 1/4 x Xeon 2.4 GHz/8 GB Total: 17 servers OpenManage	2 x DL745 8/32 x AMD 2.3 GHz/128 GB 1 x DL580 4/16 x Xeon 2.93 Ghz/64 GB 4 x DL380 2/8 x Xeon 2.5 GHz/32 GB 3 x DL360 2/8 x Xeon 2.0 GHz/16 GB 5 x DL320 1/4 x Xeon 2.5 GHz/8 GB Total: 15 servers Insight Control Environment	2 x x3950 8/32 x Xeon 2.4 GHz/128 GB 1 x x3850 4/16 x Xeon 2.93 GHz/64 GB 4 x x3650 2/8 x Xeon 2.5 GHz/32 GB 3 x x3550 2/8 x Xeon 2.0 GHz/16 GB 5 x x3250 1/4 x Xeon 2.5 GHz/8 GB Total: 15 servers IBM Systems Director
DISK SYSTEMS		
CX3-20 (mirrored) 16.8 TB FC CX3-20 (failover) 14.4 TB FC Total: 31.2 TB NaviSphere Manager, PowerPath, SnapView, SAN Copy, MirrorView	EVA4400 (mirrored) 16.8 TB FC EVA4400 (failover) 14.4 TB FC Total: 31.2 TB CommandView, SecurePath, Business Copy, Continuous Access	DS4700 (mirrored) 16.8 TB FC DS4700 (failover) 14.4 TB FC Total: 31.2 TB DS4000 Storage Manager, Host Kits, FlashCopy, VolumeCopy, Enhanced Remote Mirroring

TRANSPORTATION COMPANY		
BUSINESS PROFILE		
Regional hub of multinational logistics management company	700+ employees Single main facilities complex	Warehousing, shipping & administrative operations
APPLICATIONS & PLATFORMS		
Business applications Logistics management system, customer portal, office applications, facilities management, SQL Server databases	**Infrastructure** Active Directory, Apache, Citrix, domain controllers, file & print serving, firewalls, Lotus Domino, software updates, system management, VirtualCenter, **Development, test & training instances**	**Windows Server 2003** **50+ VMware virtual machines**
SERVERS		
Dell 2 x R905 4/16 x AMD 2.3 GHz/64 GB 2 x R900 4/16 x Xeon 2.93 GHz/64 GB 1 x R805 2/8 x AMD 2.2GHz/32 GB 2 x 1950 III 2/8 x Xeon 3.0 GHz/32 GB 3 x 1950 III 2/8 x Xeon 2.0 GHz/16 GB Total: 10 servers OpenManage	**Hewlett-Packard** 1 x DL785 8/32 x AMD 2.3 GHz/128 GB 2 x DL580 4/16 x Xeon 2.93 GHz/64 GB 2 x DL360 2/8 x Xeon 3.0 GHz/32 GB 3 x DL360 2/8 x Xeon 2.0 GHz/16 GB Total: 8 servers Insight Control Environment	**IBM** 1 x x3950 8/32 x Xeon 2.4 GHz/128 GB 2 x x3850 4/16 x Xeon 2.93 GHz/64 GB 2 x x3650 2/8 x Xeon 3.0 GHz/32 GB 3 x x3550 2/8 x Xeon 2.0 GHz/16 GB Total: 8 servers IBM Systems Director
DISK SYSTEMS		
CX3-10 9.6 TB SAS AX4-5F 9.0 TB SATA Total: 18.6 TB NaviSphere Manager, PowerPath, SnapView, SAN Copy	MSA2212fc 9.6 TB SAS MSA2212fc 9.0 TB SATA Total: 18.6 TB Snapshot, Volume Copy	DS3400 9.6 TB SAS DS3400 9.0 TB SATA Total: 18.6 TB FlashCopy, VolumeCopy

GOVERNMENT AGENCY		
BUSINESS PROFILE		
State government agency	2,000+ employees at 70+ offices	Infrastructure, development & support applications
APPLICATIONS & PLATFORMS		
Business applications Development, test & training instances (VMware)	**Infrastructure** Antivirus, Apache, Citrix, firewalls, domain controllers, FTP servers, intrusion detection, ISA, IT reporting, Sendmail, SMTP gateways, Squid, system management, various	**Linux operating systems** **c. 60 VMware virtual machines**
SERVERS		
Dell 2 x 2950 III 2/8 x Xeon 3.0 GHz/32 GB 2 x 2950 III 2/8 x Xeon 2.5 GHz/24 GB 6 x 2950 III 2/8 x Xeon 2.5 GHz/16 GB 2 x 1950 III 2/8 x Xeon 2.5 GHz/16 GB 7 x 1950 III 2/8 x Xeon 2.0 GHz/16 GB 2 x R200 1/4 x Xeon 2.13 GHz/4 GB 3 x R200 1/2 x Core Duo 2.4 GHz/2 GB Total: 24 servers OpenManage	**Hewlett-Packard** 2 x DL380 2/8 x Xeon 3.0 GHz/32 GB 2 x DL360 2/8 x Xeon 2.5 GHz/24 GB 6 x DL380 2/8 x Xeon 2.5 GHz/16 GB 2 x DL360 2/8 x Xeon 2.5 GHz/16 GB 7 x DL360 2/8 x Xeon 1.6 GHz/16 GB 2 x DL160 1/4 x Xeon 2.0 GHz/4 GB 3 x DL140 1/2 x Xeon 2.33 GHz/2 GB Total: 24 servers Insight Control Environment	**IBM** 2 x x3650 2/8 x Xeon 3.0 GHz/32 GB 2 x x3650 2/8 x Xeon 2.5 GHz/24 GB 6 x x3650 2/8 x Xeon 2.5 GHz/16 GB 2 x x3550 2/8 x Xeon 2.5 GHz/16 GB 7 x x3550 2/8 x Xeon 1.6 GHz/16 GB 2 x x3250 1/4 x Xeon 2.0 GHz/4 GB 3 x x3250 M21/2 x Core Duo 2.4 GHz/2 GB Total: 24 servers IBM Systems Director
DISK SYSTEMS		
AX4-5F 7.0 TB SAS Total: 7.0 TB PowerPath, SnapView, SAN Copy	MSA2212fc 7.0 TB SAS Total: 7.0 TB Snapshot, Volume Copy	DS3400 7.0 TB SAS Total: 7.0 TB FlashCopy, VolumeCopy

Server Configurations

Server configurations were, as a general principle, equipped with current technology quad-core Xeon processors. Exceptions were as follows:

- ***Low-end applications***. For some low-end applications, server models incorporated inexpensive Intel Celeron, Core Duo, or dual-core Xeon processors. Quad core Xeon-based servers, however, were included where these were offered at approximately the same price as, or at a lower price than models based on less powerful processors.
- ***Opteron-based blade servers***. For the financial services company profile, comparisons were based on Dell M1000e, HP c3000, and IBM BladeCenter H frames equipped with dual core Opteron processors. Organizational units that supplied data for this profile employed such configurations for specific securities and currency trading applications.
- ***Opteron-based rack servers***. Four-way rack servers equipped with quad core Opteron processors were employed in Dell, HP, and IBM scenarios respectively for a compute-intensive supply chain planning application in the manufacturing company profile.

  For profiles where IBM scenarios included 8- and 16-processor x3950 models equipped with Xeon quad core technology, HP equivalents were 8-processor DL785 models equipped with Opteron quad-core technology. This was the case for the financial services, manufacturing, telecommunications, and transportation company profiles.

  As HP did not offer Xeon-based eight-processor or larger servers when the report was prepared, the DL785 represented the nearest HP equivalent to the x3950 platform. Multiple 8-way DL785s provided similar capability to the 16-way x3950 model in the IBM scenario for the manufacturing company profile.

  As the company did not offer 8-way or larger servers incorporating Xeon or Opteron technology when the report was prepared, multiple 4-way R900 (quad core Xeon-based) or R905 (quad core Opteron-based) were employed in scenarios for the same profiles to provide similar capability to 8- and 16-way x3950s and 8-way DL785s.

  In the transportation company profile, spreading a key business application across multiple physical servers required use of an additional Dell 2-way Opteron-based R805 server.

Dell, HP, or IBM servers, wherever possible, were configured with the same components and technologies; e.g., 16 GB of main memory was implemented as 8 x 2 GB dual in-line memory modules (DIMMs) for comparable PowerEdge, ProLiant, and System x servers. This was also the case for disk drives, interface cards, power supplies, and other server components, as well as for blade switches. Where vendors offered dissimilar options, the least expensive functional equivalent was employed.

Servers were sized to run Windows Server 2003, Red Hat Enterprise Linux 5, or SUSE Linux Enterprise Server 10, along with VMware Infrastructure 3, and Microsoft and third-party clustered failover solutions where appropriate. Because there was little user production experience with Windows Server 2008 when this report was prepared, it was decided not to size configurations for this operating system.

All Dell, HP, and IBM servers are equipped with OpenManage, HP ICE, and IBM Systems Director toolsets respectively, including system administration, virtual machine management, and power management modules of these.

Disk System Configurations

Configurations for all disk systems include dual controllers, RAID 5 technology, and 4 Gbps Fibre Channel (FC) SAN interfaces.

Dell CX3, HP EVA, and IBM DS4000 systems incorporate 300 GB 4Gbps FC drives operating at 15,000 revolutions per minute (15K rpm) or, for the financial services and transportation company profiles, 1 TB SATA drives; while configurations for Dell AX4, HP MSA2212, and IBM DS3400 systems incorporate 300 GB or 1 TB Serial Attached SCSI (SAS) drives operating at 15K rpm.

Systems software for disk systems consists of the vendor offerings shown in figure 9.

Figure 9
Disk Systems Software for Dell, HP, and IBM Cost Comparisons

	DELL	HP	IBM
System Management	NaviSphere Manager	CommandView	DS4000 Storage Manager, DS3000 Storage Manager
Internal Copy	SnapView, SAN Copy	Business Copy, Volume Copy	FlashCopy, VolumeCopy
Remote Copy	MirrorView	Continuous Access	Enhanced Remote Mirroring*
Host Access	PowerPath	SecurePath	Windows/Linux Host Kits

*Includes Metro Mirror, Global Mirror & Global Copy

As for servers, disk systems were wherever possible configured with the same hardware and software components and technologies. Where vendors offered dissimilar options, the least expensive functional equivalent was again employed.

All references to disk system size are for "raw" physical capacity.

IBM and Sun Comparisons

Profile Installations

Profile installations for IBM and Sun cost comparisons are summarized in figure 10.

Numbers of processors and cores are again shown for each server or group of servers – e.g., "4/16 x AMD 2.3 GHz" refers to a configuration with four quad-core Opteron 2.4 GHz processors for a total of 16 cores, while "2/8 x Xeon 2.5 GHz" refers to a configuration with two quad-core Xeon 2.5 GHz processors for a total of eight cores. All servers are rack-mounted or blade models.

Profile installations for these were constructed in the same manner as for Dell, HP, and IBM comparisons, using data on applications, server and disk system bases, use of server virtualization tools, system administration staffing and other variables supplied by organizational units in 11 large companies in technology manufacturing, financial services, and energy industries. Companies were in the same approximate size ranges, with similar business profiles. Again, a "best practices" approach was adopted.

Organizations had migrated some or all of their applications from Solaris on Sun SPARC-, UltraSPARC-, and/or Opteron-based servers to Linux operating systems on x86 servers.

Some units reported older-technology Opteron- and/or Intel-based servers. Where this was the case, configurations were translated to current technology Sun Opteron-based x86 models based on user-supplied data, functional descriptions, Sun recommended upgrades and replacements, application and workload requirements, industry configuration norms for major applications, and other variables.

Figure 10

Profile Installations for IBM and Sun Cost Comparisons

TECHNOLOGY COMPANY	
BUSINESS PROFILE	
Regional manufacturing & logistics complex of $5 billion+ global electronics company	Assembly plant, distribution center & administrative facilities with 1,000+ employees
APPLICATIONS & PLATFORMS	
CRM, ERP, business intelligence, e-mail, file/print servers, gateways, Internet & intranet infrastructure, network management, office applications, warehouse management	Development, test & training instances 40+ VMware virtual machines
SERVERS	
IBM 2 x x3850 4/16 x Xeon 2.4 GHz/64 GB 1 x x3850 4/16 x Xeon 2.93 GHz/64 GB 1 x x3650 2/8 x Xeon 2.5 GHz/32 GB 1 x x3650 2/8 x Xeon 2.5 GHz/16 GB 6 x x3550 2/8 x Xeon 2.5 GHz/16 GB 3 x x3550 2/8 x Xeon 2.5 GHz/8 GB 2 x x3250 1/2 x 1.87 GHz/4 GB Total: 16 servers IBM Systems Director	**Sun** 2 x X4600 4/16 x AMD 2.3 GHz/64 GB 1 x X4440 4/16 x AMD 2.3 GHz/64 GB 1 x X4240 2/8 x AMD 2.3 GHz/32 GB 1 x X4240 2/8 x AMD 2.3 GHz/16 GB 2 x X4200 2/4 x AMD 2.8 GHz/16 GB 4 x X4140 2/8 x AMD 2.3 GHz16 GB 3 x X4100 2/4 x AMD 2.6 GHz/8 GB 2 x X2100 1/2 x AMD 1.8 GHz/4 GB Total: 16 servers
DISK SYSTEMS	
DS4800 (mirrored) 28.8 TB FC DS4800 (failover) 24.0 TB FC Total: 52.8 TB DS4000 Storage Manager, Host Kits, FlashCopy, VolumeCopy, Enhanced Remote Mirroring	6540 (mirrored) 28.8 TB FC 6540 (failover) 24.0 TB FC Total: 52.8 TB Common Array Manager, Data Snapshot, Data Volume Copy, Data Replicator

ENERGY COMPANY	
BUSINESS PROFILE	
Marketing, sales & customer service applications of $10 billion+ independent oil & gas producer	300+ internal users + customer Internet access
APPLICATIONS & PLATFORMS	
CRM/customer self-service, decision support, e-mail, file/print servers, service desk, online advertising, Internet infrastructure	Development & test instances (VMware) 20+ VMware
SERVERS	
IBM 2 x x3550 2/8 x Xeon 2.66 GHz/32 GB 2 x x3550 2/8 x Xeon 2.5 GHz/32 GB 8 x x3550 2/8 x Xeon 2.5 GHz/16 GB 1 x x3550 2/4 x Xeon 3.0 GHz/8 GB 2 x x3550 2/4 x Xeon 3.0 GHz/8 GB 1 x x3250 1/2 x Xeon 3.0 GHz/8 GB 5 x x3250 1/2 x Xeon 1.87 GHz/4 GB Total: 21 servers IBM Systems Director	**Sun** 4 x X4140 2/8 x AMD 2.3 GHz/32 GB 7 x X4140 2/8 x AMD 2.3 GHz/16 GB 1 x X4100 2/4 x AMD 2.8 GHz/16 GB 1 x X4100 2/4 x AMD 2.6 GHz/8 GB 2 x X2200 2/4 x AMD 2.6 GHz/16 GB 1 x X2100 1/2 x AMD 2.6 GHz/8 GB 5 x X2100 1/2 x AMD 1.8 GHz/4 GB Total: 21 servers
DISK SYSTEMS	
DS3400 10.8 TB SAS Total: 10.8 TB DS3000 Storage Manager, FlashCopy	2540 10.8 TB SAS Total: 10.8 TB Common Array Manager, Data Snapshot

FINANCIAL SERVICES COMPANY	
BUSINESS PROFILE	
Local operations of multinational investment bank	Subsidiary headquarters + sales offices 600+ employees
APPLICATIONS & PLATFORMS	
Blade Servers Securities trading, market data, database applications, file & print serving, financial reporting, intranet infrastructure Development, test & training instances	**Rack Servers** Anti-money laundering, back-end systems, CRM, intranet & Internet infrastructure, Lotus Domino, risk analytics, security applications 60+ VMware virtual machines
SERVERS	
IBM BladeCenter H 8 x LS21 2/4 x AMD 3.0 GHz/16 GB 2 x LS41 4/8 x AMD 3.0 GHz/32 GB BladeCenter H 6 x LS21 2/4 x AMD 3.0 GHz/16 GB 4 x LS41 4/8 x AMD 3.0 GHz/32 GB 2 x x3850 4/16 x Xeon 2.4 GHz/64 GB 2 x x3650 2/8 x Xeon 2.5 GHz/32 GB 2 x x3550 2/8 x Xeon 2.5 GHz/32 GB 2 x x3550 2/8 x Xeon 2.5 GHz/24 GB 1 x x3550 2/4 x Xeon 3.0 GHz/16 GB 2 x x3550 2/8 x Xeon 2.5 GHz/16 GB 1 x x3250 1/2 x Xeon 3.0 GHz/8 GB 3 x x3250 1/2 x Xeon 1.87 GHz/4 GB Total: 35 servers IBM Systems Director	**Sun** Blade 8000 Modular System 8 x X8440 2/4 x AMD 3.0 GHz/16 GB 2 x X8440 4/8 x AMD 3.0 GHZ/32 GB Blade 8000 Modular System 6 x X8440 2/4 x AMD 3.0 GHz/16 GB 4 x X8440 4/8 x AMD 3.0 GHZ/32 GB 2 x X4440 4/16 x AMD 2.3 GHz/64 GB 2 x X4240 2/8 x AMD 2.3 GHz/32 GB 2 x X4140 2/8 x AMD 2.3 GHz/32 GB 2 x X4140 2/8 x AMD 2.3 GHz/24 GB 1 x X4140 2/4 x AMD 2.4 GHz/16 GB 2 x X4100 2/4 x AMD 2.4 GHz/16 GB 1 x X2100 1/2 x AMD 2.6 GHz/8 GB 3 x X2100 1/2 x AMD 1.8 GHz/4 GB Total: 35 servers
DISK SYSTEMS	
DS4700 (mirrored) 19.2 TB FC DS4700 (failover) 14.4 TB Total: 33.6 TB DS4000 Storage Manager, Host Kits, FlashCopy, VolumeCopy, Enhanced Remote Mirroring	6140 (mirrored) 19.2 TB FC 6140 (failover) 14.4 TB FC Total: 33.6 TB Common Array Manager, Data Snapshot, Data Volume Copy, Data Replicator

With one exception, IBM and Sun servers are Intel Xeon- and Opteron-based respectively. IBM servers were sized to correspond in terms of functionality and approximate performance to Sun equivalents.

The exception is that IBM Opteron-based BladeCenter LS21 and LS41 servers were employed for the financial services company profile because this technology was required for specific applications. The Sun scenario included comparable Sun Blade 8000 Opteron-based X8440 servers.

As for Dell, HP, and IBM comparisons, units often did not supply detailed data for numbers of VMware virtual machines. Numbers of these shown in profiles are thus again approximate.

Servers were sized to run Red Hat Enterprise Linux 5 or SUSE Linux Enterprise Server 10, along with VMware Infrastructure 3, and third-party clustered failover solutions where appropriate. System x servers are equipped with IBM Systems Director toolsets, including system administration, virtual machine management, and power management modules. As there is no functionally equivalent Sun offering, Sun servers were not equipped with comparable software.

Units employed a variety of Sun, EMC, and other vendors' disk systems, including older-technology models of these. These were translated into functionally equivalent current technology models of Sun StorageTek 2500 and 6000 Arrays, and IBM DS3000 and DS4000 systems based on installed capacity, industry configuration norms for major applications, and application and workload requirements.

Systems software for disk systems consists of the vendor offerings shown in figure 11.

Figure 11
Disk Systems Software for IBM and Sun Cost Comparisons

	IBM	SUN
System Management	DS4000 Storage Manager, DS3000 Storage Manager	Common Array Manager
Internal Copy	FlashCopy, VolumeCopy	Data Snapshot, Data Volume Copy
Remote Copy	Enhanced Remote Mirroring*	Data Replicator
Host Access	Linux Host Kits	N/A

*Includes Metro Mirror, Global Mirror & Global Copy

These offerings provide functionality comparable to disk systems software employed in Dell, HP, and IBM cost comparisons.

Cost Calculations

Hardware, Software and Maintenance

For all comparisons, costs include hardware acquisition and three-year 24x7 maintenance for server and disk system models and configurations indicated.

For Dell, HP, and IBM cost comparisons, server software costs are for licenses and three-year update and support subscriptions for Dell OpenManage, HP ICE, and IBM Systems Director including Active Energy Manager. For IBM scenarios for IBM and Sun comparisons, software costs are for licenses and three-year update and support subscriptions for IBM Systems Director including Active Energy Manager.

Disk systems software products include license and three-year support costs for the products listed in figures 9 and 11 above.

Calculations do not include license and support costs for operating systems, VMware tools, failover solutions, and other software, which would be the same or similar for all platforms.

Costs were calculated using discounted vendor U.S. list prices current when this report was prepared.

Personnel Costs

Personnel costs were calculated for the numbers of FTE server and storage administrators shown in figures 12 and 13.

Calculations were based on annual average salaries of US $79,748 for server administrators handling Windows, or Windows and Linux platforms for Dell, HP, and IBM comparisons; $77,289 for Linux server administrators for Sun migration comparisons; and $68,232 for storage administrators for both sets of comparisons. Salaries were increased by 29.2 percent to allow for bonuses, benefits, training, and other personnel-related cost items.

Figure 12

Numbers of FTE Personnel for Dell, HP, and IBM Comparisons

	DELL	HP	IBM
FINANCIAL SERVICES COMPANY			
Server administration	2.85	2.6	2.15
Storage administration	0.7	0.6	0.6
MANUFACTURING COMPANY			
Server administration	1.75	1.55	1.3
Storage administration	0.35	0.3	0.3
INSURANCE COMPANY			
Server administration	0.55	0.5	0.45
Storage administration	0.3	0.25	0.25
TELECOMMUNICATIONS COMPANY			
Server administration	0.8	0.75	0.65
Storage administration	0.2	0.15	0.15
TRANSPORTATION COMPANY			
Server administration	0.6	0.55	0.45
Storage administration	0.15	0.15	0.15
GOVERNMENT AGENCY			
Server administration	0.85	0.8	0.65
Storage administration	0.1	0.1	0.1

Figure 13

Numbers of FTE Personnel for IBM and Sun Comparisons

	IBM	SUN
TECHNOLOGY COMPANY		
Server administration	0.7	1.0
Storage administration	0.3	0.25
FINANCIAL SERVICES COMPANY		
Server administration	1.35	1.85
Storage administration	0.2	0.25
ENERGY COMPANY		
Server administration	0.5	0.6
Storage administration	0.1	0.1

Facilities Costs

These include three components:

1. ***Data center occupancy***. Calculations were based on vendor specifications for standard rack mount units. All servers and disk systems were housed in 42U racks. Allowance was also made for service clearances and inactive areas. Occupancy costs were calculated using a conservative assumption for annual average cost per square foot for existing facilities (i.e., costs do not include new facilities construction).

2. ***Electricity consumption***. Watts consumed were calculated using vendor specifications and calculation tools for servers and disk systems. Specific utilization levels and hours of operation for each profile were then applied, and a conservative assumption for average price per kilowatt/hour was then employed to determine three-year costs.

3. ***Support equipment***. Allowance was also made for the costs of power and cooling equipment, including chillers, computer room air conditioning (CRAC), uninterruptible power supplies (UPS), power distribution systems, and other items. Costs for these include hardware acquisition, maintenance, data center occupancy, and electricity consumption.

   Calculations were based on configurations of widely used support equipment appropriate for electricity consumption and heat generation by servers and disk systems in each profile. Where appropriate, costs were based on prorated values; e.g., if vendor systems required 25 percent of the output of a 40-ton chiller ("ton," in this context, is a standard metric for cooling capability), calculations were for 25 percent of three-year costs for this equipment.

   Electricity and data center occupancy costs for support equipment were calculated in the same manner as for servers and disk systems.

All facilities calculations are for U.S. costs.

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