



A Total Cost of Ownership (TCO) Analysis of 64-bit, 4-way Web Application Servers

Overview

Robert Frances Group (RFG) has analyzed the cost of ownership for mid-range servers built on the current generation of commodity 64-bit processors and popular server operating systems. The servers studied employ [IBM Corp.](#) POWER5, [Advanced Micro Devices, Inc.](#) (AMD) x86-64 (Opteron), [Intel Corp.](#) EM64T, and [Intel Corp.](#) Itanium 2 processors. To provide a basis for comparison, RFG examined a common task facing enterprises today: the creation and hosting of an interactive Web application on a server environment configured to support development, testing, and deployment for a typical moderate-demand workload. Examples include electronic customer relationship management (eCRM), HR self-service systems, or the in-house front end for a back-end financial services account management system.

In this analysis, RFG found that POWER5 on the IBM OpenPower system provided a more cost-effective target environment for this class of tasks than the alternative systems. In particular, IBM's combination of fast execution of Java byte code and hardware-based virtualization technology on OpenPower provided a significant cost advantage over competing solutions. The OpenPower 720 provided greater functionality, with a 12-percent lower TCO than a [Microsoft Corp.](#) Windows 2003 Server running on [Dell, Inc.](#) PowerEdge EM64T-based systems over a three-year period. RFG also found that the OpenPower 720 offered a 25-percent lower TCO than Solaris running on [Sun Microsystems, Inc.](#) Sun Fire AMD Opteron-based systems, and a 33-percent lower TCO than HP-UX 11i running on [Hewlett-Packard Co.](#) (HP) Itanium 2 systems. A substantial contributor to OpenPower's TCO advantage for realistic workloads was found to be the mainframe-heritage virtualization afforded by its logical partitioning (LPAR) capability.

The following table summarizes the TCO for each mid-range system. The projected TCO for moderate workload 4-way systems includes operating system and application software, 16 gigabytes (GB) of memory per processor, and 73-GB direct attached storage hard drives per processor. The configuration excludes commonly configured network attached storage (NAS) and other network peripherals. The system is configured to support development, test, and staging/deployment using industry standard software development best practices.

Server	Operating System	Processor	TCO
IBM OpenPower 720	Linux 2.6 (SLES 9)	POWER5	\$133,169
Dell PowerEdge 6850 and 2950	Windows 2003 SEE	EM64T	\$150,864
Sun Fire v40z and v20z	Solaris 10	Opteron	\$170,420
HP rx4640-8 and rx2620	HP-UX 11i	Itanium 2	\$185,536

Methodology

***Task and Target Environment Selection***

The implementation of moderate-workload, Web-accessed enterprise services is a common challenge for IT executives. Examples of moderate-workload services include eCRM, employee HR self-service, or an in-house front end for a back-end financial services account management system.

To identify suitable target environments for such enterprise application workloads, RFG considered a hypothetical environment containing two 4-way systems, each configured with 16 GB of memory and 73-GB hard drives to serve as Web application servers. The use of two servers reflects sizing based on peak performance and of the redundancy needed to meet today's high availability requirements. The application server tier is connected to a pre-existing back-end database server, such as an HR or customer account database. Since the primary goal is to provide a framework for evaluating OpenPower compared to other platforms, the EM64T system is configured with Microsoft Windows 2003 Server Enterprise Edition, and the AMD Opteron systems runs Solaris 10. The Itanium 2 system runs HP-UX 11i.

Configuring to Support Best Practices

In a well-managed enterprise software development and deployment environment, software development and quality assurance (QA) testing activities are conducted not on the production server, but rather on similarly-configured separate computing platforms. New application versions are released from the staging server to the production server for public use, only after being certified by a QA team. Consistent with such real-world best practices, in this study, a testing system (for use by development teams) and a staging system (for use by operational teams to test software/configuration changes before deployment on the production system) were configured for each environment under evaluation.

Testing and staging servers normally require independence from the production server in processing workload and access rights, but do not require the full performance of an entirely dedicated system. This provides the system designer with the opportunity to make effective use of a computing platform's virtualization features, whether designed into the hardware or added to it using an appropriate software virtualization tool (e.g. VMWare's ESX). Since the AMD Opteron, Intel EM64T, and Itanium 2 systems do not have hardware virtualization capabilities, and VMWare does not currently support 64-bit virtual processors running in a 64-bit mode, virtualization is not available for the Itanium processor family. Therefore two inexpensive 2-way systems were required for the testing and staging servers for the AMD Opteron, EM64T, and Itanium 2 target environments.

The OpenPower architecture provides direct hardware-level support for the creation of logical partitions (LPARs) that meet the independence requirements of this study. The testing and staging servers for the OpenPower environment accordingly are implemented using logical partitions, and thus not do require any additional hardware. Although this reduces the total CPU count of the OpenPower configuration, its leadership SPEC JBB2000 performance (between 20 and 40 percent higher than any of the other configurations among the systems tested)¹ provides additional capacity for development and test workloads concurrent with production. The hardware-based partitioning provided on the OpenPower servers provides for complete isolation of resources (including completely distinct operating system instances) with the ability to guarantee needed CPU, I/O, and memory capacity for the production partitions. These are all capabilities not available on the Intel- and AMD-based platforms.

Pricing, TCO Modeling, and Other Experimental Design Factors

Where possible, software and hardware elements were specified for each server configuration to be identical in all environments. Cost elements, such as back-up software, network hubs, and storage area network (SAN) arrays have been excluded from this study to simplify the comparison. Any variation in

¹Source: <http://www.spec.org/jbb2000/results/>



such support facilities should therefore be factored in for a specific environment. Because hardware and software purchase discounts vary widely from company to company, all prices reflect publicly available manufacturer suggested retail price (MSRP) values in U.S. dollars. Software support discounts were used when publicly available. This specifically applies to support options for the JBoss application server, where a 5-percent discount for a three-year support option was available. This discount price was included as part of the annual 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.

AMD Opteron-based systems and Intel EM64T-based systems were of special interest in this study. RFG is witnessing significant adoption and interest in these 64-bit systems, making them viable target platforms for comparison.

Three-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 as well as RISC-based servers can have a life cycle of 5 to 7 years for organizations in some industries or business sectors.

HP did not respond to numerous attempts to obtain support cost pricing for HP-UX on Itanium 2 systems. Hence, RFG has estimated that the annual support costs would be approximately 18 percent of the per processor cost of HP-UX 11i operating environments.²

Target Environments

The following systems are used as deployment targets for this analysis. Each system was chosen to meet the requirements for the hypothetical environment without significantly exceeding them, providing the most cost-effective solution for each case. In addition, the JBoss application server, a popular open source cross-platform application server, was specified for implementation on each system, to adequately meet the Web application server requirements for this study.

Environment 1: IBM OpenPower 720

OpenPower is a family of entry-level IBM POWER5 systems for the Linux operating system environment. The IBM POWER5 architecture is the fifth generation of IBM POWER technology. This system is configured with four 1650-megahertz (MHz) POWER5 processors and 16 GB of RAM. The software stack consists of [Novell, Inc.](#)'s SUSE Linux Enterprise Server 9 operating system and the JBoss application server. IBM's Power Hypervisor and Virtual I/O Server technology will be used to create LPARs to provide isolated application and development environments.

Environment 2: Dell PowerEdge 6850 running Microsoft Windows 2003 Server Enterprise Edition

This system is configured with four 3.16-gigahertz (GHz) Intel Xeon 64-bit processors and 16 GB of RAM. The software stack consists of Microsoft Windows 2003 Server Enterprise Edition, which is included in the server hardware cost, and JBoss application server. Two Dell PowerEdge 2850s operate as the testing and staging systems, and are configured with two 3600-MHz Intel Xeon 64-bit processors and 8 GB of RAM.

² HP-UX 11i operating environment can be purchased from the Hewlett-Packard Co. Web site at <http://software.hp.com/portal/swdepot/displayProductsList.do?category=OE>

Environment 3: Sun Fire v40z running Solaris 10

This system is configured with four AMD Opteron 850 2400-MHz processors and 16 GB of RAM. The software stack consists of Solaris 10 and JBoss application server. In addition, two Sun Fire v20zs are configured with two 2400-MHz AMD Opteron 250 processors and 8 GB of RAM as testing and staging servers. Sun's dynamic partitioning capability, called containers, is available with the Solaris 10 operating system. Solaris 10 containers allow system 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 with hardware-assisted virtualization. In addition, containers are not capable of testing operating system updates and patches, as all containers must boot from a single operating system image. For this reason, RFG specified two additional 2-way servers for use as testing and staging servers.

Environment 4: HP rx4640-8 Itanium 2 systems running HP-UX 11i v2

The system is configured with four 1500-MHz Intel Itanium 2 processors and 16 GB of RAM. The software stack consists of HP-UX 11i v2 operating system and the JBoss application server. Two HP rx2620 dual processor Itanium 2 systems with 1.3 GHz and 8 GB of RAM were chosen as the testing and staging systems.

Summary of 4-way and 2-way Server Hardware Costs

The following tables summarize the hardware costs for each of the four target environments.

Production Server Hardware Costs

Environment	Cost
1- OpenPower 720	\$58,604
2- Dell PowerEdge 6850	\$36,480
3- Sun Fire v40z	\$57,772
4- HP rx4640-8	\$64,130

Testing and Staging Server Hardware Costs

Environment	Cost
1- N/A	\$0
2- Dell PowerEdge 2850	\$21,252
3- Sun Fire v20z	\$15,370
4- HP rx2620	\$26,870

Target Environment Analysis

The following describes the actual hardware configuration for one year using the costs in the previous section.

Environment 1

An OpenPower 720 server with four 1650-MHz processors and 16 GB of RAM is priced at \$26,582. An additional 4-way OpenPower 720 is configured the same for purposes of redundancy.

Year 1 Costs

Environment 1	Cost
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OpenPower 720	\$26,582
OpenPower 720	\$26,582
Power Hypervisor and Virtual I/O Server	\$4720
Total	\$58,604

Environment 2

A Dell PowerEdge 6850 configured with four 3.16-GHz Intel Xeon 64-bit processors and 16 GB of RAM, and configured with Windows 2003 Server is priced at \$18,240. A second 6850 is configured exactly the same for purposes of redundancy and high availability. Two Dell PowerEdge 2850s, each configured with two 3600-MHz Intel Xeon 64-bit processors and 8 GB of RAM is priced at \$10,626.

Year 1 Costs

Environment 2	Cost
Dell PowerEdge 6850	\$18,240
Dell PowerEdge 6850	\$18,240
Dell PowerEdge 2850	\$10,626
Dell PowerEdge 2850	\$10,626
Total	\$57,732

Environment 3

A Sun Fire v40z configured with four AMD Opteron 850 2400-MHz processors and 16 GB of RAM is priced at \$28,886. An additional Sun Fire v40z is configured with the same amount of memory and disk. A Sun Fire v20z configured with two 2400-MHz AMD Opteron 250 processors and 8 GB of RAM is priced at \$7,685.

Year 1 Costs

Environment 3	Cost
Sun Fire v40z	\$28,886
Sun Fire v40z	\$28,886
Sun Fire v20z	\$7,685
Sun Fire v20z	\$7,685
Total	\$73,142

Environment 4

An HP rx4640-8 with four 1500-MHz Intel Itanium 2 processors and 16 GB of RAM is priced at \$32,065. An HP rx2620 dual processor Itanium 2 system with 1.3 GHz and 8 GB of RAM is priced at \$13,435.

Year 1 Costs

Environment 4	Cost
HP rx4640-8	\$32,065
HP rx4640-8	\$32,065
HP rx2620	\$13,435
HP rx2620	\$13,435
Total	\$91,000

***Server Hardware Cost Summary***

The following table summaries the total hardware costs for each environment.

Environment	Cost
OpenPower 720	\$58,604
Dell PowerEdge 6850 and 2850	\$57,732
Sun Fire v40z and v20z	\$73,142
HP rx4640-8 and rx2620	\$91,000

Hardware Maintenance Costs

Typically, hardware maintenance costs are 10 percent of the system costs. However, the OpenPower 720 has three-year maintenance included at no additional cost. Hence the cost for the four environments is as follows:

Environment	Year 1	Year 2	Year 3	Total
OpenPower 720	\$0	\$0	\$0	\$0
Dell PowerEdge 6850 and 2850	\$5,772	\$5,772	\$5,772	\$17,316
Sun Fire v40z and v20z	\$7,314	\$7,314	\$7,314	\$21,942
HP rx4640-8 and rx2620	\$9,100	\$9,100	\$9,100	\$27,300

OpenPower Power Hypervisor and Virtual I/O Maintenance Costs

IBM's Power Hypervisor and Virtual I/O Server technology enables LPARs to create isolated application and development environments. IBM's OpenPower Virtual I/O server is only available on IBM solutions. (As stated earlier, RFG considered adding a software-based virtualization solution to the EM64T and AMD Opteron environments. However, VMWare only supports 32-bit applications, and would not be able to take advantage of the 64-bit extensions on EM64T and AMD Opteron systems.) The annual maintenance cost of the OpenPower Virtual I/O server is \$90 per processor per year. Since there are eight processors, the cost per year is \$720.

IBM's Power Hypervisor and Virtual I/O Server technology is \$590 per processor, plus \$90 per processor per year maintenance. Since there are two four-way OpenPower 720 systems, the one time cost for the Power Hypervisor is \$4,720. The cost per year for eight OpenPower processors is \$720 per year. The total cost for the OpenPower Hypervisor and Virtual I/O maintenance is \$6,880.

Environment 1	Year 1	Year	Year 3	Total
Virtual I/O Server Maintenance	\$720	\$720	\$720	\$2,160

IBM Power Hypervisor	\$4,720	\$0	\$0	\$4,720
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Operating System Costs

The cost of an operating system is generally included in the system configuration cost. While HP-UX 11i is supported on HP Itanium 2 systems, it is not an option for users who choose to configure and purchase the rx2620 and the rx4640 online. HP-UX 11i is available separate from the server hardware, at a cost of \$750 per processor. Hence, the operating system cost was added subsequent to configuring Environment 4. Readers who may want to do their own calculations may find it helpful to know that a three-year subscription license for Suse Linux Enterprise Server 9 is \$1,335 per OpenPower 720 system. Microsoft Windows 2003 Server Enterprise Edition with 25 Client Access Licenses (CALs) is \$3,295 per system. Solaris 10 is sold by subscription and with support, and is accounted for in the operating system support cost category.

The following table lists the total operating system costs for all target environments.

Operating System	Total
SUSE Linux Enterprise Server 9	\$2,670
Microsoft Windows 2003 Server	\$13,180
Solaris 10	N/A
HP-UX 11i	\$9,000

Operating System Software Support Costs

HP, Microsoft, Novell, and Sun provide support options with their products that are priced on an annual basis. Novell's SUSE Linux Enterprise Server and Sun's Solaris 10 support services are available by subscription. Microsoft software support is typically licensed on a per-incident basis, where incidents are purchased as part of an enterprise license contract. Also, there is an obligatory maintenance charge of 25 percent of the operating system cost per year. The cost of a Microsoft five-incident support for Windows per system per year is \$200. Sun Solaris 10 premium support is \$360 per CPU per year. SUSE Linux enterprise server is \$900 per server per year, which includes 24x7 access and a maximum four-hour response time.

In addition, Microsoft offers some limited support options as part of Software Assurance. However, for Software Assurance, Microsoft reviews the actual purchase history for the preceding 12 months against the forecasted price level for each product pool. For the first year-end review, Microsoft will check to see if one-third of the total forecast was met to determine whether the price level should be reset. For the second year-end review, Microsoft will check that two-thirds of the forecast was met. Depending on the actual purchase history, the price level may be assessed upwards, downward, or remain the same. 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 for SUSE and Solaris and a five-incident support pack for Windows per year. RFG selected the highest level of support for this comparison. Based on conversations with its customers, RFG believes these choices reflect those typically made by enterprise IT executives.

HP did not respond to numerous attempts to obtain support cost pricing for HP-UX on Itanium 2 systems. The cost to license HP-UX 11i is \$750 per processor, and software support costs range from 15 to 20 percent of the software license cost per year. RFG based the cost to license HP-UX 11i at 18 percent of the software cost, and estimates that the annual operating system support cost for HP-UX is \$1,620 per year.

***Operating System Support Costs***

Operating System	Year 1	Year 2	Year 3	Total
SUSE Linux Enterprise Server 9	\$1,800	\$1,800	\$1,800	\$5,400
Microsoft Windows 2003 Server	\$4,095	\$4,095	\$4,095	\$12,285
Solaris 10	\$4,320	\$4,320	\$4,320	\$12,960
HP-UX 11i	\$1,620	\$1,620	\$1,620	\$4,860

System Administration Support Costs

To determine administrative costs, RFG relied on servers-per-administrator ratios that it had calculated based on past studies and numerous conversations with 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 is 75 servers per administrator, Solaris is 80 servers per administrator, and Windows is 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. RFG also added 30 percent 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 Microsoft administrator. RFG believes the ratios between the environments reflect a realistic expectation for most enterprise environments.

Administrator Cost Summary (Annual)

Environment	Number of System Administrators per Server	Cost	Total
OpenPower/Linux	1/75	\$97,110	\$1,295
Dell PowerEdge/Windows	1/50	\$83,850	\$1,677
Sun Fire/Solaris	1/80	\$103,350	\$1,292
HP Itanium 2/HP-UX	1/80	\$103,350	\$1,292

JBoss Application Server Support Costs

JBoss Platinum support for 24x7 two-hour response is priced from \$19,500 per application per year. This price applies to the 4-way production environments.

Qualitative and Quantitative Issues

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 cost of HP hardware support and HP-UX support is not readily available on HP's Web site, and approximations were created using 10 percent of the hardware cost and 18 percent of the software cost.

Summary of Findings

The following tables summarize the total costs for each environment.

Environment 1

OpenPower 720 Server	\$58,504
Three-Year Virtual I/O Server Maintenance	\$2,160
Power Hypervisor	\$4,720

Novell Suse Linux Support	\$5,400
Three-Year System Administrator Cost	\$3,885



Three-Year JBoss Premium Support Costs	\$58,500
Total	\$133,169

Three-Year Microsoft Windows 2003 Server Incident Support	\$2,400
Three-Year Microsoft Windows 2003 Server Maintenance	\$9,885
Three-Year System Administrator Cost	\$5,031
Three-Year JBoss Premium Support	\$58,500
Total	\$150,864

Environment 2

Dell PowerEdge 6850 and 2850 Servers	\$57,732
Three-Year Server Hardware Maintenance	\$17,316

Environment 3

Sun Fire v40z and v20z Server Hardware	\$73,142
Three-Year Server Hardware Maintenance	\$21,942
Three-Year Solaris 10 Support Cost	\$12,960
Three-year System Administrator Cost	\$3,876
Three-Year JBoss Premium Support	\$58,500
Total	\$170,420

HP rx4640-8 and rx2620 Server Hardware	\$91,000
Three-Year Server Hardware Maintenance	\$27,300
Three-year HP-UX 11i Support Cost	\$4,860
Three-year System Administrator Cost	\$3,876
Three-Year JBoss Premium Support	\$58,500
Total	\$185,536

Environment 4***Conclusions***

The four environments in this analysis are competitive examples of the most popular options available to enterprises as high-performance, mid-range application and database servers. All provide 64-bit addressing, are based on commodity (versus proprietary) chip sets, and support the full range of enterprise middleware offerings. Importantly, our TCO analysis takes into account the hardware, software, and support costs of implementing accepted software development best practices. The TCO and price-performance advantage goes to IBM's OpenPower offering.

Most enterprises find that their low- and mid-range servers are less than 10 percent utilized on a 24x7 basis, as compared to 60 to 80 percent utilization of mainframe systems. The need for separate hardware frames to isolate development and test workloads safely is a major contributor to this waste. By building mid-range, commodity-priced systems using technology derived from its mainframe product lines, IBM has produced a server with standout performance, as well as reliability, availability, and scalability (RAS) features that include true hardware-level virtualization. POWER5 users interviewed by RFG in conjunction with other studies have shown a level of confidence in using IBM's LPAR capability and virtual machines that RFG has yet to see from most users of the software-based virtualization technologies available from IBM competitors. Hardware-based LPARs and virtualization are available from some other vendors' mainframe product lines, but have not been made available in systems at price points and system sizes comparable to the OpenPower 720.



The cost of system administration *versus* the cost of hardware acquisition has become increasingly important elements in TCO. IBM has contributed to a new school of thought that says breakthrough performance and low-cost commodity hardware are not mutually exclusive. An expression of this evolution is the IBM OpenPower platform. This solution encompasses a family of entry-level IBM POWER5 systems optimized for the Linux operating system environment. The low cost and flexibility of the OpenPower platform means that IT executives do not need to make tradeoffs between capital and operating expense in the selection of a general purpose server hardware platform.

In conclusion, RFG found that the OpenPower 720 server has a lower TCO than less expensive AMD- and Intel-based hardware. The OpenPower 720 system provides additional scalability to address future workload requirements painlessly. It is significant that the IBM OpenPower platform's Power Hypervisor and Virtual I/O Server technology provide for isolated application environments – functionality not available on AMD- and Intel-based systems today. The latter systems are often attractive due to perceived low initial acquisition costs for a single server. However, in the context of real-world deployment involving development, testing, and staging systems, the need to employ additional machines instead of using hardware virtualization technologies that allow multiple systems to run on a single machine, often results in higher overall TCO. Ultimately, RFG believes long-term TCO is generally lower on systems that incorporate hardware virtualization.

RFG believes OpenPower will be highly appealing to customers, as awareness grows of its Linux support, virtualization capabilities, and ability to achieve better performance scalability per processor and price-performance relative to Itanium and commodity IA-32 and x86 64-bit architectures.

RFG analyst Stacey Quandt wrote this Custom Research Note. Interested readers should contact RFG Client Services to arrange further discussion or an interview with Ms. Quandt.

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