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## Benchmarks prove the performance of the Red Hat Enterprise Linux platform

**By: Nick Carr, Jeremy Hogan and Jonathan Opp**  
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### **Abstract**

This paper describes how database benchmarks demonstrate the performance of Red Hat Enterprise Linux AS and Oracle9i Database running on HP ProLiant hardware. Combined with the compelling Total Cost of Ownership model presented by this software and hardware combination, the paper shows why solutions such as this are rapidly replacing proprietary RISC/Unix and Microsoft Windows solutions.

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## Executive Summary

During the Summer of 2002 TPC-C and ECperf Benchmark results were published that dramatically demonstrated the benefits of migrating to a Red Hat Enterprise Linux/Intel-based Architecture/HP ProLiant platform. These configurations can offer significant performance and cost advantages over a traditional RISC/Unix environment.

HP ProLiant servers delivered the first Linux TPC-C benchmark results running Oracle9i RAC on Red Hat Linux Advanced Server (this product has since been renamed to Red Hat Enterprise Linux AS<sup>1</sup>). In that benchmark, an 8-node, 32-processor cluster of DL580 servers achieved 138,362.03 transactions per minute (tpmC) at a cost of \$17.38/tpmC, setting a new price performance world record for a clustered database. This benchmark illustrated the price/performance leadership of Red Hat Enterprise Linux AS on HP ProLiant Intel-based servers, out-performing a configuration running Microsoft Windows 2000 Advanced Server and Microsoft SQL Server 2000 on a IBM eServer xSeries 370 cluster with 32 processors.

(1)As of October 16, 2002: HP ProLiant DL580R, with 32 Intel Pentium III 900 MHz processors, Oracle9i Database Release 2 with Real Application Clusters on Red Hat Linux Advanced Server, 138,362.03, \$17.21/tpmC, available 03/05/03.

(2)As of October 16, 2002: HP ProLiant DL580R, with 32 Intel Pentium III 900 MHz processors, Oracle9i Database Release 2 with Real Application Clusters on Windows 2000 Advanced Server, 137,260.89 tpmC, \$18.46/tpmC, available 9/6/02.

(3)As of October 16, 2002: IBM eServer xSeries 370 with 32 Intel Pentium III 900 MHz processors, Microsoft SQL Server 2000 on Windows 2000 Advanced Server, 121,319.23 tpmC, \$18.97 tpmC, available 5/31/01.

Source: Transaction Processing Council (TPC), <http://www.tpc.org>

With this benchmark, HP ProLiant servers became the first industry-standard server platform to offer enterprise-class performance for a clustered Oracle Database in a Linux environment. It clearly demonstrates the cost and maintenance benefits of running Linux-based software and industry-standard hardware in enterprise operating environments.

The objective of this document is to describe the levels of stability, scalability and reliability that can be achieved using this platform. In each case presented, the Red Hat/Oracle/HP combination was the clear winner in price and performance. Simply put, these solutions deliver better performance for the price. In certain comparisons the performance improvements are very significant and achievable at a fraction of the cost of other solutions.

## Price/Performance

Red Hat Enterprise Linux AS has been optimized to provide exceptional

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1 In March 2003 Red Hat Linux Advanced Server was renamed to Red Hat Enterprise Linux AS. While this paper generally refers to the product by its new name, the benchmarks described, and the audited and published results, were completed prior to the name change. As a result the original name is used in all formal benchmark documentation.

performance on Intel X86-compatible chipsets. Real-world examples from enterprise users suggest that Red Hat Enterprise Linux AS 2.1 running on the Intel Pentium 4 chip is able to match the performance of Solaris 8 when running natively compiled C/C++ or Java code. Additional optimizations in specific instances have been able to achieve two-to-five times increases in performance over the application performance on Solaris. It is important to recognize that with less expensive Intel-based hardware, it is probable that customers can purchase substantially faster and more well-equipped industry-standard systems than they would be able to get for the same price from with Solaris, allowing a dramatic leap over Solaris in cost/performance.

Such statements, however, are directed only at raw processing performance. In terms of I/O and network throughput, evidence suggests that the two architectures are closer to parity. Fibre Channel attached storage reads, for example, will not usually be noticeably faster on Linux than Solaris. However, this still permits Linux a cost/performance edge because of the high value of HP ProLiant servers. In certain networking circumstances, Linux is able to best Solaris performance, although more at the application level than in terms of raw TCP/IP or UDP throughput capabilities.

## TPC-C and ECperf Benchmarks

The following paragraphs describe the recent audited benchmark results achieved on the Red Hat Enterprise Linux AS operating system. It is worth noting the rapid advances that have been made in Linux performance over the past 12-18 months; the figures achieved in these benchmarks are nearly double what could have been reached in 1999 or 2000. This rate of improvement underscores the effectiveness of the Open Source development methodology when combined with the experience of industry leaders such as Oracle and HP.

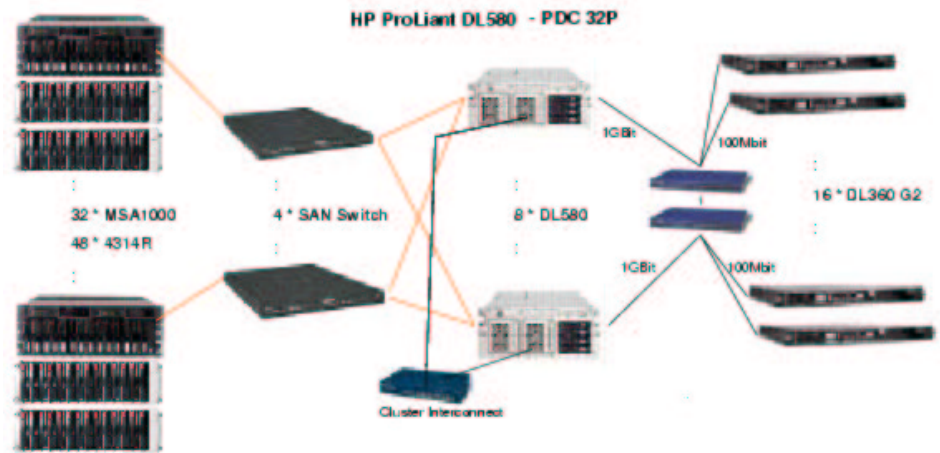
### TPC-C Benchmark

Benchmark C from the Transaction Processing Performance Council is an online transaction processing (OLTP) database server benchmark. The TPC-C is a highly regarded benchmark that simulates a variety of transactions at various user loads. The benchmark measures the throughput of a database server in an OLTP client/server environment. The power and capacity of database software and server hardware are measured in transactions per minute (tpmC).

The benchmark compares the tpmC results with the cost of hardware, software and support for three years to get price/performance values.

TPC-C simulates an environment where a body of virtual users is measured performing a variety of interactive transactions. The best simulations are not limited to a particular branch, but reflect an industry of activity. Though the test focuses on online retail activity, the results are applicable to any enterprise that must manage the sale and distribution of any product or service.

The configuration used by the Red Hat Enterprise Linux AS, Oracle9i Real Application Clusters (RAC) and HP ProLiant server benchmark is shown in Figure 1. Eight 4-CPU DL580 servers hosted the Oracle9i Real Application Clusters database, which was located on 18TB of storage (configured using SAN Fibre Channel switches and 32 HP MSA1000 storage subsystems). The complete configuration had approximately 1,000 disk drives. 16 dual processor DL360 systems were configured as the database clients.



**Figure 1 - TPC-C Benchmark Configuration**

HP ProLiant DL580 G1 servers running Red Hat Enterprise Linux AS not only delivered the first Linux TPC-C benchmark results running Oracle9i Real Application Clusters, but also set a new world record in price/performance for a clustered database.

Table 1 outlines the results from the three benchmarks published on the Transaction Processing Performance Council web site.

Company	Throughput	TPC-C Performance	Price/System	Operating Database
Hewlett Packard	138,362 tpmC	\$17.87	Red Hat Linux Advanced Server 2.1	Oracle9i/RAC
IBM	121,319 tpmC	\$18.97	Microsoft Windows 2000 Advanced Server	SQL Server 2000
Hewlett Packard	137,260 tpmC	\$18.46	Microsoft Windows 2000 Advanced Server	Oracle9i/RAC

**Table 1 - TPC-C Benchmark Results**

.As of September 17, 2002: HP ProLiant DL580R, with 32 Intel Pentium III 900 MHz processors, Oracle9i Database Release 2 with Real Application Clusters on Red Hat Enterprise Linux AS, 138,362.03 (Oracle best 32 processor cluster result - original publication date 9/16/02), \$17.38/tpmC, available 03/05/03 (1). HP ProLiant DL580R, with 32 Intel Pentium III 900 MHz processors, Oracle9i Database Release 2 with Real Application Clusters on Windows 2000 Advanced Server, 137,260.89 tpmC, \$18.27/tpmC, available 9/6/02. IBM eServer xSeries 370 with 32 Intel Pentium III 900 MHz processors, Microsoft SQL Server 2000 on Windows 2000 Advanced Server, 121,319.23 tpmC (Microsoft best 32-processor cluster result - result withdrawn 9/17/02), \$18.97 tpmC, available

5/31/01 (2). The TPC-C is an OLTP (online transaction processing) benchmark developed by the Transaction Processing Performance Council (TPC). The TPC-C benchmark defines a rigorous standard for calculating performance and price/performance measured by transaction per minute (tpmC) and \$/tpmC, respectively. Source: Transaction Processing Council (TPC), <http://www.tpc.org>

The table illustrates that you get greater business throughput with a Red Hat, HP, Oracle system than with Microsoft Windows 2000, at a lower cost. The solution provides more transactions completed, more customers served, for a lower cost of selling in terms of time and price.

The Executive Summary Report for the benchmark is included in the Appendices, and results from all TPC benchmarks can be found at <http://www.tpc.org>.

## ECperf Benchmark

ECperf is a benchmark for measuring performance and scalability of J2EE servers. ECperf measures the performance and scalability of distributed JavaBeans applications under interactive load patterns. It is a relatively new benchmark, designed for today's application server market.

ECperf uses the metaphor of a manufacturing and supply chain management system to create a real-life, enterprise-level distributed application problem. It stresses enterprise JavaBean capability to handle complex interactive transaction environments. Like TPC-C, ECperf compares the number of transactions to the cost of ownership over a period of time. The configuration for the recent Red Hat Enterprise Linux AS, Oracle9i Application Server (Oracle9iAS) and HP ProLiant benchmark is shown in Figure 2. The Application Servers were comprised of three dual-CPU DL360 G2 servers while the Database Server comprised a single 4-CPU ML570R configured with 16GB of memory and approximately 160GB of disk space.

Table 2 compares the performance of three recent ECperf benchmarks. The HP DL360G2 solution, which used Red Hat Enterprise Linux AS and Oracle9iAS, is the price/performance winner. In fact, at the time of writing, this benchmark is the current world record holder.

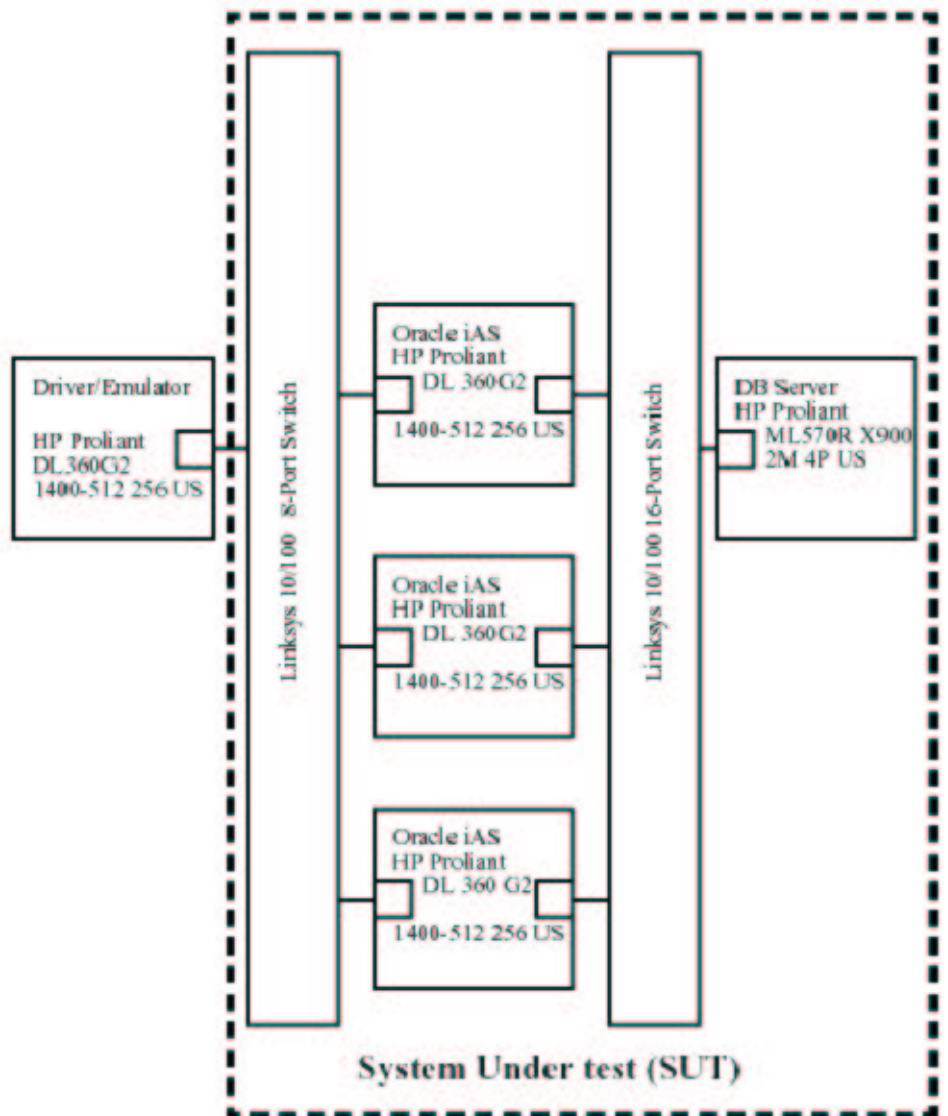
System	Bbops/min @ STD	Price \$/Bbops/min @ STD
HP DL360G2 cluster	24639.37	\$5.00
Dell Power Edge 4600	8286.73	\$6.00
IBM eServer x330 cluster	32581.47	\$11.00

**Table 2 – ECperf Benchmark Results**

ECperf is a J2EE application server benchmark that represents real-world business applications; ECperf results indicate how much a specific hardware and software configuration costs to operate, and how much performance it delivers. For more information, see <http://ecperf.theserverside.com/ecperf/index.jsp>.

The Summary Statement for the benchmark is included in the Appendices, and results from all ECperf benchmarks can be found at <http://www.theserverside.com/ecperf>.

Figure 2 - ECperf Benchmark Configuration



## Total Cost of Ownership

Modern benchmarks such as TPC-C and ECperf attempt to synthesize the complete cost of a given computing environment – as seen above, they include both price/performance and raw performance results. In most cases the price/performance results are the most useful to potential customers, since achieving a leading performance figure is generally a matter of configuring the largest possible system. But in order to provide price/performance figures the benchmark auditors require that vendors provide guaranteed costs for hardware and software, and up to three years of 24x7 support (in the case of TPC-C). This

ensures that the figures are based in reality.

However, benchmark price/performance figures do not tell the whole story because there are other costs that real-world IT departments must consider. These include less tangible elements, such as IT staffing and training levels, upgrade costs, migration or porting costs, security management, capital depreciation rates, vendor discounts, and acquisition of other software and hardware (for example: storage management software or printers). Cost analyses that take the complete IT infrastructure into account--known as Total Cost of Ownership (TCO) studies--are typically undertaken by industry analyst groups, such as IDC, Gartner, or the Robert Frances Group.

## IDC TCO Study

While Red Hat Enterprise Linux products have been garnering leadership benchmark figures, industry analyst reports on Linux solutions have also widely reported the considerable TCO savings that can be achieved. A recent IDC research study revealed the three-year cost of ownership savings and return on investment for enterprises that migrated their RISC/Unix/Oracle environments to Oracle running Red Hat Enterprise Linux on Intel-based platforms such as HP ProLiant servers.

To summarize, IDC found that "organizations running Oracle Database on Red Hat Enterprise Linux and Intel-based platforms incur roughly half the total costs of organizations with a Unix environments."

Oracle Database implementations on Linux were, on average, 49% less costly over a three-year period. Linux had cost advantages in multiple areas, including hardware, software and IT staffing. Table 3 shows the IDC survey results for an average 100-user implementation.

Costs per User (100 Users)	Linux	Unix
Hardware	\$1,077.00	\$3,060.00
Software	\$1,058.00	\$2,627.00
IT Staff	\$942.00	\$4,507.00
Other	\$4,423.00	\$4,874.00
<b>Total Costs</b>	<b>\$7,500.00</b>	<b>\$15,068.00</b>

Table 3 - Three year cost comparison (\$). Source IDC, 2002

The study also found costs for deploying Oracle Database on the Red Hat Linux and Intel-based platform were more than repaid by savings achieved through increased efficiency, productivity, and availability. Average savings totaled \$625,559 annually per firm surveyed, a 714% return on investment (Table 4).



Three-year ROI	Three-year Total
Total average benefits	\$1,876,677.00
Total investment	\$209,081.00
Cash flow	\$1,667,596.00
Net present value	\$1,492,477.00
ROI	714%
Payback	120 days

**Table 4 - Three year ROI Analysis. Source IDC, 2002**

According to IDC analyst Randy Perry, "IDC believes a successful challenge to Unix is possible, given the compelling cost advantages presented by Red Hat Linux on Intel-based servers. The business case for considering Red Hat Linux on industry standard servers is certainly being made. Now it needs to be heard and considered by IT and business decision makers."

In order to gather sufficient data, these results were recorded over a three-year period. A full copy of the IDC report can be obtained at [http://www.redhat.com/mktg/idc\\_sep02](http://www.redhat.com/mktg/idc_sep02).

## Robert Frances TCO study

Recent study by the Robert Frances Group (RFG) compared the cost of Red Hat Linux solutions against Sun Solaris and Microsoft Windows solutions. To summarize, RFG found "that Linux was the least expensive platform to deploy and operate. Although some initial costs were higher at points, the ability to massively scale the product without paying additional license fees can yield significant cost savings over the long term."

Case	Year 1	Year 2	Year 3
Linux	\$49,931.00	\$62,203.00	\$74,475.00
Solaris	\$421,718.00	\$491,619.00	\$561,520.00
Windows	\$91,724.00	\$141,193.00	\$190,662.00

**Table 5 - Three Year Cost Comparison. Source: Robert Frances Group, 2002**

As mentioned earlier, benchmarks do not include such costs as IT staff salaries, even though they can be a significant component of the overall TCO. Table 6 compares expected administrator costs for Windows, Solaris and Linux.

Case	Salary per Admin	Servers per Admin	Salary per Server
Linux	\$71,400.00	44	\$1,623.00
Solaris	\$85,844.00	6.4	\$13,413.00
Windows	\$65,500.00	10	\$6,850.00

**Table 6 - Administrator salaries/server. Source: Robert Frances Group, 2002**

The report concludes: "RFG believes IT executives should examine and pilot Linux server deployments, as the oft-quoted cost savings possible by deploying the platform were confirmed by this study...Overall, given its low cost and flexible licensing requirements, lack of proprietary vendor goals, high level of security, and general stability and usability, Linux is worth considering for most types of server deployments."

A full copy of the RFG report can be obtained at <http://www-1.ibm.com/linux/RFG-LinuxTCO-vFINAL-Jul2002.pdf>.

## Red Hat Enterprise Linux product family

A major component in achieving the benchmark results described above is the provision of a robust, high performance operating system. The operating system used, Red Hat Enterprise Linux AS, takes the value and features inherent in the standard Red Hat Linux platform and adds the reliability, availability, scalability, and manageability features that enterprises require in mission-critical IT deployments.

The Red Hat Enterprise Linux product family has grown from a single product in early 2002 to a portfolio of products that cover a wide range of commercial computing needs. The original product, Red Hat Linux Advanced Server was used for the benchmarks described in this paper. However, all the products in the Red Hat Enterprise Linux family share the same core software components, so that benchmark results obtained with one member of the family can generally be assumed relevant to other family members. By early 2003 the Red Hat Enterprise family contained the following products:

- Red Hat Enterprise Linux AS (originally named Red Hat Linux Advanced Server). This product is the top-of-the-line server operating system solution. It provides support for the largest X86-based systems and is appropriate for large departmental and corporate IT deployments
- Red Hat Enterprise Linux ES. This is a variant of the AS product designed for entry-level and mid-range server deployments.
- Red Hat Enterprise Linux WS. This is the client-side partner to the AS and ES server products. It is suitable for client-server applications and

technical/commercial desktop applications.

- Red Hat Linux Advanced Server for the Itanium Processor. This product provides equivalent functionality as Red Hat Enterprise Linux AS, but supports Intel's Itanium 2 processors.
- Red Hat Linux Advanced Workstation for the Itanium Processor. This product provides equivalent functionality as Red Hat Enterprise Linux WS, but supports Intel's Itanium 2 processors.

During the development of Red Hat Enterprise Linux AS, Red Hat engineers worked closely with Oracle and HP development groups to provide the capabilities that these experienced, industry-leading suppliers required. The following table details some of the kernel enhancements of Red Hat Enterprise Linux products. In combination these features significantly improved the performance of the kernel, providing a critical foundation for the record beating benchmark results.

Feature	Function	Benefit
Asynchronous I/O	I/O operations do not need to block application processing	Improved application I/O performance - especially for high-end multiuser environments
Fine-grain I/O Spinlocks	Enable parallel I/O processing on SMP systems	Improved SCSI & Fibre Channel I/O performance for SMP systems
Bounce Buffer Elimination	Removal of bounce buffer permits direct memory access I/O operations in systems with large memory (>GB)	Improved application performance; reduced in-memory copy operations
Improved Process Scheduler	Process-CPU affinity in SMP systems. Per-CPU process scheduling improves CPU cache hit rate and reduces scheduler spinlock contention	Improved application performance and system throughput

**Table 7 - Red Hat Enterprise Linux kernel performance enhancements**

The Red Hat Enterprise Linux family has been enthusiastically adopted by leading ISVs and OEMs. It is certified by top software and hardware vendors like Oracle, HP, Veritas, BEA and Dell. It is delivered using an extended release cycle, 12-18 months, compared to 4-6 months for the traditional Red Hat Linux Professional and Personal consumer/retail products. This allows IT managers to lock down their systems on a single, stable release.

In addition to the kernel features described above, Red Hat Enterprise Linux products provides a number of other capabilities, including:

- **High availability clustering.** This feature permits almost any application, such as Web or file and print server, to be made highly available, but was not required by the TPC-C benchmark, which used the clustering capabilities inherent in the Oracle9i Real Application Clusters product. (Note: This capability is provided in Red Hat Enterprise Linux AS only.)
- **Load-balancing clustering.** Provides the ability to distribute and load balance IP-based traffic and network service requests across a farm of

servers. This improves network availability and scalability. (Note: This capability is provided in Red Hat Enterprise Linux AS only.)

- **Java support.** Inclusion of a JDK/JRE integrated into the operating system.
- **ISV certification.** Red Hat worked with key enterprise software vendors to develop Red Hat Enterprise Linux products. Its features and stability are such that most enterprise ISV vendors have selected it as the most suitable platform on which to certify their applications.
- **Subscriptions.** Red Hat Enterprise Linux products are purchased as an annual subscription, which includes comprehensive support: upgrades, unlimited incident remedial services, and software updates through Red Hat Network.

For additional information on Red Hat Enterprise Linux performance, scalability and availability features refer to the relevant white papers at: <http://www.redhat.com/software/advancedserver/technical/whitepapers.html>.

## Oracle9i Real Application Clusters

Oracle9i Real Application Clusters (RAC) offers major enhancements in the areas of scalability, availability and manageability. The most significant technology breakthrough is the complete implementation of its shared cache architecture that for the first time enables highly scalable applications to be built without worrying about data partitioning. With RAC, you can scale efficiently by simply adding servers to your overall cluster as the demand grows and provide a higher availability solution than traditional cluster databases. This is because RAC provides near continuous, uninterrupted data access with minimal interruption as a result of hardware and software component failures. The system is resilient to multiple node losses and end-users never notice component failures.

The Real Application Clusters architecture presents DBAs with a single management entity--a single system image. And this single system image is preserved across the cluster for all management operations.

DBAs can perform installation, configuration, backup, upgrade, and monitoring functions once. Oracle then automatically distributes the execution of these management functions to the appropriate nodes within the cluster. The DBA thus manages one virtual server.

### Key benefits of RAC

- **Pay as you grow**

The ability to harness the less expensive processing power of cost-effective servers is just the start of the cost savings you will realize with Oracle9i Real Application Clusters. The ability to easily implement a scale out solution means that you do not have to pay for processing power until you actually need it.

- **Predictable Scalability**

RAC gives you scalability on demand because you no longer have to predict your scalability needs. You simply add servers to your Real Application Clusters database, as you need them.

- **TCO benefits**

With RAC, you can lower the overall TCO of your system by using cost-effective hardware, lower personnel cost and lower cost of downtime to your business.

- **Scalability with Availability**

Oracle9i Real Application Clusters provide highly available systems with the same hardware and software used to deliver scalability. Every server in a Real Application Clusters database acts as a backup for every other server in the cluster. Real Application Clusters provide a "hot standby" system, which means that the users of a failed server can be failed over to an active server in less than one minute.

- **Server Consolidation**

With RAC, you can scale your enterprise database across many machines, as you need them. This capability makes server consolidation an attractive target. Since a Real Application Clusters database is managed like a single Oracle instance, you can reduce your overall cost of maintenance as you consolidate servers.

To get more information on Oracle9i Real Application Clusters, please visit <http://www.oracle.com>

## HP ProLiant

The TPC-C and ECperf benchmarks discussed in this paper both required significant hardware infrastructure. For the TPC-C benchmark, the value of the hardware configuration exceeded \$1.5M, with over \$800,000 for the storage subsystem alone. For both benchmarks, Hewlett Packard industry standard ProLiant servers were chosen. The HP ProLiant DL and ML series servers that were used are ideal to meet the rigorous and growing demands of today's business-critical data center and ASP/ISP computing environments.

For technical specifications on all the hardware components used by the benchmarks please refer to the appropriate pages at <http://www.hp.com/linux>. However, a brief look at the the new ProLiant DL580 Generation 2 (G2) system, provides an indication of the capabilities of the HP ProLiant sever family.

The DL580 -G2 is an enterprise-class, 4-CPU server designed for environments that require maximum computing power and robust high-availability features in a versatile, rack-optimized form factor. It combines maximum levels of compute performance, system availability, and manageability with a flexible, rack-optimized design to deliver outstanding resource efficiencies to the enterprise data center.

The ProLiant DL580 G2 boasts an impressive array features:

- Hot-pluggable and redundant components, including embedded RAID and advanced multibit ECC memory correction technology. Design excellence in serviceability and manageability enables rapid setup and deployment, easy management, and tool-free maintenance of multiple servers.
- Outstanding manageability through Insight Manager, Remote Insight Manager Lights-Out Edition, and SmartStart:
  - HP Insight Manager monitors and controls the operation of HP servers and clients, and provides remote server management in corporate data centers and remote sites. Insight Manager reduces system management costs by providing centralized fault, configuration and performance information, improves operational efficiency through extensive remote management capabilities, and decreases server downtime through proactive fault management and version control.
  - HP Remote Insight Lights-Out Edition eliminates many of the problems of centralized management by giving IT administrators 7x24x365 access to their servers, providing full control of hardware and operating systems through a client browser that can be used no matter where they are.
  - The HP SmartStart for Servers tool configures HP hardware, loads optimized drivers, and assists with software installation. It also provides functionality for integrating operating systems on HP servers to achieve optimum reliability and performance.

## An HP ProLiant Customer: Primestream

Primestream is a Florida-based corporation founded in January 2000 by a group of experienced broadcasting and telecommunications executives to exploit the Internet's potential as a medium for secure delivery and acceleration of all types of digital content and applications, including audio, video and other forms of corporate collaboration and communications.

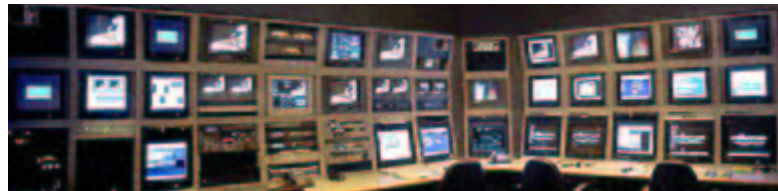


Figure 3 - Primestream Network Operations Center

The following quote from the CEO of Primestream summarizes the value of the HP range of servers:

*"Overall, ProLiant servers are highly stable. As you can imagine, that's critical to*

*our business - our customers expect excellent transmission capabilities from us, 24x7. We've found that other servers either have high initial rates of failure, or can't go a long time without problems. ProLiant servers work right out of the box - and continue doing so."*

-- Claudio Lisman, CEO, Primestream

## Conclusion


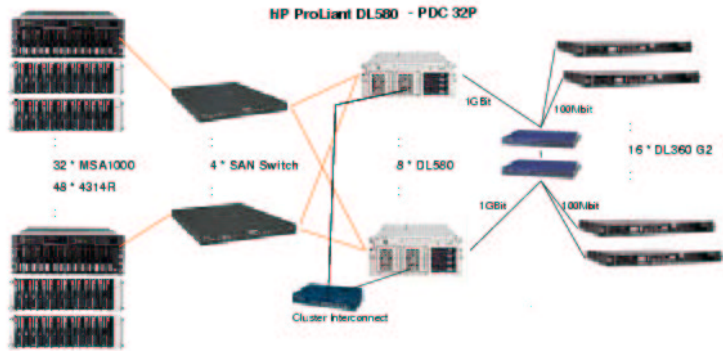
The successful combination of the Red Hat Enterprise Linux AS operating system, Oracle9i Real Application Clusters and Oracle9i Application Server, and Hewlett Packard DL and ML series servers has delivered impressive, conclusive results for two of the IT industry's toughest benchmarks--TPC-C and ECperf. These benchmarks are widely respected for their relevance to real-world situations. Customers adopting these technologies will benefit from the same potent mix of high performance at an unbeatable price. Red Hat Enterprise Linux AS provides the foundation that brings together the pricing advantages of commodity Intel-based hardware with the performance and scalability that was previously only available from proprietary Unix environments.

Red Hat, Oracle and HP have worked together closely to create a strong partnership that delivers leadership customer solutions today, and will continue to do so in the future. The three companies continue to work together on future products, including development and testing of Oracle Database with Red Hat Enterprise Linux products on Itanium 2 based, 64-bit servers and workstations (a TPC-C benchmark using an HP RX5670 Itanium 2, with Oracle 10i and *Red Hat Linux Advanced Server for the Itanium Processor* was published in November 2002). Oracle recently released its Cluster File System under the GPL license and is now working closely with Red Hat to help bring this exciting technology to the Red Hat Enterprise Linux family.

IT managers wishing to benefit from reduced Total Cost of Ownership, leadership performance, and adherence to industry standards while demanding that their vendors are stable and have a long-term commitment to their technologies need look no further than Red Hat, Oracle and Hewlett Packard.

## Appendix A - TPC-C Executive Summary

The Full Disclosure Report for the TPC-C benchmark runs to 219 pages, and can be obtained at <http://www.tpc.org>. The three page Executive Summary report is shown below.

		<b>HP ProLiant DL580 – PDC 32P C/S</b>		<b>TPC-C Rev. 5.0</b>	
				Report Date: September 16, 2002	
Total System Cost		TPC-C Throughput		Price Performance	
<b>\$2,380,546</b>		<b>138,362.03 tpmC</b>		<b>\$17.21</b>	
				Availability Date	
				<b>March 5, 2003*</b>	
				Hardware available now	
Processors		Database Manager		Operating System	
32 PIII X900/ MHz/2MB-Servers 16 PIII 1400 MHz/ 133/256K - Clients		Oracle 9i Enterprise Edi. Rel. 2 with Real Application Clusters and Partitioning Options		Red Hat Linux Advanced Server	
				Other Software	
				BEA Tuxedo 8.0	
				Number of Users	
				<b>115200</b>	
 <p style="text-align: center;"><b>HP ProLiant DL580 - PDC 32P</b></p>					
<b>System Components</b>		<b>Server</b>		<b>Clients</b>	
	Quantity	Description	Quantity	Description	
Processor	32	Pentium III X900MHz/2MB	32	Pentium III 1400 MHz/133/ 256K	
Memory	32	4 GB	64	1 GB	
Disk Controllers	32	FCA 2214 - Fibre Channel HBA			
	32	Modular SAN Array 1000			
	48	StorageWorks Enclosure Model 4314R			
	4	StorageWorks SAN Switch 2/18 EL			
Disk Drives	976	18.2-GB 15K	16	18.2-GB 10K	
Total Storage	16	18.2-GB 10K			
		18054 GB			
Tape Drives	1	12/24-Gigabyte DAT			





<b>Numerical Quantities Summary</b>			
<b>MQTH, Computed Maximum Qualified Throughput</b>		<b>138,362.03 tpmC</b>	
<b>Response Times (in seconds)</b>	<b>Average</b>	<b>90%</b>	<b>Maximum</b>
New-Order	0.893	1.992	85.290
Payment	0.574	1.146	84.770
Order-Status	0.643	1.339	45.256
Delivery (interactive portion)	0.260	0.349	81.913
Delivery (deferred portion)	0.419	0.793	82.654
Stock-Level	0.581	0.831	81.376
Menu	0.102	0.102	0.328
<b>Transaction Mix, in percent of total transaction</b>			
New-Order			44.916%
Payment			43.019%
Order-Status			4.020%
Delivery			4.025%
Stock-Level			4.020%
<b>Emulation Delay (in seconds)</b>		<b>Resp.Time</b>	<b>Menu</b>
New-Order		0.10	0.10
Payment		0.10	0.10
Order-Status		0.10	0.10
Delivery (interactive)		0.10	0.10
Stock-Level		0.10	0.10
<b>Keying/Think Times (in seconds)</b>	<b>Min.</b>	<b>Average</b>	<b>Max.</b>
New-Order	18.005/0.000	18.008/13.406	18.022/134.006
Payment	3.0100/0.000	3.018/12.016	3.032/120.045
Order-Status	2.0100/0.000	2.018/10.015	2.031/100.077
Delivery (interactive)	2.0100/0.000	2.018/5.025	2.031/50.179
Stock-Level	2.0100/0.000	2.018/5.014	2.030/50.096
<b>Test Duration</b>			
Ramp-up time			102 minutes
Measurement interval			120 minutes
Transactions (all types) completed during measurement interval			38,453,521
Ramp down time			56 minutes
<b>Checkpointing</b>			
Number of checkpoints			4
Checkpoint interval			30 minutes

## Appendix B - ECPERF Summary Statement

The Full Disclosure Report for the ECperf benchmark runs to 25 pages, and can be obtained at <http://www.theserverside.com/ecperf>. The summary statement from the report is shown below:

### 7.3 Summary Statement

#### 7.3.1 Summary Statement

##### Application Server

HP: Hewlett-Packard DL360G2  
Oracle: Oracle9iAS Release 2 Standard Edition v9.0.2.1.0  
Oracle: Oracle JDBC Driver v9.0.2.1.0 (Type 2)  
Oracle: Oracle Client v9.2.0.1.0  
Red Hat: Red Hat Linux Advanced Server 2.1

##### Database Server

HP: Hewlett-Packard ML570R  
Oracle: Oracle9i Release 2 Standard Edition v9.2.0.1.0  
Red Hat: Red Hat Linux Advanced Server 2.1

##### Networking

Linksys: Etherfast 10/100 Dual Speed 8 Port Switch, Model #ZXS88R  
Etherfast 10/100 Dual Speed 16 Port Switch, Model #DSSX16

Metrics: 24,639.37 BBops/min @ STD, S5/BBops/min @ STD

Availability Date: 9/17/2002

Bean Deployment Mode: CMP only