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White Paper

Advantages and Efficiencies of Oracle SPARC S7 Server Over Commodity Alternatives

This report was developed by Edison Group, Inc. with Oracle assistance and funding. This report may utilize information, including publicly available data, provided by various companies and sources, including Oracle. The opinions are those of Edison Group, Inc. and do not necessarily represent Oracle's position.

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Executive Summary

This whitepaper explores the new SPARC S7 server features and then compares this offering to a similar x86 offering.

The key characteristics of the SPARC S7 to be highlighted are:

- Designed for scale-out and cloud infrastructures
- SPARC S7 processor with greater core performance than the latest Intel Xeon E5 processor
- Software in Silicon which offers hardware-based features such as data acceleration and security

The SPARC S7 is then compared to a similar x86 solution from three different perspectives, namely performance, risk and cost.

Performance matters as business markets are driving IT to provide an environment that:

- Continuously provides real-time results.
- Processes more complex workload stacks.
- Optimizes usage of per-core software licenses.

Risk matters today and into the foreseeable future, as challenges to secure systems and data are becoming more frequent and invasive from within and from outside. Oracle SPARC systems approach risk management from multiple perspectives.

Cost matters today and into the foreseeable future because IT departments continue to reduce costs in response to enterprise-wide expense-reduction initiatives. This study shows that the Oracle SPARC S7 systems have 43% to 48% lower total cost of ownership compared to the similar x86/Linux-based systems. This is largely due to the higher core efficiency of the SPARC S7 processor, and higher system software costs associated with commodity alternatives, such as Red Hat Enterprise Linux and VMware virtualization.

Comprehensive, Fully Integrated

By integrating hardware, operating system, virtualization and applications, the Oracle SPARC platform's co-engineered nature is capable of maintaining performance and lowering risk at highly competitive prices. Enterprise-ready from the outset, Oracle Solaris was the first comprehensive OS for the cloud with a demonstrated history of performance.

SPARC S7 Scale-Out and Cloud Server

Edison's evaluation focuses on Oracle's SPARC S7, scale-out and cloud offering, and the SPARC S7 processor's new "Software in Silicon" technology that was introduced by Edison in a previous whitepaper[1].

The SPARC S7 processor has 8 powerful cores and 8 threads per core which take advantage of the engineered hardware and software integration that delivers improved processing speed and performance. Oracle's design approach adds capabilities in one layer of the stack that can be leveraged by other layers in the stack.

As shown later in this paper, this translates into maximum overall and per core performance especially for Java applications and databases.

Oracle's "Software in Silicon" technology provides some clear examples of this approach:

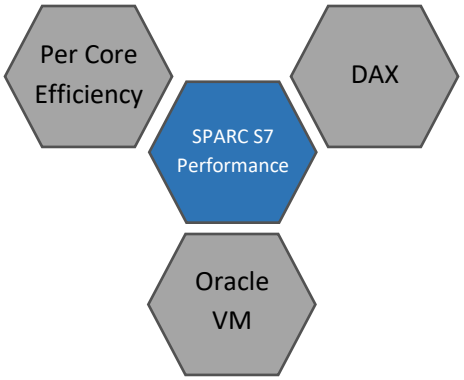
- SQL in Silicon – hardware accelerators built into the processor accelerate Oracle Database In-Memory query performance and speed up analytic workloads.
- Silicon Secured Memory–an innovative new layer of security protecting against unauthorized, malicious or inadvertent, access to data in memory.
- Encryption Acceleration – support for 15 unique encryption ciphers.

Keep in mind Oracle's "Hardware and Software Engineered Together" approach and the on-going development of technologies with expanded support for both scale-out and cloud workloads as we now focus on performance, risk aversion and total cost of ownership (TCO).

[1] http://www.theedison.com/index.php/publications/library-edison/260-oracle-software-in-silicon

Performance

This study reveals that Oracle's new SPARC S7 servers meet enterprise's performance needs better than latest Intel x86-based servers. In this section of the paper we examine per core efficiency, data analytics acceleration, virtualization, and then demonstrate how these features enhance performance for two use cases, namely database and Java.



Per Core Efficiency

Oracle SPARC servers have delivered greater per-core efficiencies with every new iteration of the processor. In comparison, Intel Xeon x86 systems have delivered a relatively flat, or even marginally declining, per-core performance over the last four years. Figure 1 shows relative per-core performance trend based on select published benchmark results and using SPARC T4 and first Intel Xeon E5 as baseline, respectively.

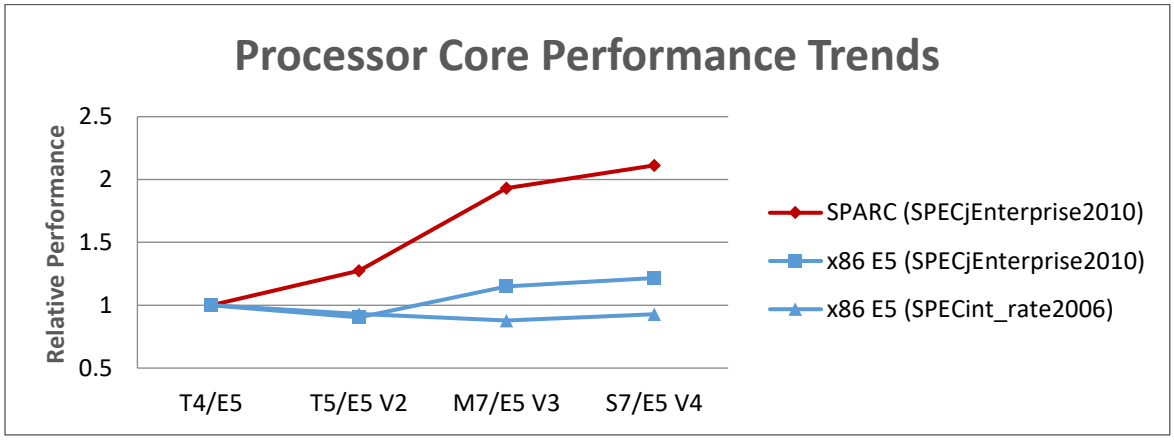


Figure 1 – SPARC and Intel Xeon E5 per core performance trends

The new SPARC S7 processor has eight cores and operates at a frequency of 4.27GHz. Presently, SPARC systems have typically 60%-85% greater per-core efficiency than comparable x86 systems by leveraging architectural improvements in the RISC-based SPARC architecture, and integrating key technologies on chip. Table 1 shows a comparison using the current SPECjbb2015 Maximum jOPS results (per-core throughput) for the SPARC S7-2 server and select commodity alternatives. There are two results for both E5 V4 based systems, optimized for either Maximum or Critical jOPS

Processor	SPECjbb2015 Max jOPS per Core	SPARC Core Advantage (%)
SPARC S7-2 (2x SPARC S7 processors)	4,112	n/a
HPE ProLiant DL360 Gen9 (2x E5-2699 V4)	2,774	48%
Cisco UCS C220 M4 (2x E5-2699 V4)	2,680	53%
HPE ProLiant DL360 Gen9 (2x E5-2699 V4)	2,205	86%
Cisco UCS C220 M4 (2x E5-2699 V4)	2,152	91%

Table 1 – SPARC S7 vs. x86 Server Per Core SPECjbb2015 Benchmark Comparison

Data Analytics Acceleration (DAX)

In addition to the large memory bandwidth and high clock speed, the SPARC S7 processor also incorporates the same SQL in Silicon technology as the larger SPARC M7 processor[2]. Each SPARC S7 processor incorporates four Data Analytics Accelerator (DAX) units, which process independent data streams, and free up the actual SPARC S7 processor cores to do other work.

DAX units significantly enhance database analytics performance. Using SQL in Silicon, DAX and Oracle Database In-Memory features, enterprise users can run OLTP workloads, reporting and analytics simultaneously on the same system, avoiding ETL (Extract-Transfer-Load) operations and perform queries on the latest data.

Benchmark tests show that the 8-core SPARC S7 processor with DAX outperforms the 22-core Intel Xeon E5-2699 V4 by up to 2.8 times on in-memory analytic queries. The SPARC S7 core delivered 7.7 times (see figure 2) better throughput in the test using a real cardinality database (RCDB) star schema[3].

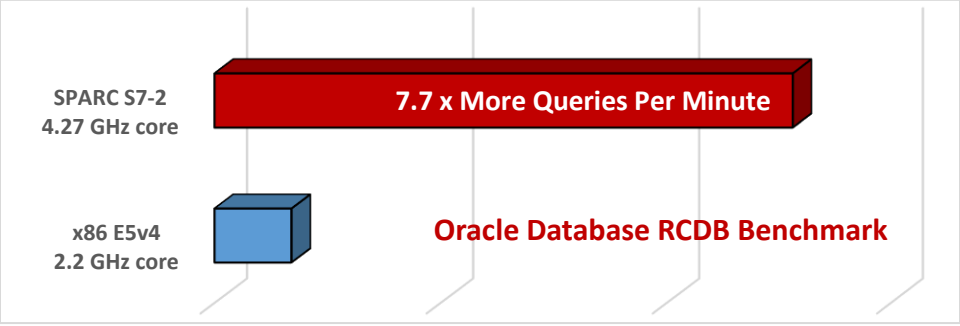


Figure 2: Oracle Database RCDB Benchmark SPARC S7 versus Intel x86

2 http://www.theedison.com/index.php/publications/library-edison/260-oracle-software-in-silicon
3 https://blogs.oracle.com/BestPerf/entry/20160629_imdb_sparc_s7_2

The specialized functions that DAX units can perform for the database can also benefit applications written in higher-level languages such as the Java 8 Stream API. Speedups of over 20 times have been measured[4].

Virtualization - Oracle VM Server for SPARC and Oracle Solaris Zones

Oracle VM Server for SPARC is a very low overhead, firmware-based hypervisor virtualization technology that supports secure live migration as virtual machines (VM) transit from server to server. The virtualization technology improves resource utilization, enables consolidation of disparate workloads while maintaining isolation and availability.

Oracle Solaris Zones, a container technology, is a fully integrated OS virtualization technology that allows thousands of software-isolated instances to be deployed in a single instance of Oracle Solaris. Oracle Solaris Zones reduce the administrative burden and cost as fewer OS instance are needed.

Oracle's virtualization, included at no charge, shows greater performance benefits over a typical industry offering from competition such as VMware:

- VMware's overheads have been shown to impair consolidation ratios — VMware demonstrated a 7% to 17% performance loss on simple I/O and network (VM vs. native)[5] and suffered a 12% performance loss on IBM WebSphere (VM vs. native).[6]
- Oracle VM Server for SPARC and Oracle Solaris Zones on SPARC servers showed a less than 1% performance loss, versus native, on CPU-intensive workloads.
- Oracle VM Server for SPARC hypervisor has low overhead because it is a small firmware layer that is tightly integrated with the processor.
- Oracle VM templates can be used to support applications like CRM and ERP, which reduces provisioning time. Provisioning with Oracle VM tools has been measured to be seven to 10 times faster than competition.

Improved Performance for Java and Database Applications

The SPARC S7 processors are optimized for scale-out and cloud infrastructure. Cloud based applications often run Java and database workloads. SPARC systems demonstrate high performance in running these applications.

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[4] https://community.oracle.com/docs/DOC-1006352

[5] vSphere5: IBM x86 PerformanceCharacteristics-InfoSphereInformationServerVMware.pdf , vSphere4: http://www.VMware.com/pdf/

[6] VMware & IBM: http://www.slideshare.net/rjmcdougall/virtualization-primer-for-java-developers

Memory bandwidth is important for achieving high performance and it isa key aspect of the SPARC S7 server architecture. Based on STREAM benchmark results the 8-core SPARC S7 processor has twice the memory bandwidth per core compared to the 22-core Intel Xeon E5-2699 V4 processor[7].

The figure below presents the Java and database efficiency advantage of SPARC S7 over latest x86 systems. The following performance comparison is based on workloads that are run without SQL In Silicon or DAX acceleration, since these are not available for x86 systems, and allow true comparison of raw processor bandwidth.

- Java - SPARC S7 systems show an approximate 1.7 times greater per core performance, in comparison to the x86 systems with E5-2699 V4 processor. This is based on a variety of Java benchmark results.
- Database – SPARC S7 systems also show about 1.6 times per core performance advantage for OLTP workloads against the x86 systems with E5-2699 V4 processor. This is based on in-house benchmark tests run by Oracle.

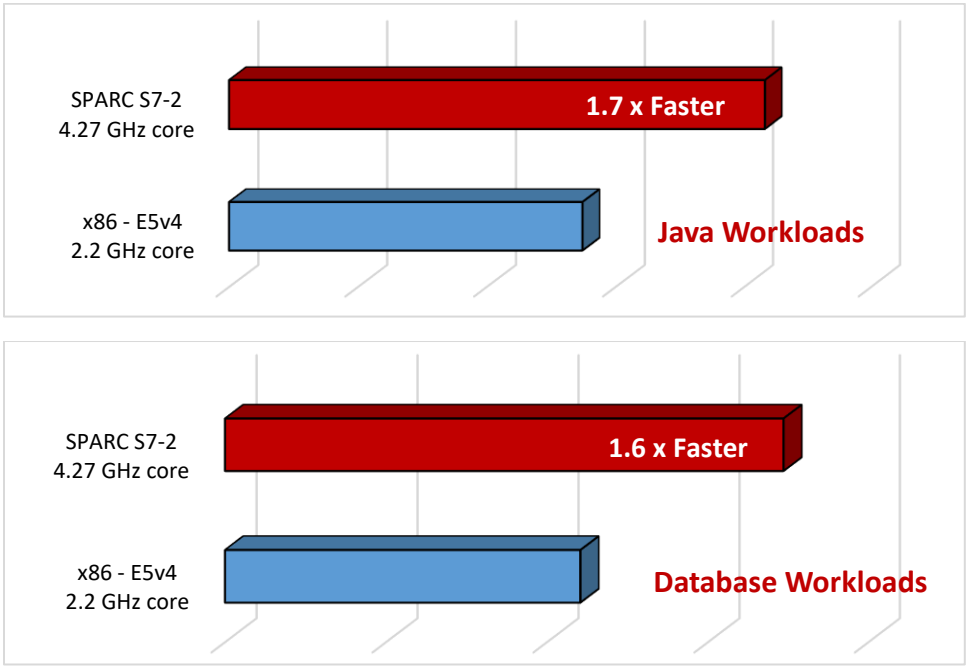


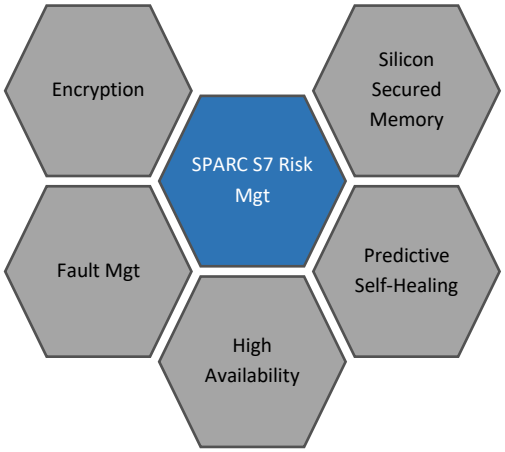
Figure 3: Core performance comparison of SPARC S7 and x86 E5v4 for Java and database workloads

The acceleration of database analytics and Java workloads using DAX can improve processing speeds 8 or 20 times, respectively. DAX acceleration is supported with the In-Memory option for Oracle Database 12C, which automatically takes advantage of SQL in Silicon.

[7] https://blogs.oracle.com/BestPerf/entry/20160629_stream_sparc_s7_2

Risk Management

Oracle's SPARC S7 platform running Oracle Solaris has built-in security that provides a level of data center protection that is difficult to match in even the most secure x86 server.



Oracle SPARC S7 and Silicon Secured Memory

Oracle adds a new layer of security with Software in Silicon feature known as "Silicon Secured Memory." Silicon Secured Memory protects programs and data that are in memory on systems from a number of memory attack techniques, including buffer over-writes and buffer over-reads. With Silicon Secured Memory, applications are only able to access their own dedicated memory regions, thereby protecting application memory space. Malicious applications cannot access the memory space of applications protected by Silicon Secured Memory.

Unique to Oracle this new functionality, can help in two primary ways:

1. Software programmers can identify issues with memory allocation and improper memory accesses by running debugger tools, provided by Oracle for SPARC servers, both in development and crucially on live environments, with little to no performance impact.
2. During production, illegal access is prevented from occurring. Even if hackers were able to install code on a system, Silicon Secured Memory would prevent that code from accessing sensitive data belonging to other applications or databases[8].

Silicon Secured Memory is implemented, at no extra cost to users, directly in the hardware, enabling an additional layer of security for production environments without impacting performance. Additionally, by using Solaris Studio, developers can expedite finding and fixing an elusive class of memory-access bugs to improve quality of their software.

[8] FYI - watch this short video about how Silicon Secured Memory protects against memory attacks: Silicon Secured Memory stops the Heartbleed attack point. http://download.oracle.com/SSM/SSM-Demo.html.

Encryption

While encryption is not a new technology, the associated challenges of performance loss, administrative complexity and added costs for specialized equipment have greatly limited encryption's adoption in the data center. With the increase in frequency and sophistication of cyber attacks, it is no longer adequate to focus security efforts primarily at the perimeter; IT shops need to assume that illicit users will gain access to their network at some point. As a result, Edison recommends that enterprises develop an encryption strategy and look to protect all enterprise data, whether it is in motion or at rest.

Oracle's new SPARC S7 processor includes hardware acceleration for 15 unique encryption ciphers and is the clear performance leader. The SPARC S7 encryption ciphers are instructions in the processor, available with no added cost, and deliver data security with negligible performance loss. Figure 4 shows two published SPECjEnterprise2010 benchmark results using the Oracle SPARC S7 servers. One of the tests is run traditionally with no encryption to maximize performance. The other result is based on a fully encrypted environment with a difference of less than 2% in throughput.

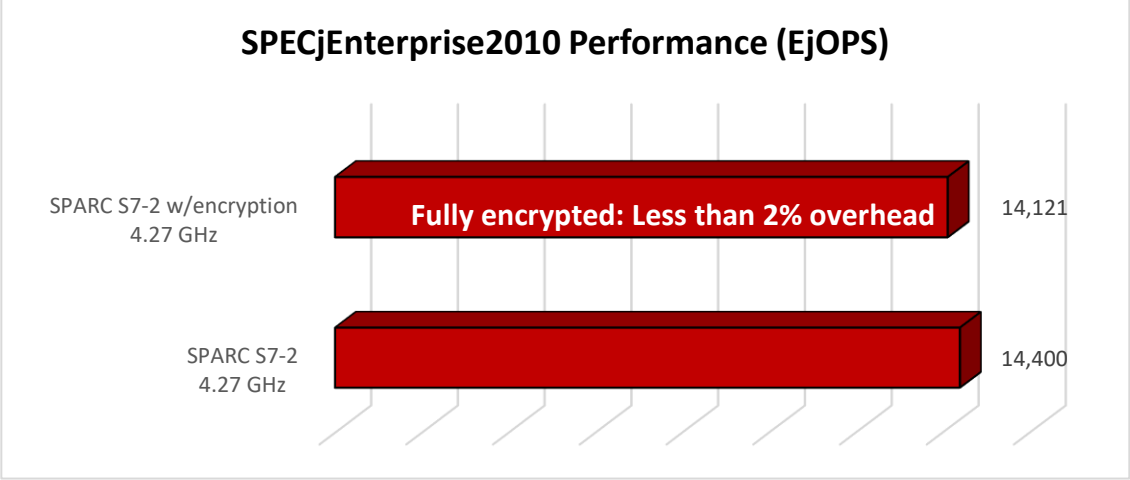


Figure 4: SPARC S7 SPECjEnterprise2010 performance comparison between fully encrypted and unencrypted and unsecure environment[9]

AES (Advanced Encryption Standard) and specifically AES- CFB, AES-CBC, and AES-GCM modes are most critical for environments containing database farms, cloud infrastructure, and general application stacks where data at rest security requirements are mandated.

[9] https://blogs.oracle.com/BestPerf/entry/20160629_jent_sparc_s7_2

The graph below shows how the SPARC S7 systems perform in comparison to the x86 based E5-v4 systems in encryption using AES 256-CFB which is a popular encryption algorithm for database and cloud.

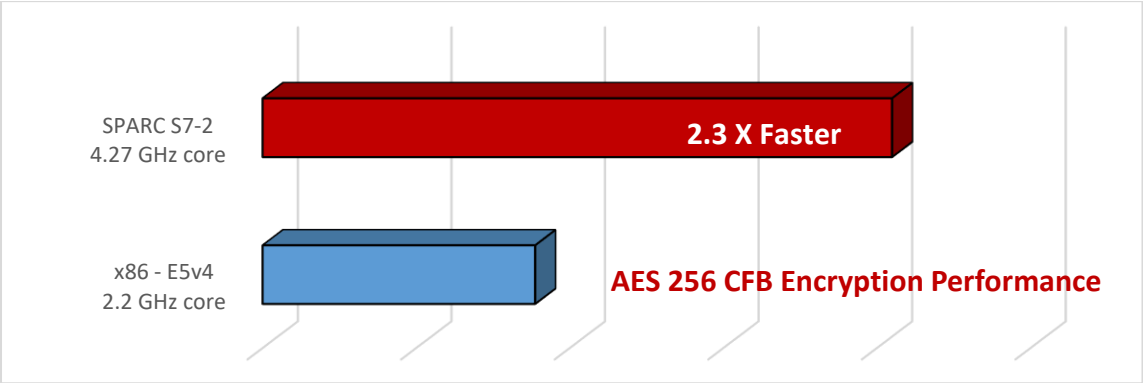


Figure 5: SPARC S7 vs. E5v4 performance on the highest security ciphers[10]

By looking at the performance of the SPARC S7 systems over the x86 systems using this benchmark, we can see that the former performs 2.3 times faster. Performance at scale with AES-based encryption speaks to both system capability and efficiency. Enterprise users are able to leverage the significant performance capabilities to perform operations more quickly than other offerings, while requiring fewer servers to achieve equal or better results. Furthermore, the use of SPARC S7 encryption does not adversely affect the performance of production applications.

The Oracle solution saves time by efficiently handling encryption in the processor silicon without causing significant degradation and without burdening the main processor instruction pipeline. Putting this in perspective, while many other offerings rely on external co-processors and/or un-accelerated encryption software to encrypt data, the Oracle solution provides fully automated, hardware encrypted strategies that illustrate tight integration of built-in encryption hardware and encryption software.

Combining the Silicon Secured Memory and encryption capabilities enables enterprises to provide a broad layer of data protection without the previously existed tradeoffs such as performance loss and cost increase.

Security Compliance and Immutable Systems

No environment is static. Changes are eventually made and therefore data centers must manage system settings on an on-going basis in order to maintain compliancy as

[10] https://blogs.oracle.com/BestPerf/entry/201606029_aes_sparc_s7

required. The Oracle Solaris operating system has built-in security compliance testing features that can automatically audit customer's infrastructure, and report deviations that can be immediately addressed with the help of remediation steps provided. The compliance system provides pre-defined industry standard compliance templates such as PCI-DSS, and allows the customer to configure their own compliance templates. Furthermore, Oracle Solaris includes a feature called Immutable Zones that makes a zone tamper-proof. An Immutable Zone has fixed settings; the configuration is never mutated or modified.

Fault Management Architecture and RAS

System software layers contribute enormously to Reliability, Availability and Serviceability (RAS) functionality. For example, the predictive self-healing capabilities that are implemented in the Oracle Solaris operating system and Oracle Integrated Lights Out Manager (Oracle ILOM) firmware as part of the Oracle Solaris Fault Management Architecture (FMA) are essential elements for ensuring high availability for hardware and application software. This applies even for the scale-out infrastructures which are based on smaller server nodes with lesser in-box RAS features compared to the large scale-up server system.

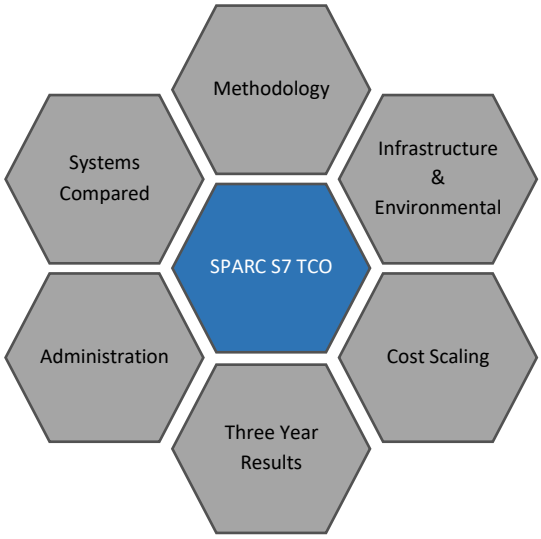
Furthermore, Oracle's layered virtualization technologies help isolate virtual machines and applications—providing redundancy and hardware independence, as well as facilitating easy application mobility between systems. Due to this isolation, if a single application or OS instance should fail or encounter an error, it is prevented from causing downtime across the entire system. The isolation of workloads makes the Oracle stack a secure choice for hosting the Tier-1 applications critical to enterprise success.

High Availability

In addition to the built-in RAS features, middleware, clustering and database disaster recovery software can all be employed to further increase the RAS levels.

Oracle Solaris Cluster works to create isolation and to protect both VMs and Oracle Solaris Zones from outages stemming from hardware or software failure. Should circumstances call for disaster recovery, an Oracle solution (e.g. Oracle Data Guard and the Maximum Availability Architecture) offers aggressive reclamation capabilities that enable a swift return to optimum operability. For example, customers can fail over applications from a primary to a secondary site, if need arises.

Total Cost of Ownership



From a Total Cost of Ownership (TCO) perspective, a data center equipped with Oracle SPARC servers is 43% less expensive than one equipped with x86 alternatives when including Oracle WebLogic middleware, and 48% when comparing the server platforms only and excluding the cost of middleware. The cost advantage exists primarily because of superior hardware efficiency and the pricing of the system software. To achieve the same performance levels, an Oracle-equipped data center requires less hardware, (i.e. processor cores) than an x86-equipped data center. Also, Oracle SPARC servers include, free of charge, all essential system software such as the OS, virtualization and system management tools. The following TCO study demonstrates the cost advantage of the SPARC solution.

Methodology of TCO Analysis

The TCO model reviews the costs associated with the acquisition, installation, licensing, maintenance, and brick-and-mortar infrastructure needs of a server solution. Within this study, list prices are used throughout; no discounts are applied.

The cost components reviewed include:

- Hardware acquisition and maintenance
- OS licensing and maintenance
- Virtualization licensing and maintenance
- System Management software licensing and maintenance
- Network licensing and maintenance
- Facility costs including space, power, and equipment
- Staffing costs

Total Cost of Ownership includes all costs that are needed to procure and sustain operations. These include all maintenance, power, space, and staffing costs, using a three-year horizon with 24x7 support levels. All cost components are included as either capital costs or operating costs. Hardware is assumed to be refreshed every three years or longer, so hardware upgrade or replacement is not a factor in this analysis.

Systems Under Comparison

Given the relative performance of the Oracle and x86-based systems, this analysis considers two multi-server networks:

System Component/Vendor	Oracle	X86
Server Hardware	(20) SPARC S7-2 Servers w/ two 8-core 4.27GHz SPARC S7 processors, 256GB of RAM, two 600GB internal hard disk drives and dual-redundant power supplies	(23) HPE ProLiant DL360 Gen9 system with dual Intel Xeon E5-2650 V4 processors w/256GB of RAM, two 600GB internal hard disk drives and dual-redundant power supplies
OS	Oracle Solaris 11.3	Red Hat Enterprise Linux (RHEL) 2S, unlimited virtual nodes with Smart Management
OS Add-Ons	None	Red Hat Load Balancer, and Red Hat Scalable File System
Virtualization	Oracle Solaris Zones for OS virtualization and Oracle VM Server for SPARC for software partitioning (include with OS)	VMware vSphere Enterprise Plus, licensed per processor, and VMware vCenter Server Standard, licensed per site
System Management Tools	Oracle Integrated Lights Out Manager (ILOM), Oracle Enterprise Manager Ops Center, and Oracle Enterprise Manager framework (included with OS)	HPE Insight Control, and HPE Integrated Lights Out (iLO)
Switches, Cables and Racks	10 Gbps Ethernet using two Cisco Nexus 5548P Ethernet switches at the top of a single rack	10 Gbps Ethernet using two Cisco Nexus 5548P Ethernet switches at the top of a single rack

Table 2: TCO Comparative System Descriptions

Infrastructure and Environmental

Both solutions use similar rack mount hardware with equivalent cost per rack, with all equipment fitting into a single rack. Oracle solution uses 3 fewer rack units (RU). Both solutions assume rental of facility space in New York City, and staff with salaries based on New York City salaries for either Oracle Solaris or RHEL/VMware-experienced personnel. Power cost is based on custom power estimations for each server technology, scaled by a constant factor to account for server cooling and general facility HVAC consumption.

SPARC/Oracle Solaris Requires Fewer Administrators[11]

The integrated simplicity of an Oracle SPARC/Oracle Solaris solution extends up to the management level. A feature unique to Oracle systems, the system management tools (e.g. Oracle VM Manager and Enterprise Manager Ops Center) are designed to monitor, patch, provision, and support operating systems, virtualization technologies, Oracle servers, storage, and networks, all as a single architecture. This lowers both administrative/IT personnel costs and risk by reducing the number and breadth of error-prone manual tasks, as well as administrative resources required per server.

Cost Scaling

For TCO calculations, many costs scale in some way with the size of the installation. Oracle solution runs with both fewer servers (20 servers to 23 servers) and fewer physical cores (see figure 6). Along with the high core efficiency of the SPARC S7 processor, this is the other reason for significant cost reduction because it leads to savings in software licensing.

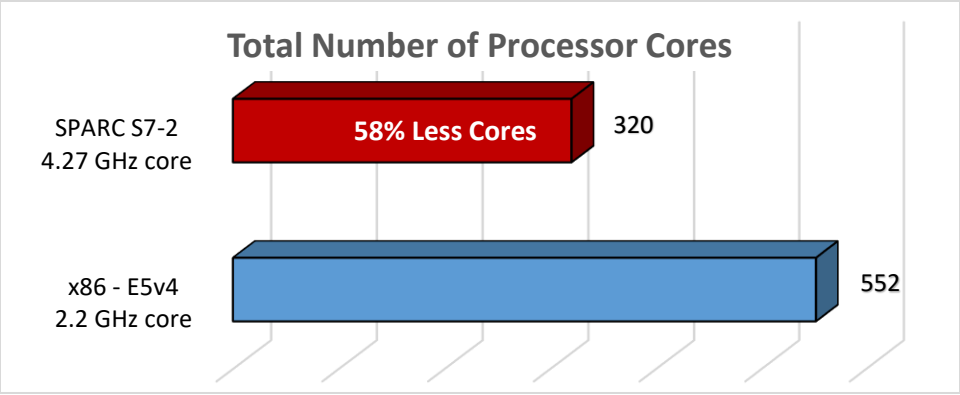


Figure 6: Processor Core Count Comparison

[11] ZDNet: http://www.zdnet.com/blog/murphy/cost-comparison-solarissparc-vs-linuxx86/1020

Three Year TCO Results

The Table 3 represents both capital and operating costs for a three-year period. Cost of support and subscriptions is based on a 24x7 level services.

Total Cost of Ownership	Oracle	HPE	Difference	
Capital Cost				
Server Hardware	$392,480	$321,793	($105,255)	(21.1%)
OS		$0		
Virtualization		166,765		
System Management Tools		9,177		
Switches, Cables and Racks	61,190	61,190	0	0%
Subtotal Cap. Cost (w/o Middleware)	**$453,670**	**$558,925**	**($105,255)**	**(18.8%)**
Middleware (Oracle WebLogic)	1,600,000	2,760,000	(1,160,000)	(42%)
Subtotal Capital Cost	**$2,053,670**	**$3,318,925**	**($1,265,255)**	**(38.1%)**
Operating Cost				
Server Hardware	$141,293	$32,292	($376,675)	(72.7%)
OS		335,412		
Virtualization		125,109		
System Management Tools		25,154		
Switches, Cables and Racks	13,968	13,968	0	0.0%
Power	60,288	47,019	13,270	28.2%
Space	20,366	23,143	(2,777)	(12.0%)
Staffing	67,800	303,600	(235,800)	(77.7%)
Subtotal Op. Cost (w/o Middleware)	**$303,715**	**$905,697**	**($601,982)**	**(66.5%)**
Middleware (Oracle WebLogic)	1,056,000	1,821,600	(765,600)	(42.0%)
Subtotal Operating Cost	**$1,359,715**	**$2,709,725**	**($1,367,582)**	**(50.1%)**
TCO (w/o Middleware)	**$757,385**	**$1,464,622**	**($707,237)**	**(48.3%)**
Total Cost of Ownership	**$3,413,385**	**$6,046,222**	**($2,632,837)**	**(43.5%)**

Table 3: Total Cost of Ownership Over 3 Years

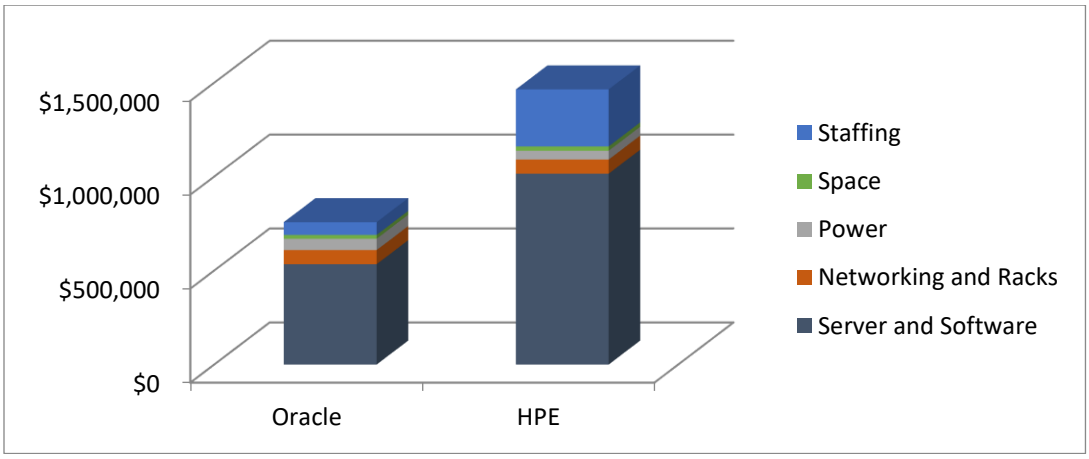


Figure 7: Systems TCO (excl. Middleware)

When you take acquisition and operating costs over a three-year period, and exclude middleware costs, the Oracle SPARC S7 solution is 48.3% or $707,237 less expensive than a similar x86 alternative.

Middleware Cost Impact

When you include middleware, the Oracle SPARC S7 solution is 43.5% or $2,632,837 less expensive than an equivalent x86 alternative.

Conclusion

The SPARC S7 processor is an evolutionary advance over the recently released SPARC M7 processor. It has been designed to support both scale-out and cloud workloads more effectively. Compared to the latest x86 systems the SPARC S7 server delivers a per-core throughput for Java and Database applications that is 1.7 and 1.6 times higher, respectively.

Additional capabilities like the data analytics accelerator (DAX) units increase performance up to 8 or 20 times for database and java applications, respectively.

Using Oracle VM Server for your virtualized environments minimizes performance loss in consolidated environment, 1%, vs. anywhere from 7% to 17% performance loss from VMware or IBM WebSphere. In addition, provisioning using Oracle VM Server is significantly faster than the two aforementioned competitor products.

Security and risk aversion are a key focus in the SPARC S7 Server. This is evidenced by the use of Silicon Secured Memory, which protects application memory to prevent data breach/loss due to over-reads or over-writes. SPARC S7 servers use the latest encryption techniques which are extremely efficient imparting less than a 2% loss in performance when activated.

Security compliance is addressed by the Oracle Solaris operating system through the ability to automatically audit SPARC infrastructure, and report deviations that can be immediately addressed. There are also features that address both fault management and provide high availability.

From a total cost of ownership perspective over a three-year period, Oracle SPARC S7 is 43% or $2.6M less expensive than a similar x86-based system. This is due to cost differences in both hardware and software as well as reduced maintenance costs. The lower number of SPARC S7 Servers and associated cores per server contributes to the lower licensing cost since there are 58% fewer overall cores.

Based on all of the information summarized above, it is clear that for scale-out and cloud-based application workloads, the SPARC S7 must be considered an attractive choice.