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Technical White Paper

Understanding the Security and Performance Advantages of a Complete Oracle Solution with Software in Silicon

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Table of Contents

Executive Summary

A key challenge for enterprise IT is maintaining high performance, while meeting increasingly stringent requirements for security and reliability. In addition, budget constraints, and a seemingly endless sprawl of physical and virtual systems, increase delivery complexity. Enterprise IT managers continue to face difficult decisions on how to deliver enterprise performance, security, and reliability to users within their budgets.

Considering the value added by Big Data, Cloud, Database Farming, and blazing application speed on purpose-built platforms, business managers and IT executives considering solutions to run increasingly complex applications face a dizzying array of vendor platforms.

This technical/business white paper assesses new infrastructure choices from Oracle, and how they can help organizations meet their performance and security requirements without tradeoffs.

At the center of Oracle's offerings in Edison's evaluation lies the new Oracle SPARC M7 processor, which features new technology Oracle calls "Software in Silicon." With 32 cores and 256 threads per processor, the SPARC M7 marks nearly a 300 percent improvement over the previous generation SPARC M6 processor[1]. The SPARC M7 processor is used across the full range of new Oracle SPARC Systems including the SPARC T7 Servers with one to four sockets, the SPARC M7 Servers with eight or 16 sockets and the new Oracle SuperCluster M7.

According to Oracle, their design approach is to engineer software and hardware products together or put another way, add capabilities in one layer of the stack that specifically help a different layer work better. 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 analytic workloads.
- Security in Silicon – provides a innovative new layer of security for data in memory known as Silicon Secured Memory (SSM). Added to that is broad, automated, high performance encryption, both built into the processor.

[1] Page 6 – Oracle's SPARC T7 and SPARC M7 Server Architecture http://www.oracle.com/technetwork/server-storage/sun-sparc-enterprise/documentation/sparc-t7-m7-server-architecture-2702877.pdf

- Secure Live Virtual Machine Migration – Oracle Solaris 11's live migration feature automatically engages the hardware encryption engines to protect potentially sensitive data, for example account numbers or login in credentials, from snooping on the network.

At the core of Oracle's high performance, highly secure integrated approach to IT platform solutions, the Oracle SPARC M7 processor is a significant advance in Oracle's processor design and a solid foundation to the already robust Oracle portfolio of hardware and software. The SPARC M7 is the processor used in the SPARC T7 and SPARC M7 servers.

Modernizing to Solve Enterprise IT Challenges

Enterprise IT shops face enormous pressure to provide the best returns on investment while conducting business as efficiently as possible. In addition, IT security concerns are constantly evaluated against the reduced performance and increased costs associated with staying highly secure. For example, deploying encryption provides a valuable layer of protection, however, without hardware assistance, encryption siphons critical compute cycles away from enterprise systems that need to execute tasks as quickly as possible. IT shops face a tough choice: either investing in costly infrastructure to bolster existing IT systems, or in the extreme, requiring additional peripheral or third-party hardware to off-load security encryption tasks.

Oracle takes a unique approach in the way it addresses crucial security concerns, while maintaining the highest levels of performance. The review of Oracle solutions that overcome these difficult business/IT issues is summarized below.

Oracle SPARC M7 and Software in Silicon Functionalities

Enterprise IT managers face tough challenges combating constant attempts to access corporate assets by cybercriminals who routinely exploit system software vulnerabilities and probe for any sign of weakness. Enterprise IT managers are left considering enhanced security measures, which could result in reduced efficiency or costly infrastructure enhancements. Needing to maintain additional infrastructure to enhance system security can be exceedingly costly in terms of both hardware and degraded performance.

Oracle adds a new layer of security with a 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 overwrites and buffer over reads. With Silicon Secured Memory, applications are only able to access their own dedicated memory regions, thereby protecting application memory space.

This new functionality, unique to Oracle, can help in two primary ways. First, software programmers can identify issues with memory allocation and improper memory accesses by running debugger tools, both in development and on live environments, with little to no performance impact. Second, during production, illegal accesses are prevented from occurring. 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. For more information about how Silicon Secured Memory protects against memory attacks, watch this short video on how Silicon Secured Memory stops the Heartbleed attack point http://download.oracle.com/SSM/SSM-Demo.html.

Silicon Secured Memory is implemented 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.

Removing Barriers to Data Encryption

While encryption is not a new technology, the 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 cyberattacks, 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 M7 processor supports 15 unique encryption ciphers and is the clear performance leader, as shown later in the paper. The SPARC M7 encryption ciphers are instructions in the processor, available with no added cost, and deliver data security with negligible performance loss.

The protection offered by network encryption, Silicon Secured Memory, and encryption-on-disk strategies is important. However, of equal importance is the cost of being highly secured while providing adequate performance. Oracle's integrated approach does not increase costs or significantly degrade performance, while providing robust security.

Cybercriminals know that valuable enterprise and user data is commonly found inside enterprise systems running database servers. While protecting enterprise storage systems and network infrastructure peripheral equipment is important, most enterprise software being run today requires databases as a backend facility in hosting, managing, and performing end-user functions. Therefore, guarding against unauthorized access to enterprise database systems is a critical component in safeguarding consumer and enterprise assets.

Oracle Database Transparent Database Encryption (TDE), a security option for Oracle Database, is fully integrated with the SPARC M7 processor encryption accelerators to deliver protection without performance loss. Acceleration of encryption is automatic after enabling Oracle TDE, and since it is built into the processors there is minimal administration required to ensure that sensitive data stored in databases is protected on storage.

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.

The following graph demonstrates how the SPARC M7 processor compares to other processors used by their competitors.

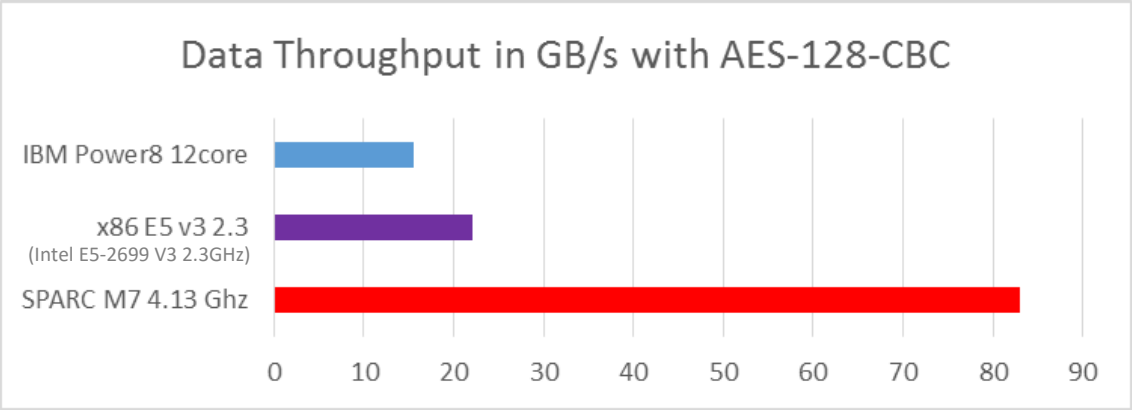

Figure 1: Data Throughput in Gigabytes per Second Under AES 128 CBC[2]

Based on benchmark information provided by Oracle, the SPARC M7 processor is nearly four times faster than the x86 processor, and more than five times faster than an IBM POWER8-based system. Performance at scale with AES-based encryption speaks to both system capability and efficiency, as enterprise users are able to leverage the significant performance capabilities to perform more operations quicker than other offerings, while requiring less infrastructure to achieve equal or better results.

The Oracle solution saves time by efficiently handling encryption in hardware without causing significant degradation. 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 and deliver added security for data in motion, data in memory, and data at rest.

[2] https://blogs.oracle.com/BestPerf/entry/20151025_aes_t7_2

Oracle Performance and Efficiency

Oracle's business focus is on enterprise class computing including cloud, database, ERP applications, web environments, etc. Currently, Oracle claims over 20 world record performance numbers with their SPARC M7 and T7 systems. The focus of the following section is on performance related features, and reviewing the data behind a few of these performance claims.

Oracle Database Workloads

Database operations are a typical use case that demonstrates the advantage of Oracle's solution. SPARC M7 processors have 32 cores with eight threads per core, fast DDR4 based memory DIMMs, fast internal bandwidth between the processor and system components, and high (4.13Ghz) clock speeds.

In addition to the large memory bandwidth, high clock speed, large number of cores and redesigned cache architecture, Oracle has also introduced new Software in Silicon technology called SQL in Silicon. SQL in Silicon provides query acceleration delivered by Data Analytics Accelerators, or DAX, which, like the security features discussed before, are built into the processor itself. Oracle Database In-Memory, an option for Oracle Database 12*c*, automatically takes advantage of SQL in Silicon. Each SPARC M7 processor incorporates eight DAX co-processors, each with four pipelines, or engines. By leveraging DAX, users can take advantage of the built-in ability to process 32 independent data streams, while freeing up the actual M7 processor cores to do other work.

Putting the combination of SPARC M7 processors and Oracle Database 12*c* into perspective, when companies want to run analytics, the data is extracted from an OLTP database, transformed, then loaded into data warehouse databases prior to running queries. Trying to run queries on standard OLTP databases is a slow process that also reduces the performance of the OLTP database. This is why data is typically offloaded to data warehouse engines for processing.

The Software in Silicon capabilities found in the SPARC M7 processors offer users a simpler, less labor intensive alternative to the data offload steps, prior to the analytics processing step. Instead, using SQL in Silicon with Oracle Database In-Memory, enterprise users can run OLTP workloads and reporting and analytics on the same system, avoiding ETL (Extract-Transfer-Load) operations and perform queries on the latest data. This is more efficient and less costly than traditional methods.

Using benchmark information provided by Oracle, the benefit of DAX to the overall Oracle integrated approach to performance can be viewed in Figure 2, showing a DAX enabled system (SPARC T7-1 with on SPARC M7 processor) versus an x86 server.

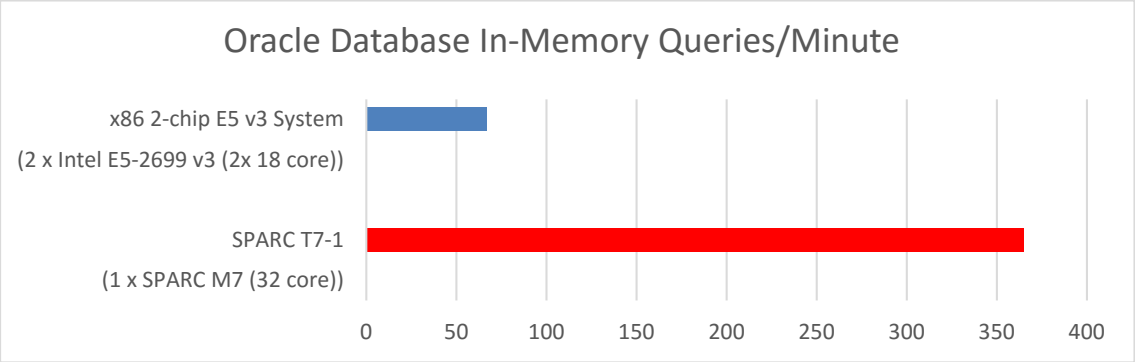

Figure 2: Oracle Database In-Memory Query Performance SPARC M7 versus Intel x86[3]

The SPAR T7-1 delivers 5.4x more queries when compared to the x86 based E5 v3 system. Note that the Oracle system uses a single SPARC M7 processor, versus a two-processor design for the x86 server.

Comparing Accelerator Technologies

Recently, some hardware vendors have created products to accelerate important business computing tasks, such as enterprise grade analytics. The use of GPUs (Graphics Processing Units) and other co-processor strategies are becoming the norm in some environments that need faster processing. Edison looked deeper at these acceleration technologies to assess relative strengths and vendor sustainable advantage.

IBM uses CAPI[4] or Coherent Accelerator Processor Interface on IBM POWER8 systems to enable users to connect custom acceleration engines. The challenge with CAPI, when measuring performance against a SPARC M7-based infrastructure, is in the limitation of I/O capacity to system memory. No matter how much faster a GPU or other co-processor may be on paper, the extra horsepower being supplied will have a limited impact if the architecture is constrained by the rate in which you can move data in and out of the special co-processor.

In a review of Oracle supplied performance data, a SPARC T7-4 server (with four- SPARC M7 processors) was compared directly to an IBM S824 server (2-CAPI, four-processor design). While the IBM S824 server's bandwidth to the IBM CAPI Accelerators is 12.2GB/s[5], the Oracle T7-4 bandwidth from memory to the DAX units is 600GB/s. The SPARC T7-4 has 49 times

[3] https://blogs.oracle.com/BestPerf/entry/20151025_imdb_t7_1
[4] http://www-304.ibm.com/webapp/set2/sas/f/capi/home.html
[5] http://developer.download.nvidia.com/compute/cuda/5_5/power8/docs/CUDA_Getting_Started_Linux.pdf

greater transfer bandwidth than the IBM S824, which means the SPARC T7-4 can move data to and from memory to the DAX units much faster than the IBM S824 can move data to and from the CAPI. Edison believes the data transfer rate for the accelerator technology can significantly affect analytics and query performance.

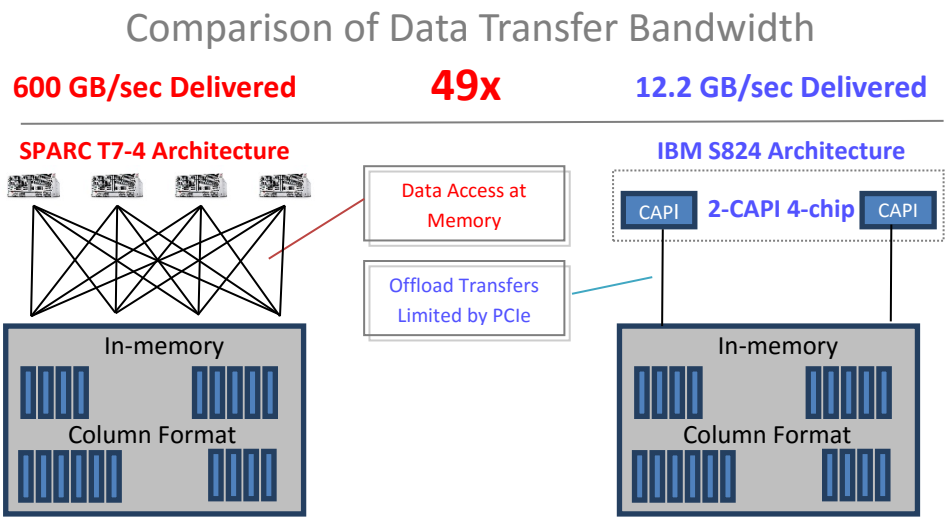

Figure 3: Analytics Acceleration Oracle SPARC T7-4 versus IBM S824

The architectural strengths demonstrated in Figure 3 lead us to conclude that the SPARC M7 Systems with DAX technology may be better suited for large query workloads, compared to other acceleration technology options. As the use of data analytics, machine learning and other forms of iterative analytical processing continue to grow, DAX technology built into SPARC M7 and presumably future processors provides an excellent alternative to traditional architectures. Figure 2 shows performance advantages for large-scale database or structure data queries; the following section looks at analytics performance for unstructured data workloads.

Unstructured Data Performance

Big Data and the use of Hadoop are on the rise. While one would expect the Oracle SPARC M7 to perform well when running Oracle specific software, the Oracle architecture also shows strong results in non-Oracle Big Data operations.

Edison reviewed results provided by Oracle regarding system performance when running the popular Terasort benchmark[6] and provides a condensed version of the results below.

[6] https://blogs.oracle.com/BestPerf/entry/20151025_terasort_t7_4

System	Processor	Sort Rate (GB/min Per Chip)	SPARC M7 Advantage
Oracle T7-4 1 node	4.13Ghz SPARC M7	35.2 (unsecure)	-
Oracle T7-4 1 node	4.13Ghz SPARC M7	32.2 (secure) AES-256-GCM Encryption	Baseline
Dell R720xd 32 nodes	2.8Ghz E5-2680 v2	8.9 est. (unsecure)	3.6x
IBM S822L 8 node 6c/ch	3.5 POWER8	7.5 (unsecure)	4.3x

Table 1: Oracle and Big Data Advantages

The Oracle solution clearly dominates throughput performance. An important point to note in the configuration is that the Oracle system shows a clear performance advantage even while using the previously mentioned security features. Security, once a feature (and really now a requirement) that nearly always would have resulted in performance degradation is clearly not an issue with the Oracle solution.

Independent third party benchmarks are more compelling than Oracle supplied benchmark information. The Oracle SPARC M7 chip measured under the SPEC™ SPECjEnterprise™ benchmark[7] as illustrated in Figure 4, leads in performance[8] as compared to competitors like the IBM POWER 8 solution as well as x86 processor-based solutions.

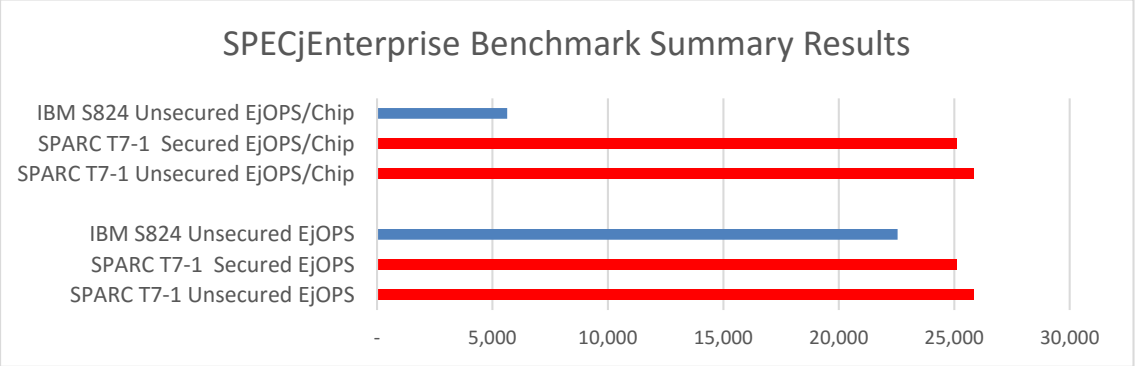

Figure 4: SPECjEnterprise2010 and Oracle SPARC M7 Performance Comparison[9]

[7] SPEC and the benchmark name SPECjEnterprise are registered trademarks of the Standard Performance Evaluation Corporation. Results from www.spec.org as of 10/25/2015. (SPARC T7-1, 25,818.85 SPECjEnterprise2010 EjOPS (unsecure); SPARC T7-1, 25,093.06 SPECjEnterprise2010 EjOPS (secure); Oracle Server X5-2, 21,504.30 SPECjEnterprise2010 EjOPS (unsecure); IBM Power S824, 22,543.34 SPECjEnterprise2010 EjOPS (unsecure); IBM x3650 M5, 19,282.14 SPECjEnterprise2010 EjOPS (unsecure).)

[8] https://blogs.oracle.com/BestPerf/entry/20151025_imdb_t7_1

[9] http://www.oracle.com/us/solutions/performance-scalability/sparc-t7-1-specjenterprise2010-2735227.html

According to Oracle, SPARC M7-based servers hold 20-plus world records[10] for performance, a clear testimony to the company's commitment to performance excellence while offering highly secure environments for enterprise users.

Software in Silicon Open Technology

As of the publication of this document, Oracle has announced a Software in Silicon Developer Program and open APIs for developers to access both the Silicon Secured Memory security functions and the Data Analytics Accelerators. As shown earlier, the DAX technology provides major acceleration of Oracle Database 12*c*; opening DAX technology for others to leverage for analytics and their own applications is a promising new development.

Additional Benefits through a Complete, Single Vendor Solution

The challenges of integrating, managing, patching, servicing and maintaining the required service levels for a multi-vendor environment can't be overstated. While the trend has been to move to commodity hardware and open source software, in many cases any up front savings are eclipsed by the added costs of administering complex, piecemeal solutions. As a complete solution provider, Oracle engineers and tests products together to deliver new capabilities, improve quality and simplify management when products are deployed together.

While the list of examples is extensive, here are a few -

- Oracle Database In-Memory leverages the SPARC M7 Data Analytics Accelerators.
- When running on Oracle Solaris 11, Oracle Database 12c is automatically protected by Silicon Secured Memory.
- Oracle Solaris 11 provides integrated patching with rollback for the complete environment versus using different tools for the hardware, OS, virtualization layer, etc.
- Live VM migration automatically leverages encryption acceleration to ensure data is protected from network snooping during migrations.
- Enterprise Manager 13c and Enterprise Manager Ops Center provide management of the complete environment.
- Legacy application migration is simplified by the Oracle Solaris guaranteed binary compatibility program.
- A single service organization provides greater accountability.

[10] http://www.oracle.com/us/solutions/performance-scalability/sun-sparc-enterprise-t-servers-078532.html

The traditional approach of evaluating architecture components separately has it shortcomings. Decision makers are encouraged to consider how the various components will be deployed and managed, as a complete solution, when evaluating their buying criteria.

Financial Implications of the New Oracle Systems

While thus far we've examined the security and performance advantages, the financial implications of these new systems must also be considered. The following provides a quick snapshot comparison of the Total Cost of Acquisition, plus five-year maintenance costs, for a moderate sized data center upgrade representing approximately half a rack of Oracle systems, and the equivalent in performance for IBM.

Financial Comparison Methodology

Edison relied on published benchmarks to select configurations for the financial comparison for roughly equivalent performance measures. One difference is that the Oracle SPARC T7-1 system benchmarks were run with encrypted data, and IBM Power System S824 benchmarks did not use encrypted data. Encrypting data can introduce performance overhead but also increases the security of data.

Assumptions and methodology –

- Independently published benchmark results were used to determine comparable server models.
- Server configurations analyzed included commonly deployed options. The analysis did not attempt to price specific configurations used in the benchmarks.
- Analysis included typical server system software – operating system and virtualization software licenses including maintenance subscriptions.
- Cost of networking and storage infrastructure were assumed to be equal.

To arrive at similarly performing system models, Edison settled on the publicly available benchmark results for SPECjEnterprise2010. The benchmark is the third generation of the SPEC organization's Java Platform Enterprise Edition (Java EE) end-to-end industry benchmark. In effect, this benchmark tests a load placed against an application server that is connected to a database backend, a common scenario in enterprise application deployments. Test results leveraged for this comparison are shown in Figure 4 and are available at www.spec.org.

	Oracle	IBM
Performance Comparison		
Server Platform	Oracle SPARC T7-1	IBM Power System S824
Performance per System SPECjEnterprise2010	25,093.06 EjOPS (Encrypted)	22,543.34 EjOPS (Un-encrypted)
Server Count	10	11
Aggregate Performance SPECjEnterprise2010	250,180 EjOPS	247,973 EjOPS
Rack Units	2U x 10 = 20U	4U x 12 = 48U
System Details		
Server Platform	Oracle SPARC T7-1	IBM Power System S824
Platform Specs	1 x SPARC M7 4.13GHz CPU (32 cores), 128 GB memory, 1,200 GB disk	4 x POWER8 3.52GHz CPU (6 cores, 24 total), 128 GB memory, 1,200 GB disk
OS	Oracle Solaris	IBM AIX Enterprise Edition
Virtualization	Oracle VM Server for SPARC, Oracle Solaris Zones	PowerVM Enterprise Edition
System Management Tools	Oracle Enterprise Manager Ops Center	Systems Director (included in AIX EE, Base Console)
Remote Management (remote console hardware not included)	ILOM	HMC
Configuration Summary	10 servers 360 cores 1,280 GB memory 20U rack space 250,180 EjOPS	11 servers 240 cores 1,408 GB memory 44U rack space 247,973 EjOPS

Table 2: Configuration Details

It is important to note that in the Oracle configuration, data was encrypted on the network and on storage to provide a higher level of security. Additionally, even with the extra security measures, the Oracle configuration demonstrated an 11 percent performance advantage per system over published results from IBM.

Pricing Comparison

Configurations that represent a moderate sized data center upgrade were chosen for the comparison.

	Oracle Pricing (Per unit)	Oracle Pricing Total (10 units)	IBM Pricing (Per unit)	IBM Pricing Total (11 units)
Acquisition and Support Pricing				
Server (Purchase)	$39,795	$397,950	$64,801	$712,811
HW Service/Support (Purchase + 5 Yrs. Maint.)	23,877	238,770	11,877	130,647
OS (Purchase + 5 Yrs. Maint.)	Included	Included	29,832	328,153
Virtualization (Purchase + 5 Yrs. Maint.)	Included	Included	22,440	246,840
System Management Tools (Purchase + 5 Yrs. Maint.)	Included	Included	Included	Included
Remote Management (Purchase + 5 Yrs. Maint.)	Included	Included	Included	Included
Total		**$636,720**		**$1,418,450**
5 Year Difference				**+$781,730**
5 Year Difference as a % of Oracle Costs				**123%**

Table 3: Price Comparison Details

Based on our research and the assumptions reviewed above, an IBM Power System S824 based solution is 123 percent more expensive than an Oracle SPARC T7-1 based solution over a five-year period. For similar use cases and performance: $1,418,450 vs. $636,720, a $781,730 difference. The table above provides the detail comparison and costs in each major category.

Conclusion and Recommendations

This whitepaper focuses on the newest processor release by Oracle, SPARC M7.

First, the inclusion of Software in Silicon, software embedded in the processor chip, provides significant advantages in encryption, processing speed, and analytics acceleration, while maintaining compelling price points.

Second, this is the start of an architectural roadmap that extends many years into the future, thus providing acquisition and support protection for users.

Third, based on Oracle's holistic approach, which enables smooth product integration and function, and feature synergies, it makes sense to consider a complete Oracle-based solution.

Companies looking at making a platform refresh or considering a migration should assess the advantages in security, analytics and general performance offered by the Oracle solution suite.

Those looking for breakthroughs in the analytics and big data areas should consider Oracle's Software in Silicon technology and strategy for hardware acceleration.

Finally, understanding the complete deployed solution including administrative and support models, is key to making the correct choice. When making purchasing decisions for the areas mentioned in this paper: encryption, performance, analytics, and big data, should include Oracle as part of their final decision set.